Stakeholders' View, Consumers' Preferences and Demand for Plant-based Eggs: A Cross-Country Investigation

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Declaration of Original Authorship

I confirm that this is my own work and the use of all material from other sources has been properly and fully acknowledged.

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ABSTRACT

This thesis aims at investigating stakeholder's perception and consumers' associations, preferences, and demand for plant-based eggs, which have been developed to provide consumers with a healthier, animal-free, and environmentally friendlier alternative to conventional eggs. In order to achieve the study objectives, five research papers have been developed, which form the five chapters of this thesis. The first is a review of the literature on consumers' preferences for conventional eggs from the past ten years, showing that consumers are predominantly influenced by intrinsic (e.g., colour, size) and extrinsic product attributes, and particularly by the method of production (e.g., cage, free-range). The second paper explores egg stakeholders' view on plant-based eggs, as well as the challenges and future development for plant-based eggs from the producers. Results show that despite egg stakeholders struggle to offer an alternative to conventional eggs to people who cannot or do not eat eggs (e.g., vegans), they are doubtful that plant-based eggs would have the same nutritional properties and functionalities in cooking than conventional eggs. On the other hand, plant-based egg manufacturers aim to replicate eggs in all its characteristics, in order to offer consumers a product with similar features. In the third manuscript, consumers' associations with plant-based eggs are investigated. 'Price' emerges as the first association that comes to consumers' mind when plant-based eggs are presented to them, which however has a negative meaning because plant-based eggs are expected to be more expensive than conventional eggs. Next, 'healthy', 'animal welfare' and 'sustainability' are relevant associations which are given a positive meaning. In the fourth paper, consumers' preferences for intrinsic (e.g., colour, shape, taste) and extrinsic attributes (e.g., price, packaging, country of origin) of plant-based eggs are

explored. What emerge is that consumers demand a plant-based egg with similar physical characteristics to conventional eggs, but appreciate it being healthier and more environmentally sustainable. In the last study, the influence of different communication channels (website, social media, and labels) on consumers' preferences and willingness to pay for plant-based eggs is explored. Results show that free-range eggs were the most preferred egg products, followed by barn eggs, plant-based eggs made with peas, cage eggs and plant-based eggs made with soy. Social media is the most effective channel to communicate plant-based eggs to consumers as it increases their willingness to pay. Overall, the findings emerged from this thesis provide useful insights for plant-based egg manufactures, as well as for policy makers involved in the promotion of healthier and sustainable behaviour.

Chapter I – **Introduction & Literature Review**

Eggs are one of the most widespread staple food products around the world, rich in high-quality proteins, available at low prices, and consumed on a large scale (Lesnierowski and Stangierski, 2018). Today, the global egg production is of approximately 66.4 million tonnes and it is projected to raise of further 50 % by 2050 as result of the growing global population and demand for protein food at low price (FAO, 2017). However, the production and consumption of eggs still raise a number of concerns related to human health, animal welfare, environmental sustainability, and safety (see Chapter 1, "Introduction and Literature Review"). First, egg allergy is considered one of the eight major food allergens, together with cow's milk, nuts, fish, and soy (Shah and Walker, 2001). Globally, more than 8% of children suffer from egg allergy at 12 months, and about 2% until the fourth year of age (Loh and Tang, 2018). In addition, eggs contain cholesterol and thus consumption should be moderated to avoid increasing the level of cholesterol in humans' blood (Fernandez, 2010). Second, there is growing concern towards the animal welfare standards of the egg industries. In fact, most of the eggs worldwide are produced using a cage-based system, where hens have limited space to freely move and are not allowed to go outside of the hatcheries (Buller and Roe, 2014). Third, the production of eggs is still highly unsustainable, representing about 9% of the total greenhouse gas (GHG) emission of the livestock production (FAO, 2016). Last, the production of eggs generates concerns due to a series of recent food safety scandals, such as the salmonella outbreak in the United States (USA) in 2015 (Li, Bernard, Johnston, Messer, & Kaiser, 2017; Whiley & Ross, 2015) or the egg contamination from Fipronil pesticide in Europe in 2017 (Li et al., 2019).

These issues prompted the need for the development of alternatives to conventional eggs. An example is the plant-based eggs which are made through processes of isolation or fermentation using plant-based ingredients such as legumes, soy, peas, cereals etc. (The Good Food Institute, 2018). Several start-ups and industries are currently working on these products like JUST ltd. and Spero Food from the USA, Fumi Ingredient from the Netherlands, and the University of Udine from Italy (Askew, 2017; Food Navigator, 2019). These companies are developing different prototypes of plant-based eggs, such as the liquid plant-based eggs, which is made with mung beans, pumpkin seeds etc.; the powder plant-based eggs, which is made with fermented yeast; and the egg-shaped plant-based eggs which resemble the shape of conventional eggs and are made with soy (see Chapter 4, "Consumers' Preferences for Intrinsic and Extrinsic Product Attributes of Plant-based Eggs: An Exploratory Study in the United Kingdom and Italy"). Compared to conventional eggs, plant-based eggs claim to have several advantages. First, because plant-based eggs do not come from hens, they are allergen-free and cholesterol-free. Second, because no animals are involved in the supply chain, they solve the issues related to the poor animal welfare standards of the egg industry, its safety and are suitable for vegan consumers. Third, although no scientific evidences have been published yet, plant-based eggs also claim to be more environmentally sustainable than conventional eggs, as their production does not include intensive farming (The Good Food Institute, 2018).

Given the numerous benefits of plant-based eggs, these might become serious competitors of conventional eggs and might potentially replace the consumption of

the latter in the long run. If this happens, it will cause the closing of the global egg supply chain, leading to heavy economical losses (Stephens et al., 2018). In countries like China, for example, the biggest egg producer worldwide, this would equal to the loss of US$ 37 billion yearly (Yang et al., 2018). However, in order to develop a product that is able to replicate eggs and more importantly to fulfill consumers' expectations and necessities, it is vital to understand consumers' preferences and behaviour towards conventional eggs. Therefore, the next section of this thesis presents a revision of the literature on this topic, by summarizing the findings from the last ten years of academic publications. Currently, however, most of the developed prototypes of plant-based eggs are yet commercially unavailable. In fact, in order for the plant-based eggs to be launched in the market, they will first have to satisfy specific food safety standards imposed by global regulatory associations such as the Food and Drug Administration (FDA) in the USA and the European Food Safety Authority (EFSA) in the European Union (EU) (Stephens et al., 2018). Plant-based egg manufacturers will also have to comply with a series of policy legislations regarding, for example, how to label these products. In fact, in several countries worldwide there still is an ongoing debate on how to label plant-based food alternatives given that the use of animal food-related names (e.g., burger, sausages, milk) might mislead consumers on the real nature of these products (Carrenõ and Dolle, 2018). In the EU for example, plant-based milk alternatives cannot longer be labelled as 'milk', but only as 'beverages' or 'drink' (Court of Justice of the European Union, 2017). Given all these issues, exploring manufacturers' views on plant-based eggs, as well as plant-based egg producers' prospective on the production and regulatory challenges they are facing to launch their products into the market is crucial, although still missing from the available

literature. This thesis fills this gap of knowledge by reporting an in-depth interview study with conventional egg stakeholders and plant-based egg manufacturers. In addition to compelling with the requirements imposed by the food safety authorities and the policy regulations, it is vital for plant-based eggs to accommodate consumers' expectations and preferences in order to be successful (Moors and Donders, 2009). Thus, the second part of this thesis aimed at investigating consumers' associations and preferences for plant-based eggs in order to inform manufacturers on how to better develop these products and accommodate consumers' expectations. Last, this thesis also provides information on consumers' preferences and willingness to pay (WTP) for plant-based eggs, as well as insights on how to best communicate these products to the public. Because plant-based egg manufacturers will have different channels of communication available to promote their products to consumers, the effects of communicating the benefits of plant-based eggs (cholesterol- and allergen-free, animal free and environmentally friendly) using different communication channels (e.g., the company website, social media, labels) on consumers' preferences and WTP have been explored in order to suggest producers how to efficiently market and communicate their products.

In summary, this thesis is set against the following specific research objectives:

(i) What are consumer's preferences for conventional eggs?

(ii) What are stakeholders' views on plant-based eggs?

(iii) What are consumers' perceptions towards plant-based eggs?

(iv) What are consumers' preferences for intrinsic and extrinsic attributes for plant-based eggs?

(v) What are the effects of different communication channels on consumers' preferences and willingness to pay for plant-based eggs?

In order to achieve these aims, five research papers have been developed which form the five chapters of this PhD thesis. The structure of this thesis is presented below.

The next section of this paragraph (Section 1) addresses the first research question of this thesis by providing a review of the status of the literature towards the topic of consumers' preferences for conventional eggs, considering peer-reviewed papers in English language and published between 2011-2020. Results have been presented following the Mojet model of consumers food and drinking behaviour (Köster, 2009), and served as the basis for identifying attribute preferences that influence the purchase of eggs.

Chapter II answers the second research question of this project by showing the results from explorative research employing in-depth interviews with egg producers, with the aim of investigating their views on plant-based eggs, as well as with plant-based egg manufacturers and researchers to understand challenges related to the production, marketing, and regulation of these products.

Chapter III responds to the third research question of this work, by using concept mapping to elicit their semantic associations. Concept mapping also allowed to explore which information are positive, negative, or more or less important for

consumers. Knowing this information is important for plant-based egg manufacturers to better market and communicate their products to the public.

Chapter IV addresses the fourth research question of this thesis by investigating consumers' preferences for intrinsic and extrinsic plant-based egg attributes, which is vital for plant-based eggs manufacturers to better refine their products based on consumers' expectations and needs.

Chapter V explores the effects of different communication channels on consumers' preferences and willingness to pay for plant-based eggs, employing a choice experiment methodology and answering the fifth research question of this thesis. This study provides useful insight on the most effective channel of communications for plant-based eggs in order to develop efficient marketing campaigns.

This thesis concludes with a discussion of the findings emerged from this work, a conclusion, and a future research avenues section.

In this research project, three prototypes of plant-based eggs have been tested, namely the liquid, the powder, and the egg-shaped plant-based eggs. The former is developed through a protein fermentation process, and it is made from vegetable sources like beans, pumpkin seeds etc (James, 2019). Few examples are already available in the US market from companies like JUST ltd. and Spero Food (Gilliver, 2019). The powder plant-based egg is produced through a fermentation process and it is developed by companies such as Clara Food in the US and FUMI Ingredients in the Netherlands, although is not yet available in any market (Carrington, 2018).

Last, the egg-shaped plant-based egg is developed by extracting the protein from soy, green peas etc. by, for example, the University of Udine (Italy), and is yet unavailable to consumers (Askew, 2017).

1. Consumer Behaviour, Perceptions, and Preferences towards Eggs: A Review of the Literature and Discussion of Industry Implications[1]

[1] This article was published in October 2020. Full reference: Rondoni, A., Asioli, D., Millan, E., 2020. "Consumer behaviour, perceptions, and preferences towards eggs: A review of the literature and discussion of industry implications." Trends Food Sci. Technol. 106, 391–401. DOI: 10.1016/j.tifs.2020.10.038

Abstract

During the last decades, several challenges have significantly affected the egg industry, such as the increasing consumer demand for animal welfare, the need for more sustainable food production, and the growing human health and food security issues related to egg consumption. The industry has responded by supplying a large variety of new eggs in the market. A better understanding of consumer behaviour, perceptions, and preferences for eggs is vital for industries to efficiently meet the expected, growing, and complex consumer demand. The focus of this review is threefold: (i) to identify the main factors that drive consumer behaviour perceptions, and preferences towards eggs; (ii) to discuss implications for industries and policy makers; and (iii) to identify research gaps to be addressed in future studies. A total of 34 consumer studies were identified, reviewed, and discussed. Consumer preferences for eggs are mainly driven by intrinsic and extrinsic characteristics, as well as socio-cultural factors. While price is very important, especially in developing countries, production method in developed countries is a relevant sub-factor, from which consumers make inferences about the health, safety, and sensory properties of eggs. Sensory properties, like eggshell, yolk colours, and size, are also main determinants of egg purchases. Egg producers should better inform consumers about the differences between the various methods of production and the sensory properties of eggs. Finally, this review revealed the need to investigate more factors beyond intrinsic and extrinsic product characteristics as well as the lack of consumer studies in developing countries and on the growing plant-based egg trend.

Keywords: Review; Consumer preferences; Eggs; Industry implications; Policy implications; Future research avenues.

1.1 Introduction

Eggs are one of the most important, widespread staple food products around the world, rich in high-quality proteins, available at low prices, and consumed on a large scale (Lesnierowski and Stangierski, 2018). During the last decades, the egg industry has been affected by several critical issues and challenges that have strongly influenced the economics of eggs. First, there are increasing societal concerns towards intensified animal breeding and herding, which are perceived to reduce animal welfare (Malone and Lusk, 2016; Montossi et al., 2018; Napolitano et al., 2010). For example, most of the eggs worldwide are produced using a cage-based system, where hens have very limited space to move and are not allowed to go outside of the hatcheries (Buller and Roe, 2014), and this poses serious animal welfare concerns. The importance of this issue is signalled by the increasing consumer preference for alternative production systems, causing a shift from conventional battery cage housing systems[2] (hereafter called caged egg) to cage-free production systems[3] (hereafter called cage-free egg) (e.g., barn, free-range etc.) (Norwood and Lusk, 2011a; Parisi et al., 2015; Zakowska-Biemans and Tekień, 2017). Second,

[2]Battery cage housing systems are indoor-based systems, which typically hold five to ten hens each. The minimum floor space allowance may vary from country to country (e.g., in the United States it is 432.3 cm^2 per hen). The water line is located inside the cage and the feeder runs on the outside of the cage front (UEP, 2017).

[3] In cage free production systems, hens are not kept in cages and are free to walk around the houses, to perch on roosts, and to lay eggs in nests (European Commission, 1999). Cage free systems can be barn or aviary, free-range or organic. In barn and aviary systems, hens are given a minimum of 0.09-0.14 m^2. The barn system has a section of raised slatted or wire flooring with nest boxes, feeders and nipple drinkers. In the aviary system, the houses are provided with vertical space on which the hens can stand and perch. The laying hens have access to the all house, and they may lay eggs either in the next boxes or on the slatted floor or litter area (UEP, 2017). In free-range systems, hens may be housed within an aviary or barn and are provide with outdoor access via holes in the side of the building (UEP, 2017). Finally, organic systems can be either free-range or pasture based. In order to be certified as organic, the production process has to meet certain requirements such as avoiding the use of antibiotics (UEP, 2017).

egg production can cause large greenhouse gas (GHG) emissions (Abín et al., 2018). Indeed, recent data shows that egg production alone is responsible for 9% of the total emissions of livestock production (FAO, 2016). This is because it relies on a large number of natural resources, such as cereals for feeding the hens, and on high levels of land, water, and energy use (Dekker et al., 2011; Leinonen et al., 2012). Third, the increasing demand for more extensive egg production systems, including cage-free systems, has also resulted in a higher risk for avian flu outbreaks (Koch and Elbers, 2006). Indeed, during the last years, several food safety scandals, which caused concerns among consumers, happened in the egg industry, such as the salmonella outbreak in the US in 2015 (Li, Bernard, Johnston, Messer, & Kaiser, 2017; Whiley & Ross, 2015) or the egg contamination from Fipronil pesticide in Europe in 2017 (Li et al., 2019). Fourth, there is an increasing number of human health diseases related to the nutritional components of eggs, such as allergies (Loh and Tang, 2018) and high cholesterol (McNamara, 2015; Zhu et al., 2018), which affect consumer preferences and actual consumption of eggs. Fifth, the continuing growth of the world population is expected to stimulate egg demand (+50% by 2035), which poses serious challenges to increasing egg production in a sustainable manner (FAO, 2017).

These critical issues and challenges, combined with the increasing and complex consumer demand for healthful and sustainable food products (Grunert et al., 2014), have prompted two responses in the egg industry, among others: (i) to introduce into the market a large variety of new eggs, which differ in terms of intrinsic and extrinsic attributes, such as organic, free-range,

enriched eggs, etc., as well as plant-based eggs[4] (Barnkob et al., 2020; Surai and Sparks, 2001) and (ii) to develop new measures to enhance animal welfare standards in egg farms, like, for example, removing the beak trimming practice[5] (Hester and Shea-Moore, 2005) or using the innovative dual-purpose poultry system[6] (Krautwald-Junghanns et al., 2018) as a means to avoid male culling[7] (Krautwald-Junghanns et al., 2018). Despite the increasing market shift towards new and different types of eggs and the large number of consumer studies on eggs (Lu et al., 2013; Lusk, 2010), there is a lack of clear understanding about how consumers have responded to these changes and how their behaviour, perceptions, and preferences for eggs have evolved during the last years. Shedding light on this topic can guide egg practitioners in

[4] Plant-based egg has been developed either through protein isolation or protein fermentation. The protein fermentation method follows an acellular production, where protein and fats components in eggs can be re-produced through a process of fermentation of microbes like yeast or algae (Geng et al., 2011).

[5] The beak trimming consists in removing 1/3 to 1/2 of the beak in order to avoid injuries to other birds in case of cannibalism events or aggressions (Karcher and Mench, 2018).

[6] The dual-purpose poultry is a technique where females are kept producing eggs and males to produce meat with the aim to avoid the so-called 'one-day old chick' practice of culling males' chicken due to their poor meat production and keep only female chicks (Gangnat et al., 2018).

[7] Male culling, also called 'one-day old chick', is related to the practice of culling new born male chickens because of the fact that males cannot lay eggs and poor meat production and therefore only female chicks (Gangnat et al., 2018).

developing and marketing new types of eggs and support policy makers' efforts to provide better regulations in line with societal concerns and to understand how to more efficiently inform consumers. Moreover, to the best knowledge of the authors, a coherent overview of the factors that affect consumer behaviour, perceptions, and preferences towards eggs during the last years is missing.

This review aims at filling this void by reviewing and discussing the academic consumer research on eggs from the last ten years aiming to (i) identify the main factors that drive consumer behaviour, perceptions, and preferences for eggs, (ii) discuss implications for egg industries and policy makers, and (iii) identify research gaps to be addressed in future studies.

To conceptualize, identify, and categorize literature findings on consumer behaviour, perceptions, and preferences towards eggs, the present review considers the well-known Mojet's model (Köster, 2009), which identifies the essential categories of factors that influence eating and drinking behaviour and, thus, consumer food choices. This framework has recently been used to synthesize literature findings and describe drivers of food purchases regarding, for example, clean labels (Asioli et al., 2017a).

This review is structured as follows. First, a description of the applied methodology used in this study is illustrated together with an overview of the selected studies. Then, the findings of the reviewed studies are structured in accordance with Mojet’s model. Finally, a summary

discussion and implications for industries, policy makers, and future research avenues are provided.

2. Methodology

A literature search was conducted on the following four online catalogues: Scopus, Science Direct, AgEcon Search, and Web of Science. The following keywords or keyword combinations have been searched in the title or abstract: “eggs”, AND “consumers” AND “preferences”, OR “attitude”, OR “perception”, OR “choice”, OR “behaviour”, OR “purchase intention”, OR “willingness to pay”. The review was restricted to English-language, peer reviewed empirical articles examining consumer behaviour, perceptions, attitudes, preferences, and willingness to pay for eggs, published in scientific journals during the last ten years (2010–2019). The decision to limit the search to the last ten years came from the need to offer an overview of the latest studies. Initially, we searched for the same keywords in all four catalogues. A total of 5,030 articles were identified at the first step: 1,866 articles from AgEcon Search, 1,480 articles from Web of Science, 884 articles from Science Direct, and 800 articles from Scopus. Next, the articles not belonging to the agricultural, food, economics, and marketing fields were excluded (4,734). A total of 269 articles were retained at the second step. From these, another 235 studies were excluded either because they were duplications (76) or because their topics were not strictly related to the consumer research subject (159), resulting in a total of 34 articles. The full list of articles included in this review is presented in Table A1 in Appendix A.

The selection process clearly indicates that the number of articles on the reviewed topic has increased during the last ten years, with a notable jump during the last four years, whereas fewer articles were found between 2010 and 2015 (Fig. 1).

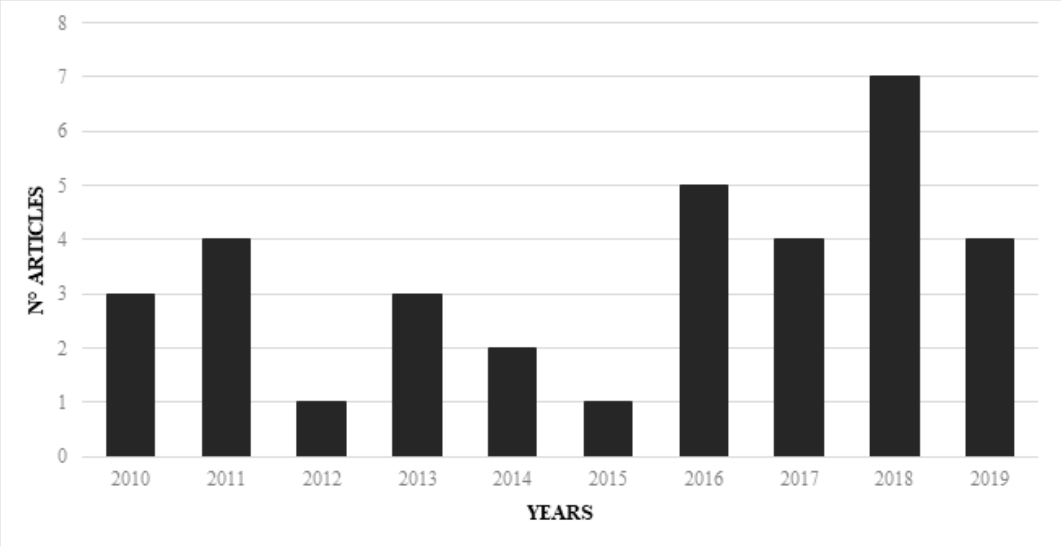

Fig. 1 - Number of research articles included in the topic of consumer research on eggs from Scopus, Science Direct, AgEcon Search, and Web of Science databases at 31.12.2019 (search terms: "eggs", AND "consumers" AND "preferences", OR "attitude", OR "perception", OR "choice", OR "behaviour", OR "purchase intention", OR "willingness to pay").

In terms of geographical coverage, the majority of the studies were conducted in developed countries such as the United States (12 articles), Spain (5 articles), Canada (3 articles), Australia (2 articles), the United Kingdom (2 articles), Italy (1 article), Poland (1 article), Norway (1 article), Denmark (1 article), and Switzerland (1 article). Fewer articles were found in developing countries, such as Brazil (2 articles), Turkey (1 article), Malaysia (1 article), Chile

(1 article), and Ghana (1 article). In terms of research methodologies used in these studies, most articles (29) applied a quantitative approach, mainly using choice experiments or conjoint analysis. Only two of the analysed articles applied a qualitative approach (e.g., focus groups and sentence completion tasks), and two further articles used a mixed methodology including both qualitative and quantitative techniques. Finally, one article used a sensory testing methodology. Regarding their sample size, the quantitative studies varied from a minimum of 74 to a maximum of about 6,378 consumers.

A number of factors that drive consumers' behaviour, perceptions and preferences for eggs were identified and commented on within the literature. In order to have a coherent way of identifying and categorising the factors, we used the well-known model proposed by Mojet (Köster, 2009), which categorize the factors and the sub-factors that influence consumer behaviour and food choice (Fig.2).

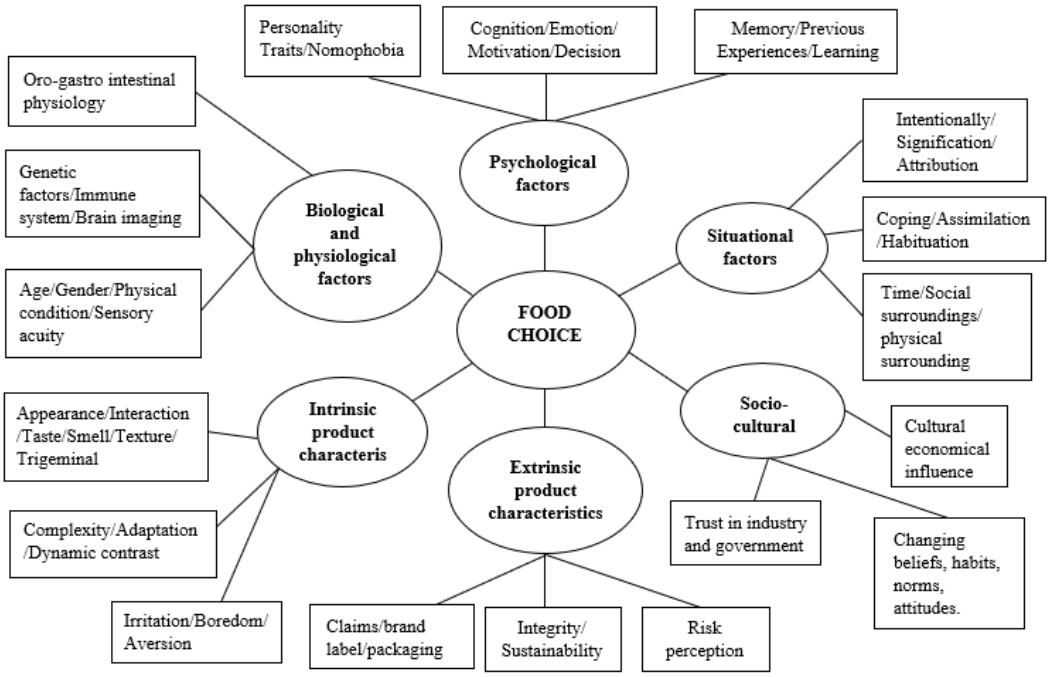

Fig. 2 - Essential factors and sub-factors that influence eating and drinking behaviour and food choice (Source: (Köster, 2009).

3. Results

This section provides an overview of the factors driving consumer behaviour, perceptions, and preferences for eggs, examined in the reviewed studies. In line with Mojet's model, all six categories of factors (e.g., intrinsic and extrinsic product characteristics, and socio-cultural, situational, psychological, biological, and physiological factors) were identified. We found varying levels of importance of specific sub-factors, which are reported in Fig. 3. It is relevant to acknowledge that the borderlines between different factors (e.g., between psychological and socio-cultural factors) may be blurred.

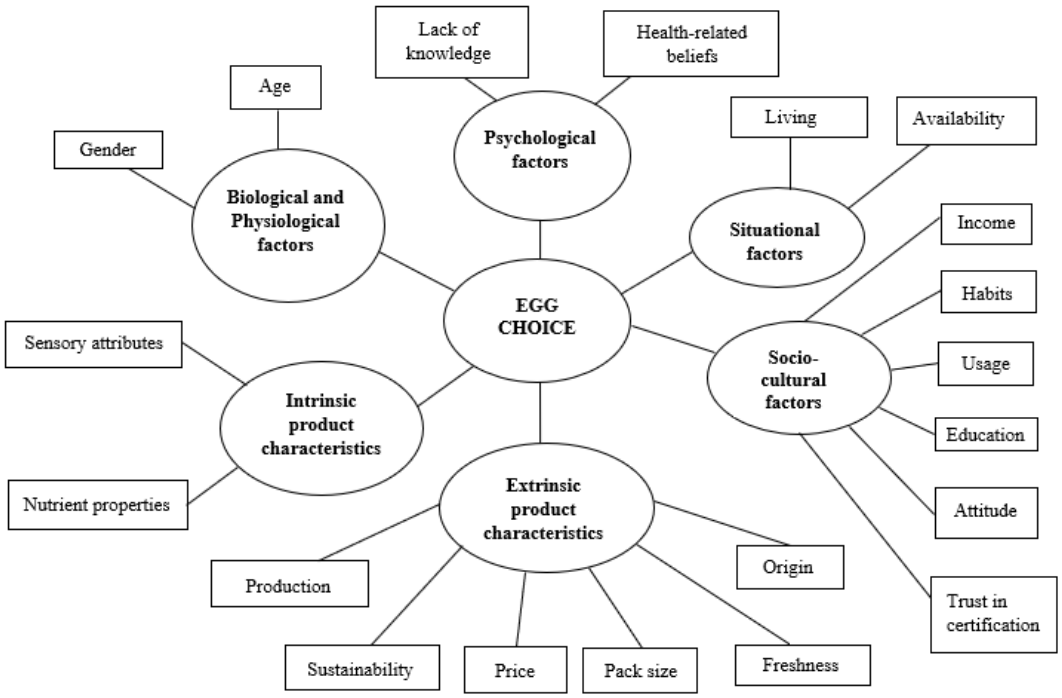

Fig. 3 - Essential factors and sub-factors that drive consumer behaviour, perceptions, and preferences for eggs, adapted from Mojet's model. Sub-factors were identified from the literature review of the 34 articles.

Considering the **intrinsic product characteristics**, *sensory attributes* (e.g., *size*, *eggshell colour*, *appearance*, and *yolk colour*) and *nutrient properties* (*omega-3-enriched*) were the most relevant factors affecting consumer behaviour, perceptions, and preferences towards eggs. Concerning *size*, consumers from Malaysia (Ahmad Hanis et al., 2013), Ghana (Ayim-Akonor and Akonor, 2014), and Spain (Baba et al., 2017; Mesías et al., 2011) showed higher preferences for larger eggs rather than smaller ones. The preference for large eggs may be attributable to the fact that many recipes are made using large size eggs (Ochs et al., 2019). In addition, Ayim-Akonor and Akonor (2014) showed that shoppers from Ghana believed that

large eggs are more healthful because they may come from better-fed chickens. With reference to eggshell *colour*, brown eggs were more liked than white eggs by consumers from Malaysia (Ahmad Hanis et al., 2013), Ghana, Brazil (Ayim-Akonor and Akonor, 2014), and the United States (J. B. Chang et al., 2010) while Heng, Peterson, & Li (2013), who conducted a study in the United States, found that consumers showed preferences for white eggs. Eggshell colour preferences may be driven by higher familiarity of consumers with certain types of eggs as well as availability in the markets where they live (Pelletier, 2017). Another important intrinsic attribute is *appearance*. Wardy, Sae-Eaw, Sriwattana, No, & Prinyawiwatkul (2015) showed that US consumers do not like visible cracks on the eggshell. Fourth, yolk *colour* is an important factor which determines product re-purchase (Bray and Ankeny, 2017). A deep yellow is preferred to a pale yellow coloration by consumers from Ghana (Ayim-Akonor and Akonor, 2014) and the United States (Heng et al., 2013). Consumer preferences for bright yellow yolk colour emerged, and it can be argued that this may be because brighter colour food is often associated as fresher, more healthful, and safer (Ngapo et al., 2017). By comparing consumer preferences for yolk colour between omega-3-enriched, free-range, and caged eggs, it emerged that caged-eggs had higher yolk colour acceptance (Baba et al., 2017). *Taste, flavour*, and *odour* linked to production methods also emerged as sub-factors that affect consumer preferences for eggs. For example, United Kingdom (Pettersson et al., 2016) and Australian consumers (Bray and Ankeny, 2017) believed that free-range eggs had a better taste than caged eggs because hens are "happier" in free-range based systems than in caged. Baba et al. (2017) found that consumer preferences for flavour were higher for barn and free-range eggs than for omega-3-enriched eggs. In terms of *nutrient properties*, Heng et al. (2013), Ahmad Hanis et al. (2013), and Mesías et al. (2011) found that US, Malaysian, and Spanish consumers, respectively, were

unwilling to pay a premium price for omega-3-enriched eggs. Similarly, Lu, Cranfield, and Widowski (2013) conducted a survey in the United States to investigate consumer preferences for different egg production systems and found that consumers were unwilling to pay a premium price for omega-3-enriched eggs. This may be due to the fact that consumers might have a low grade of familiarity with omega-3-enriched eggs (Baba et al., 2017), or they might have limited knowledge of the benefits of these products (Sass et al., 2018).

Factors of **extrinsic product characteristics,** like *production method, sustainability, price*, *pack size*, *freshness*, and *origin*, were found to drive consumer behaviour, perceptions, and preferences towards eggs. Specifically, for *production method*, consumers prefer cage-free eggs rather than caged eggs. Indeed, consumers from Spain (Lopez-Galan et al., 2013), the United States (Norwood and Lusk, 2011a; Ochs et al., 2019), Brazil, Chile (Teixeira et al., 2018), and the United Kingdom (Pettersson et al., 2016) showed higher willingness to pay (WTP) for eggs produced in cage-free systems because they are perceived to be produced with higher animal welfare standards (Doyon et al., 2016). In a study carried out in California, Lusk (2010) showed that after the implementation of Proposition 2[8], the demand for cage-free eggs significantly increased compared to the demand in states like Texas, where Proposition 2 was not implemented. Interestingly, different findings emerged regarding the preference towards

[8] Proposition 2 stipulated that the minimum cage size needed for chickens to perform particular behaviours (e.g., they must be able "to lie down, stand up, fully extend their legs, and also turn around freely for the majority of the day") (Proposition 2, 2008),

different types of cage-free systems. While consumers from Spain were found to be willing to pay higher prices for free-range eggs rather than organic eggs (Gracia et al., 2014; Rahmani et al., 2019), Andersen (2011) found that Danish consumers were willing to pay higher prices for organic rather than barn or free-range eggs. In addition, Guney (2019) showed that Turkish consumers were willing to pay higher prices for organic eggs because they were perceived to be more healthful, more nutritious, and tastier, than caged eggs. In countries like the United States where the egg industry is still mainly based on caged egg systems (Karcher and Mench, 2018), a potential rise in the market share of cage-free eggs is anticipated, although it will likely remain a niche market (Lusk, 2018).

Some studies reported a link between animal welfare and food safety. Consumers perceived that eggs produced by hens raised with higher animal welfare standards were safer to eat (Ochs et al., 2018). For example, Li et al. (2017) found that US consumers were willing to pay a premium price for organic eggs after the recall of a half billion eggs in 2010 due to a salmonella outbreak, because they were thought to be safer than caged. Similarly, Taiwanese consumers were found to be willing to pay a higher price for cage-free eggs because they were associated with higher food safety standards (Yang, 2018). Regarding animal welfare, some research investigated consumer preferences for new production method practices providing higher animal welfare standards (Krautwald-Junghanns et al., 2018; Rodenburg et al., 2008). For example, US consumers were willing to pay higher prices for removing the beak trimming practice from production (Ochs et al., 2018). Another study reported that Canadian consumers were willing to pay higher prices for adding further objects in barn systems, such as perches,

nesting areas, and scratching pads, to allow more usable space for the hens (Doyon et al., 2016). Gangnat et al. (2018) revealed that Danish consumers were willing to pay higher prices for eggs if the practice of dual-purpose poultry was applied in production. Regarding other extrinsic characteristics like *sustainability*, evidence suggests that Brazilian and Chilean consumers were unwilling to pay a premium price for sustainable eggs, produced with reduced amounts of water and higher standards of manure treatment (Teixeira et al., 2018). Similarly, Spanish consumers were found to be unwilling to pay a premium price for eggs claimed to be produced with reduced greenhouse gas (GHG) emissions and water use (Rahmani et al., 2019). On the other hand, US consumers were willing to pay a premium price for organic-fed and vegetarian-fed eggs, which have a lower impact on the environment (Heng et al., 2013). *Price* was the most important factor for consumers when purchasing eggs from Malaysia (Ahmad Hanis et al., 2013), Ghana (Ayim-Akonor and Akonor, 2014), Spain (Baba et al., 2017), Poland (Zakowska-Biemans and Tekień, 2017), and Canada (Allender and Richards, 2010). In terms of *pack size*, Ahmad Hanis et al. (2013) reported that Malaysian consumers prefer larger pack sizes (e.g., ten to thirty eggs per pack) to smaller (e.g., six or less than six eggs per pack), because of the lower price per egg. *Freshness* was particularly important for US consumers who indicated shelf life as the most salient attribute for them when they buy eggs (Wardy et al., 2015). Concerning *origin*, consumers from Spain showed a stronger preference and higher willingness to pay for locally-produced than imported eggs (Baba et al., 2017; Gracia et al., 2014; Lopez-Galan et al., 2013).

The **socio-cultural factors** of *income, food habits, usage, educational level, attitudes,* and *trust in the certification institution* were found to significantly affect consumer behaviour, perception, preferences, and willingness to pay for eggs. As for *income*, some contradictory findings were reported. While Andersen (2011) found that higher-income Danish shoppers were willing to pay a higher price for free-range and organic eggs, and Yang (2018) reported that higher-income Taiwanese consumers were willing to pay higher prices for barn and free-range eggs, Vecchio & Annunziata (2012) found that higher-income Italian consumers were not willing to pay higher prices for free-range eggs. Surprisingly, differences between the reported willingness to pay among households with different incomes in the United States were found not to significantly affect consumer purchase behaviour for eggs (Spain et al., 2018). Food purchasing *habits* can affect consumers purchases of eggs. For example Gerini, Alfnes, & Schjøll (2016) found that Norwegian consumers who usually buy organic food tend to buy more organic eggs than those who only sometimes buy organic food. Interestingly, egg purchasing was found to be driven also by the *use* that consumers make of them and how many they need. For example, if eggs are purchased for baking, United Kingdom consumers are likely to prefer caged eggs, whereas in recipes where eggs are the main ingredient (e.g., omelettes, hard-boiled eggs, etc.), they would more likely use free-range eggs and would also be willing to pay a premium price for them (Pettersson et al., 2016). Concerning *education*, more highly educated Taiwanese consumers were found to be willing to pay higher prices for eggs with animal welfare information than those with a lower educational level (Yang, 2018). In Canada, consumers with a higher educational level and income were found to prefer free-range eggs, whereas those with a lower educational level and income preferred white eggs (Bejaei et al., 2011). Consumer *attitudes*, such as pro-animal welfare and pro-environmental attitudes, also

affect consumer purchasing behaviour and willingness to pay for eggs. With respect to pro-animal welfare attitudes, Spanish (Lopez-Galan et al., 2013), US (Norwood and Lusk, 2011b; Spain et al., 2018), Brazilian, Chilean (Teixeira et al., 2018), and United Kingdom consumers (Bennett et al., 2016) who expressed concern for animal welfare conditions on farms also showed higher willingness to pay for cage-free eggs. Conversely, Vecchio & Annunziata (2012) showed that although Italian consumers expressed concern for animal welfare standards, they rarely purchased cage-free eggs. Consumers' pro-environmental attitudes were found to positively affect shoppers' willingness to pay for free-range and organic eggs in Spain (Andersen, 2011), but this did not necessarily translate into willingness to pay a higher price for eco-friendly produced eggs (Teixeira et al., 2018). Last, *trust in the certification institution* is an important sub-factor. Indeed, consumers' willingness to pay for eggs with enhanced animal welfare standards (e.g., free-range and organic) in the United Kingdom (Bennett et al., 2016) and in the United States (Spain et al., 2018) increased only if the animal welfare label was accredited by an external third-party institution or by the federal government.

Among the **psychological factors**, *lack of knowledge* and *health-related beliefs* were found to affect consumer purchases of eggs. Güney & Giraldo (2019) revealed that Turkish consumers were reluctant to purchase organic eggs because they do not know the characteristics of organic egg production. This may be because consumers still may not be aware of the differences between the different production systems. Similarly, Vecchio & Annunziata (2012) showed that consumers were unaware of the meaning of the current labelling system for eggs. This also emerged in Pettersson et al. (2016), who compared the understanding of consumers and experts

towards animal welfare in the context of egg production and found that both believed that "space allowance" was the major benefit in free-range production; however, "giving access to the outside," "fresh air," and "giving access to the sunlight" were rated low by the experts and very high by consumers. Also, other practices used in egg production were still largely unknown by consumers as shown by Gangnat et al. (2018), who found that only 17% of the Swiss respondents indicated they knew about male chick culling and dual-purpose poultry practices. In terms of *health-related beliefs*, consumers from Ghana preferred brown eggs to white because they were thought to be more healthful and to contain a lower cholesterol ratio (Ayim-Akonor and Akonor, 2014). Bray & Ankeny (2017) conducted a qualitative study with Australian consumers and found that consumers believed that cage-free eggs are more healthful than caged eggs because of the healthier diet that hens are believed to follow in cage-free systems (e.g., free from chemicals, hormones, and added antibiotics).

Among the **biological and physiological factors**, *gender* and *age* have been found to influence consumer preferences for eggs. British women tend to buy more free-range eggs than other types of cage-free or caged eggs than men (Pettersson et al., 2016). This is in line with past research that showed that women generally give more importance to animal welfare than men (Vanhonacker et al., 2010). From an investigation carried out by Rahmani et al. (2019), it emerged that young Spanish consumers (e.g., less than 40 years) were willing to pay higher prices for free-range and organic eggs than caged-eggs. In contrast, older (e.g., older than 40 years) Danish (Andersen, 2011) and Taiwanese consumers (Yang, 2018) were willing to pay

higher prices for free-range and organic eggs, and this can be explained by the fact that older people may have higher income than younger consumers.

Finally, the **situational (i.e., contextual) factors** of *living area* and *availability* have been found to affect consumer preferences for eggs. With regard to *living area*, Andersen (2011) conducted a study in Denmark and found that shoppers from urbanized areas were willing to pay higher prices for cage-free eggs than caged eggs. Furthermore, *availability* of different egg types in stores was found to negatively influence consumer preferences in some countries. For example, Turkish consumers were sceptical to buy organic eggs because they were not used to them due to the scarce availability in shops and retail markets (Güney and Giraldo, 2019).

4. Discussion & Conclusions

The following discussion is structured according to the objectives guiding this review, and, thus, it first summarizes the factors influencing consumer behaviour and preferences for eggs, follows up with a discussion of the implications for egg industries and policy makers, and concludes with an analysis of the research gaps that emerged from the review possibly to be addressed in future studies.

4.1 Consumer behaviour, perceptions, and preferences for eggs

Based on the outcomes that emerged from this review, several considerations can be derived. First, although eggs are one of the most popular and widely consumed staple foods around the world, relatively few studies have investigated consumer behaviour, perceptions, and preferences towards eggs. Also, most of them are concentrated in developed countries, especially the United States. Second, based on Mojet's model (Köster, 2009), intrinsic, extrinsic, socio-cultural, situational, biological, and physiological factors affect consumer behaviour, perceptions, and preferences towards eggs. Thus, we can conclude that a large variety of drivers have been found to affect consumer behaviour, perceptions, and preferences towards eggs, according to the empirical consumer studies from the past ten years. Third, it seems that product characteristics (e.g., intrinsic, and extrinsic) are the most investigated factors that affect consumer preferences for eggs. Specifically, production method and sensory attributes are relevant sub-factors in affecting consumer preferences for eggs, particularly in North and South America as well as in European countries. Interestingly, several studies showed that there is a complex consumer-perceived interaction between production method and other product attributes. Specifically, consumers perceive that production method may affect the healthfulness, food safety, and sensory properties of eggs. Concerning sensory attributes, eggshell and yolk colours, appearance, and taste are relevant factors affecting consumer behaviour, perceptions, and preferences for eggs. These findings are corroborated by a large number of studies that indicate sensory attributes are influencing factors affecting consumer food choices (De Pelsmaeker et al., 2013; Grunert, 2005). Interestingly, while in developed countries a heterogeneous preference between brown and white eggshells emerged, in developing countries consumers prefer brown eggshells. Fourth, in terms of socio-demographic characteristics, those with higher income, the young, females, and educated consumers prefer

cage-free eggs and are willing to pay higher prices for them. Fifth, a few studies have investigated the environmental sustainability issues, in terms of reduced greenhouse gas (GHG) emission and water use; these showed that consumers do not pay much attention to this element when purchasing eggs. Sixth, price has been found to be a key determinant for egg purchases, especially in developing countries. Finally, consumer habits and attitudes toward sustainability, health, and animal welfare may affect consumer behaviour, perceptions, and preferences towards eggs.

4.2 Implications for food producers and policy makers

Several implications for egg producers can be derived from the outcomes of this review. First, egg producers should expect that a diversity of factors impact egg purchasing and, thus, need to be prepared to take the diversity of these drivers into account in developing new types of eggs. Specifically, intrinsic and extrinsic product characteristics as well as socio-cultural factors influence consumer preferences for eggs significantly, while less can be concluded or known for the remaining factors. Second, in developed countries, the production method is a crucial attribute that drives consumers when they purchase eggs, partly because consumers infer healthfulness, food safety, and sensory properties of eggs from the type of production method. Thus, it is important that egg producers communicate to consumers the benefits of higher animal welfare standards through labelling and the effect that the production method has on healthfulness, food safety, and sensory properties of the products, if any, for marketing and transparency purposes. Third, it looks like those with higher income, the young, females, and educated consumers are more attracted to cage-free eggs and might be the segment of

consumers to launch the cage-free egg market. Fourth, in terms of sensory attributes, eggshell colour and yolk appearance emerged as key sensory attributes together with the size of the eggs, which food producers should consider when marketing eggs. Therefore, a better communication of sensory attributes on the label would help consumers to find the type of eggs that they wish to buy, for example, by indicating on the label the colour of the yolk. Lastly, price seems to be a key driver for egg purchasing, especially in developing countries, which should be considered in the marketing strategies to lower the prices of eggs in those markets.

For policy makers interacting with egg producers, production method and sensory attributes are major drivers, which suggest that they need to consider how to ensure that consumers are not misled by information about these factors in any way. Specifically, it would be very important that policy makers are able to better regulate the production method by informing consumers about the different types of cage-free eggs, supporting, for example, the adoption of standards and certifications so that consumers can make more informed choices using independent third party certification (Yang, 2018). Similarly, as consumers are still unwilling to pay more for omega-3 enriched eggs, as well as for eggs produced with reduced GHG emissions, policy makers should work with producers to better inform consumers about the health and environmental benefits that can be derived from purchasing these eggs. Finally, policy makers should also aim to support measures that allow a reduction of prices for eggs in developing countries, in order to allow all consumers to afford to purchase eggs.

4.3 Future research directions

This review has brought forth several questions in need of further investigation. First, future studies should ascertain more clearly the influence of the production method on consumer-perceived health and sensory benefits and potential food safety risks both from food science and marketing sides. Second, it would be interesting to establish how egg preferences differ across diverse consumer groups. In addition, future studies, similar to the work done by Lusk (2018), can try to estimate the market for cage-free eggs in different countries. Third, most of the existing consumer studies on eggs are from developed countries. Our findings indicate some cultural variations in egg preferences and consumption. Therefore, research on consumer behaviour, perceptions, and preferences for eggs in emerging markets will broaden our understanding of this subject. Fourth, further research needs to be undertaken to better investigate the behavioural drivers of consumer decision making for eggs. For instance, future studies could use structural equation modelling (SEM) to investigate the strength of the effects of the factors identified in this paper for egg products to better understand how they contribute to consumer choice decisions. Fifth, it would be interesting to establish whether the inclusion of various psychological factors (e.g., risk preferences, time preferences, and personality, among others) into economic models of consumer demand could improve their predictive power and, thus, help to better understand consumer decision making processes for egg products. Sixth, further experimental investigations are needed to explore how consumers value the sensory aspects of eggs by using different consumer valuation methods, such as experimental auctions or real choice experiments as proposed by Asioli, Varela, et al. (2017). Seventh, new technologies aiming to enhance animal welfare standards in the egg industry have

been recently developed, such as a system for detecting the in-ovo gender of chicks[9]. However, since the adoption of these new practices could be very expensive for egg producers, research should be conducted to estimate consumer willingness to pay for eggs produced with these new technologies to compare with costs of production in order evaluate the economic sustainability for producers. In terms of eco-sustainability, a new frontier of feeding systems is driving towards insect-based feed (Borrelli et al., 2017). Thus, future studies should investigate the effect of insect-fed both on nutritional and sensory properties, as well as consumer preferences for this type of eggs. Eight, there is a need to conduct more research to improve the sensory and nutritional properties of eggs able to develop new egg products that better meet consumers' needs and wishes, for example enriched eggs (Barnkob et al., 2020). Finally, although this literature review provides a quite comprehensive understanding of consumers' behaviour for conventional eggs, it also shows missing knowledge consumers' behaviour for plant-based eggs, which is important in order to provide useful information for plant-based egg producers and policy makers. The remaining sections of the thesis fill these gaps of knowledge. In particular, the next chapter (Chapter II) explores the prospective of stakeholders and retailers on plant-based eggs. After that, Chapter III describes consumers' associations for plant-based eggs. Last, consumers' preferences and willingness to pay for plant-based eggs are reported in Chapter 4 and 5, respectively.

[9] One of these systems use radioimmunoassay (RIA) technology to determine embryos gender (Tran et al., 2010); others have checked for estrone sulphate which is higher in females and identified gender with an accuracy of 84% for 8 days of incubation and of 98%-100% for 9 days (Weissmann et al., 2013).

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Appendix A

Table A1 - Overview of the selected articles (n=34) about consumer behaviour, perceptions, and preferences towards eggs.

NO.	AUTHORS	COUNTRY OF INVESTIGATION	METHODOLOGY	SAMPLE SIZE	FINDINGS
1	Allender & Richards (2010)	Canada	Quantitative (Choice Experiment)	2,000	• Consumers were unwilling to pay a premium price for cage-free eggs, particularly those from larger households and/or households with lower income.
2	Ahmad Hanis *et al. (*2013)	Malaysia	Quantitative (Conjoint analysis) and qualitative (Focus groups)	202 for the conjoint analysis 33 for the focus groups	• Consumers were willing to pay a premium price for eggs of large size, enriched with omega 3, of brown eggshell, and packaged in boxes of ten eggs per pack.
3	Al-Ajeeli *et al.* (2018)	United States	Sensory consumer test	60	• Consumers preferred the texture of scrambled eggs from hens fed with soybean-free diet than for scrambled eggs from hens fed with soybean meal diet. • Consumers preferred the flavour of the hard-cooked eggs from the caged system than from the free-range system.
4	Andersen, (2011)	Denmark	Quantitative (Choice experiment)	2,000	• Consumers were willing to pay a premium price for increasing animal welfare standards in egg production. • Consumers' willingness to pay for organic eggs was higher than it was for barn and free-range eggs.

5	Ayim-Akonor and Akonor (2014)	Ghana	Quantitative (Self-administered questionnaire)	448	• Consumers showed higher preferences for eggs from locally raised hens than free-range eggs, large sized, brown eggshell, and deep yellow yolk. • Most consumers believed that consuming eggs would increase cholesterol in the blood.
6	Baba, Kallas and Realini (2017)	Spain	Quantitative (Analytical hierarchy process AHP)	122	• Compared to free-range eggs, omega-3-enriched eggs had lower flavour acceptance, as well as higher yolk-colour and odour acceptance. Consumers gave more importance to cage-free production and price of eggs followed by the origin and egg size.
7	Bejaei, Wiseman, & Cheng (2011)	Canada	Quantitative (Questionnaire)	1,027	• Free-range egg consumers came from smaller households and had a higher education level and income than white- and caged-egg consumers. • Price was the most important attribute for consumers when purchasing eggs.
8	Bennett *et al.* (2016)	United Kingdom	Qualitative (Focus groups) and quantitative (Online questionnaire)	40 for focus groups and 1,776 for online questionnaire	• While consumers had a very positive attitude towards free-range eggs, they were especially uninformed about some aspects of free-range egg production, such as the injurious pecking.
9	Bray and Ankeny (2017)	Australia	Qualitative (Focus groups)	73	• Free-range and cage-free eggs were perceived to have higher quality, nutrition, and safety and better sensory characteristics than caged eggs. • Free-range egg purchasing was more often associated with the willingness to avoid "industrialized" eggs than of the valuing of hens' animal welfare.
10	Chang, Lusk and Norwood (2010)	United States	Quantitative (Analysis of point of sales scanner data from 2007 to 2009)	-	• A significant premium price was paid for cage-free eggs. However, about 42% of the typically observed premium for cage-free eggs was attributable to egg colour rather than differences in hens' living conditions.
11	Doyon *et al*, (2016)	Canada	Quantitative (Choice experiment)	572	• Consumers were willing to pay more for cage-free eggs but not for enriching cage space or adding scratch pads and dust baths.

12	Gangnat *et al.* (2018)	Switzerland	Quantitative (Choice experiment)	402	• Consumers' knowledge about poultry production was low. • The dual-purpose poultry alternative was preferred to chick culling, but no preference emerged between dual-purpose poultry and in-ovo sexing. • Consumers' willingness to pay for dual-purpose poultry was lower for chickens than eggs.
13	Gerini, Alfnes and Schjøll (2016)	Norway	Quantitative (Choice experiment)	900	• Consumers purchasing organic food more often were also willing to pay more for organic eggs than cage-free eggs. • Consumers who occasionally purchase organic products were unwilling to pay more for organic eggs than for cage-free eggs. • A segment of consumers avoiding organic eggs, even when they cost the same as other eggs, was also found.
14	Gracia, Barreiro-Hurlé and López-Galán (2014)	Spain	Choice experiment	400	• Consumers were found to be willing to pay higher prices for barn, free-range, and/or organic eggs instead of caged eggs as well as for local, regional, and national eggs over imported eggs.
15	Guney (2019)	Turkey	Quantitative (Choice experiment)	552	• Consumers perceived organic eggs to be healthful, nutritious, and delicious. • Also, individual benefits had greater relevance than collectivist benefits on the consumer choice to purchase organic eggs.
16	Heng, Peterson and Li (2013)	United States	Quantitative (Choice experiment)	449	• Consumers perceived caged-egg systems as reducing hens' welfare and were willing to pay a premium price for eggs produced in cage-free egg systems.
17	Li *et al.* (2017)	United States	Two experiments (A first and a second follow-up of the first)	117 in the first and 74 in the second experiment	• Consumers' willingness to pay for organic eggs increased after the 2010 recall caused by a salmonella outbreak in the US.
18	Lopez-Galan, Gracia and Barreiro-Hurle (2013)	Spain	Quantitative (Choice experiment)	803	• Consumers were willing to pay higher prices for packages of six free-range and organic eggs than for bigger packages of free-range eggs.

19	Lu, Cranfield and Widowski (2013)	United States	Quantitative (Choice experiment)	750	• Consumers were willing to pay a premium for free-range eggs, but not for caged eggs. • A positive, marginal willingness to pay emerged for cage-free systems, outdoor access, and access to nest boxes, perches, and scratching pads.
20	Lusk (2010)	United States	Quantitative (Retailer scanner data from 2005 to 2009)	-	• After the approval of Proposition 2 in California, demand for cage-free and organic eggs increased over time, whereas demand for caged eggs fell.
21	Lusk (2018)	United States	Quantitative (Choice experiments)	2,000	• Potential for an increasing market-share for cage-free eggs emerged, however, it will likely remain a niche market.
22	Mesías *et al.* (2011)	Spain	Quantitative (Conjoint analysis)	361	• Price was found to be the most important attribute determining consumer preferences, followed by rearing conditions.
23	Norwood and Lusk (2011)	United States	Quantitative (Calibrated auction-conjoint method CACM)	291	• Consumers were willing to pay higher prices for a dozen eggs raised in an aviary and pasture system than for eggs raised in cage systems.
24	Ochs *et al.* (2018)	United States	Quantitative (Online survey)	2,813	• Consumers perceived cage-free aviaries and free-range systems as achieving the same positive impact on hen health and stress as well as the environment compared to caged-egg systems.
25	Ochs *et al.*, (2019)	United States	Quantitative (Choice experiment)	2,813	• When respondents were shown videos of egg production systems, they were not able to differentiate between a cage-free aviary and enriched colony housings, whereas with no video information willingness to pay was higher for cage-free systems.
26	Pettersson *et al.* *(*2016)	United Kingdom	Quantitative (Questionnaire)	6,378	• Consumers preferred free-range eggs because hens were believed to be “happier” and “healthier” and eggs were perceived to taste better.

					• Compared to animal welfare specialists, respondents differed in their views on factors contributing to hen welfare, but their views on resource suitability were similar.
27	Rahmani et al. (2019)	Spain	Quantitative (Choice experiment)	520	• Consumers were willing to pay higher prices for free-range eggs, but not for organic eggs. • Consumer were willing to pay higher prices for reducing GHG emissions and water use.
28	Sass *et al.* (2018)	Brazil	Qualitative (Completion task technique)	100	• "Health" and "price" emerged as positive factors that drive egg purchasing and consumption.
29	Spain *et al.* (2018)	United States	Quantitative (Online survey)	1,000	• Most consumers showed interest for labels providing information on how hens were raised and believed there should be an objective third party to ensure farm animal welfare reliability.
30	Teixeira, Larraín and Hötzel (2018)	Brazil and Chile	Quantitative (Online survey)	358 Brazilian and 358 Chilean	• Consumers were concerned about animal welfare, naturalness, hygiene, production, and ethical aspects of egg production, which many associated with improved health, sensory, and nutritional quality of the eggs.
31	Vecchio and Annunziata (2012)	Italy	Quantitative (Online survey)	300	• Consumers were unaware of the current mandatory labelling system for eggs.
32	Wardy *et al.* (2015)	United States	Quantitative (Online survey)	320	• Consumers valued freshness and appearance, such as the absence of visible cracks on the eggshell.
33	Yang, Y. (2018)	Taiwan	Quantitative (Online survey)	322	• Consumers showed awareness about the different types of production methods such as battery cages, free range etc. • Older and higher-income consumers were willing to pay higher prices for barn and free-range eggs than younger and lower-income consumers.

					• Buddhists and Taoists were willing to pay more than those who were not. • Consumers were willing to pay higher prices for cage-free eggs because they were perceived to be safer.
34	Zakowska-Biemans and Tekień (2017)	Poland	Quantitative (Choice experiment)	935	• Price and production method were the factors that more significantly affected consumer preferences, while nutrition and health claims, egg size, package size, and hen breed were far less important.

Chapter II - **Plant-based Eggs: Views of Industry Practitioners and Experts**[10]

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Abstract

Plant-based eggs have been recently developed by food practitioners as an alternative to conventional eggs. However, there is uncertainty on how the current egg market will react to plant-based eggs, as well as lack of knowledge about product development and regulations. In this manuscript, we explored this issue by conducting in-depth interviews with egg industries and retailers, as well as with plant-based egg manufacturers. Results show that despite egg manufacturers are struggling to provide an alternative to people who do not consume eggs, they are sceptical that plant-based eggs can replicate all eggs' nutrients and functionalities. Furthermore, egg industries do not see plant-based eggs as potential competitors to their products, while plant-based egg manufactures argue that they will directly compete with eggs. Also, there is uncertainty on how to label and name plant-based eggs, which has important implications in terms of marketing and policy labelling of these new products.

Keywords: Egg practitioners; Plant-based eggs; In-depth interview.

1. Introduction

In Europe, egg demand is estimated to increase of 20% by 2030 (International Egg Commission, 2013). However, during the last decades, several critical issues have affected the egg industry (Rondoni et al., 2020). First, the growing problems related to egg allergies (Savage et al., 2007) and the discussion about whether egg intake has effects on the level of cholesterol in humans (McNamara, 2015), have increased consumers' concern towards the consumption of eggs. Second, in the European Union, consumers' increasing interest in animal welfare standards led to the banning of cage systems in 2012 (Bray and Ankeny, 2017; Heng and Peterson, 2018) and since then, only barn, free-range, and organic are allowed as production methods (UEP, 2017). Third, several food safety scandals, such as for example, the salmonella outbreak in 2015 in the United States (Whiley and Ross, 2015) and the Fipronil scandal in 2017 in the European Union (European Commission, 2017) contributed to increase consumers' scepticism for eggs. Fourth, the egg industry is responsible alone for about 10% of total livestock emissions (FAO, 2016), which creates concern in regard to how to meet the expected growing egg demand in a sustainable manner (FAO, 2017). These critical issues have prompted the egg industry to review its production system and increased the variety of egg products offered in the market, for example, in terms of production method (e.g., organic eggs, free-range eggs, etc.) and nutritional properties (e.g., omega-3 eggs, etc.) (Baba et al., 2017; J. B. Chang et al., 2010).

In addition to these new products, another solution to the growing and complex demand for eggs are the so called "plant-based eggs", also defined as "vegan eggs",

“egg substitutes”, or “egg replacers” (The Good Food Institute, 2018). Plant-based eggs are an alternative to conventional eggs that are not produced from hens but use raw materials that originate from plants, such as, for example, legumes, cereals, or algae, which are able to replicate similar functionalities to eggs, like stabilization, emulsification, gelation etc. (The Good Food Institute, 2018). In the last few years, several prototypes of plant-based eggs have been developed in different countries, including the United States, Brazil, and Italy, from both start-up businesses and research centres (Rondoni et al., 2021b). For instance, examples of liquid plant-based eggs produced through a process of protein isolation and sold in bottles are already available to consumers in the US market (Watson and Shoup, 2019). Other types of plant-based eggs (e.g., powder or egg-shaped) are developed through protein fermentation or isolation processes but are not yet available in the market (Carrington, 2018). Compared to conventional eggs, plant-based eggs have several advantages. First, since plant-based eggs are produced without hens, they are allergen-free and cholesterol-free, hence could offer a solution for consumers who suffer from egg allergy or have health issues related to cholesterol (Brown and Schrader, 2006). Second, plant-based eggs are not produced by hens, and thus they are not affected by animal-related diseases (e.g., salmonella or the avian-flu) (Whiley and Ross, 2015), which are critical issues in conventional egg production. Third, as food safety scandals have an impact on the industry economy, plant-based eggs also offer a stable solution to the high price volatility that affects the egg market (Tu et al., 2019). Last, the manufacture of plant-based eggs is claimed to be more environmentally sustainable than conventional egg production, although

accurate data about its environmental impact are not yet available (The Good Food Institute, 2018).

Since the development and production of plant-based eggs is still at the beginning stage, the issues in terms of production, marketing, and regulations in relation to these new products are still unknown. To the best knowledge of the authors, no previous studies have investigated practitioners' perceptions, experiences, and challenges regarding plant-based eggs. In addition, how egg industries and retailers are responding to plant-based eggs, as well as to the new and more complex consumer demand, remains unexplored. Hence, the present study aims at shedding light on these issues by investigating (i) what are future trends and barriers in today's conventional egg market; (ii) egg industry and retailer's perception for plant-based eggs; (iii) what challenges are start-up businesses and researchers experiencing in terms of product development, marketing, and policy regulations for plant-based eggs.

To achieve these objectives, we conducted two studies, hereafter called Study One and Study Two. In Study One, we investigated future trends and barriers in today's egg market and how the egg industry and retailers perceive plant-based eggs by interviewing egg industries and retailers from the United Kingdom and Italy. We chose the United Kingdom and Italy because they are the next largest egg producers in Europe after France and Germany, producing about 1.2 and 1.1 million tonnes of eggs per year, respectively (International Egg Commission, 2014). In detail, the British egg market is worth about US $1.01 billion (UK Government, 2020a), with

39 million commercial laying hens and 1.200 commercial farms (International Egg Commission, 2013). Most of these are concentrated in the south of the country (UK Government, 2020a). In Italy, the egg market has a value of US $1.13 billion, with 38.9 million commercial laying hens and 1.800 commercial farms (International Egg Commission, 2015). The two regions of Veneto and Lombardy in the north account for more than 50% of production. The remaining 50% is distributed between the centre and the south of Italy (ISMEA, 2019). In Study Two, we investigated challenges in terms of product development, marketing, and policy regulations for plant-based eggs by interviewing plant-based egg start-ups and researchers. In Study Two, we did not limit the research to any country in order to get enough material as to the best knowledge of the authors, only a few scientists and businesses are yet working on these products.

This exploratory research provides unique insights for practitioners about the production, marketing, and regulatory challenges that plant-based eggs might face in today's dynamic market and contributes to advance the research on new animal-based food substitutes like the plant-based eggs.

This paper is structured as follows. The next section describes the methodology used to achieve the study's objectives. The results are presented in section three, which is followed by a discussion and conclusion presented in the final section four.

2. Methodology

2.1 Exploratory research: In-depth interviews

Exploratory research based on qualitative data collection techniques was adopted because of its suitability due to the absence of previous studies investigating plant-based eggs from a supply perspective. The exploratory research enables the evaluation of the complexity and rich diversity of the practitioners' experiences and perceptions relying upon the collection of a large amount of information from few subjects, rather than only small pieces of information from a large sample. Exploratory research is useful to provide guidance and generate hypotheses for further research since it provides in-depth and context-rich information, although in most cases the findings cannot be considered conclusive because of the qualitative nature (Myers, 2009).

Among the different types of qualitative research methods, in-depth interview was chosen because it is optimal for collecting data on individuals' histories, perspectives, expectations, and experiences (Molteni and Troilo, 2007), and because it allows the use of some pre-formulated questions, covering the aspects that are expected to be discussed (Malhotra, 2017). In-depth interview is "an unstructured, direct, personal interview in which a single participant is probed by an experienced interviewer to uncover underlying motivations, feelings, and beliefs on a topic" (Malhotra, 2017, p. 209). Furthermore, we used the semi-structured qualitative interview schedule because its flexibility and validity are proven by the fact that it is the most widely used interviewing format for qualitative research

(DiCicco-Bloom and Crabtree, 2006; Madsen and Petermans, 2019; Theerachun et al., 2013; Wongprawmas et al., 2012). As indicated in the introduction, in order to achieve the research's aims, we conducted two different studies (Study One and Study Two). Given the objectives of Study One to explore new trends and barriers in the egg market, and egg stakeholder's opinions about plant-based eggs, marketing managers and/or owners from the egg industries and buyers from the retailers were chosen as interviewees. Specifically, marketing managers were identified as the best respondents because they are responsible for the marketing, communication, promotion, and sales activities within the company, and thus, they are likely to be the most informed about future market trends, as well as about possible consumers' reactions for plant-based eggs. Similarly, the owners are responsible for making the strategic decisions within the company and so they are knowledgeable about the current and future market trends. Because most egg industries are small-medium enterprises (SMEs), either marketing managers and owners were suitable given that in SMEs, the ownership and marketing management activities are often performed by the same person. Regarding the retailers, the buyers are responsible for sourcing and introducing products in the stores, so they are aware about consumers' preferences for eggs and may be able to predict consumers' opinion about plant-based eggs. For Study Two, start-up owners and researchers working on plant-based eggs were identified as the best respondents for our research purposes. In particular, the companies' owners and marketing managers are responsible for the marketing and the promotion of plant-based eggs and deal with policy regulations. Thus, they are likely to be the most knowledgeable in terms of current and future trends in the plant-based egg market, as well as about

possible policy issues that might impact the plant-based eggs. In addition, the scientists are responsible for the development of the plant-based eggs, hence they have in-depth knowledge about current challenges and future development of these products.

In the semi-structured interview, interviewer and interviewee are engaged in a formal discussion by using an interview guideline, which is basically a set of predetermined open-ended questions/topics (DiCicco-Bloom and Crabtree, 2006), previously designed for this study to serve as a non-binding outline of the discussion, following the research aims mentioned above. The guidelines developed for Study One, and to be addressed to egg firms and retailers, were structured beginning with a series of ice-breaking questions about the company and the role of the interviewee in the company. This was followed by a series of questions related to their experience with the sales and marketing of their eggs and egg products. The last part of the guidelines was composed by questions aiming at investigating their perceptions of plant-based eggs, after a brief presentation of the products using short videos and images. The guidelines were developed in English and then translated into Italian for the interviews with the egg industries and retailers from Italy. The guidelines for Study Two were also developed in English and were still composed by a series of ice-breaking questions, followed by some questions on the marketing, research and production, and regulation of plant-based eggs.

2.2 Recruitment of the respondents

A list of egg industries and retailers from the United Kingdom and Italy for Study One and plant-based egg start-up businesses and researchers for Study Two was drawn after conducting an extensive search, and the most appropriate respondents able to answer the study research questions were identified. All respondents were recruited by purposive non-stochastic sampling. The snowball sampling procedure was also applied (Malhotra, 2017). Potential respondents were contacted in advance via email and phone. In total, for Study One, 22 interviews were conducted, including 12 with egg firms, of which 7 were from the United Kingdom and 5 from Italy, and 10 participants from the retail sector, including 4 from the United Kingdom and 6 from Italy. For Study Two 6 plant-based egg start-up businesses and 3 researchers were interviewed (see Table 1).

Table 1 – Respondents' sample and position for Studies One and Two.

RESPONDENTS POSITION	SAMPLE
Study 1	
United Kingdom egg firms	**7**
Owner	4
Sales and Marketing Manager	3
Italian egg firms	**5**
Owner	4
Brand Manager	1
United Kingdom retailers	**4**
Buyer	3
Innovation Manager	1
Italian retailers	**6**
Buyer	5
Marketing Manager	1

Study 2	
Plant-based egg start-up businesses	**6**
Marketing Manager	1
Owner	4
Director of Strategy and Analytics	1
Plant-based egg researchers	**3**
Food Scientists	1
Senior Research Scientist	1
Professor	1

2.3 Interview procedure

Twenty-two interviews from Study One and nine interviews from Study Two were administered during summer 2019. The interview schedule was sent to respondents in advance together with the participatory information sheet, and interviews ranged between 30–45 minutes in duration. For convenience, the interviews were settled at respondents' best time and location and were conducted in person or using Skype/phone by an experienced researcher, while an assistant took notes. Interviews were audio-recorded if permitted by the respondent. The interviews in the United Kingdom were conducted in English and in Italy in Italian. Records were then archived. Interviews' audio-records were transcribed verbatim and then read and re-read singularly to get a deep understanding of their meaning. The interviews conducted in Italian were first transcribed in the original language and then translated into English. Given the exploratory nature of this research, it was decided not to impose a theoretical model or framework on the data acquisition and data analysis. Informed consent was obtained by all participants and the study was approved by a university ethical committee.

2.4 Data analysis

In qualitative research, data collection and data analysis may happen at the same time, and the researcher may need to go back and forth between different steps (Thorne, 2000). In this research, some preliminary data analysis was done immediately after each interview by identifying emerging themes and constructing initial conceptual maps from each interview. When all the data was collected, thematic analysis of the participants' responses was developed to analyse them. Thematic analysis "is a method for identifying, analysing, organizing, describing, and reporting themes found within a data set" (Nowell, Norris, White, & Moules, 2017, p.1). Nvivo 12 (Burlington, United States) qualitative software for data management was used to facilitate the data analysis. During the first step of thematic analysis, the researchers started to familiarise themselves with the results by reading and re-reading the entire data set and trying to become well acquainted with the data (Braun and Clarke, 2006). In the next step, a preliminary coding was performed aiming to identify information related to the research questions. Coding is a way of "indexing or mapping data, to provide an overview of disparate data that allows the researcher to make sense of them in relation to their research questions" (Elliott, 2018, p. 2850). Inductive coding was applied for data analysis, which is when codes are developed by directly examining the data (Blair, 2015). This process is also defined as "data-driven" coding (Braun and Clarke, 2006). To ensure reliability and consistency in the coding process, data has been coded twice by the researcher and another member of the research team independently and results compared. Coded information was read again, code names were redefined where necessary, and codes with similar meanings were merged. Once the data had been

coded, themes were identified in order to include a series of similar concepts contained in the dataset under a single, more specific theme that could help to summarize the text (Attride-Stirling, 2001). The themes were reviewed separately by the research team members and, later, together to discuss possible different points of view. Eventually, themes were deleted if they were not supported by enough data, while others were added when the data allowed doing so. Sub-themes also emerged and were recorded after consensus amongst the researchers was reached. The data analysis showed that a level of saturation was achieved (e.g., new data did not bring additional insights from those already captured).

3. Results

In this section the results that emerged from the in-depth interviews of Studies One and Two are presented. Table 2 provides a summary of the key themes and outcomes that emerged from Study One. In both studies, results are structured based on different themes that emerged during the in-depth interviews. It is worth noting that the data were collected prior to the Covid-19 pandemic, which has had an impact on the egg market. In the United Kingdom, for example, consumers appear to be more conscious about the safety and the quality of the food they eat compared to prior the pandemic and reduced the consumption of animal-based food products (e.g., meat, milk, eggs etc.) in favour of plant-based meat alternatives (e.g., the sales of plant-based burger and minced meat substitutes rose of 50% in the last year) (Office for National Statistics, 2020). If this trend continues, the demand for new plant-based food alternatives may increase in the future, facilitating the access into

the market of products like the plant-based eggs. On the contrary, in Italy the sale of eggs has been increasing of 56% since the Covid-19 outbreak, due to the increment of at home cooking (ISTAT, 2019). In this regard, if plant-based eggs can replicate the same cooking applications of conventional eggs, it might be pleasantly welcomed by consumers as an alternative to conventional eggs. In addition, during the pandemic, the egg supply chain has suffered from the closure of restaurants and caterings, which account for the 21% and 29% of the egg market in the United Kingdom and Italy, respectively (ISTAT, 2019; Office for National Statistics, 2020; UK Government, 2020a). However, this demand is expected to raise again once the foodservice sector will reopen, although these businesses should be able to adapt to the new preferences and habits that consumers have adopted during the past year. This might include the consumption of healthier and more sustainable food products, such as for example the plant-based eggs, which represent a healthier, more sustainable, and versatile product compared to conventional eggs.

Table 2 – Key themes and outcomes emerged from Study One.

No.	Themes	Outcomes
1	Future trends in the egg market	Growing market segment for organic and free-range eggs in the United Kingdom and Italy, respectively.
2	Barriers in the egg market	High competitiveness in the egg market both in the United Kingdom and Italy. Challenges in providing an alternative to conventional eggs. Logistic limitations.

3	Introduction of new products	Development of new products that are richer in nutrients in the United Kingdom. Development of new of new ready-to-eat egg products both in the United Kingdom and Italy.
4	Reaction to plant-based eggs	Conventional eggs are perceived to be healthier than plant-based eggs by the United Kingdom industries. Plant-based eggs are expected to be more expensive than conventional eggs by both Italy and the United Kingdom industries. Plant-based eggs are expected to be less natural than conventional eggs by both Italy and the United Kingdom industries. Industries from both the United Kingdom and Italy were not willing to introduce plant-based eggs in their portfolio of products. Italian retailers are sceptical about whether plant-based eggs will be able to replicate all eggs' functionalities in cooking. The liquid plant-based eggs could be the most suitable for consumers as it is easier to use. The United Kingdom retailers were more interested in the plant-based eggs than the Italians.

Study One - Results from interviews with egg industries and retailers

In order to preserve their anonymity, participants have been renamed as indicated in Table 3 below and numbered in chronological order based on when the interviews were conducted.

Table 3 - Respondents interviewed for Study One.

		INDUSTRIES	
United Kingdom	**No. employees**	**Italy**	**No. employees**
Firm 1 ENG	65	Firm 1 ITA	50
Firm 2 ENG	8	Firm 2 ITA	766

Firm 3 ENG	24	Firm 3 ITA	41
Firm 4 ENG	13	Firm 4 ITA	12
Firm 5 ENG	58	Firm 5 ITA	55
Firm 6 ENG	625	-	
Firm 7 ENG	27	-	
RETAILERS			
United Kingdom	**No. employees**	**Italy**	**No. employees**
Retailer 1 ENG	>110k	Retailer 1 ITA	>10k
Retailer 2 ENG	>180k	Retailer 2 ITA	>5k
Retailer 3 ENG	>165k	Retailer 3 ITA	>5k
Retailer 4 ENG	>120k	Retailer 4 ITA	>5k
-	-	Retailer 5 ITA	>7k
-	-	Retailer 6 ITA	>10k

Theme 1: Future trends in the egg market

Results show that Italian industries and retailers are foreseeing a growing market segment for organic eggs, whereas in the United Kingdom, the fastest growing market segment is expected to be free-range eggs. In addition, both countries (the United Kingdom and Italy) have shown a growing demand for higher animal welfare and sustainability standards in egg production, also attributable to the "cage-free by 2025" initiative promoted by several supermarket chains across Europe, which aim to sell only cage-free eggs (e.g., barn, free-range etc.) within the next five years (The Guardian, 2016). A United Kingdom firm mentioned:

> *By 2025 the aim in Europe is to reach "no cage at all" in production, so that is sort of where I think the market and the industry is going.* (Firm 7 ENG)

Moreover, the market segment of liquid eggs and liquid egg whites is expected to increase both in the United Kingdom and Italy, although it will remain a niche market, which serves those consumers who seek convenience products because they are quick and easy to prepare compared to the conventional eggshell eggs. A United Kingdom retailer indicated:

> *The segment of liquid egg and egg whites in bottles is going very well, too, although I do not think it will ever cover a big share of the market.* (Retailer 3 ENG)

Theme 2: Barriers in the egg market

A barrier that emerged from egg industries for both the United Kingdom and Italy is related to the high competitiveness in the egg sector, which forces egg industries to sell their products at lower prices, as mentioned by a United Kingdom firm:

> *The egg market is a saturated market and there are loads of competitors, especially out there and supermarkets ask for more at the lower price.* (Firm 7 ENG)

Interestingly, another barrier that emerged from both egg firms and retailers for both the United Kingdom and Italy is the challenge of providing an alternative to conventional eggs to the growing segment of vegetarian and vegan consumers, as mentioned by a United Kingdom industry and an Italian retailer:

> *We also had a few vegetarians who came to us asking if they can eat our eggs, so I think this is in fact a limitation.* (Firm 6 UK)

> *The thing I am noticing is that some vegan consumers ask us if they can eat our eggs and ask about who the producers is/are.* (Retailer 1 ITA)

An additional issue, which has been raised by both egg producers and retailers who participated in this study, is related to the logistics of eggs. Indeed, eggs are an extremely fragile product, which limits the possibility for the industries to expand and reach supermarkets/shops located far from the farms, as well as the chance of expanding their products' portfolio from the retailers' perspective, as noted in the United Kingdom by an industry and a retailer:

> *Sometimes we need to get rid of a line of egg or we cannot include it in our portfolio because the producers are located too far away from us, and the delivery may be too risky.* (Retailer 1 ENG)

For us as business, the main barrier is about delivering the food at the right time in good condition. (Firm 5 ENG)

Theme 3: Introduction of new products

From the interviews with the United Kingdom egg industries and retailers, it emerged that product development is focused on developing new products that are richer in nutrients and, therefore, have improved health appeal (e.g., eggs from chickens fed with algae,[11] etc.):

Then we have a line of eggs whose hens are fed with algae… they have a very high nutritional value. (Firm 6 ENG)

Another theme that emerged was the introduction of new ready-to-eat egg products, which are convenient because they could be easily and quickly cooked to satisfy consumers' demand for simple and quick cooking but are also healthy at the same time. According to two industries, one in the United Kingdom and one in Italy:

We introduced poached egg, which you either know how to do it or not. And even if you do know, you may not have enough time to prepare it. (Firm 1 ENG)

[11] Eggs from hens fed with algae have reduced cholesterol level in the yolk and increased linoleic acid and arachidonic acid levels (Ginzberg et al., 2000).

> *In the last few years, we have introduced about 15 products, all egg-processed, such as ready-made omelettes, crepes, and pancakes. We made them in different versions, five cereals, hemp flour, classic.* (Firm 2 ITA)

Theme 4: Reaction to plant-based eggs

Potential limitations of plant-based eggs

From the interviews conducted in the United Kingdom with egg industries, it emerged that one issue with plant-based eggs is related to its perceived limited healthiness compared to conventional eggs:

> *I think in terms of cholesterol, at least in the UK. According to the British Heart Foundation, eggs would not contribute to cholesterol, so I don't see any benefits in this sense. In terms of being healthier, I very much feel that eating good quality of eggs would be probably healthier than plant-based egg because they are natural.* (Firm 2 ENG)

> *I think that people will continue liking natural products. I believe it is quite unlikely that people will stop using conventional eggs and will just use plant-based egg because it is a processed and artificial food. And it also is not very recommendable for humans' health.* (Firm 7 ENG)

In addition, the predicted high difference in price of plant-based eggs compared to conventional eggs emerged as another potential limitation. An Italian firm asserted:

> *The price. If people are happy with the costing side, then the chances are that it may work, mostly in Western countries in the next ten years; otherwise, it will simply not have any chance to work.* (Firm 6 ITA)

Industries are also sceptical about the actual environmental friendliness of plant-based eggs' production as pointed out by a United Kingdom industry:

> *Until someone comes and says, "This is your footprint for your plant-based egg", I am not going to be able to trust this kind of production.* (Firm 6 ENG)

From the interviews with retailers in the United Kingdom and Italy, it emerged that another limitation of plant-based eggs may be linked to the difficulties of these new products to replicate all eggs' functionalities in cooking (e.g., emulsifying etc.) and whether they have a large number of ingredients. Indeed, consumers have started to read the ingredients list more carefully prior to purchasing food products to infer their naturalness and healthiness: the shorter the ingredients list, the more likely the product will be judged as "natural" and "healthy", sometimes called "clean labels" (Asioli et al., 2017a). These views are captured in the following excerpts from one United Kingdom retailer and one Italian retailer:

Egg is a very flexible product, and it is used in a lot of recipes. So, if the use of the plant-based egg is limited to just a few, for example, I do not think that people will continue buying it and that is because it just does not have all the functionalities they need. (Retailer 4 ITA)

The list of ingredients of the vegan substitutes until now was quite long and this makes the product look less natural. (Retailer 2 ENG)

Positive characteristics of plant-based eggs

With regard to respondents' beliefs about the positive characteristics of plant-based eggs, respondents highlighted the importance of developing an alternative to an important staple food, such as eggs, that is allergen- and cholesterol-free and, therefore, could be a suitable product for vegans, vegetarians, and flexitarian consumers but also to consumers with health-related issues (e.g., allergies, high cholesterol, etc.) as pointed out by two retailers from the United Kingdom and Italy:

I think it can be an option for the flexitarian consumers who are looking for alternative sources of proteins other than meat. (Retailer 3 ITA)

I think, of course, if you are a vegan customer and cannot eat eggs, it gives you the opportunity to kind of enjoy the same

> *thing… But also, another key element is allergens… egg allergy is a real issue. So, I think the great thing about plant-based eggs is when you can make the consumers still enjoy special things like a birthday cake… that is the key.* (Retailer 2 ENG)

Potential market competition between plant-based and conventional eggs

In terms of whether plant-based eggs could be a potential competitor to conventional eggs, respondents argued that due to the fact that plant-based eggs are not yet in the market, it is not possible to compare those products. However, respondents think that consumers will continue to prefer buying natural food, such as conventional eggs, because the plant-based eggs will target consumers that have different needs (e.g., consumers that have allergies to eggs or that are vegans). Therefore, the conventional egg and the plant-based egg are expected to serve different market segments, as mentioned by an Italian firm:

> *I do not think they will necessarily compete. I think there may be two separate markets for them. One for people who have allergies or who are more concerned about the impact that the food they eat has on the environment and one for all the other consumers.* (Firm 4 ITA)

Potential form of sales

Between the different prototypes of plant-based eggs available (liquid, powder, and egg-shaped), respondents identified the liquid version as more suitable because consumers are already familiar with liquid eggs, and they know how to use it, as pointed out by an Italian firm:

> *Liquid, because everyone knows what it is and how to use a liquid egg.* (Firm 4 ITA)

However, in the Italian market, the inability of separating the yolk and the albumen in the liquid version of plant-based egg is foreseen as a possible limitation for this product, as it limits its flexibility and usage, as pointed out by an Italian retailer:

> *Italian consumers, especially women who still prepare handmade pasta or cakes… they may need to separate the yolk from the albumen to make some cakes etc.* (Retailer 3 ITA)

Willingness to introduce plant-based eggs in industries and retailers' portfolios

The egg industries who participated in this study, from both the United Kingdom and Italy, were unwilling to consider introducing plant-based eggs in their portfolio because they see it as an "unnatural" product, and they claimed not to have the right technologies to support this type of business. As two industries indicated:

We only produce and sell what it is naturally produced by our hens.

(Firm 2 ENG)

We would not even have the technologies needed for that.

(Firm 2 ITA)

From the retailers' perspective, buyers from the United Kingdom showed a higher level of interest in plant-based eggs than Italians. Indeed, Italian retailers have noted a drop in the sales of vegan products, and, therefore, they would not be willing to include this new product on their shelves, as pointed out by a retailer:

The sale of the vegan food is dropping down… Therefore, we are not very willing to think about introducing another plant-based product like the vegan egg in this moment. (Retailer 3 ITA)

Study 2 - Results from interviews with researchers and start-up businesses

As for Study One, in order to preserve their anonymity, respondents of Study Two have been renamed numbered in chronological order based on when the interviews were conducted (e.g., Researcher 1, Researcher 2, Start-up 1, Start-up 2 etc.). Table

4 provides an overview of the key themes and outcomes that emerged from Study Two.

Table 4 – Key themes and outcomes emerged from Study Two.

No.	Themes	Outcomes
1	Challenges in product development of plant-based eggs	Replicating all the functionalities and taste of conventional eggs. High costs of the ingredients. Limited capacity of start-up producers to scale the product.
2	Future developments of plant-based eggs	Increasing the flexibility of plant-based eggs. Increasing the palatability of plant-based eggs.
3	Future marketing strategies for plant-based eggs	Positioning plant-based eggs close to conventional eggs in the supermarkets.
4	Potential market competition between plant-based and conventional eggs	Plant-based eggs will directly compete with conventional eggs according to the start-ups.
5	Policy regulations	Policy regulations might limit the possibility of using "eggs" to name the plant-based eggs. The European Union safety authority will have to approve plant-based eggs before they are launched into the market.

Theme 1: Challenges in product development of plant-based eggs

According to the researchers and start-up businesses interviewed, the main challenge about plant-based eggs lies in the difficulties of replicating all the functionalities and taste of conventional eggs. Product development requires significant long-term investments, which not all companies are able to sustain,

particularly small businesses. In addition, given the novelty of the plant-based egg, there are no consumer research studies about their acceptance and the potential market for plant-based eggs, which contributes to creating uncertainties, as pointed out by a start-up business and a researcher:

> *I think of it as a big product development challenge because in order to get all the functionalities of egg with one product… if the research really requires a lot of time, then there is no quick return on investment and most companies are not in the position to do that… I think that there is not the marketing research either to show that the consumers want this product and would go and buy it if it is being produced.* (Researcher 1)

> *The main challenge was to find the right formulation, keep consistency with the taste and the functionality of the egg.* (Start-up 6)

Other challenges that emerged are related to the high costs of the ingredients and the ability of small industries to scale the product, which makes the overall costs to produce plant-based eggs still significantly higher than conventional eggs as indicated by a start-up business:

> *The critical issue in the production and actually the most challenging, I would say is "scale". For the small companies*

> *like us, it is hard to compete in the beginning, purely in the base of price, because you do not have the scale yet.* (Start-up 2)

Theme 2: Future developments of plant-based eggs

Our study revealed a difference of opinions between the start-up businesses who are producing plant-based eggs for food manufacturers and those producing them for consumers. Specifically, the former is interested in increasing the flexibility of their product to make them usable for different types of final purposes (e.g., for baking, scrambled eggs, etc.) whereas the latter aim to continue improving their product in order to meet consumers' expectations and increase the palatability of their plant-based eggs by enhancing the level of taste and texture. The first excerpt below captures the views of the start-up businesses serving the food industry market, whereas the second excerpt reflects the views of the start-ups targeting the consumer market.

> *Our goal is not to produce a single, standalone product, but really to make a much greater impact in B2B suppliers to the industry… for us the bigger damage that we see is food safety. We do want price stability; we want the same product with the same functionalities every single time. All these things are unimaginable in the egg industry today.* (Start-up 2)

> *It must meet the consumers' expectations, as a stand-alone product. It is important that the taste and texture do not go too far from those of a conventional egg.* (Start-up 1)

Theme 3: Future marketing strategies for plant-based eggs

The start-up businesses interviewed that sell plant-based eggs to consumers aim to position plant-based eggs close to conventional eggs in the stores to increase the familiarity of these new products, as pointed out by a start-up business:

> *Potentially, omnivorous consumers may like the plant-based egg more than others, because vegan people, they already do not eat eggs… That is why we want to place the plant-based egg just side-by-side to the conventional eggs in the retailer's shops' shelves. So, when you go to the supermarket you will find the plant-based egg right next to the conventional boxes of eggs so that people can see it and think "why not try this one?"* (Start-up 1)

Theme 4: Potential market competition between plant-based and conventional eggs

In terms of whether plant-based eggs could compete with conventional eggs, it emerged that the main purpose for the development of plant-based eggs was to provide consumers with an alternative to eggs. Thus, they will necessarily compete

with conventional eggs to obtain higher market share, as mentioned by a start-up business:

> *We develop our product to offer an alternative to conventional eggs, so I would say eggs should be our main competitor.* (Start-up 5)

Theme 5: Labelling regulations

The start-up businesses interviewed believe that the new proposal amended by animal food producers, proposing a ban on the use of animal-related foods' names to name plant-based alternatives, will also affect them if it becomes an effective law in the future as stated by a start-up business:

> *I think regulation is a problem for every company in this sector because you have countries like France where they are making it illegal to consider all the vegan protein products to call it like "veggie burgers", "vegan egg", and "vegan milk", and I think that is a risk for every company, including us.* (Start-up 2)

European start-up businesses are using algae and fermentation processes to produce ingredients for plant-based eggs, but these have not been extensively used yet in the European Union market and are being adversely affected by the stipulations of the Novel Food Policy regulation (EU Regulation, 2015). Specifically, start-up

businesses need to wait until they get approval from the European Union in order to market their product, as pointed out by a start-up business:

> *For us, the main challenge is legislation, because we are under the novel food procedure, so we must go through this, and this basically means that we have waiting time for one and a half years. If it was not for this novel food procedure, I would just start preparing and ordering for the factories in three months. We have to wait for a year and a half to get approval from the European Union before marketing our product.* (Start-up 3)

4. Discussion and conclusion

The main goals of this research were to explore the opinions of egg industries and retailers as well as start-up businesses and researchers for conventional and plant-based eggs. Specifically, we had three main objectives.

First, we investigated future trends and barriers in today's egg market and found that there is an increasing supply and demand for eggs produced with higher animal welfare and sustainability standards. These findings are corroborated by Pettersson et al. (2016), who found that consumers from the United Kingdom were willing to pay a premium price for eggs produced in cage-free systems. Regarding the barriers, the increasing competition in the egg industry forces producers to sell their products at lower prices, which affects the capacity particularly of SMEs to be

competitive in the market. In addition, egg industries struggle to provide an alternative to conventional eggs to the growing consumer segments of flexitarians, vegetarians, and vegans (Mintel, 2017), as well as those people suffering from health problems related to egg consumption. Thus, in a saturated eggs market, plant-based eggs may contribute further to market differentiation. Indeed, given the limitations in providing an alternative to conventional eggs to those people who do not want or cannot consume conventional eggs, plant-based eggs may not directly cannibalize the conventional egg market, but instead both conventional and plant-based eggs could coexist together and target different consumer segments. Moreover, the fact that conventional eggs are a fragile product creates difficulties for retailers to expand their offerings to eggs produced by farms that are located far from the point of sales. Also, there is an increasing consumer demand for more nutritious and convenient eggs.

Second, we explored egg practitioners' reactions to plant-based eggs. Relevant differences emerged between egg industries and retailers. The egg industries expect higher costs of production for plant-based eggs compared to conventional eggs, as well as the perceived lower healthiness and naturalness of plant-based eggs to be potential limitations to the development and marketing of these new products. In fact, processed food is often seen as less natural and even harmful to humans' health by consumers (Coppola and Verneau, 2010). This is also in line with the results that emerged in research from Vainio et al. (2016), who found that consumers are still concerned about the perceived lack of naturalness of plant-based meat. However, it

should also be argued that consumers still struggle to define what they perceive as "natural" or "unnatural" when it comes to food (Siipi, 2013). Also, the higher price of plant-based foods compared to conventional animal-based food emerged in the literature as a factor that negatively influences consumers' purchases (Peschel et al., 2019). In this sense, implementing the so-called practice "value-informed pricing", in which consumers help enterprises to settle the price for a new product based on its perceived benefits could help to increase the performance of the plant-based egg, as confirmed by existing literature (Ingenbleek et al., 2010). Furthermore, there is scepticism about the actual environmental friendliness of plant-based eggs. Interestingly, past research revealed that giving consumers evidence of higher sustainability standards of plant-based food compared to animal-based food would positively influence consumers' attitudes towards them (Hoek et al., 2011). Moreover, plant-based egg firms are advised to promote sustainability orientation messages which have been shown to positively affect new product performance (Claudy et al., 2016). In addition, the United Kingdom industries claimed that the cholesterol-free characteristic of plant-based eggs should not be seen as a plus of these products, as the British Heart Foundation has recently shown that the consumption of eggs does not affect the level of cholesterol in a human's body (British Heart Foundation, 2018). However, egg industries' opinions on plant-based eggs can be biased as they may perceive them as potential future competitors for their market. On the contrary, we found that retailers from both the United Kingdom and Italy believed that the plant-based eggs could be a valuable alternative to eggs, although they are sceptical about plant-based eggs' ability to replicate all eggs' functionalities. For example, the impossibility to separate the

yolk and the albumen in the liquid version of plant-based eggs is foreseen as a possible issue for this product, as it limits its flexibility and usage. Past research confirms that the limited cooking versatility of plant-based meats was found to be a limitation for consumers (Jallinoja et al., 2016). In addition, respondents identified the liquid version as the most suitable because consumers are already familiar with liquid egg, and they know how to use it.

Third, we explored challenges in terms of product development, marketing, and policy regulations for plant-based eggs by interviewing start-up businesses and researchers. In terms of R&D and production, the main problem is related to the difficulties for plant-based eggs to replicate the functionalities and taste of conventional eggs, which could limit their appeal as corroborated by (Rondoni et al., 2021b). This finding is corroborated by previous studies on plant-based meat, which revealed that poor taste and texture still act as major barriers for consumers' acceptance for plant-based foods (Cliceri et al., 2018), particularly among people who are not vegan or vegetarian and consume plant-based meat alternatives never or rarely (Hoek et al., 2011). Regarding marketing issues, plant-based egg start-up businesses aim to position plant-based eggs close to conventional eggs' shelves in retail markets, which can be useful to increase familiarity with the new products. Concerning policy regulations, one of the main issues that creates uncertainty is related to how plant-based eggs will be labelled and named. Similar issues have been investigated also in relation to plant-based meat, and it was found that the

name and labelling affect consumers' acceptance of these new products (Carrenõ and Dolle, 2018).

4.1 Implications for policy makers, plant-based egg manufacturers and food services

This study provides several relevant implications and recommendations for producers and policy makers. First, given consumers' concern about animal welfare and sustainability standards in egg production, policy makers should work with producers to better inform consumers about the different types of cage-free eggs, supporting, for example, the adoption of standards and certifications so that consumers can make more informed choices. Similarly, policy makers and egg producers should better advise consumers about the environmental benefits that can be derived from purchasing eggs produced with higher sustainability standards. Also, because of the high price competitiveness, new policies should be developed to regulate pricing standards in the egg market. Second, the production of plant-based eggs needs large investments in terms of R&D and experts in order to develop products that could have nutritional and sensory properties that meet consumers' expectations and needs. In addition, it is very important that plant-based eggs producers identify cheap but appropriate raw materials to produce plant-based eggs, to keep the price low and increase their business competitiveness. Third, with the increasing negative concerns that animal food consumption is raising among consumers, plant-based food companies are advised to carefully decide how to position their products in the market. Indeed, by emphasizing the similarities

between animal foods and plant-based alternatives, they may lose the animal-friendly and sustainability messages, which have been major drivers for the marketing and sales of other plant-based foods (Sexton, 2016). Similarly, plant-based egg producers should be aware that vegetarian and vegan consumers, who are accustomed to plant-based foods, may seek alternatives that do not remind them of animal food tastes and textures, as they have usually developed a strong dislike for animal foods' sensory properties (Fessler et al., 2003). Fourth, given the limited applications of plant-based eggs in cooking compared to conventional eggs, plant-based egg manufacturers are advised to indicate to consumers how to use it, for example, by adding instructions on their packaging explaining which applications plant-based eggs are suitable for and how to prepare them. Fifth, because of the evidence that emerged in past studies about the positive influence that information on higher sustainability standards has on the purchase of plant-based foods (Hoek et al., 2011), policy makers and plant-based egg producers are advised to work closely to provide consumers with information about the sustainability of these new products, using for example, carbon footprint labels. Sixth, policy makers need to regulate plant-based eggs, particularly in terms of labelling policies to clearly define how plant-based eggs should be labelled, for example, if these new products could be called "egg" or not. Eight, the food and catering services will have to adapt to new consumers' demands when the lockdown due to the Covid-19 pandemic is eased. Recent studies show that as consequence of the pandemic, consumers are looking for food products that are richer in nutrients and health benefits, together with higher food safety standards (Butu et al., 2020). In particular, there is a growing demand for plant-based foods which are perceived safer and healthier than

meat products (Datassentail, 2020). In addition, food services are advised to expand their range of options in order to attract consumers and get them used to eat out again. Plant-based eggs have the potential to increase the variety of products offered to consumers if they will be able to replicate all egg's functionalities, given the high flexibility in cooking of the latter.

4.2 Future research directions

Several research avenues emerged from this study. First, there is a need to perform research to test different plant-based raw materials to identify the most suitable ingredients, able to produce plant-based eggs that have good food properties but are, at the same time, of low cost to make them affordable for consumers to purchase. Second, given that the success of plant-based eggs will be determined by consumers' reaction to these new products, research on consumers' acceptance for plant-based eggs should be conducted. For example, consumers' perception for plant-based eggs could be explored using methodologies such as concept mapping, which allow to visualize costumers' associations with these new products graphically (Grebitus and Bruhn, 2008). Furthermore, there is a need to investigate consumers' willingness to pay (WTP) for plant-based eggs, and to explore specific consumer segments, such as vegans, vegetarians, or flexitarians, as possible consumer targets for these new products. It would be also interesting to compare consumers' acceptance of plant-based eggs in both developed and developing countries, given the increasing protein demand in the latter in recent years. In addition, the effect of different communication framings and channels on

consumers' WTP for plant-based eggs could also be explored, in order for plant-based egg companies to develop efficient marketing communications. Consumers' reaction to different names for plant-based eggs that do or do not include the word "egg" are also worth investigated. Last, it would be interesting to conduct sensory tests coupled with real choice experiments or experimental auctions in a real market scenario and using real products (Alfnes and Rickertsen, 2010; Asioli et al., 2020; Lusk and Shogren, 2007) to investigate consumers' WTP for plant-based eggs in more realistic settings.

To conclude, our research identified several critical issues that should be addressed and investigated more in-depth, which have important implications for R&D, production, marketing, and future labelling policies both for plant-based egg producers and policy makers.

Chapter III – **Exploring Consumers' Perceptions of Plant-based Eggs Using Concept Mapping and Semantic Network Analysis**[12]

[12] This article was published in July 2021. Full reference: Rondoni, A., Grebitus, C., Millan, E. & Asioli, D. 2021. "Exploring consumers' perceptions of plant-based eggs using concept mapping and semantic network analysis." Food quality and preference, vol. 94, pp. 104327. DOI: 10.1016/j.foodqual.2021.104327

Abstract

Plant-based eggs offer a healthy, animal-free, and more environmentally sustainable alternative to conventional eggs. Given the novelty of these products, it is vital to understand consumers' perceptions before their market launch. Perception is based on product associations stored in consumers' memory as semantic networks. In this study we used the graphic procedure concept mapping to elicit associations of 180 consumers from the UK and Italy to explore perceptions of three types of plant-based eggs, namely liquid, powder, and egg-shaped. Concept mapping also allowed to investigate the relevance that these associations have for the consumers. Results show more complex associations among participants in the UK than Italy for all three types of plant-based eggs. 'Price' is the most frequently mentioned association by consumers in both countries. In terms of relevance, participants evaluated 'healthy', 'animal welfare' and 'sustainability' as the most important and positive attributes of plant-based eggs. Furthermore, the semantic network analysis showed that the health benefits of plant-based eggs is quickly activated in consumers' mind and should therefore be emphasized when marketing these products. 'Use' of plant-based eggs, e.g., baking, is also a key association, particularly in the UK for the egg-shaped version. However, 'use' was generally lower rated, suggesting that the limited applications of this product (only hard-boiled) may be perceived negatively. These findings provide insights into the psychology of consumers' acceptance of plant-based eggs and have important implications for designing successful marketing strategies for promoting plant-based eggs.

Keywords: Consumers' associations; Concept mapping; Relevance measure; Plant-based food alternative.

1. Introduction

The demand for new non-meat alternatives is on the rise with the market for plant-based animal-product alternatives reaching a value of US $553 million in 2015 (Koba, 2015). Recently, plant-based eggs were developed through a process of isolation or fermentation of plant-based ingredients, such as legumes and cereals (The Good Food Institute, 2018). Plant-based eggs provide an alternative to conventional eggs, whose consumption still causes controversies among consumers for a number of reasons (Rondoni et al., 2020). One is the increasing number of health issues related to egg consumption, such as allergies and high cholesterol (McNamara, 2015; Zhu et al., 2018). Another concern relates to low animal welfare standards in egg production worldwide, which still uses predominantly cage-based systems where hens have limited space to move (Buller and Roe, 2014). With regards to sustainability issues, egg production contributes to 9% of the emissions generated by the total livestock production (FAO, 2016).

Though plant-based eggs have advantages regarding health, animal welfare and sustainability, they need to be accepted by consumers in order to be successful in the marketplace (Rondoni et al., 2021b). Consumers form different attitudes towards a new food depending on the perceptions and associations they develop once introduced to the product (Grunert et al., 2004). Perceptions and associations are based on exposure, attention, processing and storage of information in memory (Olson and Jacoby, 1972). For example, a different colour of plant-based meats compared to conventional meat has been found to increase consumers' scepticism towards taste and texture of the former (Cliceri et al., 2018). Similarly, past negative

experiences with plant-based animal-product alternatives could affect consumers' perceptions of new plant-based alternatives in terms of taste and nutritional values (Weinrich, 2018). Meanwhile, vegetarians and consumers who often eat plant-based animal-product alternatives, appreciate the fact that meat substitutes do not resemble actual meat taste and texture because these individuals have usually developed a strong dislike for the sensory properties of meat (Fessler et al., 2003). Therefore, one can argue that these consumers might have a more positive attitude towards a plant-based egg that is not a full imitation of the conventional egg.

In order to investigate consumers' perceptions of plant-based eggs, associations can be obtained by using elicitation techniques, such as concept mapping (CM) (Grebitus and Bruhn, 2008). Knowing consumers' perceptions and how they might react to a product at the stage of product development and before market introduction is important for food manufacturers (Costa and Jongen, 2006; Lee et al., 2013; Mugge et al., 2018). CM also allows to understand what value they assign to the associations they have stored (Stoyanov et al., 2017). For example, it provides information about whether something is perceived as positive or negative (Peschel et al., 2019). In esscence, CM can reveal consumers' product perception and evaluation to be used by companies to develop educational or promotional campaigns.

Hence, the aim of this study is to investigate consumers' perceptions towards plant-based eggs in the UK and Italy. The two countries were chosen because they are among the largest egg markets in Europe. The UK egg market is worth US $1,01

billion and the country has a total of 39 million commercial egg laying hens (UK Government, 2020a). The Italian egg market is worth US $1,13 billion, and the country is home to 38.9 million egg laying hens housed across 1,800 commercial farms (International Egg Commission, 2015).

In particular, we investigated the following research questions:

(i) What are consumers' associations of plant-based eggs?

(ii) What is the relevance (important/less important, positive/negative) of these associations?

(iii) What are similarities and differences between consumers' perceptions of plant-based eggs in the UK and Italy?

This study contributes to the literature by being the first to apply CM to new food products that are not in the market, yet. We show which associations dominate consumers' perceptions with regards to a new food, such as the plant-based egg, and analyze how these associations are related to each other. In addition, we develop a scale to shed light on the importance of the associations within the semantic network[13]. Finally, this study is the first to apply the CM technique in an online environment.

[13] In this manuscript 'semantic networks' and 'associative networks' are used interchangeably.

The structure of this paper is as follows. The next section describes the theoretical background. Section three explains the methodology applied, followed by section four where the empirical results are presented. The last section discusses the study findings, suggests industry implications, and highlights future research avenues.

2. Theoretical background

Knowledge in memory is organized in so-called cognitive structures (Zinkhan and Braunsberger, 2004). Cognitive structures explain the processing of information and influence cognitive processes including evaluation (Jooyoung and Morris, 2007). From a theoretical perspective, cognitive structures can be seen as a network of associated concepts, such as semantic networks consisting of a number of attributes (Grunert and Grunert, 1995; Lehmann, 1992). Consumers develop semantic networks for the foods they consume (Lehmann, 1992), however they can also develop associations for foods they have not yet consumed, such as plant-based eggs, based on experiences with similar products like eggs and plant-based animal-product alternatives.

The model of the associative network considers knowledge as a structure of lines and nodes, where nodes are units of information/concepts and the lines show relationships among the concepts (Sirsi et al., 1996). For example, there can be a relationship from a product, such as *egg* to *chicken* and *fried or boiled egg*. The lines can also depict how strong the associations between the different concepts are (Collins and Loftus, 1975; Cowley and Mitchell, 2003).

The associations stored in memory assist consumers with information processing and guide their product evaluations and choices (Grunert and Grunert, 1995). Information stored in a semantic network is retrieved by activation that spreads from concepts (associations) in working memory based on the spreading activation network theory (Collins and Loftus, 1975). The activation flows from the association (node) that is activated first through all directly related concepts (Cowley and Mitchell, 2003; Martin, 1985). Depending on how strong the activation is, it flows from node to node in a network, activating the whole knowledge domain. When associations are linked directly to each other, the information retrieval from memory is the fastest (Henderson et al., 1998). Only activated information can be included in the decision making process (Alba and Hasher, 1983).

Associative networks have been investigated by previous research related to the fields of marketing, food science, and agribusiness (French & Smith, 2013; Ilicic & Webster, 2015; Grebitus *et al.*, 2020; Seitz and Roosen, 2015; Peschel *et al.*, 2019). Findings from these studies showed that associative networks provide valuable information about physical product attributes and benefits, as well as, information on associations that are in the center or periphery of a person's cognitive structures (Zinkhan and Braunsberger, 2004). When these associations are uncovered they can provide a host of information about perception and evaluation related to the product which can then be used by companies, for example, to develop educational or promotional campaigns.

3. Methodology

3.1 Concept mapping

A method to represent product associations (e.g., semantic networks) graphically is CM. CM is a graphing technique where participants freely write down all associations they think of with regards to a stimulus, in this study the different types of plant-based eggs (Hay et al., 2008; Rye and Rubba, 1998). The CM technique activates cognitive structures and allows to access both, the content and the organization of the structures. CM usually starts with a key concept, in our case 'plant-based egg', followed by more concepts/associations that can be related to the key concept and/or to each other (Jonassen and Marra, 1994). Participants are recalling associations and link them to each other as they see fit (McLinden, 2013). Thus, the maps depict the web of knowledge of an individual stored in memory (Nesbit et al., 2016). CM was originally developed in the field of learning and education (Hay et al., 2008), and was adapted for application in food and agricultural marketing by Grebitus (2008). Since then it has been applied for a number of studies on food product perception, for example by Hasimu, Marchesini, & Canavari (2017), Peschel et al. (2019) and Seitz & Roosen (2015). Findings from these studies provide evidence that semantic networks entail information about physical product attributes and benefits, as well as, information on which associations are in the center or periphery of the network.

3.2 Study products

In this study, we applied CM to identify and visualize the semantic networks of associations for three types of plant-based egg, namely the liquid, powder, and egg-shaped plant-based egg (The Good Food Institute, 2018). The liquid version of plant-based egg is packaged in a bottle and is made by isolating the protein contained in vegetable sources, such as mung beans and pumpkin seeds by companies like JUST Ltd. and Spero Food ltd. These products are already available in the US market (James, 2019). The plant-based egg powder is developed by fermenting microbes, such as yeast or algae by the US company Clara food and the Netherland's FUMI Ingredients (Geng et al., 2011). This type is not yet available for consumers. Last, the egg-shaped plant-based egg tries to replicate all the physical components of chicken eggs e.g., albumen, yolk and egg-shell, and is created by extracting the protein from soya, green peas, etc. (The Good Food Institute, 2018). An example is the plant-based egg from the University of Udine, Italy (Askew, 2017). Like the plant-based egg powder, the egg-shaped alternative is not available in the market place, yet.

3.3 Design of the study

The CM task was completed during the first part of a broader study conducted in Summer 2020, aimed at investigating UK and Italian consumers' perceptions, preferences, and expectations for plant-based eggs. The total sample was composed of 180 individuals, 90 from the UK and 90 from Italy. Each of the two samples was divided in three sub-groups of 30 consumers in each country. The first group was presented with the egg-shaped version of the plant-based egg, the second with the

liquid, and the third with the powder as the key concept of the concept map. In order to construct the concept maps, participants first watched a brief video developed by the researchers for each plant-based egg type. The videos were about 1:20 minutes long and described the characteristics of plant-based egg, covering information about method of production, ingredients, and cooking applications. The transcripts of the videos and the videos are available in Appendices A and B, respectively. To limit bias, we restricted the information provided to the essential characteristics of these products. The text was brief and neutral using lay language. However, we acknowledge that some of the associations might be a result of learning from the video. Nonetheless, new products are always introduced to consumers when they are launched into the market and thus, the videos were used to reflect this. In fact, exploring associations for plant-based eggs without giving participants any information on the products would lead to unrealistic data as it is unlikely that consumers are exposed to any new product without first being introduced to it. Additionally, it is not unusual that consumers are given some information before developing their concept maps, as a means to stimulate their perceptions. For example, Grebitus & Bruhn (2008) provided their participants with eight "pre-determined concepts" derived from the literature before participants started creating their concept maps. Furthermore, our main interest was in the relationships among associations, which are independent from the video. The videos' scripts were drafted in English first and were translated to Italian for the data collection in Italy. The Italian scripts were then back translated into English to assure correct translation. Translation was performed by two members of the research team who are native Italian speakers. The videos had subtitles, where the UK participants

watched the videos with the English subtitles and the Italian participants with the Italian subtitles. The videos, together with the whole study protocol, were pre-tested with UK and Italian participants to ensure equivalence and consistency between the two groups.

After watching the video participants were asked to write down the key concept of the study in the centre of a sheet of paper, namely "plant-based egg". Then, following Grebitus *et al.* (2020), participants were asked to write down anything that comes to their mind in relation to the product they watched in the video. Next, they had to indicate which of the associations were positive with a (+) and which were negative with a (-). Participants were also asked to write (!!) close to the associations that they believed were important to them and (X) close to those concepts that they considered to be less important. Symbols could be used together (e.g., +!!), or not used at all in case none of them were applicable. Using indications of positive/negative is similar to Peschel et al. (2019) and Grebitus et al. (2020). These measures provide recommendations specifically for designing marketing activities. For instance, an association might be positive but not relevant for a consumer. Hence, marketing activities should rather focus on associations that are both, positive and relevant. Conversely, relevant but negative associations could be counteracted.

Due to the Covid-19 pandemic, the study was conducted on the online platform Zoom. Informed consent was obtained from all study participants and the study was approved by a University Ethics committee.

3.4 Sample characteristics

Participants were recruited using a consumer online database (https://www.respondent.io/). Participation was limited to UK and Italian citizens, aged 18 and above, who were responsible for household grocery shopping. Information on education, income, and egg consumption was collected. A sample size of 90 participants in each country was obtained for a total of N=180. The socio-demographic characteristics of the two samples are presented in Table C.1 in Appendix C. The results show that the hypothesis of equality of means between socio-demographic characteristics across the two countries is not rejected at the 5% significance level for gender and age, while the UK participants were more educated, had a higher income and consumed more eggs than Italians.

3.5 Data analysis

3.5.1 Content analysis

Content analysis can be defined as a formal system for drawing conclusions from observations of content (Y. H. Chang et al., 2010). It refers to the conceptual meaning contained in associations (Martin, 1985) and is systematic and objective because the categories are set up in a way that all relevant content is analysed using the same procedure (Neuendorf, 2002). Content analysis is described as quantitative because it records numerical values or frequencies with which the various defined types of content occur (Krippendorff, 2004). The actual analysis of the content lies in its classification by means of a category system. This is useful to investigate the associations within a certain context. Therefore, the elicited associative networks,

e.g., the concepts written down by the interviewees are summed up, structured and put into categories (Krippendorff, 2004). To create a set of categories it is necessary that the categories are pertinent to the objectives of the study, functional and manageable (Peschel et al., 2019). Categories have to be mutually exclusive, exhaustive and reliable in that a unit of analysis can only be placed in one category and every unit of analysis should be able to be placed into an existing category (Krippendorff, 2004). Once the coding approach is completed, the frequency of occurrence of the associations is calculated. In our study, the human code resulted in 12 themes and 45 codes (see Table 1). The categorization into different themes was done following previous studies. “Environment” for example also appears in Hasimu et al. (2017) and Peschel et al. (2019) to categorize associations like “pollution”, “environmentally friendly” etc. Similarly, “taste” and “price” emerge in Grebitus & Bruhn (2008).

Table 1. Overview of associative themes

THEMES	CODES
Price	Price Price point Expensive Costs Affordable
Sustainability	Sustainable Environmentally friendly Eco-sustainable Good for the environment Good for the planet
Taste	Good taste Taste should be similar to eggs Sceptical on the taste
Animal welfare	Animal-friendly Animal-free No battery farms No intensive farming

	Cruelty-free Less animal exploitation Respect the animals
Healthy	Health Health benefits Healthier than eggs
Use	Baking Cooking Limited Limited uses Limited applications Limited versatility
Shelf-life	Expiry date Durability How long it lasts Longer shelf-life than eggs
Allergen-free	No allergies Intolerances Allergic reactions Anti-allergen
Nutritional values	Nutritional Nutritional properties Calories
Protein	Proteins More proteins No protein
Vegan	Vegan
Texture	Texture

3.5.2 Relevance of associations

The impact of the association on perception is determined by calculating the average relevance of each category of associations. This is obtained by attaching a different value to each symbol that is assigned by the participants. These values provide information on which associations would be meaningful to use for target-oriented marketing activities. For instance, associations with higher overall values would have the strongest and most positive effect on a favourable perception of a product. The more relevant and positive an association, the more relevant and

positively perceived is the product which ultimately leads to a purchase decision. In this study, we developed relevance measures ranging from 1 to 9.

3.5.3 Network analysis

The relations, positions and importance of the associations within the semantic network elicited with CM can be measured using network analysis (Grebitus, 2008). This unveils those concepts which are particularly influential in spreading information within the semantic network (Henderson et al., 1998). The impact of single attributes is examined by means of centrality measurements. The three most common indices of centrality are degree, closeness, and betweenness centrality as decribed below.

Degree centrality (C_D) of a node, p_d, is defined as the number of other points (p_e) that have a direct relation to that node, p_d (Freeman, 1978). C_D for a node p_d is obtanied as:

$$C_D(p_d) = \sum_{e=1}^{t} a(p_e, p_d) \text{ for } e \neq d \qquad (1)$$

where t = the number of nodes in the network and a (p_e, p_d) = 1 if and only if p_e and p_d are connected by a line, 0 otherwise.

Closeness centrality (C_C) is about the distance of a concept to all others (Henderson et al., 1998). It focuses on the shortest path, the so-called geodesic, between two associations (Knoke, D., & Kuklinski, 1982). Note, that in some networks there might be more than one geodesic path between two nodes, i.e., more than one path between the two nodes that are equally short in distance. The difference between

degree and closeness centrality is that the former takes only the direct relations of a concept into account, whereas the latter also accounts for indirect relationships (Henderson et al., 1998). The higher the closeness centrality the quicker the nodes will activate the others within the same network (Grebitus and Bruhn, 2008). C_C for a node p_d is defined as:

$$C_C(p_d) = \left[\sum_{e=1}^{t} r(p_e, p_d) \right]^{-1} \text{ for } e \neq d \quad (2)$$

where $r(p_e, p_d)$ is the number of lines linking nodes *e* and *d* (the geodesic, i.e. shortest path).

Betweenness centrality (C_B) represents the probability that p_f falls on a randomly selected geodesic connecting *e* and *d* (Freeman, 1978). C_B is defined as:

$$C_B(p_f) = \sum_{e}^{t} \sum_{d}^{s} b_{ed}(p_f) \quad (3)$$

for all $(e < d) \neq f$, and where $b_{ed}(p_f) = \frac{g_{ed}(p_f)}{g_{ed}}$ g_{ed} represents the number of geodesic paths from point *e* to point *d* that contain p_f. A node with a high betweenness centrality falls on several geodesics, and therefore is responsible for the activation from one node to another. The UCInet 6.0 software for network analysis was employed to create individual networks, as well as, to calculate centrality measures (Borgatti, Everett, & Freeman, 2002).

4. Empirical Results

4.1 Perception and evaluation of plant-based eggs

As a first step in the data analysis, we counted the number of consumers' associations with the three types of plant-based eggs from the UK and Italy. Results from the descriptive analysis (counting) are reported in Table 2. They show that the semantic networks from participants in the UK entail a higher number of associations (595, 519 and 522) compared to Italian participants' networks (366, 275 and 322) for the three products, egg-shaped, liquid and powder, respectively. In particular, the egg-shaped plant-based egg was the one with the highest number of associations in both countries, whereas the liquid one had the lowest. When comparing the number of associations for each type of plant-based egg between the two countries, we found that they are significantly different from each other at 1% level (p-value<.001). This means that the number of words is dependent on participants' origin (UK or Italian). Also, when comparing the number of associations for each prototype of plant-based eggs in each country we found that there were statistically significant differences for the UK groups at 5% level (p-value=.04), and statistically significant differences for Italy at 10% level (p-value=.06). This means that in both countries the number of associations varies by type of plant-based eggs.

Table 2. Descriptive statistics of the number of associations with plant-based eggs

PLANT-BASED EGG TYPE	EGG-SHAPED			LIQUID			POWDER			P-value between plant-based eggs within each country (UK and IT)
Country	**UK**	**IT**	**P-value**	**UK**	**IT**	**P-value**	**UK**	**IT**	**P-value**	
Min	8	6		7	4		7	6		p-value between UK groups = .04
Max	44	27	<.001	34	15	<.001	41	20	<.001	
Sum	595	366		519	275		522	322		p-value between IT groups = .06
Mean	19.56	12.03		17.13	9.9		17.21	10.76		
Standard deviation	5.37	8.94		2.84	7.15		3.53	8.00		

Note: Min and Max represent the minimum and maximum number of associations emerged from each country. Sum. is the total number of associations. UK= United Kingdom; IT= Italy. The p-values under the "egg-shaped", "liquid" and "powder" columns reports the statistical significance between the values emerged from the two countries (UK and Italy) for the same type of plant-based product (egg-shaped, liquid and powder). The last column on the right reports the statistical significance between the two countries regardless of the plant-based egg type. A Mann-Whitney test was employed to calculate statistical significance.

Then, we counted how often the respective associations were mentioned by participants applying frequency analysis to our content analysis (see Table 4 below, Frequency columns). Results show that in the UK, 'price' was the most frequently mentioned attribute across the three types of plant-based eggs, followed by 'sustainability'. 'Healthy' ranked third for egg-shaped (67%), while 'taste' ranked third for the liquid (60%) and powder (69%) plant-based eggs. In Italy, 'price' was

the most frequently mentioned association for the egg-shaped (90%) and powder (83%) plant-based eggs, whereas ‘use’ was the most frequent association for liquid plant-based egg (57%). Still in the Italian networks, ‘sustainability’ was mentioned frequently for all plant-based eggs, followed by ‘taste’. ‘Animal welfare’ was also frequently mentioned for egg-shaped (43%) and powder (40%) prototypes, and so was ‘protein’ (43%) for the powder plant-based egg. However, ‘protein’ did not appear among the most frequent associations in the UK for any of the alternatives. Interestingly, ‘vegan’ was not even on the list of the top associations in the Italian data, whereas it was more frequently reported than ‘healthy’ in the UK for the powder plant-based egg. ‘Allergen-free’ emerged more often from the Italian semantic networks, particularly for liquid and powder plant-based eggs.

Next, we accounted for the perceived relevance of different types of plant-based egg, e.g., the calculations based on evaluation (positive or negative) and importance (important, and less important, neutral), and their respective combinations (e.g., +!!, -!!, etc.). We used an exploratory approach to develop the relevance measures shown in Table 3, which means we investigated the data that emerged from our study to attach the most appropriate value to the associations.

Table 3. Overview of symbols and corresponding values

Symbol	**-!!**	**-**	**-X**	**X**	**Null**	**+X**	**+**	**!!**	**+!!**
Value	1	2	3	4	5	6	7	8	9

Note: The symbols are aligned from the least valuable on the left (-!!) to the most (+!!) on the right.

As “price” was the most frequently mentioned association, we took “price” as our reference point for developing the scale in Table 3. Past literature widely shows that “price” is one of the most relevant factors for consumers when making their purchases (Albari and Safitri, 2018; Font-i-Furnols and Guerrero, 2014; Huang, 2013; Lusk and Briggeman, 2009; Verbeke et al., 2015b). In most of the concept maps, the participants attributed the value “-!!” to “price”. This means that, for them “price” is an important attribute, but one that has a negative value. The concept maps indicate that this is because consumers expect plant-based eggs to be priced higher than conventional eggs. The higher price is something that would most likely discourage them to choose plant-based eggs over conventional eggs. Therefore, we assign the lowest value on the scale to “-!!” (-!!=1) because something that is important, but negative is not as relevant in terms of purchase consideration. On the other hand, the consumer decision-making literature shows that attributes consumers perceive to be important most likely lead to purchase considerations (Grunert, 2002; Olsen et al., 2017). Hence, we infer that the positive sign “+” next to “!!” leads to more relevance for an attribute compared to “!!” only. This is in line with our findings showing that the association “health” was frequently given both important and positive values (indicated with +!!=9). This evaluation means that the health benefits of plant-based eggs were the most relevant to consumers and therefore would likely motivate positively their behaviour. Consequently, “important” associations (!!) were given a higher value (=8) than the “positive” associations (=7). The positive and less important associations (+X) were still given a higher value (=6) than the negative (-) or the less important associations (X), because the + symbol still indicates a positive meaning. To decide on the values of

the negative associations (-), and the negative and less important associations (-X), we referred to our results and saw that that the limitations in cooking of plant-based eggs were often given a negative value, as the limited flexibility of these products compared to conventional eggs emerged as a relevant downside. On the other hand, negative and less important factors like “fake eggs”, “sounds weird”, “unusual”, were indicated as negative and less important, meaning that they have a lower relevance for consumers than the negative associations. Thus, we gave a lower value (2) to the negative associations (-) and a slightly higher value (3) to the negative and less important associations (-X).

Once we developed the relevance scale in Table 3, we analysed whether the concepts written down were positive or negative, and important or unimportant for participants. In terms of average relevance (see Table 4, ‘Average value’ column), ‘sustainability’ scored highest in both countries for all types of plant-based egg, besides the case of ‘healthy’ for UK consumers for powder plant-based egg. ‘Healthy’ scored highest in the UK for the powder plant-based egg, followed by ‘shelf-life’ and ‘animal welfare’. ‘Animal welfare’ scored higher than ‘taste’ for all prototypes in Italy, meaning that ‘taste’ is negatively perceived, whereas the absence of hens in the plant-based egg production and its higher animal welfare standards compared to conventional egg production, was positively perceived. ‘Allergen-free’ scored particularly high in the Italian semantic networks. ‘Price’, scored the lowest for Italians with the egg-shaped and powder plant-based eggs, meaning that participants associated it mainly with negative values. ‘Use’, however,

has the lowest value for the UK for the egg-shaped plant-based egg, suggesting that the limited flexibility of this product is perceived negatively. We also compared the number of associations that both countries have in common with the Mann Whitey test. Results show the following: 'price' p-value=.19, 'taste' p-value=.10, 'animal welfare' p-value=.07, 'use' p-value=.82, 'sustainability' p-value=.04, and 'healthy' p-value=.04. Hence, some associations are mentioned similarly frequently (use-related and price-related concepts) but others are mentioned more or less often in the respective countries (e.g., animal-welfare and health-related concepts). Nevertheless, several p-values are borderline, suggesting that there might be some dependency, e.g., for taste-related concepts. An overview of the most frequently mentioned concepts related to plant-based eggs (merging together all three prototypes in the analysis) and their relevance are reported in Table D.1 in Appendix D.

Table 4. Most frequent associations with plant-based eggs and respective relevance

		Frequency in absolute number		**Frequency in %**		**Average value of relevance**		**P-value between countries (UK and IT)**
Themes	**Plant-based egg type**	**UK**	**IT**	**UK**	**IT**	**UK**	**IT**	
Price	Egg-shaped	27	25	90%	83%	3.8	2.8	
	Liquid	25	22	83%	33%	2.9	2.8	p = .19
	Powder	25	25	83%	83%	3	1.9	

Sustainability	Egg-shaped	20	16	67%	53%	6.6	9	
	Liquid	21	16	70%	53%	8	8.2	$p = .04$
	Powder	23	15	80%	50%	7.7	8.2	
Taste	Egg-shaped	16	16	53%	50%	5.3	7.3	
	Liquid	20	15	60%	50%	6.7	5.3	$p = .10$
	Powder	16	12	60%	40%	5.2	7.1	
Animal welfare	Egg-shaped	18	13	60%	43%	6	8.5	
	Liquid	15	10	50%	33%	6.6	8.4	$p = .07$
	Powder	13	12	43%	40%	6.8	7.2	
Healthy	Egg-shaped	20	9	67%	30%	6.6	8.8	
	Liquid	17	7	57%	23%	8.1	9	$p = .04$
	Powder	17	8	57%	27%	8.2	8.7	
Use	Egg-shaped	6	17	20%	57%	2.5	2.7	
	Liquid	18	17	60%	57%	6.9	3.8	$p = .82$
	Powder	11	9	37%	30%	5.4	2.5	
Protein	Egg-shaped	-	10	-	33%	-	6.4	
	Liquid	-	6	-	20%	-	7.9	-
	Powder	-	14	-	43%	-	5.7	
Shelf-life	Egg-shaped	9	-	30%	-	3	-	
	Liquid	18	10	50%	33%	5.6	6.0	-
	Powder	14	12	47%	40%	21.0	7.3	

Allergen-free	Egg-shaped	-	-	-	-	-	-	
	Liquid	-	5	-	17%	-	2.8	-
	Powder	12	9	40%	30%	4.7	8.3	
Nutritional values	Egg-shaped	-	7	-	23%	-	7.2	
	Liquid	-	-	-	-	-	-	-
	Powder	-	-	-	-	-	-	
Vegan	Egg-shaped	7	-	23%	-	3.5	-	
	Liquid	-	-	-	-	-	-	-
	Powder	18	-	60%	-	5.3	-	
Texture	Egg-shaped	-	-	-	-	-	-	
	Liquid	6	-	20%	-	6.8	-	-
	Powder	-	-	-	-	-	-	

Note: The frequency indicates the number of times an association emerged from each country. The average value of relevance indicates the relevance assigned by participants to each association and it is calculated using the relevance scale developed for this study in Table 3. Statistical significance between countries for the common associations has also been calculated, merging the relevance values for the three plant-based eggs. A Mann-Whitney test was employed to calculate statistical significance.

Table 5 provides an overview of the descriptive statistics regarding the relevance assigned by participants to the associations in the concept maps. Overall, the egg-shaped and the powder plant-based eggs have the highest number of positive attributes in the UK and Italy, respectively. The egg-shaped plant-based egg also had the highest number of positive and important associations in the UK networks, whereas the liquid had the highest number in Italy. The powder and egg-shaped

plant-based eggs attributed to the highest numbers of negative associations for the UK and Italy, respectively. We calculated significance between countries for each symbol using the Mann Whitney test and found no significant differences (p-values>.05) except for "-!!" associations (p-value=.04). Hence the number of symbols is not dependent on the participant's origin (UK or Italian).

Table 5. Relevance of associations with plant-based eggs

Values	Plant-based egg type	Frequency		%		P-values between countries (UK and IT)
		UK	IT	UK	IT	
Positive associations (+)	Egg-shaped	64	55	10.75%	15.02%	
	Liquid	49	24	9.44%	8.72%	p = .82
	Powder	61	68	11.68%	21.11%	
Negative associations (-)	Egg-shaped	35	27	5.88%	7.37%	
	Liquid	35	7	6.74%	2.54%	p = .46
	Powder	40	24	7.66%	7.45%	
Important associations (!!)	Egg-shaped	36	33	6.05%	9.01%	
	Liquid	44	10	8.47%	3.63%	p = .05
	Powder	45	23	8.62%	7.14%	
Less important associations (X)	Egg-shaped	20	28	3.36%	7.65%	
	Liquid	16	6	3.08%	2.18%	p = .27
	Powder	38	7	7.27%	2.17%	
Positive/Important associations (+!!)	Egg-shaped	149	91	24.53%	24.86%	
	Liquid	115	118	22.15%	42.90%	p = .27
	Powder	108	104	20.68%	32.29%	
Positive/Less important associations (+X)	Egg-shaped	50	26	8.40%	7.10%	
	Liquid	52	12	10.01%	4.36%	p = .05
	Powder	33	22	6.32%	6.83%	
	Egg-shaped	40	47	6.72%	12.84	

Negative/Important associations (-!!)	Liquid	84	47	16.18%	17.09%	$p = .04$
	Powder	38	51	7.27%	15.83%	
Negative/Less important associations (-X)	Egg-shaped	34	13	5.71%	3.55%	
	Liquid	40	24	7.70%	8.72%	$p = .50$
	Powder	31	13	5.93%	4.03%	
Neutral associations	Egg-shaped	166	44	27.89%	12.02%	
	Liquid	83	27	15.99%	9.81%	$p = .05$
	Powder	95	10	18.19%	3.10%	

Note: The frequency indicates the number of times an association was assigned a given value (e.g., positive, negative, important etc.). Statistical significance between countries for each merged value merged has also been calculated employing Mann-Whitney test.

4.2 Associative networks for different types of plant-based eggs

4.2.1 Relationships between associations

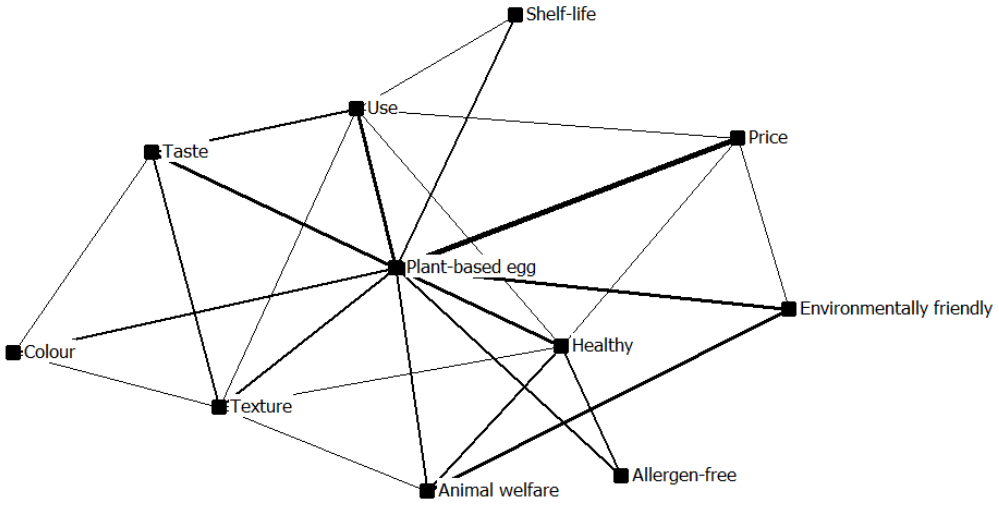
After determining the most frequent associations and their relevance in participants' concept maps, we analysed the structure of the semantic networks. The larger the number of concepts that are activated, the higher is the dimensionality of the cognitive structure. Participants with more complex knowledge structures are likely to use more concepts when building their concept map (McLinden, 2013). As shown by the content analysis, the semantic networks from the UK participants are more complex than those from Italians for all three prototypes of plant-based egg. In order to investigate the concept maps, we constructed matrixes between the most frequently mentioned attributes showing the relation in percent between the Top-10 associations for each type of plant-based egg, egg-shaped, liquid and powder, for each country (see Appendix E). For instance, 'price' was mentioned most often, hence 'price' was included in the matrix, and relationships between price and plant-

based egg, as well as, between price and other attributes were indicated as a percentage share.

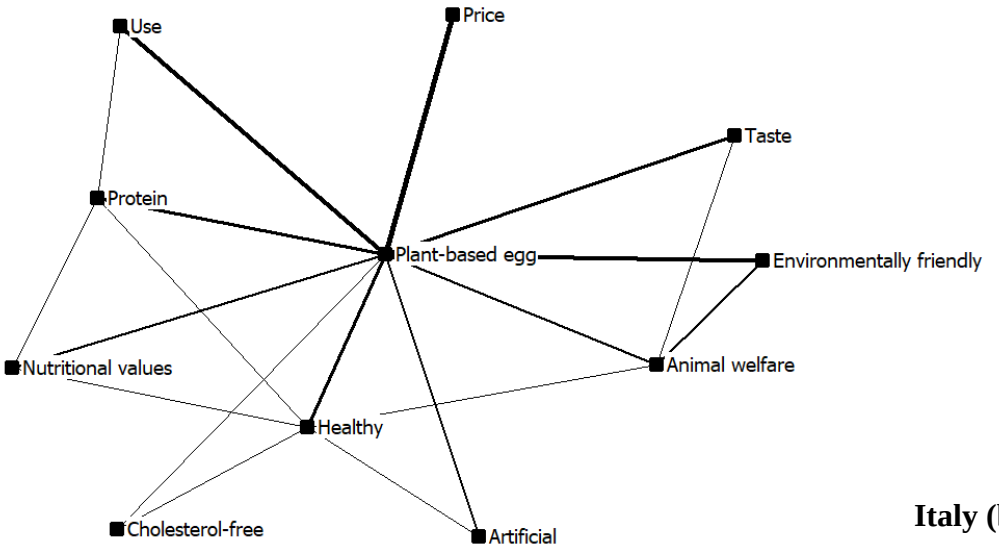
Particularly, Table E.5 and table E.6 in Appendix E indicate strong connections among all concepts in the 'plant-based egg' networks. 'Price' is the most strongly connected association with 'plant-based egg', confirming that it is the first association being activated when thinking about plant-based egg. 'Price' is followed by 'healthy' in the UK and by 'use' in Italy, confirming the importance of 'use' that was already displayed in the content analysis. Still, among Italians, 'sustainability' is often connected with 'animal welfare,' and 'healthy' is often linked with 'protein' and 'cholesterol-free'. 'Price,' 'healthy' and 'sustainability' appear most often, and 'shelf-life' emerged as strongly connected with 'price', 'sustainability', and 'use' leading to rapid activation. 'Sustainability' was often linked to 'animal welfare'. Associations related to the 'use' of plant-based eggs were often connected to different sub-associations, such as, fried eggs and omelettes, which were mainly linked to the different cooking applications. Associations, such as, 'allergen-free' and 'cholesterol-free' are less frequently linked to strong concepts, such as, 'price' and 'sustainability'.

Figures 1, 2 and 3 are graphic representations of the top-10 associations for plant-based eggs by country. These figures provide insights on participants' perceptions of the individual products and highlight differences by country. While 'price', 'healthy' and 'environmentally friendly' appeared in all maps in both countries, other associations, such as 'protein' and 'cholesterol-free' only appeared in the Italian maps. The association 'use', which emerged from both UK and Italian

concept maps, is linked to a number of associations for UK consumers, such as ‘taste’, ‘texture’, ‘healthy’, and ‘shelf-life’, whereas it is mainly linked to ‘shelf-life’ in the Italian networks.



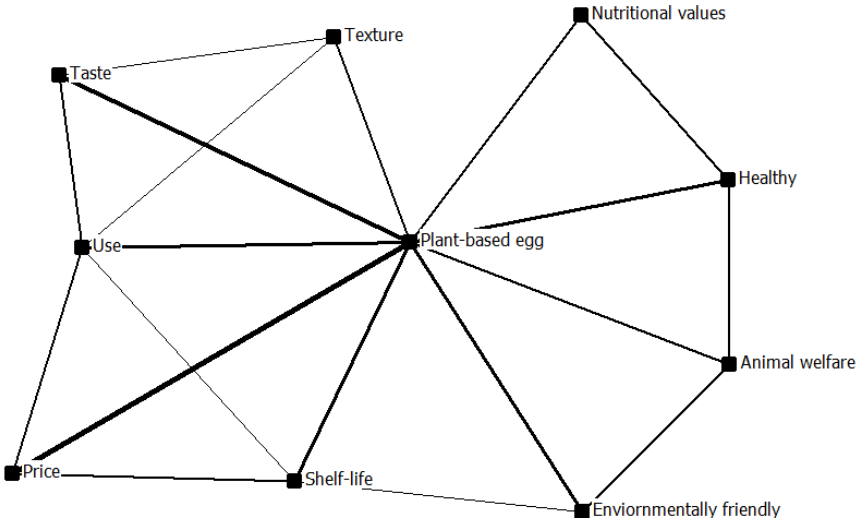
UK (a)



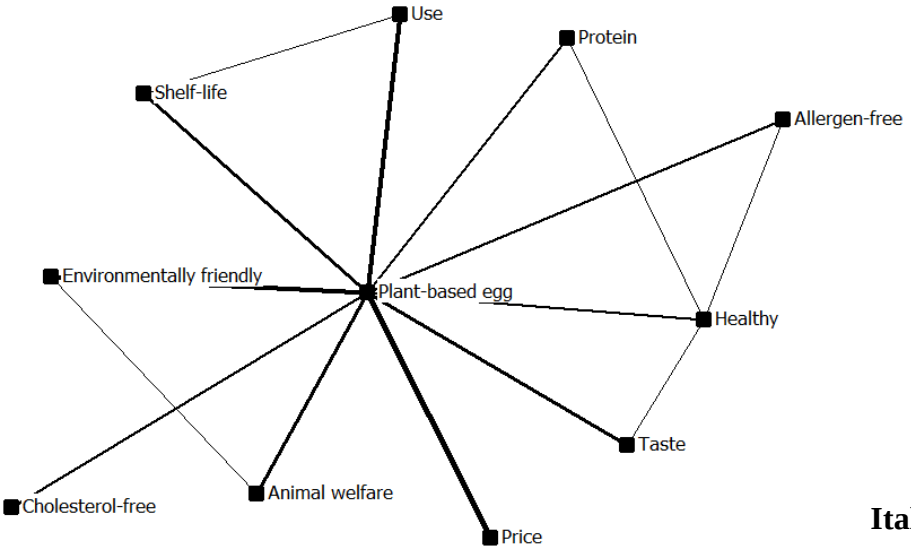
Italy (b)

Fig. 1 – Network of the Top-10 associations of UK (a) and Italian (b) consumers for the egg-shaped plant-based egg.

Note: Created with UCInet 6.0 software (Borgatti, Everett, & Freeman, 2002). Thickness of lines represent the frequency of the associations.



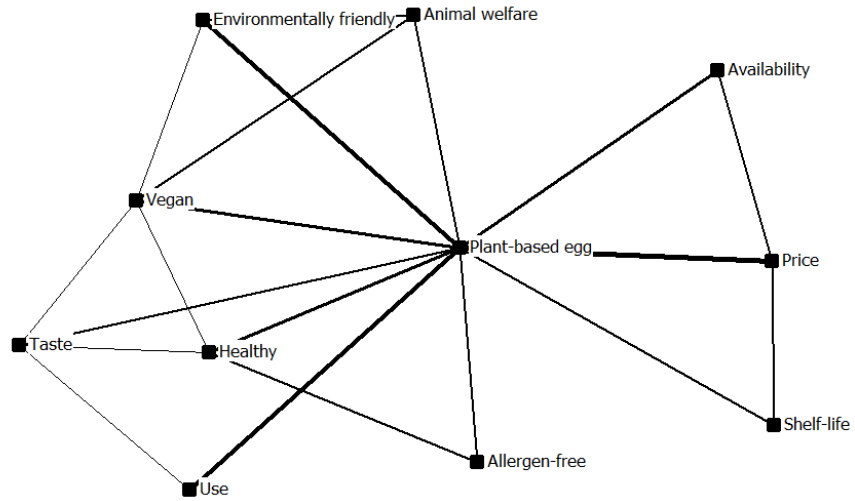
UK (a)



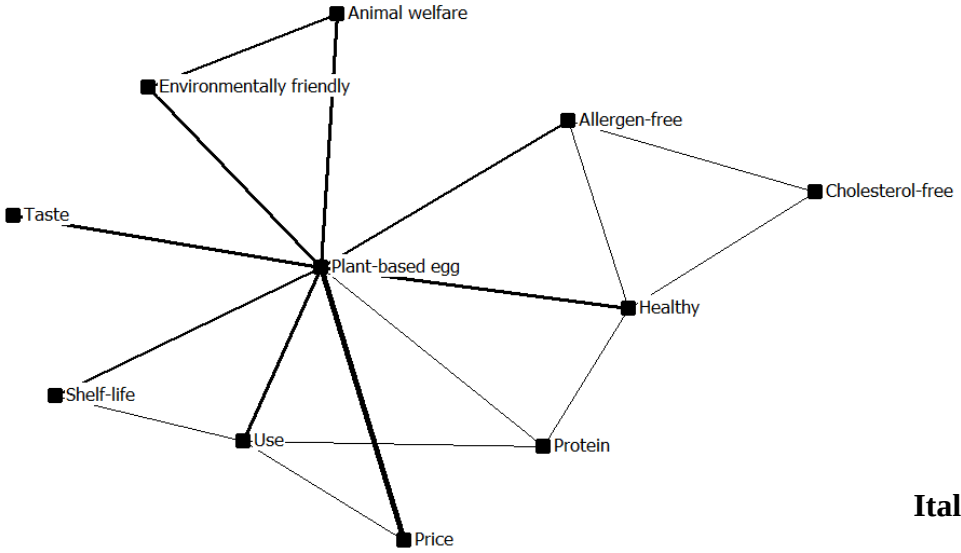
Italy (b)

Fig. 2 – Network of the Top-10 associations of UK (a) and Italian (b) consumers for the liquid plant-based egg.

Note: Created with UCInet 6.0 software (Borgatti, Everett, & Freeman, 2002). Thickness of lines represent the frequency of the associations.



UK (a)



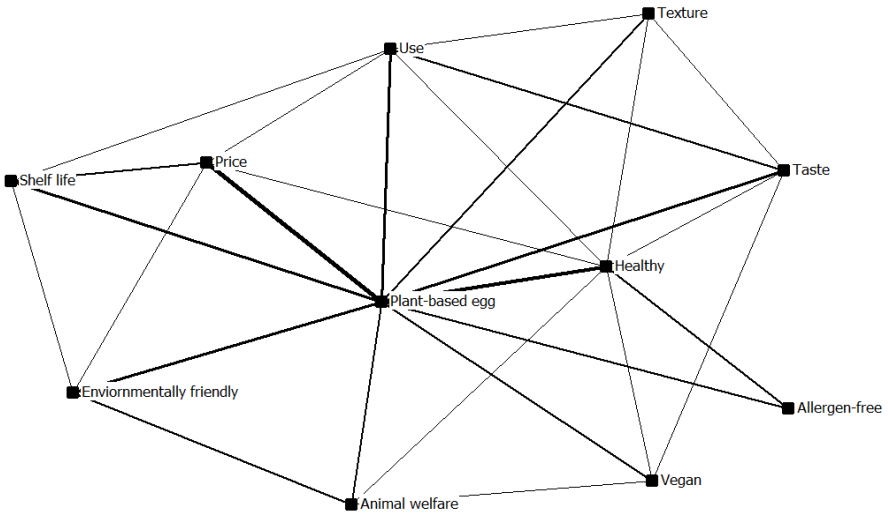
Italy (b)

Fig. 3 - Network of the Top-10 associations of UK (a) and Italian (b) consumers for the powder plant-based egg.

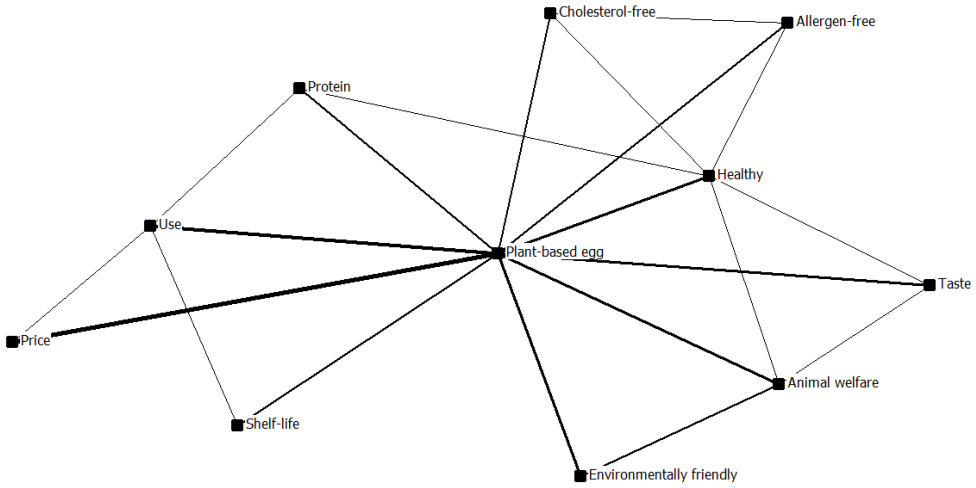
Note: Created with UCInet 6.0 software (Borgatti, Everett, & Freeman, 2002). Thickness of lines represent the frequency of the associations.

Figure 4 shows the graphic representation of the associations between the top-10 most frequently mentioned networks from the UK and Italy. This aggregated map

provides insights into consumers' perceptions of the overall concept, the plant-based eggs. The strength of relationships is shown by the thickness of the lines, the thicker the line, the stronger the association. The figures show strong links between plant-based egg and 'price,' 'taste', 'use' and 'sustainability' in both countries. Interestingly, 'allergen-free' has a rather strong connection with all plant-based eggs for consumers in the UK but not so for Italian consumers. In Appendix F we report a graphic representation of the Top-10 associations with aggregated results from all plant-based eggs from both countries.



UK (a)



Italy (b)

Fig. 4 - Network of the Top-10 associations of UK (a) and Italian (b) consumers for all prototypes of plant-based eggs

Note: Created with UCInet 6.0 software (Borgatti, Everett, & Freeman, 2002). Thickness of lines represent the frequency of the associations.

4.2.2 Centrality measurements

To measure the importance of associations within a semantic network we calculate centrality measures (degree, closeness, and betweenness). As reported in Tables 6-8, in both countries, 'price' has the highest degree centrality for all prototypes of plant-based eggs. This suggests that 'price' is the first association being activated by consumers from both countries, except for the egg-shaped plant-based egg for the UK participants, where 'taste' is activated before 'price.' This means that information on 'taste' should be provided for this group of consumers in order to activate other associations.

In terms of closeness centrality, in the networks from the UK participants, 'healthy' and 'use' scored high for the egg-shaped plant-based egg, 'healthy' and 'taste' for the liquid product, and just 'healthy' for the powder plant-based egg. This suggests that the association 'healthy' will be activated regardless of the type of plant-based egg, and that it has a strong capacity of activating other associations, which is important when it comes to communication and promotional activities. In the Italian semantic networks, closeness centrality is higher for the associations 'animal welfare' and 'healthy' for the egg-shaped plant-based egg, 'cholesterol-free' for the liquid, and 'healthy' for the powder product. Interestingly, 'shelf-life' has high centrality measures for all plant-based eggs in the UK, and it has a particularly high value for the powder plant-based egg. In contrast to this, in the Italian semantic networks 'shelf-life' has high centrality measures for the powder plant-based egg only. However, it is generally perceived positively as indicated by high relevance particularly for the liquid plant-based egg.

Table 6. Centrality measures for semantic networks: egg-shaped plant-based egg

	Degree (C_D)		nCloseness (CC)		nBetweenness (CD)	
	UK	**IT**	**UK**	**IT**	**UK**	**IT**
Plant-based egg	92.00	107.00	100.00	100.00	40.16	73.70
Price	22.00	21.00	62.50	52.63	1.66	0.00
Healthy	22.00	17.00	71.42	71.42	6.66	11.48
Taste	23.00	13.00	62.50	55.55	0.66	0.00
Sustainability	19.00	21.00	58.82	55.55	0.66	0.00
Use	19.00	19.00	71.42	55.55	6.33	3.33
Animal welfare	20.00	13.00	62.50	62.50	1.16	0.00
Shelf-life	9.00	-	55.55	-	0.00	-
Allergen-free	11.00	-	55.55	-	1.16	-
Texture	17.00	-	66.66	-	3.66	-
Colour	10.00	-	58.82	-	0.00	-
Protein	-	13.00	-	62.50	-	1.85
Cholesterol-free	-	6.00	-	55.55	-	0.00
Artificial	-	5.00	-	55.55	-	-
Nutritional values	-	9.00	-	58.82	-	-

Table 7. Centrality measures for semantic networks: liquid plant-based egg

	Degree (C_D)		nCloseness (CC)		nBetweenness (CD)	
	UK	**IT**	**UK**	**IT**	**UK**	**IT**
Plant-based egg	96.00	112.00	100.00	100.00	59.72	85.55
Price	30.00	21.00	60.00	16.00	0.00	0.00
Healthy	21.00	15.00	60.00	16.00	1.38	3.33
Taste	21.00	14.00	60.00	18.00	0.00	0.00
Sustainability	18.00	20.00	60.00	18.00	1.38	0.00
Use	24.00	15.00	69.23	18.00	5.55	0.00
Animal welfare	16.00	12.00	60.00	18.00	1.38	0.00
Shelf-life	16.00	10.00	64.28	18.00	2.77	0.00
Nutritional values	9.00	-	56.25	-	0.00	-
Texture	9.00	-	60.00	-	0.00	-
Allergen-free	-	8.00	-	18.00	-	0.00
Protein	-	9.00	-	18.00	-	0.00
Cholesterol-free	-	8.00	-	19.00	-	0.00

Table 8. Centrality measures for semantic networks: powder plant-based egg

	Degree (C_D)		nCloseness (CC)		nBetweenness (CD)	
	UK	**IT**	**UK**	**IT**	**UK**	**IT**
Plant-based egg	113.00	98.00	100.00	90.90	67.77	73.70
Price	32.00	24.00	58.82	52.83	1.11	0.00
Healthy	24.00	19.00	62.50	62.50	2.22	11.48
Taste	18.00	14.00	62.50	50.00	2.22	0.00
Sustainability	27.00	14.00	58.82	52.63	0.00	0.00
Use	17.00	17.00	55.55	58.82	0.00	3.33
Animal welfare	20.00	15.00	58.82	52.63	0.00	0.00
Shelf-life	14.00	9.00	55.55	52.63	0.00	0.00
Allergen-free	14.00	11.00	55.55	58.82	0.00	7.40
Availability	15.00	-	55.55	-	0.00	-
Vegan	26.00	-	66.66	-	4.44	-
Protein	-	6.00	-	17.00	-	1.85
Cholesterol-free	-	5.00	-	24.00	-	0.00

5. Discussion

In this manuscript we applied CM to investigate UK and Italian consumers' semantic networks for three types of plant-based egg products. We found that 'price' was the association that appeared most often in semantic networks in both countries, followed by 'sustainability' in the UK and by 'use' in Italy. The frequency of the association 'use' reinforces the idea that the ability of using plant-based eggs as desired by consumers is likely to have a significant effect on how

they will perceive these products. The association ‘taste’ was third in the Italian semantic networks, whereas ‘healthy,’ which includes associations like ‘health benefits’ and ‘healthier than eggs,’ was third in the UK. The association between ‘health’ and plant-based animal-product alternatives also emerged in Peschel *et al.* (2019), confirming that one of the links with plant-based alternatives is ‘health’. Given the frequency of associations like ‘price’, ‘use’, and ‘health’, we conclude that consumers’ perceptions towards plant-based eggs seem to primarily rely on extrinsic product attributes. This is corroborated by previous research showing that people mainly focus on extrinsic attributes in situations of uncertainty (Grunert, 1997).

Furthermore, it seems that UK consumers developed more complex associative networks for plant-based eggs compared to Italians indicating that they have stored more information in memory. The underlying reason might be that compared to Italians, UK consumers are more familiar with plant-based animal-product alternatives given an increase in sales of up to £816 million in 2019 (Mintel, 2019). Another possible explanation is the growing number of vegan consumers in the UK which accounted for 600,000 individuals in 2019, and is projected to rise by another 50% by 2050, compared to nearly 200,000 in Italy (Mintel, 2019). Our results also suggest that because of the higher number of associations in UK semantic networks, as well as the much higher number of positive associations compared to the negative, plant-based eggs may be more easily marketed to them than to Italians. In addition, the egg-shaped plant-based egg was the one with the highest number of associations in both countries, whereas the liquid one had the lowest number. This suggests that a similar appearance to a product that consumers already know like

conventional eggs, may evoke more associations than products that look different, and are hence less familiar.

With regards to whether associations with plant-based eggs are more or less relevant to consumers, associations in the UK were more often positive and positive/important compared to the ones in Italy. However, with the overall number of associations being higher in the UK networks, the number of negative associations was also higher. In terms of plant-based egg type, the egg-shaped in the UK and the powder plant-based egg in Italy had the highest number of positive attributes in both countries. This is likely to lead to positive attitudes towards different types of plant-based eggs in each country. The powder plant-based egg in the UK and the egg-shaped plant-based egg in Italy had the highest number of negative associations. This may decrease acceptance and thus purchase likelihood. In addition, our results show that associations like 'price', 'taste', and 'use' were often negatively perceived by consumers. This is corroborated by previous studies on plant-based alternatives of animal products, which suggest that the price-level of plant-based food substitutes is perceived as high, and the sensory experience with these products as poor (Vainio, 2019; Van Loo et al., 2020).

Several observations can also be drawn from a methodological perspective. The appropriateness of using CM to evaluate consumers' perceptions of new food products in an online context as employed in this study was demonstrated by the following. First, the participants followed the protocol and completed the CM task correctly. Second, the similar number of associations that emerged (1,636 from the

UK and 963 from Italy) as compared to former research who used CM (Grebitus and Bruhn, 2008; Peschel et al., 2019; Seitz and Roosen, 2015) is another indication of the appropriateness of using this methodology online. Similarly, the centrality measures, and in particular the high closeness centrality, is in line with previous research (Grebitus and Bruhn, 2008). Third, our study results, such as the positive evaluation given to associations like "sustainability" and "health" for plant-based eggs, are similar to previous research investigating consumers' associations for plant-based animal-product alternatives (Peschel et al., 2019). Fifth, the new relevance measure revealed insights to be considered for efficient and effective marketing activities.

5.1 Industry and marketing implications

Several implications for plant-based egg producers were identified. First, associations, such as 'price', 'taste' and 'use', although being among the most frequent associations, have a rather low relevance and consumers may perceive them negatively. Thus, it is recommended to keep the price of plant-based eggs similar to the price of conventional eggs to improve consumers' acceptance. In terms of 'taste', it is advisable to achieve a taste similar to eggs and it is something that should be communicated to consumers. The association 'use' was low in score particularly for the egg-shaped plant-based egg. This is likely because it is less versatile and can only be used as a hard-boiled egg. This finding suggests that egg-shaped plant-based egg manufacturers could improve the range of applications for this product to increase its flexibility. Meanwhile, their marketing could point out

the use of plant-based hard-boiled eggs to consumers, for example providing recipes, to be more appealing to those who more frequently consume eggs hard-boiled. 'Allergen-free' scored high in the Italian semantic networks, suggesting that this aspect could be emphasized when marketing plant-based eggs in Italy. 'Sustainability' was the most frequently mentioned association in the UK semantic networks, as well as, being attributed with particularly high relevance, meaning that this aspect could be emphasized when marketing plant-based eggs in this country.

With regards to semantic networks, the association 'healthy' had the highest score in terms of centrality measurements for both countries, and for all the prototypes of plant-based eggs presented. This confirms the importance of emphasizing the health benefits of these products when promoting them, through labelling, communication campaigns, etc. In particular, in the semantic networks for the egg-shaped plant-based egg, 'allergen-free' and 'cholesterol-free' have a high degree in centrality measurements, meaning that these factors could be used in advertising. Pointing out the health benefits of plant-based eggs compared to conventional eggs is an opportunity for highlighting added-value of this product. Finally, the high centrality of 'shelf-life' for UK consumers compared to Italians signals the need to clearly indicate this aspect when marketing these products in the UK.

5.2 Future research avenues

Several research avenues emerge from this study. First, because the relevance measure in Table 3 might be open to interpretation, future studies could test it further. Second, the different types of plant-based eggs could be explored with

quantitative studies to measure, for example, consumers' willingness to pay. Third, it would be useful to investigate specific consumer segments, such as vegans, vegetarians, or flexitarians as possible targets for launching plant-based eggs. Last, consumer tests using real plant-based eggs are recommended using non-hypothetical choice experiments or experimental auctions in real market contexts (Asioli et al., 2020; Khachatryan et al., 2018; Lusk and Shogren, 2007) combined with sensory tests (Al-Ajeeli et al., 2018; Asioli et al., 2017b) for more realistic settings and valuable information.

6. Conclusions

To conclude, consumers from the UK and Italy associated 'price', 'sustainability', 'use' and 'taste' most frequently with plant-based eggs. For respondents in the UK associations evaluated as most positive and important emerged for the egg-shaped plant-based egg. For Italian participants this was the case for the powder plant-based egg. CM was shown to be an appropriate method to explore consumers' associative/semantic networks for newly developed foods like plant-based eggs. Furthermore, this was the first study to successfully employ CM in an online setting, proving the adaptability of this methodology in different research environments. This new application is important as it allows the collection of data from consumers who are geographically distant from each other.

Acknowledgments

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Transparent reporting

Pre-registration of the study is available at: https://aspredicted.org/blind.php?x=wi6ph3.

Appendix A

A.1 Transcript of the egg-shaped plant-based egg video (English version)

1. Plant-based egg provides an alternative to conventional eggs and is made with green peas as source of protein, and it comes in rounded/eggy shape.
2. The proteins are extracted from the green peas using mechanical means which involve grinding dried peas into a fine flour, and later mixing the pea flour with water, removing the fibre and starch, and creating a paste, which is then modelled by attempting to replicate the rounded shape of an egg.
3. This plant-based egg also has a yolk inside which is made using alginate, a compound found in the cell walls of brown algae.
4. The eggshell is created with a plant-based wax.
5. The plant-based egg is allergen-free, cholesterol-free, and obviously animal-free.
6. The manufacturers also claim it to be environmentally friendlier than conventional eggs.
7. The plant-based egg can be used as a hard-boiled egg, in salads, on toasts etc, for example but not for baking purposes or to make scramble eggs or omelettes.

A.2 Transcript of the egg-shaped plant-based egg video (Italian version)

1. L’uovo vegetale è un’alternativa alle uova convenzionali ed è prodotto con piselli verdi ed ha una forma arrotondata simile alle uova convenzionali.
2. Il processo di produzione consiste nell’estrarre le proteine contenute nei piselli macinandoli fino ad ottenere una farina e successivamente la farina di piselli ottenuta viene mescolata con acqua, rimuovendo la fibra e l'amido e creando una pasta, che viene poi modellata tentando di replicare la forma tondeggiante dell’uovo.
3. L’ uovo vegetale contiene anche un tuorlo all'interno, prodotto utilizzando l’alginato, un composto presente nelle pareti cellulari delle alghe brune.
4. Il guscio dell’uovo vegetale e’ creato utilizzando una cera a base vegetale.
5. L'uovo di origine vegetale è privo di allergeni e di colesterolo e la sua produzione non include l’utilizzo di animali.
6. I produttori inoltre affermano che la produzione dell’uovo vegetale sarebbe piu’ eco-sostenibile della produzione delle uova convenzionali.
7. L’uovo vegetale può essere utilizzato come uovo sodo su insalate, toast, ecc., ma non puo’ essere utilizzato per fare dolci, frittata o omelettes.

A.3 Transcript of the liquid plant-based egg video (English version)

1. The plant-based egg provides an alternative to conventional eggs and is made using mung beans, pumpkin seeds, or green peas as a source of protein and it comes in liquid shape.
2. The process of production involves separating the protein contained in the beans from the other components, such as fat, fibre and starch through a centrifugation process and other mechanical means.
3. The resulting protein powder is then mixed with other ingredients such as oil, water and carrots and turmeric extract to give the yellow colour, as well as other ingredients like dehydrated onion, sugar etc.
4. The plant-based egg is allergen-free, cholesterol-free and animal-free.
5. The manufacturers claim it to be more sustainable for the environment than the conventional egg production.
6. The final yellow liquid blend that comes out is bottled.
7. The manufacturers claim it to be more sustainable for the environment than conventional egg production.
8. The plant-based egg can be used to make plant-based scramble eggs by pouring the product into a pan, but also to make crepes, waffles, pancakes, omelettes etc. Yolk and white cannot be separated in this product.

A.4 Transcript of the liquid plant-based egg video (Italian version)

1. L’uovo vegetale è un’aternativa alle uova convenzionali, ed è prodotto con l’utilizzo di fagioli verdi, semi di zucca o fagioli verdi come fonte proteica.
2. Il processo di produzione consiste nel separare la proteina contenuta nei fagioli dagli altri componenti, quali i grassi, le fibre e l’ amido attraverso un processo di centrifugazione e altri mezzi meccanici.
3. La polvere proteica viene quindi miscelata con altri ingredienti come olio, acqua, cipolla secca, zucchero e carote ed estratto di curcuma che conferiscono il colore giallo al prodotto.
4. La miscella finale viene poi imbottigliata.
5. L’uovo vegetale e’ privo di allergeni e colesterolo, e la sua produzione non include l’utilizzo di animali.
6. I produttori affermano che è inoltre piu’ sostenibile per l'ambiente rispetto alla produzione di uova convenzionale.
7. L'uovo vegetale può essere usato per preparare uova strapazzate versando il prodotto in una padella, ma anche crepes, waffles, pancake, omelette ecc.

A.5 Transcript of the powder plant-based egg video (English version)

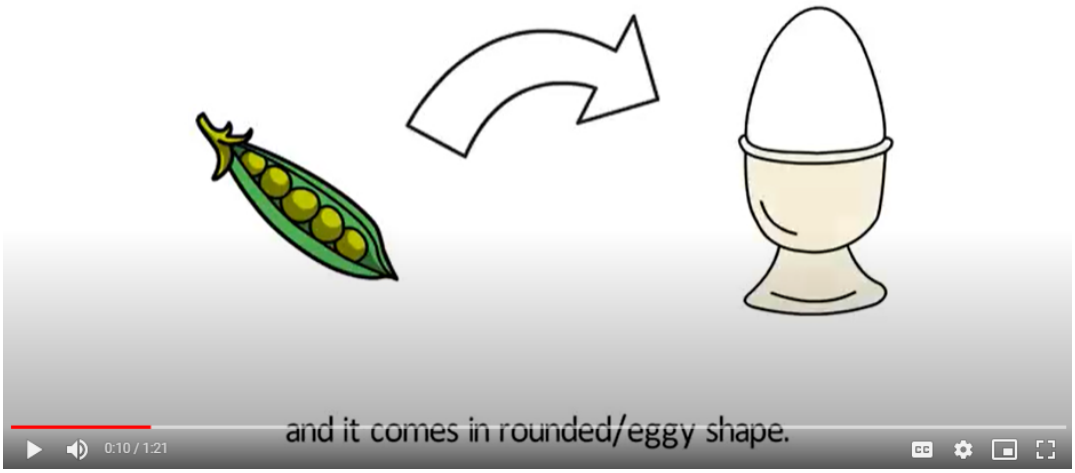
1. The plant-based egg provides an alternative to conventional egg and is produced by using yeast protein and it comes in crystal/powder shape.
2. Plant-based egg is produced through a laboratory process, where proteins, fats and water contained in eggs are recreated through yeast protein fermentation process.
3. The plant-based egg is allergen-free, cholesterol-free, and animal-free.
4. Also, the manufacturers claim it to be more sustainable for the environment than conventional egg production.
5. Plant-based egg when mixed with water, can be used to make meringues, as well as pancakes. However, it does not replicate all other egg applications, like scramble eggs, hard boiled etc.

A.6 Transcript of the powder plant-based egg video (Italian version)

1. L’uovo vegetale è un’alternativa alle uova convenzionali ed è prodotto utilizzando le proteine contenute nel lievito e si presenta in forma di cristallo/polvere.
2. L'uovo vegetale viene prodotto attraverso un processo laboratoriale, in cui proteine, grassi e acqua contenuti nelle uova vengono ricreati fermentando le proteine contenute nel lievito.
3. L’uovo vegetale è privo di allergeni e colesterolo e la sua produzione non include l’utilizzo di animali.
4. Inoltre, i produttori sostengono che la produzione dell’uovo vegetale sia più sostenibile per l'ambiente rispetto alla produzione delle uova convenzionali
5. L’ uovo vegetale, se miscelato con acqua, può essere utilizzato per preparare meringhe e pancake. Tuttavia, non e’ utilizzabile per cucinare pietanze come uova strapazzate, sode ecc.

Appendix B

Video B.1 Plant-based egg video, egg-shape (English version)

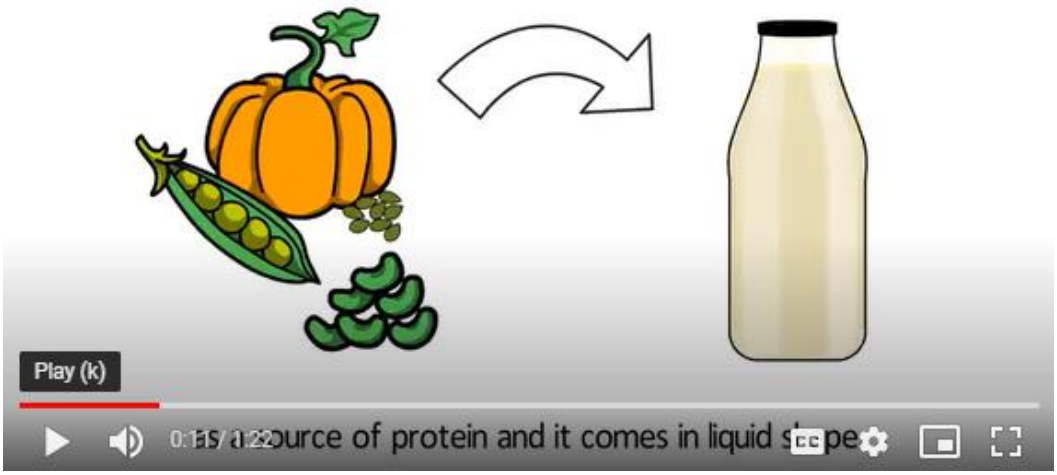


Download:
https://drive.google.com/file/d/15gFYFj9NAdL8nwfPViFV3kiEttWfymzL/view?usp=sharing

Video B.2 Plant-based egg video, egg-shape (Italian version)

Download: https://drive.google.com/file/d/11Cix0e-pwSy2Jg8WyGbQsVdryzTJwiUO/view?usp=sharing

Video B.3 Plant-based egg video, liquid-shape (English version)



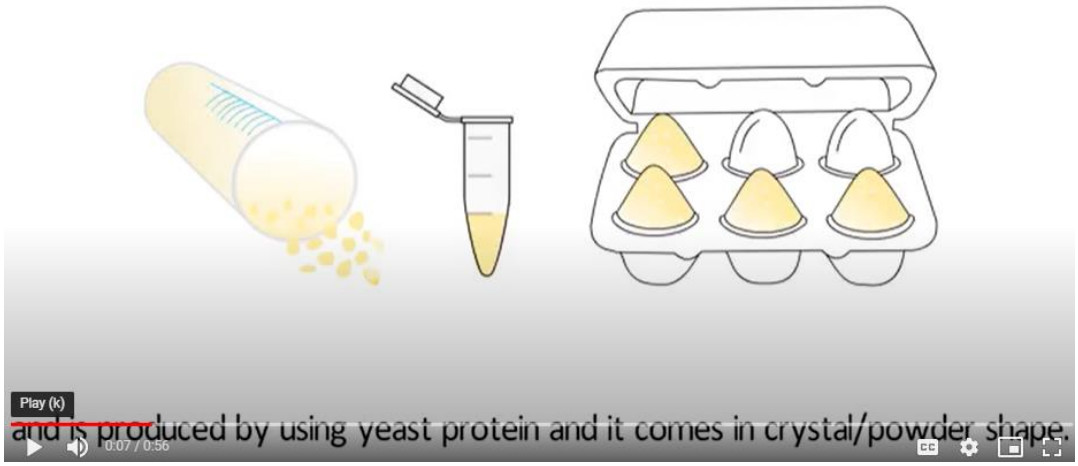
Download:

https://drive.google.com/file/d/1l2rDPQYk3Uctx5NAoVav3QDc33879h9J/view?usp=sharing

Video B.4 Plant-based egg video, liquid-shape (Italian version)

Download: https://drive.google.com/file/d/1SyKRCVhC-wRKitbAqCA0PXDLOCOxU-9f/view?usp=sharing

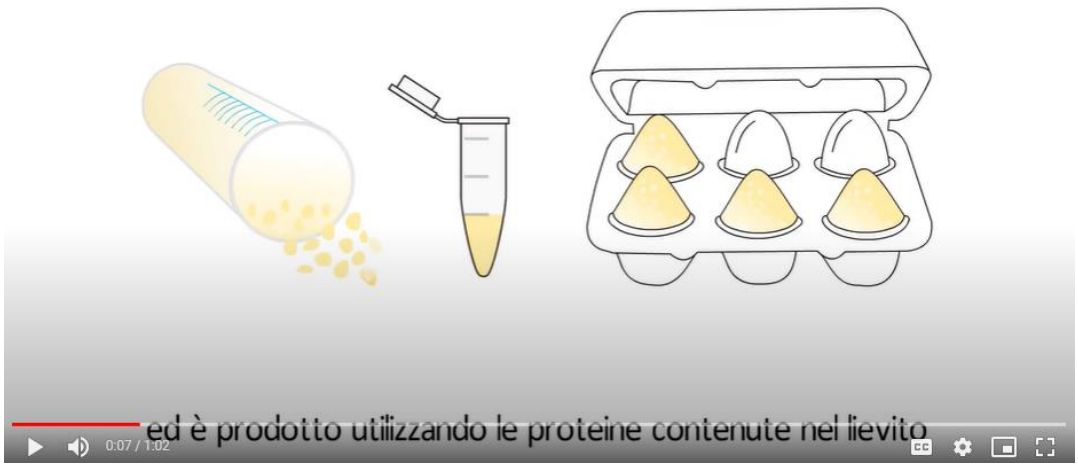
Video B.5 Plant-based egg video, powder-shape (English version)



Download:

https://drive.google.com/file/d/1BbyayGqt4kdlPofZBoEuzScB6wouSdwu/view?usp=sharing

Video B.6 Plant-based egg video, liquid-shape (Italian version)



Download: https://drive.google.com/file/d/184VAJn1lbsi3XAwsbMQYb_n8-Gc9UOGi/view?usp=sharing

Appendix C

Table C.1 Sample characteristics

SOCIO-DEMOGRAPHICS	UK (N = 90)	IT (N = 90)
Gender		
Male	57 (63.30%)	62 (68.90%)
Female	33 (36.70%)	28 (31.10%)
Mann U (z=0.79, p=0.432)		
Pr=.431		
Age		
18-24	7 (7.80%)	5 (5.60%)
25-34	42 (46.70%)	26 (28.90%)
35-44	19 (21.10%)	27 (30.00%)
45-54	16 (17.80%)	22 (24.40%)
55-64	6 (6.70%)	9 (10.00%)
65+	-	1 (1.10%)
Mann U (z=-2.43, p=.015)		
Pr=.115		
Education		
High School	21 (23.30%)	47 (52.20%)
Bachelor	47 (52.20%)	20 (22.20%)
Master	18 (20.00%)	21 (23.30%)
PHD	4 (4.40%)	2 (2.20%)
Mann U (z=2.66, p=0.007)		
Pr=0.00		
Income		
Less than £10,000	4 (4.40%)	11 (12.20%)
£10,000 to £19,999	4 (4.40%)	22 (24.20%)
£20,000 to £29,999	31 (34.40%)	38 (42.20%)
£30,000 to £39,999	37 (41.10%)	13 (14.40%)
£40,000 to £49,999	10 (11.10%)	4 (4.40%)

£50,000 to £59,999	4 (4.40%)	2 (2.20%)
Add other categories		
Mann U (z=5.241, p.000)		
Pr=.000		
Egg consumption		
Never	9 (10.00%)	5 (5.60%)
Few times per month	4 (4.40%)	4 (4.40%)
Once a week	2 (2.20%)	7 (7.80%)
2-3 times per week	35 (38.90%)	54 (60.5%)
4-5 times per week or more	18 (20.00%)	17 (18.90%)
Daily	22 (24.40%)	3 (3.30%)
Mann U (z=-2.76, p=.0.006)		
Pr=.001		

Note: A Mann U Test was employed to test statistical significance between countries for the socio-demographics above. The resulting P-values show no statistical difference in age between the two countries, whereas there are statistical differences in education, income, and egg consumption.

Appendix D

Table D.1 Overview of most frequent associations with plant-based eggs (merged results from liquid, powder and egg-shaped)

	Absolute number		%		Average value	
Theme	**UK**	**IT**	**UK**	**IT**	**UK**	**IT**
Price	77	72	86%	80%	3.3	2.5
Sustainability	65	45	72%	50%	7.8	8.5
Taste	55	43	61%	48%	6.1	6.5
Animal welfare	46	35	51%	42%	6.8	8.2
Healthy	54	24	60%	27%	7.9	6.7
Use	35	43	39%	48%	4.8	3.1
Shelf-life	41	24	46%	27%	6.2	7
Allergen-free	24	16	27%	18%	6.8	8.5

Appendix E

Table E.1 Relation between Top-10 concepts for the UK: egg-shaped plant-based egg (n=30)

	Plant-based egg	Price	Animal welfare	Sustainability	Healthy	Shelf-life	Taste	Texture	Use	Colour	Allergen-free
Plant-based egg	-	63.30%	20.00%	30.00%	33.30%	23.30%	40.00%	20.00%	33.30%	23.30%	20.00%
Price	63.30%	-	0	16.60%	6.60%	0	0	0	13.30%	0	0
Animal welfare	20.00%	0	-	30.00%	13.30%	0	0	0	0	0	0
Sustainability	30.00%	16.60%	30.00%	-	0	0	0	0	0	0	0
Healthy	33.30%	6.60%	13.30%	0	-	0	0	3.30%	3.30%	0	16.60%
Shelf-life	23.30%	0	0	0	0	-	0	0	2.00%	0	0
Taste	40.00%	0	0	0	0	0	-	20.00%	13.30%	10.00%	0
Texture	20.00%	0	3.30%	0	3.30%	0	20%	-	3.30%	13.30%	0
Use	33.30%	13.30%	0	0	3.30%	20.00%	13.30%	3.30%	-	0	0
Colour	23.30%	0	0	0	0	0	10%	13.30%	0	-	0
Allergen-free	20.00%	0	0	0	16.60%	0	0	0	0	0	-

Table E.1.1 Relation between the Top-10 concepts for Italy: egg-shaped plant-based egg (n=30)

	Plant-based egg	Animal welfare	Sustainability	Healthy	Price	Protein	Taste	Use	Nutritional values	Artificial	Cholesterol-free
Plant-based egg	-	20.00%	53.30%	33.3%	70.00%	33.30%	40.00%	60.00%	23.30%	13.30%	10.00%
Animal welfare	20.00%	-	16.60%	3.3%	0	0	3.30%	0	0	0	0
Sustainability	53.3%	16.60%	-	0	0	0	0	0	0	0	0
Healthy	33.3%	3.30%	0	-	0	3.30%	0	0	3.30%	3.30%	10.00%
Price	70.00%	0	0	0	-	0	0	0	0	0	0
Protein	33.3%	0	0	3.30%	0	-	0	3.30%	3.30%	0	0
Taste	40.00%	3.30%	0	0	0	0	-	0	0	0	0
Use	60.00%	0	0	0	0	3.30%	0	-	0	0	0
Nutritional values	23.30%	0	0	3.30%	0	3.30%	0	0	-	0	0
Artificial	13.30%	0	0	3.30%	0	0	0	0	0	-	0
Cholesterol-free	10.00%	0	0	3.30%	0	0	0	0	0	0	-

Table E.2. Relation between the Top-10 concepts for the UK: the liquid plant-based egg (n=30)

	Plant-based egg	Animal welfare	Sustainability	Healthy	Nutritional values	Price	Shelf-life	Taste	Texture	Use
Plant-based egg	-	23.30%	40.00%	40.00%	13.30%	73.30%	30.00%	50.00%	13.30%	36.60%
Animal welfare	23.30%	-	16.60%	13.30%	0	0	0	0	0	0
Sustainability	40.00%	16.60%	-	0	0	0	3.30%	0	0	0
Healthy	40.00%	13.30%	0	-	16.60%	0	0	0	0	0
Nutritional values	13.30%	0	0	16.60%	-	0	0	0	0	0
Price	73.30%	0	0	0	0	-	13.30%	0	0	13.30%
Shelf-life	30.00%	0	3.30%	0	0	13.30%	-	0	0	6.60%
Taste	50.00%	0	0	0	0	0	0	-	6.60%	13.30%
Texture	13.30%	0	0	0	0	0	0	6.60%	-	10.00%
Use	36.60%	0	0	0	0	13.30%	6.60%	13.30%	10.00%	-

Table E.2.1. Relation between the Top-10 concepts for Italy: the liquid plant-based egg (n=30)

	Plant-based egg	Animal welfare	Sustainability	Price	Protein	Shelf-life	Taste	Use	Healthy	Cholesterol-free	Allergen-free
Plant-based egg	-	33.30%	30.00%	70.00%	20.00%	30.00%	40.00%	46.60%	26.60%	26.60%	20.00%
Animal welfare	33.30%	-	6.60%	0	0	0	0	0	0	0	0
Sustainability	30.00%	6.60%	-	0	0	0	0	0	0	0	0
Price	70.00%	0	0	-	0	0	0	0	0	0	0
Protein	20.00%	0	0	0	-	0	0	0	3.33%	0	0
Shelf-life	30.00%	0	0	0	0	-	0	3.33%	6.60%	0	0
Taste	40.00%	0	0	0	0	0	-	0	6.60%	0	0
Use	46.60%	0	0	0	0	3.330%	0	-	0	0	0
Healthy	26.60%	0	0	0	3.330%	6.60%	6.60%	0	-	3.330%	6.60%
Cholesterol-free	26.60%	0	0	0	0	0	0	0	3.33%	-	3.33%
Allergen-free	20.00%	0	0	0	0	0	0	0	6.60%	3.33%	-

Table E.3. Relation between the Top-10 concepts for the UK: the powder plant-based egg (n=30)

	Plant-based egg	Allergen-free	Animal welfare	Environmentally friendly	Healthy	Price	Shelf-life	Taste	Vegan	Use	Availability
Plant-based egg	-	23.30%	23.30%	50%	33.30%	70%	26.60%	30%	36.60%	50%	33.30%
Allergen-free	23.30%	-	0	0	23.30%	0	0	0	0	0	0
Animal welfare	23.30%	0	-	26.60%	0	0	0	0	16.60%	0	0
Environmentally friendly	50%	0	26.60%	-	0	0	0	0	13.30%	0	0
Healthy	33.30%	23.30%	0	0	-	0	0	13.30%	10%	0	0
Price	70%	0	0	0	0	-	20%	0	0	0	16.60%
Shelf-life	26.60%	0	0	0	0	20%	-	0	0	0	0
Taste	30%	0	0	0	13.30%	0	0	-	10%	6.60%	0
Vegan	36.60%	0	16.60%	13.30%	10%	0	0	10%	-	0	0
Use	50%	0	0	0	0	0	0	6.60%	0	-	0
Availability	33.30%	0	0	0	0	16.60%	0	0	0	0	-

Table E.3.1. Relation between the Top-10 concepts for Italy: the powder plant-based egg (n=30)

	Plant-based egg	Allergen-free	Animal welfare	Cholesterol-free	Sustainability	Healthy	Price	Protein	Shelf-life	Taste	Use
Plant-based egg	-	16.60%	36.60%	0	33.30%	36.60%	76.60%	6.60%	26.60%	46.60%	46.60%
Allergen-free	16.60%	-	0	10.00%	0	10.00%	0	0	0	0	0
Animal welfare	36.60%	0	-	0	13.30%	0	0	0	0	0	0
Cholesterol-free	0	10.00%	0	-	0	6.60%	0	0	0	0	0
Sustainability	33.30%	0	13.30%	0	-	0	0	0	0	0	0
Healthy	36.60%	10.00%	0	6.60%	0	-	0	10.00%	0	0	0
Price	76.60%	0	0	0	0	0	-	0	0	0	3.30%
Protein	6.60%	0	0	0	0	10.00%	0	-	0	0	3.30%
Shelf-life	26.60%	0	0	0	0	0	0	0	-	0	3.30%
Taste	46.60%	0	0	0	0	0	0	0	0	-	0
Use	46.60%	0	0	0	0	0	3.30%	3.30%	3.30%	0	-

Table E.4. Associations between the Top-10 concepts in percentage of participants from the UK and Italy (n=180).

	Plant-based egg	Price	Environmentally friendly	Taste	Healthy	Animal welfare	Shelf life	Use	Vegan	Allergen-free	Texture
Plant-based egg	-	70.50%	44.40%	41.10%	38.80%	26.10%	22.70%	45.50%	6.10%	13.30%	5.50%
Price	70.50%	-	0.50%	0	0.50%	0	5.50%	3.30%	0	0	0
Environmentally friendly	44.40%	0.50%	-	0	0	18.30%	0.50%	0	2.20%	0	0
Taste	41.10%	0	0	-	3.30%	0.50%	0	5.50%	1.80%	0	4.40%
Healthy	38.80%	0.50%	0	3.30%	-	5%	0	0.50%	1.80%	6.60%	0.50%
Animal welfare	26.10%	0	18.30%	0.50%	5%	-	0	0	2.70%	0	0
Shelf life	22.70%	5.50%	0.50%	0	0	0	-	3.30%	2.70%	0	0
Use	45.50%	3.30%	0	5.50%	0.50%	0	3.30%	-	0	0	2.22%
Vegan	6.10%	0	2.20%	1.80%	1.80%	2.70%	2.70%	0	-	0	0
Allergen-free	13.30%	0	0	0	6.60%	0	0	0	0	-	0
Texture	5.50%	0	0	4.40%	0.50%	0	0	2.20%	0	0	-

Table E.5 Associations between Top-10 concepts in percentage for UK (n=90)

	Plant-based egg	Price	Environmentally friendly	Taste	Healthy	Animal welfare	Shelf life	Use	Vegan	Allergen-free	Texture
Plant-based egg	-	70.50%	44.40%	41.10%	38.80%	26.10%	22.70%	45.50%	6.10%	13.30%	5.50%
Price	70.50%	-	0.50%	0	0.50%	0	5.50%	3.30%	0	0	0
Environmentally friendly	44.40%	0.50%	-	0	0	18.30%	0.50%	0	2.20%	0	0
Taste	41.10%	0	0	-	3.30%	0.50%	0	5.50%	1.80%	0	4.40%
Healthy	38.80%	0.50%	0	3.30%	-	5%	0	0.50%	1.80%	6.60%	0.50%
Animal welfare	26.10%	0	18.30%	0.50%	5%	-	0	0	2.70%	0	0
Shelf life	22.70%	5.50%	0.50%	0	0	0	-	3.30%	2.70%	0	0
Use	45.50%	3.30%	0	5.50%	0.50%	0	3.30%	-	0	0	2.22%
Vegan	6.10%	0	2.20%	1.80%	1.80%	2.70%	2.70%	0	-	0	0
Allergen-free	13.30%	0	0	0	6.60%	0	0	0	0	-	0
Texture	5.50%	0	0	4.40%	0.50%	0	0	2.20%	0	0	-

Table E.6 Associations between the Top-10 concepts in percentage for Italy (n=90)

	Plant-based egg	Price	Environmentally friendly	Taste	Use	Animal welfare	Protein	Healthy	Shelf-life	Allergen-free	Cholesterol-free
Plant-based egg	-	72.20%	37.70%	42.20%	51.10%	30%	20%	32.20%	18.80%	12.20%	12.20%
Price	72.20%	-	0	0	1.10%	0	0	0	0	0	0
Environmentally friendly	37.70%	0	-	0	0	12.20%	0	0	0	0	0
Taste	42.20%	0	0	-	0	1.10%	0	2.20%	0	0	0
Use	51.10%	1.10%	0	0	-	0	2.20%	0	2.20%	0	0
Animal welfare	30%	0	12.20%	1.10%	0	-	0	1.10%	0	0	0
Protein	20%	0	0	0	2.20%	0	-	7.70%	0	0	0
Healthy	32.20%	0	0	2.20%	0	1.10%	7.70%	-	0	2.20%	6.60%
Shelf-life	18.80%	0	0	0	2.20%	0	0	0	-	0	0
Allergen-free	12.20%	0	0	0	0	0	0	2.20%	0	-	3.30%
Cholesterol-free	12.20%	0	0	0	0	0	0	6.60%	0	3.30%	-

Appendix F

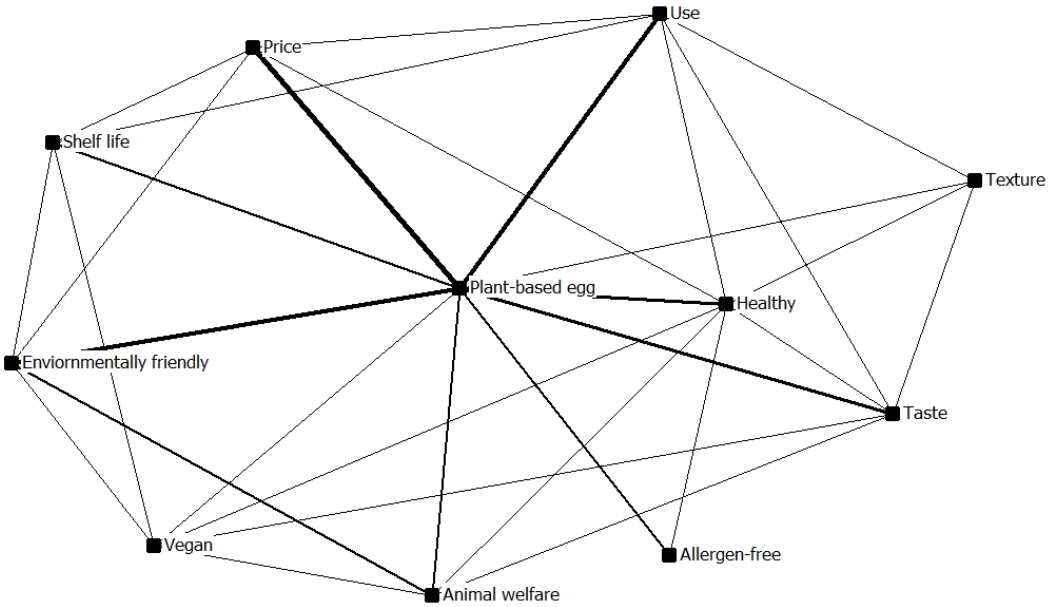


Fig. F.1 - Network of the Top-10 associations with the aggregated plant-based eggs from both countries.

Note: Created with UCInet 6.0 software (Borgatti, Everett, & Freeman, 2002). Thickness of lines represent the frequency of the associations.

Chapter IV - **Consumers' Preferences for Intrinsic and Extrinsic Product Attributes of Plant-based Eggs: An Exploratory Study in the United Kingdom and Italy**[14]

[14] This article was published in March 2021. Full reference: Rondoni, A., Millan, E. & Asioli, D. 2021, "Consumers' preferences for intrinsic and extrinsic product attributes of plant-based eggs: an exploratory study in the United Kingdom and Italy", British food journal (1966), vol. ahead-of-print, no. ahead-of-print. DOI: 10.1108/BFJ-11-2020-1054

Abstract

Purpose - Plant-based eggs have recently been developed to provide consumers with a healthier, animal-friendlier, and more sustainable alternative to conventional eggs. The purpose of this paper is to investigate intrinsic and extrinsic attribute preferences for three prototypes of plant-based egg, namely the liquid, powder, and egg-shaped.

Design/methodology/approach – Nine focus groups in the United Kingdom and nine in Italy were conducted, with a total of 180 participants. Thematic analysis of results was performed.

Findings – In terms of intrinsic product attributes, consumers' preferences for colour, shape, taste, ingredients, nutrients, method of production and shelf-life for plant-based eggs were revealed. Regarding the extrinsic attributes, preferences for price, packaging, country of origin and product naming emerged. Similarities and differences between consumers from the two countries are also discussed. Differences in preferences emerged also between vegan and non-vegan consumers.

Research limitations/implications – This study adds to the existing knowledge on consumers' preferences for new plant-based food alternatives and identifies future quantitative approaches based on qualitative findings.

Practical implications – Results from this study can assist plant-based egg manufacturers in improving their products in line with consumers' expectations, which may help reducing risk of product failure.

Originality/value - This study is the first to investigate consumers' preferences, expectations, and needs for plant-based eggs and provides information which can be practically applied by manufacturers, as well as suggestions for future research.

Keywords: Plant-based eggs; Consumers; Preferences; Focus groups; United Kingdom; Italy.

1. Introduction

During the last decade, the global plant-based market reached a value of US$ 11.1 in 2019, and it is projected to increase further up to US$ 35.8 million by 2027 (Polaris Market Research, 2020). The growing demand for plant-based foods generate the making of new products, such as the plant-based eggs which have been recently developed to provide consumers with an alternative to conventional eggs. Plant-based eggs, also known as “vegan eggs”, “egg substitutes”, or “replacers”, are made using plant ingredients such as legumes, cereals etc., through processes of protein isolation or fermentation (The Good Food Institute, 2018). Compared to conventional eggs, the plant-based eggs are claimed to be allergen-, cholesterol- and animal-free, as well as environmentally friendlier (The Good Food Institute, 2018). Three of the most promising and innovative prototypes of plant-based eggs are the so-called liquid, powder, and egg-shaped plant-based eggs (see Fig.1). The liquid plant-based egg is produced by isolating the protein contained in vegetable sources such as mung beans, pumpkin seeds, etc. and it is sold in bottle (James, 2019) (Fig.1a). It can be used to make different types of foods, such as for example scrambled eggs, omelets, pancakes, etc. by pouring the product directly into a hot pan (Watson and Shoup, 2019). The liquid plant-based egg is already available in the United States market produced by, for example, JUST Ltd. and Spero Food (Gilliver, 2019). The powder plant-based egg, which is developed by fermenting yeast or algae, can be used for more limited cooking applications than liquid plant-based eggs like meringue (Geng et al., 2011) (Fig.1b). Currently, Clara Food (United States) and FUMI Ingredients (The Netherlands) are producing powder plant-based egg (Carrington, 2018), but it is not yet available in the market. Last,

the egg-shaped plant-based egg is produced by extracting the protein from soy, green peas, etc. and try to replicate all the physical components of conventional eggs (e.g., albumen, yolk and eggshell) (The Good Food Institute, 2018) (Fig.1c). One prototype of egg-shaped plant-based egg has been developed by the University of Udine (Italy) aiming to replicate a hard-boiled conventional egg (Askew, 2017). Like the powder plant-based eggs, the egg-shaped plant-based egg is not available to food market yet.

If plant-based eggs will replace conventional eggs, this will bring both economic and social changes (Stephens et al., 2018). In particular, two possible scenarios might be expected. In the first one, plant-based eggs may fully replace conventional eggs. This would lead to the failure of the economy linked to the global egg supply chain which will cause issues from an economic (e.g., farms failures, etc.) and social (e.g., loss of jobs, food security, etc.) prospective. On the other hand, however, the replacement of conventional eggs with plant-based eggs might bring positive effects in terms of the development of new economical sources linked to the new supply chain of plant-based eggs (e.g., new farms producing ingredients for plant-based eggs, etc.). In addition, from an environmental and animal welfare prospective, the interruption of the production of conventional eggs will reduce the emissions and land use generated by the intensive egg farming, which still follows a battery cage-based system in most countries worldwide, where hens are kept in the hatcheries with limited space to freely move and do not have access to the outside (UEP, 2017). In addition, it would also lead to the reduction of those health issues related to egg consumption, such as for example egg allergy or the increase of cholesterol (Rondoni et al., 2020). A third possible scenario is that plant-based

eggs might be consumed alongside conventional eggs, leading to the so-called "additional effect" (Stephens et al., 2018), which instead would bring a general increase of egg demand, as both plant-based and conventional eggs will be consumed. In this circumstance, more egg options will be available to consumers which will be able to satisfy the needs of those segments of people who cannot consume conventional eggs for specific needs or preferences (e.g., vegans, consumers suffering from egg allergies etc.). From a supply chain prospective, either plant-based eggs might be incorporated in the production of conventional eggs by egg manufacturers, or they will remain the domain of start-ups and scientists.

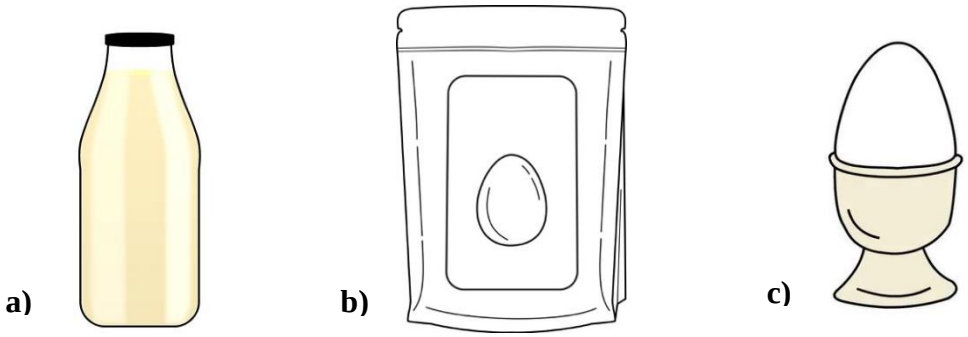


Fig. 1 Examples of plant-based egg prototypes from left to right: a) liquid, b) powder, and c) egg-shaped.

In any case, the success of plant-based eggs will be determined by whether consumers will accept these products. In order to be adopted by consumers, plant-

based eggs must accommodate their requests and needs. Thus, having information on consumers' preferences for plant-based eggs is vital for plant-based egg manufacturers before launching these products into the market to make sure they are in line with consumers' expectations. This is particularly important in modern times given the high volatility of consumers' preferences (Linnemann et al., 2006), and in turn it may help reducing the risk of product failure (van Kleef et al., 2005). However, investigating consumers food choice behaviour is challenging as it is influenced by several factors (Grunert, 2002). These factors can be related to the product itself, such as for example the intrinsic (e.g., colour, taste, smell etc.) and extrinsic product attributes (e.g., price, packaging, shelf-life etc.), as well as to consumers' personal factors (e.g., biological, physiological, socio-demographic etc.), and environmental factors (e.g., shopping context, marketing influences etc.) (Köster, 2009). In the context of new food products like the plant-based eggs, additional elements such as food neophobia, defined as the fear of unfamiliar food, food safety, higher price etc. might further affect consumers' behaviour (Hoek et al., 2011; Verbeke et al., 2015a; Verneau et al., 2014). Regarding plant-based foods, several factors have been identified to discourage consumers from purchasing them. For example, a different colour of plant-based meat compared to conventional meat has been found to increase consumers' skepticism towards taste and texture of the former (Cliceri et al., 2018). In addition, consumers were found to be disappointment by the taste of plant-based alternatives compared to conventional animal foods (McCarthy et al., 2017). On the contrary, vegetarians, as well as those people who are used to eat plant-based foods seemed to appreciate the difference in taste (Fessler et al., 2003). Thus, given the complexity of consumers' preferences

and behaviour, it is vital for manufacturers to explore consumers' preferences for plant-based eggs to develop and market these products by including consumers' voice since the early stages of development. To the best of the authors' knowledge, this is the first study investigating on this topic.

To fill this void, we conducted an explorative study employing focus groups (FGs) by comparing United Kingdom and Italy. Specifically, we investigated intrinsic and extrinsic product attribute preferences for the prototypes of plant-based egg, namely the liquid, powder, and egg-shaped (The Good Food Institute, 2018). We explored intrinsic and extrinsic product attributes because these are key determinants of consumers' food choices (Grunert, 2005; Köster, 2009), and also because they drive consumers' preferences for conventional eggs, as shown by Rondoni et al. (2020). Intrinsic attributes include the sensory, chemical, and physical characteristics of a food product, which cannot be altered without modifying the product composition (e.g., colour, odour, fat content, etc.) (Grunert, 2002; Olson, & Jacoby, 1972), while extrinsic attributes are not physical elements of a product (e.g., price, brand, country of origin, etc.), and therefore, they can be changed without altering the product's composition (Jaeger, 2006; Lähteenmäki, 2013; Olson, & Jacoby, 1972). The United Kingdom and Italy were selected for this study as they are among the largest markets of eggs in Europe with an average of 206 and 189 eggs consumed per capita per year (International Egg Commission, 2013). Although being rather small countries compared to Japan, China and Paraguay which are the biggest egg consumers markets in the world with an average consumption of 320, 310 and 300

eggs per year per person (Windhorst, 2014), the average egg consumption of the United Kingdom and Italy is projected to increase of further 12% and 11% respectively by 2050 (International Egg Commission, 2013; UK Government, 2020a).

2. Methodology

2.1 Exploratory research: Focus groups

A qualitative methodology employing focus groups (FGs) discussions was used to address the study objectives. FGs are deemed appropriate to gain insights into exploring consumers' perceptions, expectations and preferences for food products (Fernqvist et al., 2015; van Dijk et al., 2012), and particularly with new food products, as little knowledge is available (Elzerman et al., 2013; Shan et al., 2017, 2016). In view of the safety measures issued after the start of the Covid-19 pandemic, the FGs were conducted online using the meeting platform Zoom (Archibald et al., 2019). The use of the Internet for qualitative data collection has considerably increased in the past years, also because it gives the possibility to collect information from respondents who are geographically distant from each other (Zwaanswijk and Van Dulmen, 2014).

2.2 Study design: Recruitment and composition of the focus groups

We planned to conduct 9 FGs both in the United Kingdom and Italy with a target number of 6-12 participants for each FG. Participants were recruited using the

database https://www.respondent.io/. Participation was limited to the United Kingdom and Italian citizens only, aged above 18 years, and who were responsible for their household food shopping. Participants were initially screened on the afore-mentioned criteria by administering a short questionnaire. In addition, socio-demographic information (gender, age, education, income and egg consumption) was also collected. The participant information sheet to inform consumers about the study was sent in advance together with the questionnaire. Once suitable respondents were identified, they were invited to participate in one of the FG discussions by selecting their preferred date and time, among a series of pre-defined slots. Participants were also informed that they will be rewarded with £20 Amazon voucher for the United Kingdom and €22 Amazon voucher for the Italians, upon completing the FG. A total of 9 FGs per country were conducted, composed of 10 participant each (see Table C.1 in Appendix C in Chapter 3). The number of participants and of FGs conducted was sufficient to reach the saturation level, which is when new information no longer emerges (Malterud et al., 2016). Indeed, (Breakwell, 2008) and (Guest et al., 2017) showed that the most relevant themes in a FG study already emerge after three FGs and all themes and codes after six with 8-10 participants for each group. Participants were allocated to achieve balance of observable characteristics in terms of gender and age across the FGs in the United Kingdom and Italy. The results show that the hypothesis of equality of means between socio-demographic characteristics across the two countries is not rejected at the 5% significance level for gender and age, while the United Kingdom participants were more educated, richer and consume more eggs than Italians.

2.3 Focus groups procedure

During the FGs, the interviewer and the interviewees were engaged in a group discussion following a set of predetermined open-ended questions defined by the study objectives (DiCicco-Bloom and Crabtree, 2006). The FG protocol was shared in five sections: (i) the moderator provided a brief introduction of the research and asked participants to introduce themselves as ice-breaker; (ii) participants were presented with a video describing the plant-based egg's characteristics and potential benefits and they were then asked to individually develop concept maps as a mean to investigate their cognitive associations with the plant-based egg; (iii) a group discussion to explore consumers' expectations, perceptions and needs for intrinsic product attributes of plant-based was performed; (iv) a group discussion to explore consumers' expectations, preferences and needs for extrinsic attributes of plant-based eggs was conducted; (v) conclusion and greetings (see Appendix A for the full protocol). In this paper, we will only focus on the results emerged from the group discussion, excluding results from the concept mapping task. The reason why we decided to exclude the results from the concept mapping paper was twofold. First, the concept map was developed to investigate consumers' impression towards plant-based eggs from an individualistic perspective, whereas the focus groups aimed at exploring consumers' preferences for intrinsic and extrinsic product attributes for plant-based eggs from a group perspective. Second, the amount of data collected from the two tasks was significantly big to fit coherently in a single paper.

The FG protocol was first written in English, then translated into Italian for the FGs with the Italian participants, and then back translated to ensure consistency. FG discussions were conducted during summer 2020. The FGs were run by an experienced interviewer as moderator with the support of an assistant who took notes. The FGs in United Kingdom were conducted in English while the FGs conducted in Italy were conducted in Italian. The FGs lasted about 90 minutes on average and were audio-recorded with the permission of the study participants. Each FG was followed by a debriefing session between the moderator and the note taker where the main elements emerged from the study were briefly discussed. The study has obtained ethical clearance from a University Ethics Committee.

2.4 Data analysis

After each FG, the audio-records were transcribed verbatim. Notes from the note taker were also integrated where necessary to give information on participants' non-verbal behaviour (e.g., hesitation before answering to a question, uncertainty etc.). The FGs conducted in Italian were first transcribed in the original language and then translated into English (example of transcripts is reported in Appendix B). The transcripts were analysed using thematic analysis of participants' responses. Thematic analysis "is a method for identifying, analysing, organizing, describing, and reporting themes found within a data set" (Nowell, Norris, White, & Moules, 2017, p.1). NVivo 12 (QSR International, Burlington, United States) qualitative software was used to facilitate the data management and the analysis. In the first step of the thematic analysis, the researchers started to familiarise themselves with

the results by reading and re-reading the entire data set (Braun and Clarke, 2006). In the second step, a preliminary inductive coding scheme was developed aiming to identify textual evidence and support to the research questions (Blair, 2015; Braun and Clarke, 2006). To ensure reliability and consistency in the coding process, the data was coded independently by one researcher and then another research and the results compared. Coded information was read again, code names were redefined where necessary, and codes with similar meanings were merged. Once the data had been coded, major recurring themes were identified bringing together similar concepts and ideas contained in the dataset and thus helping to summarize the textual data (Attride-Stirling, 2001). The themes were reviewed independently by the research team members and, later, together to establish possible different points of view. Sub-themes were also identified and recorded after consensus amongst the researchers was reached. The data analysis showed that a level of saturation was achieved, and new data did not bring additional insights from those already captured. An example of the schemes developed to visualize the themes and codes is reported in Appendix C.

3. Results

In this section the results from the FGs discussions are presented. To support our interpretations, consumers' statements (or parts of them) are cited in the text together with the reference to the FGs (e.g., FG1, etc.), country (United Kingdom: UK; Italy: ITA) and indicating the prototype of plant-based eggs being discussed,

using the abbreviations EPBE (egg-shaped plant-based egg), LPBE (liquid plant-based egg), and PBE (powder plant-based egg).

3.1 Consumers' preferences for intrinsic attributes of plant-based eggs

Colour, shape, taste, ingredients, nutrients, method of production, and *shelf-life* emerged as the most relevant intrinsic attributes for the plant-based eggs explored in this study. In particular, "*colour*" was mentioned 45 and 41 times by the United Kingdom and Italian consumers respectively, "*shape*" 52 and 60 times, "*taste*" 68 and 72 times, "*ingredients*" 47 and 45 times, "*nutrients*" 61 and 68 times, "*method of production*" 46 and 43 times, and "*shelf-life*" 55 and 57 times.

Regarding *colour*, participants from both the United Kingdom and Italy showed preferences for a colour similar to conventional eggs for the liquid (e.g., yellow), and the egg-shaped plant-based egg (e.g., white for the albumen and yellow for the yolk).

> "*I would expect it to be yellow, because that reminds me the colour of conventional eggs.*" (FG 5, ITA, LPBE)

With the powder plant-based egg, Italians still showed preferences for a colour similar to conventional eggs (e.g., yellow), whereas the United Kingdom expressed preferences for a light colour (e.g., white), which would allow to not alter the aspect of the baked goods, as powder plant-based egg is mainly used as ingredient in baking applications.

> "*If it (the powder plant-based egg) is mainly used in baking, I think the colour should be neutral, white I would say, otherwise it would affect my recipes. I would be disappointed if my pancakes had a different colour from their conventional.*" (FG7, UK, PBE)

Consumers from both countries recommended avoiding colours like brown, which could occur because of the use of legumes or algae as ingredients, which would put people off from trying it.

> "*If the colour was brown because they are made with algae for example, I think many people would be disappointed.*" (FG1, ITA, EPBE)

They also mentioned that only natural colorants should be used. Furthermore, only those participants who already consumed plant-based foods mentioned to not necessarily expect the colour of the plant-based eggs to be the same as conventional eggs because they were aware that plant-based foods may be different in colour compared to animal foods.

About the *shape*, contrasting preferences and expectations were identified. Consumers from both the United Kingdom and Italy were expecting that plant-based eggs to resemble the *shape* of an egg, when tested with the liquid and powder plant-based eggs. The Italian participants also mentioned that if the shape of plant-based eggs differed greatly from conventional eggs, it would be more difficult to find and notice in the supermarkets. However, they also mentioned that a liquid or

powder shape would make the product more practical and less wasteful in terms of eggshell waste. Two United Kingdom participants who suffered from egg allergies and being tested with the egg-shaped plant-based egg, expressed a strong aversion towards the idea of mimicking the shape of conventional eggs because they would associate this product with something risky for their health.

> "*Me and my son have an allergy to eggs and nuts. I would prefer something that does not look like an egg, not the same shape, not the same size, not the eggshell. If we eat eggs, that could be fatal, so I would not want anything that looks or replicates eggs.*" (FG3, UK, EPBE)

Because the shape of the plant-based eggs has effects on the applicability and versatility of these products in cooking, participants from both the United Kingdom and Italy expressed preferences for a plant-based egg that works the same as eggs, for example to make scrambled eggs or poached, hard-boiled etc.

> "*I would like to break the eggs and use the plant-based egg in the same way to make scrambled eggs, omelettes, cakes, and things like that.*" (FG3, UK, EPBE)

With the powder and egg-shaped plant-based eggs, Italian consumers mentioned the necessity of having an alternative for both the yolk and the albumen separately to be able to make recipes like for example carbonara sauce or handmade pasta.

> "*My favourite pasta is carbonara and I need to use only the yolk to make the carbonara sauce, so the I need a plant-based*

egg for the yolk and a plant-based egg for the white." (FG9, ITA, PBE)

Also, Italian participants recommended adding few recipes on the packaging together with pictures showing how plant-based eggs could be used in cooking.

A large number of participants from both the United Kingdom and Italy expressed their preference for a similar *taste* to conventional eggs for both the liquid and the egg-shaped plant-based eggs:

"*I would like the taste of the plant-based egg to be as close as possible to the taste of conventional eggs.*" (FG4, ITA, LPBE)

However, vegans and consumers suffering from egg allergies showed preference for a pleasant taste, which should not necessarily replicate eggs.

"*I have no idea of how an egg would taste like as I cannot eat eggs, so to me as long as it tastes good, it would be fine.*" (FG2, UK, EPBE)

For the powder plant-based egg, the United Kingdom participants expressed a preference for a neutral taste as it is used in recipes and should not alter the taste of the final product.

"*If you use it like an ingredient, I think the taste is less relevant. Or it should be neutral actually.*" (UK, PBE)

Regarding the *ingredients*, consumers from both countries that explored the liquid plant-based egg showed preferences towards the use of beans or pumpkin seeds for familiarity reasons and recommended to avoid the use of soya. United Kingdom participants also mentioned the importance of having a 'clean' ingredient label (e.g., short ingredient list) for the liquid plant-based egg which would be another indicator of safety of the product.

> "*I think it would worry me if the ingredients' list was too long.*"
>
> (FG8, UK, LPBE)

In contrast, vegan consumers showed a greater acceptance of several plant-based ingredients (e.g., soya, yeast, beans etc.), because they were more familiar with those ingredients. With the powder plant-based egg, both the United Kingdom and Italian participants were sceptical towards the use of yeast or algae as ingredient for plant-based eggs because of their uncertainty of food safety of yeast or algae, but they were positive towards the use of legumes like beans.

> "*I am certainly more used to eat beans than yeast. I guess it should be made clear that the product is good and the yeast safe to eat.*" (FG6, ITA, LPBE)

Few United Kingdom participants suggested that an organic certification would help to increase consumer trust towards the use of the algae as ingredient for the plant-based egg.

Consumers from United Kingdom and Italy showed a strong interest for the *nutritional content* of plant-based eggs, as eggs are well-known to be a good source of nutrients, thus they preferred a nutritional content similar to conventional eggs in terms of vitamins and omega-3, but with lower fat and calories content.

> "*Eggs are known to be a very good source of proteins, vitamins, it is a complete food in terms of nutrients, so I think the same or similar nutrients would be enough.*" (FG4, ITA, LPBE)

Particularly with the powder plant-based egg, the level of protein was one of the most frequently mentioned attributes, and consumers expressed preferences towards a similar, if not higher, protein value to eggs.

> "*One of the main reasons why I do eat eggs is because of their good level of proteins. So, I think it should have at least the same level of proteins or even higher if possible.*" (FG5, UK, PBE)

Regarding the *method of production* of plant-based eggs, consumers from United Kingdom and Italy showed some food safety concerns about the higher level of processing necessary for the production of plant-based eggs. Thus, they suggested the need for certified safety standards to secure people's trust in the product. Also, both the United Kingdom and Italian consumers showed a positive attitude towards the information that the production of plant-based egg does not involve the use of animals because of health (e.g., allergen- and cholesterol-free), safety (e.g., it is free from contaminations such as salmonella, antibiotics etc.), and animal welfare reasons (e.g., hens are not involved in the production), provided in the informational

video showed by the FG moderator. Participants also emphasized that these aspects should be clearly communicated as they would make the product more appealing. Particularly, consumers from both countries showed a strong negative attitude towards cage egg production. Such sentiments were predominant amongst vegans, who said to have stopped eating eggs because of the poor animal welfare standards in egg production. Finally, regarding the claim of the plant-based egg to be more environmentally sustainable than egg production, both the United Kingdom and Italian consumers expressed a positive attitude towards that. However, they admitted that they consider sustainability information less important than nutritional values, for example, when they purchase for food.

> "*I have to say that it is not my main priority when I buy food. I rarely look at whether the product is environmentally friendly or not before buying it.*" (FG3, ITA, EPBE)

It is interesting to note that a few Italian consumers mentioned animal products like beef and pork as having the highest negative environmental impact, whereas eggs were seen to be a rather sustainable product. Also, some participants from both countries expressed scepticism with regards to the sustainability of the plant-based eggs. In order to overcome this scepticism, consumers suggested that some more information should be made available on these regards.

Shelf-life was one of the most salient characteristics discussed by all FGs. Both Italian and United Kingdom participants exposed to the liquid plant-based egg expressed views that the shelf-life should not be too long, otherwise they would be

concerned on whether it contains preservatives. They also mentioned their preference for a double shelf-life, one before and another one after opening the bottle.

> "*I think here we should distinguish between prior and after opening the bottle. In general, I do not think it should last too long, maybe around 10/15 days.*" (FG6, ITA, LPBE)

In contrast, the FGs that explored the powder plant-based egg showed that participants from United Kingdom and Italy expressed preferences for an extended shelf-life for the powder plant-based egg compared to conventional eggs because it is a dry product, and they can use it as a "backup plan" in case they run out of eggs.

> "*I think if the plant-based egg could have a similar or longer shelf-life, that would be a major benefit.*" (FG9, UK, PBE)

Furthermore, for the egg-shaped plant-based egg, consumers from both the United Kingdom and Italy indicated that plant-based eggs should have at least a similar or even longer shelf-life than conventional eggs because the latter has a too short shelf-life.

> "*I agree, at least one month. Eggs last several days, so I would be happy to see a similar or slightly longer shelf-life compared to eggs.*" (FG1, ITA, EPBE)

3.2 Consumers' preferences for extrinsic attributes of plant-based eggs

Price, *packaging*, *country of origin*, and *name* emerged as the most relevant and discussed extrinsic attributes for the different types of plant-based eggs. Specifically, "*price*" was mentioned 65 and 71 times by the United Kingdom and Italian consumers respectively, "*packaging*" 26 and 31 times, "*country of origin*" 24 and 28 times and "*name*" 19 and 26 times.

Price was the extrinsic attribute most frequently discussed during the FGs and results were similar across the three different types of plant-based egg discussed in this study. Both the United Kingdom and Italian consumers think that conventional and plant-based eggs need to have similar prices. Only consumers who were already familiar with plant-based foods expected that plant-based eggs to have higher price than conventional eggs which can negatively affect the purchase of plant-based eggs from large families.

> "*I am a mum of three, and we consume loads of eggs in my family because they taste good, I can do a lot of things with them, they are nutritious and most importantly, they are cheap. So, I do not think I will ever be able to buy the plant-based egg if it is much more expensive than normal eggs.*" (FG1, UK, EPBE)

Still in relation to price, two United Kingdom participants already had experience with other types of egg alternative like aquafaba, which they said to be potentially

much cheaper than plant-based eggs, and thus that it would not be worth for them switching to these new alternatives.

> *"There is something already available which is similar to this, which is aquafaba, which is very cheap, and it is the same purpose as this one, whereas this plant-based eggs looks to be a more expensive alternative to aquafaba and a more expensive alternative to eggs, so I am thinking, why should I choose a more expensive option to do the same things I can already do with the other cheaper solutions?"* (FG6, UK, PBE)

In regard to the *packaging*, both United Kingdom and Italian consumers expressed preferences for a recyclable and environmentally sustainable packaging which will also contribute to reinforce the sustainability message of the plant-based egg. In particular, glass and tetra pack were the preferred materials for the packaging of the liquid plant-based egg. In addition, the Italians expressed preferences for a transparent packaging because this would allow to see the product before purchase. With the powder plant-based egg, preferences were for a bag packaging made of either tetra pack or paper, while with the egg-shaped plant-based egg preferences were for a similar packaging to conventional egg box which would make it easier to identify in the stores, and because cardboard is easily recyclable. However, some Italian participants also mentioned that a similar packaging make it difficult to distinguish one product from another if they are placed in the same isle of the supermarket.

> "*If you want to use the same box of eggs, you should make sure that it is clearly stated on the packaging that it is a plant-based egg and not an egg so that consumers will not be disappointed by opening the box and find something different.*" (FG2, ITA, EPBE)

The United Kingdom and Italy participants showed similar preferences for *country of origin* of plant-based eggs. Strong preferences for a local production were shown due to perceived higher food safety standards, which are particularly important for a new product to increase people's trust. In particular, since the beginning of the Covid-19 pandemic, the participants stated to give more importance to country of origin of foods because it is believed that some countries have higher safety standards (e.g., European countries) than others (e.g., China or the United States).

> "*I think I would check where the plant-based egg has been made and if I see made in America or in China, I would not be happy with it. They have different regulations and safety standards compared to Italy and Europe, so I guess that would have an effect on my personal evaluation of the product.*" (FG3, ITA, PBE)

Plant-based eggs of local origin were also preferred because it supports local economy that has been negatively affected by covid-19 pandemic, and it is a more sustainable product because of lower carbon footprint compared to plant-based eggs from a different country.

> "*If it is imported from far away, the carbon footprint of the plant-based egg will become very big, and it will lose the sustainability claim.*" (FG8, UK, LPBE)

Participants from the United Kingdom and Italy preferred to have the *name* "egg" reported in the label because it would make easier to understand the nature of the product. Furthermore, other names like "substitute" or "plant-based" to differentiate the plant-based egg from conventional eggs should be added alongside. Interestingly, the Italian participants also suggested not to call the plant-based eggs "vegan", which would make associate these products with something specifically tailored to vegans.

> "*I would keep the word egg, but I would not call it vegan, because that would specifically address the product to vegan people, which I do not think is what you want.*" (FG7, ITA, PBE)

4. Discussion

This manuscript explored United Kingdom and Italian consumers' preferences, expectations, and needs for intrinsic and extrinsic attributes for three different types of plant-based eggs, namely the liquid, powder, and egg-shaped plant-based eggs. Given the qualitative nature of the research, the results cannot be generalized to all United Kingdom and Italian consumers. However, some interesting elements emerged which could be used as inputs for further research, as well as a source of

speculation for plant-based egg operators. Despite the differences in terms of income, educational and egg consumption level between the United Kingdom and Italian samples in this study (Apostolidis and McLeay, 2016; Austgulen et al., 2018; Malek et al., 2019), results showed similarities in terms of preferences for plant-based eggs between the two groups. First, in terms of intrinsic attributes, consumers showed preferences for similar colours (e.g., yellow) and taste to conventional eggs. These findings are in line with Cliceri, Spinelli, Dinnella, Prescott, & Monteleone (2018) and Apostolidis & McLeay (2016) who found that both Italian and United Kingdom consumers disliked plant-based foods because of the different colour and taste compared to conventional animal products. However, we found that vegans and consumers suffering from egg allergies were seeking for plant-based eggs that have pleasant taste that not necessarily resemble the taste of conventional eggs as corroborated by Fessler, Arguello, Mekdara, & Macias (2003) for plant-based meat. Our finding of strong consumers' preference for natural colorants is in line with the growing demand of clean labelled foods, which has been registered in the last century (Asioli et al., 2017a). Besides, several food colorants and additives have been banned by the European Safety Authority EFSA and the Food and Drug Administration (FDA) considered to be harmful for humans (Amchova et al., 2015). Second, consumers showed preferences for the liquid and powder plant-based eggs rather than the egg-shaped, because they are more versatile in use and avoid eggshell waste. However, if the use was the same most people preferred the plant-based eggs to resemble the egg shape, except for those suffering from egg allergies and vegans. Third, consumers expressed greater acceptance for the use of legumes as ingredients for plant-based eggs, rather than yeast or algae, because they were

unsure about the safety of the latter, and their effect on taste. Also, they all seemed to agree on avoiding the use of soy, saying that it could have some negative health effects, for example for those suffering from soy allergy. This was also confirmed by Banovic et al. (2018) and Elzerman et al. (2015) who found greater acceptance for using legumes rather than soya for protein enriched foods, and also that a soy label on packaging negatively influenced sensory perception of meat substitutes. Consumers, also highlighted the importance of having a clean label (e.g., short ingredients list) which would reassure them about the safety and quality of the product as corroborated by Asioli et al. (2017). Fourth, consumers stated that the nutrients of plant-based eggs should be similar to conventional eggs, but lower in fat and calories content. Similarly, McCarthy *et al.* (2017) found that lower fats positively influenced the purchase of non-dairy milk alternatives. Fifth, shelf-life emerged an important attribute to plant-based eggs as corroborated by previous studies (Giménez et al., 2008; Petrescu et al., 2020). Sixth, we found that price was a relevant extrinsic attribute with the expectations that plant-based and conventional eggs should have a similar price. This finding is similar to a study from Apostolidis & McLeay (2016) who found that United Kingdom consumers were affected by the price of conventional meat when evaluating the price of plant-based meat. Seventh, consumers mentioned that the safety of plant-based egg production should be certified due to high level of processing involved. This finding is corroborated by Mancini & Antonioli (2020), who found that Italians acceptance towards lab-grown meat increased when it was certified to be safe. Eight, consumers expressed preferences for environmentally friendly and recyclable packaging as also confirmed by Magnier et al. (2016). Ninth, consumers showed preferences for a

local production for the plant-based eggs for safety, sustainability, and economic motivations. This result is in line with Apostolidis & McLeay (2016) who found that United Kingdom consumers preferred meat substitutes of local production. Tenth, our results showed that the names "egg" together with "substitute" or "plant-based" should be used to name the plant-based eggs to avoid consumers' confusion with conventional eggs. The importance of choosing an appropriate name for a new food product has already been proved as being vital for manufacturers as it can potentially impact consumers' acceptance (Frewer et al., 2011).

4.1 Implications for plant-based egg manufacturers and social impact

Several implications for plant-based egg manufacturers can be derived from this study. First, producers are advised to clearly identify their target market to launch the plant-based eggs (e.g., vegans) in order to better develop (particularly from a physical and sensory prospective) and market the product to specific consumers' expectations and needs. Second, no artificial colourants should be added to plant-based eggs. Having said that, the less appealing colour of natural food products is often a deterrent for consumers and some food additives could be a solution to mask such unpleasant feature (Martins et al., 2016). Thus, manufacturers need to find a compromise between these different consumers' needs. Third, given the differences in preferences regarding the shape of these products, plant-based eggs could come in two variants, a more conventional form for the regular consumers and a more adapted form for people with allergies. Fourth, we suggest that the price of the plant-based eggs should be similar to the price of conventional eggs in order to be

competitive in the market. Although this might be challenging to achieve at the initial stage of product launch, it might gradually happen if plant-based eggs are positively accepted by consumers, as well as if manufacturers will be able to grab investor's attention, as it is happening in the plant-based meat market (Piper, 2020). Fifth, it is recommended that in order to be appealing to a broader public, the health benefits, environmental friendliness, and food safety of the plant-based eggs should be certified, and then clearly communicated to consumers. Sixth, plant-based egg producers should use ingredients of local origin as well as certify the food safety production. Last, manufacturers are also advised to expand the applications of the plant-based eggs, and in particular of the egg-shaped plant-based egg which has the biggest limitations, in order to be able to replicate similar uses to conventional eggs and to accommodate the needs of a larger consumers' target.

In addition, the development of the plant-based eggs supply chain might affect the conventional egg supply chain. Similarly to the what would happen if meat alternatives took advantage over conventional meat production (Stephens et al., 2018), we might expect two possible scenarios. One, plant-based eggs might cause a 'substitution effect' leading to a progressive reduction or full replacement of conventional egg supply chain in favour of plant-based eggs. This prospective is expected to reduce the economy around conventional eggs production (e.g., labour, occupation etc.), which can negatively impact local economies especially in low-income countries (e.g., reduction of employment and income, food security, etc.).

In this case, policymakers can support traditional eggs producers in the transition to the production of alternatives like the plant-base eggs.

4.2 Future research avenues

Several research avenues emerged from this study. First, quantitative research should be conducted to test the importance of intrinsic and extrinsic attributes in affecting consumers' acceptance and willingness to pay (WTP) for plant-based eggs also to compare with costs of production useful for cost and benefits analysis. Second, it would be interesting to explore and compare consumers' acceptance for plant-based eggs from both developed and developing countries, given the increasing protein demand in the latter in recent years (Masuda and Goldsmith, 2012). Third, there is need to investigate preferences, habits, and attitudes of specific consumers' segments, such as consumers suffering from egg allergies or intolerance, vegans, vegetarians, or flexitarians as possible targets for launching plant-based eggs. Last, sensory tests coupled with real choice experiments or experimental auctions in a real market scenario (Alfnes and Rickertsen, 2010; Asioli et al., 2020; Lusk and Shogren, 2007) using real products should be conducted to investigate consumers' preferences and WTP for plant-based eggs to get more realistic information with external validation.

5. Conclusion

To conclude, our findings revealed that both intrinsic and extrinsic attributes play a key role in consumers' acceptance of the different prototypes of plant-based eggs. Differences emerged among the two countries in analysis, as well as between consumers following different types of diet (e.g., vegans). These findings provide new insights that can be used for developing and marketing plant-based eggs to better meet consumers expectations and needs for plant-based eggs.

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Transparent reporting

Pre-registration of the study is available at: https://aspredicted.org/blind.php?x=wi6ph3.

Appendix A

FGs protocol

1) DISCUSSION WARM UP (10/15 minutes)

- (*Welcome participants and presentation of myself and of the aim of the research*): Welcome everyone and thank you for joining this group discussion today. I am Agnese Rondoni, PhD student in Consumers' Behaviour at the University of Reading. The aim of today's discussion is about investigating on consumers' preferences about new alternatives to eggs.
- Ask participants to briefly present themselves (e.g., name/nickname, profession, place of living etc.).
- The participants information sheet below will be given to participants now.

2) EXPLORING CONSUMERS' PREFERENCES FOR INTRINSIC AND EXTRINSIC PLANT-BASED EGG ATTRIBUTES

(*Questions about consumers' preferences for plant-based egg intrinsic attributes*) Going a little more in details, we would like to know what do you think about plant-based egg colour? [Prompts: Which colour would you prefer? Pallid or bright yellow?]

1. What do you think about the shape of this product? [Prompts: Do you like the fact that it is liquid? Or would you want it to look more like an egg?]

2. What are your expectations about the taste of the plant-based egg? [Prompts: How would you prefer it to?]
3. What do you think about its ingredients? [Prompts: This one is made of mung beans. Would you prefer other ingredients to this one?]
4. About the plant-based egg nutritional values, is there anything you would prefer it to have? [Prompts: How would you want the level of proteins/vitamins/fats to be?]
5. What do you think about the method of production? [Prompts: This one is made through protein isolation. What do you think about it? Would you like it or not? What do you think that the production is animal-free? What do you think that the production is environmentally sustainable?]
6. (*Questions about consumers' preferences for plant-based egg extrinsic attributes*) What do you think about its price? [Prompt: How much do you think is a reasonable price for this product?]
7. What do you think about plant-based egg packaging? [Prompts: Do you want it to be recyclable?]
8. Any preferences in terms of country of origin for this product?
9. How would you prefer the plant-based egg to be named? [Prompts: Would you keep the name "egg" to call it?]
10. (*Questions about consumers' preferences for the use of the plant-based egg*) What do you think about its usage? [Prompts: How would you like to be able to use plant-based eggs?]

Appendix B

Examples of interview transcripts

FG1 UK audio transcript – Egg-shape plant-based egg

16/05/2020 (10 people)

Moderator: Thanks everyone for joining this focus group research. Now we are going to be talking about your preferences and expectations about different aspects of the plant-based egg. For example, in relation to taste, what would be your preference? Do you have any expectations?

Aaron (30, M): I think, personally, the taste should be the same as an egg.

Katie (36, F): Yes, I also believe that the taste should be there. Otherwise, there is no point of calling it plant-based egg or egg substitute. It is just something else.

Olivia (18, F): Same, I would also expect the plant-based egg to have the same taste as eggs and the same consistency.

Chris (47, F): I agree. I eat eggs every day, so I would miss the taste of eggs, if the plant-based egg had a different one. Also, I would be disappointed to buy an alternative to eggs and then figure out that it has all a different taste.

Katie (36y, F): To me personally, the taste does not necessarily need to replicate the egg's taste. It just needs to be palatable.

Sian (31, F): To me, although the (egg) taste should be there, I always add spicy when I cook, or salt etc. so I can adapt it to my personal taste rather than others' taste.

Moderator: What are your expectations in terms of the shelf-life of the plant-based egg?

Duncan (34, M): It was me. When I saw the product I immediately thought, where should I keep it? Is it in the fridge? It would be nice if it had a longer shelf-life than eggs.

Stacey (31, F): I agree with Duncan, the shelf-life should be longer than eggs. Eggs run out very quickly and especially if you have children and your household size is big, eggs are the best source of nutrition you can have, but they do not last long. So, I think if the plant-based egg could have a longer shelf-life, that would be a major benefit.

Amy (34, F): I personally eat eggs every day, so shelf-life has not been a problem for me in the consumption of eggs. Having said that, a shelf-life would still be essential, like in every food product.

Katie (36, F): Also, to me the shelf like would be important. Although sometimes the shelf-life causes issue and increases the level of waste in the supermarkets. So, I think it is nice to have a shelf-life, but it should be realistic and should be helpful to indicate a good degree of condition of the food, which is acceptable for human consumption.

Chris (47, F): I also eat eggs every day like Amy, so I rarely waste eggs. A similar shelf-life to normal eggs would be fine for me.

Moderator: What are your expectations in terms of the nutritional values of the plant-based eggs?

Alexis (52, F): To me, the main reason why I consume eggs is because they contain a good level of protein. So, my expectation for the plant-based egg would be to have at least the same level of proteins as normal eggs.

Olivia (18, F): Yes, I do agree. But I would be interested to know about the nutritional values of the plant-based egg in general, so say the level of zinc is important, the omega-3 etc.

Katie (36, F): To me it would be nice if the plant-based egg could contain even a higher level of protein than conventional eggs. I would be happy to see if there is an actual benefit in the plant-based egg from a nutritional perspective which is instead missing in eggs.

Amy (34, F): I agree, a higher level of protein than eggs would be nice.

Sian (31, F): To me protein level is certainly important. However, if I see that the level of protein is consistently higher in plant-based food egg than in normal eggs, I will wonder why, what do they do to increase the level of protein so significantly?

Aaron (30, M): Agree, it should contain a good level of protein, but not too much. Also, all the other nutrients, omega-3, vitamins should be there.

Chris (47, M): I think everyone is aware of eggs' very good nutritional values, so I think maintaining the same nutritional values of eggs in the plant-based egg would be good for consumers.

Moderator: What do you think that the plant-based egg is a cholesterol-free product?

Alexis (52, F): I think that is a really good thing. Actually, especially for people at my age, I think it may be a very important factor.

Katie (36, F): To me also, the cholesterol-free is an appealing factor. My dad suffer from high cholesterol, he has to control and manage it, and that is a challenge not just for him, but also for us as family members when we have to decide what to cook and prepare for lunch or dinner.

Duncan (34, M): Honestly, as I do not suffer from high cholesterol, and none in my family does is not something I would very much look into. But I guess it is good for people with high cholesterol.

Aaron (30, M): Same for me, I am young, and I do not have cholesterol issues, so that would not be an important factor for me to decide whether to buy the plant-based egg or not.

Moderator: What are your preferences about the shape of the plant-based egg?

Aaron (30, M): I do not really see the shape of an egg to be important to me. I think it may be important for people who are buying products like replacements to meat, to try and get into a reduction of animal products because having a product that they can associate with something that they have eaten before is an easy way for them to get into it. But personally, a different shape from the conventional eggs would not bother me. I would rather just have some tofu and make some scrambled tofu or to make some avocado on toast or something like that.

Moderator: I see. Does anyone want to add anything on this?

Stacey (31, F): I am someone who is trying to eat more plant-based, and I do consume regular eggs right now, also because there are not many alternatives in the market right now. I similarly do not care so much about the shape, I think it is nice to have because it is easier to replicate the slicing you can do with hard boiled eggs, or replicate the boiling, but actually to me, I would prefer to something that could resemble the taste and making it more functional. I would very much take a non-eggy looking product, that you can also fry and scramble.

Katie (36, F): To me, the egg-shape would put me off. We know it is not an egg. I do not like the idea of the wax. For me, I would just have it in the bottles and stuff like that, so that I can have a more flexible approach and be able to cook it.

Sian (31, F): For me, I would like the plant-based egg to replicate the shape of an egg and that is for my personal relationship with eggs. My diet is 90% plant-based, mainly for health issues I had in the past and I found that being plant-based has alleviated some of the symptoms. But I still eat eggs. And for me, I want to be able to use a plant-based egg in the same way I would use eggs, so I want the whole experience of breaking the eggshell and things like that. So, it is more an emotional attachment to eggs.

Amy (34, F): I personally love eggs. I love how they taste, and I love cooking with them. So, I would really miss their rounded shape if it had a different one. Also, I think if it had the same shape off an egg, it would be more easily recognizable as an alternative for eggs in the supermarkets.

Moderator: What do you think about the ingredients of the plant-based egg? What characteristics they should have?

Aaron (30, M): You said that the albumen is pea protein and the yolk is algae protein, right?

Moderator: Yes, that is correct.

Aaron (30, M): My experience with pea protein is that it tastes disgusting.

Chris (47, F): I do not have much experience with peas or algae taste as ingredient for plant-based foods, so I do not have much to say. My biggest concern is that they may affect the taste. I mean, how can a pea taste like an egg?

Amy (34, F): I also do not have much experience with products made of pea proteins or algae. Maybe I am bit more sceptical about the algae, because it is something that I have never consumed before.

Alexis (52, F): Same, I was a bit concerned about the algae. Could we maybe have organic algae, or at least something that would prove us that they are safely produced? I think that would decrease the level of scepticism towards it.

Sian (31, F): Me, I am not keen on the soya side, so for me to have an alternative to soya is preferable. So, pea protein would be fine with me. I have seen a lot of plant-based products are made with mushrooms. Although I am not a big fan of mushrooms, I would still be fine with that. But not soya. If soya is in the ingredient list, the product just does not go into my basket.

Clare (40, F): I do not mind the idea of pea or algae as source of protein. My only concern is what colour would the product end up, that was my main concern. And also, if you remove the green colour, then how highly the product is being

processed, because I normally try to avoid thing being very processed. That would be my main concern.

Moderator: What would you expect to use the plant-based egg for?

Alexis (52, F): For me, one of the benefits of eggs is that it is such a versatile product in terms of, you can have scramble eggs, poached eggs, you can use it for baking, so it would be nice to have a couple of more uses. Obviously, it is great that you can have hard-boiled egg, but I think it would be useful if it could be scramble as well, for example.

Alexis (52, F): Yes, I think it is essential that the plant-based egg could replicate all the egg functionalities, otherwise people will keep using normal eggs as they are more versatile.

Olivia (18, F): I do love baking, so the main thing I would miss is the possibility of separating the yolk and the white in the plant-based egg.

Duncan (34, M): I would love to use the plant-based egg to make fried eggs which is something I consume pretty often.

Aaron (30, M): Personally, I do not think you can replicate eggs. Maybe you can use other things like chia seeds for baking, but I do not think you can create something that replicates all eggs' functionalities, so I would not expect that.

Sian (31, F): As I said earlier, I would like to break the eggs and use the plant-based egg in the same way to make scrambled eggs, omelettes, cakes, and things like that.

Stacey (31, F): I agree with the others on this point. I would also like to have the possibility of separating the yolk and the white. I think many people may be interested to eat the white only, like the sportsmen.

Moderator: Many of you wrote terms in relation to the price of the plant-based egg. What are your expectations in this sense?

Amy (34, F): When we talk about price, we should take into consideration that eggs are a ridiculously cheap product. People will compare the price of the plant-based egg with the price of chicken eggs, that is natural. If the price of the plant-based egg is much higher than the price of conventional egg, then I am afraid it will not have many chances to succeed.

Katie (36, F): I think the same honestly. Eggs are one of those foods that you buy at the supermarket without thinking too much about it because the price is little. I do not think consumers will want to put extra money on their grocery shopping than what they already do to buy something more expensive.

Alexis (52, F): That is true. Although I have to say, I believe it will very much depend on how many consumers suffering from egg allergies are out there. Or how many vegans. I believe these people may be willing to spend more.

Aaron (30, M): I am vegan. However, I think I would be able to pay more for a plant-based egg only if it had amazing nutritional values. Like more iron and proteins which may lack in a vegan diet. Still the price should not be too high though.

Duncan (34, M): I am not vegan, and I do not suffer from gg allergies, but I do believe that the cost of the plant-based egg should still be acceptable for everyone, not matter who, otherwise I do not think people will buy it. This because vegan people who those who have been allergic to eggs all their life, they know how to live without eating eggs. They do not need to spend crazy money for a substitute.

Olivia (18, F): Yeah, that is a good point, I agree.

Moderator: What do you think about the packaging of this product? Do you have any preferences?

Olivia (18, F): As it is an eco-friendly product, I would definitely think about a packaging that does not contain any plastic.

Stacey (31, F): Same to me. It should necessarily be environmentally friendly.

Alexis (52, F): Agree. It should definitely be plastic-free. Or maybe some recycled plastic could be used.

Sian (31, F): When I saw the sustainable claim on the video, I also assumed that the packaging would be recyclable or compostable or things like that.

Katie (36, F): I think it would be nice to replicate the same packaging as normal eggs. It would make it easier for the people to recognize that it is a new substitute for eggs in the supermarket.

Duncan (34, M): I would also like to have the same packaging as normal eggs. I think if you place the plant-based egg next to normal eggs and have the same packaging, that will make easier for the consumers to find and figure out about this new product.

Moderator: What do you think about the sustainability claim for this product?

Sian (31, F): I think it is very positive. I have tried to be vegan in my life for a while and one of the main reasons were sustainability reasons. It would definitely be a plus for me.

Katie (36, F): For me too.

Aaron (30, M): I am vegan because I care about animals' lives as well as about being more sustainable for the environment. So, that is a very important aspect for me.

Stacey (31, F): I agree. I think all citizens should be committed to sustainability nowadays.

Alexis (52, F): That is true. Although I have to say that it is not always easy to behave sustainable or to make sustainable choices because the price of sustainable products is normally much higher than the other products.

Duncan (34, M): That is so true.

Moderator: What would be your preferences about the country of origin for the plant-based egg?

Olivia (18, F): I would like a local production for this product, because I know that the safety standards of our country are very high.

Katie (36, F): Yes, me too.

Sian (31, F): Agree. I believe this could incentivize our economy too.

Stacey (31, F): Yeah, that is right. I think we need more local production, especially now after the pandemic, the economy will be bad.

Clare (40, F): That is true. I think everyone agrees that we would be happy to see a made in the UK claim on the plant-based egg. Because that will mean safety, as well as more jobs opportunities. It will be an extra chance for our economy.

Moderator: What do you think about the method of production of the plant-based egg? What would be your preferences in this regard?

Duncan (34, M): I cannot say that I have fully understood the method of production of this product fully from the videos, but I guess that is okay, that would happen anyways if I find it in the supermarket I would not know how it is made 100%.

Clare (40, F): Me neither. I would say that what would matter to me is that the product is safe to eat.

Amy (34, F): My understanding is that it is a lab-made product, am I right?

Katie (36, F): I understood so too. I think the lab-made claim should be carefully communicated to consumers. I think the producers should be transparent on how this product is produced, but I also believe that a wrong communication could give the wrong impression of this product to the public.

Stacey (31, F): I agree with that.

Olivia (18, F): Especially the older generations, I think they should be educated to these new processed foods before being able to fully accept them.

Moderator: What would you prefer about the name of the plant-based egg? Would you keep the name "egg" to call it?

Katie (36, F): Honestly, to me the problem with this product is with his name. Because you call it plant-based egg, but it is effectively a hard-boiled egg. So, if you change the name and you can call it plant-based hard-boiled egg, I think that would explain better the nature of the product, and it would be more specific as well.

Sian (31, F): Yeah, I would agree with that. You may also want to add words like "substitute" rather than plant based. I think people would associate the words "plant based" or "vegan" to something specifically referred to vegan consumers.

Stacey (31, F): Yeah, that is a good point to me as well. What I think is, you should definitely keep the word "egg" in it because otherwise people would just not understand what the product is all about.

Alexis (52, F): I agree you should keep the word "egg", at least to give people an understanding of what the product aims to replicate.

Duncan (34, M): Agree.

Amy (34, F): I agree to keep the word "egg" to call this product, but you necessarily have to put other names like "substitute" or "replacer" or "alternative" next to it to make it clear it is not like an egg and people should not expect to do the same things with it they would do with eggs.

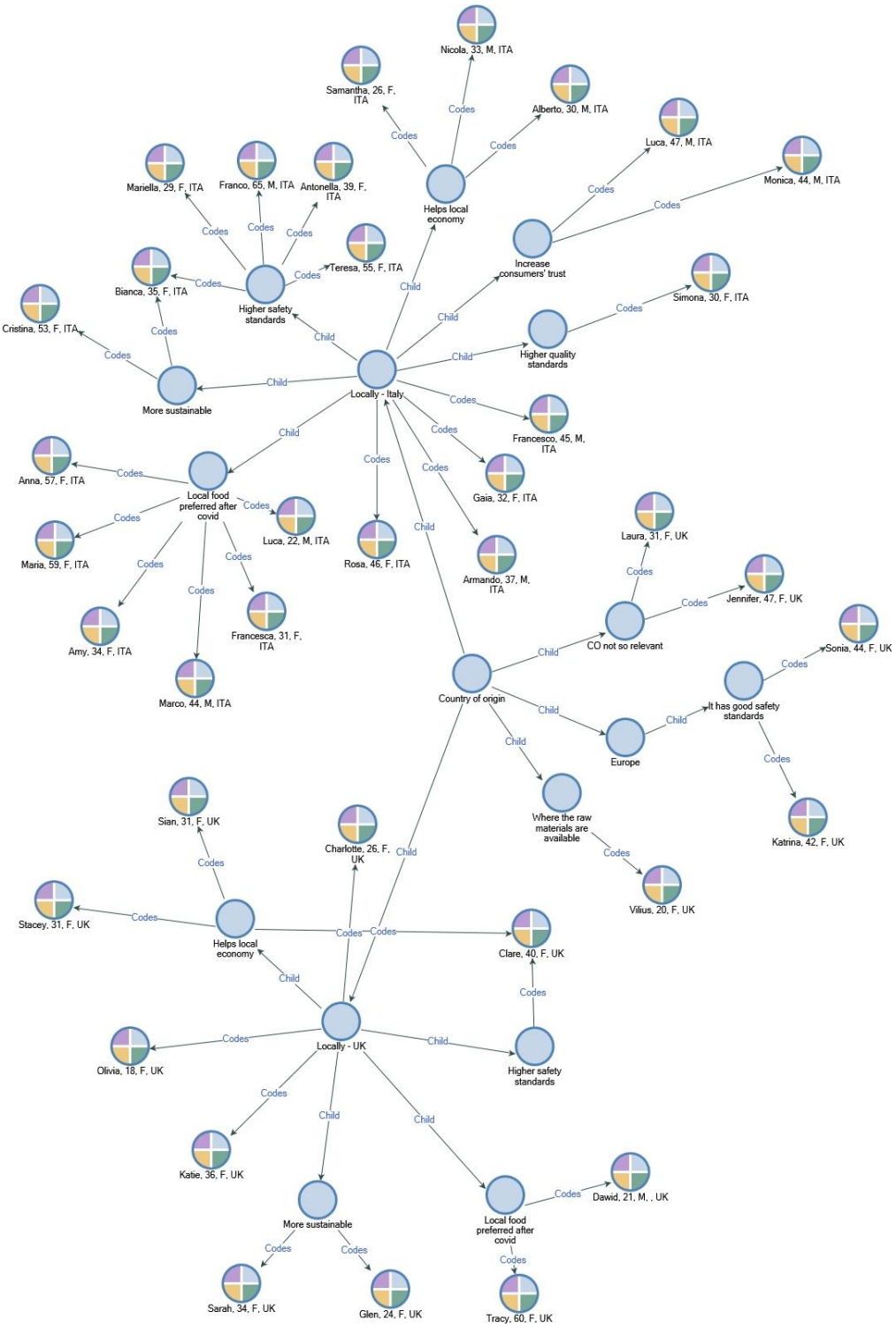
Clare (40, F): Maybe you could add a couple of recipes on the packaging to show consumers how to use it and what could be done with it, so that consumers will be clear on that.

Moderator: Thanks all for joining this focus group session today. Hope you enjoyed it!

Appendix C

Example of map created with Nvivo during the coding process

Country of origin



Chapter V - **Effects of Different Communication Channels on Consumers' Preferences and Willingness to Pay for Plant-based eggs**[15]

[15] This article has been sent out to journal in September 2021 for publication consideration.

Abstract

Plant-based eggs provide consumers with a healthy, animal-free, and more environmentally sustainable alternative to conventional eggs. Knowing how to best communicate these benefits to consumers before launching them into the market is vital to create efficient marketing campaigns. In this study the effects of three communication channels (company website, social media, and labels) on consumers' demand for plant-based eggs have been investigated for the first time. A labelled choice experiment was employed with 814 United Kingdom consumers, who were randomly allocated to four treatments which varied in the type of communication channel and then were asked to make choices between five different eggs alternatives (cage, barn, free-range, plant-based made with peas, and plant-based made with soybean). Results show that holding price constant and posing the condition of choosing one product, free-range eggs were the most preferred option, followed by barn eggs, plant-based eggs made with peas, cage eggs and plant-based eggs made with soy. We also found that social media was the most effective communication channel for increasing consumers' willingness to pay for plant-based eggs made with peas, followed by product labels. Furthermore, we found that most consumers (71%) oppose to use the word "egg" for labelling plant-based eggs. These findings provide producers with insights about the most appropriate channel to effectively communicate the benefits of the plant-based eggs to the public, and useful information for future labelling policies.

Keywords: Consumer willingness to pay; Plant-based eggs communication; Company website; Social media; Label; United Kingdom.

1. Introduction

Eggs are one of the most important, widespread staple food around the world, rich in high-quality proteins, available at low prices, and consumed on a large scale (Lesnierowski and Stangierski, 2018). The demand for eggs is expected to increase of 30% by 2030 as result of the growing global population (International Egg Commission, 2015). However, the production and consumption of eggs create several concerns related to human health, animal welfare and the environment (Rondoni et al., 2020). For example, there is an increasing number of health diseases related to egg consumption such as allergies, and eggs are considered to be a major food allergen worldwide (Shah and Walker, 2001). Globally, more than 8% of children suffer from egg allergy at 12 months of age (Loh and Tang, 2018). Further, eggs contain high levels of cholesterol (Brown and Schrader, 2006). Studies indicated that for each half egg consumed per day, people have a 6% higher risk of developing cardiovascular diseases (Ayim-Akonor and Akonor, 2014). In addition, most of the egg hatcheries worldwide still follow a cage-based system, where hens have limited space to freely move, and this causes concerns among consumers (Ochs et al., 2019; UEP, 2017). Lastly, the intensive production system of eggs causes concerns from an environmental perspective. To illustrate, egg industries alone responsible for about 9% of the total emissions of livestock production (FAO, 2016) due to the abundant use of cereals for feeding the hens, large extensions of land, water, and energy (Dekker et al., 2011; Leinonen et al., 2012).

These critical issues and challenges, combined with the increasing and complex consumer demand for healthful and sustainable food products (Grunert et al., 2014), have prompted the production of alternatives to animal-based eggs, like the plant-based eggs. Plant-based eggs are produced by extracting the proteins contained in vegetable sources, such as peas, soy, yeast, etc. through fermentation or isolations processes (The Good Food Institute, 2018). Compared to conventional eggs, plant-based eggs are claimed to have several advantages. To describe, they are allergen-, cholesterol- and animal-free, and their production is environmentally more sustainable than the production of conventional eggs (The Good Food Institute, 2018). Different prototypes of plant-based eggs have been developed so far. An example is the liquid plant-based eggs, which is produced, among others, by the US companies JUST ltd. and Spero Food, already approved for commercial sales by the Food and Drug Administration (FDA), and is now available in the US (Gilliver, 2019). Another prototype is the egg-shaped plant-based egg, which is produced, among others, by the University of Udine (Italy) using soy or green peas and replicates the more conventional shape of a conventional egg (Askew, 2017). The egg-shaped plant-based eggs are yet unavailable in any market worldwide and will have to satisfy rigorous food safety standards before being approved by Food Safety agencies worldwide (Stephens et al., 2018). In addition to these safety and regulatory issues, consumers' acceptance for these new products is another key challenge (Rondoni et al., 2021a). In fact, the adoption of plant-based eggs from consumers will determine its success in the market.

So far, only few qualitative studies have explored consumers' perceptions and preferences for plant-based eggs (Rondoni et al., 2021a, 2021b). In particular,

Rondoni et al. (2021a) investigated consumers' perception of plant-based eggs and found that 'price', 'health' (e.g., cholesterol- and allergen-free) and 'sustainability' were the most frequent associations that came to people's mind in relation with these products. In addition, Rondoni et al. (2021b) explored consumers' preferences for different attributes of plant-based eggs and found that egg eaters were looking for characteristics similar to conventional eggs (e.g., colour, smell, texture, price). On the contrary, vegans and people who cannot eat eggs, either because they suffer from egg allergies or because of high cholesterol, were not necessarily looking for characteristics similar to conventional eggs, but for a pleasant taste and a reasonable price (Rondoni et al., 2021b). However, a study exploring consumers' preferences for plant-based eggs quantitatively is yet missing. This study adds to the promising research on this topic by assessing consumers' preferences and willingness to pay (WTP) for the egg-shaped plant-based eggs using a discrete choice experiment (DCE) method (Balcombe et al., 2016b; Janßen and Langen, 2017; Yang and Hobbs, 2020). In addition, it explores the effects of communicating the benefits of plant-based eggs (e.g.., cholesterol- and allergen-free, animal-free, and environmental sustainability) using different communication channels (e.g., company website, social media, and labels). We investigated United Kingdom (UK) consumers because this country is the third largest market for eggs in Europe (UK Government, 2020a). According to the British Egg Industry Council (BEIC), in 2019 more than 13 million eggs have been consumed in the UK, with a per capita consumption of 197 eggs. This number is expected to increase further due to the growing number of flexitarian consumers in the country, who find eggs to be a good

and widely available source of proteins as an alternative to meat (The Vegan Society, 2017).

This study makes several contributions to the nascent literature on plant-based food consumption. First, to the best of the authors' knowledge, this study is the first to attempt to estimate consumers' preferences and WTP for plant-based eggs. Second, this research is the first to investigate the effects of different communication channels on consumers' preferences and WTP for plant-based eggs. Third, consumers' preferences for labelling of plant-based eggs in relation to whether the word "egg" should be used to name these new products have been explored, which is of particular relevance to policy makers. The insights brought by this research will be relevant not only to plant-based eggs manufacturers, but also to policy makers engaged in promoting healthier and more sustainable eating behaviour. This research also contributes to further expand the existing academic knowledge towards the effects of different communication channels on consumers' acceptance and willingness to pay for plant-based foods, about which little is still known.

2. Background

The information that consumers receive is likely to affect their behaviour towards the products they purchase. For example, Ye and Mattila (2021) found that information on health and social consequences of meat consumption increased consumers' preferences for plant-based meat

alternatives. Similarly, Weinrich (2018) concluded that communicating the health benefits of meat substitutes may increase the market share for these products. Concerning plant-based eggs, producers may want to communicate to consumers three main benefits of these new products, namely, health (e.g., cholesterol- and allergen-free), "animal-free" and environmental sustainability benefits. However, depending on the channel used to communicate those benefits, the information can be presented in different ways. Government agencies or scientific organizations, for example, use a scientific and impersonal language (Yang and Hobbs, 2020). Research shows that information about benefits of GMO foods provided by governments and third party organizations increases consumers' WTP more than information from private organizations, media communications, etc. (Huffman et al., 2004). Other channels that have been used to communicate food benefits' information to consumers are television, newspapers, radio, Internet (e.g., blog, social media etc.), instead use a more engaging and consumer friendlier style of communication (Barnett et al., 2011). Another way to communicate food benefits to consumers is by using food labels, in which the message is framed in a word or short phrase. Research shows that health label claims communicate well potential health benefits of functional foods to consumers (Lähteenmäki, 2013; Verbeke et al., 2009). Indeed, nowadays companies have several communication channels to choose from when designing their marketing communication strategy. However, because the selection of one communication channel over another requires efforts both in terms of financial resources and the employment of manpower in the creation of a strategic communication plan (Pan et al., 2019), it is vital for industries to choose the most effective ones based on consumers' responses. In this study we

compared three types of communication channels available to plant-based eggs companies to market their products, such as the company website, social media, and product labelling. Furthermore, we also looked at consumers' preferences for plant-based eggs labelling, which might affect their behaviour. Recently, there has been a growing debate in terms of the labelling requirements for plant-based food alternatives, in particular regarding whether animal food-related terms (e.g., burger, sausage, milk etc.) can be used to label such products, as this could mislead consumers on their real nature and composition (Carrenõ and Dolle, 2018). In Europe, this led to severe consequences and products like plant-based milk substitutes, for instance, cannot longer be labelled as 'milk', but only as 'beverages' or 'drinks' (e.g., soy/almond/rice beverages/drinks) (Court of Justice of the European Union, 2017).

3. The experiment

Experimental design

UK consumers' preferences for plant-based eggs were elicited using a labelled DCE. The choice of using a labelled design was made to avoid participants being prompted with too many information as one of the treatments already included the use of labels. Adding more attributes, in fact, could increase consumers' tiredness and add fatigue in the completion of the choice tasks. Price was kept as the only attribute as it is fundamental to estimate willingness to pay. In addition, labelled design is much less common than unlabelled and this adds some more novelty to the research (Balcombe et al., 2016a; Caputo et al., 2020; Janßen and Langen, 2017;

Rahmani et al., 2019; Van Loo et al., 2020). Participants were faced with 12 repeated choice questions, each composed by the following five egg products: free-range eggs, barn eggs, cage eggs, plant-based eggs produced with peas and plant-based eggs produced with soy. These products have been selected based on the UK national retailer sales. In particular, free-range eggs form the 67% of the total market, barn eggs the 23% and cage eggs the 10% (UK Government, 2020a). Organic eggs were excluded from the design as they only represent a tiny proportion of the UK egg market (0.2%) (UK Government, 2020a). In addition, the choice of not adding an extra option was made to limit consumers' fatigue given that they were already prompted with six different alternatives to choose from for each choice task. Having said that, it is to acknowledge that not displaying all the available products may misrepresent the scenario that consumers would normally face when buying eggs, it must be noted that they also had the chance to not buy any product in case they did not like any available alternative. Among the different prototypes of plant-based eggs, in this study the egg-shaped plant-based eggs have been tested. These products have been selected because they are one of the most promising prototypes due to their similar characteristics to conventional eggs and because they are yet unavailable in the supermarkets, and thus there is no scanner data available on these products worldwide. As the egg-shaped plant-based eggs are made either with peas or soybeans, we added both alternatives in the choice sets. The selected packaging size was a box of six eggs, being the most purchased type in the UK (UK Government, 2020a). The egg products were priced at six price levels, such as £0.90, £1.65, £2.55, £3.45. Price was kept as the only attribute as it is fundamental to estimate WTP. The price range was selected to resemble the price

of boxes of six eggs in the UK in stores, supermarkets and street markets (UK Government, 2012). An example of choice set is provided in Figure 1 below.

Figure 1. An example of choice set

The next step was to create the experimental design. An experimental design describes which hypothetical choice situations the respondents are faced with in the stated choice experiment. In order to obtain the design, the experimental setting is added in Ngene in a table of numbers in which each row represents a choice situation. The numbers in the table correspond to the attribute levels for each attribute. Different coding schemes can be used for representing the attribute levels in the experimental design. We used a linear sequence of number (e.g., cage eggs = 0, barn eggs = 1, free-range eggs = 2 etc.), which is also the most widely used type of coding. Given our experimental setting (five product types and four price levels), there were 1024 (4^5) possible choice sets. To reduce the number of options, a simultaneous orthogonal fractional design using the Ngene software was employed to reduce the number of choices to 48. However, because 48 choices were still too many for a single respondent, blocking technique was used to reduce them further. With the blocking technique, the design is reduced into smaller parts. Each block is not orthogonal by itself, only in combination with the other blocks. However, attribute level balance is

maintained within each block as much as is possible. In our case the design consisted of two blocks, which was computed in Ngene by adding the instruction ";block = 2". Within each block, the price levels of each egg type are uncorrelated with the price levels of the other egg products. This resulted in a total of 12 choice questions per participant. The DCE was introduced to consumers together with an explanation and description of the attributes and levels. Before proceeding with the choice questions, the respondents were told to imagine to be shopping in a grocery store. We also included a cheap talk (CT) script to mitigate hypothetical bias (Silva et al., 2011). The questionnaire is available in Appendix A.

Treatments

This study also assesses the effects of different communication channels (the company website, the social media, and the labels) on consumer preferences and demand for plant-based eggs. To achieve this objective, we implemented a between-subject approach, whereby participants were randomly assigned to one of four treatments displayed in Table 1.

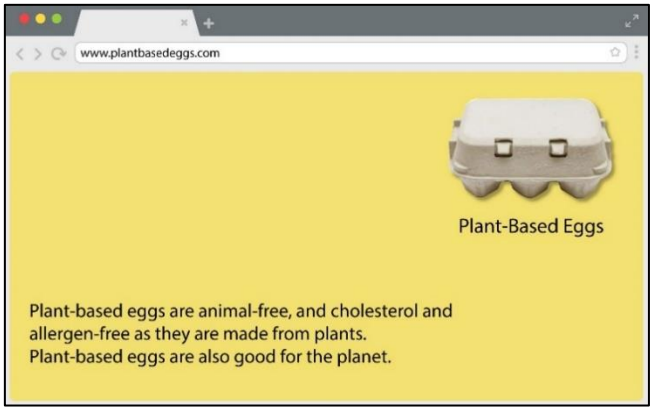
Table 1. Study treatments

Treatment No.	Description
1	DCE survey + No information
2	DCE survey + Company website communication
3	DCE survey + Social media communication
4	DCE survey + Label communication

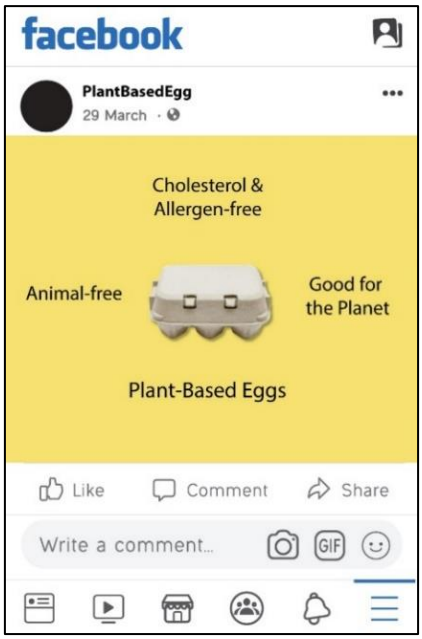
Treatment 1 (Control) is the control treatment, where respondents were provided with no information about the plant-based eggs. Treatment 2 (Website) and Treatment 3 (Social media) are the company website and social media treatments, respectively, in which information about the benefits of plant-based eggs, the health, animal and environmental benefits were communicated with two images recreating a company website and a Facebook page (Figure 2). Because no marketing material is yet available from companies producing the egg-shaped plant-based egg, the marketing communication of the largest plant-based egg company worldwide which produces the liquid plant-based egg, JUST Ltd. (Food Navigator, 2019; Watson and Shoup, 2019) was taken as landmark to create the treatments used in the experiment by using a similar design and communication style. In Treatment 4 (Labels), the same messages were conveyed using labels exogenously applied on the boxes of the egg products (Figure 2). Following Yang & Hobbs (2020), efforts were made to maintain content consistency across the three communication formats. Once the treatments were developed, they were pretested

by a small pilot group to check the plausibility and reliability of their content, as well as to assess the information homogeneity across the three messages.

a)



b)



c)

Figure 2. Examples of communication channels developed for Treatments 2, 3 and 4: a) Company website communication (top), b) Facebook (social media) communication (middle), c) Label communication (bottom).

4. Data

The data were collected through a nationwide online survey with UK consumers and run in March 2021. The survey was administered by a professional recruiting company Qualtrics LLC. We obtained informed consent from all participants in the study, and our study was approved by an institutional ethical clearance board. To ensure data quality, we took two main steps. First, to stimulate respondents to pay extra attention to the subsequent questions, we asked whether they have "devoted full attention to the questions so far", and whether, in their honest opinion, they believe we should use their responses for the study (see the questionnaire in Appendix A). We strategically placed this question right before the most important questions, such as the CE tasks. Second, we included in the study only consumers who took more than one-third of the median time duration to complete the survey. After the DCE, participants were asked questions about their preferred sources to gain information about the food they purchase in order to determine the relationship between this information and the different information channels proposed in the treatments.

Participants were selected based on gender, age, and income quotas in line with the UK national statistics. The age range was limited between 18-75 years old, and respondents should be responsible for at least half of all their household food shopping. In total, 814 completed responses were collected. Table 2 shows socio-demographic characteristics of the sample. In terms of gender, the sample was composed of 51.0% females and 49.0% males, which is in line with the UK population census data, composed of 50.64% females and 49.36% males (UK Government, 2020b). Regarding age, 16.1% of consumers were 18–32 years old, 24.4% were 33–46 years old, 32.90% were 47–61 years old and 26.6% were 62–75 years old, which is similar to the UK census of 27.30%, 25.09%, 27.99% and 16.63% respectively for these age groups (UK Government, 2020b). Almost 50% of the sample had annual income before tax less than £40,000 and 50% over £40,000. Most respondents (57.4%) have a household size of 2-3 people and more than 50% live in suburban areas. In terms of education, almost 85% of the consumers had at least an undergraduate university degree. Table B1 of Appendix B reports the socio-demographic characteristics of the sample by treatment and shows that the sample is not statistically different across the four treatments in terms of gender, age, level of education, household size, and living area, whereas it is statistically significant in terms of income and employment situation.

Table 2. Socio-demographic characteristics of the sample

Socio-demographics	Sample (%)
Gender	
Male	49.0%
Female	51.0%
Age	
18-32 years	16.1%
33-46 years	24.4%
47-61 years	32.9%
62-75 years	26.6%
Annual household income before taxes	
Less than £10,000	4.3%
£10,000 to £39,999	46.0%
£40,000 to £69,999	34.9%
£70,000 to £99,999	10.4%
£100, 000 to £150,000 or more	4.3%
I do not want to declare/I do not know	0.1%
Level of education	
Primary school	0.9%
High school	27.1%
Higher education (not university)	25.0%
Bachelor's degree	33.0%
Master's degree	11.1%
PhD	2.5%
Household size	
I live alone	20.5%
2-3 people	54.7%
3-4 people	18.7%
5-6 people	5.5%
7 or more	0.2%
Living area	
Urban area	28.4%
Suburban area	50.9%
Rural area	20.4%
Employment situation	
Student	2.0%

Independent worker (e.g., consultant)	6.7%
Private-sector worker	31.3%
Public-sector worker	13.8%
Part-time employed	12.0%
Retired	19.4%
Unemployed	3.7%
Not in paid employment (e.g., homemaker)	8.5%
Other	1.2%

5. Econometric analysis

DCE is based on the random utility theory which assumes that the utility *U* that an individual *n* derives from alternative at choice questions *t* can be expressed as $U_{njt} = V_{njt} + \varepsilon_{njt}$ (McFadden, 1973), where $V_{njt}$is the systematic component of the utility function, and ε_{njt} is the independently and identically distributed random term with an extreme value type-I (Gumbel) distribution. Given our experimental setting, V_{njt} can be expressed as follows:

$$V_{njt} = \alpha_j + \beta Price_{njt} \quad (1)$$

Where α_j is an alternative-specific constant indicating utility for alternative j relative to the opt-out option, which is normalized to zero for identification purpose. In this application the alternative specific constants are represented by cage eggs, barn eggs, free-range eggs, plant-based eggs made with peas, and plant-based eggs made with soy; β is the marginal utility of price, and $Price_{njt}$ is the price of alternative j faced by consumer n when faced with choice question t.

The data were analysed using a random parameter logit (RPL) model in Nlogit software for panel data as previous studies show that consumer preferences and demand for plant-based products are indeed heterogenous (Slade, 2018; Van Loo et al., 2020; Ye and Mattila, 2021). As shown in Train (2009), considering a sequence of choice alternatives, one for each time period **i** = **(**i_1,..., i_T). The unconditional probability that individual n makes this sequence of choices can be expressed as follows:

$$\{P_{nj}\} = \int_{\beta_n} \int_{\alpha_n} \prod_{t=1}^{T} \frac{V_{nj}}{\sum_j e^{V_{nj}}} f(\beta_n \alpha_n | \mu, \Omega) d\beta_n d\alpha_n \quad (2)$$

Where $f(\beta_n \alpha_n | \mu, \Omega)$ is the probability density function of the vector of *j* random coefficients $<\beta_n, \alpha_n>$; μ is the vector of the price coefficient and the alternative-specific constants; Ω the variance- covariance matrix of the vector of random parameters, for which the off-diagonals were assumed zero. The alternative specific constants were specified as random following a normal distribution because it is expected that individuals can exhibit either positive or negative values or preferences for the egg products. The price coefficient is assumed to follow a constrained (one-side) triangular distribution.

The estimates from the RPL model were then used to calculate the a) share of respondents with positive and negative values for each product; b) the total WTP for each product and the marginal WTP of each alternative in relation to the others as in Caputo et al. (2020); c) the conditional and unconditional market shares. In details, the share of the population with positive and negative values was calculated using the command in R software > pnorm(0, mean = X, sd = X, lower.tail = F),

where mean and standard deviation for each product type were results of the RPL model. The total WTP was calculated by dividing the mean of each product with its standard deviation. The marginal WTP of each alternative in relation to the others was obtained by dividing the total WTP of each product by the respective total WTP of the other alternative. Lastly, the unconditional and conditional (on buying an option) market share for the different egg products were calculated following Van Loo et al., (2020), and using a SIMULATION function as extension of the RPL model, where all the products were priced at £2/box. The econometric analysis was done using the Nlogit software.

6. Results

In this section, the results emerged from this study are reported. First, results from the RPL[16] estimates for the four treatments (control, website communication, social media communication, label communication) are described[17] (Table 3). Results from the RPL model the price coefficient is negative and statistically significant at the 0.10 level meaning a decrease in utility with increasing price. The estimated coefficients of each product indicate the utility of each egg product in relation to

[16] Multinomial logit (MNL) estimates that assume homogeneity in preferences is reported in Table D1 of Appendix D.

[17] Descriptive statistics of the choice of each egg product across the treatments are reported in Table C1 of Appendix C and shows that free-range eggs are the most chosen products followed by barn eggs. Cage eggs followed barn eggs in Treatment 1 (Control) and Treatment 2 (Website), whereas plant-based eggs were more preferred both in Treatment 3 (Social media) and Treatment 4 (Labels).

the “no buy” option. Thus, positive and statistically significant coefficients of the alternative specific constants indicate that, holding price constant, people prefer buying one of the egg products than nothing at all. While not statistically significant coefficients of the alternative specific constants indicate that, on average, the utility for the egg products do not differ from the no-buy option. Our results show that coefficients for cage, barn, free-range, plant-based made with peas and plant-based made with soy are statistically significant and positive in the Control and Website treatments. Plant-based eggs made with soy are negative and not statistically in the Social media and Labels treatments. The estimated standard deviation around the mean preference for all egg products are statistically significant, suggesting significant preference heterogeneity in the population. As illustrated in Train (2009), the estimated means and standard deviations of these coefficients provide information on the share of the population with positive and negative preferences.

Table 3. Results of RPL estimates by treatments Treatment

		Treatment 1 - Control (N=204)	**Treatment 2 – Website (N=200)**	**Treatment 3 – Social media (N=204)**	**Treatment 4 - Labels (N=206)**
Cage eggs[18]	**Mean**	1.00*** (0.25)	1.70*** (0.24)	0.96*** (0.26)	0.66** (0.27)
	St. Deviation	1.65*** (0.34)	2.27*** (0.23)	2.41*** (0.41)	2.41*** (0.29)
Barn eggs18	**Mean**	2.59*** (0.17)	2.56*** (0.22)	2.25*** (0.20)	2.58*** (0.16)

[18] Parameters are normally distributed.

	St. Deviation	1.45*** (0.16)	2.07*** (0.18)	1.85*** (0.19)	1.26*** (0.15)
Free-range eggs18	**Mean**	5.38*** (0.24)	5.57*** (0.25)	5.48*** (0.27)	4.31*** (0.18)
	St. Deviation	3.31*** (0.33)	2.60*** (0.17)	3.12*** (0.23)	1.85*** (0.15)
Plant-based eggs made with peas18	**Mean**	0.58* (0.32)	0.70 (0.50)	1.36*** (0.39)	0.91*** (0.34)
	St. Deviation	3.31*** (0.18)	4.82*** (0.49)	4.32*** (0.46)	2.68*** (0.22)
Plant-based eggs made with soy18	**Mean**	0.72** (0.39)	0.82* (0.42)	-0.29 (0.41)	-0.49 (0.58)
	St. Deviation	1.96*** (0.19)	3.88*** (0.54)	3.05*** (0.26)	4.20*** (0.51)
Price	**Mean**	-1.14*** (0.04)	-1.38*** (0.04)	-1.33*** (0.04)	-1.19*** (0.04)
	St. Deviation	1.14*** (0.04)	1.38*** (0.04)	1.33*** (0.04)	1.19*** (0.04)
# parms		12	12	12	12
Log likelihood		-2312	-2359	-2284	-2607
No. choices		2448	2400	2448	2472
No. people		204	200	204	206
AIC		4647.6	4741.8	4590.0	5236.6
AIC/N		1.899	1.976	1.875	2.118

Note: One, two and three asterisks signify statistical significance at the 0.01, 0.05 and 0.10 level respectively or lower. The numbers in parentheses are standard errors. AIC: Akaike's information criterion. BIC: Bayesian information criterion.

Table 4 shows the proportion of positive preference for each egg product based on the RPL model. We found that that the proportion of positive preferences for cage eggs significantly decreased in Treatment 3 (Social media) and Treatment 4 (Labels) (65.0% and 60.7% respectively) compared to Treatment 1 (Control) and Treatment 2 (Website) (72.7% and 77.3% respectively). In addition, the proportion

of positive preferences for plant-based eggs made with peas considerably increased in Treatment 3 (Social media) (62.3%) and Treatment 4 (Labels) (63.2%), compared to Treatment 1 (Control) (56.9%) and Treatment 2 (Website) (55.7%) meaning that the social media and label communication treatments respectively have the highest effect compared to the control and website communication treatments. Plant-based eggs made with soy were most preferred only in Treatment 1 (Control) (64.3%) where consumers did not receive information about the benefits of these products while these were the least preferred in the other three treatments. Unsurprisingly, free-range eggs had the highest proportion of positive preferences across the four treatments, followed by barn eggs, which is in line with the UK national retail sales showing that free-range eggs are the largest segment in the market (UK Government, 2020a).

Table 4. Proportion of positive preferences for each egg product alternative

Product alternatives	Treatment 1 - Control (N=204)	Treatment 2 – Website (N=200)	Treatment 3 – Social media (N=204)	Treatment 4 - Labels (N=206)
Cage eggs	72.7%	77.3%	65.0%	60.7%
Barn eggs	96.2%	89.1%	88.6%	97.9%
Free-range eggs	98.2%	98.3%	96.0%	99.0%
Plant-based eggs made with peas	56.9%	55.7%	62.3%	63.2%
Plant-based eggs made with soy	64.3%	58.3%	46.2%	45.3%

Table 5 reports the estimates of mean total WTP in relation to the output option based on the RPL model. The total WTP for each egg product was calculated as the ratio of the coefficient of the alternative specific constant to the price coefficient based on estimates reported in Table 3. Our results show that free-range eggs have the highest WTP ranging from £3.62 to £4.71 per box of six eggs, followed by barn eggs with a WTP range from £1.69 to £2.27. In relation to plant-based eggs, T3 (Social media) had the strongest effect on WTP for the plant-based eggs made with peas, meaning that using social media to communicate the benefits of these products increase consumers' WTP. On the contrary, Treatment 2 (Website) decreases WTP for plant-based eggs made with soy compared to Treatment 1 (Control), and Treatment 3 (Social media) and Treatment 4 (Labels) significantly decreased consumers' WTP, meaning that both social media and label communications did not have a positive effect on WTP. The mean WTP estimates based on the MNL model are reported in Table D2, Appendix D.

Table 5. Mean WTP estimates based on the RPL model

Product alternatives	Treatment 1 - Control (N=204)	Treatment 2 – Website (N=200)	Treatment 3 – Social media (N=204)	Treatment 4 - Labels (N=206)
Cage eggs vs. none	£0.87	£1.23	£0.72	£0.55
Barn eggs vs. none	£2.27	£1.85	£1.69	£2.16
Free-range eggs vs. none	£4.71	£4.03	£4.12	£3.62

Plant-based eggs made with peas vs. none	£0.50	£0.50	£1.02	£0.76
Plant-based eggs made with soy vs. none	£0.63	£0.52	-£0.21	-£0.41

Table 6 reports marginal WTP estimates between the products for each treatment. In other words, this provides information on how much consumers are willing to pay for one product in comparison to the other. Marginal WTP for each pair of product eggs was calculated as the difference between the total WTPs for the two pair of eggs. Similar to Table 5, WTP is highest for free-range eggs WTP compared to every other product. The WTP for the plant-based eggs made with soy are negative in relation to every product. In particular, the lowest WTP is between free-range eggs and plant-based eggs made with soy, confirming that consumers are WTP the most for the former and the least for the latter.

Table 6. Mean WTP estimates between products based on the RPL model

Product alternatives	Treatment 1 - Control (N=204)	Treatment 2 – Website (N=200)	Treatment 3 – Social media (N=204)	Treatment 4 - Labels (N=206)
Cage eggs vs Barn eggs	£0.38	£0.66	£0.43	£0.25
Cage eggs vs Free-range eggs	£0.18	£3.05	£0.17	£0.15

Cage eggs vs Plant-based eggs made with peas	£1.74	£2.46	£0.70	£0.72
Cage eggs vs Plant-based eggs made with soy	£1.38	£2.36	-£3.42	-£1.22
Barn eggs vs Cage eggs	£2.60	£1.50	£2.35	£3.93
Barn eggs vs Free-range eggs	£0.48	£0.46	£0.41	£0.60
Barn eggs vs Plant-based eggs made with peas	£4.54	£3.70	£1.65	£2.84
Barn eggs vs Plant-based eggs made with soy	£3.60	£3.55	-£8.05	-£2.84
Free-range eggs vs Cage eggs	£5.41	£3.28	£5.72	£6.58
Free-range eggs vs Barn eggs	£2.07	£2.17	£2.44	£1.68
Free-range eggs vs Plant-based eggs made with peas	£9.42	£8.06	£4.04	£4.76
Free-range eggs vs Plant-based eggs made with soy	£7.47	£7.75	-£19.6	-£8.83
Plant-based eggs made with peas vs Cage eggs	£0.57	£0.40	£1.42	£1.38
Plant-based eggs made with peas vs Barn eggs	£0.22	£0.27	£0.60	£0.35
Plant-based eggs made with peas vs Free-range eggs	£0.10	£0.13	£0.25	£0.21
Plant-based eggs made with peas vs	£0.79	£0.96	-£4.86	-£1.85

Plant-based eggs made with soy				
Plant-based eggs made with soy vs Cage eggs	£0.72	£0.42	-£0.30	-£0.75
Plant-based eggs made with soy vs Barn eggs	£0.28	£0.29	-£0.12	-£0.19
Plant-based eggs made with soy vs Free-range eggs	£0.13	£0.13	-£0.05	-£0.11
Plant-based eggs made with soy vs Plant-based eggs made with peas	£1.26	£1.04	-£0.20	-£0.54

In relation to potential market shares for each egg product alternatives, we looked at both unconditional and conditional market shares (conditional in buying an option) across the four treatments, assuming that all products were priced at £2/box. Figure 3 shows the unconditional predicted market share. These results reveal that free-range eggs represent the largest market share across the four treatments, occupying about a half or more of the total market share followed by barn eggs in Treatment 1 (Control) (12%) and Treatment 4 (Labels) (14%), whereas the segment of plant-based eggs made with peas is the second segment in Treatment 2 (Website) (14%) and Treatment 3 (Social media) (17%), meaning that communicating the benefits of these products using different communication channels has an effect on their potential market share. Cage eggs occupy the smallest segment in Treatment 1 (Control), Treatment 2 (Website) and Treatment 4 (Labels), meaning that

consumers prefer to buy any other product or even nothing at all than buying cage eggs.

Figure 3. Unconditional market shares

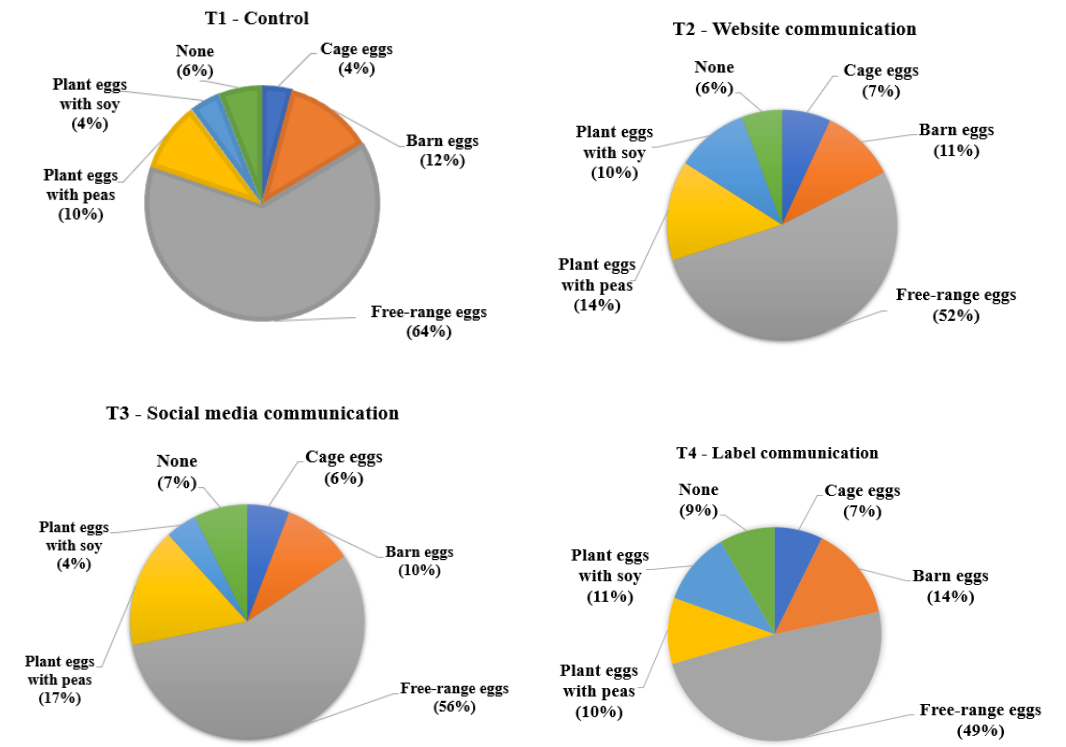
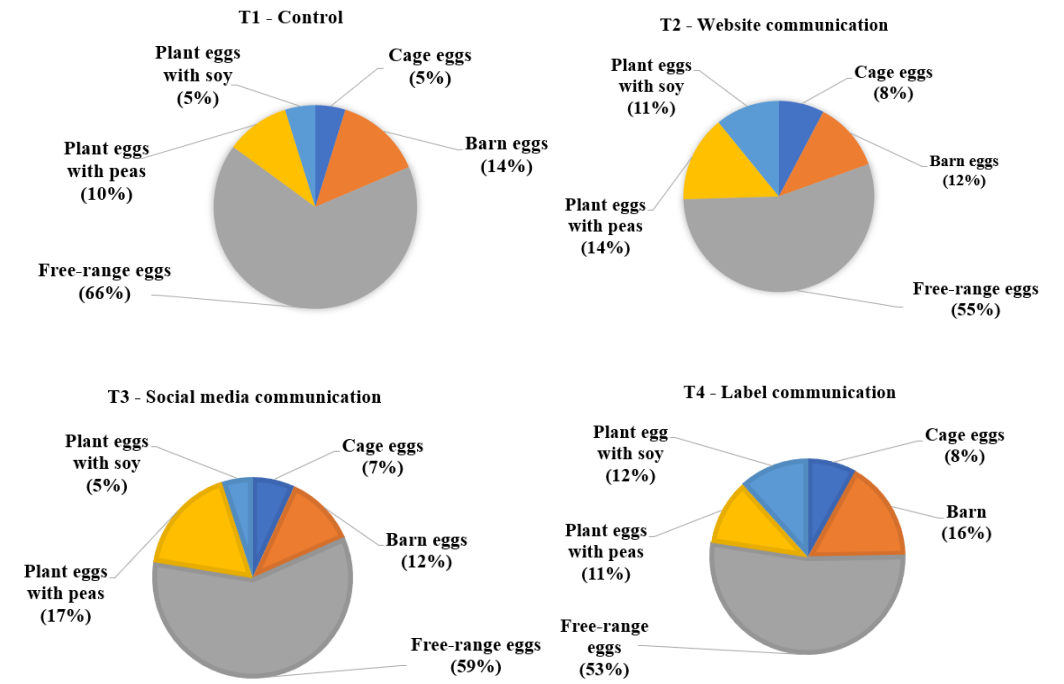


Figure 4 shows the conditional predicted market shares. When participants were conditioned on buying an option, free-range eggs still had the highest market share across the four treatments. Barn eggs were the second largest segment in Treatment 1 (Control) and Treatment 4 (Labels), and surprisingly plant-based eggs made with peas were the second largest segment in Treatment 2 (Website) and Treatment 3 (Social media). In relation to the plant-based eggs, plant-based eggs made with soy were far less preferred to plant-based eggs made with peas in Treatment 1 (Control)

and Treatment 3 (Social media), whereas they had a similar market share to plant-based eggs made with peas in Treatment 2 (Website) and even exceeded them in Treatment 4 (Labels), meaning that these could be more efficient channels of communication for plant-based eggs made with soy. In addition, cage eggs had the smallest market share in Treatment 1 (Control), Treatment 2 (Website) and Treatment 4 (Labels), meaning that consumers prefer a new alternative to eggs than cage eggs when forced to buy a product.

Figure 4. Conditional market shares (conditional on buying an option)



With regard to preferences for plant-based eggs' naming, Table 7 shows that the majority of the consumers in our sample (71.4%) support the idea that the name

"eggs" should only be used for egg products coming from hens and bred in the traditional manner, while only 28.6% oppose.

Table 7. Labelling preferences

QUESTION	Support	Oppose
Do you support or oppose that any product labelled as 'eggs' should only come from cage or free-cage hens, born, and raised in the traditional manner, rather than coming from alternative sources, such as from plants?	71.4%	28.6%

7. Discussion

This study investigated the effects of different communication channels on consumers' WTP for plant-based eggs. Some interesting results emerged from which several implications can be derived. First, we found that holding prices constant and posing the condition of choosing a product, free-range eggs were the most preferred option, followed by barn eggs, plant-based eggs made with peas, cage eggs and plant-based eggs made with soy. In Treatment 1 (Control) and Treatment 2 (Website), free-range, barn and cage eggs were preferred to plant-based eggs. These results can be explained by the fact that plant-based eggs are new products and thus that consumers are yet unfamiliar with them. Consistent with this explanation, past research showed that unfamiliarity reduces WTP (de Koning et al., 2020; Hoek et al., 2011; Marcu et al., 2015). However, in Treatment 3 (Social media) and Treatment 4 (Labels), plant-based eggs made with both peas and soy were preferred over cage eggs, meaning that when the benefits of these products

are communicated using social media and labels communications, their utility increases. This provides interesting insights for plant-based egg manufacturers on how to efficiently communicate their products to the public, particularly on which channel of communication is worth investing for their marketing advertising. In this regard, it seems that a more effective and rapid style of communication like it is used in social media and labels could be more suitable than a "wordier" communication like that of the websites. However, in regard to the social media channel, they are advised to select the most appropriate one based on the national statistics of the country where they aim to launch their products. In this study, Facebook was selected as it is the second most widely used social media after YouTube in the UK. However, in countries like China, for example, other social media platforms are being used, and two of the most popular are WeChat and QQ (Statista, 2021), which have different settings and features compared to the Western social media. Hence, plant-based egg industries should choose the most appropriate for their type of products and customize their advertising based on the characteristics of the selected social media platform. Second, plant-based eggs made with peas were liked more than plant-based eggs made with soy. This was also confirmed by Rondoni, Millan, & Asioli (2021) who showed that UK consumers avoided the use of soy as ingredient for the plant-based eggs as they were concerned about the negative effects that soy could have on their health, particularly for those suffering from soy allergy. Similarly, Banovic et al. (2018) and Elzerman et al. (2015) found greater acceptance for using legumes other than soya for protein enriched foods. In the same study, a soy label on packaging negatively influenced sensory perception of plant-based food substitutes (Banovic

et al., 2018). Hence, legumes such as peas, beans, chickpeas etc. seem a more promising route for future product development for plant-based eggs. This is also confirmed by the success of the liquid plant-based eggs from the company JUST ltd., made of mung beans, that even outsold conventional eggs in certain areas of the US (Watson and Shoup, 2019). Third, the results for the market share, both conditional and unconditional, reveal that free-range eggs are likely to remain the largest segment, followed by barn eggs. Cage eggs were the smallest segment among the conventional egg types. These results are in line with the UK national retail sales data, which show that cage eggs represent the smallest segment (10%), whereas free-range and barn eggs form the remaining 80% (UK Government, 2020a). In terms of the plant-based eggs, they are the smallest market segment in Treatment 1 (Control) and Treatment 2 (Website), but they outperform cage eggs in Treatment 3 (Social media) and Treatment 4 (Labels). This could be explained by consumers' growing concern for hens living conditions in the hatcheries, which led in 2012 to the ban of conventional cage egg systems in the European Union where hens had limited space to freely move and the introduction of enriched cages (UEP, 2017). This finding suggests that an animal-free alternative to conventional eggs might be a promising option for consumers. However, looking at the results of this study, it is reasonable to expect that with the launch of the plant-based eggs the market may experience the so-called "substitution effect" (Stephens et al., 2018), meaning that plant-based eggs are likely not to cannibalize the whole egg market, but will only cannibalize smaller proportion (e.g., cage eggs) of the market while being another option in addition to the existing ones. In fact, the availability of plant-based eggs will increase the variety of egg products available, which will

satisfy the needs of those people who do not or cannot consume conventional eggs (e.g., vegans, consumers suffering from egg allergies).

7.1 Implications for policy makers

From this study several implications for policy makers could be derived. First, it emerged that in Treatment 1 (Control) and Treatment 2 (Website) consumers preferred free-range, barn and cage eggs over plant-based eggs, although the latter have several advantages over the former. This may be explained by the fact that consumers still have limited knowledge about the effects that frequent consumption of eggs may have on their health (e.g., increasing cholesterol level), the poor animal welfare standards in most egg hatcheries worldwide, as well as the heavy gas emissions produced by the egg industries, as demonstrated by Rondoni et al. (2020). Hence, policy makers are advised to develop initiatives aimed at educating consumers on these issues and help them make more informative choices. Second, when the benefits of plant-based eggs were communicated using social media in Treatment 3 and labels in Treatment 4, these were preferred to cage eggs. These results suggest that although it is unlikely that plant-based eggs will entirely replace the consumption of conventional eggs, they might cannibalize specific segments like cage eggs. Indeed, this prospective will affect the economy around conventional egg production (e.g., labour, occupation), which may negatively impact local economies especially in low-income countries (e.g., reduction of employment and income, food security). In this case, policy makers can support traditional egg producers in the transition to the production of plant-based eggs.

Third, in terms of labelling preferences, we found that the majority of the consumers opposed the idea of using the word "egg" to name the plant-based alternatives, and thus "egg" should only be used to label eggs made by hens in the conventional manner. These results are consistent with Van Loo et al. (2020), who found that consumers opposed the idea of using the word "beef" to rename plant-based meat substitutes. Given the recent EU ban on plant-based milk alternatives to be labelled as "milk" (Court of Justice of the European Union, 2017), we may expect that this will be imposed also to other types of plant-based food alternatives, such as the plant-based eggs. In this regard, it is advisable for policy makers to settle clear regulations to avoid any misunderstanding, both from producers and consumers perspectives. It is also worth mentioning that so far evidence that labelling plant-based food alternatives using animal-based food names actually mislead consumers is yet missing (UK Parliament, 2019). Hence, policy makers could promote initiatives to educate consumers on the nature of plant-based eggs and avoid any confusion. For example, commonly recognised mandatory labels for plant-based food alternatives could be introduced to clearly indicate that these products are made using a vegetable source and not animals.

7.2 Future research avenues

To the best of the authors' knowledge, this study is the first to analyse consumers' preferences and demand for plant-based eggs. Hence, given the lack of information on this topic, more research is needed to investigate the relationship between different consumers' attitudes (e.g., food neophobia, lifestyle), habits (e.g., eating

and purchasing habits), familiarity with plant-based food alternatives etc. and preferences for plant-based eggs. Furthermore, sensory tests coupled with real choice experiments, multiple price list or experimental auctions in a real market scenario (Alfnes and Rickertsen, 2010; Asioli et al., 2020; Lusk and Shogren, 2007) should be conducted to investigate consumers' reaction to plant-based eggs and their WTP to get more realistic information with more external validation. In addition, the continue development of plant-based food alternatives pose the question on how to name these products. Hence, future studies should estimate consumers' preferences and WTP for different names of plant-based eggs when the word "egg" is either included or excluded, as well as when plant-based eggs is named as "vegan egg" or "egg substitute". Furthermore, future investigations should analyse preferences for different product attributes on plant-based eggs (e.g., labels), using tools such as eye-tracking and mouse-tracking for more accurate results (García-Madariaga et al., 2019; Khachatryan et al., 2018; Lim et al., 2018). Finally, this study focused on UK consumers. Hence, more research should be conducted in other countries such as the US, which seems to be a promising market for plant-based eggs as shown by the successful launch of the liquid prototype of plant-based eggs by companies like JUST ltd. and Spero Food (Watson and Shoup, 2019), as well as in Asia where the demand of plant-based food alternatives is increasing, particularly in Japan and China, which are the largest egg consumers and the largest egg producers worldwide, respectively (International Egg Commission, 2015; Windhorst, 2016).

8. Conclusion

In conclusion, our findings show that consumers overall prefer free-range eggs to all other egg alternatives (e.g., cage eggs, barn eggs, plant-based eggs made with peas and soybeans), meaning that this segment is likely to remain the biggest one in the UK, even after that the plant-based eggs will be launched into the market. Consumer WTP for plant-based eggs increased when the benefits of these products are communicated using a social media communication. In terms of labelling, consumers seem to widely agree that plant-based eggs should not be labelled as "eggs". Our results provide insights into consumers' psychology that can be useful for effectively communicating the potential benefits of plant-based eggs to the public, as well as to policy makers in relation to labelling preferences for these products.

Acknowledgments

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Transparent reporting

Pre-registration of the study is available at: https://aspredicted.org/blind.php?x=sf5qq8.

Appendices

Appendix A. Survey Protocol

INTRODUCTION

This study is being conducted by researchers from the University of Reading (United Kingdom). The purpose is to investigate consumers' preferences for plant-based eggs. You are being asked to participate in a research project by taking an online survey. You must be 18 or older, British citizen and responsible for at least half of your household food purchase to participate in the survey. The online survey should not take more than 15 minutes of your time. Please remember that once you have answered the question, you cannot go back, so please choose the answer carefully. You can be assured that your answers will be kept confidential and will only be released as summaries. Your name will not be collected as part of your survey response and thus can never be associated with the data. Your responses will not be individually identified or publicized. Your answers are strictly voluntary. You will not be qualified for an incentive if you drop out of the survey or give poor quality data. The collected data will be deleted by 30/08/2021.

You are free to withdraw from the survey at any time if you wish to do so. In the following screen you will find your unique ID code. Please save it and use it to address yourself if you wish to inform us about your intent to withdraw from the study after completing the survey by contacting the researcher Agnese Rondoni at: a.rondoni@pgr.reading.ac.uk. You are free to withdraw your data up until when the data is aggregated on 15/05/2021. After that, it will no longer be possible to

withdraw your contribution from the research. If you decide to withdraw, you would still be qualified for your incentive if the survey is deemed as successfully completed on our conclusion.

No personal identifier information will be collected. The submitted data will be used for statistical purposes only and statistical results will be reported in research papers, conferences, technical reports, and academic journals. In the future, the statistical data may be used for subsequent research in the area of consumers' preferences, as a basis for comparison to future results, and as an example in teaching. There are no anticipated risks in participating in this study. By participating in this survey, you will contribute to research on a better understanding of consumers' preferences for plant-based eggs that in turn can inform public policy and guidelines. This application has been reviewed according to the procedures specified by the University of Reading Research Ethics Committee and has been given a favourable ethical opinion for conduct. If you have questions about your rights as a participant, you may contact the University of Reading - School of Agriculture Policy and Development Ethics Committee, Email: sapdethics@reading.ac.uk. If you have questions at any time about the study or the procedures, (or you experience adverse effects as a result of participating in this study) you may contact us at: a.rondoni.@pgr.reading.ac.uk. Clicking the button to continue will be considered your consent to participate.

Q1. Your unique ID code is (each participant gets a different ID code)

ICE BREAKER

Q2. We care about the quality of our survey data and hope to receive the most accurate measures of your opinions, so it is important to us that you thoughtfully provide your best answer to each question in the survey. Do you commit to providing your thoughtful and honest answers to the questions in this survey?

☐ I will provide my best answers
☐ I will not provide my best answers (screen out)
☐ I can't promise either way (screen out)

Q3. What gender do you identify with?

☐ Male
☐ Female
☐ Prefer not to say

Q4. How old are you?

☐ Under 18
☐ 18-32
☐ 33-46
☐ 47-61
☐ 62-75
☐ 76 or over

Q5. Which country are you from?

If UK is not selected screen out.

Q6. Please indicate your approximate annual household income before taxes:

- ☐ Less than £10,000
- ☐ £10,000 to £19,999
- ☐ £20,000 to £29,999
- ☐ £30,000 to £39,999
- ☐ £40,000 to £49,999
- ☐ £50,000 to £59,999
- ☐ £60,000 to £69,999
- ☐ £70,000 to £79,999
- ☐ £80,000 to £89,999
- ☐ £90,000 to £99,999
- ☐ £100,000 to £149,999
- ☐ £150,000 or more
- ☐ I do not want to declare
- ☐ I do not know

Q7. Are you fully or partially responsible for food purchases?

- ☐ I am primarily responsible for food purchase
- ☐ I am responsible for more than half of food purchases
- ☐ I am responsible for less than half of food purchases (screen out)
- ☐ I am not responsible for food purchases (screen out)

SCRIPTS

Script 1

On the following screens you will see a series of egg products. You will be asked to select which type of eggs you prefer to buy among different available options. All the products adhere to food safety regulations and have the same characteristics (e.g., taste, shape, brands etc.) except for the method of production (e.g., free-range, plant-based etc.) and price.

Now, we will explain the different characteristics of the egg products in detail:

1. **PRODUCTION METHOD:** It refers to how eggs are produced. The eggs you will see are produced using one of the following five methods:

    - Cage eggs are produced in indoor-based systems which typically hold five to ten hens each, which are never allowed to go out.

    - Barn eggs are produced in indoor-based systems where hens can move freely around the house but are never allowed to go out.

    - Free-range eggs are produced in indoor-based systems where hens are provided with outdoor access via holes in the side of the building and can go out once or twice per day, within one hectare of outdoor range for every 2,500 hens.

    - Plant-based eggs produced with peas are produced from a plant-based source (peas) through protein isolation or protein fermentation processes.

- Plant-based eggs produced with soybean are produced from a plant-based source (soybean) through protein isolation or protein fermentation processes.

2. **PRICE:** It refers to the price in £/box of 6 eggs.

Script 2

BEFORE YOU PROCEED, PLEASE TAKE TIME TO CAREFULLY READ THE FOLLOWING INSTRUCTIONS

Imagine you are in your usual supermarket and considering the purchase of eggs. In the following, you will see a series of choice questions. Each choice question includes a description of five different packages of egg. All the products adhere to food safety regulations and have the same characteristics (e.g., taste, safety, brands etc.) except for the method of production and the price. In each choice question, please indicate the egg product that you would choose to purchase. You may also choose NOT TO PURCHASE any product.

Please carefully examine each option before you make a decision and select the decision that you would make based on your own preferences. Previous similar studies show that people often respond in one way but act differently. In studies where people do not actually have to pay money for a product when indicating a particular preference, people state a higher willingness to pay than what one

actually is willing to pay for the good in the store. A possible reason for this is that people do not really consider how large the impact of this extra cost actually is on the available family budget. It is easy to be generous when you do not really have to pay for it. In the store, people might think in a different way: the amount of money spent on this good cannot be spent on other things. We ask you to respond to each of the following choice questions just exactly as you would if you were in a real store and had to pay for your choice, considering the impact that any extra cost may have on yours and your family budget. Please keep this in mind when answering the following choice questions.

IMPORTANT

Please CHOOSE ONLY ONE option on each page. Or you may choose "If these were the only available options, I would not purchase any of them".

- Assume that the options on each page are the only ones available.
- Do not compare options on different pages.
- Once you have made your choice and moved on to the next question, you cannot go back. The choices are all separate so you do not and should not try to remember previous choices.
- You might see a few options that may seem counter-intuitive (e.g., a lower price, but a higher quality in your personal opinion). Be assured that this is not an error, but part of the design of the survey. Simply choose the option in each choice question that you prefer the most, based on its characteristics.

We hope you will enjoy taking part in this study! 😊

QUALITY CONTROL

Q8. Before proceeding to the next set of questions, we want to ask for your feedback about the responses you provided so far. It is vital to our study that we only include responses from participants who devoted their full attention to this study. In your honest opinion, should we use your responses, or should we discard your responses since you did not devote your full attention to the questions so far?

☐ Yes, I have devoted full attention to the questions so far and I think you should use my responses for your study.

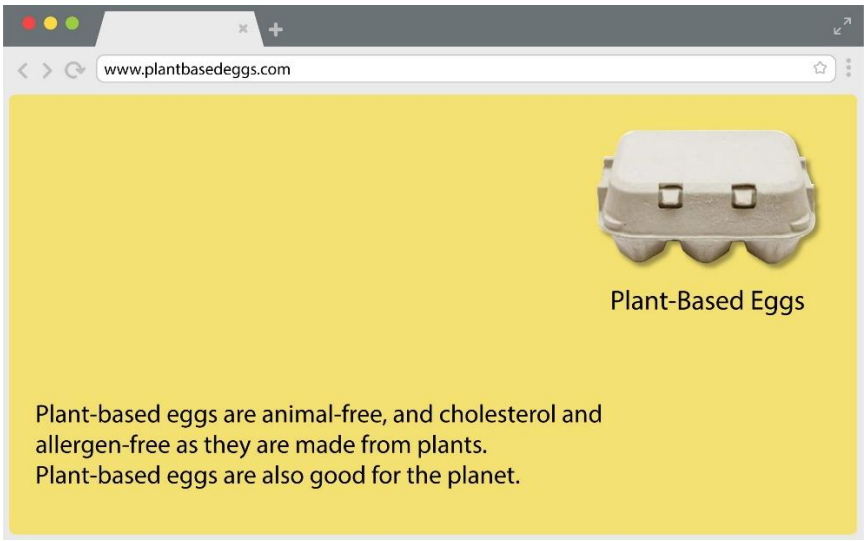
☐ No, I have not devoted full attention to the questions so far and I think you should not use my responses for your study. (screen out)

TREATMENT 1 – CONTROL (200 consumers)

Please proceed to the next page to start the test.

TREATMENT 2 – WEBSITE COMMUNICATION (200 consumers)

Please read the following information carefully before starting the survey. You can only press the start button after 20 seconds.



TREATMENT 3 – SOCIAL MEDIA COMMUNICATION (200 consumers)

Please read the information in the imagine below carefully before starting the survey. You can only press the start button after 20 seconds.

CHOICE SET - BLOCK 1 – 100 consumers

Q9. Imagine you are in a store and you would like to purchase a box of 6 eggs. Which option would you choose?

Q10. Imagine you are in a store and you would like to purchase a box of 6 eggs. Which option would you choose?

Q11. Imagine you are in a store and you would like to purchase a box of 6 eggs.

Which option would you choose?

Q12. Imagine you are in a store and you would like to purchase a box of 6 eggs.

Which option would you choose?

Q13. Imagine you are in a store and you would like to purchase a box of 6 eggs. Which option would you choose?

Q14. Imagine you are in a store and you would like to purchase a box of 6 eggs. Which option would you choose?

Q15. Imagine you are in a store and you would like to purchase a box of 6 eggs.

Which option would you choose?

Q16. Imagine you are in a store and you would like to purchase a box of 6 eggs.

Which option would you choose?

Q17. Imagine you are in a store and you would like to purchase a box of 6 eggs.

Which option would you choose?

Q18. Imagine you are in a store and you would like to purchase a box of 6 eggs.

Which option would you choose?

Q19. Imagine you are in a store and you would like to purchase a box of 6 eggs.

Which option would you choose?

Q20. Imagine you are in a store and you would like to purchase a box of 6 eggs.

Which option would you choose?

CHOICE SET – BLOCK 2 – 100 consumers

Q21. Imagine you are in a store and you would like to purchase a box of 6 eggs. Which option would you choose?

Q22. Imagine you are in a store and you would like to purchase a box of 6 eggs. Which option would you choose?

Q23. Imagine you are in a store and you would like to purchase a box of 6 eggs. Which option would you choose?

Q24. Imagine you are in a store and you would like to purchase a box of 6 eggs. Which option would you choose?

Q25. Imagine you are in a store and you would like to purchase a box of 6 eggs.

Which option would you choose?

Q26. Imagine you are in a store and you would like to purchase a box of 6 eggs.

Which option would you choose?

Q27. Imagine you are in a store and you would like to purchase a box of 6 eggs.

Which option would you choose?

Q28. Imagine you are in a store and you would like to purchase a box of 6 eggs.

Which option would you choose?

Q29. Imagine you are in a store and you would like to purchase a box of 6 eggs.

Which option would you choose?

Q30. Imagine you are in a store and you would like to purchase a box of 6 eggs.

Which option would you choose?

Q31. Imagine you are in a store and you would like to purchase a box of 6 eggs.

Which option would you choose?

Q32. Imagine you are in a store and you would like to purchase a box of 6 eggs.

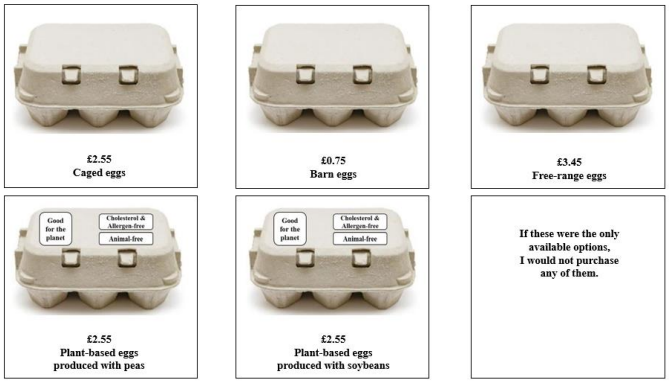
Which option would you choose?

TREATMENT 4 – LABELING COMMUNICATION (200 consumers)

Please proceed to the next page to start the test.

BLOCK 1 – TREATMENT 4 (100 consumers)

Q33. Imagine you are in a store and you would like to purchase a box of 6 eggs. Which option would you choose?



Q34. Imagine you are in a store and you would like to purchase a box of 6 eggs. Which option would you choose?

Q35. Imagine you are in a store and you would like to purchase a box of 6 eggs.

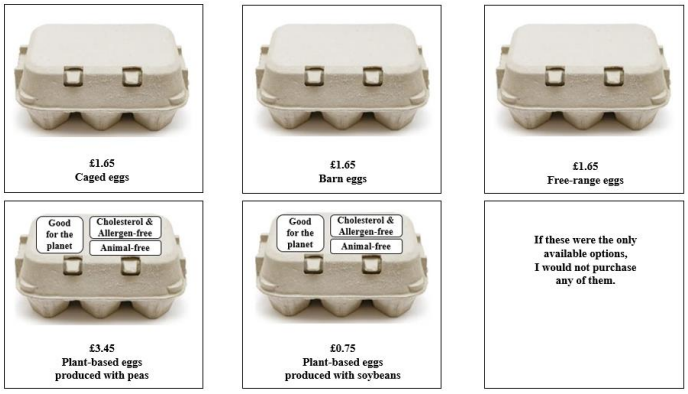
Which option would you choose?

Q36. Imagine you are in a store and you would like to purchase a box of 6 eggs.

Which option would you choose?

Q37. Imagine you are in a store and you would like to purchase a box of 6 eggs.

Which option would you choose?



Q38. Imagine you are in a store and you would like to purchase a box of 6 eggs.

Which option would you choose?

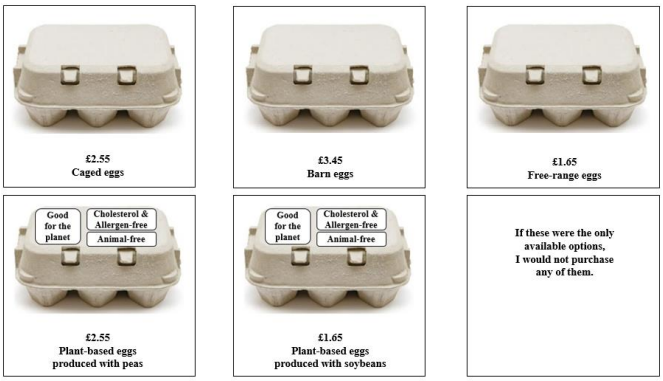
Q39. Imagine you are in a store and you would like to purchase a box of 6 eggs.

Which option would you choose?

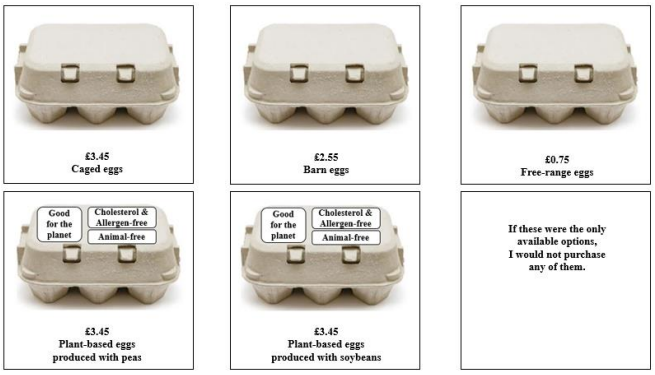
Q40. Imagine you are in a store and you would like to purchase a box of 6 eggs.

Which option would you choose?

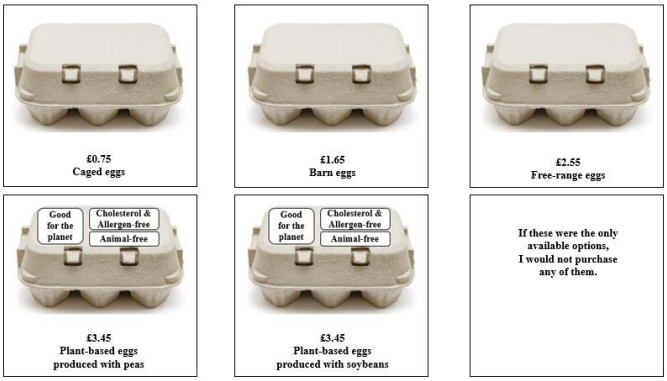
Q41. Imagine you are in a store and you would like to purchase a box of 6 eggs. Which option would you choose?



Q42. Imagine you are in a store and you would like to purchase a box of 6 eggs. Which option would you choose?

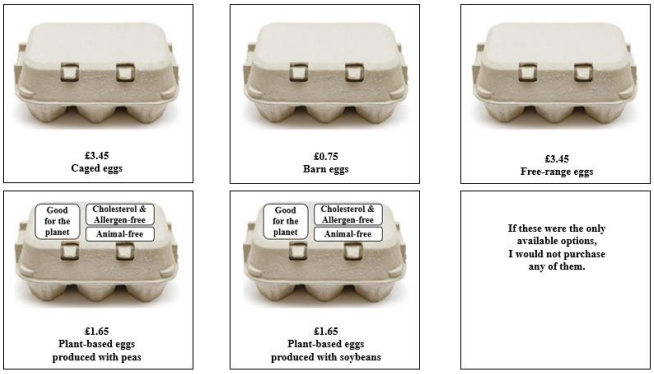


Q43. Imagine you are in a store and you would like to purchase a box of 6 eggs. Which option would you choose?



Q44. Imagine you are in a store and you would like to purchase a box of 6 eggs.

Which option would you choose?



BLOCK 2 – TREATMENT 4 (100 consumers)

Q45. Imagine you are in a store and you would like to purchase a box of 6 eggs.

Which option would you choose?

Q46. Imagine you are in a store and you would like to purchase a box of 6 eggs.

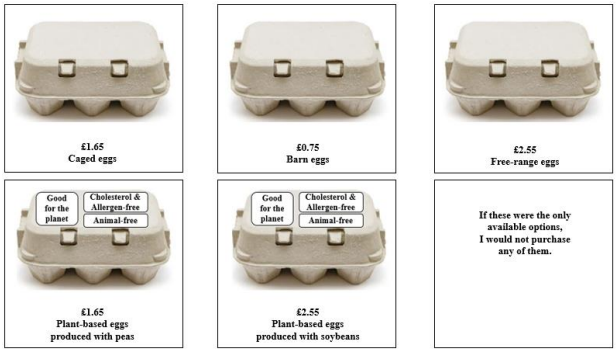
Which option would you choose?

Q47. Imagine you are in a store and you would like to purchase a box of 6 eggs.

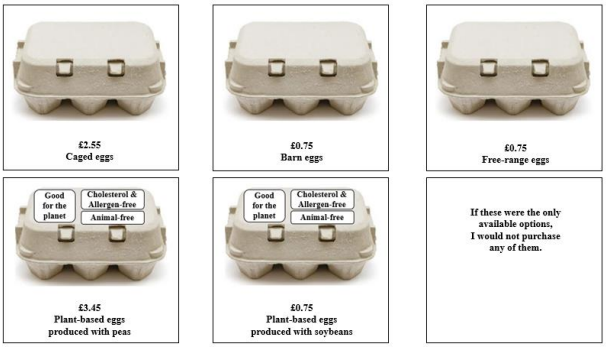
Which option would you choose?

Q48. Imagine you are in a store and you would like to purchase a box of 6 eggs.

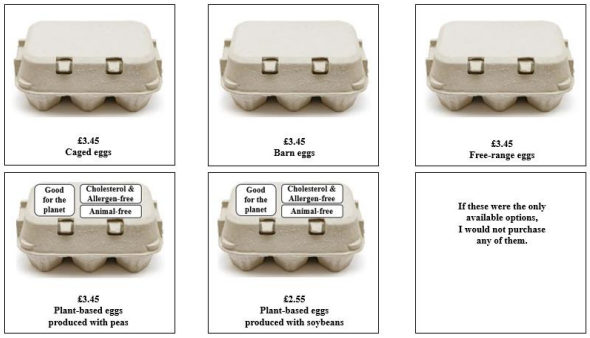
Which option would you choose?



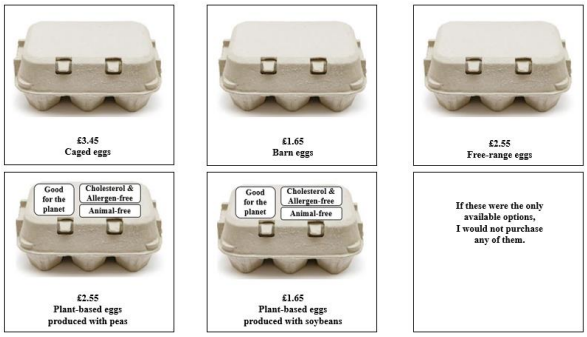
Q49. Imagine you are in a store and you would like to purchase a box of 6 eggs. Which option would you choose?



Q50. Imagine you are in a store and you would like to purchase a box of 6 eggs. Which option would you choose?



Q51. Imagine you are in a store and you would like to purchase a box of 6 eggs. Which option would you choose?

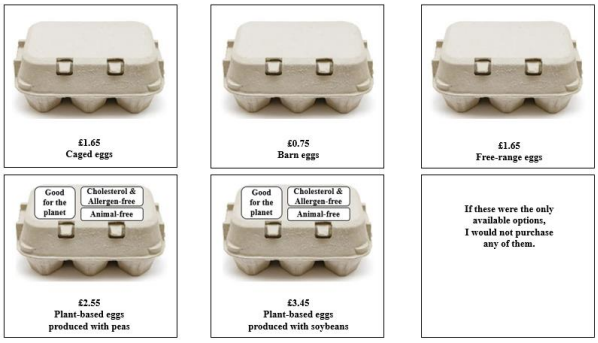


Q52. Imagine you are in a store and you would like to purchase a box of 6 eggs.

Which option would you choose?

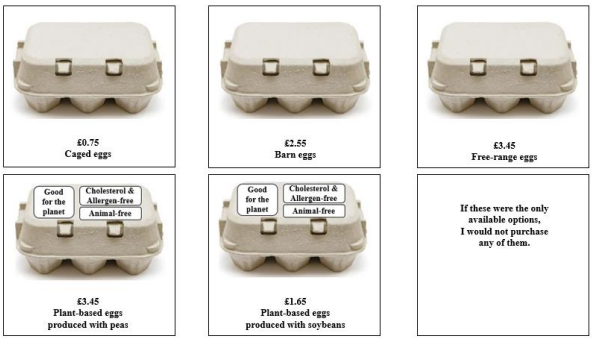
Q53. Imagine you are in a store and you would like to purchase a box of 6 eggs.

Which option would you choose?



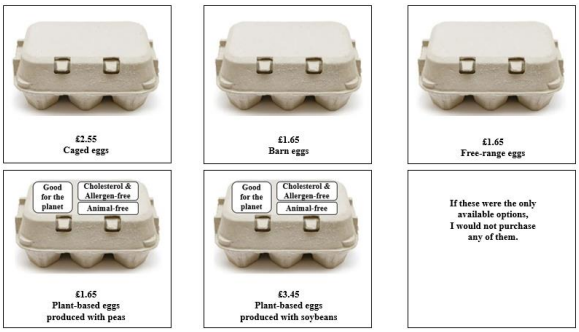
Q54. Imagine you are in a store and you would like to purchase a box of 6 eggs.

Which option would you choose?



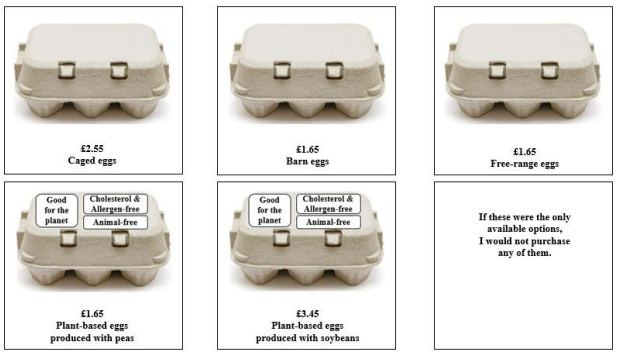
Q55. Imagine you are i in a store and you would like to purchase a box of 6 eggs.

Which option would you choose?



Q56. Imagine you are in a store and you would like to purchase a box of 6 eggs.

Which option would you choose?



Q57. Imagine you are in a store and you would like to purchase a box of 6 eggs.

Which option would you choose?

EGG PURCHASING HABITS

Q58. How frequently do you purchase chicken eggs?

- ☐ Never
- ☐ Less than once a month
- ☐ Once a month
- ☐ 2-3 times a month
- ☐ Once a week
- ☐ Twice a week
- ☐ 3-4 times a week
- ☐ 5-6 times a week
- ☐ Everyday

Q59. Why do you never buy chicken eggs? Please check all that apply.

- ☐ Because I am vegan
- ☐ Because I suffer from high cholesterol
- ☐ Because I suffer from egg allergy
- ☐ I do not like the taste
- ☐ Eggs are too expensive
- ☐ The boxes of eggs available are too big
- ☐ The boxes of eggs available are too small
- ☐ Because hens are not treated well in the egg farms
- ☐ The production of eggs is environmentally unsustainable
- ☐ Other, please specify

Q60. How important are the following criteria when buying eggs?

	Very unimportant	**Unimportant**	**Neither important nor unimportant**	**Important**	**Very important**
Taste					
Origin					
Size (e.g., medium, large etc.)					
Colour (e.g., brown, white etc.)					
Pack size					
Production method (e.g., free-range, organic etc.)					
Shelf-life					
Nutritional values					
Packaging type (e.g., carbon, plastic etc.)					
Information on the impact on the environment					
Brand					
Price					
Other, please specify					

Q61. Please give us your opinion on the following statements.

	Strongly disagree	**Disagree**	**Neither disagree nor agree**	**Agree**	**Strongly agree**
Choosing eggs is a big decision in my life					
I attach great importance to select eggs					
I do not usually get overconcerned about choosing eggs					
Which egg I choose does not really matter to me					
Choosing eggs takes a lot of careful thought					
Decisions about selecting eggs are serious, important decisions					

PLANT-BASED FOODS PURCHASING HABITS

Q62. How often have you purchased plant-based food alternatives (e.g., plant-based meat, milk etc.) in the last three months?

- ☐ Never
- ☐ Less than once a month
- ☐ Once a month
- ☐ 2-3 times a month
- ☐ Once a week
- ☐ Twice a week
- ☐ 3-4 times a week
- ☐ 5-6 times a week

- ☐ Everyday

Q63. How likely are you to buy plant-based food alternatives (e.g., plant-based meat, milk etc.) in the next month?

- ☐ Very unlikely
- ☐ Unlikely
- ☐ Neither likely nor unlikely
- ☐ Likely
- ☐ Very unlikely

FAMILIARITY WITH PLANT-BASED EGGS

Q64. How familiar are you with plant-based eggs?

- ☐ Very unfamiliar
- ☐ Unfamiliar
- ☐ Neither unfamiliar nor familiar
- ☐ Familiar
- ☐ Very familiar

Q65. How often have you purchased any of the following plant-based egg alternatives the last three months?

	Never	**Less than once a month**	**Once a month**	**2-3 times a month**	**Once a week**	**Twice a week**	**3-4 times a week**	**5-6 times a week**	**Everyday**
Aquafaba-based egg substitutes									
Chia seeds-based egg substitutes									
Tofu-based egg substitutes									
Other, please specify									

Q66. How likely are you to buy any of the following plant-based egg alternatives in the next month?

	Very Unlikely	**Unlikely**	**Neither unlikely nor likely**	**Likely**	**Very likely**
Aquafaba-based egg substitutes					
Chia seeds-based egg substitutes					
Tofu-based egg substitutes					
Other, please specify					

Q67. Imagine you are in a supermarket and face the option of buying plant-based eggs. Which of the following factors will motivate you to buy plant-based eggs instead than conventional eggs (cage, free-range, etc.)?

	Strongly disagree	**Disagree**	**Neither agree nor disagree**	**Agree**	**Strongly agree**
Plant-based eggs are healthier					
Plant-based eggs are cholesterol-free and allergen-free					
Plant-based eggs are better in quality					
Plant-based eggs are better for the environment					
Plant-based eggs production does not involve hens					
Plant-based eggs are more fashionable					
Plant-based eggs have higher nutritional values					
Other, please specify					

Q68. Imagine you are in a supermarket and face the option of buying plant-based eggs. Which of the following factors discourage you from buying plant-based eggs in favour of conventional eggs (cage, free-range, etc.)?

	Strongly disagree	**Disagree**	**Neither agree nor disagree**	**Agree**	**Strongly agree**
Poor taste					
High price					
Poor availability					
Unfamiliarity with plant-based foods					

Disbelief that plant-based food is better					
Unsatisfactory appearance					
Poor quality					
Other, please specify					

Q69. Do you support or oppose that any product labelled as 'eggs' should only come from cage or free-cage hens, born, and raised in the traditional manner, rather than coming from alternative sources, such as from plants?

- ☐ Support
- ☐ Oppose

DIET TYPE

Q70. Which of the following is the diet that you regularly adopt? (Please only mark one of the option - the one that best resembles your diet).

- ☐ Full time meat eater (eating red meat, fish, and chicken)
- ☐ Flexitarian (reducing meat intake but eating meat now and then)
- ☐ Pollotarian (eating no red meat, but eat fish, chicken, and other poultry)
- ☐ Pescotarian (eating no red meat or chicken, but eat fish and shellfish)
- ☐ Macrobiotic consumer (eating unprocessed, organic, and locally grown foods, with a great overlap with foods consumed in a vegetarian diet, yet also including certain kinds of meat)

☐ Lacto-ovo vegetarian (eating no meat or fish, but eating eggs and dairy produce)

☐ Lacto-vegetarian (eating no meat, fish, or eggs, but eating dairy produce)

☐ Ovo-vegetarian (eating no meat, fish, or dairy produce, but eating eggs)

☐ Vegan (eating no meat and using no products of animal origin)

Q71. Do you or any of your family member suffer from any of the following illnesses (Please check all that apply)

☐ High cholesterol

☐ Egg allergies

☐ Diabetes

☐ Hearth diseases

☐ None of these

FOOD INFORMATION SOURCE

Q72. How frequently do you use the following sources to gather information about the food you purchase/eat?

	Never	**Rarely (Less than once a month)**	**Sometimes (3-4 times a month or more)**	**Often (2-3 times a week or more)**	**Everyday**
YouTube					
Facebook					
Instagram					
Other social media (LinkedIn Tik Tok, Pinterest, Snaptchat etc.)					
Food companies' website					
Food labels					
Governmental websites					
Newspaper					
Word of mouth					
Other, please specify					

SCALES OF ATTITUDES

FOOD NEOPHOBIA SCALE

Q73. The following statements deal with attitudes related to new foods. Please give us your opinion:

	Strongly disagree	**Disagree**	**Somewhat disagree**	**Neither agree nor disagree**	**Somewhat agree**	**Agree**	**Strongly agree**
I am constantly sampling new and different foods							
I don’t trust new foods							
If I don’t know what a food is, I won’t try it							
I like foods from different cultures							
Ethnic food looks too weird to eat							
At dinner parties, I will try new foods							
I am afraid to eat things I have never had before							
I am very particular about the foods I eat							
I will eat almost anything							

I like to try new ethnic restaurants							

HEALTH SCALE

Q74. The following statements deal with attitudes related to health attitudes. Please give us your opinion:

	Strongly disagree	**Disagree**	**Somewhat disagree**	**Neither agree nor disagree**	**Somewhat agree**	**Agree**	**Strongly agree**
The healthiness of food has little impact on my food choices							
I am very particular about the healthiness of the food I eat							
I eat what I like, and I do not worry much about the healthiness of food							
It is important for me that my diet is low in fat							
I always follow a healthy and balanced diet							
It is important for me that my daily diet contains a lot							

of vitamins and minerals							
The healthiness of snacks makes no difference to me							
I do not avoid foods, even if they may raise my cholesterol							
I do not avoid foods, even if they may be high in sugar content							
I pay attention to the salt intake in my diet							

NEW ECOLOGICAL PARADIGM SCALE

Q75. The following statements deal with attitudes related to ecological attitudes.

Please give us your opinion:

	Strongly Disagree	**Disagree**	**Neither agree nor disagree**	**Agree**	**Strongly agree**
We are approaching the limit of the number of people the Earth can support					
Humans have the right to modify the natural environment to suit their needs					
When humans interfere with nature it often					

produces disastrous consequences					
Human ingenuity will ensure that we do not make the Earth unlivable					
Humans are seriously abusing the environment					
The Earth has plenty of natural resources if we just learn how to develop them					
Plants and animals have as much right as humans to exist					
The balance of nature is strong enough to cope with the impacts of modern industrial nations					
Despite our special abilities, humans are still subject to the laws of nature					
The so-called "ecological crisis" facing humankind has been greatly exaggerated					
The Earth is like a spaceship with very limited room and resources					
Humans were meant to rule over the rest of nature					
The balance of nature is very delicate and easily upset					
Humans will eventually learn enough about how nature works to be able to control it					

If things continue on their present course, we will soon experience a major ecological catastrophe					

POLITICAL ORIENTATION

Q76. When it comes to politics, do you usually think of yourself as…

- ☐ Extremely liberal
- ☐ Slightly liberal
- ☐ Moderate or middle of the road
- ☐ Slightly conservative
- ☐ Extremely conservative
- ☐ I do not know

DEMOGRAPHIC QUESTIONS

Q77. What is your level of education?

- ☐ Primary school
- ☐ Secondary/Middle school
- ☐ High school/College qualification (e.g., Diploma)
- ☐ University Degree (e.g., BA, BSc, Master, PhD, PGCE_
- ☐ Other, please specify

Q78. How many people live in your household including you?

- ☐ I live alone
- ☐ 2-3 people

- ☐ 3-4 people
- ☐ 5-6 people
- ☐ 7 or more

Q79. Where do you live?

- ☐ Urban area
- ☐ Suburban area
- ☐ Rural area

Q80. What is your employment situation?

- ☐ Student
- ☐ Independent worker (e.g., consultant)
- ☐ Private-sector worker
- ☐ Public-sector worker
- ☐ Retired
- ☐ Unemployed (seeking work)
- ☐ Not in paid employment (not seeking work, e.g., house husband, housewife)
- ☐ Other, please specify: _____

Thank you!

If you have any comments regarding this survey, please enter them in the box.

Appendix B

Table B1. Socio-demographic characteristics of the sample by treatment

Variable	Treatment 1 (CON) (N=204)	Treatment 2 (WEB) (N=200)	Treatment 3 (SOC) (N=204)	Treatment 4 (LAB) (N=206)	Total
Gender					
Male	49.0%	49.0%	48.5%	49.5%	49.0%
Female	51.0%	51.0%	51.5%	50.5%	51.0%
Pearsonchi2(2) =0.04 Pr = 0.99					
Age					
18-32	14.7%	17.0%	17.2%	15.5%	16.1%
33-46	34.3%	30.5%	31.9%	34.0%	24.4%
47-61	23.0%	30.0%	27.5%	26.7%	32.9%
62-75	27.9%	22.5%	17.2%	23.8%	26.6%
Chi-squared (9) =7.73 Probability = 0.56					
Level of education					
Primary school	0.5%	1.0%	1.0%	1.5%	1.0%
High school	24.0%	29.5%	28.9%	26.2%	27.1%
Higher education (not university)	25.5%	26.5%	26.5%	21.8%	25.1%
Bachelor's degree	33.3%	30.5%	33.8%	34.5%	33.0%
Master's degree	15.2%	10.0%	8.3%	11.2%	11.2%
PhD	1.5%	2.5%	1.5%	4.9%	2.6%
Chi-squared(15)=14.92 Probability = 0.45					
Annual household income before taxes					
	1.5 %	4.0%	8.8%	2.9%	4.3%
Less than £10,000	48.5%	45.5%	42.1%	47.1%	46.0%
£10,000 to £39,999	31.9%	35.5%	31.3%	41.2%	34.9%
£40,000 to £69,999	14.2%	10.5%	11.2%	5.8%	10.4%
£70,000 to £99,999	3.9%	4.5%	5.9%	2.9%	4.3%
£100, 000 to £150,000 or more	0.0%	0.0%	0.5%	0.0%	0.1%
I do not want to declare/I do not know					
Chi-squared (12)					

=28.47					
Probability = 0.00					
Household size					
I live alone	22.5%	21.0%	18.6%	19.9%	20.5%
2-3 people	55.9%	50.5%	57.8%	54.9%	54.7%
3-4 people	16.2%	21.5%	19.1%	18.4%	18.7%
5-6 people	5.4%	7.0%	4.4%	5.3%	5.5%
7 or more	0.0%	0.0%	0.0%	1.5%	0.2%
Chi-squared (12) = 13.55					
Probability = 0.33					
Living area					
Urban area	28.9%	25.5%	27.5%	31.1%	28.4%
Suburban area	49.5%	58.0%	48.0%	49.5%	50.9%
Rural area	21.6%	16.5%	24.5%	19.4%	20.4%
Pearson chi2(6) = 7.01					
Pr = 0.32					
Employment situation					
	1.0%	2.5%	2.5%	1.9%	2.0%
Student	6.4%	18.0%	8.8%	2.9%	6.7%
Independent					
worker (e.g.,	32.4%	35.5%	27.9%	29.6%	31.3%
consultant)	15.2%	10.5%	14.2%	15.5%	13.8%
Private-sector	13.2%	7.5%	11.8%	15.0%	12.0%
worker	20.6%	18.0%	18.6%	20.9%	19.4%
Public-sector	0.5%	5.5%	5.9%	2.9%	3.7%
worker	8.3%	8.5%	8.8%	8.3%	8.5%
Part-time					
employed	2.5%	3.0%	1.5%	2.9%	1.2%
Retired					
Unemployed					
Not in paid employment (e.g., homemaker)					
Other					
Pearson chi2 (24) = 49.49					
Pr =0.00					

Note: A chi-square test was employed to determine whether there is a statistically significant difference between variables among the four treatments.

Appendix C

Table C1. Descriptive statistics of consumers choice for each egg alternative

Treatments	Frequencies	Cage eggs	Barn eggs	Free-range eggs	Plant-based eggs made with peas	Plant-based eggs made with soy	None	Total	
								N. choices	N. people
1	Count	139	317	1415	174	155	248	2448	204
	%	6.2%	12.9%	51.6%	8.8%	7.7%	12.5%	100	
2	Count	173	327	1148	236	197	319	2400	200
	%	7.2%	13.6%	47.8%	9.8%	8.2%	13.2%	100	
3	Count	143	274	1283	226	194	328	2448	204
	%	5.8%	11.1%	52.4%	9.2%	7.9%	13.3%	100	
4	Count	158	343	1202	229	209	331	2472	206
	%	6.3%	13.8%	48.6%	9.2%	8.4%	13.3%	100	
Total	Count	613	1261	5048	865	755	1226	9768	814
	%	6.2%	12.9%	51.6%	8.8%	7.7%	12.5%	100	

Appendix D

Table D1. Results from MNL estimates

MNL estimates	Treatment 1 (CON) (N=204)	Treatment 2 (WEB) (N=200)	Treatment 3 (SOC) (N=204)	Treatment 4 (LAB) (N=206)
Cage vs none	0.97***	1.07***	0.74***	0.91***
Barn vs none	1.84***	1.75***	1.42***	1.73***
Free-range vs none	3.62***	3.27***	3.23***	3.24***
Plant-based with soy vs none	1.20***	1.40***	1.22***	1.30***
Plant-based with peas vs none	1.08***	1.20***	1.06***	1.20***
Price	-0.72***	-0.79***	-0.74***	-0.78***

Note: Threes asterisks represent statistical significance at the 0.01 level.

Table D2. Mean WTP estimates based on the MNL model

Product alternatives	Treatment 1 (CON) (N=204)	Treatment 2 (WEB) (N=200)	Treatment 3 (SOC) (N=204)	Treatment 4 (LAB) (N=206)
Cage eggs vs. none	£1.35	£1.35	£1.00	£1.17
Barn eggs vs. none	£2.55	£2.21	£1.92	£2.22
Free-range eggs vs. none	£5.03	£4.14	£4.36	£4.15
Plant-based eggs made with peas vs. none	£1.67	£1.78	£1.65	£1.67
Plant-based eggs made with soy vs. none	£1.50	£0.90	£0.70	£1.53

Chapter VI – ***Discussion and Conclusions***

The aim of this thesis was to investigate the current market and consumers' reaction to a new alternative to conventional eggs, the plant-based eggs, which are not made from hens but using plant ingredients such as legumes, soy, cereals etc. This topic is particularly relevant given the increasing global demand for eggs and the numerous controversies associated with its consumption (e.g., egg allergies, the level of cholesterol in eggs) and production (e.g., food safety issues, poor animal welfare standard in the egg farms, sustainability). The findings have important implications from both manufacturers and policy makers perspectives on how to best promote these products and facilitate the transition towards the consumption of healthier and more sustainable foods.

Overall, it is shown that given the current limitations of the egg stakeholders to provide an alternative to eggs to those people who do not or cannot eat eggs, plant-based eggs might represent a valid substitute. Nonetheless, in order to be pleasantly welcomed by consumers it is advisable to accommodate consumers' expectations, it is advised to follow their input since the early stage of product development. In particular, consumers expressed preferences for different intrinsic (colour, shape, odour etc.) and extrinsic (price, packaging, country of origin etc.) characteristics. In the Italian market, the limitation of separating the albumen from the yolk in current plant-based eggs alternatives seemed one of the major issues as several recipes require these two elements to be used separately. Therefore, it is advisable for plant-based eggs manufacturer to carefully select their market target and to develop their product based on consumers' necessities. From the prospective of

plant-based egg start-ups, the biggest challenge they are facing is to get approval by international food safety authorities to launch them into the market. For example, the liquid prototype of plant-based eggs from the company JUST ltd. has already been approved and launched in the USA, but not yet in the EU and this because it is made with mung beans which are an unpopular ingredient in the EU and thus, they need to be carefully investigated. In this regard, to facilitate the diffusion of new plant-based product alternatives and to make them always more available to consumers, food safety authorities should provide clear instruction about their regulation process in order to make it as easy as possible and the industries should carefully follow the rules to facilitate their job.

This thesis also provides results in regard to consumers' associations with plant-based eggs. 'Price' was the most recurring association and was mostly given a negative evaluation, suggesting that consumers might expect plant-based eggs to be more expensive than conventional eggs. Hence, manufacturers are recommended to try to keep their prices as competitive as possible to incentive the purchase of their products. In addition, given the positive meaning that consumers assign to associations related to the plant-based eggs being healthier, animal-free, and more environmentally sustainable than conventional eggs, manufacturers are encouraged to emphasize this characteristic when marketing their products using labels for examples, and policy makers are advised to promote initiatives to inform consumers of the advantages of consuming and purchasing plant-based eggs in favour of conventional eggs. In particular, plant-based eggs might well fit the growing

consumers' demand for food products that are richer in nutrients and health benefits, as result of the Covid-19 pandemic.

Last, this thesis provides insights on consumers' WTP for plant-based eggs, as well as on the most preferable channel of communication that manufacturers should consider using to communicate their products to the public. Results show that despite free-range eggs continue to be the most favourite type of eggs, plant-based eggs made with peas are praised by the UK consumers. This suggests that ingredients other than soy should be considered when producing plant-based eggs. In addition, considering communicating the health, animal welfare and environmental benefits of plant-based eggs using a social media style of communication seems beneficial to increase consumers' WTP for these products. However, as already happened with other plant-based food alternatives of conventional animal-based foods, it is expectable that plant-based eggs will not directly cannibalize the egg market, but that will be offered alongside conventional eggs, expanding the offer of eggs, and accommodating the needs of different consumers segments (e.g., those who do not or cannot eat eggs). This works also provides information in regard to consumers' preferences for plant-based egg naming and reveal that consumers seem to oppose the idea of using the word "egg" to label the plant-based eggs. Globally, the debate on whether using animal foods (e.g., burger, sausages) to rename plant-based foods may confuse consumers on the real nature of these products and therefore on whether plant-based foods can continue to be labelled as such is still open and a clear regulation on this matter is

yet missing. In the EU, this blurred with the ban of labelling plant-based milk alternatives as “milk”. Therefore, this legislation is likely to impact labelling regulations for plant-based eggs too. Hence, manufacturers are advised to look for name alternatives that could well resonate with consumers and facilitate their understanding of these new products. On the other hand, policy makers should develop clear regulations on this matter to facilitate the marketing of these products.

Future research avenues

To the best of the author’s knowledge the studies reported in this thesis are the first to investigate the current market and consumers’ viewpoint on plant-based eggs, meaning that the literature on this topic is still at its infancy. Therefore, several other research could be conducted to enrich the existing literature. First, as this work focused on consumers from the United Kingdom and Italy, future research could be conducted in other countries, like Asia for example, where the production and demand for conventional eggs, as well as for plant-based food alternatives is on the raise and see whether preferences and demand change. Second, unlabelled choice experiment could be employed together with eye-tracking or mouse tracking to investigate consumers’ preferences for different information (e.g., labels) on plant-based eggs, which provide interesting information on how to better market these products. Third, sensory tests coupled with real choice experiments or experimental auctions in a real market scenario using real products should be conducted to investigate consumers’ preferences and willingness to pay for plant-based eggs to get more realistic information and to refine the taste of these products based on

consumers' opinion. Fourth, given the uncertainty around how plant-based eggs will be labelled, there is need to investigate consumers' preferences for plant-based eggs labelled with and without the use of the word "eggs", and see whether this affects their behaviour. Fifth, in-store studies exploring the effects of different position strategies for plant-based eggs (e.g., next to conventional eggs or in the 'vegan product isle') should be conducted.

References

Abín, R., Laca, Amanda, Laca, Adriana, Díaz, M., 2018. Environmental assesment of intensive egg production: A Spanish case study. J. Clean. Prod. 179, 160–168.

Ahmad Hanis, I.A.H., Mad Nasir, S., Jinap, S., Alias, R., Ab Karim, M.S., 2013. Consumer's preferences for eggs attributes in Malaysia: Evidence from conjoint survey. Int. Food Res. J. 20, 2865–2872.

Al-Ajeeli, M.N., Miller, R.K., Leyva, H., Hashim, M.M., Abdaljaleel, R.A., Jameel, Y., Bailey, C.A., 2018. Consumer acceptance of eggs from Hy-Line Brown layers fed soybean or soybean-free diets using cage or free-range rearing systems. Poult. Sci. 97, 1848–1851.

Alba, J.W., Hasher, L., 1983. Is memory schematic? Psychol. Bull. 93, 203–231. https://doi.org/10.1037/0033-2909.93.2.203

Albari, Safitri, I., 2018. The influence of product price on consumers' purchasing decisions. Rev. Integr. Bus. Econ. Res. 7, 328–337.

Alfnes, F., Rickertsen, K., 2010. Non-market valuation: Experimental methods, in: Lusk, J.L., Roosen, J., Shogren, J.F. (Eds.), The Economics of Food Consumption and Policy. "Oxford University Press." https://doi.org/10.1093/oxfordhb/9780199569441.013.0009

Allender, W.J., Richards, T.J., 2010. Consumer impact of animal welfare regulation in the California poultry industry. J. Agric. Resour. Econ. 35, 424–442.

Amchova, P., Kotolova, H., Ruda-Kucerova, J., 2015. Health safety issues of synthetic food colorants. Regul. Toxicol. Pharmacol. 73, 914–922. https://doi.org/10.1016/j.yrtph.2015.09.026

Andersen, L.M., 2011. Animal welfare and eggs - Cheap talk or money on the counter? J. Agric. Econ. 62, 565–584.

Apostolidis, C., McLeay, F., 2016. Should we stop meating like this? Reducing meat consumption through substitution. Food Policy 65, 74–89. https://doi.org/10.1016/j.foodpol.2016.11.002

Archibald, M.M., Ambagtsheer, R.C., Casey, M.G., Lawless, M., 2019. Using Zoom Videoconferencing for Qualitative Data Collection: Perceptions and Experiences of Researchers and Participants. Int. J. Qual. Methods 18, 1–8. https://doi.org/10.1177/1609406919874596

Asioli, D., Aschemann-Witzel, J., Caputo, V., Vecchio, R., Annunziata, A., Næs, T., Varela, P., 2017a. Making sense of the "clean label" trends: A review of consumer food choice behavior and discussion of industry implications. Food Res. Int. 99, 58–71.

Asioli, D., Mignani, A., Alfnes, F., 2020. Quick and easy? Respondent evaluations of the Becker–DeGroot–Marschak and multiple price list valuation mechanisms. Agribusiness 1–20. https://doi.org/10.1002/agr.21668

Asioli, D., Varela, P., Hersleth, M., Almli, V.L., Olsen, N.V., Næs, T., 2017b. A discussion of recent methodologies for combining sensory and extrinsic product properties in consumer studies. Food Qual. Prefer. 56, 266–273.

Askew, K., 2017. Vegan hard-boiled egg developed by Udine students. Food Navig.

Attride-Stirling, J., 2001. Thematic networks: An analytic tool for qualitative research. Qual. Res. 1, 385–405. https://doi.org/10.1177/146879410100100307

Austgulen, M.H., Skuland, S.E., Schjøll, A., Alfnes, F., 2018. Consumer readiness to reduce meat consumption for the purpose of environmental sustainability: Insights from Norway. Sustain. 10, 1–24. https://doi.org/10.3390/su10093058

Ayim-Akonor, M., Akonor, P.T., 2014. Egg consumption: Patterns, preferences and perceptions among consumers in Accra metropolitan area. Int. Food Res. J. 21, 1457–1463.

Baba, Y., Kallas, Z., Realini, C., 2017. Application of the analytical hierarchy process to evaluate consumer acceptance and preferences for omega-3 enriched eggs. Br. Food J. 119, 1459–1472.

Balcombe, K., Bradley, D., Fraser, I., Hussein, M., 2016a. Consumer preferences regarding country of origin for multiple meat products. Food Policy. https://doi.org/10.1016/j.foodpol.2016.09.008

Balcombe, K., Fraser, I., Lowe, B., Souza Monteiro, D., 2016b. Information Customization and Food Choice. Am. J. Agric. Econ. 98, 54–73. https://doi.org/10.1093/ajae/aav033

Banovic, M., Lähteenmäki, L., Arvola, A., Pennanen, K., Duta, D.E., Brückner-

Gühmann, M., Grunert, K.G., 2018. Foods with increased protein content: A qualitative study on European consumer preferences and perceptions. Appetite 125, 233–243. https://doi.org/10.1016/j.appet.2018.01.034

Barnett, J., McConnon, A., Kennedy, J., Raats, M., Shepherd, R., Verbeke, W., Fletcher, J., Kuttschreuter, M., Lima, L., Wills, J., Wall, P., 2011. Development of strategies for effective communication of food risks and benefits across Europe: Design and conceptual framework of the FoodRisC project. BMC Public Health 11, 1–9. https://doi.org/10.1186/1471-2458-11-308

Barnkob, L.L., Argyraki, A., Jakobsen, J., 2020. Naturally enhanced eggs as a source of vitamin D: A review. Trends Food Sci. Technol. https://doi.org/10.1016/j.tifs.2020.05.018

Bejaei, M., Wiseman, K., Cheng, K.M., 2011. Influences of demographic characteristics, attitudes, and preferences of consumers on table egg consumption in British Columbia, Canada. Poult. Sci. 90, 1088–1095.

Bennett, R.M., Jones, P.J., Nicol, C.J., Tranter, R.B., Weeks, C.A., 2016. Consumer attitudes to injurious pecking in free-range egg production. Anim. Welf.

Blair, E., 2015. A reflexive exploration of two qualitative data coding techniques. J. Methods Meas. Soc. Sci. 6, 14–29. https://doi.org/10.2458/v6i1.18772

Borgatti, Everett, & Freeman, L., 2002. Ucinet for windows: software for social network analysis. Harvard: Analytic Technologies.

Borrelli, L., Coretti, L., Dipineto, L., Bovera, F., Menna, F., Chiariotti, L., Nizza, A., Lembo, F., Fioretti, A., 2017. Insect-based diet, a promising nutritional source, modulates gut microbiota composition and SCFAs production in laying hens. Sci. Rep. 7, 1–11.

Braun, V., Clarke, V., 2006. Using thematic analysis in psychology. Qual. Res. Psychol. 3, 77–10. https://doi.org/10.1191/1478088706qp063oa

Bray, H.J., Ankeny, R.A., 2017. Happy Chickens Lay Tastier Eggs: Motivations for Buying Free-range Eggs in Australia. Anthrozoos 30, 213–226.

Breakwell, G.M., 2008. Doing Social Psychology Research, Doing Social Psychology Research. https://doi.org/10.1002/9780470776278

British Hearth Foundation, 2018. Can eating an egg a day reduce your risk of heart diseases? [WWW Document]. URL https://www.bhf.org.uk/informationsupport/heart-matters-magazine/news/behind-the-headlines/eggs-and-heart-risk

Brown, D.J., Schrader, L.F., 2006. Cholesterol Information and Shell Egg Consumption. Am. J. Agric. Econ. 72, 548–555. https://doi.org/10.2307/1243023

Buller, H., Roe, E., 2014. Modifying and commodifying farm animal welfare: The economisation of layer chickens. J. Rural Stud. 33, 141–149.

Butu, A., Brumă, I.S., Tanasă, L., Rodino, S., Vasiliu, C.D., Doboș, S., Butu, M., 2020. The impact of COVID-19 crisis upon the consumer buying behavior of fresh vegetables directly from local producers. Case study: The quarantined

area of Suceava County, Romania. Int. J. Environ. Res. Public Health 17, 1–25. https://doi.org/10.3390/ijerph17155485

Caputo, V., Lusk, J.L., Nayga, R.M., 2020. Am I Getting a Good Deal? Reference-DependentDecision Making When the Reference Price Is Uncertain. Am. J. Agric. Econ. 102, 132–153. https://doi.org/10.1093/ajae/aaz042

Carrenõ, I., Dolle, T., 2018. Tofu steaks? Developments on the naming and marketing of plant-based foods in the aftermath of the TofuTown judgement. Eur. J. Risk Regul. 9, 575–584. https://doi.org/10.1017/err.2018.43

Carrington, D., 2018. The new food: meet the startups racing to reinvent the meal. Guard.

Chang, J.B., Lusk, J.L., Norwood, F.B., 2010. The price of happy hens: A hedonic analysis of retail egg prices. J. Agric. Resour. Econ. 35, 406–423.

Chang, Y.H., Chang, C.Y., Tseng, Y.H., 2010. Trends of science education research: An automatic content analysis. J. Sci. Educ. Technol. 19, 315–331. https://doi.org/10.1007/s10956-009-9202-2

Claudy, M.C., Peterson, M., Pagell, M., 2016. The Roles of Sustainability Orientation and Market Knowledge Competence in New Product Development Success. J. Prod. Innov. Manag. 33, 72–85. https://doi.org/10.1111/jpim.12343

Cliceri, D., Spinelli, S., Dinnella, C., Prescott, J., Monteleone, E., 2018. The influence of psychological traits, beliefs and taste responsiveness on implicit

attitudes toward plant- and animal-based dishes among vegetarians, flexitarians and omnivores. Food Qual. Prefer. 68, 276–291. https://doi.org/10.1016/j.foodqual.2018.03.020

Collins, A.M., Loftus, E.F., 1975. A spreading-activation theory of semantic processing. Psychol. Rev. 82, 407–428. https://doi.org/10.1037/0033-295X.82.6.407

Coppola, A., Verneau, F., 2010. Naturalness and Consumer Choices: The Case of Microfiltered Milk, in: Proceedings of the 4th International European Forum on System Dynamics and Innovation in Food Networks.

Costa, A.I.A., Jongen, W.M.F., 2006. New insights into consumer-led food product development. Trends Food Sci. Technol. 17, 457–465. https://doi.org/10.1016/j.tifs.2006.02.003

Court of Justice of the European Union, 2017. Purely plant-based products cannot, in principle, be marketed with designations such as ‘milk’, ‘cream’, ‘butter’, ‘cheese’ or ‘yoghurt’, which are reserved by EU law for animal products.

Cowley, E., Mitchell, A.A., 2003. The Moderating Effect of Product Knowledge on the Learning and Organization of Product Information. J. Consum. Res. 30, 443–454. https://doi.org/10.1086/378620

Datassentail, 2020. COVID-19 report 18: Where’s the meat?

de Koning, W., Dean, D., Vriesekoop, F., Aguiar, L.K., Anderson, M., Mongondry, P., Oppong-Gyamfi, M., Urbano, B., Luciano, C.A.G., Jiang, B., Hao, W., Eastwick, E., Virgil, Z.J., Boereboom, A., 2020. Drivers and

inhibitors in the acceptance of meat alternatives: The case of plant and insect-based proteins. Foods 9. https://doi.org/10.3390/foods9091292

De Pelsmaeker, S., Dewettinck, K., Gellynck, X., 2013. The possibility of using tasting as a presentation method for sensory stimuli in conjoint analysis. Trends Food Sci. Technol. 29, 108–115.

Dekker, S.E.M., de Boer, I.J.M., Vermeij, I., Aarnink, A.J.A., Koerkamp, P.W.G.G., 2011. Ecological and economic evaluation of Dutch egg production systems. Livest. Sci. 139, 109–121.

DiCicco-Bloom, B., Crabtree, B.F., 2006. The qualitative research interview. Med. Educ. 40, 314–321. https://doi.org/10.1111/j.1365-2929.2006.02418.x

Doyon, M., Bergeron, S., Cranfield, J., Tamini, L., Criner, G., 2016. Consumer Preferences for Improved Hen Housing: Is a Cage a Cage?, in: Canadian Journal of Agricultural Economics. pp. 739–751.

Elliott, V., 2018. Thinking about the coding process in qualitative data analysis. Qual. Rep. 23, 2850–2861.

Elzerman, J.E., Hoek, A.C., van Boekel, M.J.A.S., Luning, P.A., 2015. Appropriateness, acceptance and sensory preferences based on visual information: A web-based survey on meat substitutes in a meal context. Food Qual. Prefer. 42, 56–65. https://doi.org/10.1016/j.foodqual.2015.01.010

Elzerman, J.E., van Boekel, M.A.J.S., Luning, P.A., 2013. Exploring meat substitutes: Consumer experiences and contextual factors. Br. Food J. 115, 700–710. https://doi.org/10.1108/00070701311331490

EU Regulation, 2015. Regulation (EU) 2015/2283 of the European Parliament and of the Council.

European Commission, 2017. Fipronil in eggs: Factsheet – December 2017.

European Commission, 1999. Protection of laying hens [WWW Document]. URL https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=LEGISSUM:l12067&from=EN

FAO, 2017. Gateway to poultry production and products [WWW Document]. URL http://www.fao.org/poultry-production-products/production/en/

FAO, 2016. The state of food and agriculture: Climate change, agriculture and food security. Rome (Italy).

Fernandez, M.L., 2010. Effects of eggs on plasma lipoproteins in healthy populations. Food Funct. https://doi.org/10.1039/c0fo00088d

Fernqvist, F., Spendrup, S., Ekelund, L., 2015. Changing consumer intake of potato, A focus group study. Br. Food J. 117, 210–221. https://doi.org/10.1108/BFJ-05-2013-0112

Fessler, D.M.T., Arguello, A.P., Mekdara, J.M., Macias, R., 2003. Disgust sensitivity and meat consumption: A test of an emotivist account of moral vegetarianism. Appetite 41, 31–41. https://doi.org/10.1016/S0195-6663(03)00037-0

Font-i-Furnols, M., Guerrero, L., 2014. Consumer preference, behavior and perception about meat and meat products: An overview. Meat Sci. https://doi.org/10.1016/j.meatsci.2014.06.025

Food Navigator, 2019. JUST predicts mid 2020 launch in EU yet China number one priority for scrambled egg alternative.

Freeman, L.C., 1978. Centrality in social networks conceptual clarification. Soc. Networks 1, 215–239. https://doi.org/10.1016/0378-8733(78)90021-7

French, A., Smith, G., 2013. Measuring brand association strength: A consumer based brand equity approach. Eur. J. Mark. 47, 1356–1367. https://doi.org/10.1108/03090561311324363

Frewer, L.J., Bergmann, K., Brennan, M., Lion, R., Meertens, R., Rowe, G., Siegrist, M., Vereijken, C., 2011. Consumer response to novel agri-food technologies: Implications for predicting consumer acceptance of emerging food technologies. Trends Food Sci. Technol. 22, 442–456. https://doi.org/10.1016/j.tifs.2011.05.005

Gangnat, I.D.M., Mueller, S., Kreuzer, M., Messikommer, R.E., Siegrist, M., Visschers, V.H.M., 2018. Swiss consumers' willingness to pay and attitudes regarding dual-purpose poultry and eggs. Poult. Sci. 97, 1089–1098.

García-Madariaga, J., Blasco López, M.F., Burgos, I.M., Virto, N.R., 2019. Do isolated packaging variables influence consumers' attention and preferences? Physiol. Behav. https://doi.org/10.1016/j.physbeh.2018.04.030

Geng, H., Song, H., Qi, J., Cui, D., 2011. Sustained release of VEGF from PLGA-nanoparticles embedded thermo-sensitive hydrogel in full-thickness porcine bladder acellular matrix. Nanoscale Res. Lett. 312, 1–8. https://doi.org/10.1186/1556-276X-6-312

Gerini, F., Alfnes, F., Schjøll, A., 2016. Organic- and Animal Welfare-labelled Eggs: Competing for the Same Consumers? J. Agric. Econ. 67, 471–490.

Gilliver, L., 2019. Plant-Based JUST Egg To Launch In Over 2,000 Stores Across US. Plant-based News.

Giménez, A.N.A., Ares, G., Gámbaro, A., 2008. Consumer Attitude Toward Shelf-Life Labeling. J. Sens. Stud. 23, 871–883. https://doi.org/10.1111/j.1745-459X.2008.00192.x

Ginzberg, A., Cohen, M., Sod-Moriah, U.A., Shany, S., Rosenshtrauch, A., Arad, S., 2000. Chickens fed with biomass of the red microalga Porphyridium sp. have reduced blood cholesterol level and modified fatty acid composition in egg yolk. J. Appl. Phycol. 12, 325–330. https://doi.org/10.1023/A:1008102622276

Gracia, A., Barreiro-Hurlé, J., López-Galán, B., 2014. Are Local and Organic Claims Complements or Substitutes? A Consumer Preferences Study for Eggs. J. Agric. Econ. 65, 49–67.

Grebitus, C., 2008. Food quality from the consumer's perspective: An empirical analysis of perceived pork quality.

Grebitus, C., Bruhn, M., 2008. Analyzing semantic networks of pork quality by means of concept mapping. Food Qual. Prefer. 19, 86–96. https://doi.org/10.1016/j.foodqual.2007.07.007

Grebitus, C., Chenarides, L., Muenich, R., Mahalov, A., 2020. Consumers' Perception of Urban Farming—An Exploratory Study. Front. Sustain. Food

Syst. 4, 1–13. https://doi.org/10.3389/fsufs.2020.00079

Grunert, K.G., 2005. Food quality and safety: Consumer perception and demand. Eur. Rev. Agric. Econ. 32, 369–391.

Grunert, K.G., 2002. Current issues in the understanding of consumer food choice. Trends Food Sci. Technol. 13, 275–285.

Grunert, K.G., 1997. What's in a steak? A cross-cultural study on the quality perception of beef. Food Qual. Prefer. 8, 157–174.

Grunert, K.G., Bredahl, L., Brunsø, K., 2004. Consumer perception of meat quality and implications for product development in the meat sector - A review. Meat Sci. 66, 259–272. https://doi.org/10.1016/S0309-1740(03)00130-X

Grunert, K.G., Grunert, S.C., 1995. Measuring subjective meaning structures by the laddering method: Theoretical considerations and methodological problems. Int. J. Res. Mark. 12, 209–225. https://doi.org/10.1016/0167-8116(95)00022-T

Grunert, K.G., Hieke, S., Wills, J., 2014. Sustainability labels on food products: Consumer motivation, understanding and use. Food Policy 44, 177–189.

Guest, G., Namey, E., McKenna, K., 2017. How Many Focus Groups Are Enough? Building an Evidence Base for Nonprobability Sample Sizes. Field methods 29, 3–22. https://doi.org/10.1177/1525822X16639015

Güney, O.I., Giraldo, L., 2019. Consumers' attitudes and willingness to pay for organic eggs: A discrete choice experiment study in Turkey. Br. Food J. 122,

678–692.

Hasimu, H., Marchesini, S., Canavari, M., 2017. A concept mapping study on organic food consumers in Shanghai, China. Appetite 108, 191–202. https://doi.org/10.1016/j.appet.2016.09.019

Hay, D., Kinchin, I., Lygo-Baker, S., 2008. Making learning visible: The role of concept mapping in higher education. Stud. High. Educ. 33, 295–311. https://doi.org/10.1080/03075070802049251

Henderson, G.R., Iacobucci, D., Calder, B.J., 1998. Brand diagnostics: Mapping branding effects using consumer associative networks. Eur. J. Oper. Res. 111, 306–327. https://doi.org/10.1016/S0377-2217(98)00151-9

Heng, Y., Peterson, H.H., 2018. Interaction Effects among Labeled Attributes for Eggs in the United States. J. Int. Food Agribus. Mark. 30, 236–250. https://doi.org/10.1080/08974438.2017.1413610

Heng, Y., Peterson, H.H., Li, X., 2013. Consumer attitudes toward farm-animal welfare: The case of laying hens. J. Agric. Resour. Econ. 38, 418–434.

Hester, P.Y., Shea-Moore, M., 2005. Beak trimming egg-laying strains of chickens. Worlds. Poult. Sci. J. 59, 458–474. https://doi.org/10.1079/wps20030029

Hoek, A.C., Luning, P.A., Weijzen, P., Engels, W., Kok, F.J., de Graaf, C., 2011. Replacement of meat by meat substitutes. A survey on person- and product-related factors in consumer acceptance. Appetite 56, 662–673. https://doi.org/10.1016/j.appet.2011.02.001

Huang, L., 2013. Factors Affecting Consumers Preferences for Specialty Eggs in Canada. Dep. Bioresour. Policy, Bus. Econ.

Huffman, W.E., Rousu, M., Shogren, J.F., Tegene, A., 2004. Who do consumers trust for information: The case of genetically modified foods? Am. J. Agric. Econ. 86, 1222–1229. https://doi.org/10.1111/j.0002-9092.2004.00669.x

Ilicic, J., Webster, C.M., 2015. Consumer values of corporate and celebrity brand associations. Qual. Mark. Res. 18, 164–187. https://doi.org/10.1108/QMR-06-2013-0037

Ingenbleek, P.T.M., Frambach, R.T., Verhallen, T.M.M., 2010. The role of value-informed pricing in market-oriented product innovation management. J. Prod. Innov. Manag. 27, 1032–1046. https://doi.org/10.1111/j.1540-5885.2010.00769.x

International Egg Commission, 2015. Egg Industry Review 2015.

International Egg Commission, 2014. Global egg production dynamics – past, present and future of a remarkable success story. London (United Kingdom).

International Egg Commission, 2013. Atlas of the Global Egg Industry. London (United Kingdom).

ISMEA, 2019. Il comparto delle uova da consumo. Rome (Italy).

ISTAT, 2019. Aspetti della vita quotidiana - Persone : Salumi, carni, uova, pesce - età, titolo di studio [WWW Document]. URL http://dati.istat.it/index.aspx?queryid=16811

Jaeger, S.R., 2006. Non-sensory factors in sensory science research. Food Qual. Prefer. 17, 132–144.

Jallinoja, P., Niva, M., Latvala, T., 2016. Future of sustainable eating? Examining the potential for expanding bean eating in a meat-eating culture. Futures 83, 4–14. https://doi.org/10.1016/j.futures.2016.03.006

James, L., 2019. With Plant-Based Eggs and Lab-Grown Meat, JUST Inc. Is Transforming Food.

Janßen, D., Langen, N., 2017. The bunch of sustainability labels – Do consumers differentiate? J. Clean. Prod. 143, 1233–1245. https://doi.org/10.1016/j.jclepro.2016.11.171

Jonassen, D.H., Marra, R.M., 1994. Concept mapping and other formalisms as mindtools for representing knowledge. Alt-J 2, 50–56. https://doi.org/10.1080/0968776940020107

Jooyoung, K., Morris, J.D., 2007. The power of affective response and cognitive structure in product-trial attitude formation. J. Advert. 36, 95–106. https://doi.org/10.2753/JOA0091-3367360107

Karcher and Mench, 2018. Overview of commercial poultry production systems and their main welfare challenges, in: Adance in Poultry Welfare.

Khachatryan, H., Rihn, A., Behe, B., Hall, C., Campbell, B., Dennis, J., Yue, C., 2018. Visual attention, buying impulsiveness, and consumer behavior. Mark. Lett. 29, 23–35. https://doi.org/10.1007/s11002-018-9446-9

Knoke, D., & Kuklinski, J.H., 1982. Network Analysis.

Koba, 2015. Fake meat sales are growing, but is it really better for you?

Koch, G., Elbers, A.R.W., 2006. Outdoor ranging of poultry: A major risk factor for the introduction and development of High-Pathogenecity Avian Influenza. NJAS - Wageningen J. Life Sci. 54, 179–194.

Köster, E.P., 2009. Diversity in the determinants of food choice: A psychological perspective. Food Qual. Prefer. 20, 70–82.

Krautwald-Junghanns, M.-E., Cramer, K., Fischer, B., Förster, A., Galli, R., Kremer, F., Mapesa, E.U., Meissner, S., Preisinger, R., Preusse, G., Schnabel, C., Steiner, G., Bartels, T., 2018. Current approaches to avoid the culling of day-old male chicks in the layer industry, with special reference to spectroscopic methods. Poult. Sci. 97, 749–757. https://doi.org/10.3382/PS/PEX389

Krippendorff, 2004. Content analysis: an introduction to its methodology. SAGE Publications Ltd., London, UK.

Lähteenmäki, L., 2013. Claiming health in food products. Food Qual. Prefer. 27, 196–201.

Lee, S., Lee, J.H., Garrett, T.C., 2013. A study of the attitude toward convergent products: A focus on the consumer perception of functionalities. J. Prod. Innov. Manag. 30, 123–135. https://doi.org/10.1111/j.1540-5885.2012.00991.x

Lehmann, 1992. Semantic networks. Comput. Math. Applic. 23, 1–50.

Leinonen, I., Williams, A.G., Wiseman, J., Guy, J., Kyriazakis, I., 2012.

Predicting the environmental impacts of chicken systems in the united kingdom through a life cycle assessment: Egg production systems. Poult. Sci. 91, 26–40.

Lesnierowski, G., Stangierski, J., 2018. What's new in chicken egg research and technology for human health promotion? - A review. Trends Food Sci. Technol. 71, 46–51. https://doi.org/10.1016/j.tifs.2017.10.022

Li, T., Bernard, J.C., Johnston, Z.A., Messer, K.D., Kaiser, H.M., 2017. Consumer preferences before and after a food safety scare: An experimental analysis of the 2010 egg recall. Food Policy 66, 25–34.

Li, Xianjiang, Li, H., Ma, W., Guo, Z., Li, Xiuqin, Song, S., Tang, H., Li, Xiaomin, Zhang, Q., 2019. Development of precise GC-EI-MS method to determine the residual fipronil and its metabolites in chicken egg. Food Chem. 281, 85–90.

Lim, S.L., Penrod, M.T., Ha, O.R., Bruce, J.M., Bruce, A.S., 2018. Calorie Labeling Promotes Dietary Self-Control by Shifting the Temporal Dynamics of Health- and Taste-Attribute Integration in Overweight Individuals. Psychol. Sci. https://doi.org/10.1177/0956797617737871

Linnemann, A.R., Benner, M., Verkerk, R., Van Boekel, M.A.J.S., 2006. Consumer-driven food product development. Trends Food Sci. Technol. 17, 184–190. https://doi.org/10.1016/j.tifs.2005.11.015

Loh, W., Tang, M.L.K., 2018. The epidemiology of food allergy in the global context. Int. J. Environ. Res. Public Health 2043, 1–8.

Lopez-Galan, B., Gracia, A., Barreiro-Hurle, J., 2013. What comes first, origin or production method? An investigation into the relative importance of different attributes in the demand for eggs. Spanish J. Agric. Res. 11, 305–315.

Lu, Y., Cranfield, J., Widowski, T., 2013. Consumer Preference for Eggs from Enhanced Animal Welfare Production System: A Stated Choice Analysis. 2013 Annu. Meet. August 4-6, 2013, Washington, D.C.

Lusk, J.L., 2018. Consumer preferences for cage-free eggs and impacts of retailer pledges. Agribusiness 35, 129–148.

Lusk, J.L., 2010. The effect of proposition 2 on the demand for eggs in California. J. Agric. Food Ind. Organ. 8.

Lusk, J.L., Briggeman, B.C., 2009. Food values. Am. J. Agric. Econ. 91, 184–196. https://doi.org/10.1111/j.1467-8276.2008.01175.x

Lusk, J.L., Shogren, J.F., 2007. Experimental Auctions. Methods and Applications in Economic and Marketing Research. Cambridge University Press, Cambridge.

Madsen, S.M., Petermans, A., 2019. Designing retail - Unravelling coping strategies through emphatic interviewing owner managers. J. Retail. Consum. Serv. 55, 101884. https://doi.org/10.1016/j.jretconser.2019.101884

Magnier, L., Schoormans, J., Mugge, R., 2016. Judging a product by its cover: Packaging sustainability and perceptions of quality in food products. Food Qual. Prefer. 53, 132–142. https://doi.org/10.1016/j.foodqual.2016.06.006

Malek, L., Umberger, W.J., Goddard, E., 2019. Committed vs. uncommitted meat

eaters: Understanding willingness to change protein consumption. Appetite 138, 115–126. https://doi.org/10.1016/j.appet.2019.03.024

Malhotra, B. and W., 2017. Marketing Research: An applied approach, 3rd ed. Harlow, UK. Pearson Education.

Malone, T., Lusk, J.L., 2016. Putting the chicken before the egg price: An ex post analysis of California's battery cage ban. J. Agric. Resour. Econ.

Malterud, K., Siersma, V.D., Guassora, A.D., 2016. Sample Size in Qualitative Interview Studies: Guided by Information Power. Qual. Health Res. 26, 1753–1760. https://doi.org/10.1177/1049732315617444

Mancini, M.C., Antonioli, F., 2020. To what extent are consumers' perception and acceptance of alternative meat production systems affected by information? The case of cultured meat. Animals 10. https://doi.org/10.3390/ani10040656

Marcu, A., Gaspar, R., Rutsaert, P., Seibt, B., Fletcher, D., Verbeke, W., Barnett, J., 2015. Analogies, metaphors, and wondering about the future: Lay sense-making around synthetic meat. Public Underst. Sci. https://doi.org/10.1177/0963662514521106

Martin, 1985. Measuring Clients' Cognitive Competence in Research on Counseling. J. Couns. Dev. 63, 556–560.

Martins, N., Roriz, C.L., Morales, P., Barros, L., Ferreira, I.C.F.R., 2016. Food colorants: Challenges, opportunities and current desires of agro-industries to ensure consumer expectations and regulatory practices. Trends Food Sci. Technol. 52, 1–15. https://doi.org/10.1016/j.tifs.2016.03.009

Masuda, T., Goldsmith, P.D., 2012. China's meat and egg production and soybean meal demand for feed: An elasticity analysis and long-term projections? Int. Food Agribus. Manag. Rev. 5, 543–566.

McCarthy, K.S., Parker, M., Ameerally, A., Drake, S.L., Drake, M.A., 2017. Drivers of choice for fluid milk versus plant-based alternatives: What are consumer perceptions of fluid milk? J. Dairy Sci. 100, 6125–6138. https://doi.org/10.3168/jds.2016-12519

McFadden, D., 1973. Conditional logit analysis of qualitative choice behavior. Front. Econom. https://doi.org/10.1108/eb028592

McLinden, D., 2013. Concept maps as network data: Analysis of a concept map using the methods of social network analysis. Eval. Program Plann. 36, 40–48. https://doi.org/10.1016/j.evalprogplan.2012.05.001

McNamara, D.J., 2015. The fifty year rehabilitation of the egg. Nutrients 7, 8716–8722.

Mesías, F.J., Martínez-Carrasco, F., Martínez, J.M., Gaspar, P., 2011. Functional and organic eggs as an alternative to conventional production: A conjoint analysis of consumers' preferences. J. Sci. Food Agric. 91, 532–538.

Mintel, 2019. UK Meat-Free Foods Market Report.

Mintel, 2017. Meat-free Foods. United Kingdom.

Molteni and Troilo, 2007. Ricerche di Marketing. McGraw-Hill, Milano, Italy.

Montossi, F., Cazzuli, F., Brito, G., Realini, C., Luzardo, S., Rovira, P., Font-I-

Furnols, M., 2018. The challenges of aligning consumer preferences and production systems: Analysing the case of a small beef meat exporting country. Int. J. Agric. Policy Res. 6, 144–159.

Moors, E., Donders, R., 2009. Understanding consumer needs and preferences in new product development: the case of functional food innovations. Intellect. Prop.

Mugge, R., Dahl, D.W., Schoormans, J.P.L., 2018. "What You See, Is What You Get?" Guidelines for Influencing Consumers' Perceptions of Consumer Durables through Product Appearance. J. Prod. Innov. Manag. 35, 309–329. https://doi.org/10.1111/jpim.12403

Myers, M.D., 2009. Qualitative research in business and management. SAGE Publications Ltd., London, UK.

Napolitano, F., Girolami, A., Braghieri, A., 2010. Consumer liking and willingness to pay for high welfare animal-based products. Trends Food Sci. Technol. 21, 537–543.

Nesbit, J.C., Adesope, O.O., Nesbit, J.C., Adesope, O.O., 2016. Learning with Concept and Knowledge Maps : A Meta-Analysis. Am. Educ. Res. Assoc. 76, 413–448.

Neuendorf, K. a, 2002. A Flowchart for the Typical Process of Content Analysis Research from The Content Analysis Guidebook , by Kimberly A . Neuendorf. Online.

Ngapo, T.M., Braña Varela, D., Rubio Lozano, M.S., 2017. Mexican consumers

at the point of meat purchase. Beef choice. Meat Sci. 134, 34–43.

Norwood, F.B., Lusk, J.L., 2011a. A calibrated auction-conjoint valuation method: Valuing pork and eggs produced under differing animal welfare conditions. J. Environ. Econ. Manage. 62, 80–94.

Norwood, F.B., Lusk, J.L., 2011b. Compassion, by the Pound: The Economics of Farm Animal Welfare, Compassion, by the Pound: The Economics of Farm Animal Welfare.

Nowell, L.S., Norris, J.M., White, D.E., Moules, N.J., 2017. Thematic Analysis: Striving to Meet the Trustworthiness Criteria. Int. J. Qual. Methods 16, 1–13. https://doi.org/10.1177/1609406917733847

Ochs, D.S., Wolf, C.A., Widmar, N.J.O., Bir, C., 2018. Consumer perceptions of egg-laying hen housing systems. Poult. Sci. 97, 1848–1851.

Ochs, Wolf, C.A., Widmar, N.O., Bir, C., Lai, J., 2019. Hen housing system information effects on U.S. egg demand. Food Policy 87, 101743.

Office for National Statistics, 2020. Impact of COVID-19 pandemic on grocery shopping behaviours. London (United Kingdom).

Olsen, S.O., Tuu, H.H., Grunert, K.G., 2017. Attribute importance segmentation of Norwegian seafood consumers: The inclusion of salient packaging attributes. Appetite 117, 214–223. https://doi.org/10.1016/j.appet.2017.06.028

Olson, & Jacoby, J., 1972. Cue utilization in the quality perception process. Chicago, IL: Association for Consumer Research, pp. 167–179.

Pan, Y., Torres, I.M., Zúñiga, M.A., 2019. Social Media Communications and Marketing Strategy: A Taxonomical Review of Potential Explanatory Approaches. J. Internet Commer. 18, 73–90. https://doi.org/10.1080/15332861.2019.1567187

Parisi, M.A., Northcutt, J.K., Smith, D.P., Steinberg, E.L., Dawson, P.L., 2015. Microbiological contamination of shell eggs produced in conventional and free-range housing systems. Food Control 47, 161–165.

Pelletier, N., 2017. Life cycle assessment of Canadian egg products, with differentiation by hen housing system type. J. Clean. Prod. 152, 167–180.

Peschel, A.O., Kazemi, S., Liebichová, M., Sarraf, S.C.M., Aschemann-Witzel, J., 2019. Consumers' associative networks of plant-based food product communications. Food Qual. Prefer. 75, 145–156. https://doi.org/10.1016/j.foodqual.2019.02.015

Petrescu, D.C., Vermeir, I., Petrescu-Mag, R.M., 2020. Consumer understanding of food quality, healthiness, and environmental impact: A cross-national perspective. Int. J. Environ. Res. Public Health 17. https://doi.org/10.3390/ijerph17010169

Pettersson, I.C., Weeks, C.A., Wilson, L.R.M., Nicol, C.J., 2016. Consumer perceptions of free-range laying hen welfare. Br. Food J. 118, 1999–2013.

Piper, 2020. The next challenge for plant-based meat: Winning the price war against animal meat [WWW Document]. URL https://www.vox.com/future-perfect/21366607/beyond-impossible-plant-based-meat-factory-farming

Polaris Market Research, 2020. Plant-Based Meat Market Share, Size, Trends, Industry Analysis Report, By Source (Soy, Wheat, Pea, and Others); By Product (Burger Patties, Sausages, Strips & Nuggets, Meatballs, Others); By Application (Retail Outlets, Foodservice, E-commerce), By Region.

Proposition 2, 2008. Proposition 2 [WWW Document]. URL https://web.archive.org/web/20090410080219/http://voterguide.sos.ca.gov/past/2008/general/title-sum/prop2-title-sum.htm

Rahmani, D., Kallas, Z., Pappa, M., Gil, J.M., 2019. Are Consumers' Egg Preferences Influenced by Animal-Welfare Conditions and Environmental Impacts? Sustainability 11, 6218.

Rodenburg, T.B., Tuyttens, F.A.M., de Reu, K., Herman, L., Zoons, J., Sonck, B., 2008. Welfare assessment of laying hens in furnished cages and non-cage systems: Assimilating expert opinion. Anim. Welf. 17, 355–361.

Rondoni, A., Asioli, D., Millan, E., 2020. Consumer behaviour, perceptions, and preferences towards eggs: A review of the literature and discussion of industry implications. Trends Food Sci. Technol. 106, 391–401.

Rondoni, A., Grebitus, C., Millan, E., Asioli, D., 2021a. Exploring consumers ' perceptions of plant-based eggs using concept mapping and semantic network analysis. Food Qual. Prefer. 94, 104327. https://doi.org/10.1016/j.foodqual.2021.104327

Rondoni, A., Millan, E., Asioli, D., 2021b. Consumers ' preferences for intrinsic and extrinsic product attributes of plant-based eggs : an exploratory study in

the United Kingdom and Italy. Br. Food J. ahead-of-p. https://doi.org/10.1108/BFJ-11-2020-1054

Rye, J.A., Rubba, P.A., 1998. An Exploration of the Concept Map as an Interview Tool to Facilitate the Externalization of Students' Understandings about Global Atmospheric Change. J. Res. Sci. Teach. 35, 521–546. https://doi.org/10.1002/(SICI)1098-2736(199805)35:5<521::AID-TEA4>3.0.CO;2-R

Sass, C.A.B., Kuriya, S., Da Silva, G. V., Silva, H.L.A., Da Cruz, A.G., Esmerino, E.A., Freitas, M.Q., 2018. Completion task to uncover consumer's perception: A case study using distinct types of hen's eggs. Poult. Sci. 97, 2591–2598.

Savage, J.H., Matsui, E.C., Skripak, J.M., Wood, R.A., 2007. The natural history of egg allergy. J. Allergy Clin. Immunol. 120, 1413–1417. https://doi.org/10.1016/j.jaci.2007.09.040

Seitz, C.C., Roosen, J., 2015. An empirical analysis of international consumers' associations with bavarian food products by means of concept mapping. Br. Food J. 117, 987–1006. https://doi.org/10.1108/BFJ-10-2013-0307

Sexton, A., 2016. Alternative Proteins and the (Non)Stuff of "Meat." Gastronomica 16, 66–78.

Shah, U., Walker, W.A., 2001. Food allergy, in: Pediatric Gastroenterology and Nutrition in Clinical Practice.

Shan, L.C., Regan, Á., Monahan, F.J., Li, C., Lalor, F., Murrin, C., Wall, P.G.,

McConnon, Á., 2017. Consumer preferences towards healthier reformulation of a range of processed meat products: A qualitative exploratory study. Br. Food J. https://doi.org/10.1108/BFJ-11-2016-0557

Shan, L.C., Regan, A., Monahan, F.J., Li, C., Murrin, C., Lalor, F., Wall, P.G., McConnon, A., 2016. Consumer views on "healthier" processed meat. Br. Food J. 118, 1712–1730. https://doi.org/10.1108/BFJ-11-2015-0447

Siipi, H., 2013. Is Natural Food Healthy? J. Agric. Environ. Ethics 26, 797–812. https://doi.org/10.1007/s10806-012-9406-y

Silva, A., Nayga, R.M., Campbell, B.L., Park, J.L., 2011. Revisiting Cheap Talk with New Evidence from a Field Experiment. J. Agric. Resour. Econ. 36, 280–291.

Sirsi, A.K., Ward, J.C., Reingen, P.H., 1996. Microcultural analysis of variation in sharing of causal reasoning about behavior. J. Consum. Res. 22, 345–372. https://doi.org/10.1086/209455

Slade, P., 2018. If you build it, will they eat it? Consumer preferences for plant-based and cultured meat burgers. Appetite 125, 428–437. https://doi.org/10.1016/j.appet.2018.02.030

Spain, C.V., Freund, D., Mohan-Gibbons, H., Meadow, R.G., Beacham, L., 2018. Are they buying it? United states consumers' changing attitudes toward more humanely raised meat, eggs, and dairy. Animals 128, 1–14.

Statista, 2021. Social networking in China - statistics & facts.

Stephens, N., Di Silvio, L., Dunsford, I., Ellis, M., Glencross, A., Sexton, A.,

2018. Bringing cultured meat to market: Technical, socio-political, and regulatory challenges in cellular agriculture. Trends Food Sci. Technol. 78, 155–166. https://doi.org/10.1016/j.tifs.2018.04.010

Stoyanov, S., Jablokow, K., Rosas, S.R., Wopereis, I.G.J.H., Kirschner, P.A., 2017. Concept mapping—An effective method for identifying diversity and congruity in cognitive style. Eval. Program Plann. 60, 238–244. https://doi.org/10.1016/j.evalprogplan.2016.08.015

Surai, P.F., Sparks, N.H.C., 2001. Designer eggs: From improvement of egg composition to functional food. Trends Food Sci. Technol. 12, 7–16. https://doi.org/10.1016/S0924-2244(01)00048-6

Teixeira, D.L., Larraín, R., Hötzel, M.J., 2018. Are views towards egg farming associated with Brazilian and Chilean egg consumers' purchasing habits? PLoS One 13, 1–16.

The Good Food Institute, 2018. Plant-based egg alternatives: Optimizing for functional properties and applications. Washington, DC., United States.

The Guardian, 2016. Tesco to stop selling caged hens' eggs by 2025 after petition.

The Vegan Society, 2017. Statistics [WWW Document]. URL https://www.vegansociety.com/news/media/statistics#vegandietintheuk

Theerachun, S., Speece, M., Zimmermann, W., 2013. Relationship Marketing and Micro-Retailer Brand in Traditional Markets. J. Int. Food Agribus. Mark. 25, 242–266. https://doi.org/10.1080/08974438.2013.726955

Thorne, S., 2000. Data analysis in qualitative research. Evid. Based. Nurs. 3, 68–

70. https://doi.org/10.1136/ebn.3.3.68

Train, K.E., 2009. Discrete Choice Methods with Simulation.

Tran, H.T., Ferrell, W., Butt, T.R., 2010. An estrogen sensor for poultry sex sorting. J. Anim. Sci. 88, 1358–1364. https://doi.org/10.2527/jas.2009-2212

Tu, Q., Hickey, M.E., Yang, T., Gao, S., Zhang, Q., Qu, Y., Du, X., Wang, J., He, L., 2019. A simple and rapid method for detecting the pesticide fipronil on egg shells and in liquid eggs by Raman microscopy. Food Control 96, 16–21. https://doi.org/10.1016/j.foodcont.2018.08.025

UEP, 2017. Guidelines for cage and cage-free housing.

UK Government, 2020a. United Kingdom Egg Statistics – Quarter 2, 2020.

UK Government, 2020b. Overview of the UK population.

UK Government, 2012. Eggs: trade regulations [WWW Document]. URL https://www.gov.uk/guidance/eggs-trade-regulations

UK Parliament, 2019. Lords find no evidence “vegetarian burgers” are misleading for consumers.

Vainio, A., 2019. How consumers of meat-based and plant-based diets attend to scientific and commercial information sources: Eating motives, the need for cognition and ability to evaluate information. Appetite 138, 72–79. https://doi.org/10.1016/j.appet.2019.03.017

Vainio, A., Niva, M., Jallinoja, P., Latvala, T., 2016. From beef to beans: Eating motives and the replacement of animal proteins with plant proteins among

Finnish consumers. Appetite 106, 92–100. https://doi.org/10.1016/j.appet.2016.03.002

van Dijk, H., van Kleef, E., Owen, H., Frewer, L.J., 2012. Consumer preferences regarding food-related risk-benefit messages. Br. Food J. 114, 387–400. https://doi.org/10.1108/00070701211213483

van Kleef, E., van Trijp, H.C.M., Luning, P., 2005. Consumer research in the early stages of new product development: A critical review of methods and techniques. Food Qual. Prefer. 16, 181–201. https://doi.org/10.1016/j.foodqual.2004.05.012

Van Loo, E.J., Caputo, V., Lusk, J.L., 2020. Consumer preferences for farm-raised meat, lab-grown meat, and plant-based meat alternatives: Does information or brand matter? Food Policy 95, 101931. https://doi.org/10.1016/j.foodpol.2020.101931

Vanhonacker, F., van Poucke, E., Tuyttens, F., Verbeke, W., 2010. Citizens' Views on Farm Animal Welfare and Related Information Provision: Exploratory Insights from Flanders, Belgium. J. Agric. Environ. Ethics 116, 11–20.

Vecchio, R., Annunziata, A., 2012. Italian consumer awareness of layer hens' welfare standards: A cluster analysis. Int. J. Consum. Stud. 36, 647–655.

Verbeke, W., Marcu, A., Rutsaert, P., Gaspar, R., Seibt, B., Fletcher, D., Barnett, J., 2015a. "Would you eat cultured meat?": Consumers' reactions and attitude formation in Belgium, Portugal and the United Kingdom. Meat Sci.

https://doi.org/10.1016/j.meatsci.2014.11.013

Verbeke, W., Sans, P., Van Loo, E.J., 2015b. Challenges and prospects for consumer acceptance of cultured meat. J. Integr. Agric. https://doi.org/10.1016/S2095-3119(14)60884-4

Verbeke, W., Scholderer, J., Lähteenmäki, L., 2009. Consumer appeal of nutrition and health claims in three existing product concepts. Appetite 52, 684–692. https://doi.org/10.1016/j.appet.2009.03.007

Verneau, F., Caracciolo, F., Coppola, A., Lombardi, P., 2014. Consumer fears and familiarity of processed food. The value of information provided by the FTNS. Appetite 73, 140–146. https://doi.org/10.1016/j.appet.2013.11.004

Wardy, W., Sae-Eaw, A., Sriwattana, S., No, H.K., Prinyawiwatkul, W., 2015. Assessing Consumer Emotional Responses in the Presence and Absence of Critical Quality Attributes: A Case Study with Chicken Eggs. J. Food Sci. 80, 1–7.

Watson and Shoup, 2019. Plant-based JUST Egg is already outselling established liquid egg brands at retail, claims Just CEO. Food Navig.

Weinrich, R., 2018. Cross-cultural comparison between German, French and Dutch consumer preferences for meat substitutes. Sustain. 10, 1819. https://doi.org/10.3390/su10061819

Weissmann, A., Reitemeier, S., Hahn, A., Gottschalk, J., Einspanier, A., 2013. Sexing domestic chicken before hatch: A new method for in ovo gender identification. Theriogenology 80, 199–205.

https://doi.org/10.1016/J.THERIOGENOLOGY.2013.04.014

Whiley, H., Ross, K., 2015. Salmonella and eggs: From production to plate. Int. J. Environ. Res. Public Health 12, 2543–2556.

Windhorst, H., 2016. The Asian poultry industry 1994 – 2013.

Wongprawmas, R., Canavari, M., Haas, R., Asioli, D., 2012. Gatekeepers' Perceptions of Thai Geographical Indication Products in Europe. J. Int. Food Agribus. Mark. 24, 185–200. https://doi.org/10.1080/08974438.2012.691790

Yang, Y., Hobbs, J.E., 2020. The Power of Stories: Narratives and Information Framing Effects in Science Communication. Am. J. Agric. Econ. 102, 1271–1296. https://doi.org/10.1002/ajae.12078

Yang, Y.C., 2018. Factors affecting consumers' willingness to pay for animal welfare eggs in Taiwan. Int. Food Agribus. Manag. Rev. 21, 741–754.

Yang, Z., Rose, S.P., Yang, H.M., Pirgozliev, V., Wang, Z.Y., 2018. Egg production in China. Worlds. Poult. Sci. J. 74, 417–426. https://doi.org/10.1017/S0043933918000429

Ye, T., Mattila, A.S., 2021. The effect of ad appeals and message framing on consumer responses to plant-based menu items. Int. J. Hosp. Manag. 95, 102917. https://doi.org/10.1016/j.ijhm.2021.102917

Zakowska-Biemans, S., Tekień, A., 2017. Free range, organic? Polish consumers preferences regarding information on farming system and nutritional enhancement of eggs: A discrete choice based experiment. Sustainability 9, 1–16.

Zhu, Y., Vanga, S.K., Wang, J., Raghavan, V., 2018. Impact of food processing on the structural and allergenic properties of egg white. Trends Food Sci. Technol. 78, 188–196. https://doi.org/10.1016/j.tifs.2018.06.005

Zinkhan, G.M., Braunsberger, K., 2004. The complexity of consumers' cognitive structures and its relevance to consumer behavior. J. Bus. Res. 57, 575–582. https://doi.org/10.1016/S0148-2963(02)00396-X

Zwaanswijk, M., Van Dulmen, S., 2014. Advantages of asynchronous online focus groups and face-to-face focus groups as perceived by child, adolescent and adult participants: A survey study. BMC Res. Notes 7, 1–7. https://doi.org/10.1186/1756-0500-7-756

About the author

Agnese Rondoni was born in Umbertide (PG) Italy on 24th July 1992. After completing the Leonardo da Vinci High School in Umbertide, she pursued a BA degree in Chinese language at the University of Rome "La Sapienza" where she graduated in 2015. Thereafter, she pursued a MSc in Business and Economy of Contemporary China at the University of Nottingham (UK) where she graduated in 2017 with an upper Second-Class Honours (2.1). After that she spent almost one year in China, living between Shanghai and Beijing, where she worked as Marketing Executive and Project Developer. In September 2018 she started a PhD in Consumers' behaviour and food marketing at the University of Reading (UK) within the Department of Applied Economics. While pursuing her PhD, Agnese was selected for the EIT Fellowship program for three years in a row (2019, 2020 and 2021) together with other 35 PhDs around Europe, where she worked as Marketing Associate and Consumer Researcher and Data Analyst in different FMCG companies.

Overview of completed training activities

List of the completed RRDP.

GRADUATE SCHOOL
READING RESEARCHER DEVELOPMENT PROGRAMME
CERTIFICATE OF ATTENDANCE

Student **Agnese Rondoni** (26830434) attended the following Graduate School training sessions at the University of Reading:

RRDP - How will employers interview you? 2020/12/02

RRDP - Effective CVs for doctoral researchers How to impress both employers within and outside HE 2020/11/11

RRDP - Writing a thesis as a collection of papers 2020/02/11

RRDP - How to write a paper 2020/01/29

RRDP - Statistical modelling and graphics using R 2019/10/14

RRDP - Nvivo workshop 2019/05/13

RRDP - How to write a literature review 2019/05/07

RRDP - Finding funding to support your doctoral studies 2019/03/07

RRDP - Ensuring confirmation of registration 2019/03/12

RRDP - An Essential Guide to Critical Academic Writing 2019/02/21

RRDP - How to avoid plagiarism 2019/02/19

RRDP - Basic statistics refresher 2018/11/19

RRDP - Writing a data management plan for your research project 2018/11/12

RRDP - Sourcing information for a literature review - information retrieval 2018/11/08

RRDP - Self-Management: Managing academic pressure 2018/10/25

Professor Dianne Berry
Dean of Postgraduate Research Studies

List of attended modules.

- Quantitative Methods
- Qualitative Research Methods
- Econometrics
- Micro econometrics
- Consumer Behaviour and Food Marketing
- Behavioural Economics

Awards and recognitions

Agnese was selected as one of the seven finalists for the “Three minutes thesis” award at the 2021 Doctoral Research conference of the University of Reading. Agnese was also nominated the Agri-food Economics and Social Science Research Division candidate for the 2021 PhD Researcher of the Year award.

List of published papers

- Rondoni, A., Asioli, D. & Millan, E. 2020, "Consumer behaviour, perceptions, and preferences towards eggs: A review of the literature and discussion of industry implications", Trends in food science & technology, vol. 106, pp. 391-401.
- Rondoni, A., Millan, E. & Asioli, D. 2021, "Consumers' preferences for intrinsic and extrinsic product attributes of plant-based eggs: an exploratory study in the United Kingdom and Italy", British food journal (1966), vol. ahead-of-print, no. ahead-of-print.
- Rondoni, A., Millan, E. & Asioli, D. 2021, "Plant-based Eggs: Views of Industry Practitioners and Experts", Journal of international food & agribusiness marketing, vol. ahead-of-print, no. ahead-of-print, pp. 1-24.
- Rondoni, A. & Grasso, S. 2021, "Consumers behaviour towards carbon footprint labels on food: A review of the literature and discussion of industry implications", Journal of cleaner production, vol. 301, pp. 127031.

- Rondoni, A., Grebitus, C., Millan, E. & Asioli, D. 2021, "Exploring consumers' perceptions of plant-based eggs using concept mapping and semantic network analysis", Food quality and preference, vol. 94, pp. 104327.