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UNDERSTANDING THE LOW CONSUMPTION OF PULSES AMONG FRENCH NON VEGETARIAN CONSUMERS: COMBINING DIRECT AND INDIRECT APPROACHES TO IDENTIFY BARRIERS AND OPPORTUNITIES

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Thesis Valorization

Publications in peer-reviewed journals

- **Melendrez-Ruiz**, J.; Buatois, Q.; Chambaron, S.; Monnery-Patris, S.; Arvisenet, G. French consumers know the benefits of pulses, but do not choose them: An exploratory study combining indirect and direct approaches. Appetite 2019, 141, 104311.
- **Melendrez-Ruiz**, J.; Chambaron, S.; Buatois, Q.; Monnery-Patris, S.; Arvisenet, G. A central place for meat, but what about pulses? Studying French consumers' representations of main dish structure, using an indirect approach. Food Research International 2019, 123, 790–800.
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Proceedings

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- Buatois Q, **Melendrez Ruiz** J, Chambaron S, Monnery-Patris S, Arvisenet G, “What I say is not necessary what I do: pulses consumption in French adults”, « EuroSENSE: Conference on Sensory and Consumer Research », Verona, September 2018
- Laugel V, **Melendrez Ruiz** J, Arvisenet G, Chambaron S, Monnery-Patris S, Les attitudes et représentations des professionnels de l’alimentation envers les légumes secs et leurs perceptions des mangeurs Français, « Rencontre Francophone des Legumineuses RFL », Toulouse, October 2018
- **Melendrez-Ruiz** J, Chambaron S, Monnery-Patris S, Arvisenet G, “Utilización de la prueba CATA para estudiar las representaciones, las actitudes y creencias de los consumidores franceses hacia las legumbres, según su nivel de transformación”, Congreso de la «Asociación Española de Profesionales del Análisis Sensorial (AEPAS)», San Sebastian –Spain, June 2019

Chapter I. Introduction & Theoretical framework

We, as a society, are currently going through a moment that could perhaps (and hopefully) be a breaking point, impacting positively our food habits. A few months ago, a global and unattended pandemic arrived and changed the way we were used to buying, cooking, and sharing food. With the containment due to the COVID, we were confronted with a moment of food shortage, where not all the products we were used to buy or want were available. There was a limited time to shop per day or even per week. People were challenged to cook every day for themselves and their families, as there were no open canteens, restaurants or coffee shops. There was no social gathering either, to share a meal or a drink with friends and family. Our food choices and consumption were roughly impacted and changed. We were able to adapt our consumer behavior to the moment, we learned to use the products available in the market, try different food, or combine differently our meals. The excuse behind "I don't have time to cook" was over for a while, there was time to learn to cook, to make a recipe and prepare a tasty meal. These circumstances highlighted not only the important place of the food itself but also the mutual relationship that it has with the person that buys it, cooks it, and/or consumes it. We also witnessed changes in consumers' behavior. For example in France, during this period, there was an exponential increase in the sales of lentils, especially the "Lentilles du Puy"[1], which benefited from a protected geographical indication. The increased interest regarding this product can be seen as the result of an unexpected situation (lockdown) transformed into an opportunity, and contributing to an ongoing food transition towards more sustainable food consumption patterns.

The introduction of this thesis will further focus on the current food transition and pulses consumption. Secondly, the factors related to consumers' food choices and behavior will be exposed. Following this, the different approaches that could be used to study consumer behavior will be presented. Lastly, the aim and outline of the thesis will be introduced.

[1] French National TV news report, France 3 (19/20). Aired Friday, June 19, 2020.

1. Food transition: more beans than beef, please

1.1. General context of the current food transition

During the last few years, a lot of attention has been drawn towards more sustainable food diets over the world. A sustainable diet is defined by the Food and Agriculture Organization (FAO), as a diet that contributes to nutrition and food security, with low environmental impacts, and that promotes a healthy life for present and future generations. In this sense, sustainable diets protect and respect biodiversity and ecosystems, they are safe, healthy, and nutritionally adequate. At the same time, a sustainable diet has to be accessible, economically fair and affordable, culturally acceptable, while enhancing natural and human resources (Burlingame, 2012). Moving towards a more sustainable diet is challenging in the context of a continuous increase in the global population, which is projected to be around 9.7 billion people by 2050 (United Nations, 2015).

Current food intake is based mainly on cereals (especially wheat and corn), animal protein (particularly beef and chicken), and a restricted variety of fruits and vegetables (INRA & CIRAD, 2016). Food consumption trends in developed and developing countries are focused on increased consumption of animal products, sugars, sweeteners, edible plant oil, and a decreased consumption of whole-grain cereals, vegetables, and legumes (INRA & CIRAD, 2016). In the European Union (EU) the supply of animal proteins has increased over the past 40 years, while the supply of plant proteins has been stable (de Boer et al., 2006). Meat, cereals, and milk provide the main part of the dietary proteins in EU countries. Meat contributes slightly more than cereals, while cereals, especially wheat, are the main provider of plant proteins from all plant sources (de Boer et al., 2006). Similarly, in the French population, around 70% of the total protein intake comes from animal protein, particularly meat and dairy products, while for the plant protein the main contributors are cereals (Camilleri et al., 2013). The tradition in many industrialized countries is to regard meat as a prestigious food, with a traditional belief that men need more beef than women (Booth, 1994). Meat plays an important role in human evolution and diets. It is considered as an ideal complete food, which “essentially forms packages of complete nutrients for other vertebrates” (Rozin, 2006). Meat is considered essential not only for its high nutritional value (protein content) but also for the social and cultural place it has held over time.

1.2. Proteins in animal and plant products

It is more and more recognized that, if the current food pattern continues, it will raise a major food security issue. Indeed, demographic projections show that the expected rise of the population by 2050 will increase the consumption of meat and dairy by 23% (Berners-Lee et al., 2018). To produce 1 kg of meat protein, 6 kg of plant protein are needed on average (Smil, 2002). ‘Plant proteins’ refers

to the protein from plant origin, as opposed to the animal origin. These proteins are cheaper to produce, from both monetary and environment perspectives, and more abundant than animal proteins. Despite all these advantages of plant-proteins, their direct consumption for the human diet is limited in developed countries, and nowadays proteins product from plant origin are mostly used to feed animals, to produce milk, eggs, and meat (Day, 2013). Besides, the production of proteins from animal origin requires 100 times more water than producing an equal amount of plant proteins (Aiking, 2011). To guarantee that all people could be fed by 2050, there is a need to change dietary habits, and reducing or partially replacing meat and dairy with plant-based alternatives is one of the recommended levers to achieve this change (Berners-Lee et al., 2018). This would constitute a key step towards the goal of more sustainable food consumption (de Boer et al., 2006).

But shifting the balance between proteins from animal and plant origins need to take into account the balance in amino acids intake. Indeed, proteins are a nutrient of primary importance in the human diet, yet they are not all equivalent regarding amino acid supply (Westerterp, 2006). The word proteins come from the Greek *protos* that means "first", "essential" and "the vital importance" (FFAS, 2019), and indeed, some amino-acids are essential to maintain a good health. Among the twenty amino acids necessary to cover human needs, eleven can be metabolized by the human body, while the other nine cannot be synthesized *de novo.* These nine essential amino acids[2] obligatorily need to be brought by the consumption of food (FFAS, 2019). The animal food proteins contain all the essential amino acids, contrary to most of the plant proteins, that have a deficit in one or two essential amino acids at least (Hoffman & Falvo, 2004). For instance, the cereals are rich in methionine, but deficient in lysine, while legumes are rich in lysine, but poor in methionine (Chardigny & Walrand, 2016; Schneider, 2002). To overcome the unbalanced amino acid profile and improve the nutritional quality of plant proteins, an efficient strategy is to pair certain plant-based proteins which compensate one another for their amino-acid content (e.g. a mix of cereals and legumes) (Chardigny & Walrand, 2016; Day, 2013; FFAS, 2019). Thus, the right mix of different plant protein sources can provide a sufficient amount of essential amino acids, to cover human needs. A combination of plant proteins within the same day is usually recognized to ensure a balanced intake of essential amino acids (Day, 2013). However, a recent paper suggested that complementary plant proteins should be combined within the same meal (Chardigny & Walrand, 2016). Beyond the intake of amino acids, it has been shown that a mix of plant foods, from beans, root vegetables, and green salads, provides a wide range of nutrients, with low fat content, and rich in fiber and antioxidants (Booth, 1994). It has been demonstrated that

[2] Valine, isoleucine, leucine, methionine, lysine, threonine, tryptophan, phenylalanine, and histidine (sometimes referred as semi-essential)

plant protein intake is a marker of nutritional adequacy of the diet. Plant proteins are therefore considered to contribute to a healthy diet (Camilleri et al., 2013). Diets based on plant-based products with little processing are protective, while omnivorous diets based on ultra-processed food products from animal origin are associated with a higher risk of chronic diseases (Fardet, 2017). Yet, products from animal origin also offer specific nutrients that are slightly or not present in plant proteins, like zinc, vitamin B12, omega-3 fatty acids, heme iron, and calcium (FFAS, 2019). Plant proteins are a source of other specific nutrients that are slightly or not present in animal products, such as fibers, vitamin C, magnesium, folic acid, and other phyto-micronutrients. Furthermore, there is not just one single path towards more food sustainability, as it has to take into account the role of ecological, economic, and cultural factors (de Boer et al., 2006). What will work for one country may not work for another. It has been shown that sending messages to consumers to ask them to reduce their meat consumption was not well understood and may even be counterproductive (de Boer & Aiking, 2011). Instead, other strategies must be found to promote a more sustainable diet, explaining the interest of combining both animal and plant proteins.

1.3. Legumes and pulses

For human nutrition, the most important plant groups in terms of intake are cereals grains and food legumes (Day, 2013). Within the legumes family (*Leguminosae*), we find pulses. Pulses are defined by the FAO are leguminous crops harvested exclusively for dry seeds (i.e. dried beans, lentils, and peas) that are produced for human consumption. It excludes crops used mainly for oil extraction (e.g. soybeans), and those that are harvested greens, e.g. green peas (FAO, 2016b). That means that pulses are all legumes, but not all legumes are pulses (Figure 1).

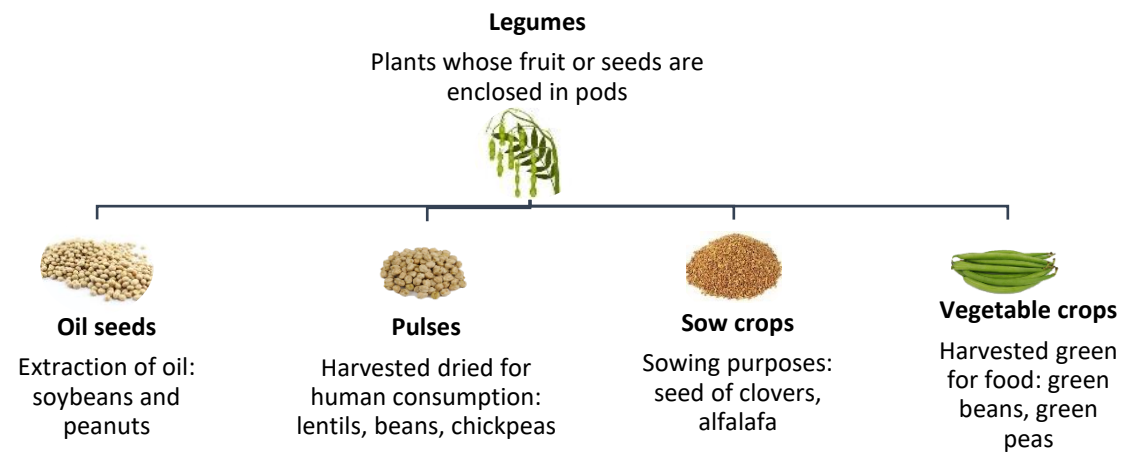


***Figure 1**. Classification of the Leguminosae family, based on the FAO (1994).*

1.4. The numerous benefits of pulses consumption

In 2016, the United Nations declared the International Year of Pulses (IYP), under the slogan "nutritious seeds for a sustainable future", to promote and increase pulses consumption over the world. In a recent report, the IYP was considered a major success, and several outreach activities were organized around the world, with educational and promotional events, to change the perception of pulses by the population. Hopefully, that perception change may remodel consumption patterns. Moreover, there was an increase in the number of collaborations and partnerships among key players that encourage governments to create and improve policies to promote production and consumption of pulses (Calles et al., 2019). One of the main reasons behind this international initiative was the fact that pulses easily fulfill all the criteria of sustainability, their production and consumption provides benefits to the environment, human health and nutrition, the economy, social and cultural aspects, animal lives and technology (Fardet, 2017).

Pulses are considered to be an essential food product to ensure food security and increase sustainability. Yet, the consumption of pulses varies around the world (Figure 2). The global per capita consumption over the last three decades is about 21 grams per day (Rawal & Navarro, 2019), which translates on average to 7.66kg per person/year. We can observe in Figure 2 the different average consumption of pulses among countries in 2017, highlighting those countries with higher and lower consumption. The inhabitants of the European Union (without the United Kingdom), consumed on average 3.78kg of pulses in 2017, while those of the region of Central America and the Caribbean consumed 15.5kg (OECD-FAO, 2019).

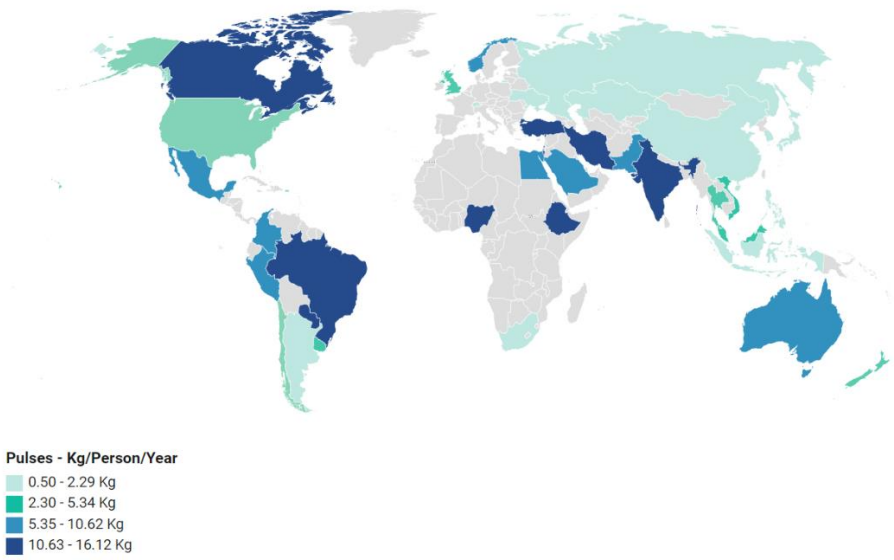


***Figure 2**. World Map reflecting the consumption of pulses per country for 2017. Grey areas represent data not available for that country. The map was created from the data of The Organization for Economic Co-operation and Development (OECD-FAO, 2019).*

The environmental benefits of pulses

Just as the other plants of the *Leguminosae* family, pulses have a property to fix nitrogen in their root nodules. The root nodules are formed by a symbiotic relationship, between the plant and the soil-borne rhizobia bacteria that are attached to the roots of the plant. The plant provides energy and nutrients to the bacteria, while the bacteria produce nitrogen. Most of the nitrogen is used for plant growth, yet a part of it is released into the soil when the plant decomposes, and the bacteria die. As a consequence, not only do pulses crops not need extra nitrogen as fertilizers, but they also improve soil fertility by releasing excess nitrogen in the soil (Rawal & Navarro, 2019). This soil protection would increase the productivity of the cultivated land and could favor effective intercropping systems, which also increase the biodiversity of the landscape (Foyer et al., 2016). In particular, it allows intercropping, which refers to a crop rotation where farmers switch between different crops such as pulses and cereals (FAO, 2016b). Besides, pulses plants require less water than other crops to grow. For example, to produce one kilogram of lentils, 1.250 liters of water are needed, compared to one kilogram of beef that needs 13.000 liters (FAO, 2016a). As a consequence, pulses can tolerate difficult environmental conditions like drought, and they can grow in a dry land where other crops are unable to grow (Iriti & Varoni, 2017). Moreover, pulses produce a small carbon footprint, which indirectly reduces greenhouse gas emissions in an agricultural cropping system (Foyer et al., 2016). The total CO_2e[3] emission of different protein-rich foods, for the production (before products leave the farm) and post-production (processing, transport, retail, cooking) were compared. To produce one kilogram of beef, around 24kg of CO_2e are released in the production, while 3 kg of CO_2e is related to the post-production. On the other hand, to produce one kilogram of lentils, a total of 0.54 kg of CO_2e emission are released in production and 0.4 kg of CO_2e in the post-production. In this case, lentils emissions mostly take place during the post-production (44% compared to 11% for beef), mostly related to the energy used in cooking (EWG, 2011). The total green-house emission generated for pulses is lower than regular animal food production, thus pulses could be considered as allies against climate change (FAO, 2016b). Overall, pulses play a major role to overcome the current sustainability challenges, and their presence in today's agriculture is essential, not only for the benefits to the environment (soil, water, CO_2 emissions) and biodiversity, but also as key products to ensure food security and nutrition.

Nutrition and Health benefits of pulses

Within the plant-based sources, pulses are the most inexpensive protein source (Asif et al., 2013). Indeed, pulses contain twice the amount of protein than cereals such as wheat or oats, and three times more than rice. For 100 grams of dry product, pulses contain mostly carbohydrates (55%-

[3] Carbon dioxide equivalent

65%), a high protein content (21%-26%), and low amounts of fat (1%-4%) (FAO, 2016b). The association of proteins from pulses and cereals is recommended, as together they provide adequate amounts of all the essential amino acids that correspond to human needs (McDermott & Wyatt, 2017). Besides those macronutrients, pulses also contain interesting micronutrients such as minerals (iron, potassium, calcium, phosphorous, zinc), water-soluble vitamins (Vitamin A), and lipid-soluble vitamins such as folate (FAO, 2016b; Iriti & Varoni, 2017).

Pulses are a rich source of dietary fibers and complex carbohydrates, which makes their Glycemic index one of the lowest among carbohydrate foods (Asif et al., 2013; Lecerf, 2016). It has been shown that regular consumption of pulses, particularly lentils, can reduce the risk of suffering type 2 diabetes in elderly people (Becerra-Tomás et al., 2018). Increasing consumption of pulses to four times a week may also reduce by 22% the risk of suffering coronary heart disease (Bazzano et al., 2001). It could also have a positive effect on weight managing (McCrory et al., 2010), due to pulses effect on short-term satiety (Lecerf, 2016; McCrory et al., 2010). Besides, due to their content of fibers, pulses consumption could help to lower by about 5% the total cholesterol - especially the LDL cholesterol (low-density lipoprotein) - and lower the triglycerides (Asif et al., 2013; Bazzano et al., 2011). Pulses also support the nervous system as they contain folic acid, whose consumption is especially important for pregnant women and newborns (FAO, 2016b).

But pulses do not have only nutritional benefits. They also contain anti-nutrient factors (ANFs), such as some non-digestible carbohydrates (Galacto-oligosaccharides - GOS), lectins, tannins, saponins (Lecerf, 2016), proteinase inhibitors, alkaloids (Pusztai et al., 2004). Those anti-nutrients can cost some discomfort during the digestion, causing bloating and flatulence, but most of the time, they are destroyed by washing, soaking in water for 4 to 8 hours, cooking processes, but also sprouting and fermentation (FAO, 2016b; Iriti & Varoni, 2017; Lecerf, 2016; Pusztai et al., 2004).

Taking all these properties into account, nutritional recommendations regarding the serving size and the frequency of consumption were emitted. A recent review suggested that 100 grams (125mL) of cooked beans, lentils, peas, or chickpeas should be considered as a minimum serving size that can help promote healthy diets. The frequency of consumption of this portion should be adjusted to the local needs and cuisine and therefore vary according to the place (Marinangeli et al., 2017). As an example, in India, 100 grams can be consumed daily without any inconvenience, but in other countries, pulses consumption frequency is no more than once or twice a week. Pulses consumption is indeed influenced by the presence of other available food products and local habits.

1.5. The supply chain of pulses in France

In 2014, the French pulses production was 40 000 tons, produced by about 2 000 producers (Schneider et al., 2015). The national production covers only 27% of the consumption (Solagro & RAC, 2016). Imports from other countries such as India, Canada, and Turkey are thus needed, to cover the demand (Gueguen & Duc, 2008). For 2014, the production of pulses in France came mainly from lentils (22 033 tons), followed by dried peas (10 280 tons), and white beans with 7 670 tons (Solagro & RAC, 2016). One-third of the global pulses production in France is under an official quality or origin label (e.g. lentilles du Puy), and around 20% of the production of pulses is organic (Schneider et al., 2015). Raw pulses represent less than 40% of the total sales of pulses. The distribution sector mostly favors transformed pulses, which represent more than 75% of the 65 000 tons of pulses sold by retailers. The market for raw pulses is equally divided between the retailers and out-of-home catering, with 15 000 tons each (Gueguen & Duc, 2008; Solagro & RAC, 2016).

For many decades, the offer of processed pulses in France was particularly limited, and the only products available were canned pulses, plain or with sauce, or used as the main ingredient in traditional stew-like recipes containing meat ("cassoulet", "petit salé aux lentilles", "chili con carne"…) The lack of technology and innovation for new and attractive pulses products was considered as a real drawback for this supply chain until the late 2000s (Gueguen & Duc, 2008). For a few years, along with the traditional canned pulse-based products, the French processing industry has started to develop new ways to add value to pulses. One of them is to increase the traceability of the product by mentioning their French origin to boost sales. Besides, new technologies have been used to formulate new transformed products, using especially lentils (e.g. ready to eat dishes in a sachet, box…) (Champ et al., 2015), pre-cooked products combining cereals and pulses, but also pasta combining wheat and pulses flour (Magrini et al., 2018). The development of new products containing pulses gives to the product an image of "good for health", especially for vegetarian and vegan people. But those new products are often ultra-processed[4], which can also represent a drawback when processes are considered as a negative point by consumers, who seek more and more "natural products". Indeed, it is usual to find in ultra-processed products, a large list of ingredients, additives, and thickeners to give color, taste, and texture to the product (Fardet, 2017).

Farmers, manufacturers, distributors, and retailers all play a role in pulses availability, which in turn is a determinant of pulses choice by consumers. But consumers also play a role in this chain.

[4] Ultra-processed foods are products, "mostly of exclusive industrial use, that result from a series of industrial processes"(Monteiro et al., 2019).

Indeed, the food supply chain is organized to offer consumers what they "want to eat, at a price they are willing to pay in a place they can get to" (Booth, 1994, p.97). The supply chain influences consumption, and consumption also impacts the supply (Marshall, 2001).

1.6. Consumption of pulses in France

For ages, pulses have been one of the main crops to feed the human population. Their benefits to the environment, health, and human nutrition have made them key products to ensure food security. The pulses consumption is linked to historical and cultural factors, which determine differences among countries. In the European Union, pulses consumption is now surprisingly low, considering their high importance as a protein food in French diet until 1945 (de Boer et al., 2006). For instance, pulses consumption in France was close to 7.2kg per person/year during the1920s (Champ et al., 2015), but this consumption has dramatically dropped to reach an average consumption of 1.4kg per person in 1985. Since then, the consumption has been slightly increased to reach 1.7kg per person in 2016 (ANSES, 2017), which corresponds to an average of 2 to 5 grams per person per day (Lecerf, 2016). This slight increase continued until 2018, when the consumption of pulses reached 2kg per person (Agreste, 2019). Due to this low consumption of pulses in France, the French High Council of Public Health recommended to increase the consumption of pulses to at least twice a week and to use them as possible substitutes for meat and poultry (HCSP, 2017). A national food consumption study evidenced that French people consume pulses differently according to their age (Figure 3). Citizens aged between 18 to 44 years old are the ones that consume more pulses (3.2kg per year), while lower consumption was found among young children and elderly people (ANSES, 2017). Besides age, consumption of pulses also may vary according to the French region and the socio-economic status (Rio, 2017).

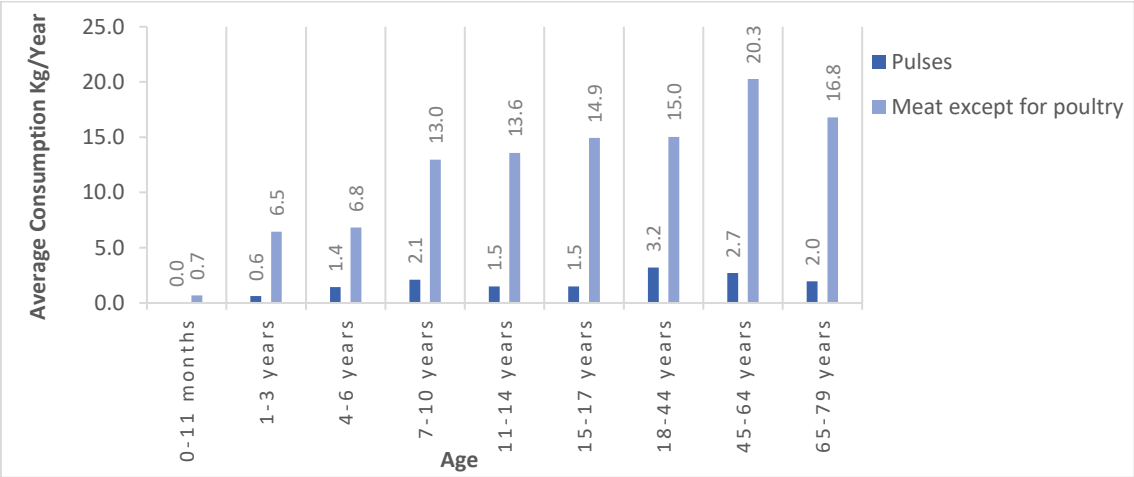


Figure 3. *The average consumption of pulses and meat (without poultry) per capita, among French consumers of different ages. Data were obtained from the National Food Consumption Study (ANSES, 2017).*

Possible factors contributing to the low consumption of pulses

Some possible hypotheses have been exposed to explain the low consumption of pulses in France, but these hypotheses have not yet been experimentally tested. They can be related to (i) the person, (ii) the society, (iii) the product itself, (iv) to the market, or (v) to the government policies (Table 1).

***Table 1**. Possible factors to explain low consumption of pulses*

The person	The society	The product itself	The market	Government policies
Bad culinary experiences at the school cafeteria (1)	Culinary traditions that mix pulses with animal products (2)	Time of preparation (1, 2, 3, 4)	Competitive market (products easier to prepare, consume, more chic, expensive) (1)	Long time positioned as a starchy in the food French Pyramid (5)
Lack of anticipation and time to cook (1)	Stereotypes (poor man's meal) (2, 3)	Soaking (except for lentils) (1, 2, 3, 4)		
Lack of ideas/ motivations to cook (1)	Expectation vary according to the presentation (raw, canned, ready-to-eat) (4)	Undesirable digestive effects (1, 2, 3, 4)	The position in the shelves at retail stores (no specific shelf for pulses) (2, 3)	
Lack of knowledge (1)		Sensory properties (green taste) (5)	The difficulty of the pulse industry to create a modern and dynamic market (4)	

* (1) Lecerf, (2016); (2) Rio,(2017); (3) Magrini, (2016); (4) Champ et al., (2015); (5) Chardigny & Walrand, (2016)

A few measures have already been taken to try to overcome these possible barriers. For example, Research & Development in the pulses sector focused on creating new products. Similarly, at the end of 2016, a national food consumption study concluded that French Nutritional recommendations should separate pulses from the starches (ANSES, 2016). Yet other barriers still need to be overcome, such as trying to better understand consumers' perception of pulses and the reasons underlying their food choices.

2. Food choices

Food choice consists of the selection and consumption of foods and beverages, by taking different aspects into account, such as what to eat (e.g. salad or sandwich), how to eat it (e.g. cold or warm), when to eat (e.g. lunch or dinner), where to eat (e.g. at a park or dining room) and with whom to eat (e.g. alone or with friends) (Sobal et al., 2006). A food choice is the result of a complicated set of processes (Ogden, 2010b), influenced by many interrelating factors (Shepherd, 2001). Food choice begins for most consumers at the point of acquisition for a precise food good, but what consumers find on the offer depends on the decision made further down the food supply chain, that are affected by economic, political, social, cultural, and biological constraints (Marshall, 2001). People make choices in a certain situation, where they can pick a product from a set of alternatives that are available at that moment (Lähteenmäki & Arvola, 2001). Food choices are usually made repetitively every day, so most of the people tend to purchase on a repeated basis, and to establish a buying routine that is used automatically and effortless to reduce the complexity of the decision making (Engel et al., 1990). Over the years, different food choice models have been proposed. A model is a simplified representation that shows the relationships between various elements of a process (Schiffman & Kanuk, 1997).

Overall, food choices are dependent on ecological, economic, and cultural factors that have developed and combined over time (de Boer et al., 2006). Together with the historical and political factors, they would all influence later individual and collective food choices. To better understand the relationships between the different factors related to the food choice, I focused on three food-choice models developed over time by Yudkin, (1956), Shepherd & Sparks, (1994), and Furst et al., (1996). As shown in Figure 4, I included the different elements proposed by each model into a single graphical representation. The different authors not always used the same words to name each factor, thus I tried to find names that could include the general meaning proposed by each author. To do so, I divided the variables into two, the ones that are related to *the Person* who makes the food choices and the ones that are linked to *the Product* itself. I will analyze hereafter the meaning and the function of each variable in food choice.

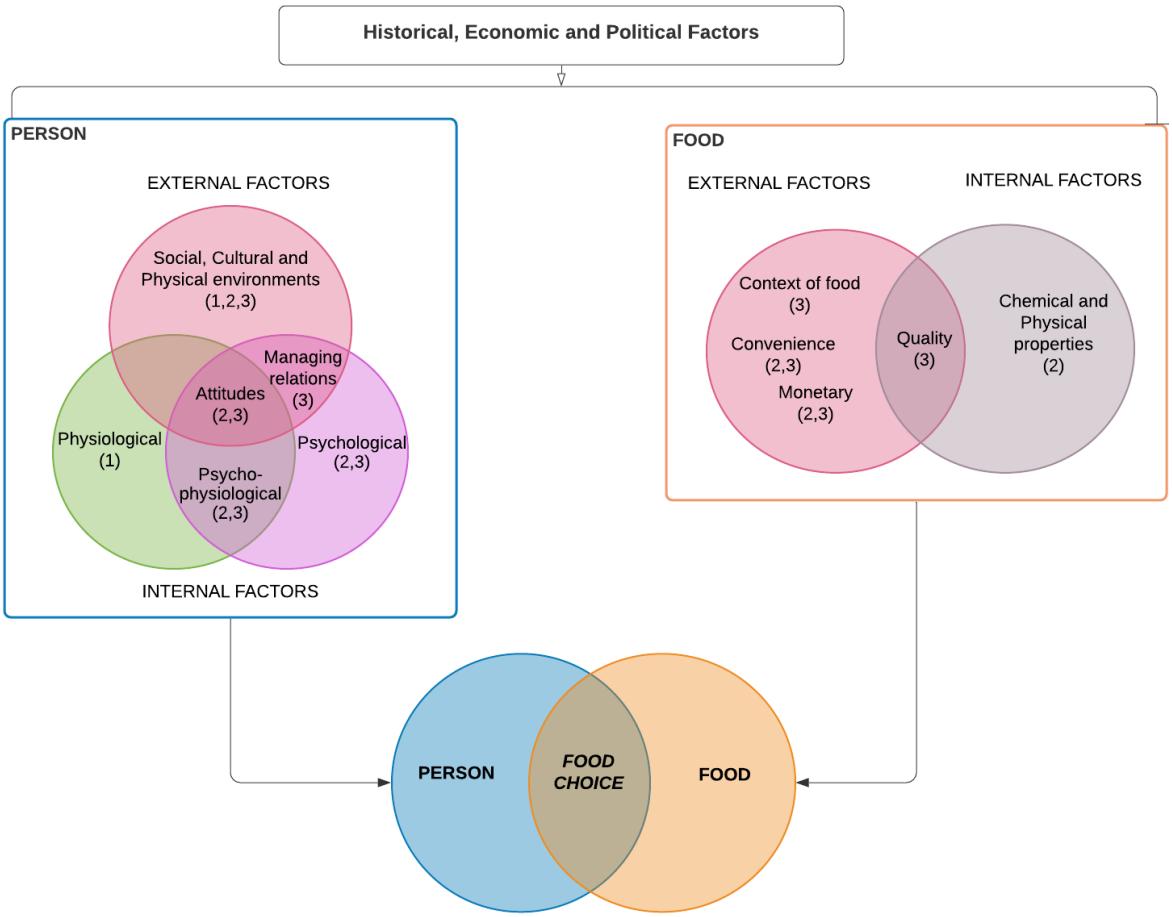


***Figure 4**. Graphical representation of a Food Choice model adapted from(1) Yudkin, (1956), (2) Shepherd & Sparks, (1994), and (3) Furst et al., (1996).*

2.1. Factors related to the Food

The factors that are related to ***the Food***, can be divided into the external and the internal. The external factors refer to those elements that are not directly related to the food product itself but to the environments (social and physical) in which foods are presented. By contrast, the internal factors are linked to the specific inner characteristics of the food product such as the chemical and physical properties.

- External factors

The **external factors related to the food that influence food choices** are context, convenience, and monetary situation. The *food context* provides the environment for food choices to occur in specific settings. It depends on food supply factors such as type of food, availability in the food system (Furst et al., 1996). As a consequence, it also includes some physical and social environments in the moment of choice. The effect of context on food choice can be demonstrated by comparing reactions to the same food product in different eating situations, for example, a natural setting showed that the

same food is rated lower in an institutional food environment than in a restaurant (Meiselman, 2006). Nevertheless, the results of the environment on food choice are less known even if the social background is recognized to play a role in the mental processes involved in habitual food choices, and in when, where, and how to consume a food product (Booth, 1994). The outcomes obtained after exposing a person in different environments may be different (Meiselman, 2006). Availability is also one of the determinants of what a person eats, as explained by Rozin, (2006) "one eats what is there, and more critically, one does not eat what is not there" (p.19). Some people are more sensitive to the food context when confronted with a food choice, while others are less influenced by the contextual factors (Furst et al., 1996). Setting a context of food choice can consist in offering extended or limited choices possibilities, or creating an ambiance that is part of the food choice process (Furst et al., 1996).

The convenience of a food product is an aspect that has gained importance in the last years: for a person, a food product should be convenient not only for preparation, buying, storing, eating (Grunert, 2006), but also by its accessibility and the time spent on its preparation (Furst et al., 1996). As a consequence, for some consumers, convenience product means ready-to-eat or ready-to-cook (Swoboda & Morschett, 2001).

Within the *monetary aspect*, the price of a food product relates the product with the person's economic situation and purchasing power (Grunert, 2006). Taking this monetary factor into account results in determining if the food is worth buying, and this frequently limits the final food choices (Furst et al., 1996). Price was shown to be one of the parameters that mostly affect people's food choices (along with sensory properties).

- Internal factors

The **internal factors** related to ***The Food*** that influence people's food choices are linked to the composition and the chemical and physical properties of the product. The chemical components of food refer to the amount of water, lipids, proteins, and carbohydrates, and the small proportions of minerals and organic compounds (Rahman & McCarthy, 1999). The physical properties of the food refer to the external characteristics of food such as the color and structure. As explained by Shepherd & Sparks, (1994), both physical and chemical components of a food product are perceived by the person in terms of sensory attributes (e.g. taste, texture). Some of the chemical components of the food directly affect the person, by for example reducing their hunger. At the same time it can create a learning association between the sensory attributes of the product and the post-ingestive consequences of its consumption (Shepherd, 2001). In the end, the properties of a food product affect the willingness of consumers to try similar foods (Lähteenmäki & Arvola, 2001).

The perceived quality of a food product results from both the internal and external characteristics of the food products. *The quality* is often associated with the sensory attributes and the price (usually, people associate better quality to higher prices). The perceived quality was shown to be determinant in the final choice (Furst et al., 1996). The sensory attributes are also an indicator of the quality of a product, the taste usually playing the most important role. Even if among individuals, the quality of a food product has different meanings, this criteria is usually taken into account in a food purchase situation, where food products are being compared (Furst et al., 1996). Yet, many aspects of the quality are unknown to the person at the time of purchase, thus they form expectations about the quality of the product (Grunert, 2006). For instance, expectations related to food nutrition and safety can be formed from the information transmitted through the packaging and labeling of a food. Packaging plays an important role in products selection because it is the major source of information for consumers, allowing them to make better choices in the market place (Grunert & van Trijp, 2014; McCullough & Best, 1980).

2.2. Factors related to the Person

The factors that are related to **The Person**, can be also divided into the external and the internal. The external factors refer to those elements that do not depend on the person executing the food choice but are related to their social environments, such as culture. The internal factors are linked to individual traits of the person making the food choice, like attitudes, mental representations, and knowledge.

- External factors:

The factors which are external to a person are known to influence food choices and can be divided into social, cultural, and physical environments.

The social factors: food choices can be influenced by the dynamics that take place with a social context, such as interpersonal relationships, social roles, and composition of the households and social groups (Furst et al., 1996). As a consequence, food is often considered as a social marker: it contributes to the distinction of one group from another. The social context not only influences the cuisine but also the social interactions during a meal (Rozin, 2006). It can condition for example who is buying the food, or what food can be bought first. Food choice decisions in families are surrounded by the role of each person in the food provision, in the shopping, and the preparation (Brown, 2006). Other social factors are related to the religion, for example, the prohibition of pork by Jews and Muslims or the adoration of cows by the Hindu. The origin of food banning in certain religions is not always clearly stated (Yudkin, 1956). However, they continue to be part of today's society and play an important role

as a social marker, which divides but also unites people. People use food as social tools and cultural symbols (Booth, 1994).

Culture is another external factor related to consumers. Culture shapes food, eating, and nutrition (Saba, 2001). For example, social customs can indicate different food habits within a society. They are usually strong and resistant to change. For instance, some products are acceptable in certain societies but not others, such as insects in Mexico or Asia. Other products, commonly accepted and consumed within a society are considered as not to be consumed during certain periods, such as pregnancy or lactation (Yudkin, 1956).

Physical environments, the third component of external factors, include geography, season, economy, and physical resources. *The geography*, together with the season, determines the food that is "at hand". It distinguishes diets around the world. Even within a country, a difference in food choices can be observed between nearby cities. Yet, the development of the shipping and methods of food preservation (canned, frozen, dried) has influenced and facilitated the availability of food products all year round and around the world (Yudkin, 1956). Within the physical environment, the economic situation of the household is another factor that considerably influences food choices. The total income of the household determines the amount of money available to buy food. One of the most powerful explanations of a diet change is generally found in an evolution of the household income (Ritson & Petrovici, 2001). Thus, For example, in UK 1955 an increase in the income of the population resulted in a higher intake of protein and fat (Yudkin, 1956). The physical factors also refer to other resources available or not for people to make food choices such as equipment, and space to cook (Furst et al., 1996). It has been shown that food access for a household not only depends on how much they can afford but also depend on where to cook (access preparations) and how to cook (cooking facilities) (Marshall, 2001).

- Internal factors

The other factors related to ***The Person*** are **internal**. These factors can be divided mainly into the physiological and psychological factors. On the one hand, the *physiological factors* are related to food intake regulation (hunger, satiation, satiety), human genetics, nutritional needs, possible individual allergies. For example, Yudkin (1956) stated that once a food allergy has been identified or a therapeutic diet has been offered to a patient, the pattern of food choice is modified. On the other hand, *psychological factors* can be explored in terms of development and cognitive models (Ogden, 2010b). The developmental approach focusses on the importance of learning and experience on the development of food preferences. Food preferences can be modified by different learning situations:

by exposure, social learning (observing other peoples' behavior can influence one own behavior), and associative learning (the memorization of physiological responses to food intake). The cognitive model of food choice focuses on individual cognition to explain food behavior, especially by insisting on the role of attitudes and beliefs. Food choice is seen as the final result of a different interrelating cognitions (Ogden, 2010b). Besides, food choice may also be influenced by the psychological difference between people regarding their personality (Shepherd, 2001).

The relationship between the physiological and psychological factors results in the *psychophysiological factors*. Here, the focus is reducing the social context on food intake and underlie the biological and psychological basis to eating (Ogden, 2010b). It examines the effect of the senses on food choice, the role of neurochemicals in the food intake such as the serotonin, the impact of psychopharmacological drugs like the nicotine, the link between what we eat and our mood (Ogden, 2010b). Besides, Furst et al., (1996) identified that the needs and preferences derived from psychological and physiological traits would determine what is meaningful to individuals when doing a food choice. The authors called it "personal factors", as it would influence cravings, preferences, and aversion to a type of food (likes/dislikes), personal food style, emotions towards foods and state of hunger.

When people are confronted with a food choice, the sensory perception (e.g. appearance, aroma, texture) is a dominant value (Furst et al., 1996). Once a person is exposed to the food stimuli and his/her attention is allocated to the product, the different senses (sight, smell, taste, touch, and hearing) detect the characteristics of the product. After being activated by the stimulus (light, sound, odorant compound…) the sensory receptors convert this stimulus into an electrical signal conveyed by the nervous system to the corresponding area of the brain (visual, auditory, or olfactory area). In the brain, the sensory information is organized and interpreted, resulting in perception (Dalenberg et al., 2018). The perception is a mental process that allows the person to interpret the information that emerges, thanks to the mental representation already attached to the sensation, under the form of words, names, images, or symbols (Gallen, 2005). Thus, the perception has two stages: first, the interaction of the stimuli with the sensory receptors, then the encoding of information.

The mental representations are involved in the second stage of the perception and constitute the result of the perceptual encoding (Gallen, 2005). The definition of **a mental representation** that we decided to use throughout this thesis is "cognitive products and individual mental processes that come from the interaction of individuals with their environment, allowing them to code the meaning of the stimuli and store this information in memory" (Gallen, 2005). Mental representations play an important role in consumer behavior related to food, as they may affect inference, judgment, and final

food choice (Bartels & Johnson, 2015). It is important to distinguish mental representations and knowledge, even if they are constantly associated. Knowledge refers to the information stored in memory, as a result of a learning process: "declarative knowledge involves the subjective facts that are known, while the procedural knowledge refers to the understanding of how these facts can be used" (Engel et al., 1990, p.282). Declarative knowledge can be divided into episodic knowledge, which refers to the information that is constrained by the time, and semantic knowledge, which contains general information that gives meaning to the world. A person can have knowledge associated to the product (includes information about the product category and brand, terminology, attributes and beliefs about it); the purchase (contains the information related to where and when a product should be purchase); and the usage (that refers to the information available on memory about how to use the product) (Engel et al., 1990).

The intersection between social factors and psychological factors could result in people's ideas and managing relationships. *The ideals* that an individual has formed over time, such as expectations, conscious or implicit assumptions about food, are the results from cultural and symbolic factors (Furst et al., 1996). These ideals could influence later food choices: they determine how food should be cooked, eaten, or plated. At the same time, when people provide, share, or receive food from other people, they usually have in consideration the other person's needs, preferences, and feelings (Sobal et al., 2006). Managing those relationships influence people's food choices, sometimes people's food habits are influenced by preference and needs expressed by people belonging to the same social group (Furst et al., 1996). The mental representations shared by a certain number of individuals from a group, result in a social representation (Trognon & Larrue, 1988). A **social representation** is defined as a construct from a set of beliefs, opinions, attitudes, and information about a certain object (Abric, 1994). The functions of the social representation are: (i) to allow the members of a social group to integrate and acquire knowledge, (ii) to facilitate communication and diffusion of knowledge, (iii) to prescribe behaviors and practices and (iv) to facilitate the appropriation of the social and external reality (Abric, 2011). Regarding food, the social representation that is collectively constructed about a food product is intrinsically related to the culture in which it takes place (Lo Monaco & Bonetto, 2019). In this sense, the social representations also play an important role in the acceptance of new products within a certain culture, by giving an image, a name and helping to shift what is unknown into something familiar (Bäckström et al., 2003). The meaning of that object or food product is created by a system of social negotiations within a social group (Rodrigues et al., 2015). Thus, social representations are important to understand why a group of people consume more or less a food product over another.

Finally, the interaction of the environmental, psychological, and physiological factors, may cause certain attitudes and beliefs that are carried on by a person. Those ***attitudes*** and ***beliefs*** are thought to influence later food choices. The perception of a food product that is being tasted by consumers in real-life situations, is not only based on the sensory characteristics of the product but also by the preconceived ideas about the product properties. If the preconceived ideas are related to what the product is, they are called product beliefs. On the contrary, if the ideas are related to consumer expectations towards the product, they are call product attitudes. Both "beliefs and attitudes are stored in memory in the form of a network of associative knowledge, like a schema" (Schifferstein, 2001, p.73). Beliefs and attitudes are formed by previous experience with the product (or similar product from the same category), by provided information through word-of-mouth, advertising, product package, and publicity in the media (Schifferstein, 2001). However, "attitudes can be formed even in the absence of experience with an object" (Engel et al., 1990, p.304). For example, consumers can form an attitude based on what they saw or heard in an advertisement. Beliefs and attitudes are variables usually studied to explain human behavior. Even if they are seen as a result of prior experiences, they are dynamic. They can change over time and are affected by consumers' frame of reference (Schifferstein, 2001).

Attitudes enable evaluation of a specific object to be favorable or unfavorable. There is a psychological tendency to evaluate a particular object, this evaluation going from extremely positive to extremely negative (Engel et al., 1990), with some degree of favor or disfavor (Eagly & Chaiken, 1993). Besides, if consumers hold favorable feelings toward the product, attitude can be a facilitator. On the contrary, when consumers have a negative feeling, it may serve as a barrier. Encouraging new attitudes, change, or adoption of new behaviors on consumers, is difficult. It is easier to influence the attitudes of those who do not feel personally involved and reinforce behaviors that already exist (Caraher & Landon, 2006). As a result, the change of attitudes and beliefs is a real challenge for researchers, the food industry, and the national and international authorities to improve healthy food habits among the population.

The associations between all the external and internal factors related to the person and the food product is a constant interaction that would influence and affect later ***food choices***. As exposed, the combination of the three models allowed us to highlight all the variables that are involved in the food choice. Besides, it is worth mentioning that other aspects such as motivations to choose a specific food product can also influence consumers' behavior. Those motivations are related to the costs, to health, weight control, the familiarity of the food, mood regulation, the natural content of the food, and ethical concerns about manufacture and country of origin (Steptoe et al., 1995). Motivations originate from a need or a motive that is activated when there is a discrepancy between the actual and

the desired state of being (Engel et al., 1990). Furthermore, communications play a central role in eating behavior (Ogden, 2010a; Verbeke & Viaene, 2001). "Food can be read as a statement about the self, as a form of social interaction or as a symbol of culture" (Ogden, 2010a, p.284). As such, the media can make people think about what they eat. When reposts of food risks are aired by the media, it has been shown that, there is a shift in the buying and food consumption (Reilly, 2006). Thus, it is of great importance to promoting healthy food eating on the media (Caraher & Landon, 2006), but information should be communicated clearly to the people. If information is transmitted under accidental exposure, it is more likely that the consumer will not perceive it consciously (Grunert, 2006).

When a person is confronted to a food choice, there is a moment in which he/she encounters a product that could satisfy his/her own motivations (*perception*), then the person would interpret the product in terms of their own *representations*, after he/she would evaluate the product favorably or not (*attitudes*) and finally, would be susceptible to carry on an action (*intentions*) that would lead him/her to engage or avoid a certain *behavior* (Gallen, 2005). To carry on a food choice, people develop different strategies, to simplify the food choice process. Those strategies take place in a different context and task related to food choice, from shopping, food preparation, or packing snacks (Furst et al., 1996). These strategies are meant to decrease the cognitive effort and time to make a decision. While initially conscious for a specific situation, they tend to become effortless when the same situation occurs repeatedly (Sobal et al., 2006).

Beyond the individual factors related to the person and the food products previously exposed, it is necessary to apprehend the links between these factors and the processes involved. I decided to take a look at a consumer behavior model to have a broader understanding of the process behind a food choice decision.

2.3. Processes related to consumer behavior

The relationship between products and consumers is mutual, as products are created based on consumers' behavior analysis, yet once the products are on the market they influence later consumer behavior (Grunert, 2006). Consumer behavior is defined as those "actions directly involved in obtaining, consuming, and disposing of products or services, including the decision processes that precede and follow these actions" (Engel et al., 1990, p.3). Engel et al., (1990), proposed that to properly understand consumer behavior, the influence of different factors need to be taken into account. They developed a consumer behavior model, also called the "Engel, Blackwell, Miniard" (EBM) model (Figure 5). They divided the factors involved in food behavior, into the environmental influences, the individual differences, and the psychological process that shape the

decision. In the previous sections, we detailed the external factors (environmental influences) and the internal factors (individual differences) influencing the decision process. We thus will focus on the present section to explain the psychological process behind consumer behavior.

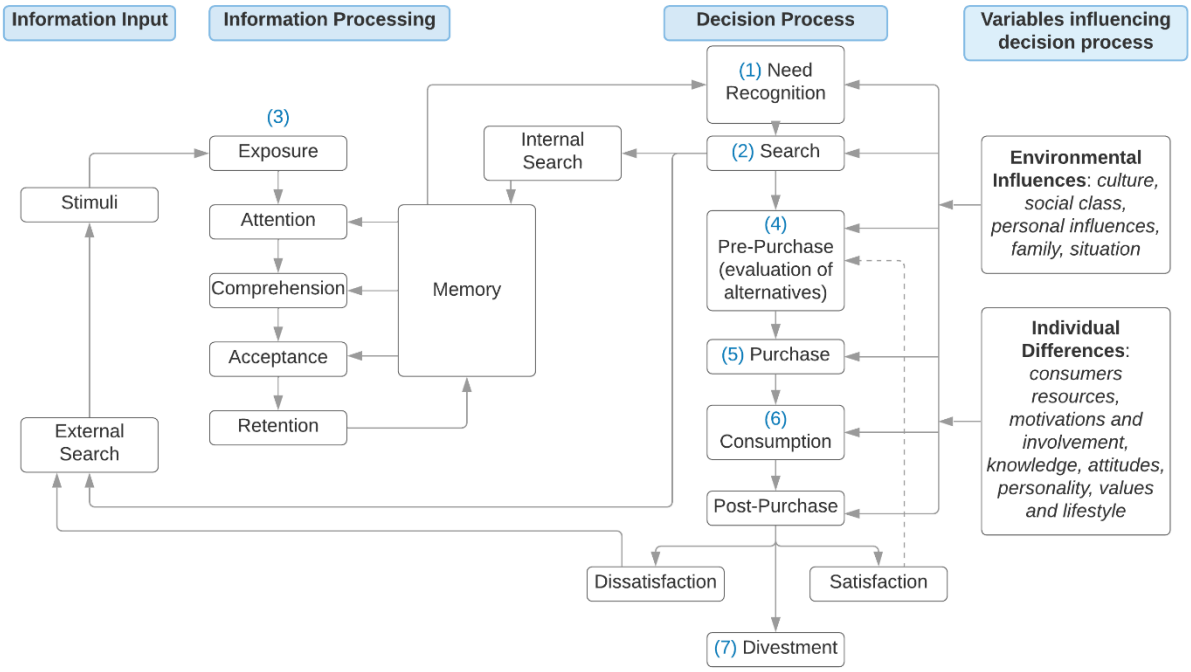


***Figure 5**. Consumer Behavior Model (EBM) adapted from Engel et al., (1990). A solid arrow indicates a direct relationship and a dotted line an indirect or feedback relationship between variables.*

In the EBM model, the psychological processes consist of the decision process on consumers' behavior that interacts with the environmental influence and individual difference. The decision processes start with (1) the recognition of the need that comes from a state of desire, then (2) if not enough information is available a search for information alternatives takes place in memory or from the external environment (e.g. advertising or word-of-mouth from others). This is followed by (3) information processing that explains the way information is transformed, reduced, elaborated, stored, recovered, and used. The information processing follows by five steps: first, exposure by proximity to the stimuli, followed by the attention allocated to the stimuli, then the interpretation, the acceptance, and finally, the retention in memory for that particular stimuli. Then, the person would enter into the (4) pre-purchase evaluation phase, evaluates options, and alternatives based on preferences and expected benefit, comparing the attributes present in the product to the personal specifications. Once the person has identified the preferred alternative among all, the (5) purchase process takes place. After the purchase, comes the (6) consumption and post-consumption evaluation it evaluates if the chosen alternative meets the needs and expectations. Here, either the person is satisfied with the

purchase or is dissatisfied when the chosen product did not fulfill the desired outcome. Both types of evaluation would be used by the person as feedback or as an opportunity to search for more external information. Finally, the (7) divestment, refers to the option given to consumers to recycle, re-use, disposal, or re-marketing.

To understand consumer food choices, we need to consider that: (i) all the internal and external factors related to the person and the food product are interrelated; (ii) every step involved in the psychological process plays an important role when executing a food choice. As a consequence, to discern the complexity behind consumer food choices, different approaches and methodologies have been proposed over time.

3. Different approaches to understand consumers' representations, attitudes, and behavior towards food

3.1. Methods and paradigms inspired by sensory evaluation, marketing, and psychology

To understand consumers' food choices and encourage changes in current food habits, different approaches have been used and combined over time. These approaches are inspired by several disciplines, principally, sensory evaluation, marketing, and cognitive psychology. Each discipline has used its own conceptual frameworks and methodologies to study consumer behavior.

The use of sensory evaluation to study food choices

Sensory evaluation is a scientific method used to evoke, measure, analyze, and interpret information originating from a product and perceived through senses (Stone & Sidel, 2004). Traditionally the sensory science has been product-oriented, focusing on the relationship between sensory evaluation and the characteristics of a product (Trijp & Schifferstein, 1995). Usually, products in the sensory evaluation are blind-labeled, and the results obtained inform about the sensory attributes of the products (Lawless & Heymann, 2010). One of the attributes that drive most of the sensory perception is taste and it tends to be a limiting factor in food choice (Furst et al., 1996). However, even if the liking for a particular food attribute can determine later choice, simply perceiving these sensory attributes does not mean that the person would or not choose a specific food product (Shepherd, 2001). Köster (2009) highlighted that sensory science focused mainly on what can be perceived, yet how and to what extent, the perceptual system influence and consumer behavior control was not taken into consideration. Sensory science focuses on the intrinsic characteristics of the

food product (e.g. taste), overlooking the influence of other extrinsic characteristics such as the price or the retail environment at the moment of food choice.

The use of marketing to study food choices

The principal objective of marketing is to combine, the product, price, promotion, and place (marketing mix) to fulfill consumers' needs in the most cost-effective way (Trijp & Schifferstein, 1995). One of the concerns in marketing is generalize the results obtained in a research context to explain and predict actual food choices in the market (Trijp & Schifferstein, 1995). As stated by Lawless & Heymann, (2010), in marketing tests, the identity of the product is based on explicit information (labels, claims, nutritional info), and the results obtained inform about the overall appeal of the product (concept, positioning, advertising). Thus, marketing focuses on the extrinsic characteristics of the products in an environment reflecting closely the real moment of food choice, but it does not provide access to the understanding of how and why consumers achieved their choices.

The use of cognitive psychology to study food choices

The goal of cognitive psychology is to "understand how people acquire, store, retrieve and use knowledge and information" (Abdi, 2002, p.445). The cognitive psychologist tries to describe the more precisely as possible the mental operations (or processes) that take place between the stimuli and a response -between a situation, the instructions, and the final behavior- (Lemaire et al., 2018). Even though eating and drinking are one of the most important and frequent human behaviors, studying consumer behavior and food choices by psychology was not always done (Abdi, 2002). Nowadays, one of the objectives of cognitive psychology is to specify the mental representations and the process involved in those representations, when an individual for example is asked to make a food choice (Lemaire et al., 2018). Usually, to understand such as psychological processes, there is a need to control closely the environment and to select several variables to be studied in which a food choice is taking place.

The interest of an integrative approach to study food choices

Each of these disciplines previously exposed contributes to understand different parts of consumer food choices, focusing on the intrinsic product properties that interest consumers (sensory), on the extrinsic product properties, and satisfying consumers' needs (marketing) and on the processes involved to explain food choices (cognitive).

Some authors have pointed out the interest to study consumers' behavior with integrative regard. Urdapilleta & Dacremont (2006) stated that the sensory evaluation is a "dynamic and multidisciplinary field in which psychologists play an important role" (p.209). But the sensory evaluation was based mostly on explicit (conscious) methods like questionnaires and scaling, whereas

decision making often occurs without conscious control (Köster, 2009). As a consequence, since 2006, there have been different advances in rapid methodologies that focus on automatic behaviors, as well as more indirect methodologies inspired from psychology, in which consumers do not have to give an explicit response (Varela & Ares, 2018). Furthermore, sensory food science is in fact at the intersection between many other disciplines and research approaches (Tuorila and Monteleone, 2009). Trijp & Schifferstein, (1995), highlighted that a closer cooperation between marketing and sensory evaluation may result in the development of new methods that relate sensory evaluation to consumer behavior. For example, the Check-All-That-Apply (CATA) method that was primarily used to study consumer perception towards brands (marketing), and then was used in the sensory evaluation as a quick descriptive method, that allows to access the reasons of consumer preferences (Valentin et al., 2012). Similarly, marketing was seen as an opportunity to apply psychological principals and techniques that would allow us to investigate human behavior in a market place (Alderson, 1952). Instead of traditional tools such as surveys, observations, or interviews to understand human behavior and decision making, marketing has used other techniques (Alvino et al., 2018), such as implicit measures, that have been shown to reduce the drawbacks related to the explicit measures and allow the study of implicit cognition (non-conscious) (Trendel & Warlop, 2005).

To better comprehend consumer behavior, the studies should be multi-faceted to understand the observed object and through this the living individual (Risvik, 2001). The observed object should be studied having in consideration both the intrinsic and extrinsic characteristics (Trijp & Schifferstein, 1995). Consequently, through this thesis, we decided to integrate the advantages of each discipline to better understand consumer food choices. In this thesis, adapted methodologies and tools are being proposed, that combine different approaches originating from different disciplines. They can be divided into three categories: direct, indirect methods and implicit measures.

3.2. A diversity of experimental methods

Direct methods and explicit measures

Direct methods refer to traditional tools such as questionnaires, surveys, or interviews that ask directly and explicitly to participants about their behavior. With such direct questioning, participants may be aware of the objective of the study and it can potentially affect the way they answer the question. Such direct measures present several drawbacks because participants' answers can be strongly influenced by factors such as social desirability[5] (Köster, 2003). When asked about the reasons

[5]As stated by Fisher, (1993) social desirability bias refers to "errors in self-report measures resulting from the desire of respondents to avoid embarrassment and project a favorable image to others".

for their choices, consumers often do not know how to explain their choices or do not want to share and explain them (Alvino et al., 2018). It is very difficult to access the reasons that motivates food choices by direct questioning. Some may say it is impossible (Thomson & Coates, 2018). Therefore, questionnaires should be used only to access observational facts, and the answers should be analyzed cautiously (Köster, 2009). As a consequence, indirect methods have been developed and implemented to allow a better understating of the non-conscious processes that influence behavior (Köster, 2009). Implicit methods go even further, by completely avoiding questioning (Thomson & Coates, 2018).

Indirect methods

Indirect methods evaluate the retention of information by participants without direct reference to the source of information (Perruchet & Nicolas, 1998). The objective of the indirect methodologies is to avoid the limits of the direct questioning, by decreasing the risk of participants being aware of the objective of the study. This allows reducing the potential biases (social desirability and questioning). Within the indirect questioning, different techniques have been developed. Among them, we can find for example the projective techniques, but also other disciplines such as ethnography.

- Projective techniques

As exposed by Mesías & Escribano (2018), the projective techniques could allow the respondents to freely express their attitudes and behavior without being influenced by social barriers. This kind of techniques is based on the non-conscious desires and feelings that may arise when participants are confronted with an ambiguous or unstructured stimulus. The projective techniques are usually classified into association, completion, construction, and expression task. In the association tasks, the participants are asked to answer the first things that come to their mind when a stimulus is presented. Depending on the stimulus (words, images …) different test can be distinguished, for example the word association task. The construction techniques ask respondents to make up a story, dialogue, or description using language and images. It can use, for example, collage construction, bubble drawing, or cartoon test or storytelling. The participants in a completion task are asked to complete an unfinished stimulus situation, like complete a sentence, a conversation, or a story. Finally, the expression techniques demand respondents to associate the feelings and attitudes of other people with a certain situation, for example, role-playing or ask third-person technique, or by the use of scenario-based design (Hoffmann et al., 2017). In a same study, it is frequent to use different projective techniques in conjunction (Mesías & Escribano, 2018).

- Ethnography

Valentin & Gomez-Corona, (2018) explained the interest of using ethnography by moving from the laboratory setting to a more natural setting, such as the participants' living room or kitchen. It allows the researcher to understand the actions that are performed by consumers (what they do), instead of what they declare to do, taking into consideration their culture rather than the individual motivations. It is used for example to study behaviors, practices, social trends, or interactions. To do so, different levels of participation can be arranged by the observer, from intervening as little as possible (passive) to be fully involved (active) in the life of the participant. The ethnography has been identified as a complementary method to study food choices in a cross-cultural context (Freedman, 2016).

Implicit measures

An implicit measure "implies that the processes by which an attribute causes the measurement outcome are automatic" (De Houwer et al., 2009, p.350). Some tests come from implicit cognition, whose objective is to capture the psychological aspects related to cognition, judgment, and actions, that may not be described by participants when asked directly, or that are not accessible by examination of personal thought and feelings (Nosek et al., 2011). The process concerned in implicit cognition is "automatic/implicit/non-conscious, underlying judgment and social behavior" (Gawronski & Payne, 2010). The implicit measures are all considered as indirect measures (Ackermann & Mathieu, 2015) as they do not rely on a direct verbal description. The most usual example of indirect/ implicit tests are: the Implicit Association Test (IAT) that measures the strength of automatic associations between concepts (Trendel & Warlop, 2005), the Go/No-go Association Task (GNAT), Lexical decision task (LDT), Word stem completion (WSC) task, and Word fragment completion (WFC). In addition, when participants are not aware of the goal of the study, eye tracking technique can be considered as an implicit measure, as it captures automatic, involuntary, and non-conscious reactions of the eye-movements (Duerrschmid & Danner, 2018). Similarly, the priming paradigm is another implicit measure that has been used to underlie non conscious factors that impact food choices, by activating mental representations triggered by non-conscious olfactory cues (Monnery-Patris & Chambaron, 2020). Indeed, Mas et al., (2019) showed that when participants are explicitly aware of the presence of olfactory cues, they change their behavior. This change in the behavior as explained by the authors may be probably related to participants guessing the real aim of the study. The implicit measure thus needs to be an automatic outcome, which is recorded from participants not knowing the real aim of the study.

3.3. Importance of the Contextual setting for consumer research

Independently of the type of method used to study and understand consumer behavior, there is a need to have into consideration the place in which the study takes place, especially when studying food choices. It is known that context impacts behavior. In the consumer research area, traditionally, research was performed in the laboratory to control all the variables. However, the need to conduct the studies in a more natural setting was highlighted. Yet, by increasing the realism of the context of a study, the control over certain variables may be limited and it may be difficult to reproduce the same setting for all the participants. As a consequence, recent approaches have been developed to overcome the limits between laboratory settings and natural contexts, such as evoked context, immersive context, and virtual reality (Galiñanes Plaza et al., 2019). These approaches can be used to better understand consumer behavior in a specific context of consumption or choice.

Evoked context

The concept of "evoked context" was introduced in the literature in 2010 when Hein, Hamid, Jaeger, and Delahunty developed an approach for evoking a consumption context in a sensory laboratory, using written scenarios (Hein et al., 2010). Hersleth, (2018) defined written scenarios as brief texts meant to evoke a sense of presence in a real situation, but they highlighted that besides the use of written scenario, it was possible to use physical elements, like decoration, music or furniture to create a more immersive environment in a consumption study. In doing so, it is possible to provide the food product a more complete meaning and to obtain responses more representative of participants' real behaviors.

Immersive context

An immersive context refers to re-create a full experience in the laboratory environment. For example, a sensory laboratory was organized in a certain way using specific lighting, changing the room temperature, adding any visual, auditory or olfactory cues to evoke a natural consumption situation (Porcherot et al., 2018). The main difference between evoked context and immersive context is that participants do not have to imagine a situation but they live it (Galiñanes Plaza et al., 2019). Different immersive environments can be created, from a buffet (Friis et al., 2017) to a bar (Sester et al., 2013). However, there are different levels of immersion, such as recreating environments with physical elements, projection of the environment using video projections, and virtual environments (Porcherot et al., 2018).

Virtual reality context

One of the most common definitions of Virtual reality (VR) is "the use of computers and human-computer interfaces to create the effect of a three-dimensional world containing interactive objects with a strong sense of three-dimensional presence" (Bryson, 1996, p.62). Virtual reality glasses or head-mounted displays can produce the feeling of being in a simulated world. It offers many possibilities, from gaming and entertainment, to learning, and communication (Porcherot et al., 2018). It has been used recently in the food domain to test consumers' food decisions in a specific environment of purchases and food intake, such as supermarket, restaurant, or kitchen (Hartmann & Siegrist, 2019). The virtual reality allows participants to be more engaged in a task, by placing them in a particular context (Galiñanes Plaza et al., 2019). Both the immersive environments and the VR have the potential to overcome the limits of a lab test, by increasing the ecological validity while controlling the environmental cues for all participants throughout the study (Hartmann & Siegrist, 2019).

3.4. Nudging as a tool to impact behavior

All the different methods previously exposed allow the understanding of consumer behavior while taking into consideration the importance of the context. Nevertheless, there is always the question of what to do when a behavior differs from the behavior commonly considered as acceptable. How can we help consumers to change their behaviors towards a more healthy and eco-friendly diet? Lambert, (2001) identified that "behavioral change can be brought by influencing the individual and/ or by affecting the environment of this individual" (p.143). Other behaviors can be prompted at the individual level by increasing knowledge of diet and health or modifying attitudes, perceptions, food preferences, motivations, and willingness to change. The environmental factors that can be used as levers to help people to change their choices include for example the family, communication channels, social norms, advertising, and food access. Usually, one of the most widely used tools to improve eating behavior is educating consumers by providing information, yet this kind of strategy rarely results in sustained improvement of eating behavior (van Kleef & van Trijp, 2018). One of the reasons for the lack of efficiency of this strategy is that consumers willing to change their eating behavior are involved both in conscious decision making, but also in automatic and non-conscious actions (de Boer et al., 2014). Food choices are considered to be low-involvement decision-making (van Kleef & van Trijp, 2018). Thus, the strategies to promote and change consumer behavior should not focus on providing elaborate information, but alternative strategies should be preferred.

As a consequence, other strategies have been developed to improve consumers' food choices, for example, those based on the concept of "nudging", which means "subtly guiding" (van Kleef & van

Trijp, 2018). A nudge, as explained by Thaler and Sunstein, is "any aspect of the choice architecture that alters people's behavior predictably without forbidding any options or significantly changing their economic incentives"(Thaler & Sunstein, 2008). The choice architecture refers to the idea that changes in the environment where a decision is made can affect individual decision making, and thus behavior, while always preserving the freedom of choice (Thaler et al., 2010). A nudge strategy is characterized by four central elements (i) do not rely on explicitly indicating "what to do" to the consumer, (ii) nudges should always encourage a more socially desirable choice, by favoring healthier or more sustainable behaviors, or decreasing the negative ones, (iii) do not remove choice options, and finally (iv) the nudge strategies are usually small, easy to implement and inexpensive (Purnhagen & van Kleef, 2018). The design of a nudging study focuses on a reshaping of the choice architecture to obtain from consumers a desirable choice or behavior (van Kleef & van Trijp, 2018). There are different classifications of the nudge strategies. Münscher et al., (2016), classify nudges taking into consideration the changes in the choice architecture by providing information, assistance, or changing the structure (arrangement of options). Hansen & Jespersen, (2013) propose to classify nudges in four categories according to their mode of thinking (reflective or automatic) and the transparency of the nudge (if the user can see the intention behind). For example, playing relaxing music while boarding a plane to calm passengers, is considered a nudge that intends to influence behavior without engaging the reflective system, but in an easy way that allows the person to identify the means behind (Transparent type I). A segmentation cue while eating chips (Geier et al., 2012), is considered a nudge that engages the reflective system while it is easy for the person to reconstruct the intention behind (Transparent type II). By contrast, changing the organization of a buffet (Wansink & Hanks, 2013) is a nudge that causes behavior change without engaging the reflective system, and the person is not likely to recognize the means (Non-transparent type I). Posting posters with human faces to increase the obedience rates of norms, engage the reflective system but people cannot have access to the intention behind (Non-transparent type II). Likewise, this classification proposed by the authors is not exhaustive, because some specific nudges may be difficult to classify, due to their complex structure (Hansen & Jespersen, 2013).

A challenge faced when using a nudge strategy is the ethical question, as participants are unaware of the intervention that has been implemented. The transparency of the intervention becomes an important aspect and could limit the effectiveness of the intervention. Indeed, transparency implies informing the participants, and so make them more attentive and conscious of the objective of the study. However, examples of transparent and efficient nudges exist: a study showed that implementing a disclosure "we help you make healthier choices" in a train station's snack shops did not impact the efficiency of the nudge strategy (Kroese et al., 2016). Having conducted a similar experiment with comparable results, Cheung et al. questioned whether the disclosing message

would still not affect the nudge if it stated the presence of the nudge itself (in that case, the re-arrangement of the product placement) (Cheung et al., 2019). There is a need for more research to explain if disclosing the nudge itself could have an impact on consumer behavior. Overall, the nudges strategy has been largely used by policy makers and private or public organizations (e.g. hospitals, train stations, public bathrooms, supermarkets) to enhance more desirable behaviors. It is a tool that could be used to encourage changes in food habits.

3.5. Brief state of the art about studies combining different approaches to understand food choices

As exposed, studying consumer behavior and food choices by a multi-layered approach seems necessary, and several studies have been done in this respect. I carried out a brief review to identify the number of articles that have used a combination of different methodologies and/or contextual setting. The search was done on Web of Science on October 2019, using two keywords: "food choice" AND one of the following options "questionnaire"; "face to face"; "survey"; "focus group"; "word association"; "projective technique"; "implicit associations"; "eye tracking"; "nudge"; "evoked context"; "immersive"; "virtual reality"; "field experiment". This search revealed 1140 articles in total. 239 articles were eliminated as they were performed with specific populations (newborns, children, teenagers, adolescents, pregnant women), thus focusing only on adults. Also all the double articles were eliminated and thus, selecting those articles that had two or three of the previous keywords, besides food choice. From the 143 articles, 99 of the articles had the words "questionnaire" and "survey", after a closer look those articles were eliminated as they used only one methodology but named it differently across the title, the abstract or the keywords. In the end, a total of 43 articles related to food choice that combined two to three different methodologies and/or contextual setting were obtained[6].

From it, 33 articles combined two different methods without any specific contextual setting. Most of the time the article used questionnaires or surveys (n=28), combined with another method, either indirect (focus groups, word associations), implicit (implicit associations, eye tracking), or with a nudge-based strategy. Three studies were found that did not use a questionnaire or survey instead combined two other methods: the word association was used in one study with a focus group and in

[6] (Abate et al., 2018; Andersen et al., 2019; Betts et al., 1995; Bevet et al., 2018; Bolos et al., 2019; Ružica Brečić et al., 2014; Ruzica Brečić et al., 2017; Brookie et al., 2017; Buckton et al., 2015; Cabral et al., 2017, 2019; Carroll et al., 2018; Cavallo & Piqueras-Fiszman, 2017; Cheung et al., 2019; Crovato et al., 2019; Fenko et al., 2018; Filimonau et al., 2017; Geaney et al., 2013; Hendrickson et al., 2006; Honkanen & Frewer, 2009; Hunt et al., 1997; Keegan et al., 2019; Krumreich et al., 2019; Laureati et al., 2006; Lombardi et al., 2017; Mancini et al., 2017; Melendrez-Ruiz et al., 2019; Mitterer-Daltoé et al., 2013; Mollen et al., 2013; Mors et al., 2018; Papies et al., 2014; Pereira da Fonseca & Salay, 2008; Rogus, 2018; Serrano-Cruz et al., 2018; Siegrist et al., 2019; Sinesio et al., 2019; Tijssen et al., 2017; van Herpen et al., 2016; van Kleef et al., 2018; Mayra M. Viana et al., 2016; Monteiro Viana et al., 2014; Walsh et al., 2009; Zhou et al., 2019).

another study with a projective technique. An additional study used a nudge-based strategy in combination with implicit associations. Furthermore, only 3 studies combined three different methodologies: one study used focus groups, a survey, and word associations; and two studies used projective techniques with survey and word associations.

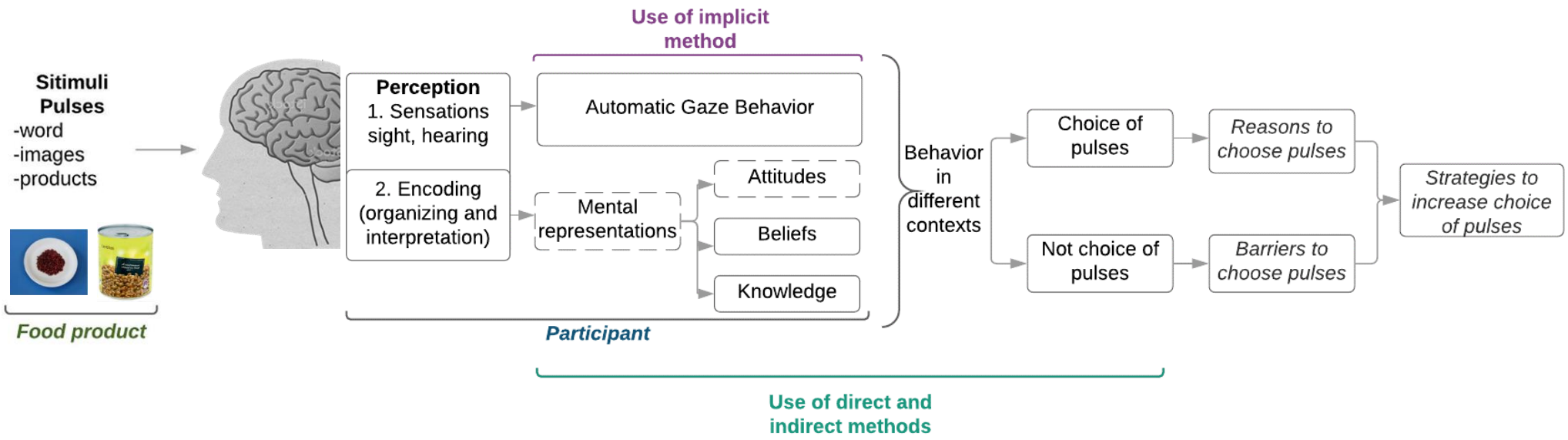
Regarding the contextual setting of the studies, 10 articles were found to use a contextual setting with other methodologies. A field experiment is usually combined with questionnaires and surveys (n=4), with a nudge-based strategy (n=1) and with eye tracking (n=1). One study used evoked contexts with a questionnaire and another one used immersive context with a questionnaire. One study used virtual reality with an eye tracking methodology. Finally, only one study used a contextual setting with two different methods: a field experiment with a nudge and a survey.

The interest in doing this search was to have an overview of the research that has used a combination of different methodologies regarding food choices. As it can be observed, some (not a lot) researches combined direct methods with indirect and implicit measures. In addition, a combination of different indirect methodologies within the same study is common, perhaps reveling that indirect methodologies can be more easily combined. Finally, it reveals little research combining contextual settings with more than one methodology, whereas this could represent an opportunity to better understand food choices. These results are encouraging, as they highlighted the ongoing attitude of researchers to use different methodologies towards a better understanding of food choice.

Structure of the thesis

A.Aim of the thesis

The research described in this thesis is part of a project called “IM’PULSES”, financed by the Institute Carnot Qualiment. The main objective of this thesis is to understand the mechanisms that underlie the choices and appropriation of pulses by French non-vegetarian consumers. To address this question, we needed to (i) understand what are the barriers to pulses consumption, among consumers and professionals from the pulse industry (the mental representations, social representations, attitudes, knowledge, beliefs), to then, (ii) propose strategies to increase pulses consumption in France, throughout the use of nudges and scenarios evoking different choice motivations. To do so, we used a combination of methods: direct (i.e. questionnaires), indirect (i.e. a projective technique using images and written scenarios, also free-word associations), and an implicit method (eye tracking). Figure 6 shows a schema of the theoretical framework of the thesis. We also used different contextual settings, natural setting, Lab context, evoked context, and in a Virtual Reality setting.



- - - Dotted lines for professionals and consumers

***Figure 6**. Schema of the theoretical framework used in this thesis.*

B. Thesis outline

To fulfill the main objective of this thesis, different research questions were identified:

- Are there differences between the social representations and attitudes of consumers and professionals from the pulse industry towards pulses?
- What are the mental representations, beliefs, and knowledge of consumers towards pulses?
- What is the place of pulses in the structure of a dish for French consumers?
- Does the level of transformation of pulses influence consumers' mental representations?
- How is the visual attention directed towards pulses in a virtual supermarket?
- Can we change consumer behavior, to increase pulses choice in a virtual supermarket, by implementing a nudge strategy or an evoked motivation of choice?
- Are there differences in the social representation towards pulses between France and another European country with a higher consumption of pulses?

To answer these questions, we first examined whether there were differences in the social representations and attitudes of consumers and professionals towards pulses (Chapter 2). Following up on this, we explored the mental representations, beliefs, and knowledge of consumers regarding pulses and we identified the place that pulses hold on a French meal (Chapter 3). We then captured the mental representations of consumers towards pulses with different levels of transformation (Chapter 4). We continued our research using a virtual reality supermarket (to mimic a more realistic environment), to investigate the visual attention of consumers and evaluate two strategies to increase the choice of pulses (Chapter 5). We compared the social representations of consumers from France and Spain towards pulses (Chapter 6). In the final part of this thesis, the main findings are discussed, and strategies are proposed to enhance consumer choice towards pulses (General Discussion). Table 2 is an overview of the thesis outline, including setting, number of participants, method, and aims.

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***Table 2**. Overview of the research chapters, including setting, number of participants, method, and aims.*

Chapter	Setting	Number of participants	Method	Aim
Chapter II	In situ	80 consumers 35 professionals	Word Association task and ranking of importance	To compare the social representation and attitudes towards pulses, of consumers and professionals of the pulse industry
			Polarity index	
Chapter III	Lab-context	120 consumers	Indirect method (food images and evoked scenarios)	To access to consumers mental representation of pulses by the use of different scenarios evoking a real-life situation
	Online		Questionnaire	Used of a direct method to understand consumer representations, knowledge and beliefs about food product
	Lab-context	120 consumers	Indirect method (food images and evoked scenarios)	To identify the structure of French main dishes in different scenarios
Chapter IV	In situ	73 consumers	Check-All-That-Apply (CATA)	Capture mental representations towards pulses with different level of transformation
	Online	144 consumers		
Chapters V	Virtual reality	108 consumers	Eye tracking	Explore gazing behavior towards different shelves and food-groups in a virtual supermarket
	Virtual reality	108 consumers	Eye tracking	
			Food choice in different evoked scenarios	Implement and evaluate a nudge strategy to increase pulse choice in a virtual supermarket
Chapter VI	In situ	60 consumers France 60 consumers Spain	Free word association task	Compare the social representation of pulses for French and Spanish participants Improve social representation assessment
			Polarity index	Attitudes towards pulses
			Questionnaire	Food habits of participants

Chapter II. Social representations towards pulses in France, from consumers and professionals of the pulses industry perspectives

This chapter will be presented under the form of a publications, accepted in Foods in 2020.

Do French Consumers Have the Same Social Representations of Pulses as Food Industry Professionals?

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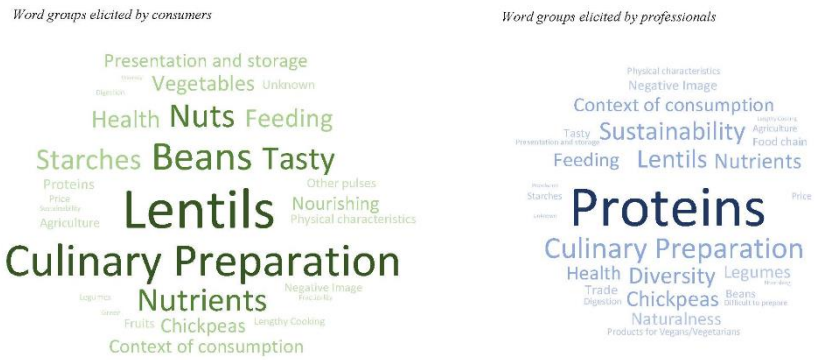
Abstract

Pulses present many advantages for human health, nutrition, sustainability, and the environment. Despite efforts in recent years by the pulse industry and national authorities to favor pulses, consumption in France remains relatively low, at 1.7 kg/per person in 2016, compared to 1920 when it was around 7.2 kg/per person. To understand social representations of pulses in France, 80 French nonvegetarian consumers and 35 professionals from the pulse industry were asked to say five words spontaneously evoked by the inductor "pulses". They then had to rank these five words in order of importance and rate their valence. The structural approach was used to analyze social representations for each group independently. Our results highlight differences in the structure and content of social representations for pulses. Consumer responses suggested only vague impressions of pulses, but taste evocations were nevertheless rated positively. By contrast, professionals tended to focus specifically on protein content and culinary preparation. These differences could explain some barriers to pulse consumption, and improved communication should be a key target. Efficient communication must consider the concepts most frequently used by consumers when referring to pulses, and those ranked as most important.

Graphical abstract



Keywords: Pulses; social representations; structural approach; pulse food industry; supply chain; professionals; word association

1. Introduction

There is growing interest worldwide in sustainable diets, and pulses present many advantages: They have a positive impact on environmental sustainability, on human nutrition and health, and on food security [1]. Despite their numerous interesting properties, however, pulses have become less popular in France over the last century [2,3], with annual consumption falling to 1.7 kg per person in 2016 [4]. The lack of technology to create new, attractive, pulse-based food products has been put forward as one of the reasons for the low consumption of pulses in France [5]. As a result, innovative technologies have been developed to propose new products, such as processed lentils (e.g., ready-to-eat dishes in sachets, or boxes) [6], and precooked products combining cereals and pulses (e.g., pasta combining wheat and pulse flour) [7]. In addition, the most recent French public nutritional campaign now provides information about pulses [8], with the aim of increasing pulse consumption in France. Nevertheless, it seems that these efforts have not yet been successful. Are they perhaps not adequately adapted to consumer expectations?

Two recent studies suggested that the main barriers to pulse consumption in France are linked to consumers' mental representations of pulses [8,9]. A mental representation is a cognitive product, based on individual mental processes that come from interaction with a person's environment, allowing the meaning of stimuli to be stored in the memory [10]. It was observed that French consumers considered lentils, beans, and chickpeas as foods for vegetarians, requiring lengthy preparation, that were not much liked, and therefore consumed infrequently [9]. Consumers knew the positive properties of lentils, chickpeas, and beans as products with a high protein content, good for the health, and for the environment. Nonetheless, they tended to use these foods only as a side product in their dishes, with an animal protein product as the central component [11].

Another type of barrier may be related to inefficient recommendations regarding pulse consumption, based on terms poorly understood by consumers. Communication campaigns aimed at guiding consumers toward healthier and more sustainable diets often use food group names, such as "pulses" or "legumes", with which French consumers are not necessarily familiar [12]. One way to explore this assumption is through the theory of social representations. A social representation is constructed from a set of beliefs, opinions, attitudes, and information about a certain object [13]. The meaning of this object is created by a system of social negotiations, within a social group [14]. One of the functions of a social representation is to allow the members of a social group to acquire and

integrate knowledge. Social representations also facilitate social communication and the transmission and diffusion of knowledge, while prescribing behavior and practices [13].

Social representations have been used to investigate whether there is shared understanding among consumers about concepts such as naturalness [15], hedonic food intake in restaurants [16], wine minerality [14], etc. The study of social representations is also particularly interesting for the study of people's reactions to new foods, such as edible flowers [17]. Social representations play a role in the transition from "what is disturbing and unknown into something familiar and known" [18] (p. 300). The opposite transition has taken place among consumers in France, in the case of pulses, which have been steadily more neglected, particularly during the twenty-first century. Consumer knowledge of pulses is therefore likely to have declined. The study of social representations may allow us to discover whether consumers share common beliefs, practices, and attitudes in relation to pulses. Comparing the social representations of pulses elicited from consumers with those from professionals in the pulse industry and consumers may provide keys to identify and resolve communication problems, which could in turn stimulate consumption. Interactions between consumers and professionals from the food sector are of vital importance, yet so far, they are not very well documented. One Australian study did focus on the relationship between farmers, food processing businesses, and consumers in relation to plant food beliefs and attitudes [19]. This study shows that industry awareness of consumers' plant food beliefs is generally misguided. In particular, barriers to plant food consumption expressed by consumers were not identified as such by food industry professionals. The authors underlined the need to increase knowledge sharing between consumers and the plant food industry, by creating stronger links between consumers, farmers, and food processing businesses [19].

One way to study social representations is the structural approach, which has been used for decades in social psychology research and applied more recently to the consumer science field to understand consumer behavior. This type of analysis provides access to the meaning that a social group attributes to the object of a social representation [20], organized and structured around a central core, composed of one or more elements [13]. The central core represents the system of values corresponding to the cultural and social norms of the group. It remains stable, thus ensuring continuity in contexts that may move and evolve [13]. In addition to the structural approach, it can also be calculate the polarity index, which is one way of accessing implicit attitudes toward the object of a social representation [21]. Attitudes are among the many variables used to investigate human behavior. They result from previous experience with the product (or a similar product from the same category) and from information obtained via word-of-mouth, advertising, product packaging, and advertising in the media [22]. Attitudes can be formed even in the absence of actual experience with

an object [23], based on what consumers have seen or heard about the object. Attitudes lead to favorable or unfavorable evaluations of a specific object. If consumers evaluate a product favorably, the use or consumption of this product may increase, whereas a negative evaluation may act as a barrier to consumption [24]. Attitudes remain dynamic and may therefore change over time.

The aim of the present study is to understand the social representations of pulses among two social groups in France: nonvegetarian consumers and professionals from the pulse industry. The hypothesis was that the social representations of professionals and consumers would have very different structures. These differences could aggravate the mismatch between the pulse products on offer and the needs of the consumer, resulting in ever lower levels of consumption. Understanding the discrepancies between the social representations of these two populations, taken together with any common elements, could provide keys for the development of strategies optimized to increase pulse consumption.

2. Materials and Methods

2.1. Participants

A total of 80 consumers (27 men and 53 women) and 35 professionals from the pulse industry in France (17 men and 18 women) participated in our study. For consumers, the two inclusion criteria were age, between 25 and 65, and no specific diet (e.g., vegetarian or vegan). Consumers were recruited on a voluntary basis, over a three-week period, from a Cultural and Social Center in Dijon, France. The pulse industry professionals were recruited from among the participants at a congress held in 2018, “2èmes Rencontres Francophones des Légumineuses (RFL2)”. The study was carried out several weeks after the congress. Additional pulse industry professionals were recruited through contacts provided by participants and from web-based sources such as “LinkedIn”. For professionals, the only inclusion criterion was to be working in a field related to the pulse supply chain. The age range for professionals was between 30 and 65 years old. The professionals who participated in our study were either experts in pulse seed selection or employed in R&D for industries that transform pulses or farmers growing at least one type of pulses (belonging either to farming cooperatives or interprofessional associations), or store managers. In addition to the three main sectors thus represented in this study (agriculture, processing, and distribution), the supply chain also includes suppliers, transporters, and warehouse managers [25,26].

2.2. Procedure

The study was conducted in accordance with the Declaration of Helsinki and was approved by the ethical committee of INSERM N°18-506. Institutional Review Board INSERM (CEEI/IRB) (IRB00003888, IORG0003254, FWA00005831).

Consumers and professionals who agreed to take part in the study were asked to read and fill out a consent form. Consumers received this form from the experimenter just before a face-to-face individual interview. Professionals from the pulse industry were first contacted by email and then received the consent form by email, with an appointment for a phone interview. For both consumers and professionals, the interview lasted from 10 to 15 min.

The experiment started with an evocation task, followed by a ranking and polarity test. A pretest was carried out with the inductor word "car", in order to ensure that participants understood the task. They were then given the inductor "pulses" ("*légumes secs*" in French). Participants had to say out loud five words or expressions that came spontaneously to mind when they heard the inductor. Once participants had given five words, they were asked to rank each of their words according to relative importance, from 1 to 5 (1 for the word that participants considered the most important and 5 for the least important). Finally, participants had to rate the valence of each of their words, by giving a score from −2 to +2: very negative (−2), negative (−1), neutral (0), positive (+1) or very positive (+2).

2.3. Analysis

All the words evoked by consumers and by professionals were analyzed qualitatively. A thematic analysis followed the phases proposed by Braun and Clarke [27]: familiarization with the data, generation of initial codes, searching for themes, reviewing themes, and defining/naming the themes. For this last step, a triangulation process was carried out [28]. Three researchers independently sorted all the words by meaning into groups based on meaning, then these three lists of word groups were compared, and the final list of word groups was validated consensually for each set of participants. The resulting word groups were translated into English using a two-way translation process.

2.3.1. Structural Approach

Each word group was then analyzed using the method proposed by Abric [29], also known as the structural approach, which is divided into two main phases.

For each set of participants, we calculated the total frequency of occurrence and the mean importance score for all the words in a given word group. Cutoff points were then determined for frequency and for importance. The frequency cutoff point was obtained by halving the total frequency

of occurrence for the word group with the highest frequency score, while the importance cutoff point was calculated by averaging mean importance scores over all word groups [29].

A social representation map was then built for each set of participants, with four zones (2 × 2) delimited by the cutoff points:

- The first zone is the *central core*, with the most frequently cited and most important word groups.
- The second zone is the *first periphery*, where the most frequently cited but less important word groups are found.
- The third zone is the *contrasting zone*, containing word groups with low citation frequency but higher importance.
- The fourth zone is the *second periphery*, containing low frequency word groups that were considered less important.

Each word group was assigned to one of the four zones of the social representation map.

2.3.2. Polarity Index

To understand the implicit attitudes in this social representation, a polarity index (P) [21] calculated for each word group.

$$Polarity\ index\ (P) = \frac{\begin{matrix} Number\ of\ positive\ words \\ in\ word\ group \end{matrix} - \begin{matrix} Number\ of\ negative\ words \\ in\ word\ group \end{matrix}}{Total\ number\ of\ words\ in\ word\ group}$$

This index ranges from −1 to +1. A P value between +0.1 and +1 indicates that most of the words in that group are positive. If P is from −1 to −0.1, it indicates that most of the words in that group are considered negative. If P is from −0.04 to +0.04, positive and negative words are likely to be equal, indicating a neutral attitude. A polarity index was calculated for each word group, independently for (i) consumers and (ii) professionals.

3. Results

In total, 575 words were proposed either by consumers (*N* = 400, from which 7 words were then deleted as meaningless) or by professionals (*N* = 175). After the thematic analysis and the

triangulation process, we obtained a total of 35 word groups, 24 of which were common to both sets of participants, while 6 groups were specific to consumers and 5 to professionals (**Table 1**).

Table 1. Frequency of use for each word group, for professionals and for consumers, with examples of words evoked for "pulses". Italics for the word group name in French.

Word group	Professionals (n=35)	Consumers (n=80)	Examples of words proposed by participants
Agriculture (*Agriculture)*	3	9	water, pesticide, planting, garden, seed
Beans *(Haricots)*	4	27	beans, white beans, dried beans
Chickpeas *(Pois Chiches)*	9	14	chickpeas
Context of consumption *(Contexte de consommation)*	8	13	childhood, family dish, winter, sharing, meal, restaurant, sport
Culinary Preparation *(Préparation culinaire)*	13	31	pressure-cooker, cooker, dish, dip, steam, recipe
Difficult to prepare *(Préparation difficile)*	2	0	hard to cook
Digestion *(Digestion)*	3	5	digestion, gas
Diversity *(Diversité)*	10	4	diversity, variety
Feeding *(Alimentation)*	8	18	food, eat, feeding
Food chain *(Filière profesionnelle)*	4	0	profession, sector, competitively
Fruits *(Fruits frais)*	0	9	apricots, bananas, grapes
Green *(Vert)*	0	5	green
Health *(Santé)*	8	17	beneficial, healthy
Legumes *(Légumineuses)*	7	6	legumes, soya beans
Lentils *(Lentilles)*	11	38	lentils, red lentils
Lengthy Cooking *(Cuisson longue)*	1	7	lengthy preparation, lengthy cooking
Naturalness *(Naturalité)*	7	0	plant-based, natural
Negative Image *(Image négative)*	5	8	not good, insipid, not very popular, unattractive, not tasty
Nourishing *(Nourrisant)*	1	13	appetite, energy, satiating, calorie
Nutrients *(Nutriments)*	9	22	iron, nutritive, high in fiber, vitamins, balanced

Nuts *(Fruits secs)*	0	23	almond, peanut, hazelnut, nut, pistachio
Other pulses *(Autres légumes secs)*	0	9	split peas, flageolet beans
Physical characteristics *(Caractéristiques physiques)*	3	9	brown, old, dehydrated, dry, solid
Population *(Population)*	1	0	population
Practicality *(Practicité)*	0	5	speed, flexibility, ease of preparation
Presentation and storage *(Présentation et conservation)*	2	13	non-perishable, box, canned, convenient
Price *(Prix)*	3	7	cost, economical, affordable
Products for Vegans/Vegetarians *(Produits vegan/végétarien)*	3	0	vegan, vegetarian
Proteins *(Protéines)*	26	10	proteins
Starches *(Féculents)*	3	20	wheat, bulgur, potato, rice, quinoa
Sustainability *(Durabilité)*	11	5	organic, environment, sustainable agriculture
Tasty *(Bon)*	4	22	good, taste, flavor, delicious, fun
Trade *(Commerce)*	5	0	import, worldwide, Italy, France
Unknown *(Inconnu)*	1	9	little known, unknown
Vegetables *(Légumes)*	0	15	carrots, spinach, green beans, salad
Total	175	393*	

- * The 7 words deleted from the original total of 400 were: game, non-exclusive, exit, telephone, car, possibility, goldfish.

3.1. Structural Approach

3.1.1. Social Representation Map for Consumers

Figure 1a shows the map for consumers. The cutoff point was 19 for frequency and 2.97 for importance.

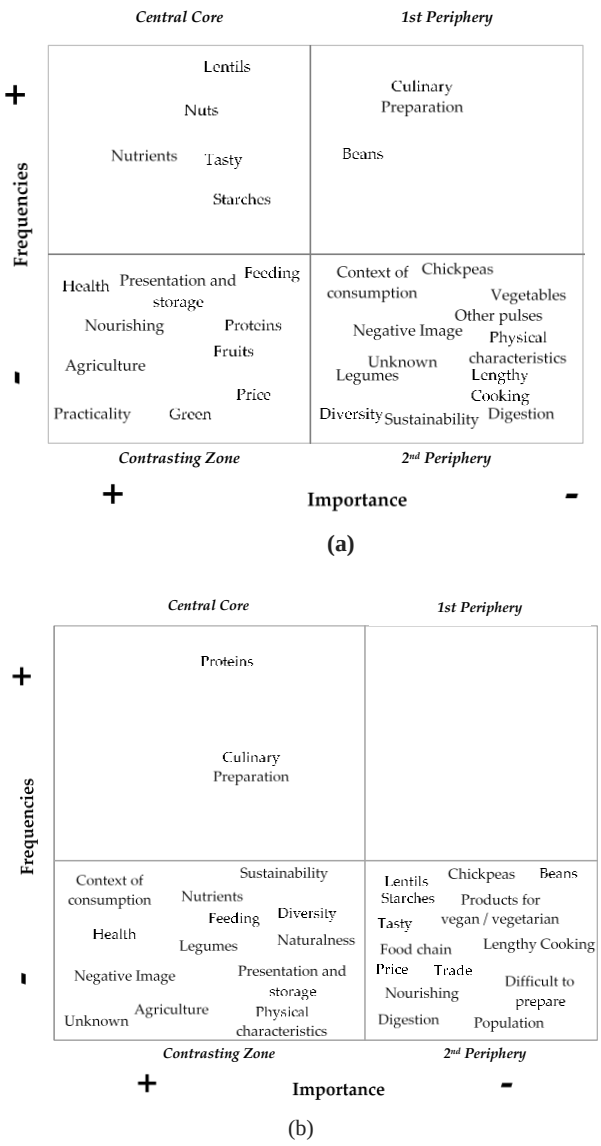


Figure 1. The social representation map for pulses among French nonvegetarian consumers (a), and for pulse food industry professionals (b).

The central core contains the word groups *lentils, nutrients, tasty,* and *starches,* but, also, surprisingly, *nuts.* The first periphery contains only two word groups (*culinary preparation* and *beans)*. The contrasting zone and the second periphery are both richer and more varied.

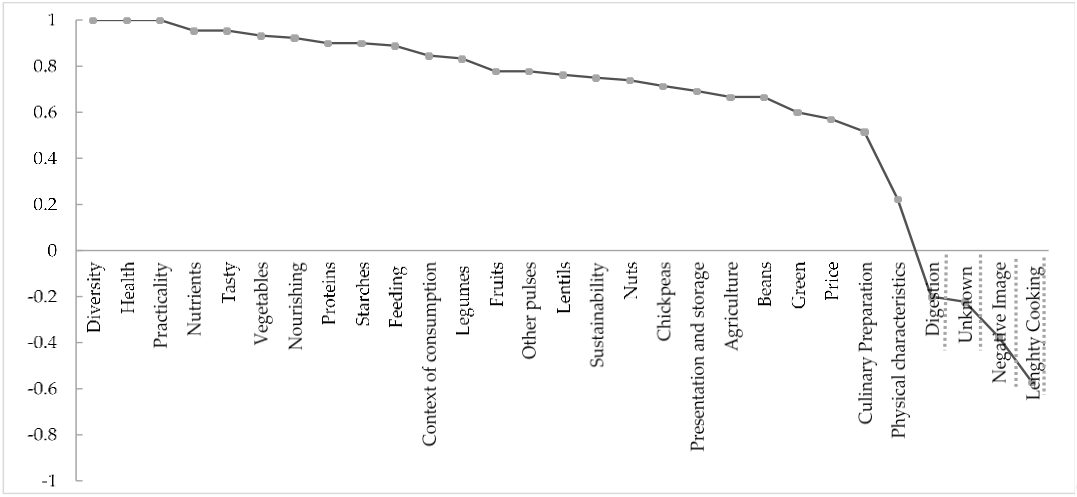
3.1.2. Social Representation Map for Professionals

Figure 1b shows the map for pulse industry professionals. The cutoff point for frequency was 13, with 3.29 the cutoff point for importance. In the central core, there were only two word groups: *protein* and *culinary preparation.* Neither of these was common to the central core of the consumer map. Interestingly, the first periphery was empty. In the contrasting zone, we found word

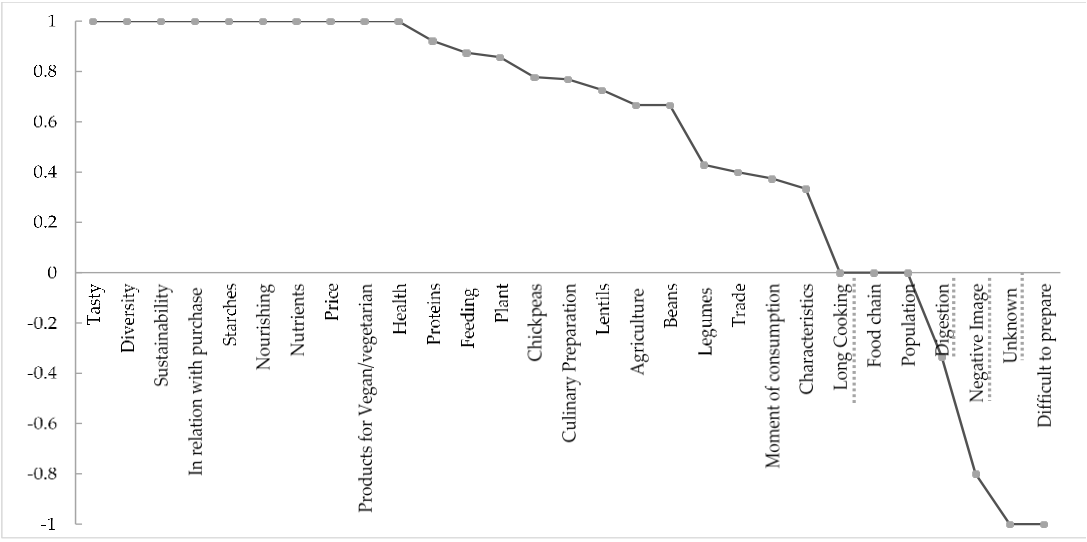
groups common to both consumers and professionals (*health, feeding*, *agriculture,* and *presentation and storage*), and others specific to professionals (*context of consumption*, *nutrients*, *sustainability*, *diversity*, *legumes*, and *naturalness*). Similarly, in the second periphery, some word groups were common to both consumers and professionals (*chickpeas*, *lengthy cooking*, and *digestion*). All the exemplars used by professionals are located in this zone (*lentils*, *chickpeas*, and *beans*).

3.2. Polarity Index

The polarity index was calculated for the word groups used by consumers (**Figure 2**a) and for those used by pulse industry professionals (**Figure 2**b).



(a)



(b)

Figure 2. Polarity Index for French non vegetarian consumers (a), and for professionals (b). The word groups underlined with a dotted line are common to both consumers and professionals, with either neutral or negative valence.

Most of the word groups have a positive valence for both sets of participants, reflecting a generally positive attitude towards pulses. Only a few word groups have negative valence; most of them (*digestion*, *unknown,* and *negative image*) are common to both consumers and professionals. Only one word group (*lengthy cooking)* is negative for consumers alone. The word group *difficult to cook* is negative for professionals, while *lengthy cooking, food chain,* and *population* are neutral for them. For consumers, none of the word groups was considered neutral.

4. Discussion

The main goal of this study was to characterize the social representations of pulses for French non vegetarian consumers and for professionals from the pulse industry in France. Results confirmed that although some word groups were shared, many were unique to one set of participants. Even when the representations for both sets of participants contained the same word groups, their positions on the maps were different. Social representations containing the same elements have been shown to be radically different when the relative positions of the elements are different [13]. Our study thus shows that the structure of social representations of pulses in France is different for consumers and for professionals:

4.1. What is the social Representation of Pulses among French Nonvegetarian Consumers?

For the inductor "pulses", the word group most frequently cited by consumers was "*lentils*", while other pulses (e.g., *beans* or *chickpeas*) were either not frequently cited or not ranked highly. These spontaneous responses show that for French nonvegetarian consumers, lentils are the most prototypical pulses. This is in line with a previous study, in which French participants declared lentils to be the most liked and most frequently consumed pulse [9].

Items in the central core are known to resist change [29]. In this study, we observed that two other food groups (*nuts* and *starches*) were located in the central core, evidencing a strong association with pulses. In the French diet, pulses and starches are often considered to have the same function in a meal. As shown by Melendrez-Ruiz et al. (2019), French participants used pulses and starches as equivalent when composing a meal, often associating only one or the other with meat and vegetables [11]. Until 2016, French nutritional recommendations placed starches (i.e., bread, cereals, potatoes) and pulses in the same food category [30]. The strong association between starches and pulses in our study could be explained by consumers confusing the two food groups with regard to their properties and use.

The food group *nuts* was even more frequently cited and similarly ranked than *starches*, a surprising result potentially indicating that many participants in our study based their answers on

semantic similarity. The inductor in French was "*légumes secs*", the appropriate translation for "pulses", but which translated literally would be "dry vegetables". The word *nut* belongs to the category "*fruits secs*" in French, producing the literal translation "dry fruits". Participants could therefore have focused on the adjective "*sec*" ("dry"), common to both expressions in French. This result reveals that strong semantic similarity between two food categories in a given language can induce overlapping representations of products belonging to different categories.

Finally, the central core of the consumer map also contains two word groups related to pulse properties, *nutrients* and *tasty.* Pulses are known to contain many nutrients (e.g., iron, fiber, vitamins) that contribute to a healthy diet [31], and consumers in our study seemed to be aware of this fact. Interestingly, this intrinsic characteristic was mentioned alongside more individual, subjective perception (i.e., hedonicity).

The elements located in the first periphery are known to strengthen the meaning of the social representation [29]. In our study, this zone only contains two word groups: *beans* and *culinary preparation*. The frequent use of *beans*, in the same manner as *lentils* in the central core, indicates that consumers tend to use exemplars to confirm their understanding of the inductor. The use of *culinary preparation* is consistent with the results of our previous study, which showed that preparation is an important concern for consumers, which reduces their willingness to choose pulses [9]. The frequent citation of words related to culinary preparation in the present study reveals that this association between pulses and cooking is well anchored in consumers' social representations.

The elements located in the contrasting zone are known to characterize consumer subgroups [29]. In our study, the great number and diversity of word groups in this zone reflect the broad range of unshared knowledge, beliefs, and attitudes regarding pulses among consumer subgroups.

The second periphery contains more idiosyncratic elements, where individual differences can be observed [32]. All the word groups considered as negative by consumers (*negative image, unknown, lengthy cooking,* and *digestion*) were located in the second periphery. This is a key result, because the second periphery contains elements susceptible to change. Previous studies hypothesized that the low consumption of pulses in France could stem from negative attitudes toward pulses. It was reported, in particular, that pulses are considered as "the poor man's meal" [2,33], not well known [3], require lengthy preparation, and may provoke unwanted digestive effects [2,3,6,33]. Our results do not confirm this hypothesis, since those attitudes are not present in the central core of social representations. This result means that negative attitudes toward pulses are not considered important and are not frequently observed among French nonvegetarian consumers but are linked only to a few individuals. As a consequence, they can be considered open to change.

4.2. What Is the Social Representation of Pulses among Pulse Industry Professionals in France?

With the inductor "pulses", professionals mostly cited two word groups: *proteins* and *culinary preparation*. This reflects a more consensual point of view about pulses, but also a focus on the functional properties of pulses. The first periphery is surprisingly empty, confirming the strength of the representation for professionals.

The frequency of citation and high ranking of the word group *proteins* reflects the deeper understanding of the nutritional properties of pulses among professionals. Compared to consumers, they have more precise knowledge of pulses' nutritional properties (*proteins* in the central core for professionals versus *nutrients* for consumers).

Professionals did not cite any fruits, vegetables, or nuts, and only rarely starches. This result indicates that they share a clear definition of pulses and do not confuse them with other food groups that are semantically similar. For professionals, *lentils*, *beans*, and *chickpeas* are located in the second periphery, confirming that they did not need to cite exemplars to define what pulses are.

Surprisingly, a great diversity of word groups is observed in the second periphery, potentially reflecting the existence of subgroups with different representations [32], which could be explained by the profiles of the professionals who participated in this study. Different levels in the pulse supply chain are represented by specific terms. Some word groups are related to the agricultural sector (*naturalness*, *agriculture*, and *sustainability*), while others are related to the processing industry (*physical characteristics*) or the distribution sector (*context of consumption*, *nutrients*, *feeding*, and *presentation and storage*).

4.3. Discrepancies between the Representations of Consumers and Professionals

Several differences were observed between the social representations of consumers and of pulse industry professionals. One of the discrepancies evidenced by our study is that knowledge of the nutritional properties of pulses is more precise for professionals than for consumers, who need to cite exemplars to confirm the meaning of pulses. Most of the word groups in the central core of the consumer map are found in the second periphery of the professional map. For consumers, *tasty* is a stable fundamental component of their representation of pulses, whereas for professionals, this word group is idiosyncratic, revealing a meaningful difference between the two populations. The high number of citations and high ranking suggest that consumers appreciate the taste of pulses, associating specific organoleptic properties with them. Surprisingly, taste is less frequently mentioned by professionals, although it could be a potential lever to increase pulse consumption. The word

group *negative image* is used differently by the two sets of participants. For consumers, it is located in the second periphery and has a polarity index of −0.4, whereas for professionals, it is located in the contrasting zone and has a polarity index of −0.8. This discrepancy indicates that professionals have slightly a more negative image of pulses than consumers have.

An apparent paradox emerged from our results. Despite not knowing pulses very well, consumers do not have a negative image of them and even express a positive opinion about their taste. By contrast, professionals, who are supposed to know pulses well, do not mention their taste. This is unexpected, because professionals should consider taste as a functional property, like protein content, and use this characteristic to encourage consumption. Professionals even expressed a more negative opinion than consumers about pulses. Responses from professionals should be interpreted with caution: They may reflect both their personal attitudes and beliefs regarding pulses, and also their view of consumers' beliefs and attitudes. In both cases, inaccurate communication about pulses centered on their protein content and preparation may be the result, although consumers would undoubtedly be more sensitive to arguments about the organoleptic properties of pulses.

Finally, the word group *unknown* is found in the same zone (second periphery) for the two sets of participants, but with a polarity index of −0.2 for consumers and −1 for professionals. For professionals, lack of knowledge with regard to pulses represents a major disadvantage for their business.

4.4. What Could Be Done to Improve Communication about Pulses?

The differences between the social representations of consumers and professionals represent a barrier to pulse consumption, and communication could be a lever to overcome this. Both sets of participants need to be involved in communication strategies.

Professionals seem to place particular value on the high protein content of pulses and think this should be an important concern for consumers. Nonetheless, this opinion is not necessarily true: Consumers rarely cited the word group *proteins*, and even though they did often mention *nutrients*, the key element for them seems to be *tasty*. Consequently, due to this discrepancy, it will be difficult to produce consensual messages to communicate efficiently about the benefits of pulses.

When questioned about pulses, consumers used some exemplars, indicating only vague and confused knowledge associated with this food group. It would be necessary to remove word groups such as *nuts* and *starches* from consumer representations to help with a clearer definition of pulses. Nevertheless, consumers cite positive qualities when they are questioned. Most of them show favorable beliefs and attitudes. Thus, there are no strong barriers to pulse consumption. A more

efficient communication strategy would use more accessible words to communicate with consumers. However, communicating about "pulses" per se can be misunderstood by consumers. As long as the term "pulses" and pulse properties remain unclear, it will be difficult to communicate efficiently. There is a clear need to map out the terms and expressions used by consumers when referring to pulses. If public authorities and the pulse industry want to use the term "pulses", educational programs and dietary recommendations should be adapted. Associating exemplars with the term "pulses" seems a necessary step, until a clearer social representation of pulses is reached. The problem of the indiscriminate use of the words "*légumes secs*" (pulses) and "*légumineuses*" (legumes) by French consumers must be addressed, because it may lead to confusion and misunderstanding.

All the sectors involved in the pulse industry should work together to overcome this difficulty. Developing the relationship between stakeholders in the supply chain is essential for the meaningful diffusion of scientific knowledge in order to bring about changes in cultural practices [5].

4.5. Strengths and Limitations

Applying the same methodology (the structural approach with polarity index calculation) to both sets of participants (consumers and professionals) provides a sound basis to assess the interplay between their social representations, attitudes, and beliefs with regard to pulses.

The small number of professionals from the pulse industry who participated in the study could be seen as a limiting factor, but it should be pointed out that this sector of activity employs relatively few people in France. With a larger number of professionals, it would be possible to form subgroups according to their main sector of activity (farmers/farming, transformation/processing, and distribution). Differences related to their main activity could thus be identified, leading to specific strategies for each sector in their communication with consumers.

5. Conclusions

Our study highlighted new insights concerning social representations of pulses for French consumers and professionals from the French pulse industry. Differences were found in the social representations of these two groups, which were identified as a possible barrier to pulse consumption.

The main results revealed that consumers do not share a clear and stable social representation of pulses as a specific food group but tend to consider each type of pulse individually (e.g., beans, lentils, and chickpeas). The properties linked to pulses are mostly positive for consumers, and *tasty* was one of the major characteristics associated with pulses. By contrast, professionals' answers were focused more on protein content and culinary preparation. This difference in focus has led to a communication breakdown between the two populations.

In order to deliver a more efficient message to consumers about pulses, two steps are necessary. First, there is a need to map out the terms and expressions used by consumers when referring to pulses. These terms should be preferred, and any alternative should be clearly defined. Secondly, efforts to improve communication should involve all stakeholders in the pulse supply chain in France, as well as external bodies such as national authorities, schools, and associations. Their main focus should be on producing clear, precise, standardized messages about what pulses are. In addition, it is important to take into consideration the importance of taste, because taste is one of the main drivers for consumers. Overall, strengthening the relationship between consumers and professionals is essential in order to overcome the main barriers to pulse consumption while developing the best strategies to promote pulses.

Efforts to achieve this goal would certainly be successful, because the few negative representations observed in our study were not stable and were shared by only a small number of people, indicating that such representations are ripe for change.

Author Contributions

Conceptualization and methodology: G.A., S.C., S.M.-P., and J.M.-R.; formal analysis, writing—original draft preparation, J.M.-R.; writing—review and editing, G.A., S.C., S.M.-P., and V.L. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors have no conflict of interest to disclose.

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From this chapter, we evidenced that the current social representation of pulses among French consumers is unclear. To go further than this first study and to understand accurately the barriers of the low consumption of pulses in France, several options were considered. First, we shifted our attention from the study of social representations to the study of individual mental representations (this will be covered by chapters III and IV), and we considered the influence of the environment on choices (Chapter V). Finally, to deepen the understanding of the social representations, a cross-cultural study was carried out (Chapter VI).

Chapter III. Use of a laboratory setting to evaluate food choices and understand consumers' mental representations, beliefs, and knowledge about pulses

Having observed that social representations about pulses is not stable for French, non-vegetarian people, for further studies, we decided to use food images, including images of pulses and pulse-based products. Indeed, not knowing precisely what consumers had in mind when asked about pulses would have represented a risk. In the current chapter, we present a study in which we used a direct (questionnaire) and an indirect method (food choice intention task) to investigate the mental representations, beliefs, and knowledge of consumers towards pulses. The results obtained by the indirect method also allowed us to study the place that pulses hold in the structure of a dish for French consumers. The results were valorized by two publications, accepted in international journals in 2019. Chapter III will be composed of these two papers.

1) French consumers know the benefits of pulses, but do not choose them: An exploratory study combining indirect and direct approaches

2) A central place for meat, but what about pulses? Studying French consumers' representations of main dish structure, using an indirect approach.

French consumers know the benefits of pulses, but do not choose them: An exploratory study combining indirect and direct approaches

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Abstract

Pulses present nutritional advantages for human health, and also contribute to food security and environmental sustainability. Despite these beneficial properties, the consumption of pulses in France has decreased over the past century. This study explores the representation of pulses among French non-vegetarian consumers, using both an indirect approach, with scenarios evoking real-life situations, and a direct approach, with an online questionnaire. For the indirect approach, based on six different scenarios, the 120 participants composed dishes by selecting three food images out of the twenty provided. One week later, for the direct approach, the same participants completed a questionnaire, with ten questions about food products, using the same images.

Results showed that spontaneous selection of pulses was low for all dish-composition situations, coherent with the low consumption of pulses declared in the questionnaire. Among possible barriers to pulse consumption were dislike of pulses, preparation difficulty, and perception of pulses as a food for vegetarians. Participants possessed theoretical knowledge about the benefits of pulses, but this knowledge seemed not to be applied to dish-composition situations. Results also highlighted the complementarity of these two methods, providing deeper understanding of consumer food habits in relation to pulses. Based on these findings, several levers are proposed to increase pulse consumption: improving familiarity with pulses, using the context of consumption, formulating trendy and innovative products, and promoting pulses as a “food for all”.

Keywords: Pulses, Indirect measure, Food choice intentions, Representations, Scenario, Evoked context

1. Introduction

Pulses have been cultivated for the past 11 000 years (Fortin, 2006), but have attracted far more attention over the last decade, because of their great potential to increase global food security and enhance environmental sustainability. According to the Food and Agriculture Organization (FAO), pulses are leguminous crops harvested exclusively for dry seed (i.e. dried beans, lentils, and peas), but excluding crops used mainly for oil extraction, e.g. soybeans, and those that are harvested green, e.g. green peas (FAO, 2016). Deep roots allow pulse plants to adapt to unfavorable conditions (Iriti & Varoni, 2017), so that they can be cultivated almost everywhere. Pulses are unique in the vegetable kingdom in that they fix nitrogen from the atmosphere, fertilizing the soil, and therefore increasing biodiversity (FAO, 2016; Schneider et al., 2015). In addition to these positive consequences for the environment, pulses present several advantages from a nutritional point of view. Many national and international authorities now highlight the benefits of regular human consumption of pulses. The United Nations declared 2016 to be the International Year of Pulses, under the slogan "nutritious seeds for a sustainable future" (FAO, 2016).

Besides being a major source of plant-based proteins, pulses are rich in dietary fibers, complex carbohydrates, minerals, and vitamins, an almost ideal basis for a healthy diet (Curran, 2012; Mudryj, Yu, & Aukema, 2014). Increasing pulse consumption to four times per week or more has been associated with a reduced risk of coronary heart disease (Bazzano et al., 2001). The high fiber content of pulses may have positive effects on short-term satiety (McCrory, Hamaker, Lovejoy, & Eichelsdoerfer, 2010), and weight loss. Pulse consumption can also present health benefits for specific populations. Frequent consumption of pulses, especially lentils, helps to prevent type 2 diabetes in older adults because of the low glycemic index (Becerra-Tomás et al., 2017). Folate, a vitamin present in pulses, reduces the risk of neural illness in newborn babies, while iron, a mineral also present in pulses, is known to prevent anemia in women, children, and babies (FAO, 2016).

Despite these benefits, pulse consumption in France has declined, from 7.2 kg in 1920 to 1.7 kg per person per year in 2016, although health authorities recommend eating pulses at least twice a week (ANSES, 2017a; HCSP, 2017, p. 7). Some hypotheses to explain low consumption in France are related to consumer issues, e.g. poor knowledge of pulses, bad memories of pulses at the school canteen; the need to plan ahead for pre-soaking, or the lack of recipe ideas and motivation (Lecerf, 2016). Cultural prejudice against pulses, seen as "the poor man's meal", might also explain low consumption (Magrini, 2016; Rio, 2017). Packaging-related issues may lower consumer expectations: pulses are often sold in cans, generally perceived as poor quality food, in comparison with foods in the form of prepared dishes or raw products (Champ, Magrini, Simon, & Le Guillou, 2015). Finally, other

reasons could be related to the food product itself, such as the time required for soaking pulses, except for lentils (12 h or overnight), and unwanted digestive effects, e.g. flatulence (Champ et al., 2015; Lecerf, 2016; Magrini, 2016; Rio, 2017). These hypotheses have not yet been experimentally tested, requiring new studies to validate them. No scientific study to date has directly investigated mental representation of pulses among consumers in France.

In a French study, declared consumption of pulses was significantly higher (0.3 times more) in men than in women (CREDOC, 2007). Different consumer profiles in relation to pulses have also been reported in countries other than France. In Finland, frequent consumption of beans was significant in young consumers (25–34 years old), and in consumers with a high level of education (Jallinoja, Niva, & Latvala, 2016). In Canada, pulse consumption was low among young Canadians (18–34 years old), and people living alone, but higher among consumers with a university education (IPSOS, 2010). Such studies, assessing consumption or willingness to consume specific products, are usually based on direct, declarative methods (web-based surveys, online interviews, or focus groups). One possible limitation of declarative methods is the potential dissociation between what participants think or say about their behavior and what they actually do (Köster, 2003).

Mental representations of food play an important role in consumer behavior and may affect inference, judgment, and food-product choice (Bartels & Johnson, 2015). Better knowledge of such mental representations may help to develop strategies to increase pulse consumption in France. A mental representation is an image that an individual has of a product, a person, an idea, or a situation. According to Gallen (2005), representations are defined as cognitive products and individual mental processes that come from the interaction of individuals with their environment, allowing them to code the meaning of the stimuli and store this information in memory. Consumers' mental representations can be investigated through direct (i) or indirect (ii) methods.

(i) Direct methods are typically questionnaires or surveys that ask people to describe their choices or the reasons for their choice, to gather information about their attitudes and behaviors. In direct methods, the questions focus on the main goal of the study, which generally results in consumers becoming aware of the research objective. Among potential biases linked to surveys and questionnaires (Mathers, Fox, & Hunn, 2009), the best known is social desirability bias, where participants seek to present a positive image of themselves to the researcher. Participants thus tend to "under-report socially undesirable attitudes and behaviors and to over-report more desirable attributes" (Latkin, Edwards, Davey-Rothwell, & Tobin, 2017). Answering a questionnaire is a complex cognitive task: it implies understanding the meaning of the questions, accessing information stored in memory, adapting this information to the situation, and then estimating the reliability of the chosen

answer in relation to all other possible answers (Krosnick, 1991). Participants may therefore select the first answer acceptable to them without going through the entire cognitive process.

(ii) In contrast, indirect questioning methods are thought to provide access to "unconsciously latent psychosocial constructs" (Antonak & Livneh, 1995). In cognitive psychology, indirect tests assess the retention of information without direct reference to the source of information (Nicolas, 1994; Perruchet & Nicolas, 1998). This type of "questioning" reduces the risk of respondents becoming aware of the research objective, and thus reduces the potential bias that could be generated if the goal of the study is known. As a consequence, results obtained by indirect methods are thought to be more reliable. Rather than asking respondents directly about their behaviors and motivations, questions are formulated in terms of other people (i.e., your friend, your family, or your students) or imaginary situations (i.e., at school, at the supermarket, or in a restaurant) (Belk, 2006).

The aim of this study was to understand the representation of pulses among French non-vegetarian consumers, using both (i) an indirect approach, with a dish-composition task, based on the use of six scenarios evoking real-life situations, and (ii) a direct method, with an online questionnaire. The direct method was expected to provide access to explicit knowledge and beliefs about food-product characteristics, while the indirect method was thought likely to generate more spontaneous behaviors in relation to food choice. The representations obtained through each approach were hypothesized to be different, yet complementary. Combining these two approaches should therefore provide broader access to consumers' mental representations of pulses. If potential barriers are identified, suitable strategies can then be developed to increase pulse consumption.

2. Material and methods

2.1. Participants

Participants had to be over 18 years old, with no specific or restrictive diet (e.g. vegetarian, or gluten-free), no food allergies, and no severe dislike of any foods. Another condition was that participants had to be in the habit of preparing meals several times a week, for themselves and/or their household, to avoid including people unused to composing dishes. To recruit participants, flyers were posted around the city in public places (university, gyms, libraries, and cultural centers). Those who replied were invited to attend an interview where researchers verified that all the above eligibility criteria were met, thus retaining 120 participants for the study. Table 1 gives an overview of the participants' main characteristics. The median age was 35, and the mean age was 39, whether for men or for women. The conditions of the study were explained, and all participants signed informed consent forms before beginning the study. To ensure participation throughout the study, participants would receive 20€ each for participation only if they had completed both tests.

Table 1. Main demographic characteristics of the participants. (* Level of education is expressed in number of years of formal schooling: Low < 12; Medium ≥ 12 and <15; High > 15).

Characteristics	Categories	Number of participants	%
Sex	Male	60	50
	Female	60	50
Age	<40 years	66	55
	>40 years	54	45
Education level*	High	41	34
	Medium	40	33
	Low	39	33
Household composition	Family	33	28
	Couple	47	39
	Living alone	40	33

All 120 participants performed two tasks. The dish-composition task, which evoked real-life situations by means of scenarios, required participants to compose suitable dishes, using images of food products. One week later, participants were required to complete an online questionnaire, based on the same set of images.

2.2. Material

2.2.1. Construction of a set of images common to both tasks

Food images were used for both the dish-composition task and the online survey, to provide identical stimuli throughout both tasks. A set of food images was therefore constructed, taking several criteria into consideration. First, all the food products belonged to the French food repertoire, and were chosen to represent the four main categories of food recommended by the *French national health and nutrition program*(PNNS) to compose a main dish. Food products were presented in the form of raw ingredients. The MFPE group included only foods of animal origin: meat, fish, poultry, and eggs. The Pulse group was composed of dried beans, lentils, and peas. The Starch group was composed of cereals and potatoes. The Vegetable group was composed of products commonly considered as vegetables by French consumers, whatever their botanic classification (broccoli, carrots, green beans, tomatoes, and zucchini).

All food products were purchased from supermarkets, and then photographed in exactly the same conditions. An equivalent volume of each raw product was presented in the center of a white porcelain plate, on a blue background. Blue, rarely a natural food color, was chosen as the background, to create good contrast with the white plate (Charbonnier, van Meer, van der Laan, Viergever, & Smeets, 2016). All photos were taken on the same day, in the same lighting conditions. During the entire photo shoot, the angle of shooting, the distance between the center of the plate and the camera lens, the position of the plate on the table, and the table itself were maintained constant.

After the photos had been standardized via Photoshop ® (luminosity, color intensity, etc.), all twenty images were printed (9cmx13cm) and plasticized. A pre-test was carried out on a small sample of participants (n = 30) to ensure that each image was identifiable, that photo quality was good, and that the amount of food was perceived as similar for each image.

2.2.2. Creation of scenarios for the dish-composition task

The dish-composition task used scenarios to create equal and comparable conditions for all participants. Six scenarios evoking real-life conditions encompassed the diversity of situations in which people make food choices (Table 2). The Everyday scenario was conceived as the control for this study. The Budget scenario evoked the constraints of waiting for payday. The Guest scenario placed participants in a social context. The Vegetarian scenario necessarily included a guest with a vegetarian diet, because participant selection criteria excluded vegetarians. For the no-cooking, out-of-home context, both the more ordinary Self-service scenario, and the more prestigious Restaurant scenario take into account French consumer food habits: they bring food from home for lunch 34% of the time; they often have lunch at the canteen (24%), or at fast-food eateries, pubs, and restaurants (21%); they eat at a friend or family member's house 18% of the time (ANSES, 2017a). Participants were given the written description for each scenario (Table 2), also presented orally, accompanied by the following instructions: “In this situation, compose a main dish using three images”.

Table 2. Scenarios used in the dish-composition task.

Title of the scenario [a]	**Script***
Everyday “as control”	In an everyday meal at your home, you have to prepare the meal.
Self-service	You decide to eat at the self-service cafeteria. All the foods represented in the images are on the menu.
Restaurant	You won a dinner at a four-star restaurant during a competition. The restaurant concept invites you to create a dish from a list of ingredients, in order to test the chef's talents.

Title of the scenario [a]	Script*
Budget	At the end of the month, after you paid most of your bills, you do not have a lot of money left and you have to prepare a cheap meal
Vegetarian	You invited a friend for a meal, which you have to prepare. You have to remember that your friend is vegetarian.
Guest	You and your partner decided to invite the couple who just moved in next door for a meal at your place.

[a] Participants were given only the text of the scenario (Script, without Title). The "Title" was created merely to identify scenarios in this paper.

2.2.3. Construction of the online questionnaire

The online questionnaire was used to obtain information about each food product individually. Ten question scripts were created to obtain ratings of different food properties by means of a 5-point ordered category scale (Table 3).

Table 3. Description of the 10 scripts in the questionnaire and corresponding scale of answers.

Question scripts	Response modalities on a 5-point ordered category scale
Rate each food according to its level of ordinariness or fanciness	From "very ordinary" to "very fancy"
Taking into consideration your habits, rate each food according to difficulty of preparation	From "easy" to "difficult"
Rate each food according to its price (Consider the presentation you consume most often)	From "not expensive" to "very expensive"
Rate each food according to masculine or feminine food habits	Rating from "very feminine" to "very masculine"
Rate each food according to its suitability for a vegetarian diet	From "not at all adapted" to "very well-adapted"
Rate each food according to its effect on health	From "very bad" to "very good"
Rate each food according to your food preferences	From "I do not like it at all" to "I like it very much"
Rate each food according to its impact on the environment	From "very bad" to "very good"
Rate each food according to its protein content	From "poor in proteins" to "rich in proteins"
Rate each food according to your frequency of consumption	From "never" to "at least once a day"

2.3. Procedure

2.3.1. Indirect approach: dish-composition task

All sessions were individual, lasted about 45 min, and took place in the laboratory. Images were placed on a table in front of the participant, in the form of a randomized 5 × 4 rectangle (Fig. 1), to avoid any effect of order or position. The experimenter asked the participant to identify each food in the images, before presenting the first scenario and asking the participant to compose a main dish, using only three images, although four food groups were represented. This parameter was used to obtain information about the relative importance of each food group for the participant.

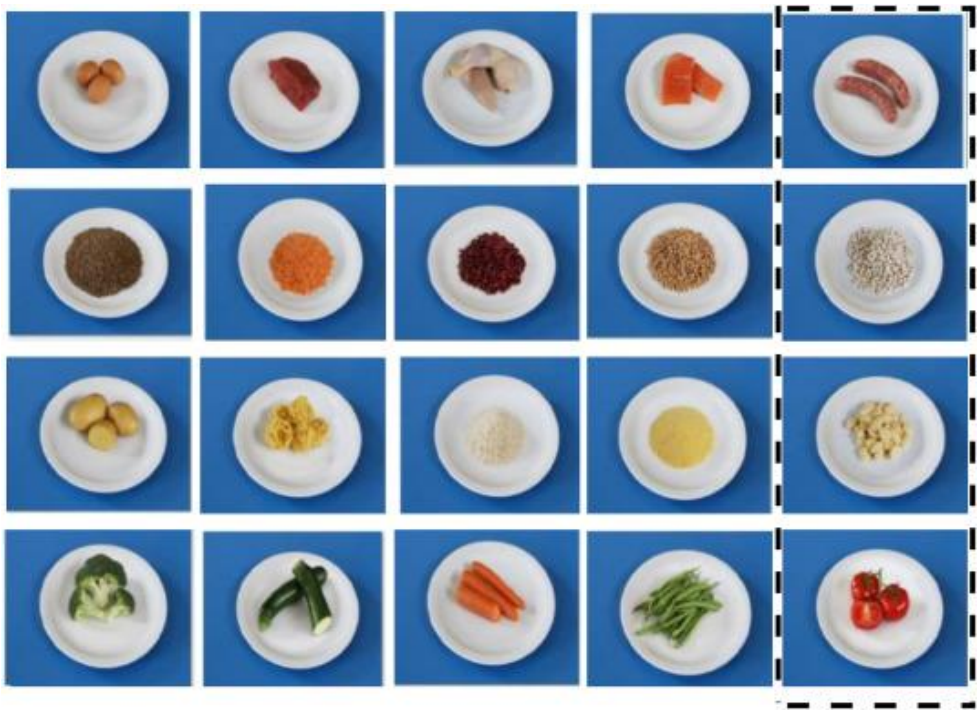

Fig. 1. Set of images created and used for both the dish-composition task and the questionnaire. Images surrounded by a dotted line were not used in the online questionnaire.

After putting the cards back on the table, participants were asked to compose another dish for the same scenario, without using the same picture triplet. For each scenario, each participant composed five dishes. Once five dishes had been created, a new scenario was presented, with the same instructions. The order of the scenarios was randomized for each participant so as not to bias the results by an order effect.

2.3.2. Direct approach: questionnaire

Seven to ten days after the dish-composition task, participants were asked to complete an online self-reported questionnaire. To maintain a constant level of attention throughout the task,

participants only evaluated sixteen of the images used in the dish-composition task (Fig. 1). To obtain this set of 16 images, one product was excluded from each food group, on the basis of low consumption in France compared to other products in that food group (i.e. sausage, white beans, and gnocchi), while tomato was excluded from the Vegetable group as it may also be used for seasoning or sauce. Both the order of the food images and the order of the questions for each image were randomized.

2.4. Analysis

2.4.1. Indirect approach: dish-composition task

The frequency with which each product was chosen by a participant for all of the scenarios was then converted into a rank. The product most frequently chosen by a participant obtained the highest rank. A Friedman test on the sum of ranks was used to determine if there were significant differences in product choice. A multiple pairwise comparison using the Nemenyi/Two-tailed test was then used to compare the frequency of choice of products in all scenarios.

The frequency of choice for pulses by each participant in each scenario was also converted into a rank as described above. A Friedman test was used to determine if the pulse chosen was different in relation to the scenario. A Nemenyi/Two-tailed test was performed to compare the choice of pulses across scenarios.

The two variables related to the intrinsic characteristics (age and sex) of the participants were used to construct a contingency table. A Correspondence Analysis (CA) with SPAD (version 5, Coheris, France) was used to visualize relationships between consumer profiles and product choices. The CA method is based on a test of independence between participant characteristics and product choice, according to a chi-square statistic.

2.4.2. Direct approach: questionnaire

For each item in the questionnaire, the answers given by each participant were ranked for each food. The product with the “lowest” score (left side of the scale) was given the lowest rank, while the product with the highest score (right side of the scale) obtained the highest rank. A Friedman test was performed on the sum of ranks and then a Nemenyi/Two-tailed test was used to compare the rank of each product for each question.

2.4.3. Complementarity between the two methods

Due to the difference in the nature of the data obtained by each method (frequencies for the dish-composition task, and ordinal data for the questionnaire), each dataset was converted into numerical format using the appropriate multivariate analysis. For the dish-composition task results, a

Correspondence Analysis (CA) was carried out on the frequency of choice for each product in each scenario. The first three dimensions accounted for 96% of the total variance (respectively, 60, 28 and 8% for axes 1 to 3). In contrast, a Multiple Correspondence Analysis (MCA) was carried out on the questionnaire results, using a table with participants and products in rows and questions in columns. The first three dimensions accounted for 73% of the total variance (respectively 47, 16 and 10% for axes 1 to 3).

A Pearson Principal Component Analysis (PCA) was then performed, using the principal coordinates of the CA and the MCA as active variables. The first three dimensions were used as observations. The correlation matrix thus obtained made it possible to compare the results of the dish-composition task with those of the questionnaire (supplementary table).

The confidence interval was set at 95% for all the analyses. The XLSTAT for Windows (Addinsoft, version 2018-1) was used for both univariate and multivariate analyses.

3. Results

3.1. Dish-composition task

3.1.1. Reliability of the indirect method

Before going into detail about food-product choice, we looked at the choices made by participants during their very first dish-composition (by scenario), and after each of the five repetitions of the dish-composition task. The frequency of choice for each food group in each scenario, taking into account all the dishes created, is shown in Table 4. These results give an overview of repeatability across the five dishes within the same scenario, but also of the variability of food-product selection between scenarios. The results in Table 4 show that participants' choice of food groups was consistent for each of the successive repetitions of the dish-composition task.

Table 4. Overall choices for each scenario in each repetition of the dish-composition task, presented by food group, (% of all choices).

Scenario		Dish 1	Dish 2	Dish 3	Dish 4	Dish 5	Total Scenario
		All 20 images taken into account					
Everyday	MFPE	30%	30%	30%	28%	30%	30%
	Pulses	6%	6%	6%	11%	7%	7%
	Starches	25%	26%	23%	23%	24%	25%
	Veggies	39%	39%	41%	38%	38%	39%

Scenario		Dish 1	Dish 2	Dish 3	Dish 4	Dish 5	Total Scenario
All 20 images taken into account							
Self-service	MFPE	32%	31%	32%	31%	30%	31%
	Pulses	8%	7%	11%	13%	14%	10%
	Starches	27%	26%	23%	23%	21%	24%
	Veggies	33%	35%	34%	33%	35%	34%
Restaurant	MFPE	34%	34%	34%	32%	29%	33%
	Pulses	18%	14%	12%	15%	14%	15%
	Starches	16%	20%	21%	20%	20%	19%
	Veggies	33%	32%	33%	33%	38%	34%
Guest	MFPE	35%	31%	33%	33%	31%	33%
	Pulses	4%	8%	9%	9%	8%	8%
	Starches	29%	24%	23%	21%	22%	24%
	Veggies	32%	36%	36%	37%	39%	36%
Budget	MFPE	26%	25%	25%	23%	23%	24%
	Pulses	8%	10%	8%	8%	13%	9%
	Starches	31%	28%	27%	27%	27%	28%
	Veggies	36%	37%	41%	42%	38%	39%
Vegetarian	MFPE	9%	8%	7%	9%	7%	8%
	Pulses	12%	18%	17%	14%	14%	15%
	Starches	25%	23%	25%	29%	28%	26%
	Veggies	54%	52%	51%	47%	51%	51%
Only 17 images taken into account, excluding those not used in the vegetarian scenario[a]							
Vegetarian	MFPE	8%	7%	6%	8%	6%	7%
	Pulses	10%	15%	14%	12%	12%	13%
	Starches	21%	20%	21%	25%	24%	22%
	Veggies	46%	44%	43%	40%	43%	43%

a Beef, sausage, and chicken were never selected in the vegetarian scenario.

3.1.2. Global frequency of choice for each food image

The frequency of choice for each food image is presented in Fig. 2. The Friedman test showed significant differences across food products (p-value < 0.0001). Overall, the Vegetable group were the

most frequently chosen (38%). In this group, the most frequently chosen product was tomatoes, followed by carrots, zucchini, green beans, and broccoli. The MFPE group represented 27% of choices: chicken was the most frequently chosen product, followed by beef, salmon, egg, and sausage. Within the Starch group (25% of choices), rice was the most frequently chosen product, followed by potato, tagliatelli, semolina, and gnocchi. The Pulse group, at only 10%, was chosen significantly less frequently for main-dish composition. Within the Pulse group, lentils were the most frequently chosen product, followed by red beans, red lentils, chickpeas, and white beans.

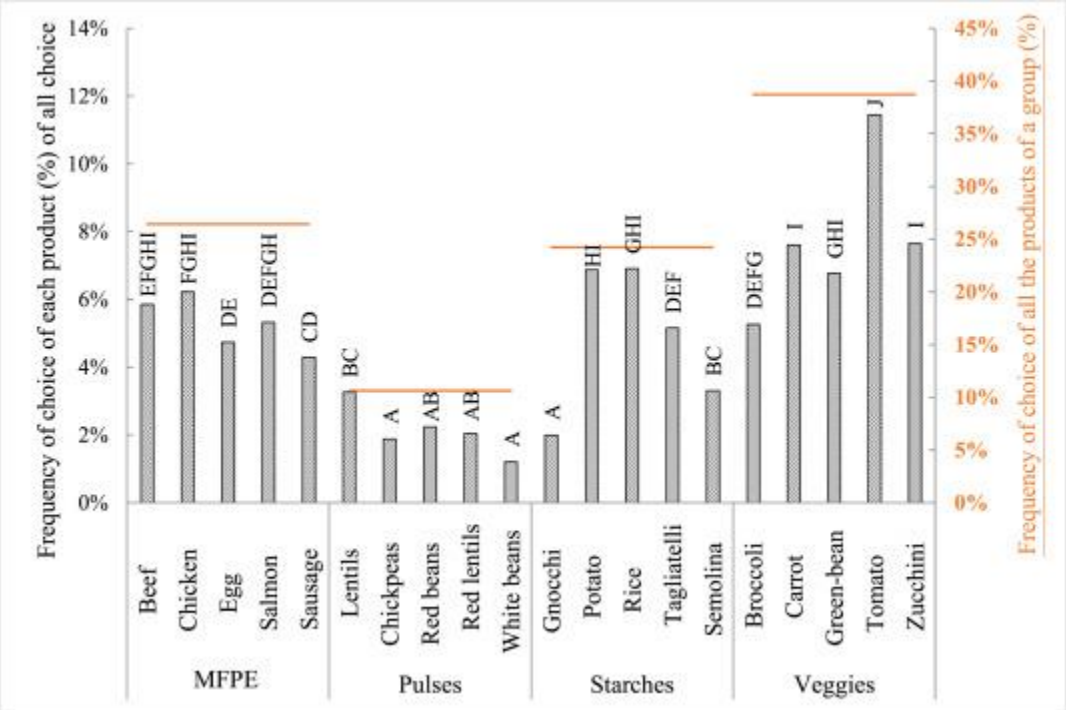

Fig. 2. Frequency of choice for every food product and food group, taking all scenarios together. Products with the same letter were chosen with comparable frequency (Nemenyi/two-tailed test; $p < 0.05$).

3.1.3. Frequency of choices for pulses, in each scenario

As food products from the Pulse group were generally those least often chosen in the dish-composition task, it was important to see if the choice of pulses was the same in each scenario. Fig. 3 shows that participants chose Pulse-group products differently for each scenario (p-value < 0.0001). Compared to the Everyday scenario (11%), considered as control, Pulse-group product frequency of choice was significantly higher in the Self-service (16%), Restaurant (23%), and Vegetarian (24%) scenarios. In the Vegetarian scenario, the range of possible choices was lower than in the other scenarios, with participants using only two of the five images from the MFPE group. In order to take this difference into account, the frequency of choice for each product was calculated on the basis of

17 possible choices, excluding those never used in the Vegetarian scenario (Table 4). Even after taking this correction into consideration, the choice of Pulse-group products was still more frequent in the Vegetarian scenario than in the Everyday scenario.

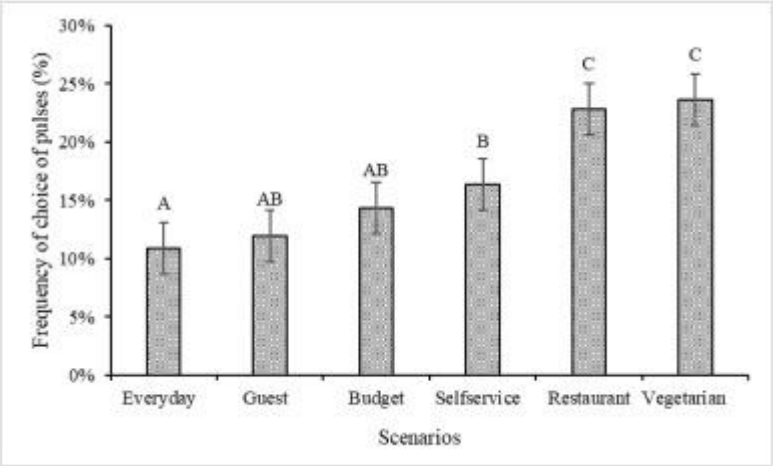

Fig. 3. Frequency of choice for pulses in each scenario. Products with the same letter were chosen with comparable frequency (Nemenyi/two-tailed test; $p < 0.05$).

3.1.4. Influence of participant characteristics on food-choice frequency for pulses

A Correspondence Analysis (CA) was used to study the associations between participant characteristics and food-product choices. Chi-square test was significant (calculated Chi-square value: 106; dfs=57; p-value<0.0001). Participants were separated into four groups, based on age and sex. The CA represented in Fig. 4shows how food-product choices vary between participants with different characteristics (age and sex). The distance between the points representing food products approximates the chi-square distance between food-product frequency of choice. Axis 1 represents 58% and axis 2 represents 27% of the total variance. Axis 1 distinguishes participants by age and axis 2 by sex; participants under 40 years of age used the images of red beans, chickpeas, and red lentils more often than older participants. In contrast, participants over 40 chose eggs and gnocchi more frequently than younger participants. Men favored MFPE products, especially red meat. Men over 40 chose sausage more often, while women over 40 tended to choose white beans and broccoli more often.

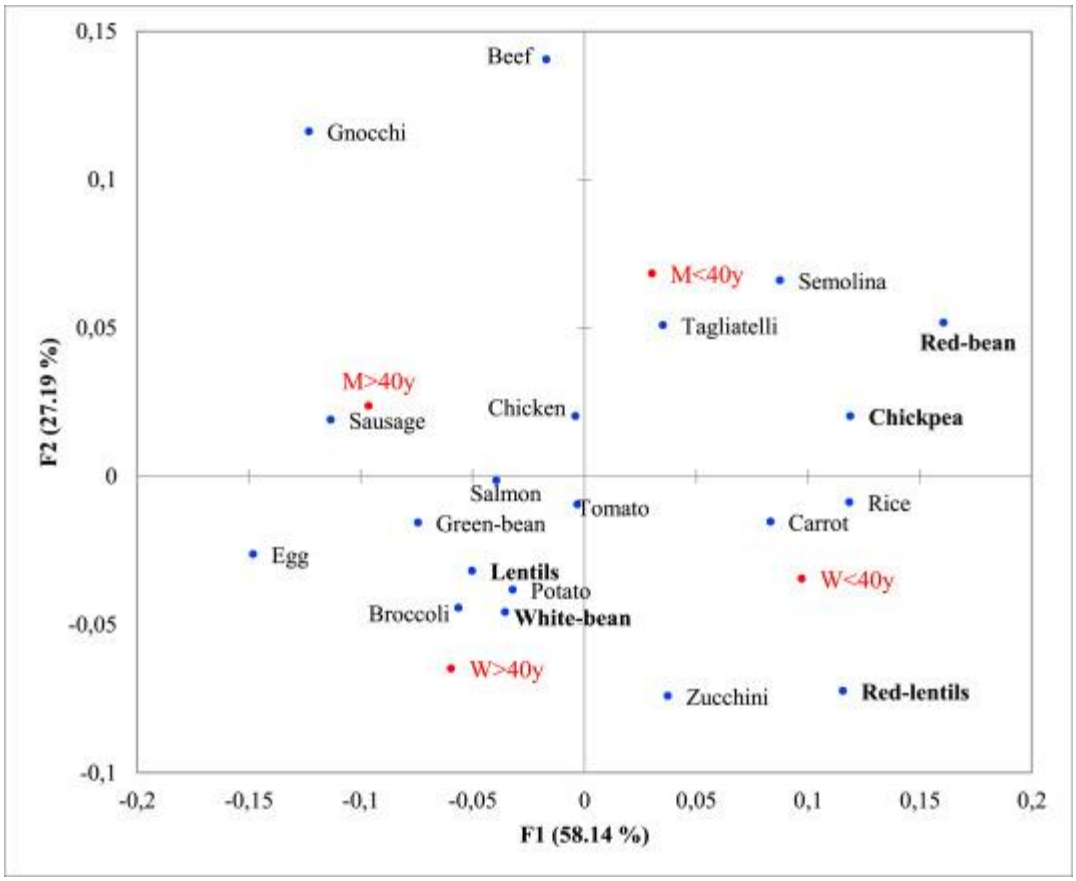

Fig. 4. Correspondence Analysis (CA) for all products in all scenarios, in relation to intrinsic participant characteristics (age-sex). Participant groups: W > 40y: women over 40 years old; W < 40y: women under 40 years old; M > 40y: men over 40 years old; M < 40y: men under 40 years old. The closer a product is to a participant group, the more often that product was chosen by that group.

3.2. Direct approach: online questionnaire

3.2.1. Scores given to the different food images

Table 5 shows a synthesis of the mean score for the sixteen food products, according to the ten evaluation criteria (question scripts). For each column, the highest score indicates the food most representative of that criterion: e.g. the fanciest, the most representative of men's food habits, the healthiest, the most well-liked, and the most frequently eaten. The results from the Friedman tests showed that there were significant differences across the products for all questions. Compared to other food groups, pulses were rated by participants as the food group most difficult to prepare, best adapted (along with the Vegetable group) for a vegetarian diet, and with the exception of lentils, the least frequently eaten and the least well liked.

Table 5. Mean of the ranks of each food product, for each question of the online questionnaire.

Product		Fancy	Difficult to prepare	Expensive	For men	For vege-tarians	Healthy	Food preference	Eco-friendly	High protein	Consum-ption
MFPE	Beef	12.03 ^{ab}	10.50 ^{ab}	15.18 ^{a}	13.87 ^{a}	1.95 ^{e}	4.85 ^{g}	8.99 ^{abcd}	3.59 ^{e}	13.55 ^{a}	10.81 ^{ab}
	Chicken	8.43 ^{de}	8.96 ^{bc}	9.62 ^{b}	4.57 ^{cde}	10.88 ^{e}	11.81 ^{defg}	7.63 ^{abcd}	10.74 ^{e}	5.20 ^{a}	6.61 ^{ab}
	Egg	6.16 ^{fg}	7.23 ^{def}	5.90 ^{efg}	5.87 ^{bcd}	10.84 ^{d}	11.59 ^{cdef}	8.95 ^{abcd}	10.89 ^{d}	4.88 ^{ab}	10.26 ^{a}
	Salmon	13.98 ^{a}	8.60 ^{ab}	11.83 ^{a}	9.50 ^{fg}	1.99 ^{e}	6.64 ^{bcd}	9.50 a	4.62 ^{e}	12.67 ^{a}	10.62 ^{cd}
Pulses	Chickpeas	8.79 ^{cd}	12.00 ^{a}	7.74 ^{def}	9.28 ^{cde}	10.59 ^{ab}	8.03 ^{cde}	5.15 ^{f}	9.50 ^{abc}	9.96 ^{c}	3.63 ^{g}
	Lentils	7.93 ^{def}	5.74 ^{ab}	7.22 ^{def}	10.51 ^{ef}	5.94 ^{a}	7.57 ^{ab}	9.41 ^{bcd}	6.89 ^{ab}	13.22 ^{bc}	11.60 ^{de}
	Red beans	9.03 ^{cd}	7.87 ^{a}	9.00 ^{cde}	5.84 ^{bcde}	11.08 ^{ab}	11.87 ^{cdef}	9.35 ^{ef}	11.13 ^{abc}	5.07 ^{c}	9.32 ^{fg}
	Red lentils	12.24 ^{ab}	10.26 ^{a}	7.59 ^{bc}	7.97 ^{g}	11.13 ^{ab}	10.57 ^{bc}	8.45 ^{ef}	9.99 ^{abc}	10.79 ^{c}	6.63 ^{g}
Starches	Potato	4.64 ^{g}	5.72 ^{ef}	4.83 ^{h}	11.73 ^{b}	9.49 ^{abc}	6.60 ^{defg}	9.98 ^{ab}	10.15 ^{ab}	5.86 ^{d}	11.29 ^{ab}
	Rice	5.76 ^{g}	11.48 ^{ef}	8.31 ^{gh}	10.01 ^{bcde}	10.44 ^{abc}	7.73 ^{cdef}	6.03 ^{abcd}	9.56 ^{bcd}	9.63 ^{d}	4.31 ^{ab}
	Semolina	6.61 ^{efg}	11.43 ^{c}	10.33 ^{gh}	5.56 ^{de}	10.68 ^{bc}	9.28 ^{efg}	5.77 ^{cde}	9.45 ^{bcd}	9.90 ^{d}	3.20 ^{ef}
	Tagliatelli	5.51 ^{g}	5.41 ^{f}	5.12 ^{h}	9.79 ^{bc}	9.48 ^{c}	7.35 ^{fg}	8.91 ^{abc}	8.45 ^{cd}	5.71 ^{d}	10.92 ^{a}
Veggies	Broccoli	10.60 ^{bc}	10.70 ^{bc}	15.16 ^{cd}	6.38 ^{g}	3.80 ^{ab}	8.53 ^{a}	10.84 ^{de}	4.48 ^{a}	13.23 ^{d}	8.17 ^{de}
	Carrots	6.58 ^{efg}	8.03 ^{cde}	5.34 ^{fgh}	8.78 ^{fg}	8.85 ^{ab}	5.98 ^{a}	7.77 ^{abcd}	8.17 ^{a}	5.90 ^{d}	6.02 ^{abc}
	Green beans	8.82 ^{cd}	4.86 ^{cd}	4.57 ^{cde}	11.06 ^{g}	8.19 ^{a}	5.65 ^{a}	9.87 ^{abcd}	7.44 ^{a}	6.15 ^{d}	11.93 ^{bc}
	Zucchini	8.89 ^{cd}	7.22 ^{cde}	8.28 ^{cde}	5.28 ^{g}	10.68 ^{ab}	11.97 ^{a}	9.42 ^{abcd}	10.98 ^{a}	4.28 ^{d}	10.67 ^{ab}

For each question, products with the same letter were chosen with comparable frequency (Nemenyi/two-tailed test; $p < 0.05$).

If we look closer, participant ratings put pulses in second place, behind vegetables, as products that are relatively good for health and the environment, and behind MFPE products, but still quite rich in proteins. All pulses, except red lentils, were identified as being in the medium price range, neither ordinary nor fancy, and corresponding to a neutral food habit, rather than particularly feminine or masculine. Ratings for red lentils placed them just behind salmon, as the second most fancy product.

The MCA (Fig. 5) reveals the modalities associated with each food product for each question. Axis 1 represents 47% of the total variance, with axis 2 representing 16%. Question scripts and response modalities are both clearly represented and well distributed. Axis 1 is characterized by food considered by participants as "very expensive", and “very bad” for the health and for the environment. The products associated with these characteristics are from the MFPE group, which are opposed on this axis to plant products from the other three groups (Pulse, Vegetable, and Starch). The positive part of Axis 2 is characterized by food considered "difficult to prepare", “not liked at all”, and “never consumed” by participants. All the pulses (except lentils, in a central position) are associated with these negative characteristics. Foods consumed “at least once a day”, but also considered "very bad for the health" are found on the negative part of axis 2. The products corresponding to these characteristics are mostly from the Starch group.

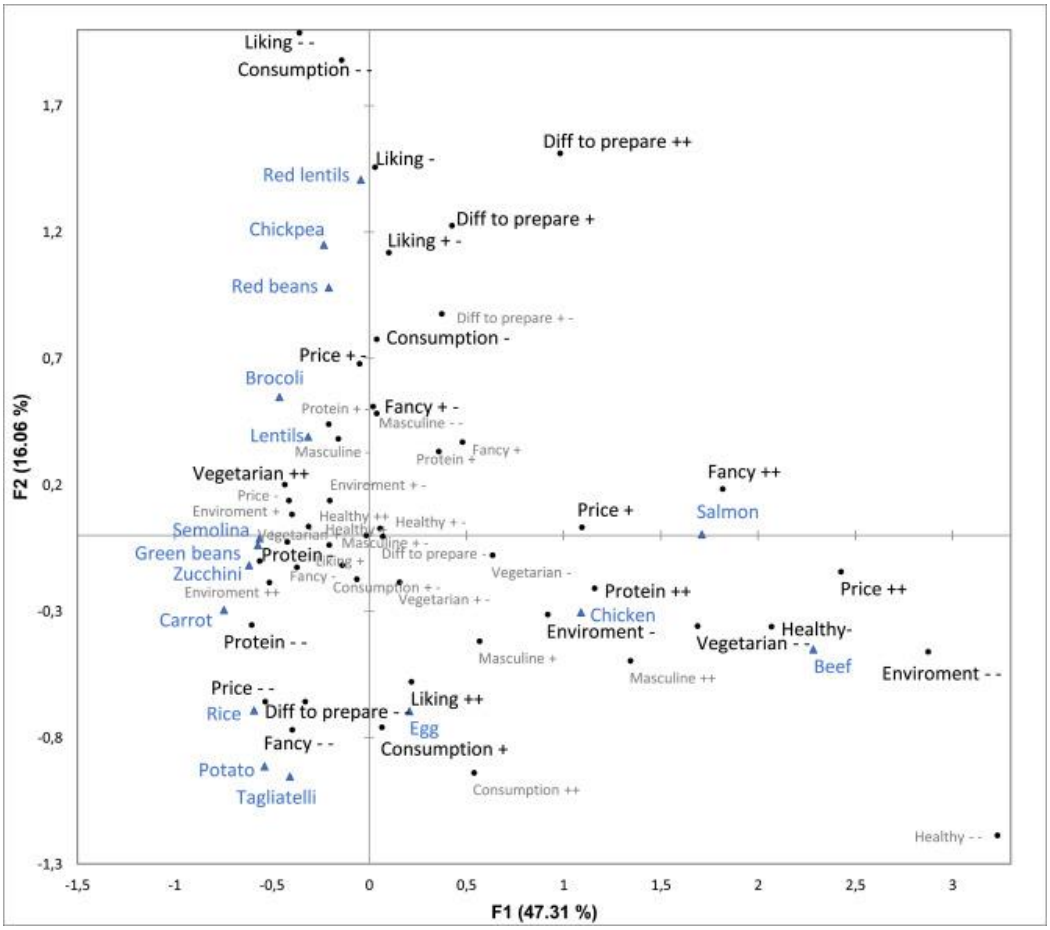

Fig. 5. Factorial map (axes 1 and 2) of Multiple Component Analysis (MCA) for food products as observations ▲ and response modalities obtained with the online questionnaire as active variables■, modalities in grey have a contribution below the mean. Axis 1 represents 47% of the total variance, with axis 2 representing 16%

3.3. Complementarity of the two approaches

The correlation matrix (Supplementary table) allows us to visualize the links between the results obtained by each of the two methods (N=3). Correlations coefficients greater than 0.997 are significant at α = 5%, and correlations coefficients greater than 0.988 are significant at α = 10%. Food choices in the Everyday scenario were significantly correlated with the consumption frequency declared in the online questionnaire for each food product. They were also correlated with "not adapted to a vegetarian diet", "rich in proteins", "not good" for either health or the environment, and corresponding to "very masculine food habits". Products chosen in the Restaurant scenario were highly correlated with the "very expensive" and "difficult to prepare" modalities. Products chosen in the Guest scenario were significantly correlated with the "very expensive", "corresponding to very masculine habits", "not adapted for a vegetarian diet" and "not good for the environment" modalities. The products chosen in the Budget scenario were correlated with the characteristics "good for health [and] the environment", and "poor in proteins". They tended to be considered "very cheap".

Food choices in the Vegetarian scenario were significantly not "very fancy". In this scenario, consumers tended not to choose products that they considered "not adapted for a vegetarian diet" (coefficient correlation: -0.927), but there was, surprisingly, no significant correlation between the products chosen in the Vegetarian scenario and those considered to be "adapted for a vegetarian diet" (coefficient correlation: 0.668). Products chosen in the Vegetarian scenario also tended to be considered as not "rich in proteins", not "very expensive" and not corresponding to "very masculine food habits". In the Everyday scenario, consumed products were also declared as not adapted to a vegetarian diet in the questionnaire with a significant correlation coefficient of 0.998.

4. Discussion

One of the main objectives was to understand mental representations of pulses among French non-vegetarian consumers, and to identify potential barriers to pulse consumption. We therefore combined an indirect and a direct method, to determine the specific properties attached to pulses in the minds of consumers. We tried to understand how these properties could influence the consumption of pulses, and to propose levers to increase pulse consumption. Three main results will be discussed: the interest of combining these two methods, how mental representations of pulses can

explain low pulse consumption, and why knowledge about pulses does not necessarily result in higher consumption. We then propose strategies to increase pulse consumption in France.

4.1. Interest of combining the two methods

To our knowledge, our study was the first to combine an innovative indirect approach with a more classical direct approach, in order to understand mental representations of pulses among French consumers. When it was possible, the same factors were studied by the two methods (consumption, difficulty to cook, product adapted for a vegetarian diet, perception of price). Depending on the parameter studied, the use of the two methods gave complementary or convergent information about consumers' mental representations of pulses.

The two methods obtained similar results, with a high correlation coefficient between the results of the dish-composition task in the Everyday scenario and the declared consumption frequency in the questionnaire. This means that, in the dish-composition task, participants did not make random choices, and that their choices genuinely reflected their declared consumption habits. This is an argument in favor of the reliability of the dish-composition task, and of the use of the Everyday scenario as the control in our study.

In the Restaurant scenario, which was meant to evoke a no-cooking, prestigious context, participants tended to choose products that they considered difficult to prepare, and to exclude those they considered easy to prepare. This result was not found in other scenarios, indicating that this scenario is suitable for the study of participants' mental representations of products they consider difficult to prepare.

These correspondences between the results of the two methods are a good indicator of the reliability of the dish-composition task with evoked scenarios (indirect method). This method was also shown to be repeatable within a given scenario, while producing different results for different scenarios. This exploratory study therefore provides a preliminary validation of the dish-composition task, which produced results comparable to those obtained with the questionnaire (direct method). Further studies will be necessary to confirm the reliability of the indirect method. In particular, reproducibility must still be confirmed, by studying several subsets of consumers from within a given population. This task may also be tested with different food products and new scenarios.

For other results, we did not find the expected correlations between the two methods. For example, the dish-composition task in the Budget scenario, meant to be an indicator of the price of products, was not significantly correlated with the declared price obtained through the questionnaire. Many studies have questioned whether consumers are reliable when asked about food price and its

importance in choice. Price is often reminiscent of a purchase situation, which is usually complex. Consumers may take other factors into account when referring to the price of products. In particular, consumer attitudes toward price may be influenced by whether the price is judged acceptable or not, taking into account all available information about the product (Grunert, 2006). In our study, the products considered to be expensive were chosen in many scenarios, including the control scenario. Information about price seems to be accessible only for products considered to be cheap. Such products were chosen more often in the Budget scenario than in the control, and less often in the Restaurant scenario. Although products considered unsuitable for a vegetarian diet tended to be chosen less frequently in the Vegetarian scenario, somewhat surprisingly this scenario was not significantly correlated with products considered suitable for vegetarians. As the participants were not themselves vegetarian, we had to include another person in the scenario to create the need to choose food adapted for a vegetarian diet. Our explanation is the following: participants had some knowledge of vegetarian food products, but did not consider them to be fancy (significant correlation coefficient: 0.998), and thus perceived them to be unsuitable for an invited guest. Social norms tend to consider healthy foods less acceptable in social situations (Zorbas et al., 2018). Participants also used significantly more often in the Guest scenario products judged unsuitable for a vegetarian diet.

The absence of a clear relationship between the results of the two methods for these two examples can be seen as an advantage of the indirect method when accessing representations that are difficult to obtain accurately with direct questioning. The questionnaire provided access to consumer knowledge and beliefs about food, while the dish-composition task provided access to food habits and attitudes towards food. Questionnaire responses are more likely than the dish-composition task to suffer from social desirability bias. For the dish-composition task, participants were not asked to give structured answers; instead, they were asked to make choices visualizing themselves in different scenarios. Consumers were not required to focus their attention on a specific food item, allowing them to answer spontaneously, without speculating on the specific aim of the study. In the Everyday scenario, participants significantly chose products that are not good for health or for the environment, suggesting that social desirability was not a major concern. In contrast, when answering the questionnaire, participants were asked to focus their attention on specific products. By doing so, they may have been tempted to imagine what might be a “suitable” answer, or what answer was expected by the experimenters, and therefore to answer accordingly.

4.2. A low global consumption of pulses, evidenced by both methods

The choices observed when people are immerged in an evoked situation are thought to reflect the actual choices they would make in the corresponding real-life situation. The overall use of pulses

during the dish-composition task was low, amounting to only 10% of all choices. Pulse images were by far the least chosen: these four images were among the six least used by participants. Thus, the dish-composition task indirectly revealed a low level of pulse consumption among participants, confirmed by the low self-declared consumption frequency of pulses, obtained from the questionnaire. The low consumption revealed by both tasks is in accordance with recent food consumption records in France, which highlighted a very low consumption of pulses (ANSES, 2017b). This shows that, based on pulse consumption, our participant sample is representative of French consumers in general. Our study thus allowed us to go further than consumption data, by accessing consumers' mental representations of pulses.

4.3. How representations of pulses can explain their low consumption

The factor that is the most highly correlated with declared non-consumption of food in our study was dislike. Hence, one of the most obvious reasons that can explain the low consumption of pulses is that they are declared to be least liked, with the exception of lentils, the pulse best appreciated by participants. A Canadian survey (IPSOS, 2010) highlighted that, when asking non-consumers to choose the relative importance of a number of factors regarding why they did not eat pulses, not liking the taste or texture of pulses emerged by far as the most important factor. Interestingly, in the same survey, taste was also the most frequent reason given for eating pulses by the group of "light, moderate, and heavy consumers". Several models are proposed in the literature listing the factors involved in food choices. Among these factors, taste is considered to be one of the main drivers of food choice and intake (Shepherd & Raats, 2006). In a study about the links between attitudes and beliefs toward various types of food, taste was shown to have the highest relationship with attitudes for most products (Shepherd & Towler, 1992). Yet the study also highlighted that perception of sensory attributes is not the only factor affecting food choices, despite its high impact on attitudes.

Another interpretation emerged from both methods used in our study. First, in the dish-composition task, participants chose pulses more often with the Restaurant and Self-service scenarios than with the Everyday scenario. The common point of these two scenarios suggests a situation in which participants do not have to prepare their meal themselves. This has to be put into perspective, using the responses to the questionnaire, which showed that participants considered pulses as the products most "difficult to cook". From this result, we can state that the difficulty of cooking pulses is one of the main obstacles to their consumption, as hypothesized by other authors (Lecerf, 2016; Rio, 2017). Because of this perceived difficulty, participants seem to avoid eating pulses when they have to prepare them themselves. Our results indicate a negative correlation between difficulty of preparation

and consumption frequency, which can be considered as an obstacle to consumption in general. This result is consistent with the IPSOS-REID survey, which indicates that, along with taste, not knowing how to prepare or cook pulses is the second most frequent reason for not eating them (IPSOS, 2010). In our study, "difficult preparation" should be interpreted cautiously, because consumers may mean "technically difficult" and/or "difficult to plan for, in the context of daily duties". Preparing a pulse dish at home involves careful planning, to allow for the necessary soaking period, in addition to the time required for the cooking process. As lentils were the only pulses not considered "difficult to cook", the time required for soaking and cooking is probably the main reason why consumers seek to avoid preparing other pulses. It is widely recognized that there is an increasing demand for convenience in meal preparation, which allows consumers to save time and avoid wasting a lot of physical and mental energy (Scholderer & Grunert, 2005). In this context, at-home pulse preparation may represent too much time and effort, and thus be incompatible with the time already taken up by work, social life, and leisure activities.

Along with taste, price and healthiness are often proposed as important determinants of food choice. The argument of price as a driver in food choice is well-known in the literature and concerns many products (Darmon & Drewnowski, 2015). In our study, the role of price as a lever of consumption is not clear. The products rated most expensive were declared to be consumed the most, and used the most in the dish-composition task in the Everyday scenario. But there was no correlation between declared price and the food chosen in the Budget scenario. It has been shown that perceived price does not involve the price of the product alone. Attitude towards price is influenced by the relationship between the objective price of the product and some reference price postulated by consumers (Grunert, 2006; Ritson & Petrovici, 2001). This reference price is integrated with other product information when forming attitudes towards purchase (Grunert, 2006). The influence of price may be heterogeneous between food categories, because other characteristics specific to a food type may come first (e.g. safety for meat, and brand for chocolate, according to Ritson & Petrovici, 2001).

Our results also showed that pulses were more often used in the Vegetarian scenario than in the other scenarios. From a methodological point of view, the Vegetarian scenario was deliberately not defined, so that participants could interpret this scenario according to their representations of what a vegetarian diet may be. Consumers tend to use a unique word ("vegetarian") when referring to different types of diets excluding meat and poultry. These diets include the vegan diet (no animal products at all), the lacto-ovo-vegetarian diet (including dairy products and eggs), and the pesco-vegetarian diet (including fish, eggs, and dairy products) (Tonstad, Butler, Yan, & Fraser, 2009). In our study, participants placed in a vegetarian context could thus be expected to exclude beef, chicken, and sausage but might still select salmon and eggs from the MFPE group, depending on their definition of

a vegetarian diet. Thus, in the Vegetarian scenario, participants could choose food products either among the four groups (selecting egg and salmon from the MFPE group), or only among the three plant-based food groups, or among fewer groups, by choosing two or three products from the same food group. In this scenario, choice of products from the MFPE group was divided by four compared to the Everyday scenario. After correcting the results of the Vegetarian scenario to take into account the total number of products chosen in this scenario, the increase in Pulse choice appears to be the highest compared to other plant products. Pulse choice after correction was multiplied by 1.8 compared to the Everyday scenario, while Starch products were not more frequently chosen and Vegetable products were only multiplied by 1.1. This is consistent with Pulse and Vegetable group products being rated in the questionnaire as the foods best adapted for a vegetarian diet. This congruence between the results of the two methods for Pulse group products indicates that consumers considered pulses as products for vegetarians. This result is coherent with a study in Finland, which identified an association between beans and vegetarianism (Jallinoja et al., 2016). A similar result was also obtained from a Canadian survey (IPSOS, 2010). Pulses may be selected by vegetarian consumers who know the importance of their high protein, fiber, and micronutrient content. This frequent consumption by vegetarians seems to be known by non-vegetarians, who tend to associate pulses with a vegetarian diet. This mental representation of pulses as a "niche product" for vegetarians could represent a barrier to consumption by non-vegetarian consumers, since frequently consumed products were declared as not adapted to a vegetarian diet in the questionnaire.

4.4. Knowledge about pulses does not necessarily result in higher consumption

Some studies have found that one of the main barriers for not adopting a plant-based diet is the lack of information (Lea, Crawford, & Worsley, 2006; Poquet, Chambaron-Ginhac, Issanchou, & Monnery-Patris, 2017). Adequate knowledge is therefore regarded as a necessary - though not sufficient - requirement for healthy sustainable food choices (Frick, 2018). In our study, questionnaire results highlighted that pulses were considered as more eco-friendly and healthy products than all the MFPE products, but less so than vegetables. In addition, pulses were evaluated as products with a relatively high protein content, just below all the foods of animal origin. This suggests that our participants have relevant knowledge about pulses; they know about their protein content, and their benefits for health and the environment. Yet it seems that this knowledge was not used during the dish-composition task, or that it may have been accessed, but that taste preferences, habits, and other characteristics were considered to be more important.

The literature on nutrition knowledge and food choice is contradictory. Some researchers have shown that nutrition knowledge is positively correlated with making healthy food choices, while other

researchers highlight a very weak relationship between nutrition knowledge and food choice. One study mentioned that much of the literature fails to clarify the influence of specific aspects of nutrition knowledge on relevant dietary outcomes (Spronk, Kullen, Burdon, & O'Connor, 2014). Merely having nutritional knowledge may not be sufficient to modify food choices. One example in France is the Programme National Nutrition Santé (PNNS), which explicitly formulates simple health recommendations for consumers "Pour votre santé, ne mangez pas trop gras, trop salé, trop sucré" (For your health, do not eat foods that are too fatty, too salty, or too sweet), yet consumer food choices are not always optimal (Chambaron, Chisin, Chabanet, Issanchou, & Brand, 2015).

4.5. Perspectives: how to include more pulses in French food habits

As knowledge about the benefits of pulses seems to be insufficient to encourage their consumption, there is a need to find other levers, not based on communication about their protein content and their interest for health and the environment. Our study allowed us to identify such levers.

Out-of-home meals could provide an opportunity to increase daily consumption of pulses in France. We have shown in our study that the Restaurant and Self-service scenarios increase the frequency of pulses being chosen. These two scenarios reflect an authentic food habit among French consumers, with 44% of lunches consumed outside the home for adults aged 18 to 44, compared to only 28% for adults aged 45 to 64 (ANSES, 2017a). More recipes with pulses could be proposed in cafeterias and restaurants, giving consumers the opportunity to get to know or rediscover pulses. By encountering the taste of pulses more often, consumers could come to appreciate them more and more, become more familiar with them, and curious about preparing pulse-based dishes for themselves. It will be necessary to help people to acquire knowledge of how to cook pulses properly, by proposing new recipes with different levels of difficulty, stating the time needed, and taking into consideration the different types of consumers and the type of foods they like.

In our study, participants used pulses similarly in the Guest scenario and the Everyday scenario, which indicates that they do not exclude pulses from a situation of social interaction. This means that pulses do not necessarily have a bad reputation among participants. In all scenarios, younger participants chose red beans, chickpeas and red lentils more frequently, which suggests a "young" product image for these particular pulses, probably linked to the fact that they are imported from other food cultures. Questionnaire results indicate that participants considered red lentils to be more fancy than other pulses, and fancier even than beef. All these results indicate that certain pulses can benefit from a positive image. One strategy to increase consumption could thus be to capitalize on this image in order to create innovative foods targeting specific consumers. For example, new products could be created in small formats, like snacks or ready-to-eat dishes, to encourage red bean and

chickpea consumption, for young consumers. These products could be inspired by other cultures, with a variety of recipes containing pulses, from Mexico (red beans) or India (chickpeas). To increase the attractiveness of these new products, it is necessary to work not only on their organoleptic properties, but also to take into account their extrinsic properties to attract young consumers' interest. For example, communication should focus on national brands, local and seasonal products, and use the internet and social media, rather than broadcasting on television/radio (ANSES, 2017a).

One final strategy that can be proposed, based on the results of our study, is not to present pulses as a food for vegetarians only. It is necessary to overcome the perceived gap between non-vegetarians and vegetarians, and to encourage all consumers to increase pulse consumption. The main barrier to this shift is probably that non-vegetarians feel that they lack information on how to compose meals around pulses if they do not refer to a traditional recipe. In France, traditional recipes involving pulses usually contain meat (Rio, 2017). It would therefore be interesting to study how French people associate pulses with other food products. Do they use pulses as a substitute for starches, since French recommendations classified them in the same group for many years? Do they use pulses as a substitute for vegetables, due to their commonly perceived healthiness, as evidenced in our study? Do they use pulses as a substitute for meat, due to their acknowledged high protein content? Answering these questions would give us more information regarding the place that pulses have in French food habits, and thus help us to develop new strategies.

4.6. Strengths and limitations

One of the strengths of our study was the use of two distinct, yet complementary methods to identify consumer representations that explained low pulse consumption. Some of the properties attributed to pulses by consumers were detected by both methods, suggesting that they are strong barriers to consumption. The price factor was tested by both approaches, but only the indirect approach revealed a possible relationship between products price and choice in a context of economical constraint. Such a result could reflect potential involvement of implicit attitudes, which have been shown to predict actual behaviors (Marty et al., 2017). More research will be necessary to confirm the importance of the barriers identified by the indirect method in our study. Other indirect approaches or implicit methods could be used to test the impact of these factors on pulse choice and consumption.

One of the main limitations to our study is that consumer behavior is not measured in real-life conditions. It is possible that food products chosen in an evoked context might not systematically be chosen in real life. Further studies will be necessary to ensure that scenarios provide a level of immersion sufficient for participants to react as they would in an authentic real-life situation. Another

limitation relates to the questionnaire, which contained ten questions for each image. Only sixteen of the twenty food products were therefore presented online, so that participants could maintain an adequate level of attention throughout the task.

5. Conclusion

By combining an indirect method (a dish-composition task with an evoked situation) with a direct method (an online questionnaire), we identified several reasons to explain the low consumption of pulses in France. Our findings provide new evidence of potential barriers to pulse consumption, linked to taste, perceived difficulty of (lengthy) preparation, and the persistent image of pulses as a food clearly associated with a vegetarian diet.

Participants possessed theoretical knowledge about pulses: they were aware of their environmental and health benefits, as well as their high protein content. Yet this awareness did not lead them to modify their food behavior by increasing their consumption of pulses. Our results showed that participants lacked practical knowledge of pulses. More information is necessary about how to cook pulses, how to associate them with other ingredients to create pulse-based dishes, and on what occasions it is appropriate to serve pulses.

To date, communication campaigns in France have simply told consumers to increase their consumption of pulses. Our study identifies other strategies that could prove effective: familiarity can be increased by focusing on out-of-home meals; trendy innovative products can be developed to fit consumer profiles; communication campaigns clearly presenting pulses as a “food for all” can modify erroneous and limited mental representations. Consumers may thus be encouraged to choose pulses more frequently in their everyday lives, with the resulting benefits for their health and for the environment.

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Appendix A. Supplementary data

Download all supplementary files included with this article

The following are the Supplementary data to this article: **Download spreadsheet (22KB)**

Copie de Correlation matrix -Complentary data:**Download spreadsheet (45KB)**

Complemantary data -raw data.xlsx.

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A central place for meat, but what about pulses? Studying French consumers' representations of main dish structure, using an indirect approach

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Abstract

Over time, meat has acquired a central place in French gastronomy. The role played by plant-based proteins, such as pulses, is less clear. In order to better understand it, this study seeks to identify how French non-vegetarian consumers structure their main dish, using an indirect approach. A total of 120 participants had to compose dishes, following six different scenarios, by selecting three images of food items out of the twenty proposed. Results provided information about: (1) the first food product chosen, and (2) how foods from different food-groups were associated. Our results indicated that (1) French non-vegetarian consumers generally constructed their main dishes using animal-based food products first. Some differences were nevertheless identified, in relation to the scenario presented, and the profile of the participants. Results also showed that (2) the food-groups most often associated within a dish were meat, starch, and vegetable. The pulse group, when used, was in general associated with the meat and vegetable food-groups. These findings provide new evidence of the structure of the French main dish. They also highlight possible levers that could be used to promote pulses to French consumers

Graphical abstract

Keywords

Indirect measures; Food choice intentions; Food associations; First food choice; Main-dish composition; Evoked context; Plant-based food

1. Introduction

The shift toward a more sustainable diet appears to be a lengthy and difficult process. Since the mid-twentieth century, consumers have regularly been submitted to injunctions to change their diet, in order to improve their nutritional intake, but these direct interventions have often led only to moderate or null short-term effects on health (Mozaffarian, Angell, Lang, & Rivera, 2018). One of the major difficulties for consumers may be that, in adapting their diet to include healthier and more sustainable foods, their focus should be on the quality, and not only on the quantity, of the food products consumed (Schösler & de Boer, 2018). The way meals are structured also needs to be addressed. The cultural definition of an appropriate meal is a major determinant of meal size and composition (Pliner & Rozin, 2000). Among other characteristics, the traditional meal in French gastronomy, as listed by the UNESCO as part of the Intangible Cultural Heritage of Humanity, should respect a given structure (UNESCO, 2010). In France, meals are usually composed of three main parts: a starter, a main dish, and then cheese or dessert. In everyday life, consumers often choose to eat either a starter with a main dish, or a main dish with a dessert. The organization of the main dish, in France, may vary according to the gender, age, and level of education of the consumer (Poulain, 2002). French women tend to eat more white meats (i.e. chicken) and vegetables, while French men tend to eat more beef (CREDOC, 2007). French consumers follow culinary scripts (i.e. implicit rules) to construct their meals, taking into account the type of food, and the context: place, time, and company (Marshall, 2000). In addition, a close relationship has been found between eating occasion (e.g. lunch, dinner, snacking, etc.) eating location (e.g. at home, at work, on a camping trip, on a train, etc.), and the foods chosen when constructing a meal (Marshall & Bell, 2003).

Whatever the type of meal, however, meat products tend to play a central role in the composition of the main dish in France. A recent survey has underlined that, for 85% of French consumers, whatever their age, protein intake comes from four food-groups, in the following proportions: meat, fish, and eggs (41%), dairy products (15%), cereals (15%), and a heterogeneous group, including sandwiches, pizza, pastries, and savory biscuits (7.6%) (ANSES, 2017b). The central place allocated to meat in France seems to be inherited from historical events. Since Antiquity, cultural prestige has been associated with meat (Quellier, 2013). During the eighteenth and nineteenth centuries, major social inequalities impacted people's access to food products, especially foods of

animal origin. In the twentieth century, there was an "animalization" of the French diet, resulting from the historical prestige value attached to meat, and from the democratization of access to animal-based food products (Boutaud & Stengel, 2016). Along with historical and societal reasons, nutritional aspects can also explain French consumers' attachment to meat. Meat is known to contain protein. Even those consumers who do not really know what a protein is know that protein is essential for health (Terrien, 2018). The taste of meat and the pleasure of eating meat are also important for consumers, and are thus clearly a barrier to any decrease in meat consumption (Poquet, Chambaron-Ginhac, Issanchou, & Monnery-Patris, 2017).

The amount of meat in the weekly French food basket has decreased since the 1980s. In 2016, the mean consumption of meat products in France - except for poultry - was about 12 to 16 kg per year/person (ANSES, 2017a; INTERBEV, 2017; Tavoularis & Sauvage, 2018). According to Boutaud and Stengel (2016), this decrease may be due to the growing interest in sustainability, animal wellbeing, and other environmental issues, since the Grenelle Environment Forum in 2007.Another possible reason is that, as meat has become more easily accessible, its social value has declined, so that consumers of higher socio-economic status now tend to eat meat less often (Tavoularis & Sauvage, 2018). Meat products may no longer completely satisfy the expectations of new generations, because of the greater variety of plant-based products now available. Sanitary crises have also caused increasing suspicion of the sanitary and nutritional characteristics of meat, particularly red meat (Boutaud & Stengel, 2016).

Even though all these problems have affected the image of animal-based food products, meat is still a central element of food in France, and other Western countries (Schösler & de Boer, 2018). Much still needs to be done to shift society's perception of red meat as "the essential product" for a healthy and wealthy diet (Sabaté, Sranacharoenpong, Harwatt, Wien, & Soret, 2015), and to encourage consumption of plant-based food, such as pulses. Protein-rich plant foods, especially pulses, present clear environmental and nutritional benefits. Plant protein intake has been shown to be an indicator of nutrient adequacy in the French diet, (Camilleri et al., 2013). Increasing the proportion of plant proteins in the human diet should also improve food security, and make more food available for the world's ever-growing population (Day, 2013). A low-meat diet is also beneficial for the environment, through the reduction of greenhouse emissions (Hedenus, Wirsenius, & Johansson, 2014), and reduced use of land, water, fuel, fertilizers, and pesticides (Smil, 2002).

Yet the consumption of pulses has declined in France over the past few decades, falling from 7.2 kg/person per year in 1920 to 1.7 kg/person per year in 2016. The current average consumption of pulses is insufficient, and should be considerably increased to at least twice a week, as possible

substitutes for meat and poultry (ANSES, 2017a, HCSP 2017). In 2016, a national food consumption study concluded that French nutritional recommendations should separate pulses from the Starch food-group, due to their higher content in protein and fiber (ANSES, 2016). All these statements show that it remains challenging to promote pulses in France as a plant-based protein source.

To promote the consumption of pulses, a study of the respective importance of the different food-groups in a meal will be necessary, in order to understand the determinants of consumer food choices. Consumer strategies for choosing foods tend to be repeated, thus forming part of their routine (Furst, Connors, Bisogni, Sobal, & Falk, 1996). Firmly established food habits may become a barrier to the integration of other foods.

To access information about consumer food choices, most studies use direct methods, including surveys and consumption questionnaires (Cerri, Thøgersen, & Testa, 2019). Such direct methods can present drawbacks. There can be dissociation between what participants think or say about their behavior and what they actually do (Köster, 2003). Direct methods are also prone to social desirability bias, where participants tend to give the best image of themselves through their answers (Latkin, Edwards, Davey-Rothwell, & Tobin, 2017). Consequently, indirect methods need to be developed to avoid such potential biases. One example of indirect methods is to formulate questions in terms of other people (e.g., friends or family) or imaginary situations (Belk, 2006). Short descriptions of a person or a social situation have long been used in social research, to improve the reliability of measures obtained by surveys or questionnaires (Alexander & Becker, 1978). In consumer studies, scenarios have been shown to be useful and efficient tools to evoke consumption contexts in the laboratory setting (Jaeger & Porcherot, 2017). The use of a written scenario leads respondents to imagine an occasion when they would consume foods, and requires them to think of that occasion while responding to the question or performing the required task. The details of the evoked situation are provided by the researcher and are therefore standardized across respondents. Scenarios have mainly been used in sensory tests, where they resulted in hedonic ratings influenced by the type of consumption context evoked (Hein, Hamid, Jaeger, & Delahunty, 2010). In a recent study, an indirect approach was proposed to study the choices made by French participants in different contexts. This method consisted in asking participants to select three food images to compose a main dish, taking into account six different contexts evoked by simple scenarios (Melendrez-Ruiz et al., in press). Each participant also completed a questionnaire about the properties of the foods used in the dish-composition task. The accuracy of the dish-composition task was assessed by several indicators. First, the dish-composition task with the control scenario (everyday, at-home) was shown to genuinely reflect participants' declared consumption habits. Secondly, the dish-composition task proved to be repeatable when using the same scenario, while producing different but consistent results for different

scenarios. The frequent choice of products declared not to be good for health or for the environment showed that this task was not affected by social desirability bias. The comparison between the foods chosen for different scenarios and the properties attached to these foods allowed us to better understand participants' representations of foods frequently consumed in France.

In the present study, the same dish-composition task was used to explore the choices made by non-vegetarian consumers in France, and to identify the typical structure of the main dish, by studying the first product that participants chose to compose a dish, and the food-group associations that they made. Sequence of choice has rarely been studied in relation to meals. The first food chosen to compose a meal at a buffet was shown to influence subsequent choices (Wansink & Hanks, 2013). When preparing a food or a beverage composed of two ingredients, changing the pouring sequence influences the global quantity and ratio of the two ingredients (Bschaden et al., 2019). The first product chosen when composing a dish could well affect overall dish-composition and the resulting food intake.

In the present study, we hypothesized that the structure of French main dishes, and particularly the central position of animal-based food products, would vary depending on the context of the meal and the characteristics of the consumers. Consumer profiles (gender and age) and context-related differences in main-dish composition could then be used to encourage healthier and more eco-friendly food choices.

2. Materials and methods

2.1. Participants

To qualify for the study, participants (*n* = 120) had to be over 18 in age, without specific or restrictive diets (e.g., vegetarian, gluten-free, etc.), and with no food allergies or severe dislike of certain foods. Another condition for participation in the study was to cook several times a week, for themselves and/or their household. Table 1 gives an overview of participant characteristics. The median (35) and the mean age (39) were the same for male and female. Participants were informed about the conditions of the study, and were asked for written informed consent before beginning the study, and were remunerated at the end.

Table 1. Main demographic characteristics of the participants.

Characteristics	Categories	Number of participants	%
Sex	Male	60	50
	Female	60	50
Age	<40	66	55

Characteristics	Categories	Number of participants	%
	>40	54	45
	High	41	34
Education [a]	Medium	40	33
	Low	39	32
	Family	33	28
Household composition	Couple	47	39
	Living alone	40	33

a Level of education expressed in number of years of formal schooling: Low <12; Medium ≥12 < 15; High ≥15.

The 120 participants were placed in simulated real-life situations, with six different scenarios, and were asked to compose a main dish using photographs of food products.

2.2. Construction of a set of images

In order to give identical information to all the participants throughout the study, the food products were presented in the form of photographs. A dataset of food products was constructed, taking several criteria into consideration. First, all the food products belonged to the traditional French culinary repertoire. They were chosen to represent the four main categories of food recently recommended by the *French National Health and Nutrition Program*(PNNS) to compose a main dish: Meat group, Starch group, Vegetable group, and Pulse group. The Meat group included meat, poultry, fish, and eggs. The Pulse group included dried beans, lentils, and peas. The Starch group included cereals and potatoes. The Vegetable group included products commonly considered as vegetables in France, regardless of their botanic classification. All the food products were presented raw, as they would be before preparing a meal.

Rigorous methodological precautions were taken. Products, purchased in supermarkets, were all photographed in the same conditions. Equivalent volumes of the raw products were presented in the center of a white porcelain plate, on a blue background. Blue was chosen to create contrast between the white plate and the background (Charbonnier, van Meer, van der Laan, Viergever, & Smeets, 2016). Photos were taken on the same day, in the same lighting conditions. During the entire photo shoot, all conditions were maintained constant: the shooting angle, the distance between the lens and the center of the plate, the position of the plate on the table, and the table itself.

After being standardized via Photoshop ® (luminosity, intensity of color, etc.), the twenty images were printed (9 cm × 13 cm) and plasticized. A pre-test was carried out on a small sample of

people (*n* = 30), who were not included in the main study. This pre-test showed that all the food items were recognized, and that the amount of food per image was judged equivalent by all the participants. The photographic quality of the images was consistent, with a mean quality score of 3.7 out of 5 (SD: 1.137); all the products were in the same group for image quality, except for salmon and tomato, which were judged more qualitative, because of the greater contrast between their color (shades of red) and the white plate (Friedman test and multiple pairwise comparison by two-tailed Nemenyi test).

2.3. Creation of scenarios for the dish-composition task

Six scenarios were created (Table 2). They were meant to evoke real-life situations in which people make food choices. The use of these scenarios also established comparable conditions for all participants during the dish-composition task. The Everyday scenario was used as a control for our study. For each scenario, a general instruction was given to participants: "In this situation, compose a main dish, using three photographs."

Table 2. Scenarios used in the dish-composition task.

Title of the scenario[a]	Script[a]	Why this scenario?
Everyday	In an everyday meal at your home, you have to prepare the meal.	As a control
Self-service	You decide to eat at the self-service canteen. On the menu, all the foods represented in the photographs are available.	As a no-cooking context
Restaurant	You won dinner at a four-star restaurant during a competition. With this restaurant's concept, you are invited to create a dish from a list of ingredients, in order to test the chef's talents.	As a no-cooking context, with a tasty dish and prestige
Budget	At the end of the month and after paying most of your bills, you do not have a lot of money and you have to prepare an economical meal	Context of budgetary constraints
Vegetarian	You have invited a friend to eat and you have to prepare the meal. You have to remember that she/he is a vegetarian.	Specific population
Guest	You and your partner decided to invite the couple who just moved in next door to dinner at your place.	Social context

a Participants were given scenario scripts with no titles; titles are only used to refer to the scenarios in this paper.

2.4. Organization of the sessions

All sessions were individual, took place in the laboratory, and lasted about 45 min. All 20 images were placed on a table in front of the participant, in the form of a 5 × 4 rectangle (Fig. 1), in a

random way, to avoid any effect of order or position. The experimenter asked the participant to identify all the foods. Then the first scenario was presented, and the participant was asked to compose a main dish according to the scenario given, using only three foods. Participants were asked to choose only three food images, but four food-groups were represented. This choice was meant to reflect the number of food products used to compose a main dish in France (usually two or three), and to avoid participants choosing one image from each food-group.

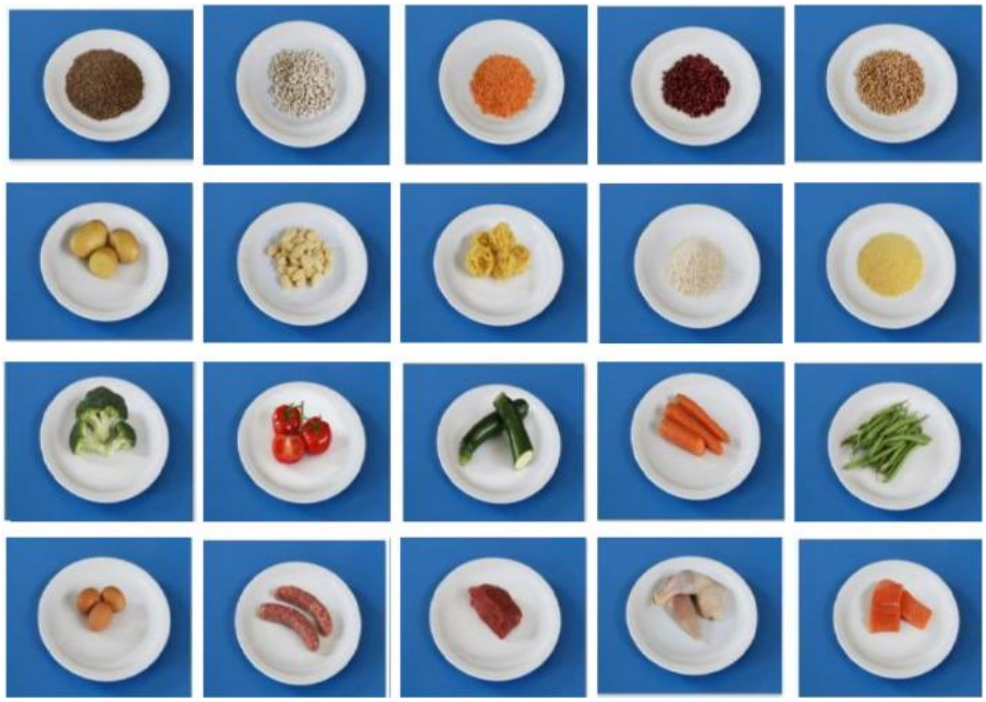

Fig. 1. Set of photographs created for the main-dish composition task.

Then the participant put the cards back on the table and was asked to compose another dish in the same conditions, without using the same food triplet. For each scenario, the participant composed five dishes. Once the five dishes had been composed, a new scenario was presented, with the same instructions. The order of the scenarios was randomized between participants so as not to bias the results by an order effect.

2.5. Statistical analysis

The XLSTAT software program for Windows (Addinsoft, version 2018–1) was used for all statistical analyses. The confidence interval was set at 95%.

2.5.1. First food product chosen in the dish-composition task (first-choice)

The first food product chosen by the participant was recorded as the first-choice for each of the five trials in the six scenarios.

Global frequency for the first food chosen.

For each food product, the global frequency of this first-choice for all six scenarios together was calculated for each participant. Food-product frequencies were then ranked, and a Friedman test was performed on the sum of the ranks to determine if the differences between food products were significant. A multiple pairwise comparison (two-tailed Nemenyi test) identified similar first-choice frequencies among food products.

Frequency of first-choice for each food-group in each scenario.

The first-choice frequencies for the five products belonging to the same food-group were summed per scenario, for each participant. These frequencies were ranked, and a Friedman test was performed on the sum of the ranks to determine if the differences between scenarios were significant for a given food-group. A multiple pairwise comparison (two-tailed Nemenyi test) identified similar first-choice frequencies among scenarios for each food-group.

Frequency of first-choice for each food-group in relation to participant characteristics.

The first-choice frequencies for the five products belonging to the same food-group were summed for each participant, for all six scenarios together. Four contingency tables were built, one for food-group and participant age (<40 and > 40), one for food-group and participant gender (male or female), one for food-group and participant household composition (single, couple, or family), and one for food-group and participant level of education (low, medium, or high). A Chi-square cell-per-cell test showed for each cell of the contingency table whether the observed values were significantly higher or lower than the theoretical values, or equal to them (Symoneaux, Galmarini, & Mehinagic, 2012).

2.5.2. Food-group associations

Each main dish composed by a participant was taken to be an association of three food products, identified by food-group. The frequencies of all possible food-group combinations were calculated, considering all scenarios together, and then each scenario separately. The order in which food products were chosen was not taken into account when listing food-group associations. In total, eleven associations were observed.

After ranking food-group association frequencies, a Friedman test was used to determine if the differences between scenarios were significant for a given food-group. These frequencies were ranked and two different Friedman tests were run, one to see if there were significant differences between associations, considering all scenarios together. A second test allowed us to compare the frequencies of the association of the Pulse and Starch food-groups, with or without meat, for each

scenario. For each Friedman test, a multiple pairwise comparison using the Nemenyi / Two-tailed test was performed.

3. Results

In order to better understand how French consumers structure their main dish, we recorded the first food product chosen in each trial (first-choice), sorted by food-group. We then examined the relationship between participant characteristics and first food-group choice. Finally, we assessed first food-group choice in relation to each scenario.

3.1. First food product chosen in the dish-composition task

3.1.1. Global frequency for the first food product chosen

The first-choice frequency for each food product is presented in Fig. 2. The Meat group (45%) was chosen more frequently in first position, followed by the Starch (28%), Vegetable (14%), and Pulse (13%) groups. Among food products, the three most frequent first-choices were salmon, chicken, and beef (each representing >10% of the first-choice). Products from different food-groups were the next most frequent choices: eggs, sausages, all the starches, and brown lentils (from 7% to 4% of the first-choice). The food products least frequently chosen in first position were all the vegetables, and all the pulses except brown lentils (from 3% to 1% of the first-choice).

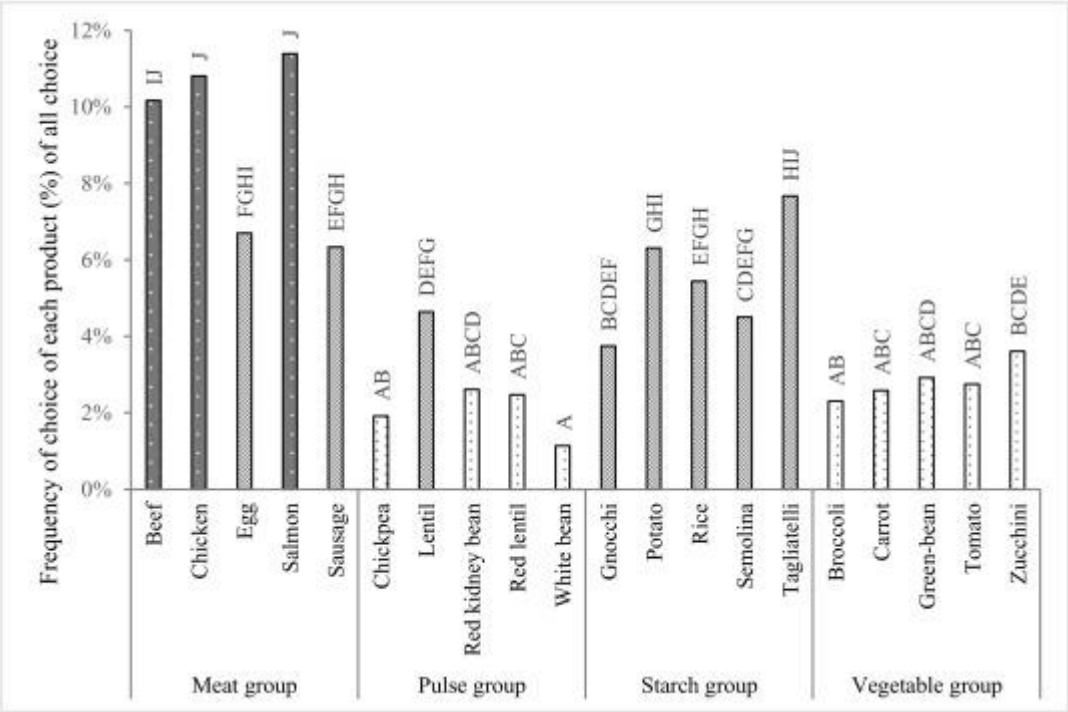

Fig. 2. Frequency of first choice for each food product, considering all scenarios together. Products with the same letter (A-J) were chosen with comparable frequency (two-tailed Nemenyi test; $p < .05$).

3.1.2. Frequency of first food-group choice, in relation to participant characteristics

The results of the Chi-square cell-per-cell analyses showed that participant characteristics contributed significantly to the frequency of the first food-group choice. First, we compared the results for male and female participants for each food-group (Table 3). Male participants more frequently chose products from the Meat group in first position, whereas female participants more frequently chose products from the Vegetable and Pulse groups in first position. There was no significant difference in first food-group choice for the Starch group. Table 3 illustrates the results obtained for each food-group in relation to the age of participants. Younger participants (aged <40) more frequently chose products from the Pulse and Starch groups in first position, whereas older participants (aged >40) more frequently chose products from the Meat group in first position. There was no significant difference in first food-group choice for the Vegetable group.

Table 3. Total first-choice frequency for each food-group by gender (Male and Female participants), by age (<40 years old and >40 years old) and by level of education, expressed in number of years of formal schooling: Low <12; Medium ≥12 < 15; High ≥15.

Food-group	**Gender**		**Age**		**Level of education**		
	Female	**Male**	**<40**	**>40**	**High**	**Medium**	**Low**
Meat	735 (−)[a]	899 (+)[a]	754	880 (+)[a]	517 (−)[a]	556	561 (+)[a]
Starch	517	479	646 (+)[a]	350 (−)[a]	359	352 (−)[a]	285
Pulse	267 (+)[a]	193	287 (+)[a]	173 (−)[a]	178 (+)[a]	145	137
Vegetable	281 (+)[a]	229 (−)[a]	293	217	176	147 (−)[a]	187 (+)[a]

a Indicates significant difference higher (+) or lower (−) than the theoretical values (Chi-square cell per-cell analysis; p-value <.05).

Level of education contributed significantly to first food-group choice (Table 3). Participants with a high level of education chose products from the Pulse group more frequently in first position, and chose products from the Meat group less frequently in first position, in comparison with participants with lower levels of education. By contrast, participants with a low education level chose products from the Meat and Vegetable groups more frequently in first position, and chose products from the Starch group less frequently in first position. In comparison with other participants, those

with a medium education level chose products from the Vegetable group less frequently in first position.

3.1.3. First-choice frequency for each food-group, for each scenario

After assessing overall first-choice frequency for each food product and food-group, the next step was to investigate if the first-choice remained constant for each scenario. A Friedman test showed that the first food-group choice was significantly different in relation to scenario for the Meat, Pulse, and Starch groups (*p*-value <.0001), but no difference was observed for the Vegetable group (p-value 0.400). Products from the Meat group were chosen in first position much less frequently in the Budget (29%) and Vegetarian (13%) scenarios, compared to the Everyday scenario (52%), considered as control. Products from the Pulse group were chosen in first position more often in the Vegetarian scenario (23%), compared to the Everyday scenario (9%). Products from the Starch group were chosen in first position more frequently in the Budget (47%) and Vegetarian (42%) scenarios, compared to the Everyday scenario (24%). The Vegetable group was the only food-group where the first-choice remained constant for each scenario, with a mean of 14% (Fig. 3).

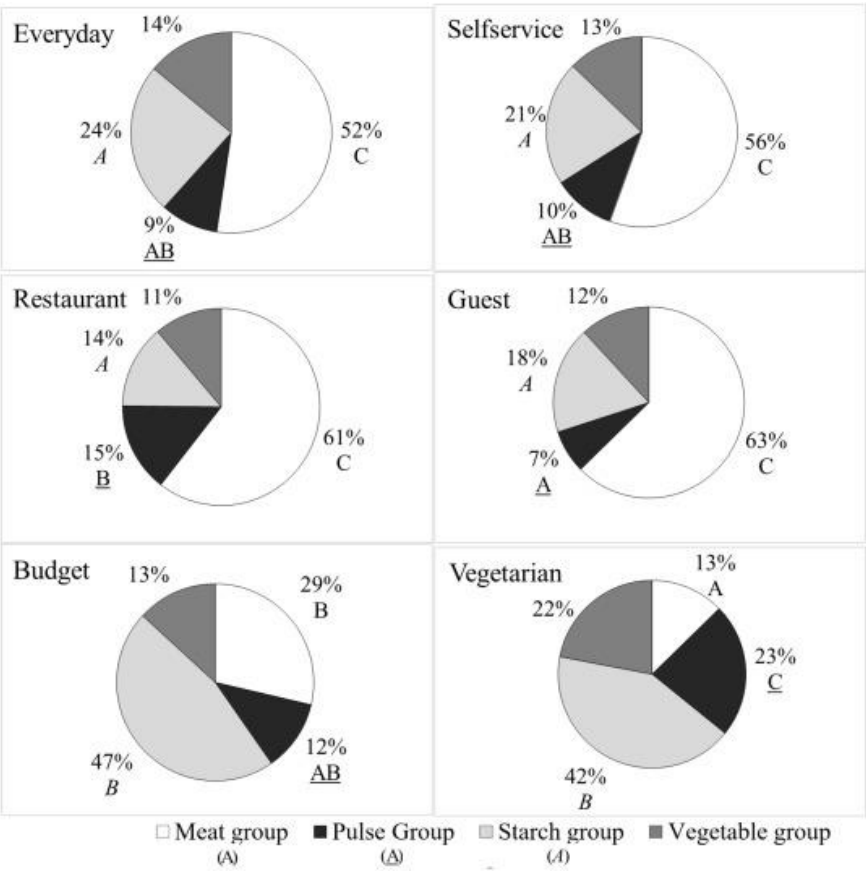

Fig. 3. First-choice frequency for each food group in each scenarios. Letters indicate comparable frequency for first food-group choice across all six scenarios (two-tailed Nemenyi test; $p < .05$).

As significant differences were observed between scenarios for the first food-group chosen by participants, we investigated whether first-choice frequency was the same for each of the five products in a food-group, across all six scenarios. With the Vegetarian scenario, the first-choice for the Meat group was either eggs (70%) or salmon (30%), while for the Pulse group, the first-choice was similar for all food products, except white beans (7%). For the Budget scenario, participants rarely chose salmon (< 3%) or beef (< 3%). In the Restaurant scenario, the most frequent first-choice for the Pulse group was red lentils (36%). In all scenarios, except the Restaurant scenario (9%), brown lentils were the most frequent first-choice for the Pulse group. However, the frequency for brown lentils was much lower for the Vegetarian scenario (27%) than for the Everyday (control) scenario (54%).

A correspondence analysis (CA) was performed on the frequency of first-choice for products across the six scenarios (Fig. 4). Axis 1 represents 70% and axis 2 represents 23% of the global variance. Axis 1 distinguishes the Vegetarian and Budget scenarios, versus all the other scenarios. Participants more frequently chose all products from the Pulse, Starch and Vegetable groups, plus egg for the Vegetarian and Budget scenarios. In contrast, salmon, beef, and chicken were most often chosen in first place in the Restaurant, Guest, Self-service and Everyday scenarios. Axis 2 shows that participants selected any of the pulses (except lentils), and any vegetable more often as first-choice for the Vegetarian scenario, while for the Budget scenario, participants tended to select egg, starches, and lentils. In the Restaurant scenario, salmon and beef were chosen in first place more frequently than in Everyday, Self-service and Guest scenarios, where chicken was used more often as a first choice.

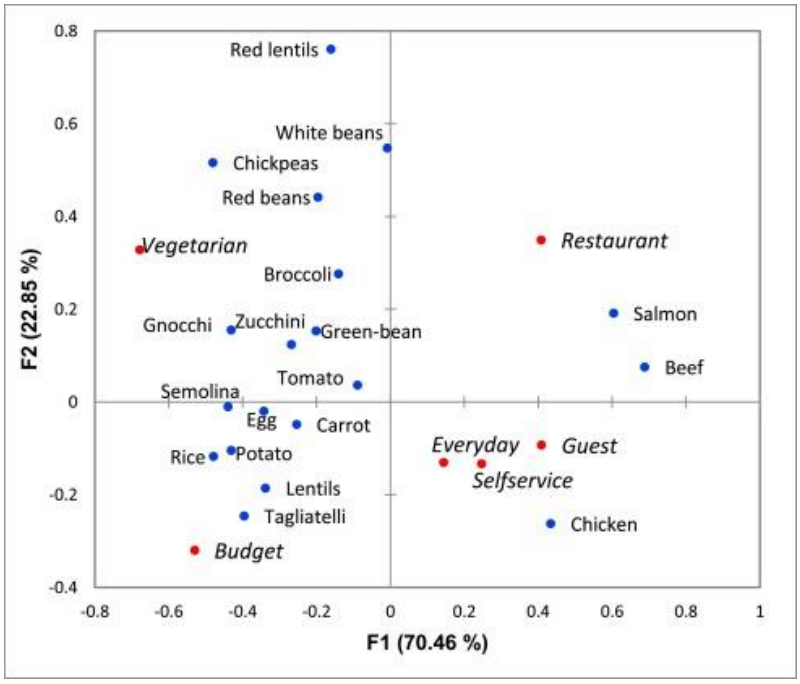

Fig. 4. Correspondence Analysis (CA) for products chosen first by participants in all the scenarios.

3.2. Food-group associations

The second part of the analysis focused on the way participants combined the four different food-groups (Meat, Pulse, Starch, and Vegetable) to create a main dish.

3.2.1. Global frequency for food-group associations

Participants had to compose a main dish using only three food images, but four different food-groups were represented: Meat (M), Pulse (P), Starch (S), and Vegetable (V). Among all combinations produced by participants, there were 11 different associations (Table 4). We summed all the associations produced for each scenario; a Friedman test showed that participants used different types of food associations to compose a main dish (*p*-value <.0001).

Table 4. Percentage for food-group associations per scenario. Percentage for food-group associations With Meat and Without Meat per scenario.

No of food-groups used	Associations	Everyday	Self service	Restaurant	Guest	Budget	Vegetarian	(%) To all the scenarios
Three	MSV	57.3	55.2	39.7	57.2	46.2	14.7	45.0
Three	MPV	10.0	17.0	22.7	12.2	7.5	3.3	12.1
Three	MPS	3.8	6.7	7.5	4.5	5.0	1.5	5.6
Three	PSV	2.3	1.2	1.5	1.8	7.7	19.0	4.8
Two	MV	12.2	9.8	13.3	14.3	6.2	3.7	11.8
Two	SV	8.0	3.8	3.0	2.7	16.8	36.2	9.9
Two	PV	2.3	1.8	2.7	1.0	2.5	13.3	3.9
Two	MS	1.8	2.2	4.2	3.5	4.0	0.7	2.7
Two	MP	1.2	1.3	3.8	1.7	1.3	0.5	1.6
Two	PS	0.0	0.3	0.3	0.0	0.3	1.7	0.4
One	Veggies	1.0	0.7	1.0	0.8	2.2	5.3	1.8
With meat (total)		86.3	92.2	91.2	93.3	70.2	24.3	78.8
Without meat (total)		13.7	7.8	8.5	6.3	29.5	75.5	21.0

Food-group associations occurring fewer than 5 times were not included in the analysis.

Food-groups: M = Meat, S = Starch, P = Pulse, and V = Vegetable.

Results show that participants composed a main dish from three food-groups (68% of all associations), in the following order: MSV (45%), MPV (12%), PSV (6%), and MPS (5%). A further 30%

of associations used only two food-groups: more frequently MV (12%) and SV (10%), and least frequently PS (0. 4%). Few associations used only one food-group: V (2%).

3.2.2. Frequency of with meat vs without meat associations, in each scenario

In order to better understand the role of meat and how other food-groups were associated with or without meat, we considered associations containing at least one meat product (MP, MS, MV, MPS, MPV, and MSV) separately from those without meat (V, PS, PV, SV, and PSV). The results from a Friedman test showed that food associations With Meat and Without Meat were significantly different across all scenarios (*p*-values <.0001).

Table 4 shows the food-group associations produced by participants. As expected, the With Meat association was lowest in the Vegetarian scenario (24.3%). For the Budget scenario, the Without Meat association increased to 29.5%.

3.2.3. Frequency of pulse-starch (PS) associations, with meat vs without meat, in each scenario

In order to understand how consumers associated plant-based protein products, we focused on the association between Pulse and Starch groups across all six scenarios (Fig. 5). Association frequencies were identified as With Meat (MPS), or Without Meat (PS and PSV). A Friedman test showed that all PS associations varied in relation to the scenario presented (p-values <.0001).

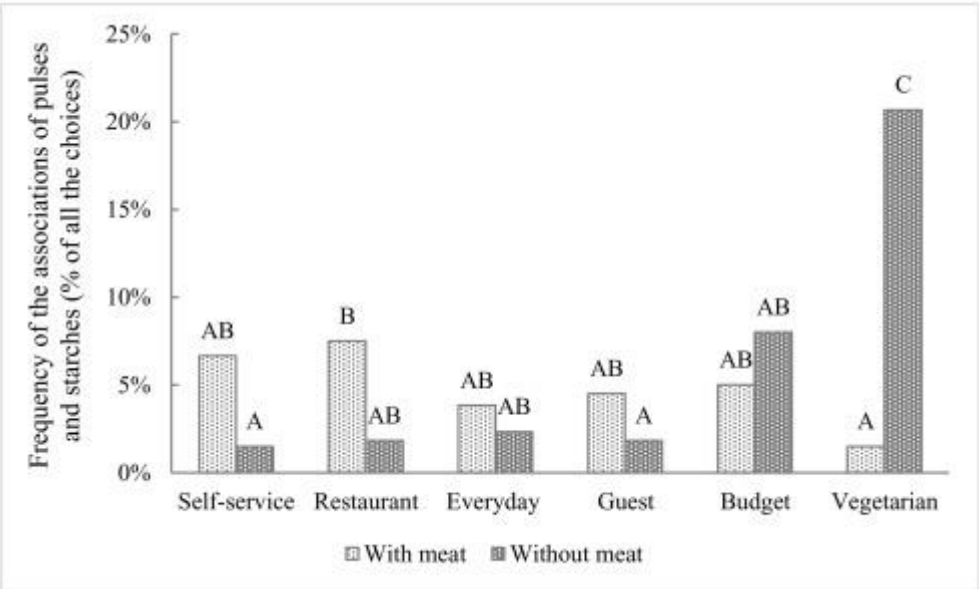

Fig. 5. Frequency of Pulse-Starch associations, grouped as With Meat and Without Meat, per scenario. Letters indicate comparable frequency for PS associations across all six scenarios (two-tailed Nemenyi test; p < .05).

Results showed that Without Meat associations were not frequent except for the Vegetarian scenario (23%). In the Restaurant and Self-service scenarios, With Meat associations were more frequent than those Without Meat. By contrast, in the Vegetarian and Budget scenarios, Without Meat associations were more frequent. In the Guest and Everyday scenarios, no difference was observed between PS associations With Meat and Without Meat.

4. Discussion

One of the main objectives of this paper was to identify how French non-vegetarian consumers composed a main dish, using an indirect approach, based on a dish-composition task with six different scenarios. Three main results will be discussed below: the central role of meat in main dishes in France, the relationship between participant characteristics and first food-product choice, and the influence of context on first-choices (food-group and food product) and food-group associations.

4.1. The central role of meat in main-dish composition

For all scenarios, almost 80% of the main dishes composed by participants contained a food product from the Meat group. As one of the six scenarios evoked a Vegetarian context, this frequency of 80% for Meat is particularly high, confirming the pre-eminent place of meat in French food habits. The most frequent first food-product choice belonged to the Meat group (45%), even though only five of the twenty photographs presented showed Meat group products. A Chinese study found that consumers generally choose in first place the food they consume most often (Ma, 2015). The first-choice can thus be considered as the most spontaneous, reflecting consumers' food habits. In our study, more than half the dishes containing a product from the Meat group were constructed around that food product. The other food-groups – Pulse, Starch, and Vegetable - were chosen to complement this first-choice (referred to here as secondary choices). Our results are in accordance with previous declarative studies suggesting that meat is perceived by French consumers to be a central element in a meal, and therefore a significant part of the French food diet (Poquet et al., 2017). This prominent position may result from the nutritional recommendation widely popularized by the National Plan for Nutrition and Health (PNNS) over the last 15 years: “Construct your main dishes around a serving of meat, fish, ham, or eggs, accompanied with vegetables and starches (potatoes, pasta, rice, wheat precooks, semolina, corn, pulses, etc.)”(PNNS, 2015). The associations produced by participants in our study show that they often followed these recommendations to construct their main dishes: the most frequent association (45% of the dishes composed) used the food-group association Meat - Starch – Vegetable (MSV). According to sociologists, the most usual French main dish can be described as being composed of “mainly a hot cooked meat, vegetable and/or starches” (Grignon, 2009). The next most frequent associations in our study (both at 12%) combined products from two or three food-groups:

Meat, Pulse, and Vegetable (MPV), or only Meat and Vegetable. The MSV association was used three times more often than MPV, which seems to reflect the PNNS recommendation (PNNS, 2015), where pulses were long placed within the Starch group, thus generating potential confusion for consumers about the properties of these two food-groups (Pulse and Starch). To clarify this point and to encourage the consumption of pulses, recommendations have recently been changed in France (in 2017), and now recommendations differentiate between the Pulse and Starch food-groups. This change is probably too recent to have had any perceptible effect on how consumers compose their main dishes in our study.

Similar main-dish compositions can be found in other countries around the world: the weekday main meal in Britain is usually composed of "one meat and two vegetables" (Marshall, 2000); the main meal in Scandinavian countries consists of boiled potatoes with meat or fish (Prättälä, 2000); in Brazil, the main meal includes rice, beans, meat, and vegetables (de Mattos & Martins, 2000). Even though these meal compositions do not seem very different from the French main dish, Grignon (2009) suggested that the mechanisms leading the composition of a main dish for a French consumer could be influenced by other characteristics than the food itself. The construction of a main dish for French people could be an "easy" way to maintain social and cultural practices, as part of their food heritage. In this sense, the food product is not the key element in itself, but rather for what it symbolizes: history, family traditions, and cultural heritage, which also guide the composition of a main dish in France (Grignon, 2009). A very strong effect of cultural heritage could be a barrier to a change in food habits. In order to better assess the strength of this cultural influence, we investigated the effect of different contexts and consumer characteristics on the composition of a main dish.

4.2. Effect of consumer characteristics on first-choices

Participant characteristics (gender, age, and level of education) significantly affected the first food-product choice. Men chose Meat products first more frequently than women did. This result is consistent with a previous study, which showed a relationship between gender, culture, and meat consumption. A higher meat consumption can be explained both by "traditional masculinity", and by a Western-type diet, where meat is readily available and not too expensive (Schösler, de Boer, Boersema, & Aiking, 2015). Decreasing the amount of meat in the diet is thought to be difficult for such consumers (Schösler et al., 2015). In our study, women chose Pulse and Vegetable products first more frequently than men did. In 2007, a French study found that women consumed more vegetables than men did, but French men consumed pulses more than women did (CREDOC, 2007). This result needs to be put in perspective, as the survey may have been prone to declarative and social desirability bias. Our study suggests that men may state that they eat more pulses, but may not use them as the

central part of their meal, while women may eat pulses less often than men, but may use them more often as the principal ingredient of their main dish.

We also found an effect of participant age on dish-composition. Participants aged over 40 chose Meat products first more frequently than younger participants. This result is in accordance with a study from Finland by Vainio, Niva, Jallinoja, and Latvala (2016), which showed an increase in meat consumption with age. The Pulse and Starch food-groups were chosen first more frequently by participants aged under 40. This result seems to indicate that, for young participants, a more central position for products from the Pulse and Starch groups compensates for using products from the Meat group less frequently as the central part of the main dish. In a survey carried out one week after the dish-composition task (Melendrez-Ruiz et al., in press), the same 120 participants perceived Starch and Pulse food products as being cheaper and more environmentally friendly than Meat products. Younger people are more sensitive to the notion of a sustainable diet, and to the necessity of reducing animal-product consumption in favor of plant-based protein products (Lacour et al., 2018). Thus, younger consumers seem more likely to adapt their main-dish composition toward a less meat-centered diet.

Our study also revealed an effect of level of education on the first food-product choice. Previous studies carried out in France and Northern Europe identified higher Meat product consumption among people with a low level of education (ANSES, 2017b; Vainio et al., 2016). Our results go further and show that, similarly to young people, those with a higher level of education are adapting the composition of their main dish, centering their choice more frequently on Pulse products and less frequently on Meat products. One explanation is that such consumers are more health aware (Shepherd, 2005).

4.3. Influence of tested scenario (evocated eating context) on main-dish composition

Both first-product choice and food-product associations showed similar trends regarding Meat products, which were chosen first, with the same frequency, in the context of the Self-service, Restaurant, Guest, and Everyday scenarios. Although the result was not significant, first-choice frequency remained higher for Meat products in the Restaurant and Guest scenarios. The frequency of With and Without Meat associations was similar in the Self-service, Restaurant, and Guest scenarios, where With Meat associations were slightly more numerous than in the Everyday scenario. The Restaurant and Guest scenarios were used to evoke a prestigious social context. The Self-service scenario also evokes a meal taken with people who are not close relatives. The results suggest that the central role of Meat products for French consumers is even higher when social interaction is involved. In France, Meat products have a more festive connotation than other food-groups, and are more frequently consumed at family meals, with an aperitif, and also during the weekend (ANSES, 2017b).

The tendency was different for the Budget and Vegetarian scenarios, where both first-product choice and food-product associations involving Meat products were less frequently observed. For the Budget scenario, the decrease in frequency for Meat products could result from the high price of meat products, as perceived by participants (Melendrez-Ruiz et al., in press). A recent study in New Zealand found that the high cost of meat was one of the main and strongest motivations to reduce meat consumption (Lentz, Connelly, Mirosa, & Jowett, 2018). This result seems to be confirmed in our study by the more frequent choice of Starch products in first place in the Budget scenario. Participants in our study declared a cheaper price for the Starch group than for other products (Melendrez-Ruiz et al., in press).

Lower frequency for Meat products was an expected result for the Vegetarian scenario, as we assumed participants would understand this scenario to evoke an eating pattern where animal products, eggs, and dairy products should be excluded from the diet (Position of the American Dietetic Association, 2009). We deliberately did not provide any explanation about the meaning of the Vegetarian scenario, because we wanted to know how people understood this diet. Several eating patterns may be judged representative of a vegetarian diet. Vegans refuse all animal products, while lacto-ovo-vegetarians include dairy products and eggs, and pesco-vegetarians will eat fish, eggs, and dairy products (Tonstad, Butler, Yan, & Fraser, 2009). In France, few adults (1.8%) declare that they follow a vegetarian diet excluding meat, and even fewer (0.1%) declare that they exclude all animal products (ANSES, 2017a). We expected that most participants would choose photographs from the Pulse, Starch, and Vegetable groups. However, many participants in our study used eggs or salmon as the first-choice for the construction of main dishes with the Vegetarian scenario. This result could indicate either that their interpretation of a vegetarian diet corresponds to the pesco-vegetarian diet, or that it was impossible for these participants not to use a Meat product as the first-choice to compose a main dish. They excluded beef, chicken, and sausage but could not avoid replacing them by another product from the Meat group, again highlighting the central role of Meat products in French main-dish composition. Another strategy to replace Meat (chicken, beef, sausage) in the Vegetarian scenario seems to have been an increased used of Pulse and Starch products in first position. By contrast, the first-choice frequency of Vegetable products was constant across all six scenarios, and the global use of Vegetable products was the same for the Vegetarian and Everyday scenarios. This consistent use of Vegetable products could be explained as an effect of nutritional recommendations in France. The PNNS states that it is important “to consume at least five portions of vegetables and/or fruits per day” (PNNS, 2011). Thus, as the use of Vegetable products is very high in main dishes, even in the Everyday context, it cannot really be increased, and so consumers may focus dietary changes on the Pulse and Starch groups rather than on Vegetable products. Still, there may be some association, in the mind of

the consumer, between the Vegetarian context and Pulse and Starch products. This strong relationship between a vegetarian diet and Pulse product consumption has been identified in Canadian consumer representations (IPSOS, 2010).

4.4. Perspectives: how to encourage healthier and more eco-friendly food choices

In this study, participants generally chose products from the Meat group in first place to compose main dishes. Constructing main dishes around Meat products may be a barrier to the shift toward a more sustainable diet (Schösler & de Boer, 2018). The literature shows that a more carnivorous diet may evoke power and strength (Quellier, 2013), and that consumers strongly attached to such a diet are less motivated to reduce their consumption of Meat products and to opt for a more plant-based diet (Graça, Calheiros, & Oliveira, 2015). One of the difficulties for consumers when decreasing their consumption of animal-based products is that of reaching an adequate level of protein intake. If no source of animal-based protein is consumed, a balanced amino-acid intake can only be reached by associating complementary plant-based food-groups (GEM-RCN, 2015), such as cereals (rich in methionine, but deficient in lysine) and pulses (rich in lysine, but poor in methionine) (Chardigny & Walrand, 2016). We therefore focused part of our analysis on the Pulse-Starch association. Instead of replacing meat by Pulse and Starch food products, participants tended to use one of these two groups to complement their first-choice of Meat food products. Yet participants in our study also knew that the Pulse products contain proteins (Melendrez-Ruiz et al., in press). These results suggest that food-product association is determined more by usage than by nutritional knowledge. This is in line with the literature showing that consumers tend to use 'taken-for-granted frames' in their daily culinary practices (de Boer & Aiking, 2017).

Few participants associated Pulse and Starch food products. In the Everyday, Guest, Self-service, and Restaurant scenarios, the With-Meat association was more frequent than the Without-Meat association, indicating that the Pulse-Starch association was not chosen for reasons of nutritional complementarity, in such contexts. This may be due to the strong impregnation of French culinary tradition, where a Pulse product is usually associated with a Meat product, such as sausage or pork (e.g. "cassoulet" or "petit-salé") (Rio, 2017). The Pulse and Starch groups are thus considered to be usual associations with Meat products. By contrast, in the Budget and Vegetarian scenarios, both Pulse and Starch food products were more often found in Without-Meat than in With-Meat associations. Nevertheless, the Starch group is more often associated with the Vegetable group than with the Pulse group, even though the Starch-Vegetable association cannot provide a satisfactory protein intake. The Pulse group was more often used as a replacement for Starch than for Meat. Taken together, these results indicate that the Pulse group does not hold a central place in main-dish composition. This can

be a barrier to the use of Pulses as the main protein intake. For consumers, the Pulse group seems to take second place in relation to Meat products.

Considering this attachment to meat in France, with the secondary position of plant-based proteins, how can main-dish composition be modified to include healthier and more eco-friendly products, such as those of the Pulse group? Recent changes to nutritional recommendations in France may help to attain this objective. The removal of Pulse products from the Starch group should lead consumers to be more aware of their high protein and fiber content, instead of focusing only on their richness in carbohydrates. The notion of a vegetarian protein dish was recently defined as a dish without meat or fish, containing other plant- or animal-based protein sources (e.g. eggs, dairy products, and cheese). Examples of possible associations of several plant-based protein products have been proposed: red beans and corn, bulgur wheat and chickpeas, lentils and rice (GEM-RCN, 2015). These recent changes in communication should improve consumer knowledge of the Pulse group. This improvement is necessary, as we observed in our study that pulses were more frequently used in main-dish composition as a replacement for Starch than in association with Starch products.

Our study suggests that other levers could be used in the short term to increase Pulse food-product consumption, together with the recent changes in communication strategies. For example, in our study, the Budget scenario context showed that participants were generally aware of the low price of Pulse and Starch food products, but seemed less aware of the nutritional interest of their association. Better communication about the nutritional interest of the Pulse-Starch association should be combined with a focus on the advantageous price of these food products. Concrete examples of plant-based main dishes should be proposed, taking into consideration the nutritional needs and budget of different consumer profiles.

Our results also highlighted the potentially negative image of the Pulse group as “products for vegetarians only”. Participants chose Pulse food products more frequently in the Vegetarian scenario, but limited their use in other scenarios. It will be necessary to find to new ways to promote the Pulse group beyond the vegetarian context.

Another strategy to promote a better-balanced, and more sustainable diet is suggested by our results. The majority of Pulse-Starch associations also involved a product from the Meat group, especially in the Restaurant and Self-service contexts. This result confirms the importance of strategies focused on “social” meals. Eating often creates barriers between human groups within the same culture (Poulain, 2002). Foods frequently consumed by higher social categories acquire a positive image. With time, these foods tend to be more and more integrated into the diets of middle and lower social groups, as a symbol of increasing social status. In our study, participants with a high level of

education more frequently chose products from the Pulse group in first position. This could be the sign of an ongoing increase in the social status of pulses, which could have a positive long-term effect on less educated communities. Strategies to encourage dietary modifications should also focus on other consumer characteristics, such as age or gender, as our study revealed that men and participants aged >40 composed their main dish around Meat products more often than was the case for women and younger participants, who more frequently built their main dish around the Pulse and Starch groups.

4.5. Strengths and limitations

One of the principal limits of our study is that consumer behavior was not measured in real-life conditions. We cannot be certain that the food products chosen for a given scenario would effectively be chosen in a real-life situation of main-dish composition. In particular, participants were forced to choose neither more nor less than three food products, which may not correspond to their daily food habits. Nevertheless, one of the strengths of our study is that the indirect approach – a dish-composition task with six different scenarios - limited many of the biases observed with direct approaches, in particular the social desirability bias (Melendrez-Ruiz et al., in press). We therefore expected to obtain more spontaneous results with this indirect protocol than with direct tolls (e.g. questionnaires).

The task we proposed could be developed further, by including different food products (e.g. dairy products), with new scenarios, and by giving more specific instructions (constructing a main dish for dinner or lunch). Although we studied the Pulse and Starch associations in a main dish, we did not study an entire meal. Recommended daily levels of protein intake may also be balanced within an entire meal (starter, dessert, dairy products, etc.), or through all foods consumed during the day.

5. Conclusions

To our knowledge, this study was the first to use an indirect approach to explore main-dish composition in France, with six different scenarios used to evoke real-life situations. Our findings provide evidence of the central role of meat in main-dish construction for French consumers, in most of the contexts evoked. The traditional focus on meat in French cuisine could be a barrier to promoting healthier and more sustainable diets, with a decrease in the use of Meat products, in favor of more plant-based products. One potential lever could be to adapt the strategy to the profile of the consumer (i.e. gender, level of education, and age).

In particular, we showed that, when pulses are used, their nutritional interest is not fully taken into account. Pulse products are more often associated with Meat than with Starch products. This could be a result of traditional French cuisine, which often associates pulses with meat, but also to a

misunderstanding of the consumer advice provided by French authorities. In such messages, for many years, pulses and starches were presented as a single group (Starch group). Recently this advice was modified to highlight the nutritional value of pulses, but it may still be too early to observe any resulting adaptation in consumer food habits. Nutritional communication may not be enough to change food habits, and so consumers should also be provided with concrete examples of how to compose main dishes that better integrate pulses, while providing adequate nutritional intake, and reducing the central place of meat in the French diet.

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Conflicts of interest

The authors have no conflict of interest to disclose.

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Chapter IV. Are consumers' mental representations influenced by the level of processing of pulse-based products?

The results of the studies presented in chapter III allowed us to determine that (1) lentils were more frequently chosen than other pulses and (2) among others, the difficulty of preparation was one of the main barriers related to pulses choice. The images used for these studies represented only raw pulses, which may not allow us to generalize the results to all pulses and pulse-based products.

To check if the representations are the same towards all types of pulses, and to study the influence of the level of processing of pulse-based product, we adapted a test used in sensory analysis, the CATA test (Check All That Apply). The results will be presented under the form of an article, ready to be submitted.

Using a CATA test to capture consumers' mental representations of pulse-based foods with different processing

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Abstract: 250 words

Pulses are known to participate in a healthier and more sustainable diet. Despite the increased availability of pulse-based foods on the French market, pulse consumption in France remains below recommended levels. The objective of this study was to capture French consumers' mental representations of various pulse-based foods with different levels of processing, using a Check-All-That-Apply (CATA) test with food images. We adapted the CATA test to capture two aspects: how consumers characterize global product features, and how they use those products. Two separate studies were carried out. In Study 1, twelve images of pulses were presented (unprocessed, processed, canned ultra-processed, and new ultra-processed) to investigate whether and how consumers differentiate between pulse-based products with different recipes and process levels. In Study 2, additional CATA tests were carried out in parallel: one with images of pulse-based products and another, with images of vegetables. We wanted to identify if the factors underlying different representations for pulse-based products were specific to pulses, or were also observed with another family of food products. Results showed that products were differentiated more by their level of processing than by the type of food product. Participants selected more positive attributes for pulse products that were unprocessed, processed, or new ultra-processed. By contrast, they used more negative attributes for ultra-processed pulse products (both canned and frozen). Our results also highlighted that the packaging format in the mental representations of pulse-based products is negligible in comparison with the nature of the product itself.

Keywords: CATA, mental representations, food choices, pulses, NOVA food classification

1. Introduction

Over the last few decades, there has been an increasing need to promote healthier and sustainable food choices. Pulses are considered to have many assets aligned with this objective. The FAO defines pulses as a type of leguminous crop that is grown mainly for human consumption, such as beans, chickpeas, lentils, and dried peas. This definition excludes other leguminous crops, such as green peas, which are classified as green vegetables, and crops used for oil extraction, such as soybeans (FAO, 2016). Pulses are very nutritious and their consumption is associated with health and nutritional benefits. Growing pulses helps to maintain the environmental sustainability of agriculture (Rawal & Navarro, 2019). Despite this rising interest in pulses, their consumption in France remains low, at only 2 kg per person in 2018 (Agreste, 2019), well below the global average consumption of 7.6 kg per person per day (Rawal & Navarro, 2019). In previous studies about social representations of pulses, it appeared that there is no well-established social representation of pulses as a food family (Melendrez-Ruiz et al., 2020). A previous study suggested that, for French people, the difficulty of preparing pulses may be one of the main barriers to their consumption (Melendrez-Ruiz, et al., 2019). In that study, French participants had to compose a dish from food pictures, in different scenarios. Participants chose pulses significantly more often when they were projected in a situation where they would not have to be cooked. As the study used only images of raw products (lentils, chickpeas, white beans, and red beans), it was not possible to infer what consumer behavior would be toward processed pulse-based products. In another study, an evocation task was carried out to understand the social representation of pulses among French non-vegetarian participants. Respondents had to cite 5 words that came spontaneously to mind when the heard the word 'Pulses' (Melendrez-Ruiz et al., 2020). Words related to culinary preparation were used quite frequently, and participants considered these words of great importance. This result reveals that, even when there is no reference to any process in the questions asked, participants spontaneously think about preparation when they think about pulses. For French people, the association between pulses and preparation is anchored in the social representations of pulses.

Taking into account this reticence concerning the preparation of pulses, there has lately been an increase in the development of processed pulse products (Métayer & Denhartigh, 2016). Innovative ready-to-eat pulse-based products are now available in France, which should help to overcome the difficulty of preparation considered by many as a barrier to consumption. It is possible to find pulses in nearly all the categories of the NOVA classification, which classifies all food products into four

groups, according to the level of industrial processing that a food product undergoes (Monteiro et al., 2018). Group 1 of this classification is composed of products that are sold in a raw state or after minimum processing (i.e. refrigeration, pasteurization, freezing, or boiling). Group 2 is composed of processed culinary ingredients (i.e. oils, butter, salt, and sugar) that are not meant to be consumed by themselves, but rather in combination with foods from group 1. Group 3 is composed of processed foods, preserved by cooking methods (e.g. fruits in syrup), non-alcoholic fermentation (e.g. bottled vegetables), or other preservation methods (e.g. canned fish), with the addition of a product from group 2. Group 4 is composed of ultra-processed foods that have undergone several processes, and that combine more than 5 ingredients (Fardet, 2018), including food products and additives, to create an attractive ready-to-eat food product. Pulse-based products exist at levels 1, 3, and 4 of this NOVA classification: unprocessed pulses (e.g. raw lentils, beans, etc.), processed pulses (e.g. cooked pulses in cans, or glass jars, or vacuum-packed) and ultra-processed foods containing pulses (e.g. ready-to-eat dishes, comprising traditional recipes, or more innovative forms, such as substitutes for traditional patties and meatballs, etc.). To our knowledge, there has been no study about consumers' mental representations of pulse-based products resulting from different types of processing. The present study aims to fill this gap, at least for France.

French consumers know what lentils, beans, and chickpeas are, and are quite well informed about their specific properties (Melendrez-Ruiz, et al., 2019), but they tend to regard each type of pulses differently. As a consequence, it seems necessary when studying French consumers' representations of pulses to avoid the generic term "Pulses", and instead to use examples of pulses. The great variety of types of pulses (i.e. red lentils, green lentils, brown lentils, white beans, red beans, black beans, chickpeas, and dried peas) together with the diversity of processing applied to these pulses makes it difficult to untangle the many barriers to pulse consumption. In these conditions, studying consumers' mental representations of pulse-based products is challenging. Mental representations are defined as cognitive products and individual mental processes that come from the interaction of individuals with their environment, allowing them to code the meaning of the stimuli and store this information in memory (Gallen, 2005). Traditional questionnaires have been used to study mental representations, but a questionnaire would be overly long and repetitive in the present case. Furthermore, social desirability bias is a known risk during direct questioning. Indirect methodologies, such as word associations, sentence completion, or projective techniques, have been developed to avoid this risk (Fisher, 1993).

The main objective of the present study was to capture French consumers' mental representations of various pulse-based products with different recipes and levels of processing. We used a methodology inspired by sensory science: an adaptation of the CATA test. Within sensory

science, the Check-All-That-Apply (CATA) technique is frequently used as a rapid sensory profiling technique. It consists of asking assessors to select from a list (words or phrases) all the attributes that they consider the most appropriate to describe a product (Valentin et al., 2012). In the food domain, some studies have adapted the CATA test, using images rather than food products. For example, images have been used to characterize the expected sensory characteristics of wine presented in different bottles (Puyares et al., 2010), and for apples with different internal defects (Antúnez et al., 2019). Such CATA tests are easy to execute for participants without any particular knowledge and do not require specific training. Product characterization obtained from consumers using a CATA test is considered to be reliable (Jaeger et al., 2013). This type of test provides an opportunity to understand rapidly the perceived expected sensory characteristics of a variety of products. In the present study, we adapted the CATA test to capture how consumers characterize products, using attributes related not to sensory characteristics, but to global product features, and to how consumers use such products.

Two separate studies were carried out to achieve this objective. In the first study, we adapted the methodology of the classical CATA test to measure whether and how consumers differentiate between pulse-based products with different levels of processing. The second study allowed us to identify more precisely the factors underlying the different representations of pulse-based products, and to determine if these factors were specific to pulses or could also be observed with another family of products.

2. Study 1

To investigate consumers' mental representations of pulse-based products with different recipes and levels of processing, an exploratory study was performed to adapt the CATA test, and collect the first results regarding differences between pulse food products.

2.1. Materials and Methods

Study 1 and Study 2 were both conducted in accordance with the Declaration of Helsinki and were approved by the ethical committee of INSERM N°18-506. Institutional Review Board INSERM (CEEI/IRB) (IRB00003888, IORG0003254, FWA00005831).

2.1.1.Sample size and participants

Participants were recruited on a voluntary basis, over three weeks, at a Cultural and Social Center in Dijon, France. The inclusion criteria were to be fluent in French, to be aged between 25 and 65, and not to have a specific, restrictive diet (e.g., vegetarian or vegan).

A bootstrapping resampling approach was used to determine the stability of the samples in the perceptual space as a function of the number of consumers. For that purpose, 1000 random subsets were obtained, for 30, 43, and 73 consumers. A Correspondence Analysis was then performed on each random subset from which the first two dimensions were extracted, to compare them with the reference map (corresponding to 30, 43, or 73 consumers) via the RV coefficient. Finally, the RV coefficient was plotted as a function of the number of consumers, considering 0.95 as the cut-off point (Blancher et al., 2012). It should be noted that the higher the Regression Vector (RV) coefficient, the greater the stability of the samples in the perceptual space (Faye et al., 2006). Figure 1 shows that all three sample sizes generated stable perceptual spaces, and that the results obtained are therefore valid, coherent with the recommended number of participants (60–80) for a CATA test (Ares et al., 2014).

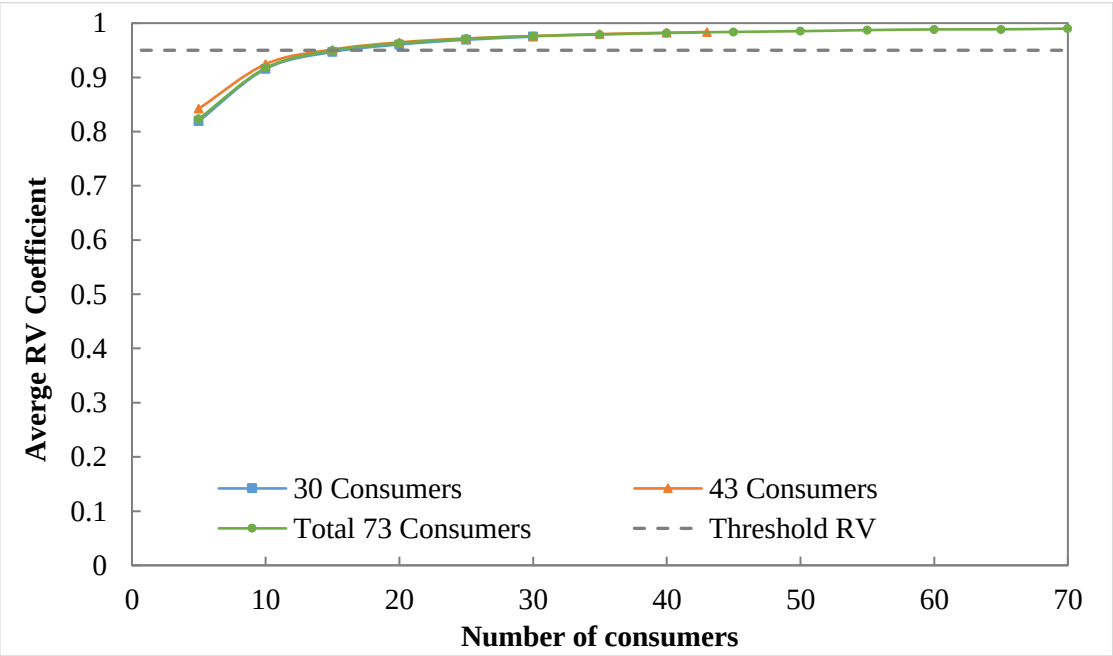

Figure 1. Impact of the number of consumers on the RV coefficient.

As a result of the bootstrap analysis, we decided to include 73 participants in the study. Their characteristics are detailed in Table 1.

Table 1. Characteristics of participants

Age/Sex	Women	Men	Total
25–34	17	5	22
35–44	20	11	31
45–54	7	3	10
55–64	9	1	10
Total	**53**	**20**	**73**

2.1.2.Experimental design

Choice of a set of images

After field observations in French supermarkets, twelve pulse-containing products were chosen. The products were selected based on their principal ingredient and on their level of processing. Three types of pulses were selected as main ingredients: lentils, white beans, and chickpeas. For each type of pulses, 4 products were chosen, according to their level of processing, following the NOVA classification (Monteiro et al., 2018): (I) unprocessed, (II) processed, (III) ultra-processed. For Group III, two representative products were selected: (IIIa) was a ready-to-eat traditional recipe, presented in a can ("traditional ultra-processed" in this article); (IIIb) was a more innovative recipe, such as pulse-based "meatball substitutes" ("new ultra-processed" in this article) (Figure 2).

The images used in the study were obtained from French online supermarkets. For each image, the brand and all claims were erased (i.e. produced in France, rich in fibers, etc.), in order not to draw attention to specific products for reasons irrelevant to the objective of our study.

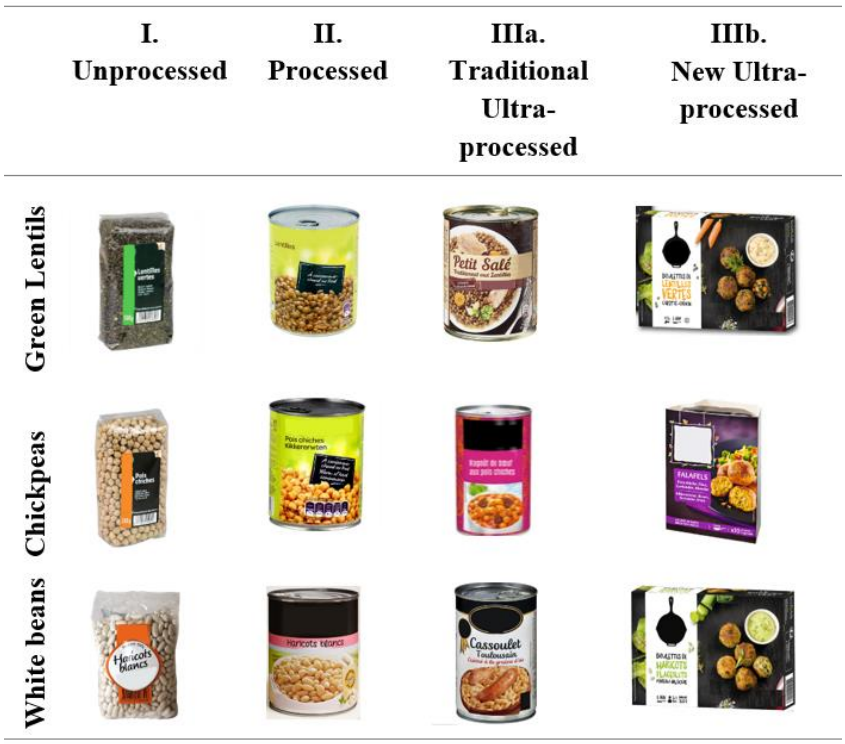

Figure 2. Images of pulse-based products used in the CATA test for Study 1, sorted by level of processing and type of pulses

List of terms used for the CATA test

The attributes used in the CATA test were collated from results of previous studies, based on the characteristics of pulses considered most common by French consumers (Magrini et al., 2018; Melendrez-Ruiz, et al., 2019; Melendrez-Ruiz, et al., 2019; Melendrez-Ruiz et al., 2020). A total of 28 terms was selected (Table 2). For each image of a pulse-based product, participants were asked to select the attributes that correspond best to their mental representation of the product represented in the image. Comparing the attributes selected for different products should allow us to understand the differences of representation between pulse-based products, and their individual specificities, and thus perhaps to explain possible barriers to their consumption.

Table 2. List of attributes used in the CATA test for Study 1

List of attributes				
It's for a solo meal	It's chic	I buy it	It's easy to find	It's organic
It's for a convivial meal	I don't like it	I don't buy it	It's hard to find	I don't know it
It's eaten mostly in winter	I really like it	It's exotic	It's for vegetarians	It's natural
It's traditional	It's good for the environment	It's local	It's for sportsmen	It gives me stomach-ache
It's modern	It's cheap	It's difficult to prepare	It's good for the health	It's trendy
It's expensive	It's easy to prepare	It's outdated		

2.1.3.Procedure

People attending the cultural center were approached by the experimenter, who invited them to participate in a study "about food", on a volunteer basis. The real aim of the study was not revealed, to avoid potential biases during the study. Those who agreed to take part in the study were asked to read and fill out a consent form. Participants were asked to sit in front of a computer to complete the CATA test, using the RedJade Software. On average, the time spent by participants was around 15 to 20 minutes. The study began with the explanation of the instructions by the experimenter. Then participants were asked to select all the attributes on the CATA list that they considered the most representative of each image presented (12 images). The image appeared at the top of the computer screen, in the center (one image at a time), and the list of attributes was listed below, in five columns. The order of presentation for the images and for the list of attributes was randomized between participants. For the same participant, the order of the list of attributes was the same for all the images, as recommended by Meyners & Castura (2016). At the end, participants filled out a short questionnaire about their age, sex, and level of education.

2.1.4.Statistical analysis

A Cochran Q test was performed on the contingence table, to determine if the frequencies of the attributes differed as a function of the image presented. If the attributes used were significantly different across the images, multiple pairwise comparisons were executed, using an exact McNemar test with Bonferroni adjustment. Significant attributes identified by the Cochran Q test were then used to carry out a Correspondence Analysis (CA) to visualize the relationships between the attributes and the images of pulse products.

Redjade software was used to build the test, and to collect the data. The XLSTAT software program for Windows (Addinsoft, version 2020-1) was used for all statistical analyses. The confidence interval was set at 95%.

2.2. Results

The Cochran Q test revealed that 27 out of the 28 attributes were used differently for each of the 12 images of pulse-based products (p-value < 0.05). The only attribute that was not used differently was "it's local". The Correspondence Analysis (CA) presented in Figure 3 shows the differences between the products. The first two axes explain 78% of the total variance. The CA shows associations between pulse-based products and attributes. Axis 1 divides products by novelty, while Axis 2 divides products by level of processing. Food products were divided by level of processing only: different pulses with the same level of processing were grouped together. Group I is composed of all products in their raw (unprocessed) presentation. These products were mainly characterized by the attributes: *natural*, *good for health*, *good for the environment,* and *difficult to prepare*. Group II, products with little processing (processed), were considered to be *cheap*, *easy to find,* and *traditional*. Group IIIa, composed of all the canned (traditional ultra-processed) products, was identified by participants as *outdated*, *it gives me stomach-ache*, and *I don't like it*. Group IIIb is composed of all the innovative (new ultra-processed) products, and the attributes used by participants for these products were: *it's chic*, *it's expensive*, and *it's modern*. The attributes selected for the two sub-groups in Group 3 were very different: canned (traditional ultra-processed) products had a more negative image than the innovative (new ultra-processed) products.

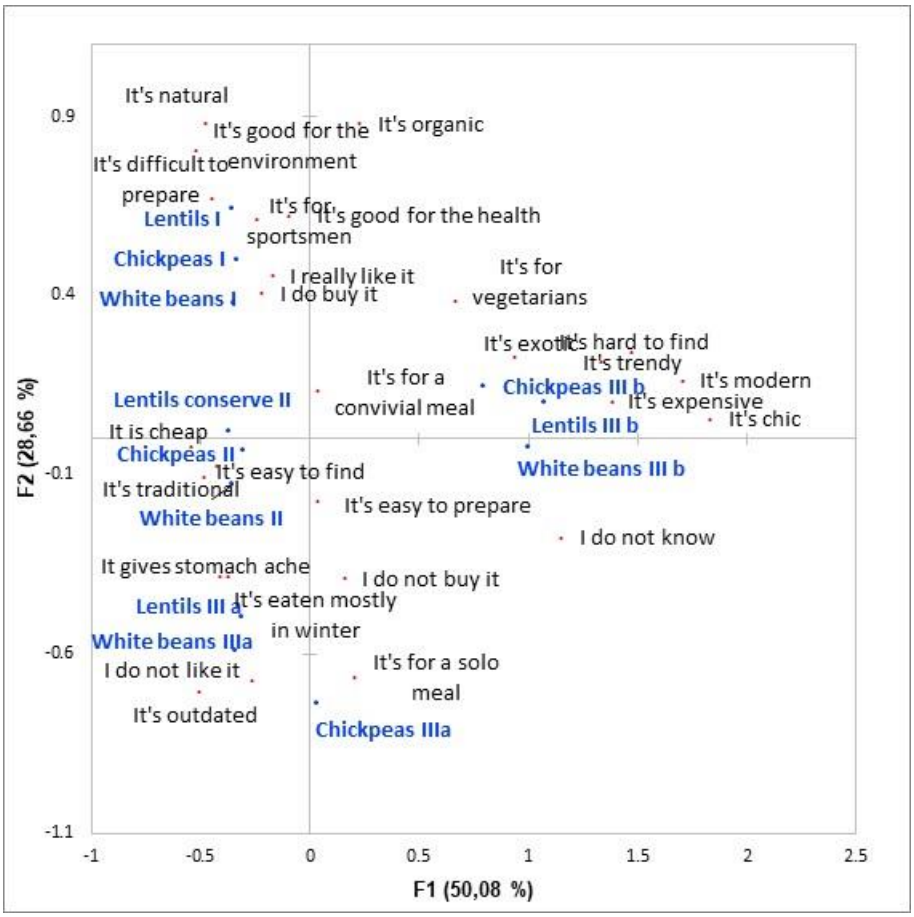

Figure 3. Correspondence Analysis (CA) for the CATA test of pulses in Study 1

This study is the first evidence that representations of pulse-based products are not the same, depending on the level of process and recipe of the products. Moreover, packaging formats may also play a role in consumer representations of pulses. The difference between pulse-based products is driven by their level of processing and/or recipe, and not by the type of pulses (lentils, chickpeas, or white beans). It was not possible to draw precise conclusions about the specific influence of the level of processing from the results of Study 1. Very different attributes were associated with the two types of ultra-processed products (traditional vs new), which suggests that the level of processing may not be the only factor influencing participants' representations. In the products selected for this study, Group IIIa may have been perceived as highly processed, and thus similar to group IIIb, or simply as canned, and thus comparable to group II. Thus, packaging format and processing may have been confounding variables in this sample of products. At this step, it is possible to question whether the negative image of traditional ultra-process products is more related to their recipe or to their presentation (packaging). Study 1 also highlighted the specificity of the observed distribution of pulse-based products by level of processing. It is unclear whether the level of processing is particularly important for this specific family of food products, or if it would be also observed with other food product families.

3. Study 2

Study 2 aimed to overcome the limitations observed in Study 1. We therefore performed two additional CATA tests, one with pulse-based products, and another with another food product family (vegetables). Pulse-based products were selected as having either different packaging formats but the same level of processing and the same type of recipe, or the same packaging format but different types of recipe and levels of processing. Vegetables were selected according to the same criteria.

3.1. Materials and Methods

3.1.1.Participants

In Study 2, two different pools of participants voluntarily completed the CATA tests online (one for vegetables and the other for pulses). Participants were recruited using a snowball sampling by email, where a link was shared over four months. In total, 108 participants began the CATA test for pulses, but only 69 participants completed it. From that number, 3 participants were eliminated: two because they followed a vegetarian diet, and one who followed a vegan diet. As shown in Table 3, 66 participants were thus included in the study. In total, 107 participants began the CATA for vegetables, but only 81 completed it. From that number, 3 participants were eliminated because they followed a vegetarian diet. The answers from 78 participants were thus included in the analysis (Table 4). For the two CATA tests, 82% of the participants were women and 18% were men. All participants included in the analysis had completely finished the test, and fulfilled all of the inclusion criteria (no specific diet, participants living in France at the time of the test). We also checked that participants spent a comparable average amount of time on each of the two tests: around 15 to 20 minutes.

Table 3. Characteristics of participants who answered the CATA test about pulses for Study 2

Age/ sex	Women	Men	Total
18–24	15	3	18
25–34	17	2	19
35–44	7	3	10
45–54	7	1	8
55–64	8	3	11
Total	**54**	**12**	**66**

Table 4. Characteristics of Participants who answered the CATA test about vegetables

Age/ sex	Women	Men	Total
18–24	13	6	19
25–34	23	3	26
35–44	8	1	9
45–54	5	2	7
55–64	15	2	17
Total	**64**	**14**	**78**

3.1.2.Experimental design

Choice of a set of images

For each CATA test, different food images were chosen. For the CATA test about pulses (Figure 4), fifteen products were selected, to represent 5 levels of processing, and 3 types of pulses. The types of pulses were partially the same as in Study 1 (lentils and white beans), but chickpeas had to be replaced by red beans because the number of processed chickpea products available in France is limited. For each type of pulses, three levels of processing were selected: (I) unprocessed, (II) processed, and (III) ultra-processed. Groups II and III were each divided into two types of packaging formats: Sub-group a) a canned product, and Sub-group b) a frozen product. For group II, the two sub-groups (a and b) each contained a product with the same recipe, belonging to the same level of NOVA classification. The same procedure was used to select the products in group III.

Figure 5 shows the food products used for the CATA test about vegetables. The selection process followed the same rules, except for the canned ultra-processed group (IIIa), which is not readily available in France. In total, twelve images were selected with three different products: spinach (épinards), zucchini (courgette), and eggplant (aubergine). For each vegetable, we found the same three levels of processing: (I) unprocessed, (II) processed, and (III) ultra-processed. For each image, both the brand and all claims were erased (i.e. produced in France, rich in fibers, etc.).

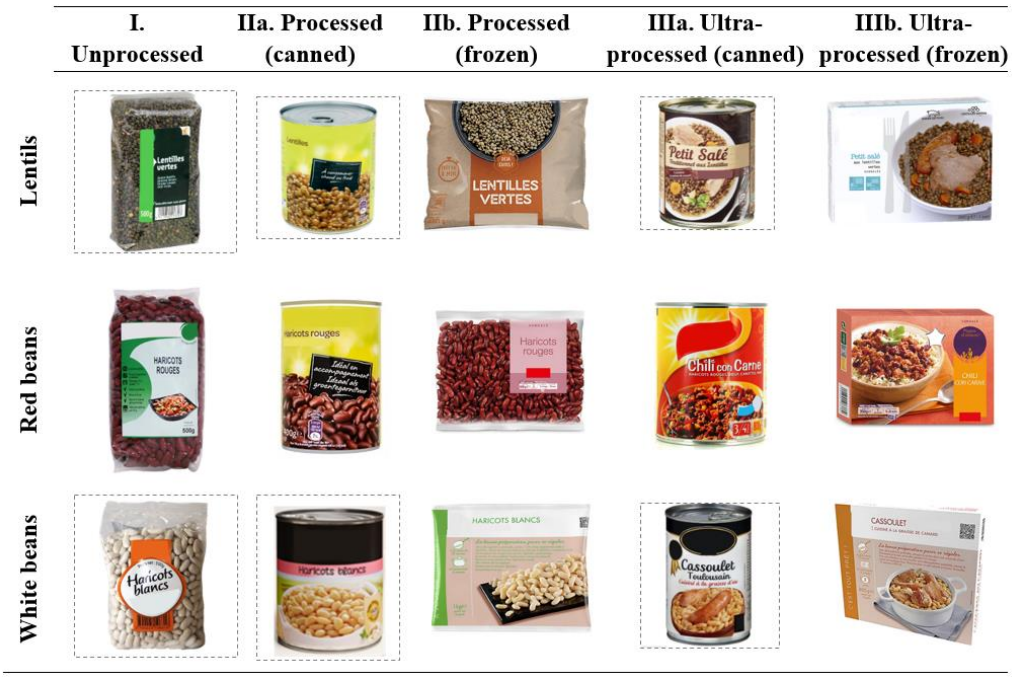

Figure 4. Images of pulse products used in the CATA test for Study 2. Dotted lines indicate products also used for Study 1.

Figure 5. Images of vegetable products used in the CATA test for Study 2.

Selection of the terms used for the CATA test

We used the 27 attributes that were significantly different in Study 1. We added two additional attributes: *it's bad for the health* and *it's eaten mostly in summer* because participants in Study 1 mentioned that these attributes were missing from the initial list. The resulting list of 29 attributes was used for the two CATA tests, for pulse-based products, and for vegetables.

3.1.3.Procedure

Both CATA tests were created using the RedJade software. A single link was created for both tests, and the program was set up in such a way that participants were automatically split into two groups: one out of every two participants completed the CATA test for pulses, while the next participant completed the CATA test for vegetables, and so on. Each participant participated in only one test. Before the start of the test, participants were given written instructions, and were asked to fill in the test on a computer to ensure a comparable quality for the product images. All the instructions were similar throughout the CATA tests, whether for pulses or for vegetables. Participants were asked to select all the attributes shown on the list that they considered to be most representative of each image presented (15 images for the CATA on pulses, and 12 images for the CATA on vegetables). Images and attributes were organized on the page as in Study 1. The order of presentation for the images and for the list of attributes was randomized between participants. For the same participant, the order of attributes was the same across all the images. Just after completing the CATA test, participants answered the single-item Food Choice Questionnaire proposed by Onwezen et al., (2019), with a seven-point scale, from 1: "not at all important" to 7: "very important". At the end, participants filled out a short questionnaire to indicate their age, sex, level of education, whether they followed a specific diet, and their administrative area (i.e. the code number for their department of residence, to confirm that they were living in France).

3.1.4.Statistical analysis

Data analyses were performed using a Cochran Q test to determine if the selection of attributes differed as a function of the image presented. If there was a significant difference, multiple pairwise comparisons were executed, using an exact McNemar test with Bonferroni adjustment. A significant test identified by the Cochran test was then used to carry out a Correspondence Analysis (CA), to visualize the relationships between the attributes and the images of pulse products or vegetables. We performed a t-test over the scores obtained for each factor throughout the single-item

Food Choice Questionnaire between the CATA of pulses and the CATA of vegetables, to see if the differences were significant.

The XLSTAT software program for Windows (Addinsoft, version 2020-1) was used for all statistical analyses. The confidence interval was set at 95%.

3.2. Results

3.2.1.Characterization of each set of respondents according to the food choice questionnaire

Table 5 shows the mean values obtained for each factor in the single-item Food Choice Questionnaire. The Student t-test showed no significant differences for each factor between the participants who answered the CATA for pulses and the participants who answered the CATA for vegetables. Thus, both pools of participants in Study 2 were driven by similar motivations.

Table 5. Mean values obtained for each factor of the Single-Item Food Choice Questionnaire

Factors FCQ	Mean Pulses	Mean Vegetables	P-value
Familiarity	3.97	4.01	0.870
Convenience	3.98	4.23	0.333
Price	4.17	4.09	0.750
Mood	4.23	4.10	0.678
Weight control	4.39	4.56	0.528
Ethical concern	4.94	4.79	0.431
Natural content	5.52	5.56	0.824
Health	5.94	5.91	0.867
Sensory appeal	6.21	6.31	0.563

3.2.2.Characterization of each set of respondents according to their personal characteristics

A Chi-square test was carried out for age, sex, and level of education between participants who answered the CATA for pulses and those who answered the CATA for vegetables. The results did not show any significant differences for age (p-value= 0.821), sex (p-value= 0.971) and level of education (p-value= 0.591). Participants from each group have similar personal characteristics.

3.2.3.*CATA test for Pulses*

The Cochran test revealed that 21 attributes were used differently for the different images of pulse-based products (p-value < 0.05). The correspondence analysis presented in Figure 6 shows the differences between products. The first two axes explain 78% of the total variance. Axis 1 mainly divides the pulse food products into two groups: raw and processed products are opposed to ultra-processed products. Participants identified the (raw) unprocessed products (I) and the (slightly) processed frozen products (IIb) as more adapted for vegetarians, good for health and for the environment, more natural and organic than the ultra-processed products. For the products from groups (I) and (II), participants more often selected the attribute *I buy it*. All the ultra-processed products, canned (IIIa) and frozen (IIIb) were grouped together and characterized by attributes such as *it gives me stomach-ache*, *it's exotic*, *it's bad for the health*, *it's expensive*, *it's for a solo meal*, *it's eaten mostly in winter*, *it's traditional*, *I don't like it*, *I don't buy it* and *it's easy to prepare*. Raw products (I) based on red beans and white beans were considered more difficult to prepare than all the other food products. By contrast, the canned processed products (IIa) were characterized as *easy to prepare*, *easy to find*, *cheap*, and *adapted for sportsmen*.

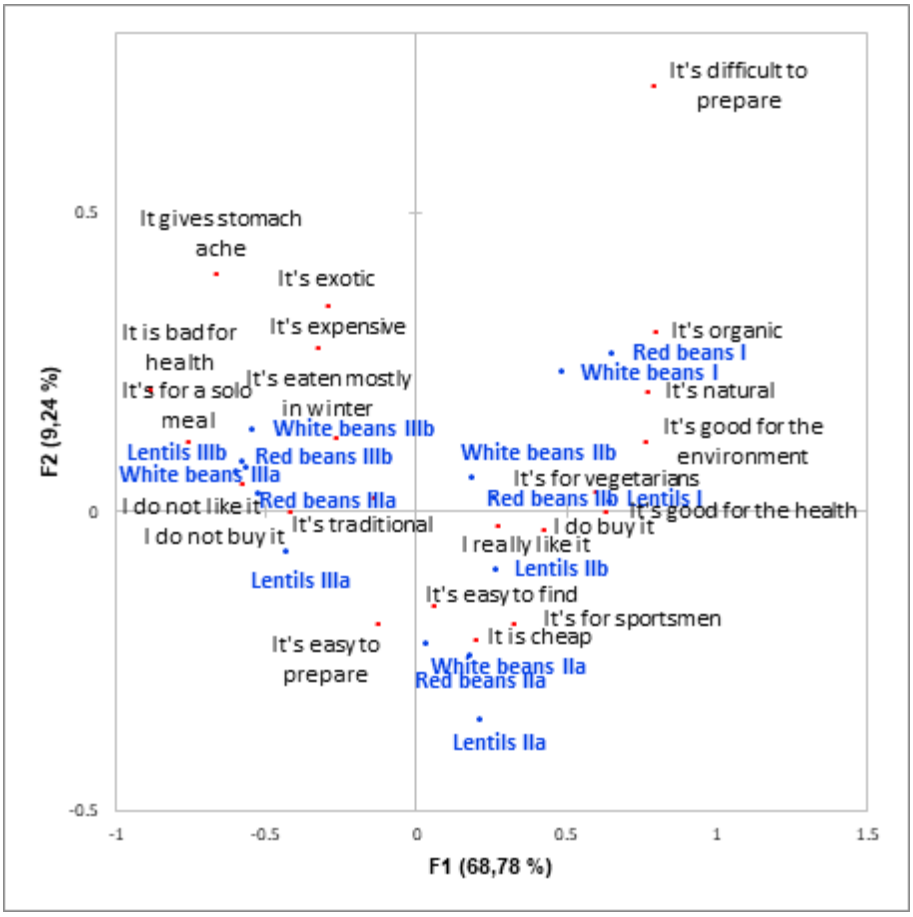

Figure 6. Correspondence Analysis (CA) for CATA on pulses in Study 2

3.2.4.CATA test for Vegetables

The results from the Cochran test showed that participants used 20 attributes differently across vegetable-based products (p-value < 0.05). The Correspondence Analysis (CA) presented in Figure 7 shows the differences between the vegetable-based products. The first two axes represent 78% of the total variance. Axis 1 opposes the (raw) unprocessed (I) and (slightly) processed frozen vegetables (IIb) to the canned processed (IIa) and ultra-processed vegetables (III). The attributes used by participants to characterize all the (raw) unprocessed products (I) and the (slightly) processed frozen products (IIb) were: *it's natural*, *it's good for the health*, *it's for vegetarians*, and *I really liked it*. By contrast, the attributes more often used for the canned processed (IIa) and ultra-processed vegetables (III) were: *it's bad for health*, *it's for a solo meal*, *it gives me stomach-ache*, *it's outdated*, *I don't buy it*, *I don't like it*, and *I don't know it*.

Axis 2 opposes raw eggplant and zucchini, associated with the attributes: *it's organic*, *it's expensive* and *it's eaten mostly in summer*, to frozen spinach, considered as cheaper than the other products: *it's cheap*.

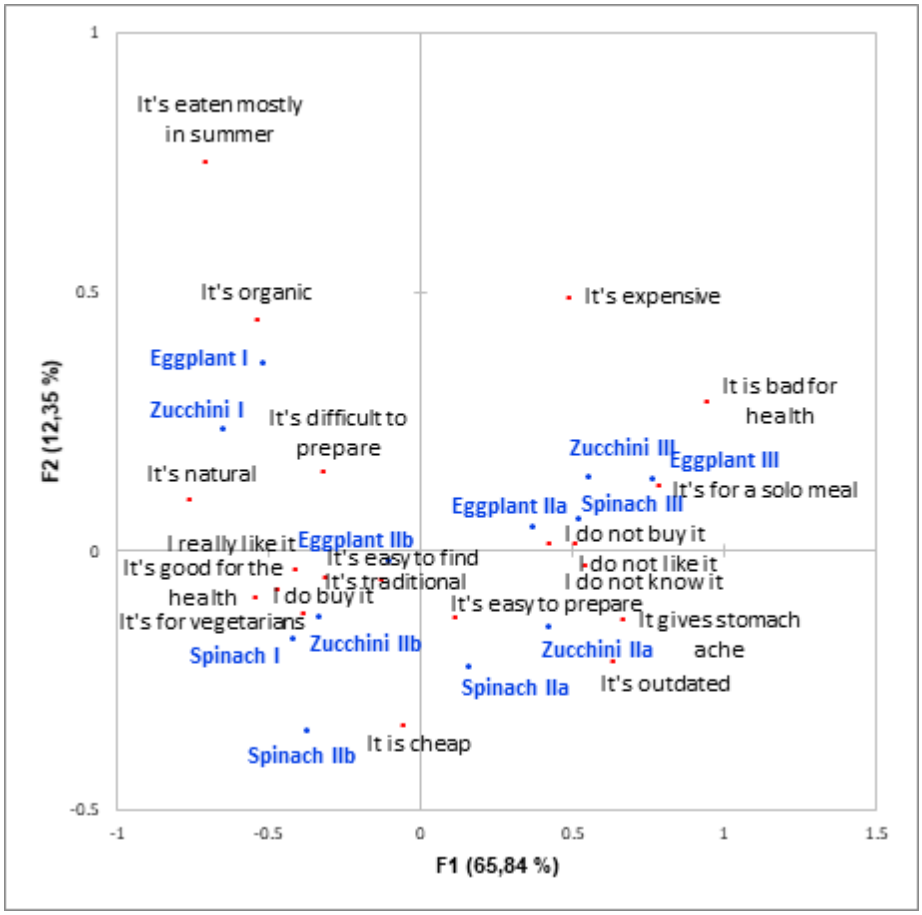

Figure 7. Correspondence Analysis (CA) for the CATA on vegetables

4. General discussion

The main objective of this study was to capture consumers' mental representations of pulses with different levels of processing, using a Check-All-That-Apply (CATA) test. We used the results of the two studies to verify: (i) if the level of processing affected the representations of consumers about pulses; (ii) if the level of processing was perceived similarly between two groups of food products; (ii) if the perceived differences of representations between products depended only on their level of processing, or also on the type of recipe or packaging format.

4.1. Does the level of processing affect mental representations of products?

One of our main findings from both Study 1 and Study 2 is that the differences between various food products that belong to the same food group (pulses or vegetables) are driven by their level of processing (unprocessed, processed, or ultra-processed), rather than by the fact that they contain the same raw product (e.g. lentils, eggplant, beans, etc.).

Although not all the products included in Studies 1 and 2 were the same, and although each study was carried out with different participants, the results from both studies show similar tendencies. Participants characterized pulses with positive attributes in their (raw) unprocessed state, and in their (slightly) processed state, whatever the packaging format (cans or bags). By contrast, we found that participants often chose negative attributes for ultra-processed pulses, whether canned and frozen, such as *outdated, it gives me stomach-ache*, *I don't like it*, and *it's bad for the health*. Our results are in accordance with a study carried out by the European Food Information Council, in which UK residents showed a preference for unprocessed foods, and perceived processed food negatively, arguing that there was a loss of nutritional and health benefits in these products (EUFIC, 2016).

4.2. Are mental representations of processed products the same for different food groups?

Study 2 allowed us to compare pulse-based products and vegetable-based products. As participants for both the CATA tests had similar characteristics, it was possible to compare results, to underline the common points and the differences between pulse- and vegetable-based products. As already observed for pulse-based products, results for raw (unprocessed) and ultra-transformed vegetable-based products were in direct opposition. Another similarity was that raw (unprocessed) and (slightly) processed frozen vegetables had positive attributes (e.g. *it's organic*, *it's natural*, *it's good for the health*, and *I like it)* while the ultra-processed frozen vegetables were characterized with negative attributes (e.g. it's *bad for the health*, and *it's expensive*). Nevertheless, we also found differences between the two groups of products. Participants used similar attributes for slightly processed canned vegetables and for ultra-processed vegetables. For pulses, slightly processed

products were characterized by attributes also used for raw (unprocessed) products. Accordingly, canned slightly processed pulses have a positive image, while canned slightly processed vegetables have a negative image. This could be explained by buying behavior in France: French adults declared that they most often buy pulse products in a metallic can (84%), followed by a glass jar (8%), plastic packaging (4%), or undetermined packaging (4%) (ANSES, 2017). By contrast, vegetables are mostly bought fresh (71%), and less often processed (29%), whether canned or frozen (UNILET, 2015). This observation suggests that French people are more familiar with canned pulses than with raw pulses, but with raw vegetables rather than with canned vegetables. Their mental representations of canned pulses may thus be stronger than those for raw pulses. There may also be a negative image of canned vegetables in general, as revealed by a Swiss study showing that canned green beans were perceived by participants to be harmful for the environment (Tobler et al., 2011). Our hypothesis to explain our result is that French people, who are more used to eating canned pulses, tend to consider this level of processing as the minimum required to overcome the difficulty of preparation.

Our results highlight that the mental representations of products resulting from an industrial process are not perceived in the same way, depending on the food group to which they belong. Mental representations seem to depend on consumers' familiarity with products.

4.3. Three key points for mental representations of pulse-based products: the recipe, the level of processing, and the packaging format

Among of the main results of Study 1 are the differences between traditional and new ultra-processed products. Such differences could be related either to the recipe or to the presentation and packaging format of the product. Traditional products contain whole pulses that are recognizable to consumers, unlike meatball substitutes, where pulses are mashed and mixed with other ingredients. As a consequence, consumers may find it hard to identify pulses in the product. All traditional ultra-processed pulses were presented in a metallic can, while new pulse products were packaged in a cardboard box. Traditional ultra-processed products were mostly characterized by negative attributes, such as *outdated, it gives me stomach-ache*, *I don't like it,* while new ultra-processed products were characterized by positive attributes (e.g. *chic, modern, etc.*). In a study carried out in the United States, canned food products were considered less safe to eat than organic and natural foods (Saulo & Moskowitz, 2011). To disentangle whether the negative image of traditional ultra-processed pulse food products was related to packaging or only dependent on the recipe, the products presented in Study 2 were all traditional recipes.

For each type of pulses, the same recipe was presented under two forms: frozen products and canned products. We found that consumers characterized both groups of ultra-processed products (canned and frozen) with negative attributes, which means that the negative mental representation is of the product itself (the recipe) and not the packaging format. Consumers also characterized with positive attributes the two slightly processed pulse-based products with the same recipe, whether frozen and canned. Another result confirms the greater importance of the recipe over the packaging format for consumers: in Study 2, frozen pulse-based products were presented in a cardboard box, as were new ultra-processed pulse-based products in Study 1. If the packaging format was the most important factor for consumers, these products would have all been characterized by positive attributes. However, the frozen products were characterized by negative attributes, but the new ultra-processed pulse products had particularly positive attributes.

4.4. How to overcome the barriers to pulses consumption

Besides being considered as natural, good for health, and for the environment, the raw pulses in our study were also characterized as *difficult to prepare*. These findings confirm the results of a previous study on raw pulses characteristic for French non-vegetarian consumers, based on a questionnaire (Melendrez-Ruiz, et al., 2019). Participants characterized pulses with little processing, presented in a metallic can, as *cheap*, and *easy to find,* which reflects the French market reality. Canned pulses shared with highly transformed pulse products the perceived characteristic of being *easy to prepare*. Generally speaking, we observed a dichotomy between raw products that have a positive image but are considered difficult to prepare, and ultra-transformed products that have a more negative image but are considered easy to prepare. This could be one of the main barriers to pulse consumption.

One of the levers to encourage pulse consumption could be to enhance the attractiveness of traditional slightly processed products, and increase the availability of frozen products. Participants identified frozen pulse-based products with the little processing as: *for vegetarians*, and *I do buy it*. This result could indicate new interest in frozen products among French consumers, even if pulses in France are mostly consumed canned (Champ et al., 2015).

New recipes for pulse-based ultra-processed foods also seem to be an interesting opportunity to increase pulse consumption. Products presented in the form of “meatballs” were related in our study to positive attributes like: *chic*, *modern*, but also *expensive*. Indeed, these trendy new products do not suffer from a negative image among French consumers. Perhaps consumers characterized these products with positive attributes because they are novel on the market, and different from traditional

pulse products. Yet precautions need to be taken, as ultra-processed foods should be limited to a maximum of 15% of the daily calorie intake (Fardet, 2017), and so should not be considered as the basis of our food consumption (Fardet, 2018). We are nevertheless aware that not all new pulse-based products are ultra-processed. There may be ready-to-eat products combining pulses with more than four other ingredients, yet not containing any additives or artificial flavors. The NOVA classification used in our research was an indicator to divide products according to their levels of processing, yet we know as the processing industry and technology keep moving, this food classification could sometime not be the best option.

Finally, supplementary studies will be necessary to investigate whether the level of processing of a pulse product would influence real-life consumer food choices in a retail environment. As shown in the current study, French participants may have positive and/or negative images about a pulse-based product because of its level of processing, but this does not necessarily mean that the same choices would be made when consumers are in a real-life context. Successfully targeted communication about pulse-based foods can be a key element to highlight the positive features of these products.

5. Conclusions

The use of the Check-All-That-Apply (CATA) test showed that pulse-based products are distinguished according to their level of processing, and not by the type of pulses they contain. We found, with another food category (vegetables), that participants tended to group products according to their level of processing. Our results show that the industrial processing a food product undergoes affects consumers' mental representations. Pulses, whether raw, slightly processed (canned and frozen), or new ultra-processed products all have a positive image. By contrast, pulse products classified as traditional ultra-processed (canned or frozen) were associated with a more negative image. The study confirmed that positive or negative attributes associated with a pulse product are related to the product itself rather than to the packaging format. The tests used in this study allowed us to identify specific mental representations about a variety of pulse-based food products, which could be seen as one of the strengths of this study. It would be interesting for future studies to determine if there are differences between consumers in mental representations about pulse-based products. For a study of this type, using a CATA test, it would be necessary to have a larger sample of participants to segment consumers into different groups, according to their socio-demographic profile or food motivations, and thus identify possible differences in the use of the list of attributes according to these specific characteristics. Overall, the results of the present study highlight some levers that

could be used by the pulse supply chain to increase pulse consumption. These levers could be used to increase the attractiveness of canned slightly processed pulses, the availability of frozen products and of new trendy pulse-based products, which are ready-to-eat but still healthy.

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Conflicts of Interest: The authors have no conflict of interest to disclose.

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Chapter V. A more realistic environment – a Virtual Supermarket – to evaluate visual attention and food choice behavior of consumers towards pulse-based products

The differences observed regarding the mental representations of consumers towards pulse-based products with different processing rise a question about consumer food choices when exposed to a large set of options. This also questions the limits of the studies carried out in Chapter three, where a limited number of images were used. Moreover, participants were placed in a laboratory setting, and despite the use of scenarios aimed to evoke a real context of food choice, we are aware that this environment is not representative of a real-life situation.

To overcome these drawbacks and integrate into our thesis project a larger variety of pulse-based products, with different levels of transformation, a more realistic environment was created thanks to virtual reality: a supermarket. This virtual setting was used to study the visual attention directed towards pulses and to evaluate the efficiency of two strategies meant to increase pulses choices.

This chapter will present the two articles issued from these results. The two artciles are ready to be submitted:

***1)** Combining eye-tracking and virtual reality to understand consumer behavior in front of virtual supermarket shelves: a case study on pulses*

***2)** An exploratory study combining two strategies to increase the choice of pulse-based food products in a virtual supermarket.*

Combining eye tracking and virtual reality to understand consumer behavior using virtual supermarket shelves: a case study on pulses

To be submitted to: Journal of business Research

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Abstract

Despite numerous health and environmental benefits, the consumption of pulses in France has decreased over the past few decades. One potential barrier to pulse consumption may be their shelf placement in French supermarkets. We studied gaze behavior toward pulses in a virtual supermarket. Products from four food categories (animal-based, pulses, starches, and vegetables) were randomly presented on 4 shelves (canned, dried, ready-to-eat, and refrigerated). A composite super-shelf then combined the canned, dried, and refrigerated shelves. Gaze behavior was recorded for the 108 participants in two screening phases: (i) the four shelves one-by-one, (ii) the super-shelf. Pulses were not strong "eye-catchers": gaze behavior toward pulses varied from shelf to shelf. Similarly, visual attention was different for each food-group during super-shelf screening. These results could be used to implement specific strategies that should be developed in supermarkets to encourage the choice of pulses by consumers, and thus increase pulse consumption.

Keywords: virtual reality, eye-tracking, pulses, implicit, gaze behavior

1. Introduction

Currently, there is a worldwide shift toward a more sustainable diet. One of the trends is the reduction in the intake of animal proteins, while increasing plant protein intake. Consequently, a great diversity of food products made with plant proteins can be found on the market, including beef, milk, and cheese substitutes, made with soy, rice, and/or nuts. Pulses are also a sustainable alternative, but

remain under-consumed, especially in European countries. In France, pulse consumption in 2016 was only 1.7 kg per person (ANSES, 2017). Pulses are defined by the FAO (2016) as a leguminous crop that is harvested exclusively for its dry seed (i.e. beans, lentils, and dried peas). It excludes crops used mainly for oil extraction (e.g. soybeans) and those harvested green (e.g. green peas).

One of the barriers to pulse consumption may be linked to their shelf placement in French supermarkets. Pulses do not benefit from specific shelves in French supermarkets, whereas in the United Kingdom or the United States, retailers dedicate shelves specifically to plant proteins (Magrini, 2016). In France, pulses can be found in several different shopping areas in a supermarket, with different types of presentation: in the fresh fruit and vegetable area (uncooked pulses); beside the starch food-groups (uncooked pulses in a cardboard box); next to ready-to-eat dishes, in the canned food area (canned pulses); or even on the shelf specifically for international foods (Rio, 2017). This dispersal of pulses over many shelves in a supermarket seems to be linked to the great diversity of products containing pulses, which differ in type and in level of transformation. Following the NOVA classification (Monteiro et al., 2018), pulses can be divided into unprocessed food (e.g. uncooked lentils, beans, etc.), processed food (e.g. cooked pulses in cans, glass jars, vacuum-packed, etc.) and ultra-processed food (e.g. ready-to-eat dishes, etc.).

Conducting a study in a real-life retail environment, such as a supermarket, is a complex procedure, with many constraints (e.g. negotiating an agreement between researchers and store managers; having some control over the many possible environmental cues, etc.). To overcome these issues, Virtual Reality (VR) can be used to maintain control of the environment for each participant, by creating a higher ecological validity than in a laboratory setting (Hartmann & Siegrist, 2019). Virtual reality is a scientific and technical domain that uses computer science (both hardware and software) and behavioral interfaces (recording sensory motor information) to simulate a virtual world that interacts with the user in real time (Fuchs & Guitton, 2011). One of the advantages of VR is the possibility of creating different environments to study consumer behavior. In the last few years, virtual supermarkets have been developed to understand consumer food choices and purchases; they are valid tools to measure consumer behavior. The results obtained are comparable to those in real-life store settings (Pizzi et al., 2019; Siegrist et al., 2019; van Herpen et al., 2016). The types of product selected, the amount of money spent, consumer responses to price promotions (van Herpen et al., 2016), the products purchased, and the amount of time spent in front of a given shelf can all be measured with VR (Pizzi et al., 2019). With such approaches, researchers can obtain data without directly asking consumers about their behavior, motivations, or choices, and thus avoid potential biases linked to direct questioning. Additional technology, such as eye-tracking devices, has lately been used in the retail environment, to assess the visual attention of consumers, and their subsequent

choices (Bialkova et al., 2020). Eye tracking measures eye movement, either through the position of the eye relative to the head, or the orientation of the eye in space (Duchowski, 2007). When participants are not aware of the goal of the study, measurement of their gaze behavior is informative about their behaviors: "eye tracking can be regarded as an implicit measurement capturing automatic, involuntary, and unconscious reactions, which are not biased by conscious cognitive thinking" (Duerrschmid & Danner, 2018, p. 281). Visual attention can be influenced by many other factors (Orquin & Mueller Loose, 2013), which may be bottom-up (e.g. image saliency, shape, color, number of images, etc.) or top-down (goal-driven attention, task instruction, individual preference). Combining VR with eye-tracking devices has been identified as an opportunity to better understand consumer behavior in a shopping environment (Meißner et al., 2017). To our knowledge, only one study to date, carried out by Siegrist et al. (2019), has combined VR and eye-tracking measures. These authors compared the purchasing behavior of consumers toward breakfast cereals, in front of a real-life supermarket shelf, and a VR supermarket shelf, by measuring the impact of nutritional information on consumers' gaze behavior. Results showed that participants had similar gazing behaviors in both real-life and virtual supermarkets.

Our study sought to explore the behavior of French consumers toward pulses, in a virtual food-shopping situation. Using a VR setting, we immersed participants in a virtual supermarket and studied their gaze behavior by eye-tracking technology. Our objectives were (i) to understand how consumers' visual attention is affected by the composition and organization of several different shelves in front of them; (ii) to compare the gaze behavior of consumers toward pulse-based products and toward products from other food-groups. We hypothesized that (H1) the visual attention of consumers toward pulses would vary according to the content and organization of the shelf presented to them. Our second hypothesis (H2) was that the visual attention of consumers would be lower toward pulses than toward other food-groups, when all food-groups were present in equal quantities on the shelf.

2. Materials and Methods

2.1. Participants

Participants (N = 120, aged between 20 and 65) were recruited from the Chemosens Platform's PanelSens database. This database complies with national data protection guidelines, and has been examined by French National authorities (Commission Nationale Informatique et Libertés – CNIL – 135 n = 1,148,039). The study was conducted in accordance with the Declaration of Helsinki and was approved by the local ethical committee of INSERM N°18-506. Institutional Review Board INSERM (CEEI/IRB) (IRB00003888, IORG0003254, FWA00005831).

The inclusion criteria for the study were to be resident in Dijon, to read, write, and speak French fluently, and to buy food in a supermarket at least once a month. The exclusion criteria were to have visual problems, to need thick eyeglasses with strong corrective lenses, to be prone to dizziness, or to follow a restrictive food diet (e.g. vegetarian, vegan, without gluten, without lactose, etc.).

Participants were convened to the study under false pretenses (i.e. to participate in a virtual reality study), in order to avoid having participants focus on pulses, which could bias their gaze behavior. At the end of the study, participants were given full information about the real objectives of the study, and were also given a €20 voucher.

Twelve participants were excluded from the study, after data collection. For ten of them, a technical problem prevented the data from being recorded. Another participant did not follow the instructions correctly, and one participant guessed the real aim of the study. Table 1 shows the characteristics of the 108 participants finally included in the study.

Table 1. Distribution of participants in the study, by age range and sex

Age	Women	Men	Total
20–35	17	15	32
36–50	24	20	44
51–65	16	16	32
Total	57	51	108

2.2. Construction of the virtual environment

2.2.1. *Selection of the food products placed on each virtual shelf*

Field observations in French supermarkets identified pulse-based food products. Four shelves were identified where the presence of pulses was more prominent: the canned goods shelf, the dried goods shelf, the refrigerated shelf, and the ready-to-eat shelf. A virtual environment was created to reproduce each of these shelves, and their composition was as similar as possible to the real-life composition of shelves in French supermarkets. (Figure 1).

Figure 1. Example of the visual design of the four shelves built for the experiment

All the products presented on the virtual shelves were products actually available in supermarkets at the time of the study. In total, 64 products were included in the experiment, sorted by food-group as follows:

- Foods from animal sources (including meat, fish, chicken, sausage, cheese, eggs, and cream), which will be referred to as animal-based products throughout this paper.
- Pulses (including lentils, dried beans, chickpeas, and dried peas)
- Starches (including pasta, rice, wheat, quinoa, and potatoes)

- Vegetables (including lettuce, tomatoes, carrots, green beans, mushrooms, spinach)

The products used in our study were selected so as to represent each food-group equally, and level of transformation, following the NOVA classification (Monteiro et al., 2018) was also taken into account (Table 2). When several references were available for a specific product, the selected product was chosen so that its color and shape would not be too different from the other products on the virtual shelf, in order to avoid possible bias related to the color or shape of the product.

Table 2. Construction of the canned, dried and refrigerated shelves

Food-groups	**Canned shelf**	**Dried shelf**	**Refrigerated shelf**	**Total "Super-shelf"**
Animal-based	2	-	10	12
Pulses	4	6	2	12
Starches	2	10	-	12
Veggies	8	-	4	12
Level of transformation				
Unprocessed	-	15	9	24
Processed	16	1	7	24

The specific food products selected were not all available from a single supermarket, so products were purchased from several French supermarkets. All products were photographed and then integrated into the virtual supermarket using a specific 3D software program. All indications about expiry date and price were removed. All the products were presented in multiple exemplars, to fill a shelf seemingly as large as a real-life supermarket shelf. This virtual environment was directly installed on the phone as a virtual application.

2.2.2.*Creation and composition of virtual shelves*

Four different shelves were created: "canned", "dried" "refrigerated", and "ready-to-eat". The first three contained products from a single food-group (starches, animal-based, pulses, or vegetables), either unprocessed or processed (Table 2). Products on the ready-to-eat shelf were all based on two major ingredients, belonging to different food-groups (Table 3), and were all classified as ultra-processed, according to the NOVA classification.

Table 3. Construction of the ready to eat dishes shelf

Food-groups		Total
Animal-based + Pulses		4
Animal-based + Starches		4
Animal-based + Veggies		4
Plant-based	Starches + Pulses	2
	Veggies + Pulses	2

The position of a food product on the shelf may influence consumers' visual attention (Duerrschmid & Danner, 2018). To avoid any potential order-effect bias, we designed four product organizations for each shelf, by changing the respective position of each food-group on the shelf (Figure 2). The R planor Package (Kobilinsky et al., 2016) was used to balance presentation order, and the four shelf organizations across participants, using a superposition of two orthogonal Latin squares to obtain a Greco-Latin square.

Figure 2. Example of the four organizations of the canned shelf used in the test, to balance the position of food-groups across participants. Red is used for animal-based products, green for vegetables, blue for starches, and orange for pulses.

To test the second hypothesis in our study, a "super-shelf" was constructed by placing the canned shelf on the left, the dried shelf in the center, and the refrigerated shelf on the right (Figure 3). The shelves were always presented in this order, but the organization within each shelf was different across participants, as previously explained (Figure 2). Here, 48 different products composed the super-shelf. When divided into food-groups, the super-shelf contained an equal number of animal-based products, pulses, starches, and vegetables.

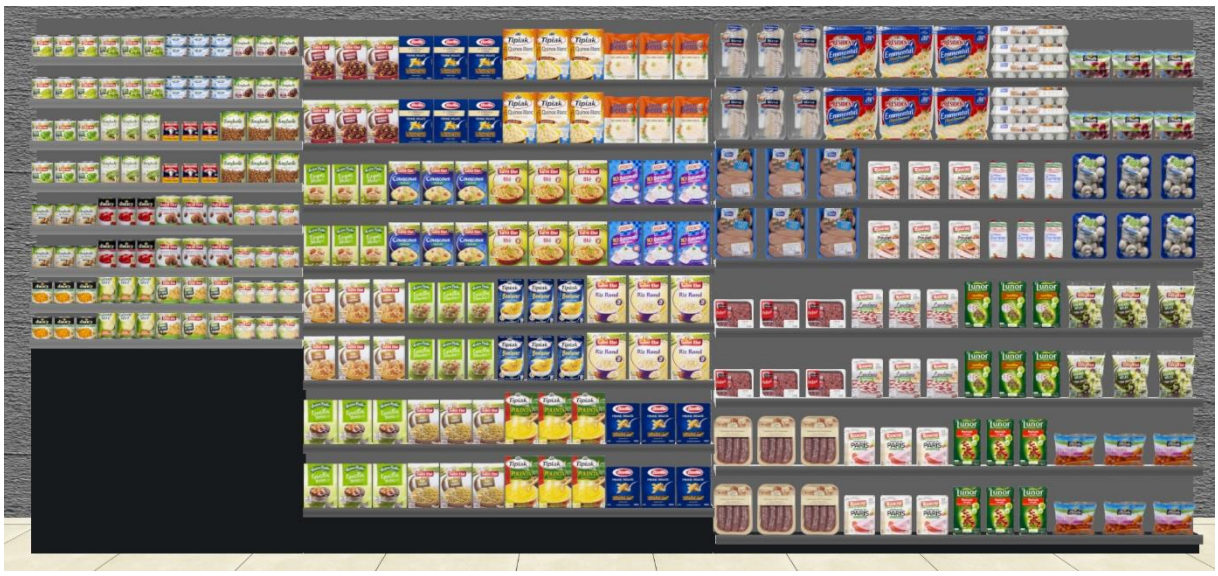

Figure 3. Example of a "super-shelf". From left to right: canned shelf, dried shelf, and refrigerated shelf

2.2.3. *Virtual Reality (VR) set up*

The Virtual Reality set up consisted of a Gear VR headset powered by Oculus, using a Samsung Galaxy S8. A Samsung hand controller was connected via bluetooth. The field of view in the headset was 101°, with an image resolution of 1480 x 1440 for each eye. For eye-tracking data, the movement of the head was used. The Strategir team developed a specific application to record the virtual eye-tracking data.

2.3 Sessions organization

2.3.1 Instruction to participants and familiarization with the device

A researcher received one participant at a time, in a neutral room of the laboratory, for a session that lasted about 15 minutes. Before starting the experiment, participants signed a consent form and were given a brief explanation regarding the material to be used (headset and hand controller). Participants were seated in a chair throughout the study. The researcher helped the

participant to put on and adjust the headset. Once ready, the participant was asked to read aloud the instructions that appeared in the virtual environment. This precaution was taken to ensure that all participants read all the instructions carefully. The session was divided into two phases: a screening of each shelf individually, and a screening of the super-shelf.

Before starting the study, a training phase was proposed to teach the participant how to use the controller, and to move through the virtual environment. The shelf used for this training phase contained hair-care products with neutral bottles (no brands, or names).

2.3.2 The Screening phase for each shelf individually

Participants had to observe the four different shelves (Figure 1) for a time-lapse of 20 seconds per shelf. A standardized distance of 1 m was fixed between each shelf and the participant. Participants were stopped in front of the center of each shelf at this distance. The instruction: "Observe the shelf in front of you" was displayed before each shelf appeared.

2.3.3 The Screening phase for the super-shelf

Once the participants had finished looking at the four shelves, they had to observe the super-shelf (see Figure 3) for a standardized time of 40 seconds. When the super-shelf appeared, participants were placed opposite its center, but participants were then able to move along the super-shelf in the virtual supermarket by using the hand controller, to get closer to the products, and/or to see one particular part of the super-shelf more closely.

2.4 Measures

Each zone delimitating a food-group on a shelf was determined as an area of interest (AOI). Each individual shelf contained four AOIs, as did the super-shelf. From the screening phases (individual shelves, and super-shelf), the following measures were obtained for each participant through the eye-tracking device:

- The first fixation (1st F): the first Area Of Interest (AOI) seen by each participant
- Time to first fixation (1st TF): time from the start of measurement until the beginning of the first fixation, for each AOI (in seconds)
- First fixation duration (1st Du): time spent on the AOI first fixed (in seconds)
- Total fixation duration (Du F): sum of all fixation durations within an AOI (in seconds)
- Total number of fixations (Nb F): number of fixations within an AOI (frequency)

Gazes shorter than 200 ms were not considered as fixations. A fixation duration was calculated when participants gazed at the same AOI at least two consecutive times for a period of 200 ms. All these gaze measures were obtained during the screening phase.

2.5 Statistical analysis

Calculations used RStudio Version 1.2.5042 (RStudio Team, 2020) with R-4.0.0 (R Core Team, 2020) with packages: “ez” (Lawrence, 2016), “agricolae” (de Mendiburu, 2020), “ PMCMR ” (Pohlert, 2014) and XLSTAT for Windows (Addinsoft, version 2018-1).

2.5.1 Gaze behavior

Descriptive statistics were used for data obtained during the screening phase of each individual shelf, as the number of food-groups within each shelf was not equal (Table 2). We transformed each measure to a ratio, obtained by dividing the raw measured value by the total number of food-products within each AOI. The size of a zone is proportional to the number of products it contains.

For data obtained during the screening of the super-shelf, we focused on the total fixation duration and the total number of Fixations. For the time measures, a one-way repeated measures ANOVA was performed, with total fixation duration as the dependent variable, AOI (food-groups) as the independent variable and participant as within-subjects. Assumptions (i) independent observations (or, more precisely, independent and identically distributed variables), (ii) the variables follow a multivariate normal distribution in the population (this assumption is not necessary if the sample size >= 25), and (iii) sphericity. When applicable, multiple pairwise comparisons were carried out with a Tukey test. For the total number of Fixations, Friedman tests followed by Nemenyi pairwise comparisons were run to determine if the differences between the total number of fixations were significant for a given food-group.

A significance level of 0.05 was set for all the analyses.

3. Results

3.1. Gaze behavior of consumer toward each individual shelf

In the screening phase, the visual attention of consumers toward each food-group was studied for each shelf independently. Table 4 shows the results obtained and transformed into ratios, taking into consideration the number of products within each AOI, for the canned, dried, and refrigerated shelves.

For the canned shelf, we can note that most consumers looked first at the vegetables, while many others looked first at starches. The time to first fixation was shorter for vegetables and longer

for animal-based products. The first fixation duration, the total fixation duration, and the total number of fixations were all shorter for vegetables, and particularly high for starches compared to other canned products.

On the dried shelf, there were only pulses and starches, because vegetables and meat are not products sold on dried product shelves in French supermarkets. Here, the first fixation of participants was a little higher for pulses than for starches. The time to the first fixation was shorter for starches than for pulses, but the first fixation duration, the total fixation duration, and the total number of fixations were all shorter for pulses than for starches.

The refrigerated shelf did not contain starches, like refrigerated shelves in French supermarkets. For this shelf, the participants looked first at vegetables. The time to the first fixation, the first fixation duration, the total fixation duration, and the total number of fixations were higher for pulses. The time to the first fixation was shorter for animal-based products than for other products, and the three other indexes were lower for vegetables.

Table 4. Gaze behavior in seconds converted into ratios (eye-tracking measures) of consumers toward each AOI (food-group) in the screening for the canned, dried, and refrigerated shelves. First fixation (1ST F, in %), Time to First Fixation (1ST TF, in sec), First Fixation Duration (1ST Du, in sec), and Number of fixations (NbF).

		Food-Groups (AOIs)			
Shelf	**Measures**	**Animal-based**	**Pulses**	**Starches**	**Vegetables**
Canned	1st F	10.61%	21.33%	31.82%	36.25%
	1st TF	2.45	0.7	0.25	0.14
	1st Du	0.9	0.5	4.15	0.34
	Du F	1.8	1.65	7.5	1.28
	Nb F	8.45	7.78	35.15	5.98
Dried	1st F	-	53.71%	46.29%	-
	1st TF	-	0.45	0.05	-
	1st Du	-	0.32	0.83	-
	Du F	-	0.93	1.50	-
	Nb F	-	4.40	7.03	-
Refrigerated	1st F	32.93%	2.67%	-	64.41%
	1st TF	0.13	2.65	-	0.93
	1st Du	0.46	0.8	-	0.38
	Du F	1.23	2.05	-	0.98
	Nb F	5.78	9.5	-	4.60

As the ready-to-eat shelf contained products combining multiple food-groups, the results were analyzed independently (Table 5). The first fixation of participants was more frequent toward pulses–veggies and less frequent toward pulses–starches. The time to first fixation was longer toward pulses and starches, and shorter for animal-based products–starches. The first fixation duration was longer for pulses–starches and shorter for animal-based products–starches and animal-based products–pulses. Finally, the total fixation duration, and the total number of fixations were higher for pulses–starches and lower for animal-based products–starches.

Table 5. Gaze behavior in seconds converted into ratios, eye-tracking measures of consumers toward each AOI (food-group) in the screening of the ready-to-eat shelf. First fixation (1ST F, in %), Time to First Fixation (1ST TF, in sec), First Fixation Duration (1ST Du, in sec), and Number of fixations (NbF).

VR Measures	Pulses–Starches	Pulses–Veggies	Animal-based–Starches	Animal-based–Veggies	Animal-based–Pulses
1st F	2.96%	33.06%	24.84%	18.09%	21.05%
1st TF	2.2	1.8	0.7	0.9	0.78
1st Du	0.7	0.5	0.43	0.53	0.43
Du F	2.1	1.5	1.3	1.35	1.5
Nb F	9.95	7	6.1	6.3	7

3.2. Gaze behavior towards the super-shelf

In a second step of the screening phase, consumers had to observe the super-shelf, where products from the four categories were presented in equal numbers. The first fixation was often for pulses and starches, and less frequently directed toward vegetables. This result needs to be considered with caution, because the dried shelf, composed of pulses and starches, was positioned in the center of the super-shelf for all participants. Therefore, participants had these products just in front of them when they ”stoodd” in front of the middle of the shelf, and the first fixation for these products could perhaps be explained by a positioning effect. Unfortunately, this positioning bias could not be avoided when designing the experiment, because of technical limitations that prevented any possibility of randomizing the position of the individual shelves within the super-shelf. Thus, in this case, the first fixation may not be informative and needs to be considered with caution, as well as the time to first fixation and first fixation duration, which directly depend on the first fixation. Here, the first fixation duration was similar across food-groups.

Consequently, to address this drawback and to measure if there were differences in the gaze behavior of participants toward the different food-groups on the super-shelf, we focused on the total duration of fixation and the total number of fixations. The repeated measures ANOVA showed significant differences between the total fixation duration and the food-groups ($p < 0.0001$). Pairwise comparisons obtained by a Tukey test (Figure 4) show that participants spent significantly more time looking at the products from the starches food-group, compared to the animal-based ($p = 0.013$) and vegetable food-groups ($p < 0.0001$). Participants observed for a longer time the pulses ($p = 0.000$) and the animal-based food-group ($p = 0.013$) compared to the vegetable food-group.

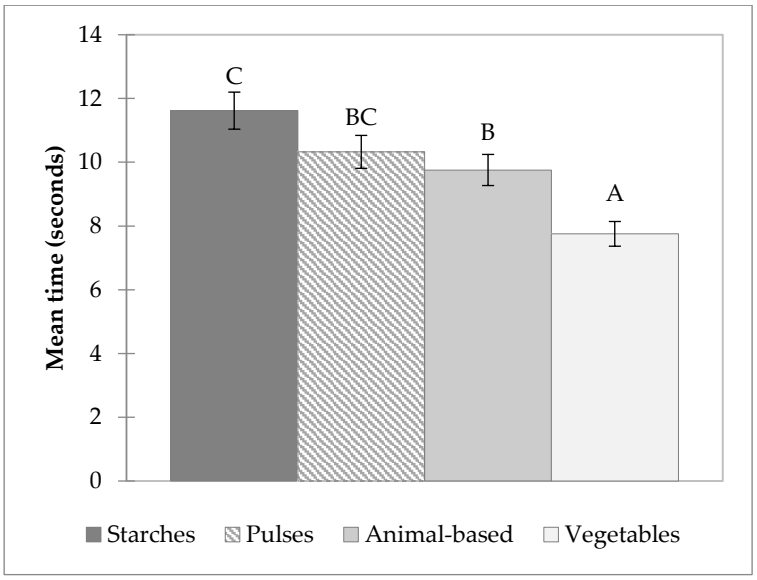

Figure 4. Mean time of total fixation duration. Products with the same letter were chosen with comparable frequency (pairwise Tukey test; $p < .05$).

Regarding the total number of fixations, results from the Friedman test showed significant differences among food-groups ($p < 0.0001$). Figure 5 shows that the starches had a higher number of fixations than the animal-based and vegetable food-groups. Pulses had a higher number of fixations than the vegetable food-group.

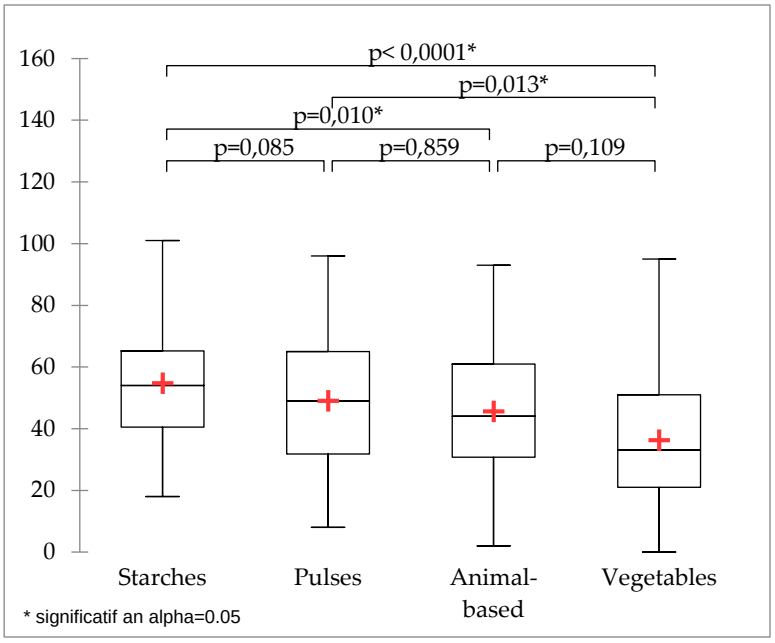

Figure 5. Box plot of the mean number of fixation for each food-group. Letters indicate a comparable number of fixations across food-groups (two-tailed Nemenyi test; p < .05).

4. Discussion

The objective of this study was to understand the gaze behavior of French consumers toward pulses in front of virtual shelves. First, participants in this study had to perform a screening of four different shelves, to understand how consumers' visual attention is affected by the composition and organization of different shelves. Then participants had to perform a screening of a super-shelf, composed of three out of the four shelves (canned, dried, and refrigerated) to compare the gaze behavior of consumers toward pulses with their gaze behavior toward other food-groups.

4.1. Does visual attention change in relation to the shelf presented?

In our study, the first fixation for a specific type of product seemed to change across shelves. In the two individual shelves where vegetables were present, they were fixated first by many participants. This suggests that attention is oriented in priority toward vegetables. In these individual shelves, pulses were rarely fixated first. By contrast, on the dried shelf, where there were no vegetables, about half the participants directed their first gaze toward pulses, and the other half toward starches. Knowing that on this shelf, there were only unprocessed pulses and starches, this result suggests two possible explanations: (i) participants' visual attention was attracted by unprocessed pulses more than by cooked and prepared pulses, and (ii) the attention toward a certain

category of products depends on the other products presented on the same shelf. Regarding the ready-to-eat shelf, the first fixation of participants was more frequently directed toward products that combined pulses and vegetables. This seems surprising, because we expected that products combining pulses and animal-based products would attract participants' visual attention, as ready-to-eat products containing pulses are generally combined with animal-based products in French supermarkets. One potential explanation of the visual attention toward vegetables on all shelves could be based on a particularly strong mental representation of vegetables for French consumers. Indeed, in the recent decade there has been a lot of public health communication promoting vegetables.

By contrast, less visual attention was directed toward products that combined pulses and starches. An effect of unfamiliarity or novelty of products for participants could explain this result. These products have only recently become available in French supermarkets, to offer consumers plant-based products as meat substitutes, because of their high-quality protein content.

Another informative measure is the time to the first fixation: the shorter this time, the "greater the capacity of the graphic properties of the area to attract visual attention" (Leon et al., 2020). In our study, the time for the first fixation varied greatly. It was short when the first product fixated was starches (dried shelf), pulses (canned shelf), and animal-based products (refrigerated shelf), while it was longer for pulses (dried shelf and refrigerated shelf) and animal-based products (canned shelf). The time to first fixation could be influenced by the composition of each shelf: as the number of products of each food-group was not the same, it may take longer to fix the gaze on a food-group represented by a smaller zone on the shelf. For the ready-to-eat shelf, the time until the first fixation was shorter toward products combining animal-based products and starches and longer toward products combining pulses and starches.

In our study, the total fixation duration and the total number of fixations were lower for pulses and higher for starches on the dried shelf. On the canned shelf, pulses are in second place after vegetables with a lower number of fixation and fixation duration values. By contrast, the total duration fixation and the total number of fixations were shorter for vegetables and higher for pulses on the refrigerated shelf. The total duration fixation and the total number of fixations for the ready-to-eat shelf was higher for products that combine pulses and starches and lower for products that combine animal-based products and starches. Hence, participants in our study looked at pulses differently on each shelf, either for long or shorter periods, showing that with the same instructions and the same time of screening, visual attention changed across shelves. These results suggest that shelf organization and presentation have an impact, yet some differences were observed between the different measures (first fixation, the time to the first fixation, the total number of fixations, and the

total duration of fixation). For instance, it may seem that the first fixation toward pulses was higher for the dried shelf, but the time to the first fixation was also higher, whereas the total fixation duration and the total number of fixations were lower. Those results may suggest that even though pulses are fixated first for the dried shelf, the overall visual attention of participants is lower. By contrast, for the ready-to-eat shelf, the products combining pulses and starches had lower first fixations but a longer time to first fixation, and a higher total number of fixations and total fixation duration.

These differences in visual attention in relation to the composition of the shelf may also be explained by the duration of the screening phase, set at 20 seconds. In a previous eye-tracking study investigating visual attention toward high calorie, low-calorie food, and non-food products for a standard six seconds, the authors found an overall visual preference (longer fixation) toward high-calorie food only in the first second, followed by a shift in visual attention which developed toward the low-calorie products (Potthoff & Schienle, 2020). This could explain why we found differences between the first fixation and the other measures, highlighting also the need to study first fixations with caution. Based on these considerations, we consider that our first hypothesis (H1: the visual attention of consumers toward pulses would vary according to the content and organization of the shelf presented to them) seems to be validated. The visual attention of French consumers toward pulses varies according to the type of shelf on which pulses are presented. Pulses attract less visual attention, which could perhaps decrease their chances of being chosen by consumers later.

4.2. Does visual attention differ toward pulses and foods from other groups?

The design of the super shelf in our study allowed us to compare the gaze behavior of consumers toward pulses with their gaze behavior toward the other food-groups. The super-shelf was constructed so that the equal number of products was equal for each food-group (starches, pulses, vegetables, and animal-based products). Participants in our study had different gaze behavior toward each food-group. They observed pulses more often and for a longer time than they observed the vegetable food-group. Thus, our second hypothesis (H2: the visual attention of consumers would be lower toward pulses than toward other food-groups, when all food-groups were present in equal quantities on the shelf) is not validated. By contrast, pulses tend to attract the visual attention of consumers more than other products. A recent study (Gere et al., 2020) has shown that product group influences gaze behavior (top-down processes) more than the perception of the color or size of a product (bottom-up processes). A previous eye-tracking study also found that participants had different fixation durations toward two different food-groups (milk chocolate and orange juice). The authors observed longer fixations toward the nutritional table for the orange juice, whereas for milk chocolate, participants looked longer at the brand (Steinhauser et al., 2019). This result suggests that

participants spend more or less time on a product depending on the characteristic of the products that interests them the most. In our study, we erased specific information such as price and expiry date from packaging, thus lessening this effect. But it cannot be excluded that participants in our study could pay more or less visual attention to a particular food-group, focusing on a characteristic meaningful to them. It has also been shown that personal preferences toward food with different forms (regular, chopped, or blended) can increase the total number of fixations and the total fixation duration (Yasui et al., 2019). Thus, we could imagine that the personal preference of consumers toward the products on the super-shelf may have influenced their gaze behavior.

4.3. Perspectives: What could be done to increase visual attention toward pulses in French supermarkets?

With our experimental design, we constructed different shelves that reflect what can be found in French supermarkets, but with a limited number of products. Our results highlighted that the gaze behavior of participants toward pulses on each shelf was different. In two out of the four shelves, visual attention was lower for pulses than for other food-groups, whereas for the super-shelf, participants looked at pulses less often than at starches. Now, imagine in a real supermarket where the number of food products is greater, pulses could become lost amongst all the other products. Therefore, based on our results, we think that one strategy to increase visual attention toward pulses in a French retail environment would be to find a way to group pulse-based products as much as possible on a single shelf. For example, pulses on the refrigerated shelf do not always need refrigeration, for example, those that are vacuum-packed. They could easily be grouped with products from the dried shelf, for example. It might be advisable to create collaboration between national brands of pulses, as it has been demonstrated that consumers find specific products on a shelf faster when they have a clear picture of the desired brand in mind (Burke & Leykin, 2014). Thus, consumers can be oriented in decision-making about pulses by reducing their mental effort. Directional cues, such as a right or left arrow beside a food product, can influence participant gazing behavior and it can be used to guide attention toward a product thus affecting later choices (Vriens et al., 2020). Other strategies like nudging have been identified, to impact consumer behavior. A nudge is defined as “any aspect of the choice architecture that alters people’s behavior predictably, without forbidding any options or significantly changing their economic incentives. To count as a mere nudge, the intervention must be easy and cheap to avoid.”(Thaler & Sunstein, 2008). Using visual nudges on the shelf, in the shopping cart, on the floors of supermarkets, or even at the checkout would be low-cost strategies but might well encourage consumers to choose pulses more often.

In eye-tracking studies, it is often supposed that the first fixated product would be the chosen one (Duerrschmid & Danner, 2018). Nevertheless, other authors have found that first fixation was not always consistent with product choice, independently of presentation. First fixation has been identified as not having any influence on consumer food choice, suggesting that the location of first fixation could be driven by visually salient products that attract the first fixation but that do not become the consumer's final choice (Gere et al., 2020; van der Laan et al., 2015). Instead, it was found that, when a product was chosen, participants had a higher number of fixations and a longer fixation duration (Gere et al., 2020). Other studies confirm that participants in an eye-tracking study increased their number of fixations and total fixation duration when they had to choose a food product during the experience (Danner et al., 2016).

4.4. Strengths and limitations

Some key drivers of attention toward a product have been identified when shoppers are just browsing at a shelf: shelf position, product presentation, proximity between categories, and visual distinction (Burke & Leykin, 2014). One strength of our study is its rigorous methodological aspect. Four different shelves were identified in the French supermarkets and re-created in a virtual environment. Participants were asked only to observe each shelf for a limited time, but were not asked to choose a product. While participants were screening each shelf, eye-tracking measures were obtained. One of the advantages of this type of assessment is that it can provide information about the possible reasons for consumer choices when exposed to a specific shelf organization, without any explicit instructions.

To protect against bias linked to a tendency to look preferentially at a specific zone, we balanced the position of the four groups of products on each individual shelf between participants, so that the measured differences in gaze behavior cannot be the result of product positioning. Our results showed that the first gaze of participants tended to be directed toward the zone located on the upper left side of the shelf (results not shown). Products positioned in this zone tend to be looked at first. Thanks to the balanced design of our study, we were able to overcome this tendency, and could therefore compare gaze behavior toward each zone of interest without any bias.

Product presentation was controlled on each shelf: on the canned shelf, only metallic cans; in the dried shelf, only cardboard; on the refrigerated shelf, only products with transparent plastic presentation, and on the ready-to-eat shelf, mainly canned products (with one exception). We also tried as much as possible to balance the different colors of product packaging on each shelf so as not to attract visual attention. Consequently, we observed that the gaze behavior measures do not depend on the positioning of food-products on each shelf. We were able to observe more realistic behavior of

consumers toward pulses in a virtual retail environment. However, unfortunately, one of the limitations is that we were not able to study the first fixation for the super-shelf, as the dried shelf was always placed in the center and the position of participants was always initially the same, in the center of the super-shelf. This limit will probably be overcome as technology progresses.

5. Conclusions

Overall, the implicit measures by eye tracking allowed us to identify the gaze behavior of French consumers toward pulses in a virtual supermarket, on four different shelves and in a super-shelf. We found that pulses were not great eye-catchers, especially for the dried and canned shelves, yet they created visual interest (consumers looked at them for some time) o, the refrigerated shelf and on the ready-to-eat shelf, revealing that visual attention toward pulses changes according to the organization of the shelf to which a consumer is exposed. In the screening of the super-shelf, pulses attracted more visual attention than vegetables but less than starches and animal-based products, which suggests differences in gaze behavior in relation to food categories. Participants allocated visual attention differently to each food-group. There is a need to develop adapted strategies in French supermarkets to incentivize consumers to choose pulses more frequently in their shopping behavior. For instance, a specific shelf for pulses could result in a more salient visual option for pulses, making them easy to find and identify; creating cues such as arrows marking the presence of a pulse product on a shelf, or implementing nudging strategies inside the retail environment.

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An exploratory study combining two strategies to encourage consumers to choose pulse-based food products in a virtual supermarket

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Abstract

Whereas pulses can be consider as interesting products to shift toward a more sustainable diet, their consumption in France remains low. This exploratory study aimed to find efficient ways to incite consumers to choose pulses, using two strategies: evoked scenarios underlying different motivations and nudge-based strategies (health-oriented or pleasure-oriented). The present study used (VR) to mimic a supermarket, allowing us to observe consumer behavior in a realistic food-choice environment. A total of 108 participants took part in two individual sessions. They performed two tasks: (i) Screening: participants observed a shelf and their gaze behavior was recorded; (ii) Food choice task: participants had to choose three food products from the supermarket shelf to compose a dish, according to different evoked scenarios. Results indicated that the nudge strategies had no impact on total fixation length, but did have an impact on the total number of fixations toward pulses. Pulses were chosen more often in the environment-oriented scenario, but other scenarios had no effect. The choice of pulses did not increase when participants were exposed only to nudges. The combination of the two strategies (nudges and evoked scenarios) had an effect on the choice of pulses, but only for specific groups of consumers, in specific scenarios.

Keywords: virtual reality (VR), eye tracking, pulses, consumer behavior, food choices, nudges

1. Introduction

For several decades, there has been increased interest worldwide in encouraging healthy and sustainable food choices, with the global objective of producing enough food for the population, while decreasing malnutrition, and reducing the use of fossil fuels in agriculture (FAO 2016). To achieve these objectives, efforts have been made to promote foods such as pulses, perceived as key products to protect the environment, improve human health, and eradicate hunger. Their low glycemic index (Becerra-Tomás et al. 2018) means that regular consumption of pulses can decrease the risk of type 2 diabetes and coronary diseases (Bazzano et al. 2001). Pulse consumption has a satiating effect, so that pulses have a positive effect on weight maintenance (McCrory et al. 2010). Pulses are rich in plant proteins, fiber, and micronutrients such as iron, and are poor in fats (Foyer et al. 2016; Lecerf 2016; FAO 2016). Despite these numerous advantages, the consumption of pulses varies across the world. Some countries, such as Mexico, are big consumers, with 9.2 kg per person in 2016 (Rawal and Navarro 2019); in many countries, however, consumption is low: below 1.7 kg per person in 2016 in France (ANSES 2017). Changing consumer behavior toward pulses represents a major challenge to promote more sustainable food. However, changing consumer behavior is very difficult because it is driven by a combination of conscious and unconscious processes. Governments and national authorities often propose public education campaigns to change behaviors. Yet it has been observed that explicit campaigns usually have a limited effect on consumer behavior. For example, Osman and Nelson (2014) mentioned the limited effects of the national campaign to reduce red meat consumption in the UK, for health and sustainability reasons (Osman and Nelson 2019). Evaluating the results of such campaigns is difficult and prone to several biases. The authors highlighted that although consumers declared a decrease in meat consumption in a public survey of consumer attitudes, the national data concerning meat consumption remained at almost the same level. There is a mismatch between what consumers report and what they do, making it even more difficult to change consumer behavior.

As many food decisions are based on non-conscious mechanisms, explicit public health campaigns and direct recommendations to increase healthy eating do not always suffice to convince people to change their behavior. Consequently, other more indirect and subtle interventions, such as an adaptation of the environment, could be more efficient in directing consumers to make healthier choices automatically (Kroese, Marchiori, and de Ridder 2016). One of these alternatives is the use of “nudges”, which are considered to be “soft tools” to impact consumer behavior. The main difference between nudging and other interventions (e.g. education campaigns) is that nudging does not try to cause behavioral change through conscious processes (Marchiori, Adriaanse, and De Ridder 2017). A nudge, as explained by Thaler and Sunstein, is “any aspect of the choice architecture that alters people’s behavior in a predictable way, without forbidding any options or significantly changing their

economic incentives" (Thaler and Sunstein 2008). Nudges alter the environment by changing the presentation of options to consumers. This altered environment can consciously or non-consciously influence consumers, without removing options or changing economic incentives. There are different types in the classification of nudges. For instance, Hansen and Jespersen sorted nudges into four categories, based on the mode of thinking (automatic or reflective) and on the transparency of the nudge (if the user can see the intentions and means behind the nudge) (Hansen and Jespersen 2013). Other authors categorized nudges based on the changes implemented in the environment by providing (i) decision information, (ii) decision structure, or (iii) decision assistance (Münscher, Vetter, and Scheuerle 2016). Whatever the classification system, for a strategy to be considered a nudge, it must not entail telling consumers what to do. It will rather consist in understanding how consumers think, and in encouraging them to make better choices (John et al. 2013). Nudging must be cheap and easy to implement; it should not remove choice options, and it should benefit a more socially desirable choice (Purnhagen and Kleef 2017). While the concept of nudging is relatively new, its principles have been evident in marketing for decades, with retail environments altering the physical and mental availability of products through rearranging supermarket and shelf layouts, and placing promotional materials at the point of purchase.

In food science, nudges have been used to increase the choice of specific food items, such as fruits and vegetables (Broers et al. 2017), or to encourage healthier eating choices by increasing healthy food products or decreasing unhealthy ones (Arno and Thomas 2016). Nudge strategies have been implemented in different contexts: a breakfast buffet at a health conference (Wansink and Hanks 2013), snack shops at a train station (Kroese, Marchiori, and de Ridder 2016), a lab self-service buffet (Friis et al. 2017), a takeaway food vendor's (Cheung et al. 2019), a coffee shop (Dayan and Bar-Hillel 2011), and supermarkets (Kalnikaite et al. 2011). These varied examples show that nudging is a potentially powerful technique to trigger a behavioral change in real-life situations. However, as it is often difficult for researchers to have access to real-life specific locations (e.g. a train station, or a supermarket), nudge strategies can also be implemented in a laboratory setting, as long as the nudge can be tested in the most realistic environment possible, such as virtual supermarkets, or test restaurants (van Kleef and van Trijp 2018). To our knowledge, to date, no study has used a nudge-based strategy in a virtual retail environment. The interest of using Virtual Reality (VR) is that it becomes possible to control the desired environment across participants, creating a higher ecological validity, compared to a test in a laboratory setting (Hartmann and Siegrist 2019); it is therefore even closer to what exists in real-life situations.

To evaluate if a nudge-based strategy has been successful, researchers measure different outcomes, for example, an increase in the choice of products, sales, servings, and/or caloric

consumption. These measures reflect the efficiency of nudges on consumer behavior. The nudge effect can also be assessed by implicit measures, such as eye tracking, to better understand the mechanisms that underline and explain behavior. It is well known that, in the decision process, eye-movements will be driven by task instructions, or by food-product properties (visual salience) (Orquin and Mueller Loose 2013). As long as consumers are not aware of the main goal of the study, the eye-tracking technique provides an implicit measurement that captures automatic and involuntary reactions (Duerrschmid and Danner 2018). Several authors have shown a strong correlation between food choices and gaze behavior: people fixated the chosen product more often and for a longer time than other products (Danner et al. 2016; Gere et al. 2016). The combination of VR and eye-tracking devices represents a major opportunity to better understand consumer behavior in a shopping environment (Meißner et al. 2017).

In the present study, we designed a virtual environment reflecting a familiar real-life context: a supermarket. The VR set-up we used recorded the gaze behavior of participants as an implicit measure, and consumer food choices as an explicit measure. It is well known that consumers' food choices are highly context-specific (Osman and Nelson 2019), and that different motivations underlie food choices on different eating occasions (Phan and Chambers 2016). Using written scenarios to create evoked contexts of consumption is meant to help participants to imagine a situation (Hein et al. 2010; Melendrez-Ruiz, et al. 2019). It would therefore be interesting to evaluate the food choices made in a virtual supermarket across different scenarios that underlie different motivations for choices. A nudging strategy was used in parallel, with a picture presented in the virtual shopping cart, in order to test if this nudge would influence consumer food choices. According to the nudge classification proposed by Hansen and Jespersen, the nudge-based strategy we proposed is classified as "Prompting of reflected choice". Our goal was to "capture the visual search processes continuously performed by automatic thinking" (Hansen and Jespersen 2013).

Our main objective was to implement an exploratory study to increase the choice of pulses by French consumers in a virtual supermarket, where other food categories were also presented, using two strategies: scenarios that evoked different choice motivations; a nudge-based strategy. We hypothesized that: (H1) the gaze behavior of consumers toward pulses would be influenced by the nudge-based strategy; (H2) the nudge-based strategy would increase the choice of pulses; (H3) the choice of food products would vary according to the evoked motivation of choice; (H4) the combination of both strategies (nudges and evoked motivation of choice) would increase the overall choice of pulses.

2. Materials and Methods

2.1. *Recruitment*

Participants (N = 120, aged between 20 and 65) were recruited from the Chemosens Platform's PanelSens database. This database complies with national data protection guidelines, and has been examined by French National authorities (Commission Nationale Informatique et Libertés – CNIL – 135 n = 1,148,039). The study was conducted in accordance with the Declaration of Helsinki, and was approved by the local ethical committee of INSERM N°18-506. Institutional Review Board INSERM (CEEI/IRB) (IRB00003888, IORG0003254, FWA00005831).

The inclusion criteria for the study were to be resident in Dijon, to read, write, and speak French fluently, and to buy food in a supermarket at least once a month. The exclusion criteria were to have visual problems, to need thick eyeglasses with strong corrective lenses, to be prone to dizziness, or to follow a restrictive food diet (e.g. vegetarian, vegan, without gluten, without lactose, etc.).

Participants were invited to the study under a false pretense (i.e. to participate in a virtual reality (VR) study), in order to avoid biasing participants' behavior by focusing on pulses. At the end of the study, an investigation questionnaire was used to confirm that participants had not understood the real purpose of the study. Once participants had completed this questionnaire, they were entirely debriefed about the real objective of the study, and received a €20 voucher.

Twelve participants were excluded from the study, after data collection. For ten of them, a technical problem prevented their data from being recorded. Another participant did not follow the instructions correctly, and one participant guessed the real aim of the study. Table 1 shows the characteristics of the 108 participants finally included in the study.

Table 1. Distribution of participants in the study by age range and gender

Age	Women	Men	Total
20-35	17	15	32
36-50	24	20	44
51-65	16	16	32
Total	57	51	108

2.2. Virtual reality (VR) set up

The VR set-up consisted of a Gear VR headset powered by Oculus, using a Samsung Galaxy S8. A Samsung hand controller was connected via Bluetooth. The field of view in the headset was 101°,

with an image resolution of 1480 x 1440 for each eye. For eye-tracking data, the movement of the head was used. The Strategir team developed a specific application to record the virtual eye-tracking data.

2.3. Construction of the shelves for the virtual supermarket

All products were photographed and then integrated into the virtual supermarket using a specific 3D software program. All indications about expiry date and price were removed. All the products were presented in multiple exemplars, to fill a shelf seemingly as large as a real-life supermarket shelf. This virtual environment was directly installed on the phone as a virtual application.

A "super-shelf" was constructed by grouping in the same visual space three shelves commonly found in French supermarkets, presenting dried, canned, and fresh products. The canned shelf was presented on the left of the super-shelf, the dried shelf in the center, and the refrigerated shelf on the right (Figure 1). The shelves were presented in this order to all the participants, but the organization within each shelf was different across participants (for further details, please see (Melendrez-Ruiz et al., to be submitted). There were 48 different products composing the super-shelf. When divided into food-groups, the super-shelf contained an equal number of animal-based products, pulses, starches, and vegetables.

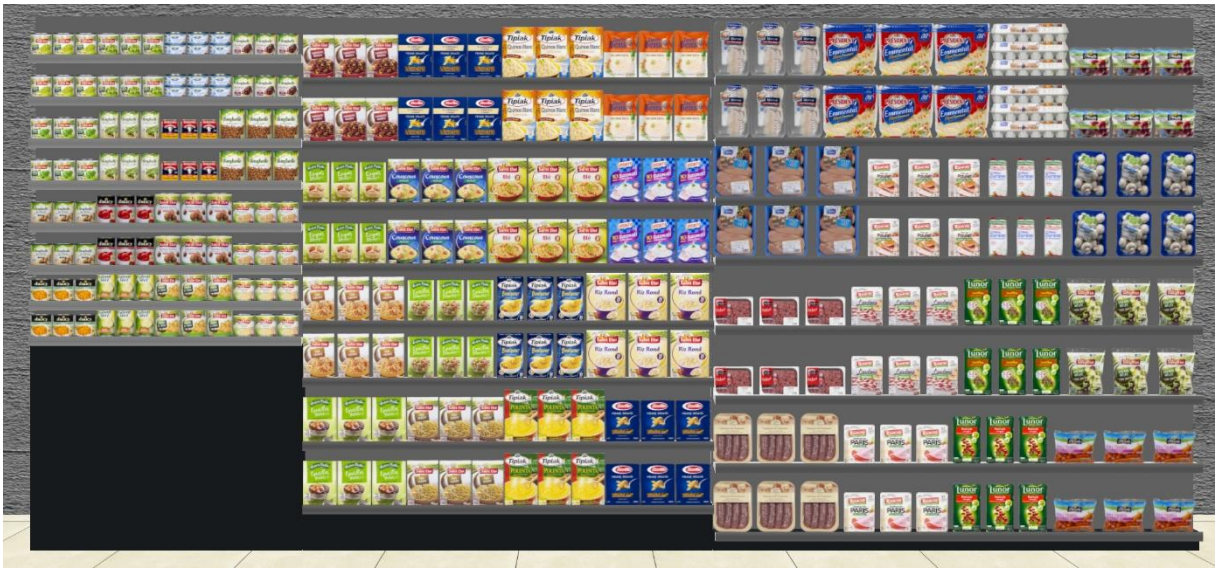

Figure 1. Example of display on the "super-shelf", with from left to right: canned, dried and refrigerated shelves

2.4. Use of scenarios to evoke food choice motivations

Four scenarios were created to evoke a particular motivation under which participants were invited to make food choices in the virtual supermarket (Table 2). The order in which scenarios were presented across participants was balanced by using a 4x4 William's Latin square.

Table 2. Scenarios used to evoke a motivation of choice

Scenario Title*	Script	Meant to
Everyday	Imagine you have decided to do your daily grocery shopping in this supermarket. Chose three products available on these shelves to build your main dish	Control condition
Well-being	Imagine you have decided to pay more attention to your health. Chose three products available on these shelves to build your main dish	Taking health issues into consideration
Environment	Imagine you have decided to pay more attention to preserving the environment. Chose three products available on these shelves to build your main dish	Taking environmental impact into consideration
Hedonic	Imagine you have decided to pay more attention to your cravings. Chose three products available on these shelves to build your main dish	The pleasure of eating

* The titles of the scenarios were not mentioned to participants. They will only be used to refer to the scenarios in this paper.

2.5. Creation of a nudge-based strategy

Two nudge-based strategies were created: one health-oriented, and the other pleasure-oriented. To do so, two images were created by writing down the words "Plaisir" (pleasure in English), or "Santé" (health, in English), using different types of pulses (e.g. beans, chickpeas, dried peas, brown lentils, and red lentils) to compose the letters of the words (Figure 2). The words were then photographed under the same lighting conditions, and were placed facing the participant inside the front of the shopping cart, in the VR setting (Figure 3). Our goal was to implement the nudging strategy without explicitly directing participants' attention to the presence of this nudge. Our nudging strategy is similar to those of other studies using social norm nudges placed in grocery carts to increase the demand for fruits/vegetables (Payne et al. 2015), or to increase the purchase of vegetables (Huitink et al. 2020).

Figure 2. Nudges used for the pleasure condition “plaisir”, and for the health condition “santé”.

Figure 3. Visual nudge placed in the shopping cart

We intended to attract the visual attention of consumers toward pulses, and thus measure the influence of nudges on consumers’ choice of pulses

2.6. Organization of the sessions

The 108 participants came to the laboratory for two different sessions, seven to ten days apart. The first session was used as a baseline, during which all participants were shown the same virtual environment and received the same instructions. The second session served to implement and evaluate the nudge-based strategy.

During the two sessions of the experiment, one researcher and one participant were installed in a neutral room. Participants were seated in a chair throughout the whole experiment. Before starting the study, participants signed the consent form. At the beginning of each session, a brief explanation was given regarding the material to be used (the headset and the hand controller). The researcher helped the participant to put on and adjust the head seat. Once the participant was ready, he/she was asked to read aloud the instruction that appeared in the virtual environment, to ensure that all participants would carefully read and understand all the instructions.

Both sessions were divided into a training phase (before starting the measurements), a screening phase, and a food choice task. The training phase was needed to teach participants how to use the controller, to move around the virtual environment, to pick up products from the virtual shelf, and to put them in the shopping cart. The virtual shelf used for this training phase contained hair and body care products, with no brands or names. During both sessions, participants used the same shopping cart from the beginning to the end of the session. The difference between the two sessions was that, in session 2, participants were exposed to a nudge. For this session, participants were divided randomly into two groups. Half of the participants (n=55) were exposed to a pleasure-oriented nudge-based strategy, while the other half (n=53) were exposed to a health-oriented nudge-based strategy.

2.6.1.Screening phase

Participants had to screen the super-shelf (see Figure 1) for a standardized duration of 40 seconds. The instruction given to participants was the following: "Simply observe the shelf in front of you". During this phase, participants were able to move in the virtual supermarket by using the hand controller, to get closer to or further from the super-shelf, so that they could look at a product or one part of the shelf more closely. All participants were centered in the middle of the super-shelf at the beginning of the screening phase.

2.6.2. Food choice task

In each session, the screening phase was followed by the food choice task. Participants stayed connected to the VR set-up, in front of the same "super-shelf", and the task was to select a product from this shelf. This task will be called the "food choice task" throughout this article, even though we are well aware that choices made in an experimental setting may not always reflect real-life choices. In our experiment, the choice of a product did not represent any commitment by participants to consume the chosen product.

The general instruction was for consumers to project themselves in a shopping context: "Imagine you are doing your grocery shopping in this supermarket, to prepare a meal that you would take in your usual environment, at home on a week-day". The first scenario was then presented on the screen. The four scenarios proposed are listed in Table 2. Participants had to observe the products available in front of them, and then choose three food products to compose a main dish, while taking into consideration the scenario they had just been given. Participants had to select the product they wanted by fixing their gaze on it. They then used the hand controller to grasp the selected product. They then validated their choice with the hand controller, to place the chosen product in the shopping cart. Once the participant had chosen three products to compose the first main dish, there was a pause of 10 seconds in front of a neutral environment (grey background). Then a new scenario was

presented. In total, each participant had to choose three food products for each of the four scenarios. Once they had finished this task, the session was over, and they were instructed to give the headset to the researcher.

2.7. Measures

We obtained two types of measurement: implicit measures (data collected by eye tracking during the screening phase), and explicit measures (triplet of products selected during the food choice task, in each of the four scenarios).

For the eye-tracking measures, areas containing products from the same food-group were defined as specific areas of interest (AOI). The super shelf contained four AOIs, each comprising either pulses, starches, animal-based products, or vegetables.

The following measures were obtained for each participant from the eye-tracking experiment:

- Total fixation duration (Du F): the sum of all fixation durations within an AOI (seconds)
- Total number of fixations (Nb F): number of fixations within an AOI (frequency)

Gazes shorter than 200 ms were not considered as fixations. A fixation duration was calculated when participants gazed at the same AOI at least two consecutive times, for a period of 200 ms. All these gaze measures were obtained during the screening phase.

The frequencies of choice for each product in each scenario were calculated from the data obtained during the food choice task.

2.8. Statistical analysis

2.8.1.Gaze behavior towards pulses in the screening phase

For the screening of the super-shelf, we focused on the total fixation duration (seconds) and the total number of fixations. First, we divided consumers by the type of nudge they were exposed to (health-oriented nudge or pleasure-oriented nudge). To study the total fixation duration, we performed one Wilcoxon tests, to compare the results from session 1 and session 2, for pulses by type of nudge. For the total number of fixations, we executed a Chi2 test, between session one and session two, for pulses by type of nudge.

2.8.2.Pulses choice in relation to nudges and sessions

To identify if there were significant differences in pulse choices between the sessions (Session 1 vs Session 2), we considered both types of nudge (health-oriented / pleasure-oriented). We carried

out two Wilcoxon tests to compare pulse choices between sessions in the control condition (i.e. everyday scenario).

2.8.3.Food choice task in relation to the four evoked scenarios

We obtained the frequency of choice for each food-group in the four different scenarios. We performed a Friedman test for each food group (4 in total) in Session 1. Four different Friedman tests were performed, followed by multiple pairwise comparisons (two-tailed Nemenyi test).

2.8.4.Combination of the two strategies: nudges and scenarios

Participants were grouped into different clusters based on their pulse choice, taking into account all scenarios in both sessions. To form the clusters, we constructed a conjunctive table. The participants were in rows, and the eight conditions in columns (each scenario in each session), with values 1 or 0 (1 if pulses were chosen, and 0 if pulses were not chosen). From this conjunctive table, we performed a Multiple Correspondence Analysis (MCA). We then performed a Hierarchical Cluster Analysis on the principal components of the MCA (participants). Once the different clusters were identified, we studied the choice of pulses in each cluster, for Session 1 and Session 2. We performed several Wilcoxon tests to see if there were significant differences between the choices made by participants toward pulses in the two sessions. These tests were performed for each cluster in each scenario, and then for each type of nudge. Finally, four separate Chi2 independence tests were performed between clusters, for age, sex, level of education, and weekly consumption of pulses.

The confidence interval was set at 95% for all the analyses. The XLSTAT for Windows program (Addinsoft, version 2020-1) was used for both univariate and multivariate analyses.

3. Results

3.1. Characteristics of participants exposed to health-oriented and pleasure-oriented nudges

As the 108 participants were randomly divided according to the type of nudge, 55 participants were exposed to the pleasure-oriented nudge, and 53 participants were exposed to the health-oriented nudge. We performed four independent Chi2 tests to verify if there were differences among participants exposed to each type of nudge (pleasure or health-oriented), regarding their personal characteristics. We found no significant differences for gender ($p=0.434$), age ($p=0.280$), level of education ($p=0.698$), or weekly consumption of pulses ($p=0.858$).

3.2. Comparison between the two sessions for gaze behavior in the screening phase

We sought to identify possible differences in the gaze behavior of consumers toward pulses, between Session 1 (with no nudges) and Session 2 (with nudges). The presence of nudging strategies

in Session 2 was the only difference between the two sessions. Thus, we analyzed differences in total fixation duration and total number of fixations between the two sessions in relation to the type of nudge.

From the Wilcoxon test, we found that the total fixation duration of consumers toward pulses between the two sessions was not different, whatever the nature of the nudge: health-oriented ($p = 0.184$), or pleasure-oriented ($p = 0.800$). By contrast, the total number of fixations toward pulses was significantly lower in Session 2 compared to Session 1, for both types of nudges: health-oriented and pleasure-oriented (Figure 4).

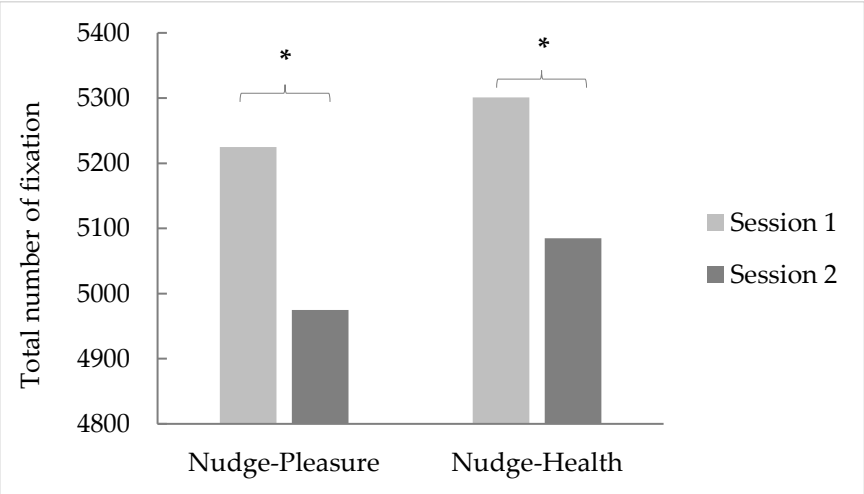

Figure 4. Total number of fixations toward pulses in each session, by type of nudge (pleasure-oriented and health-oriented). The asterisk * indicates a value significantly higher or lower than the theoretical value (Chi2 test; p-value <0.05).

3.3. *Comparison between the two sessions for the food choice task*

We compared the choice of pulses made by participants in the control condition (i.e. everyday scenario) between Session 1 and Session 2. Results from the Wilcoxon tests showed that there was no significant difference, whether for the group of participants exposed to the health-oriented nudge ($p=1$), or for those exposed to the pleasure-oriented nudge ($p=0.157$).

3.4. Comparison of the food choice task across to the four scenarios

The choices made by participants were grouped into different food groups. Considering all scenarios together, participants mainly chose animal-based products (39% of total choices), followed by vegetables (30%), starches (22%), and finally pulses (9%). Four Friedman tests were performed (one per food-group), followed by multiple pairwise comparisons (Figure 5). Consumers chose animal-based products ($p < 0.0001$) and starches ($p < 0.0001$) significantly more often in the everyday and hedonic

scenarios, than in the well-being and environment scenarios. By contrast, vegetables ($p < 0.0001$) were chosen significantly more often in the well-being and environment scenarios than in the hedonic and everyday scenarios. The pulse food-group was chosen significantly more often in the environment scenario than in the everyday scenario. The mean time spent by consumers choosing three products per scenario was 62.5 seconds in the everyday scenario, 67.8 seconds in the well-being scenario, 90.4 seconds in the environment scenario, and 63.1 seconds in the hedonic scenario.

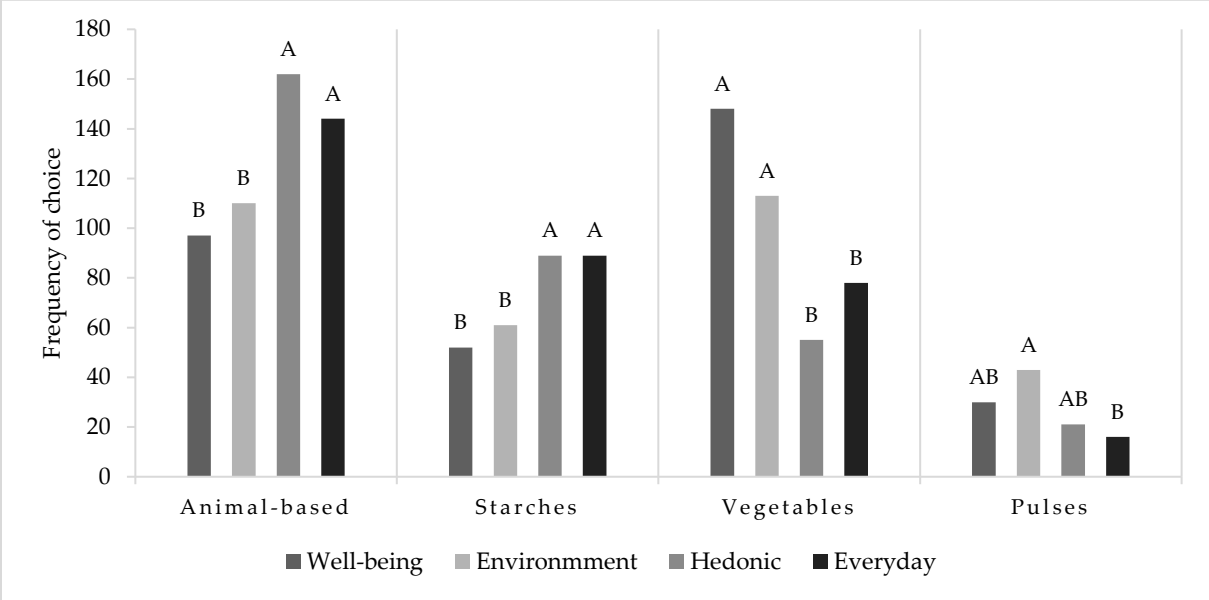

Figure 5. Frequency of choice of each food-group across the different scenarios. Within each food group, similar letters for different scenarios indicate that the frequency of choice was comparable in these scenarios (two-tailed Nemenyi test; $p < .05$).

3.4. Choice of pulses combining both strategies: scenarios and nudges

To test whether a nudge-based strategy and different motivations for choice (scenarios) could exert an impact on participants' pulse choices, we performed a Hierarchical Cluster Analysis base on the choice of pulses between Session 1 and Session 2. We obtained four different clusters.

Table 3 indicates that participants in cluster 1 are well balanced across the different characteristics. Cluster 2 is composed of the same percentage of women and men, with more participants with a higher level of education (55%), a declared higher weekly consumption of pulses (55%), and 50% aged between 36 and 50 years old. Cluster 3 is composed of more participants with a lower level of education (66%), who declared that they did not consume pulses on a weekly basis

(66%), mostly aged between 36 and 50 years old. Cluster 4 is mainly composed of women (62%), with more young participants (20-35), with the same percentage (50%) for level of education and declared weekly consumption.

Table 3. Characteristics of each cluster for sex, age, level of education, and weekly consumption of pulses (Chi2 tests; p-value <0.05).

		P-value	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Gender	Women	0.688	52.0%	50.0%	44.4%	62.5%
	Men		47.9%	50.0%	55.5%	37.5%
Age in years	20–35	0.507	27.0%	33.3%	22.2%	37.5%
	36–50		37.5%	50.0%	55.5%	29.1%
	51–65		35.4%	16.6%	22.2%	33.3%
Education level	Higher	0.518	52.0%	55.5%	33.3%	50.0%
	Lower		47.9%	44.4%	66.6%	50.0%
Consumption	Weekly/No	0.578	54.1%	44.4%	66.6%	50.0%
	Weekly/Yes		45.8%	55.5%	33.3%	50.0%

Regarding the choice of pulses made by participants in each cluster across the different scenarios, we found that participants in cluster 1 chose pulses significantly more often in Session 2 in the well-being scenario. Participants in cluster 2 chose pulses significantly more often in the everyday scenario (i.e. control) in Session 2. In cluster 3, participants did not choose pulses, whatever the session or scenario. Participants in cluster 4 chose pulses significantly less often in the well-being and everyday scenario (i.e. control) in Session 2 (Table 4)

Table 4. Choice of pulses across scenarios for each cluster in Session one (S1) and Session two (S2). N= number of participants (Wilcoxon tests; p<0.05).

Scenario/ Session	Cluster 1 (n=48)			Cluster 2 (n=18)			Cluster 3 (n=18)			Cluster 4 (n=24)		
	S1	S2	P value	S1	S2	P value	S1	S2	P value	S1	S2	P value
Well-being	3	15	0.001	8	6	0.527	0	0	N/A	19	3	0.000
Environment	25	29	0.480	7	7	1.000	0	0	N/A	11	12	0.705
Hedonic	13	14	0.841	5	3	0.414	0	0	N/A	2	0	N/A
Control	4	1	0.083	1	20	<0.0001	0	0	N/A	10	0	0.002

As two different nudge-based strategies were used, health-oriented or pleasure-oriented, we thought it would be interesting to divide our four clusters into each type of nudge. However, as the number of participants in each sub-group was low, the following results must be taken with caution, and will be further considered as a tendency to be confirmed. During Session 2, participants in cluster 1 chose pulses more often in the well-being scenario with the health nudge ($p = 0.005$, $n=24$), while those exposed to the pleasure nudge did not increase their choice of pulses ($p=0.102$, $n=24$). Participants in cluster 2 chose pulses more often in the everyday scenario with the health nudge ($p = 0.011$, $n=7$), and with the pleasure nudge ($p = 0.002$, $n=11$). Participants in cluster 4 chose pulses less often in the well-being scenario with the health nudge ($p = 0.003$, $n=14$), and with the pleasure nudge ($p=0.020$, $n=10$). They also chose pulses less often in the everyday scenario with the health nudge ($p = 0.025$, $n=14$), and with the pleasure nudge ($p = 0.025$, $n=10$).

4. Discussion

This exploratory study aimed to increase the choice of pulses by French consumers in a virtual supermarket, where products from different food groups were presented, using two strategies: scenarios that evoked different motivations for food choice (focused on environmental, well-being, and hedonic motivations), and a nudge-based strategy (health-oriented or pleasure-oriented). The impact of these two strategies on visual attention and the choice of products by participants was evaluated using an implicit approach (eye-tracking measurement), and an explicit approach (products selected using a food choice task). We first discuss the influence of nudges on gaze behavior, and then the influence on food choices of scenarios evoking motivations for choices. Finally, we will focus on the choice of pulses, either with nudges or with the combination of both strategies.

4.1. Did the presence of a nudge affect gaze behavior toward pulses?

With the device used in this study, we captured automatic and natural gaze behavior, when consumers are in front of a shelf, without any special instructions. Gaze behavior is always influenced by both bottom-up (automatic) and top-down processes. It is generally assumed that goals or task instructions (top-down) override the effect of salience (bottom-up) that appears first (Duerrschmid and Danner 2018). In our first session, gaze behavior was recorded during a limited screening time and participants were asked to look at the super-shelf, but no specific instructions were given. We can assume that the gaze behavior recorded during this session resulted mostly from automatic processes, indicating the elements to which participants' attention was attracted first.

The nudge-based strategy we used focused on pulses, and thus we expected that the visual attention of participants during Session 2 would be particularly impacted in relation to the pulse food group. Our first hypothesis (H1) stated that the gaze behavior of participants toward pulses would be

influenced by the nudge-based strategy. However, the total fixation duration toward pulses was not different between Session 1 and Session 2. Yet the total number of fixations was significantly lower in Session 2, with both types of nudges, than in Session 1. Based on these results, we can partially confirm our first hypothesis, as not all gaze measures toward pulses changed across the first and second sessions. To explain these results, we found a recent review that described two common cognitive factors that influence eye movements related to familiarity with the stimuli and task instructions (Carter and Luke 2020). In our study, the task instructions and the food presented were exactly the same for both sessions. Thus the changes regarding the total number of fixations might be explained by a learning process. Indeed, participants in the second session of our study may have felt more comfortable with the virtual environment and more familiar with pulse food products. Participants may have focused their attention more, decreasing the number of eye movements back and forth between food products, thus resulting in fewer fixations, but the same total time spent on a given AOI.

4.2. Did the different motivations of choice influence the change in choice of food products across different evoked scenarios?

The products presented in this study, whatever their food-group, were chosen more or less often in relation to the scenario presented. This observation validates our third hypothesis (H3) whereby the choice of food products would vary according to the evoked motivations of choice. We found that in the hedonic and everyday scenarios, participants made similar food choices. This could reflect the fact that hedonic motivation is the main driver influencing everyday food choices. Participants chose significantly more often starches and animal-based products in the everyday and hedonic scenarios. These results are in accordance with other studies showing that meat consumption is related to the hedonic (pleasure) response (Macdiarmid, Douglas, and Campbell 2016; Poquet et al. 2017). Participants chose vegetable products more often in the well-being and environment scenarios, which was also expected. Indeed, a French National survey (France Agrimer, 2016) showed that participants declared that they consume and buy more vegetables when they are taking into consideration respect for the environment, nutritional needs, and health. In our study, vegetables were less often associated with pleasure (the hedonic scenario).

The choice of pulses also changed in relation to the scenario presented. Pulses were chosen significantly more often in the environment scenario, and least often in the everyday scenario. In our experimental design, levels of processing were balanced between the products from the four food groups. Products from all four food groups were presented either in plastic, metallic cans, or cardboard packaging (expect for meat, which could not be presented in cardboard as that format does not exist in French supermarkets). We may therefore consider that the choice of a product in the environment

scenario was not related to the type of packaging or level of transformation, but rather to the nature of the product. Thus, the more frequent choice of pulses in the environment scenario reveals that participants knew that pulses are considered good for the environment. In our experimental design, the environment-oriented scenario was both an extrinsic and altruistic motivation, while the three other scenarios highlighted either no specific motivation, or a self-centered motivation. Intrinsic motivation consists in doing an action because it is considered "interesting and spontaneously satisfying", whereas extrinsic motivations consist in doing an action because "it leads to some separate consequence" (Deci & Ryan, 2008, p.15). An action can be considered self-centered if the consequences benefit only the person making the choice, or altruistic if the results are beneficial to others.

For participants in our study, the choice of pulses seems to result from an extrinsic and altruistic motivation (for the environment), and not from intrinsic motivations (everyday). As we demonstrated in a previous study, non-vegetarian French participants considered pulses to be good for the environment and for health, yet declared in general that they like pulses less than vegetables, starches, or meats (Melendrez-Ruiz, et al., 2019). Our results confirm that participants know that pulses are good for the environment, but show that health is not a strong enough motivation to encourage them to choose pulses. This may be because, among the food-groups considered to be good for the health, pulses do not occupy the first place, which is reserved for vegetables (Melendrez-Ruiz, et al., 2019). The positive effects on health affect the personal life of the person making the choice in the short, medium, and long term, by contrast with the effects on the environment, which are perceived to be in the long term, and thus do not affecting the person either immediately or directly. It has been demonstrated that extrinsic and altruistic motivations are weak predictors of food choice (Magnusson et al. 2003). Motivation based on respect for the environment may not be strong enough to promote pulse consumption.

In this study, we measured the time spent choosing the three food products for each scenario, allowing us to check where any given scenario was more time-consuming than the other three. On average, the mean time taken by participants to choose three food products was similar for three scenarios: 63 seconds for everyday, well-being (68 seconds), and hedonic (63 seconds), but much longer for the environment scenario (90 seconds). Participants probably needed time to take into consideration many aspects, such as the recycling properties of the packaging, the amount of natural resources used (e.g. water and land), and awareness of animal welfare. Considering all these factors implies that consumers must have prior knowledge about the product, and information that would not be necessarily be found on the packaging. If participants do not have this knowledge, it will make the choice cognitively demanding in terms of working memory resources (Orquin and Mueller Loose 2013).

Thought will require effort, and thus increase the time required to make a choice. This could reflect greater difficulty for participants to make food choices in an environmental context.

4.3. Was the choice of pulses influenced only by the nudge-based strategy, or by the combination of the nudge-based strategy and the scenarios?

To evaluate if the nudge-based strategy alone influenced the choice of pulses, we compared the choices made by participants for pulse products in the control condition (i.e. everyday scenario) between Session 1 and Session 2. We observed an overall low choice of pulses, and we did not find significant differences, as participants did not chose pulses more often during Session 2 in the control condition. Therefore, we cannot validate our second hypothesis (H2): the nudge-based strategy would increase the choice of pulses.

By contrast, the combination of both strategies (nudges and evoked scenarios) seems to influence the choice of pulses. To assess this influence, we decided to focus on the choice of pulses with a different approach, by grouping participants into different clusters based on low pulse choices across the different scenarios. We found significant differences regarding the choice of pulses between Session 1 and Session 2, but only for some groups of participants, and only in specific scenarios. The nudge-based strategy had a positive effect specifically on a group of participants (Cluster 1), who chose pulses in the well-being scenario particularly more often with the health-oriented nudge than without a nudge. Here, there is congruence between the scenario presented and the message conveyed by the nudge. The scenario sought to evoke a specific situation of choice related to health. For this group of participants, a congruent message was delivered in the right context, thus increasing the choice of pulses that were considered beneficial for health, (also shown in our previous study: Melendrez-Ruiz, et al. 2019). We expected that this congruency would also be found with the pleasure-oriented nudge and the hedonic scenario, but this was not the case. Another group of participants (Cluster 2) chose pulses in the control scenario more often with either of the nudges (health-oriented or pleasure-oriented) than without nudges. The control scenario sought to evoke regular daily food habits. In this sense, the positive effect of the nudge could be explained by the fact that French consumers are generally more pleasure-oriented with regard to food (Rozin et al. 1999). This could suggest that in French gastronomy, food hedonism is an important driver already included in the notion of daily consumption. This result could explain why the pleasure-oriented nudge had an effect in the control scenario but not in the hedonic scenario. Perhaps the hedonic scenario was more subjective for participants in our study. This group of participants (Cluster 2) is composed of the same percentage of women and men, mostly aged between 36 and 50 years old, with a slighter higher percentage of participants with a higher level of education (55%), who declared that they consume pulses on a weekly

basis (55%). This finding is in accordance with our previous study, which showed that people with higher education levels, aged less than 40 years old, tended to choose pulses first more frequently when composing a main dish (Melendrez-Ruiz, et al. 2019).

By contrast, for participants in Cluster 3, the nudge strategies did not have any effect: they did not chose pulses at all, whatever the session or scenario. In this group, participants were mostly aged between 36 and 50 years old, with a lower level of education (66%), who declared that they did not consume pulses every week (66%). The behavior of this group of participants may reflect that they do not usually buy or consume pulses. A study in Canada identified a group of participants, called "Disinterested Unreachables" by the authors, who were non-consumers of pulses, with similar characteristics (age and lower education level). For these participants, the barriers were mainly a dislike for pulses, for their flavor, and for their taste (IPSOS 2010). Other participants (in Cluster 4) chose pulses less frequently in the well-being and control scenarios, when exposed to either type of nudge strategy (health-oriented and pleasure-oriented). The presence of the nudge therefore provoked an effect opposite to the expected one for these consumers. Participants in this group are mostly women (62%), and young participants between 20 and 35 years old. Perhaps this opposite effect from the nudge is related to the type of nudge per se used in our study, which attracts visual attention toward pulses with a word (health or pleasure), but did not explicitly state, for example, "choose pulses because they are good for your health". Thus, this group of participants may have guessed the intention behind our nudge (focus on pulses), and changed their behavior by not choosing pulses (consciously or not). This could not be checked with our experimental design and would need confirmation by further studies. At the end of the study, most of the participants declared that they had seen the posters with the words "pleasure" and "health", but none of them specifically described the construction of the words made up of different types of pulses.

Based on these results, we can confirm our fourth hypothesis (H4): the combination of both strategies (nudges and evoked scenarios) increased the overall choice of pulses, but only for certain participant profiles, and in specific scenarios. We found one group of participants who did not choose pulses in either the first or the second session. These consumers declared that they did not consume pulses often, so they may not have a clear mental representation of these products, and thus the nudge did not have any effect on their behavior. These consumers may be difficult to convince about pulse consumption, because having a clear mental representation is necessary to identify, accept, choose, and consume a food product (Gallen 2005). Proposing another type of nudge, based on more explicit information, such as descriptive social norms, could be implemented for this group. A descriptive social norm is a nudge-based strategy based on the fact that people tend to want to behave in accordance with other people's behaviors in a specific situation (Beggs 2016). Some studies have successfully used

this type of nudge to promote healthier food choices in the supermarket toward fruits and vegetables, for example with a message stating "the three most popular products in this supermarket are…", other messages, included "most customers pick at least seven vegetables", or "…I frequently give my children vegetables as a snack…"(Payne et al. 2015; Huitink et al. 2020). The comparison made by potential consumers between their own behavior and the message stated in the nudge could influence their final behavior. Different social norm messages for pulses in supermarkets would have to be pre-tested, but some examples could be "the three most popular products in this supermarket are lentils, beans and chickpeas" or "most costumers pick pulses at least twice a week". The message could be displayed in the shopping cart or on the shelf of the product. This type of nudge could make consumers who do not usually buy pulses wonder if their behavior is in accordance with the social norm; they might therefore adapt their behavior, resulting in a greater choice of pulses.

For participants who selected pulses in Session 1 (no nudge), but did not choose them in Session 2 (with nudges), other types of nudges could be developed, based on a less transparent strategy. A non-transparent nudge refers to a nudge that works in a way that the person cannot identify "either the intention or the means by which behavioral change is pursued" (Hansen and Jespersen 2013). That would change behavior without engaging the reflective system, but would rely on automatic thinking in a way that is not likely to be recognized (Hansen and Jespersen 2013). Within this type of nudge, we found studies that have successfully used this strategy at take-away retailers, by changing the accessibility (place) of fruits at the front counter (Cheung et al. 2019). This strategy was also used for a lab buffet, where salads were presented in individual take-away bowls as the default option (Friis et al. 2017). A literature review highlighted that using food position or order as nudges can have a positive effect on more healthy food choices in field studies (i.e. university cafeterias, hospital cafeterias, or conference venues) and laboratory settings (Bucher et al. 2016). So we can imagine possible nudge-based strategies that could be proposed for pulses in supermarkets by changing product placement, and proposing pulse products at the checkout points of sale.

Strengths and limitations

One of the strengths of our study was the technological development by the Strategir team that combined the VR setting with eye-tracking technology. This progress allowed us to perform this experiment with high ecological validity, recording both the gaze behavior of participants and their food choices. In the food choice task, participants were exposed to a large number of different food products (48 food products) at the same time. The use of VR to test a nudge before its use in a real-life setting, such as a retail environment, could represent a real asset. Implementing a nudge in real-life

settings, such as supermarkets, can be complex, so using the VR could be the first approach to convince stakeholders of the interest of using nudge-based strategies.

Nevertheless, the low selection of pulses by consumers in general could be seen as a limit of our interpretations. We nevertheless found a way to analyze more accurately our data, taking into consideration the less frequent choice of pulses. With this type of analysis, we were able to measure the effect of nudges and evoked scenarios, and to understand differences between consumers according to their profile, seeking better explanations of consumer behavior toward pulses. The statistical analysis we used could represent an option for further studies in the nudge domain, where the difference observed are limited. The analysis that divided the clusters by type of nudge resulted in sub-groups with a low number of participants. Additional analysis would be necessary to validate our findings regarding which type of nudge had the most effect on consumer choices.

5. Conclusions

With this study, we were able to implement and evaluate two strategies that may encourage the choice of pulses. We studied gaze behavior and participant's food-choices in a virtual supermarket, in two separate sessions. We found that a nudge-based strategy did not have any impact on the total length of fixation, but had an impact on the total number of fixations toward pulses. Regarding the choice of pulses, we found that the nudge-based strategy did not have an effect between sessions, in the control condition. However, the combination of both strategies (nudges and scenarios evoking different motivations) had an effect, but only for some groups of consumers, and only in specific scenarios. The nudge strategy had a positive effect on two groups of consumers: one group that chose more pulses in the well-being scenario, mostly with the health-oriented nudge, and another group that chose pulses more in the control scenario, with either of the two nudges (health-oriented and pleasure-oriented). In contrast, nudges did not have any effect for the group of participants that did not chose pulses at all, in either session or in any scenario. Finally, the nudge had the opposite effect for one group of participants, who chose pulses less frequently in the well-being and control scenarios, when exposed to either type of nudge strategy. We highlighted the interest of proposing adapted nudge strategies for each group of participants: an accurate nudge for "specific" people, at a precise moment, in the right place. Further studies would be necessary to explain the scope within which a nudge may have an effect on gaze behavior, and the link between visual attention and food choices made by consumers.

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Chapter VI. A cross-cultural study: Consumers social representations towards pulses in France and Spain

During my thesis, I had the opportunity to achieve an international exchange. I spent three months in Spain, at Institute of Agrifood Research and Technology (IRTA-Girona), under the supervision of Dr. Luis Guerrero and Dr. Anna Claret. I took this opportunity to check if the social representations observed in Chapter II were specific to the French population or if similarities could be found with another social group. Spain seemed an interesting country to carry out this study because it is a neighboring country, with some cultural similarities, but a higher pulses consumption. This chapter will be covered by the article containing these results, which has been submitted in June 2020 to Food Quality & Preference.

Enhancing assessment of social representations in a cross-cultural context: a case study on pulses

Submitted to Food Quality and Preference on 20/06/2020

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Abstract

Culture plays an important role in the construction of social representations about food, influencing choices such as when, where, with whom, and how much to eat. Even within Europe, differences in the consumption of pulses may be observed between neighboring countries, such as France and Spain. The initial aim of this study was to compare social representations of pulses for both French and Spanish consumers, in relation to their level of education. Another goal was to improve social representation assessment in a cross-cultural context through a free word association task focusing on pulses. Methodological improvements to the structural approach were therefore proposed, combining order of citation with frequency and importance, with adapted cut-off points. The polarity index was modified, and the impact of analyzing words (raw data) or word categories was assessed. The main results from the study highlighted that, for both words and categories, there is a common cross-cultural core in the social representations of pulses related to five dimensions: *health*, *pulses*, *nutrition*, *preparation*, and *sensory aspects*. The study also identified a difference in focus between the two countries: French consumers focused on *other foods*; Spanish consumers focused on *appropriateness* and *context*. Overall, in both France and Spain, consumers have a positive attitude towards pulses. The methodological changes proposed in the present study facilitate the comparisons of results across and within countries. This research project provides valuable insights for researchers and policymakers seeking to understand the impact of culture on consumer food choices.

Keywords: social representations, structural approach, attitudes, cluster analysis, pulses

Introduction

In recent years, there has been substantial interest in alternative protein sources that might reduce the environmental impact of meat production systems. Protein-rich foods such as pulses have great potential for a more sustainable diet. Pulses are defined by the FAO as a type of leguminous crop that is harvested only for dry seed, including lentils, dried peas, and beans, but excluding other crops such as green peas, which are harvested green, and soybeans, used mainly for oil extraction (FAO, 2016). The consumption of pulses across the world varies in relation to climate, agriculture, and consumer food habits. In Europe, pulse consumption is estimated at 2.5 kg per person per year, below the global average consumption of 7 kg per person per year (FAOSTAT, 2013). In 2018, the EU Member State with the highest production and consumption of pulses was Spain (Magrini et al., 2019). Pulse consumption in Spain was estimated at 3.2 kg per person for 2018 (MAPA, 2019), while pulse consumption in France, estimated at 1.7 kg per person for 2016 (ANSES, 2017), was much lower than mean pulse consumption in Europe. The difference between these two neighboring countries shows that pulse consumption is not only linked to availability, but could imply a cultural effect. This observation constitutes an interesting starting point to investigate how culture may influence consumers' food choices.

The differences in the demographic profiles of French and Spanish consumers of pulses underline another cultural difference. In France, a recent study highlighted that consumers under 40 years of age, with a high level of education, chose pulses more frequently when constructing a main dish than older, less well-educated consumers (Melendrez-Ruiz et al., 2019). By contrast, in Spain, retired people consume the greatest quantity of pulses (5.2 kg/person/year), couples with young children consume the smallest quantity (1.9 kg/person/year), while consumers from the middle and high social classes consume more pulses than the national average (MAPA, 2019). The level of education seems to be a common key parameter that could explain the difference in pulse consumption within a country, while age might represent a difference between countries.

In both French and Spanish dietary guidelines, pulses were previously positioned in the same zone as cereals in the food pyramid proposed for guidance. In 2016, the Spanish food pyramid was updated, repositioning pulses in the same zone as white meats, fish, and eggs, with a recommended consumption of two to three servings per week (Aranceta Bartrina, 2016). In France, since 2019, pulses have been the object of a specific recommendation, in which they are no longer categorized with starches, but are considered as a specific group, because of their high fiber and protein content (HCSP, 2017). Since then, the recent French National Health and Nutrition Program 2019-2023 (PNNS) has recommended at least two servings of pulses per week as the minimum level of consumption (PNNS,

2019). The difference in consumption of pulses between the two countries may result from this three-year time lag in updating nutritional classification and recommendations, but it may also originate from long-established food habits. France is a clear example of a combination of Northern and Mediterranean diets. In the north of France, people eat more butter, margarine, and potatoes than in the south of the country, where they consume more fresh vegetables and vegetable oils (Dubuisson et al., 2010). By contrast, food habits in Spain correspond to the Mediterranean diet (Varela-Moreiras et al., 2013), which is rich in plant foods (cereals, vegetables, pulses, nuts, seeds, and fruits, including olives), with olive oil as the principal source of added fat (Bach-Faig et al., 2011). Pulses play an important role in this diet (Varela-Moreiras et al., 2013), and a weekly serving of pulses combined with cereals is recommended as a healthy protein source for people eating a Mediterranean diet (Bach-Faig et al., 2011).

All these elements, which contribute to differences in pulse consumption, may have led to different social representations of pulses between France and Spain. Within any society, social representations are shaped and marked by culture (Abric, 1994). A social representation is a construct from a set of beliefs, opinions, attitudes, and information about a certain object (Abric, 2011). Social representations are prescriptive of behavior and practices. They are collectively constructed and are composed of different elements shared within a group (Jean-Claude Abric, 2011; Wolter, 2018). The construction of a social representation seems to be similar across groups, but the resulting representations of different groups vary in relation to cultural differences (Mouret et al., 2013). Social representations that are collectively constructed about food are therefore intrinsically related to the cultures within which they exist (Lo Monaco & Bonetto, 2019). Exploring and understanding social representations will require cognitive and projective approaches. **The first objective of the present study was to compare the social representations of pulses for French and Spanish consumers with different levels of education, through a free word association task.**

A free word association task is one of the projective techniques that "provides access to the contents of social representations by asking people about the words or expressions that come to mind in reference to the object under study" (Piermattéo et al., 2018, p.17). Several improvements to this method have been proposed, to obtain more precise information. One of the most common additions is to ask respondents to classify each word cited by order of importance (ranking phase), in coherence with analysis by the structural approach (Abric, 2003). Once the frequencies and the rank of each word cited have been obtained, the analysis separates the results into low and high values (Moliner and Lo Monaco, 2017). Different methods have been proposed to calculate the cut-off point between low and high values. Initially, the cut-off point was obtained by dividing the frequency in the most frequent category by two, and by calculating the average rank for importance (Abric, 2003). Later studies in food

science calculated the cut-off point for frequency in the same way, but used a 10-point scale for rank of importance, and set the cut-off point as the average score (Rodrigues et al., 2017). The frequency cut-off point can also be identified as a natural breaking-point for frequency of occurrence in a decreasing order plot (Rodrigues, Ballester, Saenz-Navajas, & Valentin, 2015). The study of other parameters has also been proposed, such as order of citation, with a cut-off point obtained from mean values (Mäkiniemi et al., 2011). Additional input from the word association test is the polarity index proposed by De Rosa (2002), in which participants have to specify the valence of each word: positive (+), negative (-), or neutral (0). Some studies in food science, based on the method proposed by De Rosa, have asked participants to evaluate words using a seven-point scale from -3 to +3 (Bisconsin-Júnior et al., 2020; Rodrigues et al., 2017; Rodrigues et al., 2015). According to Guerrero et al., (2010), categorization into families or dimensions might simplify further analysis of the words cited. This process may also present a challenge when studying social representations through a free word association task, because it is difficult to eliminate researcher subjectivity when separating words into categories (Guerrero et al., 2010; Piermattéo et al., 2018). The structural approach can be used to assess the meaning that a group gives to an object (Moliner & Lo Monaco, 2017), but methodological challenges must be taken into account for adequate statistical analysis.

The second aim of this study was to improve the assessment of social representations through free word association in a cross-cultural context. Various methodological improvements to the structural approach were explored, such as the parameters to be included (frequency, importance, and order of citation) and their corresponding cut-off points. A modified polarity index taking into account the degree of positiveness or negativeness was also tested, and the impact of analyzing words (raw data) or word categories (dimensions) was assessed.

2. Material and methods

2.1 Participants in France and in Spain

Two different locations were selected for the study: Dijon in France (FR), and Girona in Spain (ES). These two cities were selected because of their similarity in terms of demographics and their location close to the two research centers involved in the present study (INRA and IRTA). Dijon (FR) had 155 090 inhabitants in 2016, with a total surface area of 40.41 km² (INSEE, 2019). Girona (ES) had a population of 100 266 inhabitants in 2018, with a total surface area of 39.12 km² (INE, 2019a). The average income for a consumption unit in 2016 was similar: 20 922 euros for Dijon (INSEE, 2019), and 18 828 euros for Girona (INE, 2019b). For purposes of simplification, the study will now refer to the

two countries, France and Spain, even though the cities where the data were collected are not necessarily representative of their respective countries.

Sixty participants were recruited in France and another sixty in Spain, for a total of 120 participants. The inclusion criteria for participants in both countries were to be resident in that city, aged between 25 and 65 years old, with no specific food diet (e.g. vegetarian or vegan), and without being in a situation of great economic precarity**.** Thus, only people living in a household where at least one person worked or received a pension, allowance, or annuity were eligible for inclusion. In Dijon, the recruitment process took place at a social center for youth and culture (*Maison des Jeunes et de la Culture*) over a three-week period, in 2019. This Social Center proposes cultural and physical activities for adults and children. In Girona, there was no comparable single center proposing similar activities. Thus, the study was carried out in 2019 at five different locations around the city (two cultural centers, two sports centers, and a language center), to reproduced similar recruitment conditions in both Spain and France.

For each country, an equal number of participants was recruited at higher and lower levels of education (30 in each group). A higher level of education was defined as having a university degree. As demographic characteristics were obtained after data collection, over-recruitment was necessary in each city to ensure this specific distribution of participants. Gender and age balance were ensured by random selection of participants to be excluded when a subgroup (age or gender) was overpopulated. Table 1 shows the personal characteristics of participants included in the analysis, for both countries, with a total of 39 women and 21 men in each country.

Table 1. Personal characteristics of participants in Dijon (France) and Girona (Spain).

Age range / gender	**France Level of education**			**Spain Level of education**		
	Low	**High**	**Total**	**Low**	**High**	**Total**
25 - 34	**9**	**12**	**21**	**10**	**7**	**17**
Women	7	10	17	5	3	8
Men	2	2	4	5	4	9
35 - 44	**7**	**13**	**20**	**11**	**10**	**21**
Women	4	7	11	9	8	17
Men	3	6	9	2	2	4
45 - 54	**9**	**3**	**12**	**4**	**8**	**12**
Women	5	2	7	3	4	7
Men	4	1	5	1	4	5
55 - 64	**5**	**2**	**7**	**5**	**5**	**10**
Women	3	1	4	4	3	7
Men	2	1	3	1	2	3
Total	**30**	**30**	**60**	**30**	**30**	**60**

A lower level of education indicates participants without a university degree, while a higher level of education indicates participants with a university degree.

2.2 Procedure

The study was conducted in accordance with the Declaration of Helsinki, and was approved by the INSERM ethical committee N◦18-506. Institutional Review Board INSERM (CEEI/IRB) (IRB00003888, IORG0003254, FWA00005831).

The study took place in 2019, first in Dijon and then in Girona. The same protocol was used in both cities. One of the principal researchers was present in each country to carry out data collection, translation, and to ensure that the same protocol was followed. This last point was also made possible by writing an interviewer guide containing all the instructions to be given to participants. On the day of the study, the interviewer asked those present at each location about their willingness to participate in the study. Participants who accepted were asked to read and fill out a consent form. The study was conducted individually (one interviewer and one participant at a time) and lasted around 10 minutes. The test consisted of the free word association task and a short questionnaire.

(i) Free word association task: A pretest was carried out with the inductor word "car", to ensure that participants understood the task. The task was then repeated with the inductor word "pulses" (*légumes secs* in French and *llegums* in Catalan). Participants were asked to say aloud five words, expressions, or adjectives that came spontaneously to their mind when prompted with the inductor word "pulses". Once participants had cited five words, they were asked to rank each of their words according to perceived relative importance, from 1 to 5 (1 for the word that participants considered the least important and 5 for the most important). Participants then had to rate the valence of each word, by giving a score from -2 to +2: very negative (-2), negative (-1), neutral (0), positive (+1), very positive (+2).

(ii) Questionnaire: the interviewer asked participants to indicate the packaging formats in which they would usually buy pulses by selecting the appropriate options from a list (i.e. bulk, cardboard box, plastic bag, glass jar, can, vacuum, tray, frozen, or never buy). Participants were then asked to indicate their level of agreement, using a five-point scale (from (1) totally disagree to (5) totally agree), for two sentences: i) For me, pulses belong to the taste of childhood; and ii) Pulses belong to my cultural traditions. Finally, participants provided socio-demographic information (age range, gender, number of people in their household, and level of education).

Instructions and questionnaire were written in French and then translated into Catalan. The documents were then reverse-translated to ensure precision and accuracy. At the end of the study, each participant received a free gift.

2.3 Analyses

All the words cited by participants were analyzed both qualitatively and quantitatively (frequencies). In order to facilitate the analysis of the results by researchers from each country, who did not share the same language, the principal researcher translated all words from both French and Catalan into English, in order to avoid possible translator bias. Throughout the process of data analysis, the original words remained visible, in order to ensure that the precise meaning of each word was taken into account. A table was built for each participant, containing the five words cited, associated with their order of citation, and their importance and valence, as indicated by the participant. Data analysis followed two different approaches: (i) by word (raw data) and (ii) by word category (grouping raw data into different dimensions). In raw data analysis, the minimum frequency of citation for each word and city was set at three (5%). This frequency threshold meant that some words were eliminated for some participants. For each of these participants, the order of citation and the rank of importance of the remaining words were reorganized. For categories, all the words cited in both countries, regardless of frequency, were independently grouped into categories by three researchers (pseudo-triangulation). The same three researchers together examined the categories thus obtained, and a final list of identical categories was agreed upon for both countries (Guerrero et al., 2010). Data analysis was performed on words (raw data) and on word categories (grouping raw data into different dimensions), first by country, and then by education level within each country.

Based on the frequencies obtained, a simple Correspondence Analysis (CA) was run twice, once for words and once for word categories, to visualize the relationships between countries by level of education

Cluster analysis was used to identify groups of consumers with similar social representations of pulses, regardless of country or education level. A Multiple Correspondence Analysis (MCA) was first performed over the complete disjunctive table, with word categories in columns, and participants (N=120) in rows. Each table cell indicated whether the participant mentioned that specific category (1) or did not mention it (0). A Cluster Analysis (Euclidian distance and Ward method) was then performed over the MCA principal coordinates of the observations (participants).

2.3.1 Structural approach analyses

The prototypical analysis adapted by Abric (2003) is often used to study social representations. This analysis is performed on frequency of citation and average importance to create a table (2x2) with four zones. The first zone is the central core of the representation, which contains the elements most frequently cited and considered most important. The first periphery contains elements frequently cited but considered less important. Low frequency elements of high importance are located in the contrast zone, while elements cited with low frequency and considered less important can be found in the second periphery (Moliner & Lo Monaco, 2017).

In our study, we performed fifteen analyses complementary to the classical structural approach. First, ranks of importance were transformed into a parametric measure. Two indexes were calculated: i) the Salience Index (SI), proposed by Smith and Borgatti (1997), takes into account the frequency of citation, the rank order, and the length of each participant's word list; and ii) the Cognitive Salience Index (CSI), proposed by Sutrop (2001), uses frequency and average position, without taking into account the length of the word list. These indexes have been used in qualitative studies using the free-listing technique in food menus (Libertino et al., 2012), in a health context (Fiks et al., 2011), or focusing on socio-cultural differences related to risk perception about food (Muñoz et al., 2019). For our study, we decided to use the SI for raw data analysis, and the CSI for word category analysis. The rationale behind this methodological choice was to adapt the method for word lists of fixed or variable length. For the analysis of raw data, as words cited less than three times were eliminated, participant lists did not contain the same number of words once the threshold had been applied. By contrast, for the analysis of word categories, all words were included in the analysis, and thus the length of participants' lists remained unchanged (5 words). After calculating these indexes, we multiplied the value thus obtained by the importance that each participant had given to each word. We therefore obtained a relevance value, from 0 to 1, for each of the words cited by each participant. From these results, we could also calculate the average relevance for words and word categories. This relevance measure took into account not only the importance of the word or category, but also the order in which it was mentioned, and the length of the list (only for words where the SI index was computed).

To locate elements (words or categories) in the structural approach, the cut-off points are generally determined for frequency by dividing by two the most frequent category, and for importance by calculating the average of importance (Abric, 2003). In our study, we decided to calculate the median value for both frequency and relevance (which includes importance, as explained in the previous paragraph), because the distribution of our data was not symmetrical, and some extreme values were detected in the frequency of words and categories. For this reason, the break point

proposed by Abric (2003) was not the most suitable option in our case. Once the cut-off points were established, the elements (words or categories) were then assigned to one of the four zones forming the social representation.

2.3.2 Polarity degree index

De Rosa (2002) proposed using a positive, negative, or neutral polarity index (P) to assess attitudes implicit in the social representation. We used an adaptation of this polarity index, by asking for a score for each word on a five-point scale. In order to assess more precisely the positivity or negativity of the word or category, we took into account the score given to each word, according to the following formula:

$$\text{Polarity Degree index (PD)}=\frac{\sum S}{O \times M}$$

where S = score given to each word or category, O = occurrence (frequency) of the specific word or of the total number of words within a category, M = maximum value of the scoring scale (to ensure that the index can only range from -1 to +1).

This index range can be interpreted similarly to the one proposed by De Rosa, with a score ranging from -1 to +1. Its higher precision allows us to apply a different threshold to distinguish positive and negative scores from neutral ones. We therefore propose that scores from +0.1 to +1 indicate that most of the words in that category are positive, while scores from -1 to -0.1 indicate that most of the words in that category are negative. If the score is between -0.1 and +0.1, positive and negative words tend to be balanced, and thus the resulting attitude can be regarded as neutral. Separate polarity degree indexes were constructed for the analysis of words, of categories, and of clusters.

2.3.3 Questionnaire

A two-way ANOVA was performed for each quantitative variable (household composition, scores for *belonging to the taste of childhood*, and *the role of pulses in cultural traditions*), including as fixed factors: country (France or Spain), level of education (high or low), and interaction between the two. Double interaction was only significant for household composition. For the two remaining quantitative variables (scores for childhood taste and scores for cultural traditions), one-way ANOVAs were carried out, first per country (France and Spain), and then per level of education (high and low). An additional one-way ANOVA was carried out for each cluster of consumers. When significant differences were detected, a multiple paired comparison *ad hoc* Tukey test was performed.

For the qualitative variables in the questionnaires (country, cluster, age, gender, education, and each of the packaging formats in which participants buy pulses), Chi-square cell-per-cell tests were performed for country (FR – ES), education level (high – low), and cluster.

All the analyses used the XLSTAT for Windows software (Addinsoft, France, version 2018-1).

Results

3.1. Analysis of words

3.1.1. Structural approach and polarity degree index

The 60 participants in each country cited a total of 300 words (5 words per participant, 600 words in total for the two countries). The total number of different words was 146 in France and 134 in Spain. Of these initial words, 79% in France and 78% in Spain were eliminated, because they were cited no more than twice. A total of 30 words was retained for France (Table 2), with a similar total of 29 words for Spain (Table 3), of which 10 were common to both (marked with an asterisk in Table 2 and Table 3), resulting in a total of 48 different words, with a maximum frequency of 25 citations for France and 24 for Spain.

To compare results for the two countries, and for the two levels of education, we decided to focus on words cited with higher frequency, and considered of higher relevance, located in the central core of the social representations. The other three zones were not included in analysis. To characterize the results for each country, we considered that the most frequent and relevant words were those located in the central core, for all participants, and for each subgroup (high and low levels of education).

Five words were used in both countries, by participants at both levels of education (high and low): *beans, chickpeas, good, health*, and *lentils*. Other words were specific to a country, at both levels of education: *legumes* and *rice* were in the central core for all French participants; *food*, *healthy*, *needed*, and *protein* appeared in the central core for all Spanish participants.

Other more frequent and relevant words were located in the central core for only one country, at a specific level of education. We considered that the most frequent and relevant words at subgroup level would be those found in the central core for that subgroup, as well as for all participants from that country. Thus, for French participants with a higher level of education, the most frequent and relevant words were *food, protein,* and *white beans*, while *eating* and *taste* were the most frequent and relevant words for French participants with a lower level of education. For Spanish participants with a higher level of education, the most frequent and relevant words were *cooked*, *lunch*, and *variety*,

while *cocido* and *meal* were more frequent and relevant for Spanish participants with a lower level of education. We then examined words located in the central core for a specific subgroup of participants within a country, by level of education. By contrast, with the words previously mentioned, these words characterize representations that are specific to the subgroup of participants but not to the country as a whole. Specific words located in the central core only for French participants with a higher level of education are *apricots* and *nutrient*, while *balance, cooking, green,* and *green beans* are only in the central core for French participants with a lower level of education. Spanish participants with a higher level of education were the only ones to place the words *eating, fiber*, and *tasty* in the central core. Spanish participants with a lower level of education were the only ones to place *diet, digestion*, and *garden* in the central core.

In addition to frequency and relevance, the polarity degree index (PD in Tables 2 and 3) reveals a generally positive attitude toward pulses. Differences across countries and at different levels of education were also identified by this index. In France, the word with the most negative value was *long cooking* for all French participants, particularly for those with a higher level of education. In addition, in France, the word *digestion* has a negative connotation for participants with a higher level of education, while the word *walnuts* has a negative connotation for those with a lower level of education. In Spain, the word *tasteless* was considered negative by participants at both levels of education. The word *flatulence* has a negative connotation for all Spanish participants, even more so for those with a higher level of education. The word *cocido* (a traditional dish) was also negatively perceived by Spanish participants with a higher level of education.

Table 2. Word distribution for France over the four zones of the structural approach (QSA): the central core (CORE), the first periphery (1st PERI), the second periphery (2nd PERI), and the contrast zone (CONTRA).

	Global FR				High level of education FR				Low level of education FR			
Word	**N**	**Mean SI**	**QSA**	**PD**	**N**	**Mean SI**	**QSA**	**PD**	**N**	**Mean SI**	**QSA**	**PD**
Beans *	21	0.550	*CORE*	0.55	10	0.501	*CORE*	0.40	11	0.581	*CORE*	0.68
Chickpeas *	13	0.296	*CORE*	0.58	4	0.175	*CORE*	0.50	9	0.418	*CORE*	0.61
Good *	8	0.172	*CORE*	0.81	6	0.214	*CORE*	0.92	2	0.133	*CORE*	0.50
Health *	6	0.219	*CORE*	0.92	3	0.244	*CORE*	0.83	3	0.158	*CORE*	1.00
Legumes	5	0.222	*CORE*	0.6	2	0.146	*CORE*	0.25	3	0.300	*CORE*	0.83
Lentils *	25	0.630	*CORE*	0.68	14	0.696	*CORE*	0.68	11	0.491	*CORE*	0.68
Rice	4	0.106	*CORE*	0.88	2	0.125	*CORE*	1.00	2	0.089	*CORE*	0.75
Protein *	4	0.090	*CORE*	0.88	3	0.183	*CORE*	1.00	1	0.011	*2nd PERI*	0.50
Food *	6	0.138	*CORE*	0.75	5	0.267	*CORE*	0.70	1	0.017	*2nd PERI*	1.00

White beans	4	0.092	*CORE*	0.5	3	0.107	*CORE*	0.33	1	0.075	*2nd PERI*	1.00
Taste	5	0.119	*CORE*	0.7	3	0.102	*1st PERI*	0.67	2	0.146	*CORE*	0.75
Eating*	6	0.165	*CORE*	0.83	1	0.067	*2nd PERI*	1.00	5	0.262	*CORE*	0.80
Nutrient	3	0.089	*CONTRA*	1	2	0.111	*CORE*	1.00	1	0.067	*2nd PERI*	1.00
Apricots	3	0.063	*2nd PERI*	0.67	3	0.125	*CORE*	0.67	-	-	-	-
Green beans	3	0.088	*CONTRA*	0.67	-	-	-	-	3	0.175	*CORE*	0.67
Spinach	3	0.100	*CONTRA*	0.67	-	-	-	-	3	0.200	*CORE*	0.67
Balance	3	0.079	*2nd PERI*	0.83	1	0.033	*2nd PERI*	1.00	2	0.111	*CORE*	0.75
Walnuts	3	0.083	*2nd PERI*	0.17	1	0.033	*2nd PERI*	1.00	2	0.133	*CORE*	-0.25
Cooking	4	0.079	*1st PERI*	0.25	2	0.050	*1st PERI*	0.00	2	0.111	*CORE*	0.50
Green	5	0.044	*1st PERI*	0.3	-	-	-	-	5	0.089	*CORE*	0.30
Kitchen	4	0.051	*1st PERI*	0.63	2	0.050	*1st PERI*	0.75	2	0.036	*1st PERI*	0.50
Organic	4	0.056	*1st PERI*	0.75	3	0.083	*1st PERI*	1.00	1	0.017	*2nd PERI*	0.00
Almonds	3	0.039	*2nd PERI*	0.33	2	0.042	*1st PERI*	0.00	1	0.033	*2nd PERI*	1.00
Digestion *	3	0.031	*2nd PERI*	0.33	1	0.008	*2nd PERI*	-0.50	2	0.058	*1st PERI*	0.75
Grapes	3	0.078	*2nd PERI*	0.33	1	0.133	*CONTRA*	0.50	2	0.044	*1st PERI*	0.25
Healthy *	3	0.071	*2nd PERI*	0.83	1	0.075	*2nd PERI*	1.00	2	0.067	*1st PERI*	0.75
Long cooking	3	0.030	*2nd PERI*	-0.5	3	0.059	*1st PERI*	-0.50	-	-	-	-
Potatoes	3	0.028	*2nd PERI*	1	-	-	-	-	3	0.056	*1st PERI*	1.00
Starch	3	0.067	*2nd PERI*	0.67	2	0.083	*1st PERI*	0.50	1	0.044	*2nd PERI*	1.00
Vitamins	3	0.078	*2nd PERI*	1	2	0.075	*1st PERI*	1.00	1	0.067	*2nd PERI*	1.00
Median	**4**	**0.085**	-	-	**2**	**0.105**	-	-	**2**	**0.089**	-	-

N: Frequency; SI: Mean of relevance using the Salience Index; PD: Polarity degree index.

Table 3. Word distribution for Spain over the four zones of the structural approach (QSA): the core (CORE), the first periphery (1st PERI), the second periphery (2nd PERI) and the contrast zone (CONTRA).

	Global ES				**High level of education ES**				**Low level of education ES**			
Word	**N**	**Mean SI**	**QSA**	**PD**	**N**	**Mean SI**	**QSA**	**PD**	**N**	**Mean SI**	**QSA**	**PD**
Beans *	12	0.227	*CORE*	0.67	7	0.198	*CORE*	0.57	5	0.264	*CORE*	0.60
Chickpeas *	15	0.558	*CORE*	0.63	8	0.655	*CORE*	0.69	7	0.461	*CORE*	0.57
Food *	4	0.190	*CORE*	0.75	2	0.233	*CORE*	0.75	2	0.150	*CORE*	0.75
Good *	7	0.172	*CORE*	0.71	4	0.156	*CORE*	0.63	3	0.187	*CORE*	0.83
Health *	8	0.169	*CORE*	1.00	5	0.181	*CORE*	1.00	3	0.161	*CORE*	1.00
Healthy *	24	0.524	*CORE*	0.94	11	0.450	*CORE*	1.00	13	0.594	*CORE*	0.88
Lentils *	15	0.225	*CORE*	0.63	8	0.310	*CORE*	0.69	7	0.142	*CORE*	0.57
Needed	4	0.133	*CORE*	1.00	2	0.139	*CORE*	1.00	2	0.117	*CORE*	1.00
Protein *	9	0.211	*CORE*	0.83	5	0.282	*CORE*	0.80	4	0.138	*CORE*	0.88
Cooked	4	0.102	*CORE*	0.25	3	0.139	*CORE*	0.33	1	0.067	*2nd PERI*	0.00
Lunch	5	0.120	*CORE*	0.50	4	0.200	*CORE*	0.63	1	0.033	*2nd PERI*	0.00
Variety	6	0.087	*CORE*	0.67	3	0.111	*CORE*	0.50	3	0.065	*1st PERI*	0.63
Cocido	4	0.150	*CORE*	0.13	2	0.100	*1st PERI*	-0.50	2	0.200	*CORE*	0.75
Meal	5	0.202	*CORE*	0.80	1	0.067	*2nd PERI*	1.00	4	0.336	*CORE*	0.75
Eating*	3	0.133	*CONTRA*	0.33	2	0.167	*CORE*	0.25	1	0.100	*2nd PERI*	0.50

Fiber	3	0.078	*2nd PERI*	0.67	3	0.156	*CORE*	0.67	-	-	-	-
Tasty	3	0.084	*2nd PERI*	0.50	2	0.111	*CORE*	0.50	1	0.050	*2nd PERI*	0.50
Diet	3	0.078	*2nd PERI*	0.50	-	-	-	-	3	0.156	*CORE*	0.50
Digestion *	3	0.082	*2nd PERI*	1.00	1	0.050	*2nd PERI*	1.00	2	0.113	*CORE*	1.00
Garden	3	0.078	*2nd PERI*	0.83	1	0.033	*2nd PERI*	0.50	2	0.125	*CORE*	1.00
Cheap	3	0.067	*2nd PERI*	0.33	1	0.033	*2nd PERI*	0.00	2	0.100	*1st PERI*	0.50
Flatulence	5	0.058	*1st PERI*	-0.20	2	0.047	*2nd PERI*	-0.75	3	0.069	*1st PERI*	0.17
Nature	4	0.061	*1st PERI*	0.88	1	0.017	*2nd PERI*	1.00	3	0.107	*1st PERI*	0.83
Salad	4	0.075	*1st PERI*	0.38	3	0.083	*1st PERI*	0.50	1	0.067	*2nd PERI*	0.00
Soil	5	0.065	*1st PERI*	0.80	1	0.050	*2nd PERI*	1.00	4	0.084	*1st PERI*	0.75
Energy	3	0.068	*2nd PERI*	0.83	1	0.044	*2nd PERI*	1.00	2	0.090	*1st PERI*	0.75
Iron	3	0.059	*2nd PERI*	0.50	1	0.033	*2nd PERI*	0.50	2	0.083	*1st PERI*	0.50
Peas	3	0.063	*2nd PERI*	0.67	2	0.075	*1st PERI*	0.75	1	0.050	*2nd PERI*	0.50
Tasteless	3	0.025	*2nd PERI*	-0.50	2	0.039	*1st PERI*	-0.50	1	0.011	*2nd PERI*	-0.50
Median	**4**	**0.087**	**-**	**-**	**2**	**0.111**	**-**	**-**	**2**	**0.110**	**-**	**-**

N: Frequency; SI: Mean of relevance using the Salience Index; PD: Polarity degree index.

3.1.2. Correspondence analysis (CA) for words

Correspondence analysis was used to visualize the associations between citation frequency for each word and the two levels of education in each country (Figure 1). The first axis represents 49% of the total inertia, with 33% for the second axis. The first axis characterizes countries and the second axis differentiates between education levels in France. French participants cited food products (e.g. *legumes, white beans, potatoes,* and *spinach*) more frequently than participants in Spain, who cited conceptual words (e.g. *variety, cooked, soil, lunch, health,* and *fiber*) more frequently than participants in France.

In France, the words most frequently cited by participants with a lower level of education were *potatoes, green beans, spinach, green,* and *eating*, while French participants with a higher level of education cited the words *apricots, long cooking, white beans, organic, food,* and *good*. By contrast, in Spain there was no difference between participants based on their level of education.

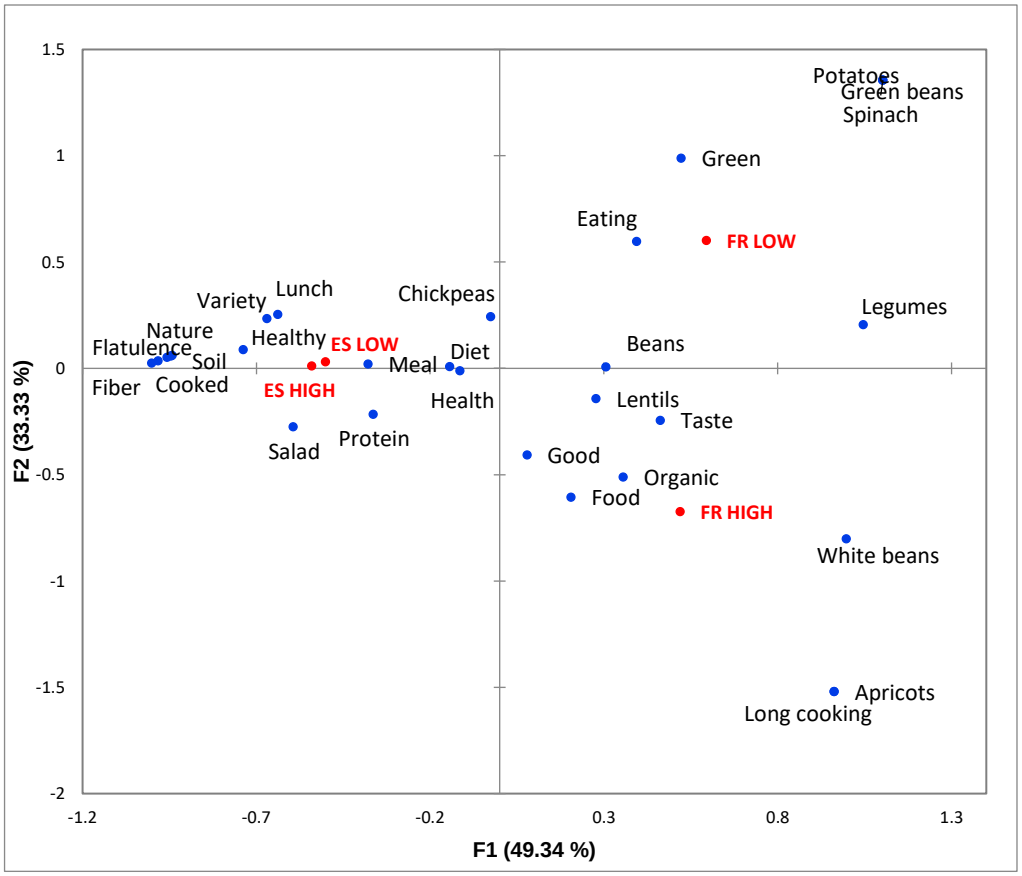

Figure 1. Correspondence analysis of word frequency, mapping education levels by country. France: FR LOW = lower level of education; FR HIGH = higher level of education. Spain: ES LOW = lower level of education; ES HIGH = higher level of education.

3.2. Analysis of word categories

All 600 words cited by the 120 participants from the two countries were then divided into 17 categories (Table 4).

Table 4. Word categories after triangulation, with examples of words for each category, and total number (N) of words in each category.

Categories	Examples	N
Agriculture	field, garden, nature, plant, soil	18
Appropriateness	good, recommended, interesting, important	26
Context	dinner, lunch, house, meal, table, share, winter	24
Convenience	comfortable, available, easy to prepare, long cooking, non-perishable, practical	23
Digestion	digestion, flatulence, guts, swollen, stomach heaviness	16
Habits	twice a week, unknown, discover, weekly, usual, trend	10
Health	good for health, health, vitality, well-being	48
Legumes	green beans, legumes, peas, peanuts, soya	17

Nutrition	balance, basic food, calories, diet, energetic, nourishment, fiber, iron, needed, protein, starch,	91
Other foods	almonds, apricots, bananas, carrots, cashews, chorizo, corn, food, grapes, potatoes, rice, spinach, walnuts	66
Preparation	boiled, *cocido*, cooked, kitchen, pot, salad, stew, side dish, recipe	53
Pulses	beans, chickpeas, coral lentils, lentils, white beans	110
Purchasing	cheap, economical, money, market, price, sachet, supermarket	12
Quality	fresh, natural, organic, quality	12
Sensory aspects	tasteless, brown, delicious, green, I love it, it's good, juicy, round, smell, soft, taste	54
Tradition	childhood, family, grandmother, culture, traditional	8
Variety	choice, options, possibility, variety	12

3.2.1.Structural approach and Polarity degree index

Table 5 for France and Table 6 for Spain show the distribution of word categories for each subgroup of participants. Five dimensions were identified as most frequent and relevant for participants in both countries and at both levels of education: *health, nutrition, preparation, pulses*, and *sensory aspects*. Other dimensions, although specific to a subgroup (high or low level of education), were considered to be particularly frequent and relevant when they were located in the central core not only for that subgroup but also for all participants from that country. This is the case for *appropriateness* and *legumes* for French participants with a lower level of education, *convenience* for French participants with a higher level of education, with *agriculture* and *other foods* for Spanish participants with a lower level of education, and *digestion* for Spanish participants with a higher level of education.

Regarding the polarity degree index, French and Spanish participants generally have a positive attitude toward all dimensions. Negative attitudes were identified only among participants with a higher level of education, in France and/or Spain: *digestion* was the only common dimension with a negative value in both countries, more prominently in France than in Spain, while the dimensions *purchasing* and *habits* were negative only in France.

Table 5. Category distribution for France over the four zones of the structural approach (QSA): the central core (CORE), the first periphery (1st PERI), the second periphery (2nd PERI) and the contrast zone (CONTRA).

	Global FR				**High level of education FR**				**Low level of education FR**			
Category	**N**	**Mean CSI**	**QSA**	**PD**	**N**	**Mean CSI**	**QSA**	**PD**	**N**	**Mean CSI**	**QSA**	**PD**
Health	13	0.353	*CORE*	0.88	6	0.383	*CORE*	0.83	7	0.345	*CORE*	0.93
Nutrition	42	0.910	*CORE*	0.81	22	0.845	*CORE*	0.84	20	1.014	*CORE*	0.78
Sensory aspects	27	0.303	*CORE*	0.33	11	0.238	*CORE*	0.50	16	0.349	*CORE*	0.22
Other foods	54	0.873	*CORE*	0.67	29	0.978	*CORE*	0.66	25	0.771	*CORE*	0.68

Preparation	24	0.289	*CORE*	0.38	14	0.342	*CORE*	0.36	10	0.246	*CORE*	0.40
Pulses	68	1.398	*CORE*	0.61	33	1.560	*CORE*	0.56	35	1.274	*CORE*	0.66
Convenience	13	0.177	*CORE*	0.50	9	0.234	*CORE*	0.39	4	0.158	*1st PERI*	0.75
Appropriateness	10	0.171	*CORE*	0.80	6	0.175	*1st PERI*	0.92	4	0.182	*CORE*	0.63
Legumes	13	0.254	*CORE*	0.62	5	0.200	*1st PERI*	0.40	8	0.309	*CORE*	0.75
Agriculture	1	0.006	*2nd PERI*	0.50	-	-	-	-	1	0.011	*2nd PERI*	0.50
Context	7	0.054	*2nd PERI*	0.50	3	0.086	*2nd PERI*	0.50	4	0.062	*1st PERI*	0.50
Digestion	4	0.042	*2nd PERI*	0.38	1	0.013	*2nd PERI*	-0.50	3	0.073	*2nd PERI*	0.67
Habits	4	0.073	*2nd PERI*	0.00	1	0.013	*2nd PERI*	-0.50	3	0.138	*2nd PERI*	0.17
Purchasing	6	0.095	*2nd PERI*	0.00	1	0.011	*2nd PERI*	-1.00	5	0.176	*CORE*	0.20
Quality	5	0.065	*2nd PERI*	0.80	4	0.126	*2nd PERI*	1.00	1	0.007	*2nd PERI*	0.00
Tradition	5	0.071	*2nd PERI*	0.70	3	0.092	*2nd PERI*	0.83	2	0.052	*2nd PERI*	0.50
Variety	4	0.053	*2nd PERI*	0.75	2	0.058	*2nd PERI*	0.75	2	0.048	*2nd PERI*	0.75
Median	**10**	0.170	-	-	**5.5**	0.188	-	-	**4**	0.176	-	-

N: Frequency; SI: Mean of relevance using the Salience Index; PD: Polarity degree index.

Table 6. Category distribution for Spain over the four zones of the structural approach (QSA): the central core (CORE), the first periphery (1st PERI), the second periphery (2nd PERI) and the contrast zone (CONTRA).

	Global ES				**High level of education ES**				**Low level of education ES**			
Category	**N**	**Mean CSI**	**QSA**	**PD**	**N**	**Mean CSI**	**QSA**	**PD**	**N**	**Mean CSI**	**QSA**	**PD**
Nutrition	49	1.001	*CORE*	0.71	22	1.016	*CORE*	0.73	27	1.001	*CORE*	0.70
Pulses	42	0.677	*CORE*	0.64	23	0.842	*CORE*	0.70	19	0.490	*CORE*	0.58
Sensory aspects	27	0.331	*CORE*	0.02	13	0.290	*CORE*	0.00	14	0.400	*CORE*	0.04
Appropriateness	16	0.327	*CORE*	0.72	8	0.359	*CORE*	0.63	8	0.504	*CORE*	0.81
Context	17	0.347	*CORE*	0.44	10	0.279	*CORE*	0.35	7	0.516	*CORE*	0.57
Health	35	0.587	*CORE*	0.96	17	0.541	*CORE*	1.00	18	0.646	*CORE*	0.92
Preparation	29	0.477	*CORE*	0.38	18	0.539	*CORE*	0.33	11	0.492	*CORE*	0.45
Agriculture	17	0.274	*CORE*	0.74	3	0.100	*2nd PERI*	0.83	14	0.447	*CORE*	0.71
Other foods	12	0.280	*CORE*	0.54	6	0.267	*CONTRA*	0.58	6	0.300	*CORE*	0.50
Digestion	12	0.152	*1st PERI*	0.13	7	0.262	*CORE*	-0.14	5	0.238	*2nd PERI*	0.50
Convenience	10	0.150	*2nd PERI*	0.55	7	0.221	*1st PERI*	0.43	3	0.297	*2nd PERI*	0.83
Habits	6	0.082	*2nd PERI*	0.00	3	0.124	*2nd PERI*	0.00	3	0.075	*2nd PERI*	0.00
Legumes	4	0.067	*2nd PERI*	0.63	3	0.114	*2nd PERI*	0.67	1	0.011	*2nd PERI*	0.50
Purchasing	6	0.075	*2nd PERI*	0.25	1	0.100	*2nd PERI*	0.00	5	0.100	*2nd PERI*	0.30
Quality	7	0.149	*2nd PERI*	0.93	2	0.075	*2nd PERI*	1.00	5	0.233	*2nd PERI*	0.90
Tradition	3	0.050	*2nd PERI*	1.00	2	0.048	*2nd PERI*	1.00	1	0.028	*2nd PERI*	1.00
Variety	8	0.083	*2nd PERI*	0.63	5	0.118	*2nd PERI*	0.50	3	0.053	*2nd PERI*	0.83
Median	**12**	0.270	-	-	**7**	0.260	-	-	**6**	0.300	-	-

N: Frequency; SI: Mean of relevance using the Salience Index; PD: Polarity degree index.

3.2.2. Correspondence analysis for categories

Correspondence analysis was used to visualize the associations between citation frequency for each category and the two levels of education in each country (Figure 2). The first axis represents 71% of the total inertia, with 19% for the second axis. The first axis characterizes countries and the second axis differentiates between education levels, particularly in Spain. French participants with a higher level of education used the category *convenience* more often. In Spain, participants with a lower level of education used words related to *agriculture, purchasing*, and *quality* more often than highly educated participants, who more frequently used words related to *variety*, *context*, *digestion*, and *preparation*.

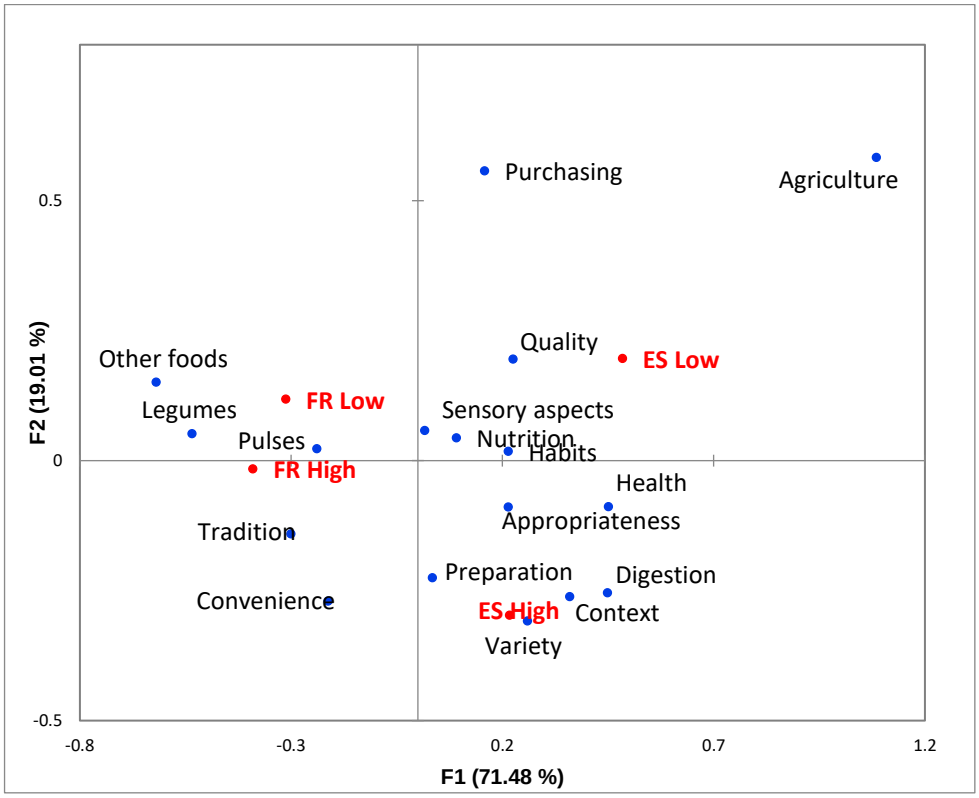

Figure 2. Correspondence analysis of category frequency, mapping education levels by country. France: FR LOW = lower level of education; FR HIGH = higher level of education. Spain: ES LOW = lower level of education; ES HIGH = higher level of education.

3.3. Cluster analysis

A cluster analysis was performed on word categories for the 120 participants to check whether characteristics other than country and level of education could be revealed by our results. Three different clusters were identified, cluster 1 (n=55), cluster 2 (n=29), and cluster 3 (n=36). Table 7 shows

four categories as being the most frequent and relevant for these three clusters: *health, nutrition, other foods*, and *sensory aspects*. Other dimensions located in the central core for two of the clusters were *pulses* for clusters 1 and 2, and *preparation* for clusters 1 and 3. Some dimensions were unique to a single cluster: *agriculture, context*, and *quality* for cluster 1, *legumes* for cluster 2, and *appropriateness* and *digestion* for cluster 3. The mean value of frequency for each dimension was computed for each cluster. Cluster 1 used words related to the *sensory* dimension more often than the other two clusters. Cluster 2 used words related to *pulses* and *other foods* more often, while Cluster 3 focused mainly on *nutrition, health*, and *preparation,* as shown in Figure 3 and Table 7.

Overall, these consumer clusters had a positive attitude toward pulses, with the only slightly negative dimension being *sensory aspects* for cluster 1. Regarding participant characteristics, cluster 2 had more French participants (80%) than cluster 1, while cluster 3 had a higher percentage (67%) of participants with a higher level of education.

Table 7. Category distribution for the three clusters over the four zones of the structural approach (QSA): the central core (CORE), the first periphery (1st PERI), the second periphery (2nd PERI), and the contrast zone (CONTRA).

	Cluster 1				**Cluster 2**				**Cluster 3**			
Categories	**N**	**Mean CSI**	**QSA**	**PD**	**N**	**Mean CSI**	**QSA**	**PD**	**N**	**Mean CSI**	**QSA**	**PD**
Health	16(-)*	0.323	*CORE*	0.91	9	0.388	*CORE*	1.00	23(+)*	0.697	*CORE*	0.93
Nutrition	34	0.898	*CORE*	0.68	13(-)*	0.486	*CORE*	0.96	44(+)*	1.467	*CORE*	0.76
Other foods	13(-)*	0.297	*CORE*	0.42	43(+)*	1.285	*CORE*	0.69	10(-)*	0.450	*CORE*	0.75
Sensory aspects	31	0.411	*CORE*	-0.03	6(-)*	0.217	*CORE*	0.67	17(+)*	0.259	*CORE*	0.38
Pulses	53	1.075	*CORE*	0.56	50(+)*	1.868	*CORE*	0.73	7(-)*	0.278	*CONTRA*	0.36
Quality	11	0.189	*CORE*	0.86	-	-	-	-	1	0.046	*2nd PERI*	1.00
Agriculture	16	0.286	*CORE*	0.72	1	0.011	*2nd PERI*	0.50	1	0.022	*2nd PERI*	1.00
Context	21	0.339	*CORE*	0.40	1	0.103	*2nd PERI*	1.00	2	0.056	*2nd PERI*	0.75
Preparation	23	0.387	*CORE*	0.48	5 (-)*	0.112	*2nd PERI*	0.30	25(+)*	0.565	*CORE*	0.30
Legumes	2	0.044	*2nd PERI*	0.50	14	0.527	*CORE*	0.61	1	0.056	*2nd PERI*	1.00
Digestion	3	0.03	*2nd PERI*	0.67	-	-	-	-	13	0.276	*CORE*	0.08
Appropriateness	11	0.18	*1st PERI*	0.82	1	0.034	*2nd PERI*	1.00	14	0.570	*CORE*	0.68
Habits	10	0.169	*2nd PERI*	0.00	-	-	-	-	-	-	-	-
Tradition	8	0.131	*2nd PERI*	0.81	-	-	-	-	-	-	-	-
Variety	1	0.073	*2nd PERI*	1.00	-	-	-	-	11	0.195	*1st PERI*	0.64
Convenience	11	0.188	*1st PERI*	0.64	2	0.046	*2nd PERI*	0.25	10	0.251	*1st PERI*	0.45
Purchasing	11	0.16	*1st PERI*	0.14	-	-	-	-	1	0.083	*2nd PERI*	0.00
Median	**11**	**0.189**			**6**	**0.217**			**10**	**0.259**		

N: Frequency; SI: Mean of relevance using the Salience Index; PD: Polarity degree index. * Indicates significant difference higher (+) or lower (−) than theoretical values (Chi-square cell-per-cell analysis; p-value <.05).

The mean frequency value for each dimension was computed for each cluster. Cluster 1 used words related to the *sensory* dimension more often than the other two clusters. Cluster 2 used words related to *pulses* and *other foods* more often. Cluster 3 focused mainly on *nutrition, health*, and *preparation,* as shown by Figure 3 and Table 7.

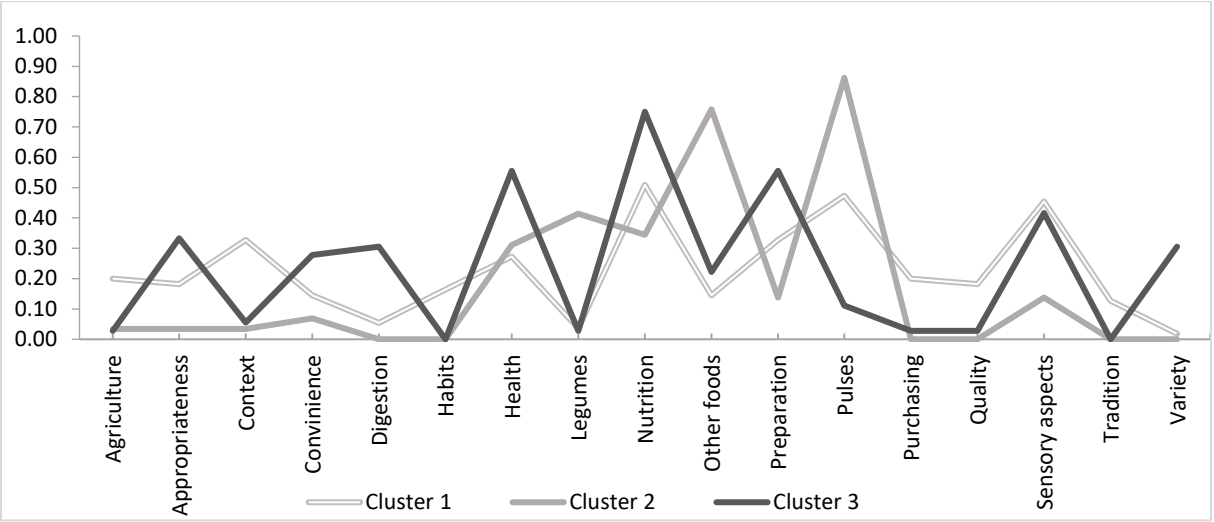

Figure 3. Mean values showing category citation frequency for each cluster

3.4. Habits and a demographic questionnaire

The analysis of variance for household composition in relation to country and level of education showed interaction ($F = 4.098$, $p = 0.045$). The mean number of people per household was higher for French participants with a higher level of education, while in Spain it was higher for participants with a lower level of education. A multiple paired-comparison Tukey test ($p < 0.05$) showed a significant effect of country on pulses belonging to the taste of childhood ($F = 4.010$, $p = 0.048$) and to cultural tradition ($F = 15.612$, $p = 0.000$). Spanish participants gave a higher score than French participants to pulses belonging to the taste of their childhood and their cultural tradition. The ANOVA performed for clusters did not show any significant differences for household composition, childhood taste, or cultural tradition.

Table 8 shows the Chi-squared result for country, education level, and clusters. No significant differences in age, gender, or education were observed ($p > 0.05$) between countries. However, when looking at the packaging formats in which participants usually buy pulses, statistical differences were detected. Spanish participants declared that they buy pulses in bulk significantly more often than French participants did. In addition, in Spain, there was a strong tendency to buy pulses in a glass jar compared to France. By contrast, French participants declared that they buy pulses in a cardboard box,

a transparent plastic bag, or in a can more often than Spanish participants. Considering all participants together and then dividing them by their level of education showed that participants with a higher level of education buy pulses in a glass jar more often than those with a lower level of education ($p < 0.05$).

Table 8. Significance for the qualitative variables evaluated in the questionnaire, in relation to country, level of education, and cluster.

Variables	Chi2 results for country	Chi2 results for level of education	Chi2 results for cluster
Country	N/A	NS	p-value=0.001
Age	NS	NS	NS
Gender	NS	NS	NS
Education	NS	N/A	p-value=0.055
Cluster	N/A	p-value=0.055	N/A
Buy in bulk	p-value=0.010	NS	NS
Buy in cardboard boxes	p-value < 0,0001	NS	NS
Buy in transparent plastic bags	p-value=0.027	NS	NS
Buy in cans	p-value=0.000	NS	NS
Buy in vacuum packs	NS	NS	NS
Buy in glass jars	p-value=0.056	p-value=0.022	NS
Buy in trays	NS	NS	NS
Buy frozen pulses	NS	NS	NS
I don't buy pulses	NS	NS	NS

(Chi-square cell-per-cell analysis; p-value <0.05). N/A: not applicable

Discussion

The first aim of this study was to compare consumers' social representations of pulses, taking into consideration their country of residence and their level of education. The results highlighted similarities between participants, but also differences that can be explained by their country, level of education, or other reasons. The second aim was to improve social representation assessment through a free word association task in a cross-cultural context. We identified some strengths and limitations that will be discussed in relation to methodological aspects.

4.1. Similarities between countries

We identified some words and word categories located in the central core that are common to both countries, unrelated to level of education. The category *pulses*, identified in the central core of the category analysis for participants from both countries, contains words that are also in the central

core of the word analysis (*beans*, *chickpeas*, and *lentils).* As previously shown (Melendrez-Ruiz et al., 2020), consumers tend to cite exemplars to confirm the meaning of the inductor word (*pulses*). These results demonstrate that participants had quite clear knowledge of what pulses are. The exemplar names they used correspond to the three most commonly consumed pulses in both countries. In France (Solagro & RAC, 2016), the most common pulses are lentils (710 g/person/year), followed by beans (610 g/person/year), while chickpeas lag far behind (76 g/person/year). In 2018 (MAPA, 2019), the most commonly consumed pulses in Spain were chickpeas (1.29 kg/person), followed by lentils (1 kg/person), and beans (<1kg/person). The fact that no other example of pulses was cited, whether in France or in Spain, shows that consumers' representations of pulses are limited in comparison with the varieties of pulses available. Specific efforts should be made to promote other pulses, such as dried peas, for example.

The *sensory* dimension was also frequent and relevant for both countries. This dimension goes beyond taste and also includes physical characteristics such as color (green and brown), and texture, which are important when referring to pulses. The evocation of a sensory attribute by a person does not necessarily mean that this person consumes that food, but may indicate that liking for this specific attribute is an important factor in determining appreciation of that particular food (Shepherd, 2001, p.117). The sensory dimension could therefore be a decisive factor in pulse consumption. A study in Canada identified 'not liking their taste' as a key reason for not eating pulses (IPSOS, 2010). This reason could also apply to the Spanish participants to our study, with a negative attitude toward the word *tasteless*.

The category *preparation* is another dimension in the central core common to both countries. This category contains items related to practical knowledge of pulses. In both countries, participants spontaneously evoked familiar cooking methods, and named a variety of dishes made with pulses. In France, the most typical dishes containing pulses are *cassoulet* (white beans with sausage), and *petit salé aux lentilles* (lentils with pork), which are considered traditional in French gastronomy (Rio, 2017). In Spanish gastronomy, pulses are used in popular recipes such as *fabada* or *empedrados* (made with white beans), *mongetes con butifarra* (beans with sausage), lentils with chorizo, and chickpeas, served puréed, stewed, or as a main dish (Medina, 2005).

The category and the word *health* were also in the central core for both countries. This finding highlights a common social representation of pulses as healthy food, shared by both cultures. This is also shown by the category *nutrition,* located in the central core for both countries. This result probably reflects the fact that consumers know the benefits of pulses for human health, as previously shown for French consumers (Melendrez-Ruiz et al., 2019). Nevertheless, the frequent use of words related to

nutrition by participants from both countries has to be considered with caution, because the components of the category *nutrition* were not the same for the two sets of participants. In the word analysis, we found only one word related to nutrition in the central core for Spain (*protein),* while French participants used many words related to nutrition *(vitamins, proteins, eating, nutrients,* and *balance*), but none of these words was located in the central core for the two French subgroups. This result means that Spanish consumers consider protein richness as the main nutritional benefit of pulses, while French consumers may simply know that pulses have interesting nutritional properties in general. The better knowledge of protein content identified among Spanish consumers may be due to the position occupied by pulses in the Spanish food pyramid, at the same level as white meats (Aranceta Bartrina, 2016).

4.2. Differences between countries

Some specific word categories were located in the central core of the social representation for one country only. In France, this was the case for the category *other foods.* Among the words in the category *other foods, rice*, and *legumes* are located in the central core in the word analysis. It is possible that the naming of starches by French participants could reveal knowledge about the importance of combining pulses and cereals to satisfy requirements in amino acids. Yet a previous study demonstrated that French consumers used pulses more often as a substitute for starches than in combination with them (Melendrez-Ruiz et al., 2019), showing that they are probably not aware of the principles of amino acid complementarity. Thus, the association of *other foods* with pulses in the present study more probably reflects confusion between pulses, legumes, and starches. This interpretation is supported by the fact that pulses were positioned in the same category as starches in the French food pyramid for many years (PNNS, 2015).

For Spanish participants, the specific word categories that were located in the central core are *appropriateness* and *context*. Within *appropriateness*, we found through the word analysis that *good* and *needed* were particularly frequent and relevant. The frequent use of these words reveals that Spanish participants consider pulses as a suitable food, adapted to many food choice situations (Mela, 2001). The *context* dimension can refer not only to the physical location where products are consumed or bought, but also to social setting, culture, and the availability of food. This dimension defines the food products that are appropriate to be consumed or not in a given situation (Schifferstein et al., 2001). The fact that both groups of Spanish participants placed *context* in the central core, unlike the French participants, reveals that Spanish consumers consider pulses a usual food in many consumption situations. These findings are consistent with the answers to the questionnaire, which indicate that Spanish participants considered pulses as being part of their childhood tastes and cultural tradition

significantly more than French participants did. It seems clear that culture influences not only the social representation but also the perceived position of pulses as belonging to Spanish food habits. This could either explain or result from their higher consumption in comparison with France.

Differences between countries were also observed regarding the formats in which consumers habitually buy pulses. Spanish participants declared that they buy pulses in glass jars (cooked) or in bulk. In Spain, pulses in bulk can be either raw or cooked, which is different from the situation in France, where pulses sold in bulk are always raw. French participants preferred to buy pulses in a cardboard box (raw), a transparent plastic bag (raw), or in cans (cooked). It thus seems that Spanish consumers favored the purchase of cooked pulses, while French consumers mostly favored buying raw pulses. This is in line with consumption data: in Spain, in 2018, there was an increase in the purchase of cooked pulses that reached the same level as raw pulses, i.e. 73 000 kg (MAPA, 2019). This result could explain the fact that French participants expressed a negative attitude towards *long cooking*, an expression that was not cited in Spain. The long cooking of pulses has already been identified as a barrier to pulse consumption in France in previous studies (Lecerf, 2016; Magrini, 2016; Melendrez-Ruiz et al., 2019; Rio, 2017). These differences between French and Spanish consumers could be explained by the availability of pulse products and the resulting consumer habits. In addition, there could be an influence of packaging on consumer perception about pulses. The packaging format in which Spanish consumers buy pulses is more often transparent, so that consumers can see the product before buying, whereas in France, packaging is more often opaque (e.g. cardboard or steel). There is evidence to suggest that "enabling the consumer to see the product, either through, or on, the packaging has a marked effect on consumer behavior" (Simmonds & Spence, 2017, p.348). As explained by these authors, transparent packaging can influence the perception of product quality, increasing trust, and perhaps positively affecting the perception of unfamiliar products (Simmonds & Spence, 2017). Consumers in Spain seem to have more opportunity to see pulses in transparent packaging, thus leading to greater trust in the product, and more willingness to buy the product in such formats. One of the possible strategies in France to increase pulse consumption could be to offer cooked pulses in transparent packaging, in order to combine short preparation time and visual cues. Currently, pulses are available either raw, taking a long time to prepare, or canned, quick to prepare but rarely visible to consumers at the moment of food choice.

4.3. Differences by level of education within countries

Some differences were identified in the central core of specific word categories and words, in relation to the level of education of participants in each country.

In both countries, words related to *convenience* were more frequent and relevant for participants with a higher level of education than for those with a lower level of education. This category contains words expressing convenience (*easy to prepare, practical,* and *non-perishable*) and inconvenience (*long cooking*). Among these words, *long cooking* was the only one that was cited more than three times, and only by French participants with a higher level of education. These results reveal that the convenience of pulses is perceived differently according to the level of education, but it is difficult to conclude, from our results, which participants find pulses more convenient than others. In addition, when calculating the polarity index, we took into account the positive and negative values of each word for each category, with the result that the *convenience* category was not identified as negative, nor as extremely positive.

French participants with a lower level of education considered items related to *purchasing* more frequent and relevant than other participants, and they also considered the words in the category *purchasing* as being particularly negative. This category mostly contains words related to price. It has often been shown, in the literature, that education level and financial resources are linked. In our study, we did not collect information about the economic situation of participants, but we can reasonably suppose from our results that the price of pulses is considered high by participants with a lower level of education because they may have limited financial resources. Pulses in France are affordable but comparatively more expensive than pasta, rice, or potatoes (price per kilo for retailer own brands: green lentils = 2.64 €, spaghetti = 0.87 €, basmati rice = 1.62 € and potatoes = 1 €, at Carrefour Drive, France in February 2020). A previous study showed that the perception of prices by French consumers corresponds to this reality: participants considered pulses more expensive than starches but less expensive than meat (Melendrez-Ruiz et al., 2019). The fact that participants with a lower level of education considered the price of pulses as negative in the present study may confirm that, in France, people compare pulses to starchy foods and not to meat, and therefore use pulses as they would use starches, as a source of carbohydrates and not as a source of proteins.

In Spain, participants with a higher level of education cited words in the category *digestion* a little more frequently than other participants. In the word analysis, this dimension is not very salient, the only word of this category cited more than three times was *flatulence*, cited in Spain with a comparably low frequency by both groups, and not cited more than three times in France. The same relative absence of digestive considerations was found in other studies. For example, digestive considerations were not considered a key factor in deciding whether or not to eat pulses (IPSOS, 2010). Nevertheless, in our results, the relatively low importance of words of this category has to be counterbalanced by the very negative salience attributed to the category and the words it contains. This result seems to indicate that although only a few participants feel concerned about disorders

consecutive to the ingestion of pulses, for those who did mention *digestion*, it was considered as a major drawback.

Finally, Spanish participants with a lower level of education used considerably more frequently than other participant's words related to *agriculture*. The words they used more often are *garden*, *nature*, and *soil*, indicating that these participants specifically associate pulses with naturalness, traditional crops and cultivation at household level. This can be linked to personal characteristics, such as having grown up in the countryside, having a vegetable garden, or working in agriculture.

4.4. Other differences between consumers, regardless of country or level of education

Another effective way to understand consumers' representations of pulses was to study the overall results regardless of country or education level. Three profiles emerged from the cluster analysis: cluster 1, cluster 2, and cluster 3. The consumers in cluster 2 referred more often to food names, either related to the legumes family (names of pulses and *legumes*) or not (other foods). It was previously hypothesized that, by citing exemplars, people attempt to confirm their understanding of the word (Melendrez-Ruiz et al., 2020). This may reveal a weakness of the concept of pulses for the participants in this cluster. This interpretation is confirmed by the fact that participants in this cluster cited significantly less frequently words related to *nutrition, preparation*, and *sensory aspects* than other participants, which may indicate that they are not very often exposed to pulses. A very large majority of consumers in this cluster were French (80%). This confirms the result obtained by the analysis for each country, according to which French consumers have a lower level of knowledge about pulses. The participants in cluster 3 focused on words related to *nutrition*, *health*, and *digestion*. All these words describe properties, revealing that consumers in this group had relatively good knowledge of pulses and their effects in the body and on health. A large majority of the consumers in this cluster had a higher level of education. It is widely admitted that people with a higher education level have broader access to a wide variety of knowledge, and this seems to be the case also for knowledge of the relationship between food and health. This knowledge of pulse properties could also be due to greater exposure to pulses as food, as suggested by the particularly high level of citation by this group of words related to *preparation* and *appropriateness*. The participants in cluster 1 are characterized by the use of words related to pulses considered as a plant (*agriculture*, *quality*). This cluster is less well defined in terms of country and level of education. It may be composed of people with more specific personal characteristics, such as having been exposed to growing crops, either by their profession, or by living in the countryside, or by having a vegetable garden. Cluster analysis was an appropriate complement to the study by country and by level of education as it allowed us to identify three main

profiles: (1) a very low level of knowledge about pulses; (2) pulses mostly considered as food, with a focus on their nutritional and health benefits, and their post-digestive effects; (3) pulses considered as crops rather than as food.

4.5. Methodological aspects: strengths and limitations

We particularly focused our analysis of results on the central core of the social representation, which represents its more frequent and important elements. The central core is recognized to be simple, concrete, and coherent; it reveals a system of values that bears the culture and the social norms of participants (Abric, 2011). By contrast, with many studies that considered only frequency and rank of importance, we chose to focus also on order of citation, using two indexes: Salience and Cognitive Salience. This analysis allowed us to improve understanding of consumers' social representations of pulses in a cross-cultural context. For example, it seems that there could be a learning process in relation to pulses. Most French consumers are located in the first phase of this learning process, which they show by citing exemplar words for pulses, names of other foods, and pulse characteristics. Most Spanish consumers are in the second part of the learning process, citing words related to *health*, *nutrition*, and *convenience*. It seems that consumers first need to identify the product, and then to acquire more precise knowledge about what pulses are for and how to use them. We also proposed an adapted calculation of the cut-off points for frequency and relevance, which took into account the median, and not the average value. With this calculation, we took into account the nature of our values, allowing us to perform a more satisfactory analysis. We also proposed the polarity degree index, an adaptation of the polarity index, in order to obtain more precise information regarding consumer attitudes toward a word or category (positive or negative).

By analyzing both words (raw data) and word categories (dimensions), greater insight into the social representation of subgroups of consumers became available. Both methods brought to light differences between participants in France and in Spain. Surprisingly, divergent results were obtained for the comparison of participants with different levels of education within a country. In France, the word analysis showed marked differences between participants by level of education. Highly educated French participants cited words such as *white beans* and *apricots*, while those with a lower level of education cited words such as *potatoes, spinach,* and *green beans*. These differences were not perceptible in the category analysis, where these words were grouped into the category *other foods*, revealing no difference between participants with higher or lower levels of education. Another example is the word *long cooking* for highly educated participants, which could be an important factor for this group of consumers, but was not revealed by the category analysis. By contrast, for Spanish participants, differences between education levels were perceptible in the category analysis. For

example, Spanish participants with a lower level of education mentioned words in the category *agriculture* more frequently. In the word analysis, these differences were not revealed because each of these words was used at a frequency below three.

The main limit in our study was that, after sorting participants by level of education for each country, or by clusters, the number of participants in each subgroup was relatively low. Participants were recruited in two relatively small cities, and it would be interesting to extend such a study to different places in each country, to confirm that these results reveal specificities of countries and not merely of specific regions. Some of our results should therefore be confirmed by further studies.

Conclusion

This study adapted and improved the assessment of the social representations of a food product in a cross-cultural context, which could constitute an interesting opportunity for future research. Our results highlighted similarities and differences among the words and categories used in each country and at both levels of education. Some categories were found in each subgroup, such as *health, pulses, nutrition, preparation*, and *sensory aspects*, while other categories were specific to one country. French participants mostly used words related to *food products*, while Spanish participants used concepts related to *appropriateness* and *context* more frequently. The cluster analysis identified three different groups of consumers, one with little knowledge of pulses, another composed of consumers considering pulses as food, and a third group perceiving pulses as crops. In addition, we found that Spanish consumers considered pulses as part of their culture and childhood more frequently than French consumers. This could explain the higher consumption of pulses in Spain compared to France. In this sense, culture not only influences the content of the social representation about pulses but also influences the perception of consumers about pulses as belonging or not to their food habits and culture. The packaging of pulses could also be a key factor to consider, and further analysis is needed to test the hypothesis proposed in the study. Finally, some strategies could be proposed in each country to encourage and increase pulse consumption. In France, for example, it would be helpful to increase not only knowledge about nutrition and health with regard to pulses, but also know-how regarding buying, cooking, and combining pulses. In Spain, it could be interesting to promote pulses as a product that is considered culturally important for consumers (by popularizing this message throughout the population). For both countries, strategies should aim at increasing the presence of pulses from childhood onward: exposing children to pulses from an early age could increase their long-term appreciation of these products.

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Chapter VII. General Discussion

This present research aimed to explore the factors and mechanisms underlying the choice of pulses by French non-vegetarian people. Firstly, methodological consideration will be discussed, then the general discussion is based on the main findings of this research. Secondly, the main findings of the thesis will be interpreted and discussed. In particular, strategies will be proposed to increase pulses consumption in France, with a practical example. Lastly, the strengths of this research will be commented.

1. Methodological considerations

Before interpreting and discussing the different findings, it is necessary to recall and explain methodological choices. The studies were carried out with French non-vegetarian participants, chosen to represent "average" individuals without any specific diet. Vegetarian and vegan consumers, who currently represent around 5% of French consumers, were not considered in this study because they hold specific food habits (they rarely eat meat, even if only 2.3% of them declare to never consume meat products) and socio-demographic characteristics (they are generally young - 18-34 years old - and usually living in urban areas) (CREDOC, 2019). In addition, vegetarian and vegan consumers in France have a higher consumption of plant-based products, to substitute animal products, compared to meat-eaters (Allès et al., 2017). In this thesis, we decided to focus on omnivorous people to have a representative sample of the consumers that follow a traditional French diet. In all the studies mentioned in this manuscript, participants signed out a consent form in which they confirmed that they did not follow a specific diet, such as vegetarian or vegan diet. Regarding the professionals that were recruited for the study presented in Chapter 2, the main selection criteria were to work in the supply chain of pulses at the period of the study. Due to the limited number of people in this situation, we could not add another selection criteria and thus we did not ask them about their diet. For the same reason, all professionals were grouped together in the study, whatever their sector of activity in the supply chain. We are conscious that differences would probably be found among professionals belonging to different sectors (e.g. farmers, transformation, retailers…).

2. A reminder of the main findings

The findings obtained in this thesis provide insights into the social representation of pulses of French non-vegetarian consumers and professionals from the pulses industry (Chapter 2). We also

studied the mental representations (Chapter 3, 4), attitudes – beliefs – knowledge (Chapter 3), visual attention (Chapter 5), and food choice behavior of consumers (Chapter 5), toward pulses. Finally, we carried out a cross-cultural study to compare the social representation and attitudes of French and Spanish consumers concerning pulses (Chapter 6).

In Chapter 2, we found that consumers used exemplars names to confirm the understanding of pulses, one of the most prototypical pulses being lentils. Consumers tend to confuse pulses and starches, probably for their properties and use, and to mismatch pulses (legumes secs) and nuts because of the strong semantic similarity in French between pulses and nuts ("Legumes secs" and "fruits secs"). Nevertheless, consumers consider pulses as nutrient-rich and tasty and they hold mostly positive attitudes toward pulses, while the few negative attitudes (negative image, unknown, lengthy cooking, digestion) are open to change. Professional from the pulses industry have another approach of pulses, based on a deeper understanding of pulses properties. They focus on the protein content and culinary preparation, and they barely consider taste. Professionals' attitudes toward pulses are slightly more negative than consumers 'ones.

In Chapter 3, we observed that when consumers had to make food choices in different contexts evoked by scenarios in a laboratory setting, the choice of pulses accounted for only 10% of total choices. Participants associated pulses with a vegetarian diet and pulses were considered more difficult to prepare than products from other food-groups. Participants declared that they did not like pulses much and not frequently consumed them (except lentils). They knew that pulses are products good for health and environment, richer in proteins than vegetables and starches but less than animal products, and they considered them medium price. Furthermore, we evidenced in this chapter that meat is a central element in a meal for French non-vegetarian consumers. The more usual structure of the main dish was meat, starches, and veggies (45%). The central role of meat increased when social interactions were involved. When pulses were presented in a dish, they were associated mostly with animal products and starches. There was an infrequent association of pulses and starches without meat in a meal. Pulses were chosen first to construct a dish in only 13% of cases, and more often in the vegetarian scenario. Women, participants under 40 years old, and those with a high level of education more frequently chose pulses first to build their meal.

In Chapter 4, we found that the differences between various food products belonging to the same food-group are driven by their level of process rather than by containing the same basic product. There is a positive mental representation toward pulses when they are unprocessed, or low-processed (canned and frozen). For ultra-processed foods, the representations and attitudes depend on the recipe: innovative recipes were considered positively, while canned and frozen products were

associated with negative attributes. This negative mental representation is toward the product itself (the recipe) and not the packaging format.

In Chapter 5, the visual attention of consumers toward pulses was measured using an eye tracking device in a virtual supermarket. We found that the gaze behavior of participants toward pulses changes according to the type and organization of the shelf to which consumers are exposed. Pulses received less visual attention than other products, especially in the dried and canned shelves. When comparing the visual attention of consumers toward pulses and other food-groups (starches, vegetables, and animal-based products) in a "super-shelf", we found differences among food-groups. Pulses received higher visual attention than vegetables, but lower than starches and animal products. Moreover, in the same supermarket virtual environment, products chosen by participants were recorded, and the influence of two strategies (motivation of choices evoked by scenarios and nudges) on the choices for pulses were evaluated. A higher choice of pulses was observed when evoking an extrinsic motivation of choice (for the environment), but a nudge-based strategy oriented to health or pleasure toward pulses did not increase the choice of pulses. However, when combining both strategies and grouping consumers into different clusters based on their pulse's choices, we found that both strategies could potentially increase pulse choice for certain groups of consumers with specific motivations of choice.

Finally, in Chapter 6, we compared the social representations and attitudes toward pulses from French and Spanish participants, considering their level of education. This cross-cultural context showed that there are common elements in the social representation among both countries related to health, pulses, nutrition, preparation, and sensory aspects, while other specific elements were found for each country. French participants mostly used words related to food products, while Spanish participants used concepts related to appropriateness and context more frequently. Spanish participants with a higher level of education cited words related to digestion, while participants with a lower level of education used words related to agriculture. French participants with a lower level of education mentioned items related to purchase more frequently than other participants. We also found that Spanish consumers considered pulses as belonging to their culture and childhood more frequently than French consumers.

3. Discussion of the main findings

The research presented in this thesis highlighted different barriers that could explain the low consumption of pulses by French non-vegetarian consumers, but it also revealed some important key-elements as possible enablers to increase pulses consumption.

Some of these factors are person-specific (internal factors), and others are not (external factors). The internal factors are linked to individual traits of the person making the food choice, like attitudes, mental representations, and knowledge. The external factors refer to those elements that do not depend on the person executing the food choice but are related to their social environment, such as culture.

3.1. Barriers to pulse consumption in France

The level of processing: a paradox

One of the main barriers to pulses consumption highlighted by our work is the **difficult preparation of pulses**. In our study, French participants declared that pulses are more difficult to prepare than products from any other food-group. This perceived difficulty of preparation influenced their choices when composing a meal (Chapter 3). It is mostly related to raw, unprocessed pulses (Chapter 4). Moreover, raw pulse-based products received less visual attention than raw starches (dried shelf of virtual supermarket, Chapter 5). This could be explained by an anchored mental representation of a greater difficulty of preparation of pulses (soaking time, and cooking) than other food-groups such as starches. Indeed, eye movements are not only directed by visual characteristics of the environment and prior experiences, but also by the mental representations of whatever the person is seeking (Hout & Goldinger, 2015). Suggesting that because of their difficult preparation, pulses may receive low attention and could potentially not be frequently chosen. However, the difficulty of preparation does not seem to be a characteristic strongly anchored in the social representation of pulses (Chapter 2, 6). These results express that the difficulty of preparation is an element that is related to the person who has to prepare pulses, exposing either a lack of knowledge on how to prepare and cook pulses or the negative perception by some individuals of the lengthy and/or difficult preparation of pulses.

A wider variety of pulse-based products have recently been developed to overcome the difficulty of preparation. Nevertheless, traditional ready-to eat are often considered by consumers as ultra-processed and have a strong negative image (Chapter 4). Ultra-processed foods are considered to be associated with an unhealthy diet and different diet-related diseases (Monteiro et al., 2018). Yet, ultra-processed and ready-to-eat products should not all be considered as a threat to consumers' health: healthiness depends on many factors not only related to the presence/absence of a process but other factors such as the ingredients and type of additives.

This paradox represents certainly a barrier to pulses consumption, since the untransformed pulses are considered not convenient and the ultra-processed alternative is not well accepted, which

ends up with a low consumption of pulses. This paradox is reflected by the choices of pulses in the studies of Chapters 3 and 5: in Chapter 3, pulses were presented raw (unprocessed) while in the studies of chapter 5, there were both unprocessed and processed pulse-based product. Despite this wider variety of pulses products, the frequency of choice for pulses did not increase in Chapter 5 compared to Chapter 3. This suggests that all types of pulse-based foods are concerned by infrequent choice, independently of their level of processing.

Observed knowledge, mental representations, and attitudes toward pulse-based products

- **An overall positive Attitude, but an infrequent choice of pulses**

We identified that participants, in our study, had essentially positive attitudes toward pulses in general, and the few negative attitudes are susceptible to change, as they are held by a small number of individuals and are not shared by the majority of the participants (Chapter 2, 6). These positive attitudes seem to be related to the positive image of unprocessed and little processed pulse-based products (Chapter 4). In social psychology, attitudes are considered to be predictors of behavior (Kraus, 1995). The relationship between behavior and attitudes is stronger for some specific situations and some people than others (Jhangiani & Tarry, 2014). A meta-analysis highlighted that attitudes influence behaviors when they are stable over time and their output is easy to remember, additionally having a direct experience with the object and being motivated to think about the object affects the relation behavior-attitude (Glasman & Albarracín, 2006). However, we found that the positive attitude toward pulses does not necessarily translate into a greater choice for these products. In our studies, we observed a low spontaneous choice of pulses, which, accounted for 9 to 13% of the overall choices, depending on the conditions of each experiment. This observed low choice of pulses could reflect the actual low consumption of pulses in France. Indeed, a recent rapport stated that the pulses consumption for 2018 was around 5.47 grams per person per day (Agreste, 2019), which is way below national recommendation of about 200 grams per week (ANSES, 2016).

We could wonder why holding positive attitudes toward pulses is not enough for French non-vegetarian consumers, to choose these products. Perhaps the barriers toward pulses consumption are too strong and are considered to be difficult to overcome, that even having positive attitudes is not enough to increase the pulse choice or maybe participants have not had constant direct experience or motivation with pulse-based products.

- **An unstable social representation of pulses**

We found that another barrier to pulse consumption is associated with an unstable social representation of pulses for French non-vegetarian consumers (Chapter 2, 6), evidenced by their need to cite exemplars to confirm the understanding of the word "pulses". Pulses are mistaken with nuts because of the strong semantic similarity of the names of these two categories of foods, in French ("legumes secs" and "fruits secs"). This confusion may be even reinforced by the very frequent association of the words "fruits" and "legumes" in many sentences used as recommendations: "Mangez 5 fruits et légumes par jour" (For a healthy life, eat at least five fruits or vegetables per day"). Besides this common confusion, pulses are also confounded with starches regarding their properties and uses. This could originate from the long-held-position of pulses in the starches group in the nutritional recommendations (PNNS, 2011). Thus, it seems that for French people a product belonging to the pulse's food-group shares some characteristics (e.g. sensory and nutritional attributes) with products from other food-groups, such as nuts (e.g. round/oval form, dried) and starches (e.g. dried, with a high percentage of carbohydrates). This could result in participants having trouble identifying the specific and unique properties of pulses, which differentiate these products from other food-groups.

- **Low association of pulses and starches**

We found a low association of pulses with starches when composing a meal (Chapter 3). Pulses are rarely associated with starches, and when products of these two groups are associated, it is often in triplets with meat. It suggests that pulses could be used as a replacement for starch rather than for a meat product. As we have just seen, the social representation of pulses is not well anchored. For this reason, starches and pulses might probably be perceived as having similar properties. It may explain why consumers do not associate them, because they may not understand the interest behind this association. Yet participants in our study were conscious of the high protein content of pulses. The explanation may be that this knowledge is fragmentary: they are probably not informed about the complementarity of pulses and starches to fulfill the balanced amino-acid requirements. This could be the reason why they considered pulses as products for vegetarian consumers (Chapters 3, 4). A study showed that French vegetarian and vegan consumers ingest a high variety of amino acids from legumes and cereals, to reach the recommended amino acid dietary recommendations without eating meat (Allès et al., 2017). On the contrary, participants in our studies did not associate these products and even seem to be confused about pulses and starches properties and uses (Chapter 2, 6). For non-vegetarian people, not understanding the reasons for the pulses-cereals association but observing it as a frequent characteristic of a vegetarian diet, may have contributed to the classification of pulses as

foods for vegetarians. Wanting to distance themselves as much as possible from vegetarians, people attached to meat may not agree to consume products that they associate with a vegetarian diet. The association of pulses to a vegetarian diet and the lack of knowledge regarding the advantages of associating pulses and starches thus represents a barrier to pulses consumption.

- **A limited knowledge about pulses**

Fortunately, on other aspects, we observed that participants to our studies had some knowledge regarding pulses. They knew raw pulses are good for the health (Chapter 3, 4). In the core of the social representation of French consumers toward pulses, we found the notion of healthy and nutrients (Chapter 2, 6). Even though, they did not spontaneously cite a lot the word "protein" when referring to the nutrients, we found that in the direct questionnaire, participants considered pulses as having higher protein contents than vegetables and starches (Chapter 3). In addition, participants know that pulses are good for the environment (Chapter 3, 4, 5). Yet, the notions regarding the environmental benefits did not appeared spontaneously in the social representation. Which could suggest that they know this information, but they have not yet integrated it as part of the representation.

Therefore, the knowledge acquired by participants about pulses indicates that there is not a lack of knowledge regarding the advantages of pulses. This knowledge regarding pulses benefits (health, environments) and protein content was not influenced by the level of education of our participants (Chapter 3, results not shown). However, we do not have information about the practical knowledge regarding pulse, we can assume from the barriers exposed previously that the difficulty of preparation could imply a lack of practical knowledge. Moreover, it seems that the knowledge is not enough driver to choose pulses products, either participants do not use this knowledge in their choices or other attributes may step over their knowledge such as taste or price.

- **Attachment to the French culinary culture**

We have seen that the culture, in general, is a determinant of food choice, in this case, the attachment to the French culinary culture is so strong that it seems that it might also influence the other barriers previously exposed, in a direct or indirect way. Indeed, we observed in Chapter 3 that meat continues to occupy a central place in the mean dish, and its association with vegetables and starches is the most frequent. Such a structure is a common feature in French gastronomy (PNNS, 2015). Besides, when pulses were used to compose a dish, they were associated mostly with animal food products. This reveals the cultural attachment of the association of pulses with animal products, probably linked to typically French dishes such as Cassoulet (white beans and pork), Petit Salé (lentils with sausage), etc...

Additionally, in the cross-cultural study (Chapter 6) we identified that the culture plays a role in the social representation toward pulses, Spanish consumers have a clearer meaning of pulses, and they considered those products as part of their culture and childhood more often than French consumers. These results suggest that in the traditional French culture the place of pulses is not favorable to increase pulses consumption in the overall population, either pulses are associated with an animal product or are not considered as a product that represents their cultural gastronomy. Attachment to meat could, therefore, provoke an indirect decrease in the consumption of pulses, except when these are associated with meat in a traditional dish where they cannot be replaced by another ingredient, because of a recipe well anchored in French culture.

3.2. Opportunities and future strategies to promote pulses consumption

Besides the barriers to pulse consumption exposed above, the current research also highlights some results that could be seen as opportunities to encourage and promote pulses consumption by French-non vegetarian consumers. These opportunities could translate into the development of new and efficient strategies. To do so, the barriers previously identified need to be tackled from a societal point of view including the industry, the national authorities, the research organizations, and other stakeholders (e.g. schools, restaurants).

Innovative processes and new products to overcome the limits of preparation and the negative image of ultra-processed foods

One strategy that could be implemented by the food industry is to develop new products that would be easy to prepare and consume, but that are not ultra-processed, since traditional ultra-processed food tend to suffer from a bad image, contrary to unprocessed or little processed products (Chapter 5). Lentils hold a privileged place for consumers, and this should be considered as an opportunity to develop new products. Indeed, lentils are considered to be less difficult to cook, are consumed more than other pulses (Chapter 3), and among other pulses lentils were usually the most product chosen (Chapter 3, 5). Lentils are the most prototypical variety of pulses (Chapter 2), which could reflect a strong cultural attachment to this product, perhaps because lentils are the most common among pulses crops in France: they are grown in a specific region (Auvergne). Lentils are also known for their quality, and often sold with a denomination of origin (PDO) such as the “Lentille verte du Puy” (Solagro & RAC, 2016). Finally, raw lentils do not need to be soak, and their cooking is shorter than other raw pulses. In this sense, the industry could develop products using other pulses but having the same advantages than lentils. For example, promote other pulses that hold an origin sign (e.g. Coco

de Paimpol, traditional white beans from the North West), develop industrial processes to decrease the soaking time of beans and chickpeas, and increase the availability of products that usually come already soaked, thus reducing the soaking and cooking time (e.g. frozen products containing pulses).

The recent pulse-based products found on the market in the form of “meatballs” or “patties” have a good image despite their high level of process (Chapter 5). Before generalizing such products, precautions should be taken regarding their nutritional composition. The industry should also have in consideration that the sensory characteristics, and especially the taste, is a particularly important criteria of acceptance of pulse-based products. Generally, when consumers are exposed to a new food product, they rarely make an effort to get information about the product or its characteristics (Grunert, 2006), because people are constant in their food choices, they hold a set of expectations and beliefs about the product that would guide their behavior (Gibson, 2006). As a consequence, all the actors in the supply chain must improve their communication with and toward consumers, regarding traditional and new pulse-based products. For example, increasing the attractiveness of little processed pulses in a can and finding a way to promote the new products more accurately, to attract the attention of people toward these products.

Similarly, from Research & Development perspectives, it would be interesting to develop more plant-based products combining pulses and starches, which from a nutritional point of view would contain all the essential amino acids. In addition, it would be useful to study the protein quality of the resulting products, determined by the digestibility and bioavailability of amino acids (Nosworthy et al., 2017). A higher digestibility value for proteins can be a good argument for the communication to consumers, by the means of a claim related to protein content and quality, for example. A concrete example of this is already being used in Canada: the addition of 25% lentil flour blend with 75% durum wheat flour, improves the balance of the essential amino acids, thus qualifying for a “Good Source of Protein” claim (Pulse Canada, 2016). Creating and reformulating food products that contain pulses and starches, such as snacks, could therefore represent an opportunity to attract the attention of consumers toward a healthy food product. Besides, sensory analysis tests would be necessary to corroborate if the new plant-based products are accepted by French non-vegetarian consumers.

Further knowledge, representations, and attitudes toward pulse-based products

- **The need for more precise knowledge**

One of the objectives of the recent French National Nutrition and Health Program 2019 – 2023 is to increase pulses consumption in the general population to at least one portion a week (PNNS,

2019). This represents the first step to achieve the nutritional recommendation proposed by the High Council of Public Health in France to consume pulses at least twice a week (HCSP, 2017). The pulse portion proposed for adults (women and men) is around 100 grams per day (ANSES, 2016). But, how can French people include these recommended values in their everyday food habits?

The national authorities play an important role as prescribers of the nutritional guidelines, the communication toward consumers, but also health professionals and industry. They should deliver alternative information to consumers, thus helping them to understand and include the recommended portion size in their diet. For example, explaining that 100 grams of cooked pulses are equivalent to mostly four full spoons. Recipes could be proposed to achieve this value during lunch, diner, or snack time. The average price of the preparation should also be used as an argument, to draw the attention of consumers toward recipes combining a low price and high nutritional value. From a nutritional point of view, another strategy should be to **emphasize the benefits of combining pulses and starches** in a dish. This kind of information seems to be even less accessible to consumers than practical information. Indeed, for a few years French national authorities have changed the recommendations and now state that pulses can be used as a replacement of meat and poultry (HCSP, 2017), but it does not explain the interest of the association of pulses and starches in terms of amino acids profile. This nutritional information regarding pulses and starches association seems to be difficult to communicate and should not be provided in scientific terms, because it should be accessible to consumers. This reveals that there is a work to be done, from the professional and research area, to communicate simply about this characteristic to the general population. A recent review highlighted the possibility to use a label for healthy carbohydrates as a strategy to allow consumers to better identify these products in the retail environment. The authors explained that a high-quality carbohydrate should have high dietary fiber, low glycemic index, and contain mainly whole grains (Marinangeli et al., 2020). In such a description, pulses can be identified as a healthy carbohydrate products. Another strategy could be to create a label for the products that combine both pulses and starches, to highlight the complete amino acid profile without needed from the consumer a high cognitive involvement.

The national authorities also need to focus **on using a unique term** when referring to pulses. Nowadays, in the nutritional recommendations, we can find the term 'pulses' ("legumes secs"), but also 'legumes' ("légumineuses") at the same time, terms that are used interchangeably. If using both terms is not an inconvenient for the people writing the nutritional recommendation, it may create confusion for consumers, which could affect their mental representations, and finally impact their behavior. A food product that is difficult to think is difficult to eat (Corbeau & Poulain, 2002). In this sense, it seems highly important to give a name and a clear definition of pulses, which could be used by national authorities, industry, and professionals to also accurately communicate to consumers.

Accordingly, the research area could also carry on a study to determine which term is best. For instance, a word association task using the word legumes "légumineuses", compare to pulses, could help in to find the most appropriate term to be used in France when communicating about pulses.

- **How to promote pulses by improving practical knowledge**

Currently, in France, there are nutritional messages regarding recommended pulses consumption (PNNS, 2019), but these recommendations may not be followed if people lack practical knowledge about how to prepare and cook pulses. Current messages are not enough accompanied by know-how information. A strategy should be to focus on increasing the knowledge about the practical use of pulses, the know-how to, pre-cook, cook, and store. This practical knowledge could decrease the strong perceived difficulty of preparation of pulses. Indeed, if people are well-informed they could be more prone to choose pulses more frequently. Transmitted information should consider different parameters such as: all the pulse-based products available, the time required to cook the different varieties of pulses (e.g. red lentils, dried peas), the step by step in the recipe making, the storage information, the final price of cooked pulses and extra tips. Additionally, the converted ratio between raw and cooked pulses should be explained, as it is in Canada, so that consumers would know that ¼ cup of raw pulses is equivalent to ½ cup of cooked pulses (around 82 to 90 grams) (Pulse Canada, 2017). Consumers thus could realize that a pulse-based products (recipes) could align with their desires and motivations, while fulfilling their nutritional needs.

The practical knowledge could be delivered for example by the national authorities in the form of communication campaigns; by the industry including this information in the packaging of their pulse-based products and by other stakeholders such a social centers or school through culinary workshops. As well, this practical information could take into account the season, the number of portion sizes, if there are kids or not, the total time, alternative options to substitute no-pulse ingredients in case of shortage, allergy or dislike. Thus, personalizing the pulse dish to the habits and lifestyle of the person making the choice.

One of the advantaged of delivering this practical knowledge to consumers would allow consumers to modify their mental representations regarding the difficulty of preparation. Having a clear mental representation on how to prepare pulses could increase the attention toward raw, unprocessed pulses in the retail environment. People who currently consume pulses have probably learnt this information from their external environment (e.g. parents, family) or are personally motivated to look for this information via the cooking blogs, books, media…etc.

- **Filling the gap between attitude and pulses choices**

We have previously exposed that there is a gap between the attitudes held by French non-vegetarian consumers toward pulses and the final choice of these products. From a research perspective, there is a need to continue to investigate the reasons behind this mismatch. For instance, other measures could be obtained to explain consumer choices and could be used to draw additional information without direct asking: for example, eye tracking measurements. Usually, participants look longer at the chosen alternative than the other alternatives (Vu et al., 2018), the total number of fixations and the total duration fixation are commonly used as predictors of consumers decision (Goyal et al., 2015). In this sense, it would be helpful to investigate the relationship between the visual attention of consumers and their food choice in a setting close to the real-life environment. Usually, in a purchase situation, two key moments can be identified in terms of food-choice decision-making. One is the first moment when products attract attention, activating emotional and positive expectations, and secondly when the elicited expectations come across with the user experience (Duerrschmid & Danner, 2018). Thus, when making a food choice, participants may look at pulse-based products particularly often, without translating this attention into a greater choice of pulse-based product. Or on the contrary, in some situations the pulse-based products could be chosen more frequently, but with low visual attention. Studying consumer choice toward pulses while investigating their gaze behavior during the moment of choice, could reveal a potential explanation of the differences between attitudes and choice.

- **New insights useful for health organizations to communicate to consumers**

We found that there is some evidence that pulses consumption could be related to specific socio-demographic characteristics of participants. Participants that tend to choose pulses more often were young, mostly women, and had a higher level of education (Chapter 3). On the contrary, those who did not choose pulses at all had a lower level of education, were mostly aged between 36-50 years of age. We also found that the level of education influences the social representation of French consumers toward pulses (Chapter 6). The level of education thus seems to be one of the factors that impact consumers' behavior toward pulse-based foods. Within the sociodemographic characteristics, it has been shown that French people with lower education level had a higher intake of red meat and processed meat compared to people with a higher education level (Méjean et al., 2016). On the contrary, French vegetarians were characterized to have a high level of education (Allès et al., 2017). This could perhaps explain why in our studies, participants with a higher education level were more prone to choose pulses frequently. Education can influence knowledge and skills (Benjamin Allès et al.,

2017). In this sense, in France, high educated people can be more susceptible to choose and consume pulses, as they may have greater knowledge about pulses characteristics, and they manage the necessary skills to prepare and cook pulses adequately.

As different profile of consumers and non-consumers were identified, there is a need to find the best strategies to communicate with each group of consumers. To do so, transdisciplinary research studies could be carried out, including Information and Communication Science (sciences de l'information et de la communication). Focuses to test different types of communication to specific groups of consumers and determine which strategy is the most adapted to communicate efficiently.

Taste at the center of the product development and effective communication strategies

We found that participants in our study associated taste to pulses (Chapter 2), but they also declared that they do not like pulses, except for lentils (Chapter 3). These results reveal that taste is an important sensory feature of pulses. Even if taste is subjective (people like or dislike pulses taste), participants tended to consider it closely related to pulses, at such a point that is was a component of the general social representation of pulses. The taste dimension is the highest motivation for French people to make a food choice (Allès et al., 2017), suggesting that perhaps the presence of the taste in the social representation is also linked to the importance of the taste within the French culture, and not only to the pulses products themselves.

Furthermore, communication strategies should focus on the connection between healthy food and enjoyment, instead of giving information about the risks or health advice (Köster, 2009). To achieve this strategy, there is a need to encourage pulses consumption throughout hedonic and personal motivation: "I like it, I do it for myself". There is a need to link enjoyment and pleasure to pulse consumption. Pleasure related to food is influenced by the frequency of consumption, personal motivations, the initial pleasure, and the most recent eating experiences (Hetherington et al., 2002). As exposed by Marty et al., (2018), pleasure from eating is partly learnt during childhood. It includes three different dimensions: sensory, interpersonal, and psychosocial. Having in consideration that French participants in one of our study declared that pulses are rarely part of their childhood taste, it could explain why nowadays adults find it hard to associate the pleasure of eating to pulses. It reveals that it could be interesting to expose children from an early age to pulses, at home, and/or school. A study found that repeated taste exposure could be used to increase the consumption and liking of

lentils by children from 3 to 6 years old (Ramsay et al., 2017). This early exposition could result in a long-term appreciation of pulse-based products later in adulthood.

Additionally, changes in the retail environment could be proposed to increase the visual attention of consumers toward pulses grouping pulses in a single shelf, creating collaborations with a national brand of pulses. Moreover, in the restaurant, self-service, and supermarket it could be possible to organize a "Day of pulses" providing pulses tasty recipes and pulses sampling. In doing so, we would increase consumers' intrinsic motivations to eat pulses (e.g. flavor, variety, and versatility). Thus, reinforcing more sustainable food choice in the long term, and reducing food choice based on external motivations. This could be also a way for consumers to know that pulses are a product for them too and not only for vegetarian consumers, a message "Pulses for All" could explicitly demonstrate to participants the place of pulse in their own food intake.

The following is a practical example that was developed having in consideration the main information that we identify as key elements that should be delivered to consumers (Figure 7).

Practical example: from the lab to the kitchen

We have previously exposed different recommendations; each strategy could have the potential to promote pulses among French non-vegetarian participants in some specific way. However, if we want to increase the chances and succeed in the mission "Pulses for All" a conjoint effort needs to be done from each of the stakeholders. For example, if we want to deliver the important information regarding the nutritional, practical facts, and the purchase advantages in the form of a recipe, we would need to:

(I) The research area would have to find the adequate amino acid balance in a recipe to obtain in a single meal all the essential amino acids from plant-based products. The authors Woolf et al., (2011) used the database vProtein, which includes several plant-based foods and provides a pair of foods necessary to satisfy essential amino acid requirements. After going thoroughly to the database, we identified possible pairs of foods that cover all the protein requirements. The combination of cooked lentils (74.93%) and oats (25.07%) have an amino acid efficiency of 86% and provide an equivalent of around 25 grams of high-quality protein per meal for an adult. The combination of both food products increases and fulfills 100% of the amino acid requirements.

(II) The research area and the industry could work together to create a recipe and/or a food product containing the two main ingredients to guarantee a complete amino acid requirement. They would have to evaluate the nutritional facts, the physical and chemical properties of the product, and consumer's sensory acceptability. The new products would need to be blend with other food products that would not only improve the taste, but also the nutritional value. In our example, we developed a recipe based on cooked lentils and oats. We called it "Lentil-balls & Zucchini noodles". This recipe takes into account the already high content of protein and carbohydrates; thus, the additional food products are mostly vegetables.

(III) Together with the research, the industry and the national authorities could provide information to consumers concerning the advantages of the new products/ recipes created. Providing information under the form of a recipe allows to highlight key points such as portion size, preparation and cooking time, but also the insist on the reasonable final price, include the main nutritional information, embrace food pleasure with a word, show a tempting picture of the final result, list all the ingredient and the step by step instructions, add a logo of the campaign message "pulses for all", lastly add storage conditions, additional information that could be useful for a consumer, and specify that the recipe follows the recommendation from the national authorities.

(IV) Finally, provide this information to consumers in the national nutritional campaigns, on the packaging of lentils food products, at supermarkets, at social centers, cooking classes, etc.

This is just one example of what could be done if all the parts involved worked together to promote pulses consumption in France.

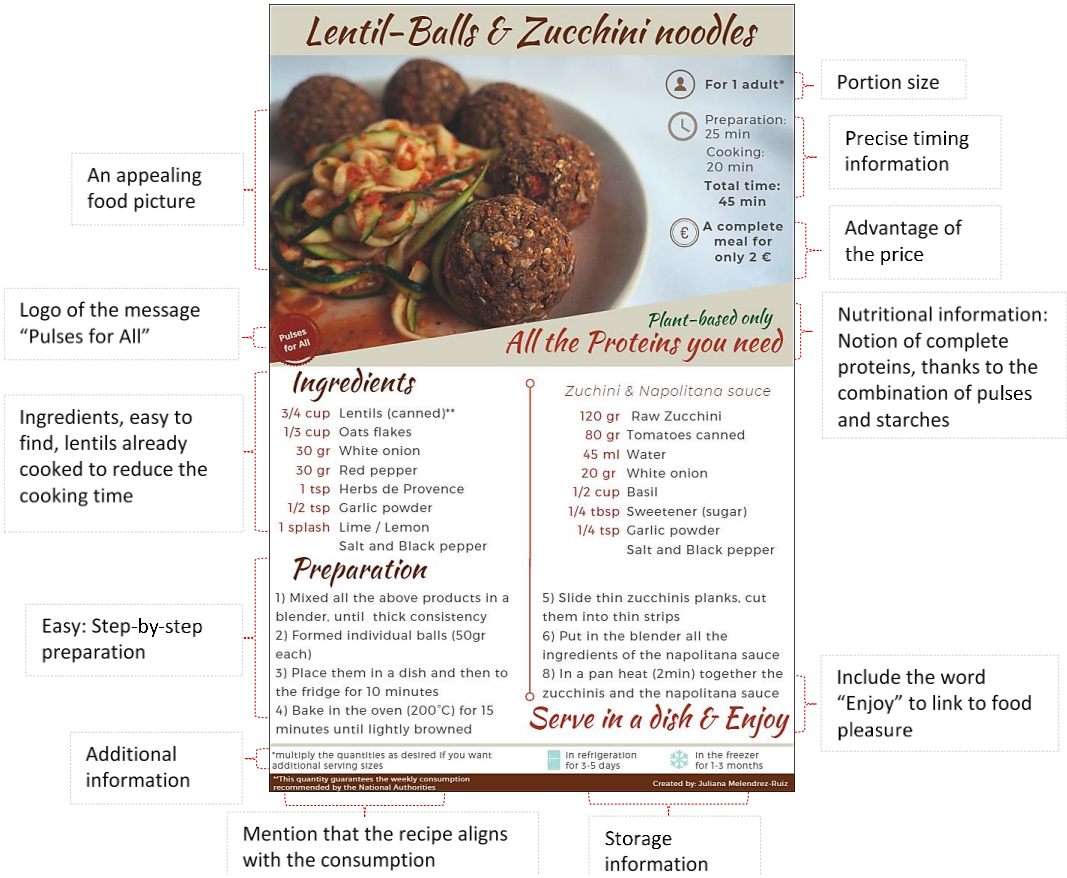

Figure 7. *Example of the communication to be delivered to consumers with all the key points identified in this thesis*

Using social context as support to increase pulses choices

Personal experience with pulse-based products, and/ or experiences in other contexts such as restaurant, self-service could be useful to overcome the mental representations that limit the relationship of consumers with pulses, especially the difficulty of preparation. Integrate pulses in those environments that have a positive social reputation, should be considered also as a strategy. Indeed, the food context in which pulses are presented to consumers influences later food choices (Chapter 3). Coll (1979) concluded that "the major influence on how much people choose to eat is where they eat" (p. 797). Participants chose more frequently pulses in a restaurant, self-service, and vegetarian context; this could suggest that pulses do not suffer from a negative reputation as they are used in different social contexts. This could represent an opportunity to other stakeholders such as restaurants and self-service to create new tasty pulse-based dishes with pulses, and include them more often in their menus.

Moreover, from a research perspective it would be interesting to carry out studies combining one of these contexts (restaurant, self-service) with a nudge strategy. A study found that in a lab buffet, when salads were divided into individual take-away bowls as a default option, the choice of salads increased (Friis et al., 2017). Changing the order of the food products in a buffet line from healthiest to least healthy can nudge participants toward a healthier meal (Wansink & Hanks, 2013). Additionally, placing healthy food products at the beginning or the end of the list within a menu at a coffee shop, increased healthier food choices (Dayan & Bar-Hillel, 2011). In other to go further, a study about a nudge-based strategy in a self-service could be implemented, by providing pulses into individual take-away bowls as a default option, or by intentionally placing pulses at the beginning of the buffet line. Additionally, in a restaurant another nudge-based strategy could implement by placing the pulse-based dishes in the top or bottom of the menu. Once the efficiency of the nudge is validated by research, it would be possible to use them widely in a real food environment. Thus, restaurants and self-services at school or working places could implement the most adapt strategies to increase pulses' choice and consumption.

Another context that can be used as support to increase the choice of pulses is the retail environment. A retail environment is considered an active context in which customers interact not only with the products, but also with the store display, with employees and even with other customers, influencing therefore customer's behavior (Argo & Dahl, 2020). In Chapter 5, we observed that a change in the retail environment (virtual supermarket) can potentially influence consumer food choices. Placing a nudge strategy in the inside front of the virtual shopping cart (facing the participant) was an external change implemented to guide smoothly consumers toward the choice of pulses. Yet,

methodological precautions need to be taken when designing a nudge for a group of consumers, as different habits and sociodemographic characteristics can impact the effective performance of the strategy.

From a research perspective, there is a need to develop further studies to identify the best nudge-based strategies to increase pulse choice in the supermarket. It seems that for consumers that have a clear mental representation of pulses, the visual nudge in the shopping cart influenced their choices in a specific context. By contrast, for participants that did not choose pulses regularly, a nudge should be created based on more explicit information such as descriptive social norms (Huitink et al., 2020; Payne et al., 2015). A descriptive social norm is a nudge-based strategy based on the statement that people tend to want to behave in accordance with other's people's behaviors in a specific situation (Beggs, 2016). Social norms are "central to the creation and perpetuation of many eating-related attitudes and behaviors" (Ogden, 2010, p.283). Tests would be necessary to investigate what is the place for the message to be displayed, in the shopping cart, in the shelf of the product or the check-out points. Furthermore, possible non-transparent nudge-based strategies could be proposed in the supermarkets for participants that perhaps do not like to follow a social norm. For example: changing the placement of the products (Cheung et al., 2019). Before going to the real retail environment, the nudges should be proved in a more realistic environment such as a virtual supermarket (van Kleef & van Trijp, 2018).

Eating pulses for the environment and myself

Finally, we identified as an opportunity for the influence of extrinsic motivation related to paying more attention to preserving the environment that increased the choice of pulses (Chapter 5). A cohort study in France highlights that people that do buy specific food for environmental reasons, tend to have mostly a healthy diet. On the contrary, participants that had lower concerns for the environment were more likely to have a traditional western diet (Allès et al., 2017). This suggests that participants that increase the choice of pulses in the scenario that underlie an environmental motivation, could potentially follow a healthier diet. Our result show that consumers do know the benefits of pulses for the environment, and this can indirectly result in more sustainable food choices. By contrast, we found that there is a low intrinsic motivation of participants to choose pulses (Chapter 5), yet the all the strategies mentioned in this section could enhance the intrinsic motivation to consume pulses more frequently as they focus on the need to create, promote and encourage personal reason to go toward pulse-based products without an external reward.

To sum up: barriers identified and strategies to be considered

Figure 8, is a schema that summarizes the main barriers to pulses consumption by French non-vegetarian consumers in this work, and some possible strategies to overcome those drawbacks and increase the overall pulses consumption.

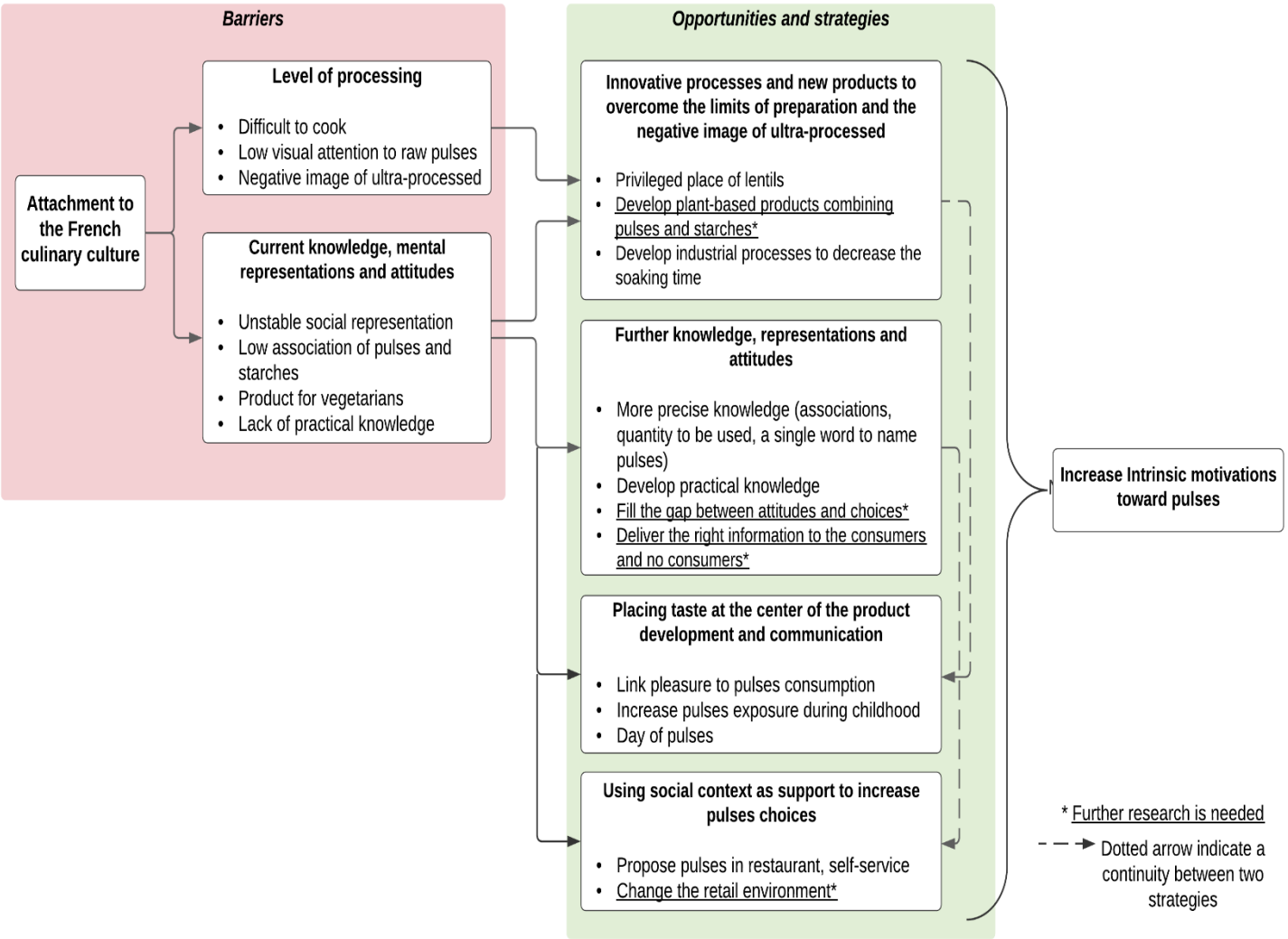

***Figure 8**. Scheme that sum up the main barriers and strategies identifies in this thesis*

4. Strengths and innovations of this research

In this thesis, we implemented different methodological adaptations or improvements:

- Throughout the thesis, different approaches and methodologies were used, allowing us to carry out direct (chapters 3, 6), semi-direct (chapter 4), indirect (chapters 2, 3, 5, 6) and implicit measures (Chapter 5). In some of the studies, we combined two methodologies. Some of the

results obtained were convergent, and others were complementary. As reported in chapter 3, we found a strong relationship between direct and indirect methods, which could be explained by the similar stimuli used in the two tasks and the quick, spontaneous responses in the self-reported questionnaires (Hofmann et al., 2005). Our studies highlight the interest of using different approaches to answer a specific objective, as it can provide wider information to better understand the research question.

- Besides, we tried to increase the ecological validity of the studies, by using different contextual settings. These settings were based on the use of contexts to evoke food choice situations (Chapter 3) or underlie food choice motivations (Chapter 5), but also on virtual reality, that allowed us to recreate an usual food choice environment (a supermarket) (Chapter 5). The construction of the virtual environment followed rigorous methodological features. It was based on field observations to represent closely the reality of the French supermarkets. Finally, in one study, we combined virtual reality settings, with an implicit methodology, while implementing a scenario and a nudge-based strategy (Chapter 5). It allowed us to study consumers' gaze behavior and food choices in an environment more realistic than a laboratory. The use of different contextual settings was considered as the main element to overcome the limits of not measuring actual food choice behavior, but still, better understand consumers' mental representations and food choices toward the object of our study –pulses– in different settings.
- We considered that the methodology used in chapter 2 could be improved to assess more accurately the social representation. So, we proposed an improvement in its analysis (Chapter 6). The qualitative data obtained were analyzed in two different ways (raw words and dimensions), showing an interest in investigating this kind of data using both types of approaches. Moreover, we included in the analysis not only the frequency and the rank of importance, but also the order of evocation. Besides, we adapted the polarity index. In addition, usually in the sensory science consumer answers can be clustered into different and understandable groups to understand consumer liking (Risvik, 2001). We identified the interest of performing this cluster analysis to grouped consumers that shared a specific social representation (Chapter 6). Segmenting participants was useful to observe different profiles that could explain the results we obtained more accurately.
- We proposed an adaptation of a methodology used in the sensory science, the CATA test (Chapter 4), to capture the mental representation and attitudes of participants instead of their perception of the sensory attributes of a product. One of the advantages of this method was the kind of answer obtained: not as direct as a questionnaire, faster and allowing us to compare different food products.

General Conclusion

The research carried out in this thesis allowed us to understand the barriers and opportunities related to the pulses' consumption by French non-vegetarian consumers. We found that the current choices and consumption of pulses are associated mostly with some drawbacks that restrain consumers to choose these products. External factors, influencing the people making the food choice but not controlled by them (e.g. culture), are associated to internal factors, specific to the person and under their control (e.g. difficulty of preparation, lack of practical knowledge, low visual attention in a situation of choice, low intrinsic motivation to eat pulses). Even if participants know examples of pulses, know about their benefits (i.e. health, environment, and protein content), and hold quite positive attitudes, this knowledge does not translate into a high choice of pulse-based products. If we want to increase the choice of pulses, the barriers previously identified need to be tackled from a societal point of view. Many actors should be involved in actions, including the pulses supply chain industry (e.g. develop the pulse-based product), the national authorities (e.g. use a unique term when referring to pulses), the research area (e.g. study the gap between attitudes and choice), and other stakeholders such as schools or restaurants (e.g. propose pulses in their menu). A joint effort from each of these actors would be necessary to encourage an increased consumption of pulses among the French population, intended to help consumers to make healthier and sustainable food choices in the long term.

Résumé en français

1. Introduction

Au cours des dernières années, beaucoup d'attention a été portée sur des régimes alimentaires plus durables dans le monde. Pour aller vers une alimentation plus durable, il faut modifier les choix alimentaires en réduisant ou en remplaçant en patrie la viande et les produits laitiers par des substituts végétaux (Berners-Lee et al., 2018). Il a été démontré qu'un apport en protéines végétales est un marqueur de l'adéquation de l'alimentation aux besoins nutritionnels, et donc d'une alimentation saine (Camilleri et al., 2013). L'alimentation à base de produits végétaux avec peu de transformation est protectrice, tandis que les régimes omnivores à base de produits alimentaires animaux et ultra-transformés sont associés à un risque plus élevé de maladies chroniques (Fardet, 2017). Les groupes végétaux qui doivent être consommés en plus grande quantité pour l'alimentation humaine sont les céréales et les légumineuses alimentaires (Day, 2013). Dans la famille des légumineuses alimentaires (leguminosae), nous trouvons des légumes secs. Les légumes secs sont définis par la FAO comme étant des légumineuses récoltées exclusivement pour les semences sèches (ex : haricots secs, lentilles et pois) qui sont produites pour la consommation humaine. Cette définition exclut les cultures utilisées principalement pour l'extraction de l'huile, comme par exemple le soja, et celles qui sont récoltées fraiches, par exemple, les pois verts. (FAO, 2016). Cela signifie que tous les légumes secs sont des légumineuses. Les légumes secs sont considérés comme un produit alimentaire essentiel pour assurer la sécurité alimentaire et accroître la durabilité. Leur présence dans l'agriculture assure des avantages pour l'environnement (sol, eau, émissions de CO2) et la biodiversité. Ce sont également des produits clés pour la sécurité alimentaire et la nutrition. Pourtant, la consommation de légumineuses dans le monde est très variable : alors que la consommation mondiale par habitant au cours des trois dernières décennies est d'environ 21 grammes par jour (Rawal et Navarro, 2019), la consommation de légumineuses en France est extrêmement faible, avec environ 2 à 5 grammes par jour (Lecerf, 2016).

Pour comprendre les barrières qui expliquent la faible consommation de légumineuses en France, il faut comprendre les mécanismes qui sous-tendent les choix alimentaires. Le choix des aliments consiste en la sélection et la consommation d'aliments et de boissons, en prenant en compte différents aspects, parmi lesquels interviennent les questions suivantes : quel produit manger, comment le manger, quand le manger, où le manger, et avec qui (Sobal et coll., 2006). Par conséquent, le choix des aliments est le résultat d'un ensemble complexe de processus (Ogden, 2010b), influencé

par de nombreux facteurs interdépendants (Shepherd, 2001), liés à la personne qui fait les choix alimentaires et au produit lui-même. Pour chaque variable, deux types de facteurs, externes et internes, permettraient d'identifier la signification et la fonction de chaque élément dans le choix alimentaire. Lorsqu'une personne est confrontée au choix d'un aliment, il lui faut séparer les produits alimentaires des produits non alimentaires. C'est dans la phase de traitement de l'information que la personne utiliserait l'information disponible pour identifier le produit (aliment ou non). Ce processus aurait lieu, au moment où une personne rencontre un stimulus qui pourrait satisfaire ses propres motivations (perception), puis la personne interpréterait le stimulus en termes de leurs propres représentations, après qu'il/elle évaluerait le produit favorablement ou non (attitudes) et enfin, la personne serait susceptible de mener une action (intentions) qui l'amènerait à adopter ou à éviter un certain comportement (Gallen, 2005) envers un produit alimentaire.

2. Objectif de la thèse

La recherche décrite dans cette thèse s'inscrit dans le cadre d'un projet intitulé « IM'PULSES », financé par l'Institut Carnot Qualiment. Les principaux objectifs de cette thèse sont de comprendre les mécanismes qui sous-tendent les choix et l'appropriation des légumes secs par les consommateurs français non végétariens. Pour répondre à cette question, nous avons cherché à (i) comprendre quels étaient les obstacles à la consommation de légumes secs chez les consommateurs et les professionnels de l'industrie des légumes secs (représentations mentales, représentations sociales, attitudes, connaissances, croyances). Ensuite (ii) nous avons proposé des stratégies pour augmenter la consommation de légumes secs en France, grâce à l'utilisation de « nudges » et contextes évoqués.

Pour atteindre ces objectifs, nous avons utilisé une combinaison de méthodes directes (p. ex., questionnaires), indirectes (projection dans un contexte donné, en utilisant des images et des scénarios écrits, libre association de mots, et une adaptation du test CATA), et une méthode implicite (suivi oculaire), dans différents environnements, tels qu'un contexte évoqué, un contexte de laboratoire, un environnement naturel et un contexte de réalité virtuelle.

Pour atteindre les objectifs de cette thèse, un certain nombre de questions de recherche ont été identifiées :

- Y a-t-il des différences entre la représentation sociale et les attitudes des consommateurs et des professionnels de l'industrie des légumineuses envers les légumes secs ?
- Quelles sont les représentations mentales, les croyances et les connaissances des consommateurs à l'égard des légumes secs ?

- Quelle est la place des légumes secs dans la structure d'un repas pour les consommateurs français ?
- Le niveau de transformation des légumes secs a-t-il une influence sur les représentations mentales des consommateurs?
- Comment l'attention visuelle est-elle dirigée vers les légumes secs dans un supermarché virtuel?
- Pouvons-nous changer le comportement des consommateurs en mettant en œuvre une stratégie d'encouragement pour accroître le choix des légumes secs dans un supermarché virtuel?
- Y a-t-il des différences de représentation sociale des légumes secs entre la France et l'Espagne?

Pour répondre aux questions précédentes, nous avons d'abord examiné s'il existe des différences dans la représentation sociale et les attitudes des consommateurs et des professionnels à l'égard des légumes secs (chapitre 2). Puis, nous avons exploré les représentations mentales, les croyances et les connaissances des consommateurs concernant les légumineuses (chapitre 3). Nous avons identifié la place que tiennent les légumes secs dans un repas français (Chapitre 4). Nous avons ensuite saisi la représentation mentale des consommateurs vers les légumineuses à différents niveaux de transformation (chapitre 5). Nous avons poursuivi nos recherches dans un supermarché virtuel, ce qui nous a permis d'étudier l'attention visuelle des consommateurs envers les légumes secs (chapitre 6), et de mettre en œuvre une stratégie d'incitation pour augmenter le choix des légumineuses (chapitre 7). Nous avons comparé les représentations sociales des consommateurs français et espagnols vers les légumineuses (chapitre 8). Dans le dernier chapitre de cette thèse, les principales conclusions sont discutées, des recommandations sur les stratégies qui pourraient améliorer le choix des consommateurs vers les légumineuses, et pour les recherches futures sont présentées (chapitre 9).

3. Principaux résultats

Chapitre 2

Parce que professionnels de l'industrie jouent un rôle important dans le développement et la disponibilité des produits alimentaires, et que les consommateurs réagissent à cette offre en fonction des différents processus et critères énumérés plus tôt, nous avons d'abord comparé la représentation sociale des consommateurs et des professionnels de l'industrie des légumineuses envers les légumes secs. Pour comprendre ces représentations sociales, 80 consommateurs non végétariens français et 35 professionnels de l'industrie des légumineuses ont été invités à prononcer cinq mots spontanément évoqués par le mot inducteur « légumes secs ». Ils devaient ensuite classer ces cinq mots par ordre

d'importance et évaluer leur valence. L'approche structurelle a été utilisée pour analyser les représentations sociales pour chaque groupe de façon indépendante. Nous avons constaté que les consommateurs utilisaient des noms d'exemplaires (lentilles, haricots, pois chiches), probablement pour confirmer leur compréhension du mot inducteur. Les lentilles étaient citées de façon particulièrement importante, ce qui indique qu'elles sont l'un des légumines sèches les plus prototypiques. Les consommateurs ont tendance à confondre les légumes secs et les féculents en ce qui concerne leurs propriétés et leur utilisation, mais ils considèrent les légumes secs comme des aliments nutritifs et bons d'un point de vue organoleptique. Par ailleurs, la forte similitude sémantique entre les légumes secs et les fruits secs en langue française, semble créer de la confusion chez les consommateurs. Cependant, ils ont surtout des attitudes positives envers les légumes secs, et les quelques attitudes négatives (liées à la méconnaissance, la cuisson longue, la digestion) sont considérées comme ouvertes au changement. Les professionnels de l'industrie des légumineuses n'ont pas cité c'exemplaires, ce qui semble indiquer une meilleure compréhension du terme inducteur. Ils se sont concentrés sur la teneur en protéines et la préparation culinaire et ils ne mentionnent pas le goût aussi souvent que les consommateurs, ce qui semble indiquer que le goût n'est pas pour eux une propriété aussi importante que la teneur en protéines. Les professionnels ont une attitude légèrement plus négative à l'égard des légumes secs que les consommateurs.

Chapitre 3

Nous avons ensuite exploré les représentations mentales des légumes secs parmi les consommateurs français non végétariens, en utilisant à la fois une approche indirecte, avec des scénarios évoquant des situations réelles (Table 1), et une approche directe, avec un questionnaire. Dans l'approche indirecte, basée sur six scénarios différents, les 120 participants ont composé des plats en sélectionnant trois images d'aliments sur les vingt fournies. Une semaine plus tard, les mêmes participants ont rempli un questionnaire comportant dix questions sur les vingt aliments de l'étude, représentés par les mêmes images.

Table 1. Titre et scénarios (seuls les scénarios ont été présentés aux participants)

Titre du scénario	Script
Tous les jours	Dans un repas quotidien à la maison, vous devez préparer le repas.
Libre-service	Vous décidez de manger en libre-service. Au menu, tous les aliments représentés sur les images sont disponibles.
Restaurant	Vous avez gagné un dîner dans un restaurant étoilé lors d'une compétition. Selon le concept du restaurant, vous êtes invités à créer un plat selon une liste d'ingrédients, afin de tester les talents du chef.
Budget	À la fin du mois et après que vous avez payé la plupart de vos factures. Vous n'avez pas beaucoup d'argent et vous devez préparer un repas bon marché.

Végétarien	Vous avez invité un ami à manger et vous devez préparer le repas. Vous devez considérer qu'il est végétarien.
Invité	Vous et votre partenaire avez décidé d'inviter le couple qui vient d'emménager chez vous à dîner.

Dans l'ensemble des scénarios évoqués, le choix des légumes secs ne représentait que 10 % du choix total. Lorsque les participants ont choisi les légumes secs, les lentilles étaient le produit le plus souvent choisi. Par rapport au scénario « témoin » (sélectionner des ingrédients pour le plat principal d'un repas quotidien), il y avait un plus grand nombre de choix de légumes secs dans les scénarios « libre-service » et « restaurant » (où la situation évoquée par le scénario n'impliquait pas de préparation de repas) et dans le scénario évoquant la préparation d'un repas pour un ami végétarien. Les jeunes de moins de 40 ans choisissent plus souvent les haricots rouges, les pois chiches et les lentilles rouges, tandis que les femmes de plus de 40 ans choisissent plus souvent les haricots blancs. Dans le questionnaire, les participants ont déclaré que les légumes secs étaient des produits bons pour la santé et l'environnement, plus riches en protéines que les légumes et les féculents mais moins que les produits animaux, pas du tout appréciés et les moins fréquemment consommés (à l'exception des lentilles les lentilles). Leur prix était considéré moyen, sauf pour les lentilles corail, considérées plus chères. Les principaux enseignements de cette étude sont que les consommateurs associent les légumes secs à un régime végétarien et que les légumes secs sont considérés comme plus difficiles à préparer que les aliments d'autres groupes alimentaires.

En utilisant l'approche indirect, nous avons également pu identifier comment les consommateurs non végétariens français structurent leur plat principal. Au total, 120 participants ont dû composer des plats, selon les six scénarios (Table 1), en sélectionnant trois images d'aliments sur les vingt proposés. Les résultats ont fourni des renseignements sur (1) le premier produit alimentaire choisi et (2) la façon dont les aliments de différents groupes alimentaires ont été associés. Nous avons constaté que la viande est un élément central du repas pour les consommateurs français non végétariens. La structure la plus habituelle d'un plat principal était : viande, féculents et légumes (45%), le rôle central de la viande augmente lorsque des interactions sociales sont impliquées (scénarios « invité » et « restaurant »). Lorsque les légumes secs étaient présents dans le plat, ils étaient associés à des féculents et des produits animaux, selon la tradition culinaire française., L'association des légumes secs avec des féculents était moins fréquente, montrant que légumes secs étaient plus souvent utilisées comme remplacement des féculents que comme un produit protéique, en remplacement de la viande. Les légumes secs ont été choisis en premier pour construire un plat seulement dans 13% des cas, et ont été plus souvent utilisés dans le scénario végétarien. Les femmes,

les jeunes participantes de moins de 40 ans et les participants ayant un niveau d'éducation élevé ont choisi les légumes secs plus fréquemment lors de la préparation d'un repas.

Chapitre 4

L'objectif de ce chapitre était de capter les représentations mentales des consommateurs français vers divers aliments à base de légumes secs avec différents niveaux de transformation. Un test CATA (Check-All-That-Apply) avec des images d'aliments a été utilisé, pour saisir comment les consommateurs caractérisent les caractéristiques globales des produits et comment ils les utilisent. Deux études différentes ont été réalisées. Dans la première partie de l'étude, douze images de produits contenant des légumes secs ont été présentées. Afin de déterminer si les consommateurs attribuent les mêmes propriétés et usages à des produits à base de légumes secs avec des procédés et des recettes différentes, les images utilisées représentaient des produits bruts, peu transformés, ultra-transformés en conserves, ou ultra-transformés innovant. Les résultats de cette étude soulignent des différences de représentations et d'usages entre les divers produits, basées plutôt sur le niveau de transformation que sur la nature du légume sec présent dans le produit. La seconde partie de cette étude avait pour but de préciser ce résultat et de vérifier s'y était propre à la famille des légumes secs où s'ils étaient également observés avec d'autres produits. Deux tests CATA similaires ont été proposés, l'un avec des images de produits à base de légumes secs et l'autre avec des images de produits à base de légumes. Les représentations mentales des produits non transformés, faiblement transformés (en conserve et congelés) et ultra-transformés innovants sont plutôt positives. En revanche, les produits à base de légumes secs ultra-transformés traditionnels (en conserve et congelé) sont considérés plus négativement. Ils sont considérés comme des produits dépassés, qui provoquent des maux de ventre, et sont mauvais pour la santé. Pour l'ensemble de ces raisons probablement, ces produits ne sont pas acceptés. Notre étude a permis de préciser que cette représentation mentale négative concerne le produit lui-même (la recette) et non le format de l'emballage. Les participants étaient plus familiers avec les légumes secs en conserve, ils les considéraient comme bon marché et pas particulièrement traitées, juste le niveau minimal pour surmonter la difficulté de la préparation des légumes secs brutes.

Chapitre 5

L'un des obstacles à la consommation de légumes secs peut être lié à leur présentation dans les supermarchés français, en particulier les rayons dans lequel ils sont présentés et leur

positionnement dans ces rayons. Nous voulions étudier le comportement visuel des consommateurs envers les légumes secs dans un supermarché. Nous avons utilisé pour cela un environnement virtuel de supermarché, ce qui nous permettant de combiner à la fois des mesures en laboratoire et un environnement réaliste qui plaçait les participants dans une situation familière de choix alimentaire. Les produits appartenant à quatre catégories d'aliments (produits animaux, légumes secs, féculents, légumes) ont été présentés aléatoirement dans quatre rayons (en conserve, séchés, prêts-à-manger, réfrigérés). Ensuite, un « super-rayon » a été construite pour rassembler dans un même espace tous les produits des rayons conserve, sec et réfrigéré. 108 participants ont dû observer chacun des rayons présentés dans un ordre aléatoire, puis ensuite, le « super-rayon ». L'attention visuelle des consommateurs envers les produits présentés a été mesurée à l'aide d'un dispositif de suivi oculaire. Nous avons constaté que le comportement du regard des participants envers les légumes secs varie selon le type et l'organisation de l'étagère à laquelle les consommateurs sont exposés. L'attention visuelle envers les légumes secs était moins importante dans les rayons sec et conserves, et plus importante dans les rayons sec et conserve, alors réfrigéré et prêt-à-consommer (légumes secs-féculents). Lorsque nous avons comparé l'attention visuelle des participants envers les légumes secs et d'autres groupes alimentaires (féculents, légumes et produits animaux) dans une seule « superétagère », nous avons constaté des différences entre les groupes alimentaires. En ce qui concerne les légumes secs, elles avaient une plus grande attention visuelle que les légumes, mais moins que les féculents et les produits animaux.

A partir du supermarché Virtual, nous avons mis en place une étude exploratoire pour augmenter les choix de légumes secs par les consommateurs français dans où d'autres catégories d'aliments étaient présentées, en utilisant deux stratégies : des contextes évoqués qui soulignent des motivations d'achat différentes (ciblées sur l'environnement, le bien-être et l'hédonisme) et des « nudges » (axés sur la santé et le plaisir). Les 108 participants ont effectué deux tâches : (i) Observation : les participants ont observé un rayon de supermarché et leur comportement visuel a été enregistré par eye-tracking, (ii) Choix alimentaire : les participants ont dû choisir trois produits alimentaires à partir du même rayon pour composer un plat.

Cette étude a mis en évidence un choix plus élevé de légumes secs dans certains scénarios. En particulier, une motivation pour l'environnement tend à augmenter les choix de légumes secs par rapport à un scénario se référant à une situation quotidienne et ne faisant pas allusion à une motivation spécifique scénario quotidien. En revanche, la stratégie utilisant des nudges axés sur la santé ou le plaisir n'a pas augmenté le choix des légumes secs. Toutefois, lorsqu'on combine les deux stratégies et qu'on regroupe les consommateurs dans des clusters différents en fonction de leurs choix de légumes secs, il apparait que les deux stratégies de nudging pourraient potentiellement accroître

le choix de légumes secs pour certains groupes de consommateurs et dans des scénarios précis. Les participants au groupe 1 choisissent plus de légumes secs dans le scénario santé avec le nudge santé, tandis que les participants au groupe 2 choisissent plus de légumes secs dans le scénario de contrôle avec les deux types de nudges. Dans un troisième groupe, les consommateurs n'ont pas choisi de légumes secs dans aucun scénario. Les consommateurs du dernier groupe ont diminué leur choix des légumes secs dans le scénario de bien-être et de contrôle sous l'effet des deux nudges.

Chapitre 6

L'objectif opérationnel de cette étude était de comparer les représentations sociales des légumes secs pour les consommateurs français et espagnols, en tenant compte de leur niveau d'éducation. Un autre objectif était méthodologique. Il s'agissait d'améliorer l'évaluation de la représentation sociale dans une contexte interculturel, grâce à une tâche d'association de libre évocation axée sur les légumes secs. Des améliorations méthodologiques de l'approche structurelle ont donc été proposées, combinant l'utilisation de l'ordre de citation avec la fréquence de citation et l'importance attribuée par les participants aux termes cités, en adaptant les seuils pour ces différents paramètres. L'indice de polarité a été modifié, et l'impact de l'analyse des mots (données brutes) ou des catégories de mots a été évalué. Ce contexte interculturel a montré qu'il existe des éléments communs dans la représentation sociale entre les deux pays en ce qui concerne la santé, les légumes secs, la nutrition, la préparation et les aspects sensoriels, alors que d'autres éléments spécifiques ont été trouvés pour chaque pays. Les participants français ont principalement utilisé des mots liés aux produits alimentaires, tandis que les participants espagnols ont plus fréquemment utilisé des concepts liés à la pertinence et au contexte. Des différences entre les participants de différents niveaux d'éducation ont été principalement observées pour la France dans l'analyse des mots et pour l'Espagne dans l'analyse des catégories de mots. En Espagne, les participants ayant un niveau d'éducation plus élevé ont cité des mots liés à la digestion, tandis que les participants ayant un niveau d'éducation plus faible ont utilisé des mots liés à l'agriculture. En France, les participants ayant un niveau d'éducation inférieur plus fréquemment des termes liés à l'achat que les autres participants.

Nous avons également constaté que les consommateurs espagnols considéraient les légumes secs comme faisant partie de leur culture et de leur enfance plus souvent que les consommateurs français, et qu'il pourrait y avoir des différences concernant le format de l'emballage dans lequel les consommateurs sont habitués à acheter des légumes secs : les Espagnols achètent plus souvent des légumes secs en vrac, avec une forte tendance à acheter dans un bocal en verre, tandis que les participants français achètent des légumes secs dans une boîte en carton, un sac en plastique transparent, ou dans une boîte plus souvent.

4. Discussion et conclusion

La recherche présentée dans cette thèse a mis en évidence différents obstacles qui pourraient expliquer la faible consommation de légumes secs en France pour les consommateurs non végétariens, mais elle a également révélé certains éléments clés pour augmenter la consommation de légumes secs. Les résultats font apparaître des facteurs externes ou internes influençant les choix de légumes secs. Les facteurs externes désignent les éléments qui ne dépendent pas directement et individuellement de la personne qui effectue le choix alimentaire, comme ses caractéristiques culturelles et sociodémographiques. Au contraire, les facteurs internes sont liés directement à des traits personnels de l'individu effectuant les choix, comme par exemple des facteurs psychologiques tels que les attitudes, les représentations mentales et la connaissance.

Les obstacles au choix des légumes secs par les consommateurs français non végétariens sont liés à l'influence de la culture française, aux différentes représentations sociales entre consommateurs et professionnels de l'industrie des légumes secs, à la difficulté de préparation perçue par les consommateurs, à l'image négative que ceux-ci ont des produits ultra-transformés à base de légumes. Une représentation sociale instable, un manque de connaissances pratiques, la tendance à considérer les légumes secs comme des produits pour végétariens et à ne pas les apprécier viennent s'ajouter à ces freins à la consommation de légumes secs. Cette faible motivation intrinsèque à manger des légumes secs se manifeste par une faible attention visuelle dans un supermarché, et une association peu fréquente des légumes secs avec des féculents.

Des leviers pour encourager la consommation des légumes secs ont également été identifiés dans ce travail. Ils sont liés au contexte social positif autour des légumes secs, avec de fortes incitations à diminuer la consommation d'aliments d'origine animale au profit d'aliments protéiques d'origine végétale, et à la connaissance par les consommateurs du contenu en protéines des légumes secs et leurs avantages en termes de santé et environnement. Des caractéristiques sociodémographiques spécifiques de certains consommateurs rendent ces leviers plus efficaces chez certains. Au niveau de la vente de légumes secs, des changements pourraient être envisagés pour inciter la consommation, tels que l'augmentation de la vente au détail, en mettant l'accent sur une meilleure communication autour les légumes secs, pour faire mieux connaître certains légumes secs moins connus que les lentilles, et promouvoir le goût des légumes secs, l'importance des recettes, en misant sur les attitudes positives et l'image positive des produits à base de légumes secs non transformés et peu transformés

Même si les légumes secs ont été dans les habitudes alimentaires françaises depuis des siècles, leur choix et leur consommation actuels sont associés principalement à certains inconvénients qui

limitent les consommateurs à choisir ces produits. Même si les participants connaissent des exemples de légumes secs, ils connaissent leurs avantages et ont une attitude positive, ce qui ne se traduit pas par un plus grand choix de produits de légumes secs. Si nous voulons augmenter le choix des légumes secs, il faut s'attaquer aux obstacles déjà identifiés dans l'industrie des légumes secs. Il serait nécessaire de développer les bonnes stratégies pour augmenter la consommation de légumes secs chez les consommateurs français non végétariens, en tenant compte également des différents avantages positifs liés aux légumes secs découverts dans cette recherche.

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Titre: Comprendre la faible consommation de légumes secs chez les consommateurs français non végétariens : combinaison d'approches directes et indirectes afin d'identifier les barrières et les opportunités

Mots clés: légumes secs; choix alimentaire; comportement des consommateurs; approches indirectes; contexte évoqué; comportement visuel

Résumé: L'objectif de cette thèse était de comprendre quels sont les barrières à la consommation de légumes secs chez les consommateurs français non végétariens, en combinant des méthodes directes, indirectes et implicites.

Après avoir montré que les représentations sociales des consommateurs sont très différentes de celles des professionnels de la filière, nous avons exploré les représentations mentales, croyances et connaissances des légumes secs chez les consommateurs. Ceci a fait apparaitre que même si les participants de nos études avaient des connaissances sur les légumes secs, ils les choisissaient peu. De plus, ils associaient plutôt les legumes secs avec la viande, qui occupe pour eux la place centrale du repas. La difficulté de préparation des légumes secs semble être un frein majeur à leur consommation. Leur niveau de transformation est un autre facteur qui influence fortement les représentations mentales qu'en ont les consommateurs.

Une étude en supermarché virtuel a montré que l'attention visuelle envers les légumes secs est différente de celle accordée à d'autres produits, et qu'elle est influencée par le rayon dans lequel ils sont présentés. Nous avons évalué l'influence de stratégies pour augmenter les choix des légumes secs dans un environnement de supermarché virtuel, par le moyen de « nudges » et de contextes évoqués qui soulignaient des motivations de choix différentes. Nous avons mis en évidence un choix plus élevé de légumes secs dans certains de ces contextes (ex: une motivation pour l'environnement tend à augmenter les choix de légumes secs). En revanche, la stratégie utilisant des « nudges » seuls n'a pas augmenté le choix des légumes secs. Mais, lorsqu'on combine ces deux stratégies, des modifications de choix chez certains participants sont observées.

Une dernière étude a permis de comparer les représentations sociales des légumes secs pour les consommateurs français et espagnols dans un contexte cross-culturel, et a montré des éléments partagés dans les représentations de ces deux populations, et des éléments spécifiques à chaque culture et au niveau d'éducation des participants.

L'ensemble de ces résultats nous a permis de proposer un certain nombre de recommandations destinées à l'industrie, aux autorités nationales et au monde de la recherche, pour contribuer à l'augmentation de la consommation de légumes secs en France.

Title: Understanding the low consumption of pulses among French non vegetarian consumers: combining direct and indirect approaches to identify barriers and opportunities

Keywords : pulses ; food choice ; consumer behavior ; indirect approaches ; evoked context; gaze behavior

Abstract: The objective of this thesis was to understand the barriers related to the consumption of pulses by French non-vegetarian consumers, by combining direct, indirect and implicit approaches.

After showing that the social representations of consumers towards pulses are very different from those of professionals of the industry, we explored the mental representations, beliefs and knowledge about pulses among consumers. We showed that, even if the participants in our study had knowledge regarding pulses, they did not choose them frequently and associated them mostly with meat, which holds the central place of their meal. The difficulty of preparation of pulses seems to be a major obstacle to their consumption. Their level of transformation is another factor that has a strong influence on consumers' mental representations.

A study in a virtual supermarket showed that visual attention is different towards pulses and other food-groups and that the shelf in which pulses are presented influences the visual attention of consumers. We evaluated the influence of strategies to increase pulses choice in a virtual supermarket, using nudges and contexts that highlighted different buying motivations. We found a higher choice of pulses in some contexts. In particular, a motivation for the environment tends to increase the choice of pulses. Te strategy using nudges alone did not increase the choice of pulses. However, when these two strategies were combined, some participants modified their choices.

A final study allowed us to compare the social representations of pulses for French and Spanish consumers in a cross-cultural context; it showed that some elements are shared in the representations of these two populations, while other elements are specific to a culture, and to the level of education of the participants.

All these results enabled us to propose some recommendations for the industry, national authorities and the research, to help to promote pulses consumption in France.

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