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Exploring Consumers' Perceptions of Plant-Based Eggs using Concept Mapping and Semantic Network Analysis

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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, Asioli, & Millan, 2020). One is the increasing number of health issues related to egg consumption, such as allergies and high cholesterol (McNamara, 2015; Zhu, Vanga, Wang, & Raghavan, 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 & 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, Millan, & Asioli, 2021). Consumers form different attitudes towards a new food depending on the perceptions and associations they develop once introduced to the product (Grunert, Bredahl, & Brunsø, 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, Spinelli, Dinnella, Prescott, & Monteleone, 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, Arguello, Mekdara, & Macias, 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 & 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 & Jongen, 2006; Lee, Lee, & Garrett, 2013; Mugge, Dahl, & Schoormans, 2018). CM also allows to understand what value they assign to the associations they have stored (Stoyanov, Jablokow, Rosas, Wopereis, & Kirschner, 2017). For example, it provides information about whether something is perceived as positive or negative (Peschel, Kazemi, Liebichová, Sarraf, & Aschemann-Witzel, 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, 2020). 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[2]. Finally, this study is the first to apply the CM technique in an online environment.

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 & Braunsberger, 2004). Cognitive structures explain the processing of information and influence cognitive processes including evaluation (Jooyoung & Morris, 2007). From a theoretical perspective, cognitive structures can be seen as a network of associated concepts, such as semantic networks

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

consisting of a number of attributes (Grunert & 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, Ward, & Reingen, 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 & Loftus, 1975; Cowley & Mitchell, 2003).

The associations stored in memory assist consumers with information processing and guide their product evaluations and choices (Grunert & 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 & Loftus, 1975). The activation flows from the association (node) that is activated first through all directly related concepts (Cowley & 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, Iacobucci, & Calder, 1998). Only activated information can be included in the decision making process (Alba & 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 & 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, Kinchin, & Lygo-Baker, 2008; Rye & 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 & 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, Adesope, Nesbit, & Adesope, 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, Song, Qi, & Cui, 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 (Chang, Chang, & Tseng, 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

255 resulted in 12 themes and 45 codes (see Table 1). The categorization into different themes was
256 done following previous studies. “Environment” for example also appears in Hasimu et al.
257 (2017) and Peschel et al. (2019) to categorize associations like “pollution”, “environmentally
258 friendly” etc. Similarly, “taste” and “price” emerge in Grebitus & Bruhn (2008).

259

260 **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:

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

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 & 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	<.001	7	4	<.001	7	6	<.001	p-value between UK groups = .04 p-value between IT groups = .06
Max	44	27		34	15		41	20		
Sum	595	366		519	275		522	322		
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 & Safitri, 2018; Font-i-Furnols & Guerrero, 2014; Huang, 2013; Lusk & Briggeman, 2009; Verbeke, Sans, & Van Loo, 2015). 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, Tuu, & Grunert, 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	$\underline{p}$ = .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%	p = .82
	Liquid	49	24	9.44%	8.72%	
	Powder	61	68	11.68%	21.11%	
Negative associations (-)	Egg-shaped	35	27	5.88%	7.37%	p = .46
	Liquid	35	7	6.74%	2.54%	
	Powder	40	24	7.66%	7.45%	
Important associations (!!)	Egg-shaped	36	33	6.05%	9.01%	p = .05
	Liquid	44	10	8.47%	3.63%	
	Powder	45	23	8.62%	7.14%	
Less important associations (X)	Egg-shaped	20	28	3.36%	7.65%	p = .27
	Liquid	16	6	3.08%	2.18%	
	Powder	38	7	7.27%	2.17%	
Positive/Important associations (+!!)	Egg-shaped	149	91	24.53%	24.86%	p = .27
	Liquid	115	118	22.15%	42.90%	
	Powder	108	104	20.68%	32.29%	
Positive/Less important associations (+X)	Egg-shaped	50	26	8.40%	7.10%	p = .05
	Liquid	52	12	10.01%	4.36%	
	Powder	33	22	6.32%	6.83%	
Negative/Important associations (-!!)	Egg-shaped	40	47	6.72%	12.84	p = .04
	Liquid	84	47	16.18%	17.09%	
	Powder	38	51	7.27%	15.83%	
Negative/Less important associations (-X)	Egg-shaped	34	13	5.71%	3.55%	p = .50
	Liquid	40	24	7.70%	8.72%	
	Powder	31	13	5.93%	4.03%	
Neutral associations	Egg-shaped	166	44	27.89%	12.02%	p = .05
	Liquid	83	27	15.99%	9.81%	
	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

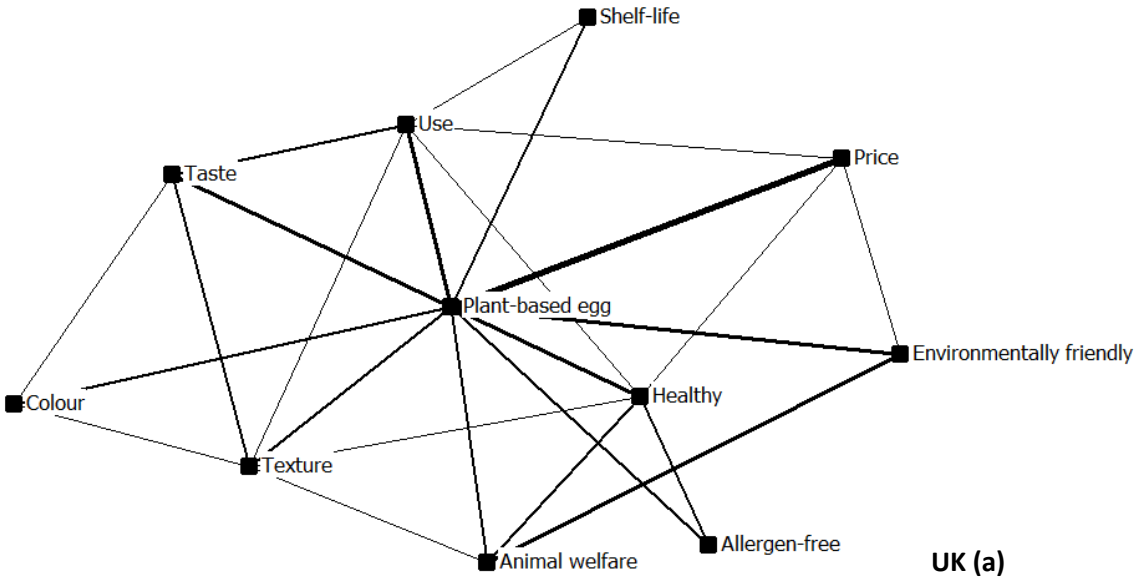
4.2.1 Relationships between associations

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.

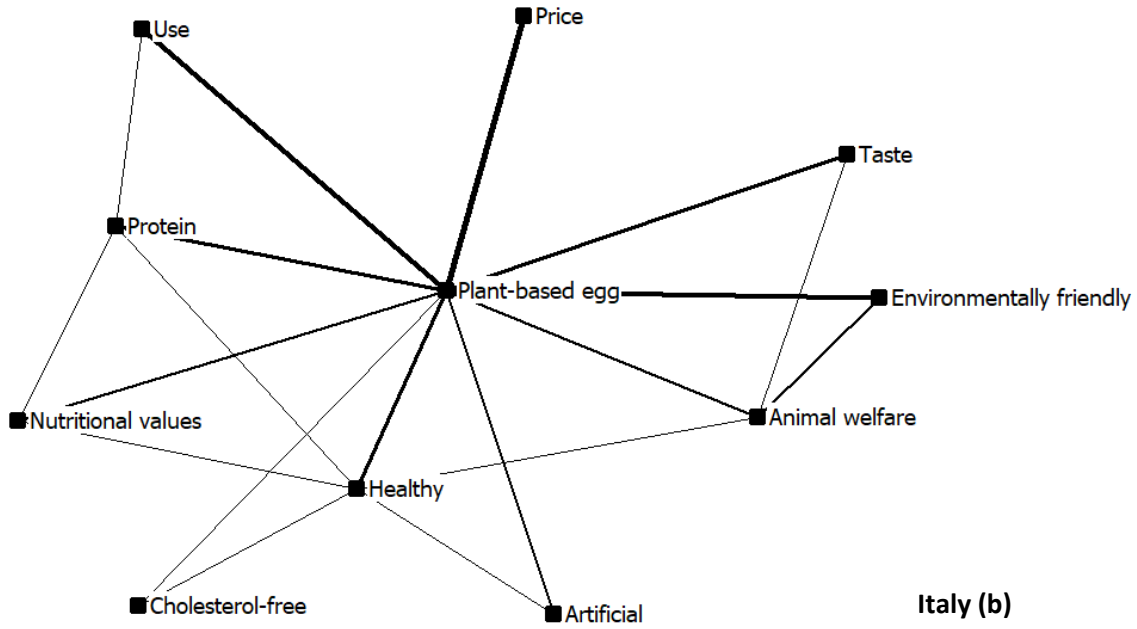
Particularly, Table E.5 and table E.6 in Appendix E indicate strong connections among all concepts in the 'plant-based egg' networks. 'Price' is the most strongly connected association with 'plant-based egg', confirming that it is the first association being activated when thinking about plant-based 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.



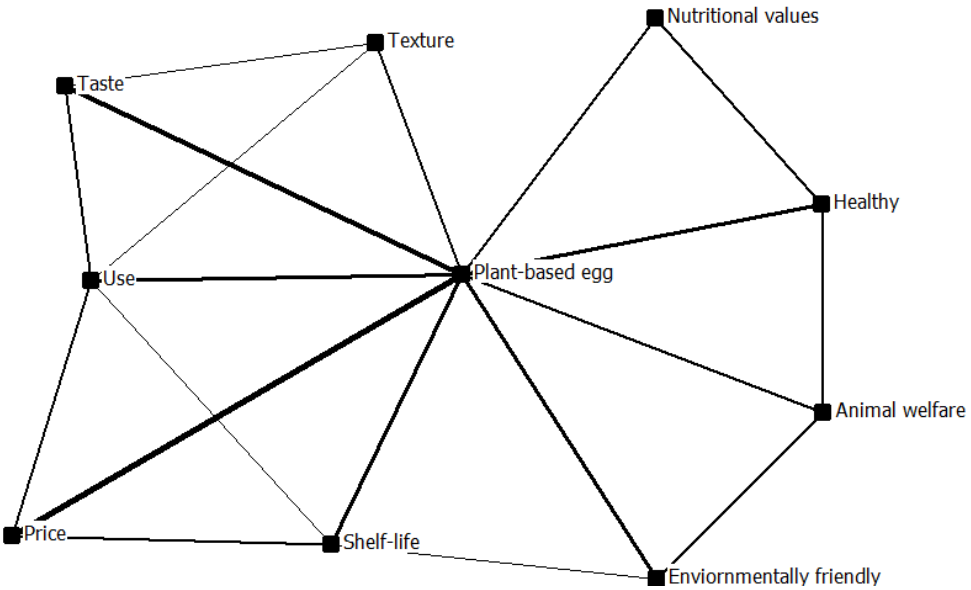
UK (a)



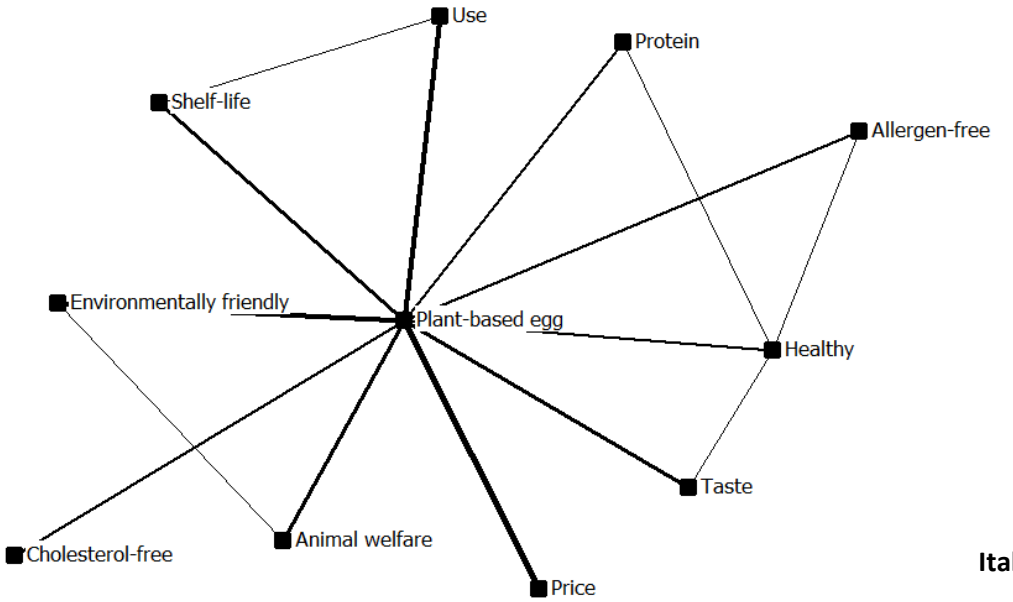
Italy (b)

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)

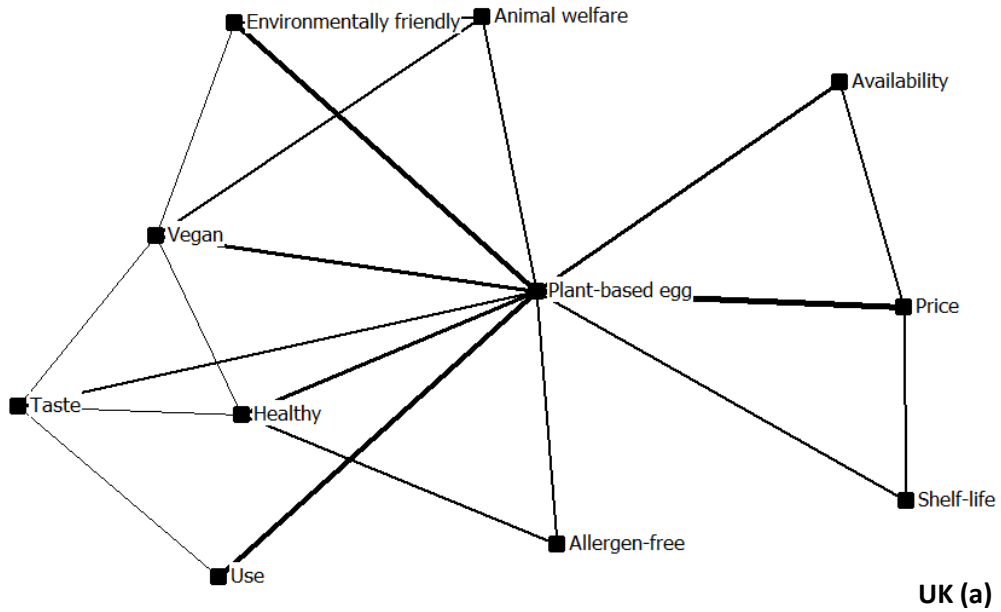
480

481 **Fig. 2 – Network of the Top-10 associations of UK (a) and Italian (b) consumers for the**

482 **liquid plant-based egg.**

483 Note: Created with UCInet 6.0 software (Borgatti, Everett, & Freeman, 2002). Thickness of

484 lines represent the frequency of the associations.



485 **UK (a)**

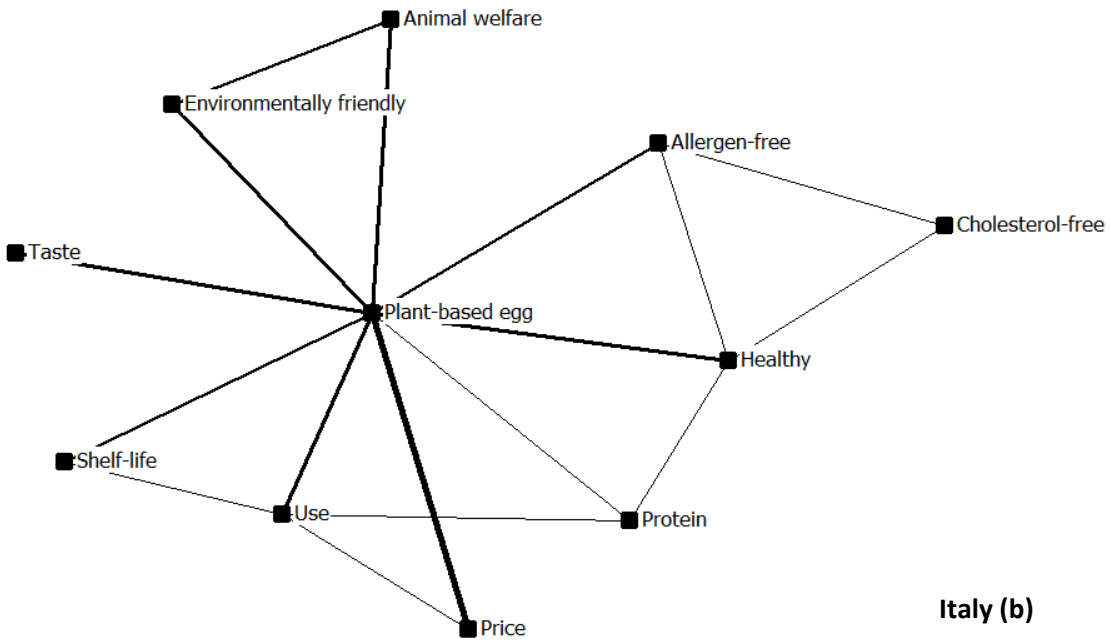
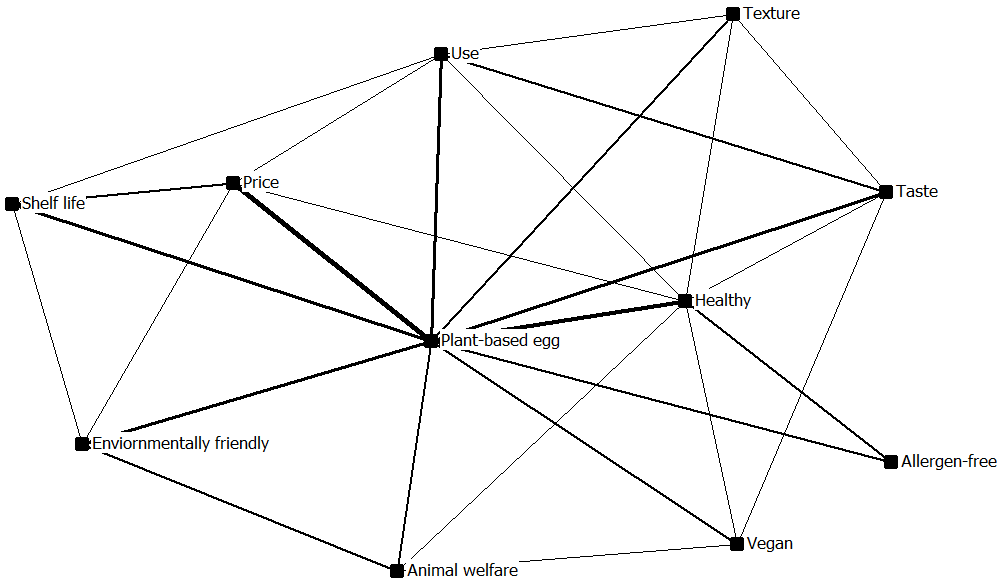


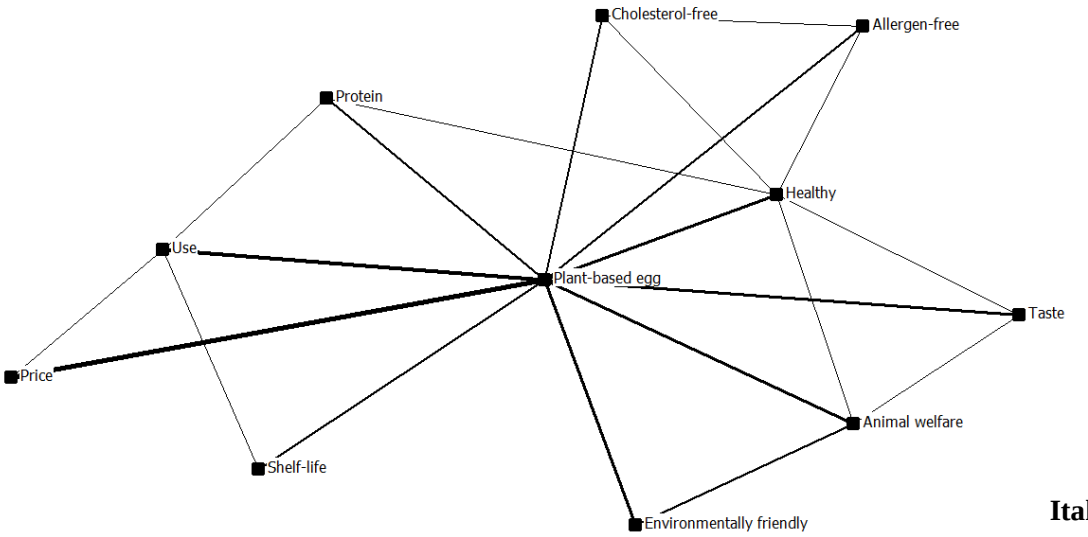
Fig. 3 - Network of the Top-10 associations of UK (a) and Italian (b) consumers for the powder plant-based egg.

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, Caputo, & Lusk, 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 & Bruhn, 2008; Peschel et al., 2019; Seitz & 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 & 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, Mignani, & Alfnes, 2020; Khachatryan et al., 2018; Lusk & Shogren, 2007) combined with sensory tests (Al-Ajeeli et al., 2018; Asioli et al., 2017) 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.

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Transparent reporting

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

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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)

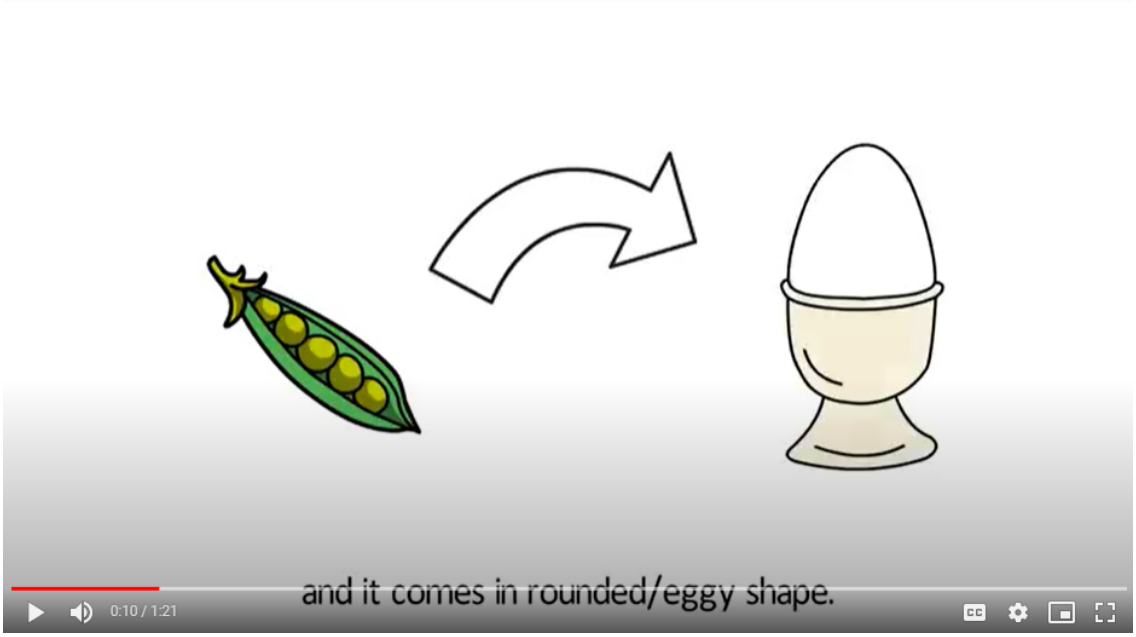
1. The plant-based egg provides an alternative to conventional egg and is produced by using yeast protein and it comes in crystal/powder shape.
2. Plant-based egg is produced through a laboratory process, where proteins, fats and water contained in eggs are recreated through yeast protein fermentation 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.

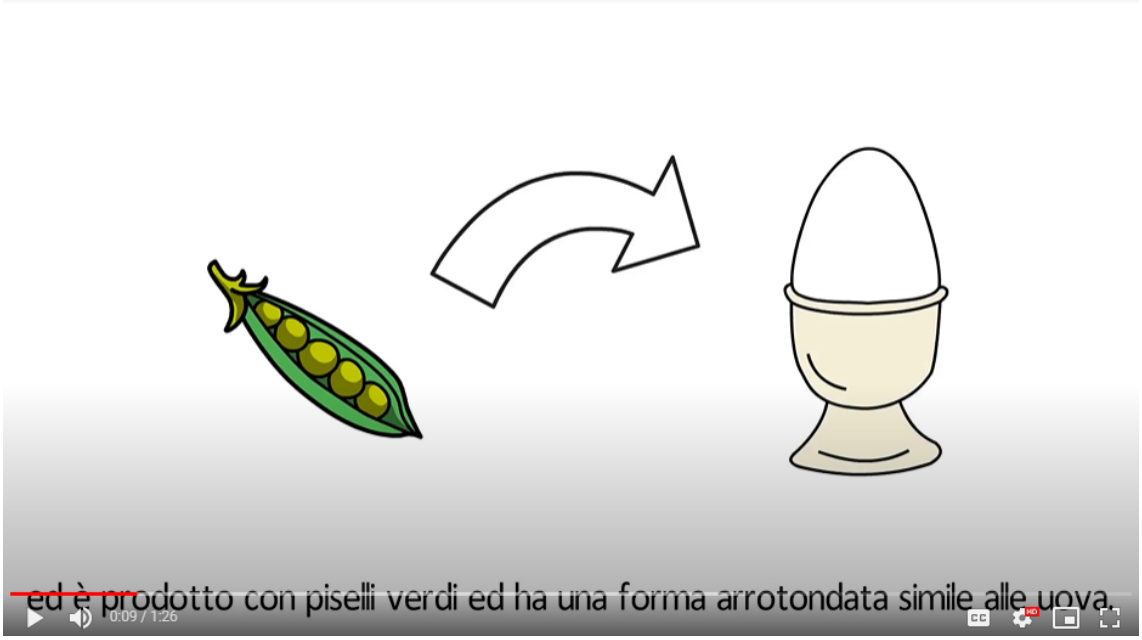
Appendix B

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



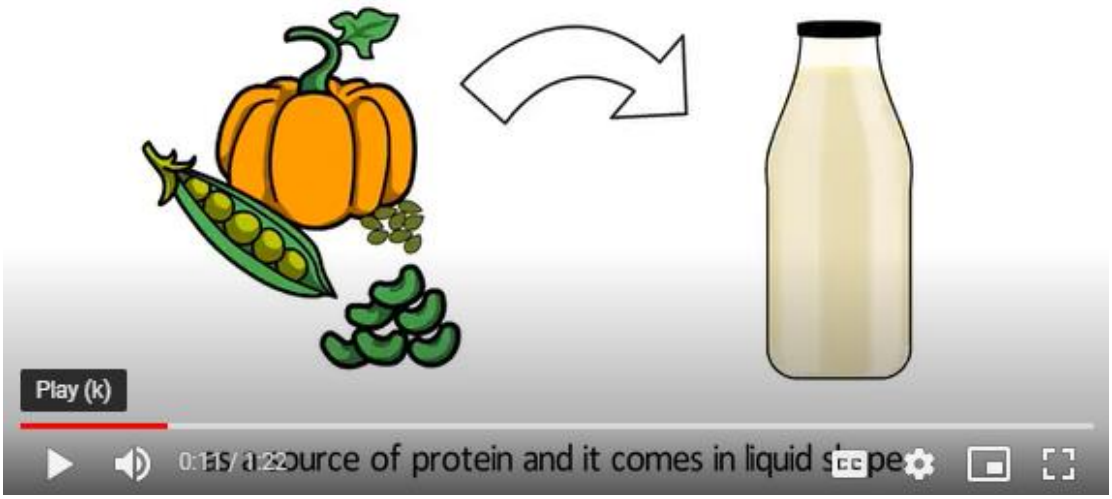
Download: **https://drive.google.com/file/d/15gFYFj9NAdL8nwfPViFV3kiEttWfymzL/view?usp=sharing**

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)

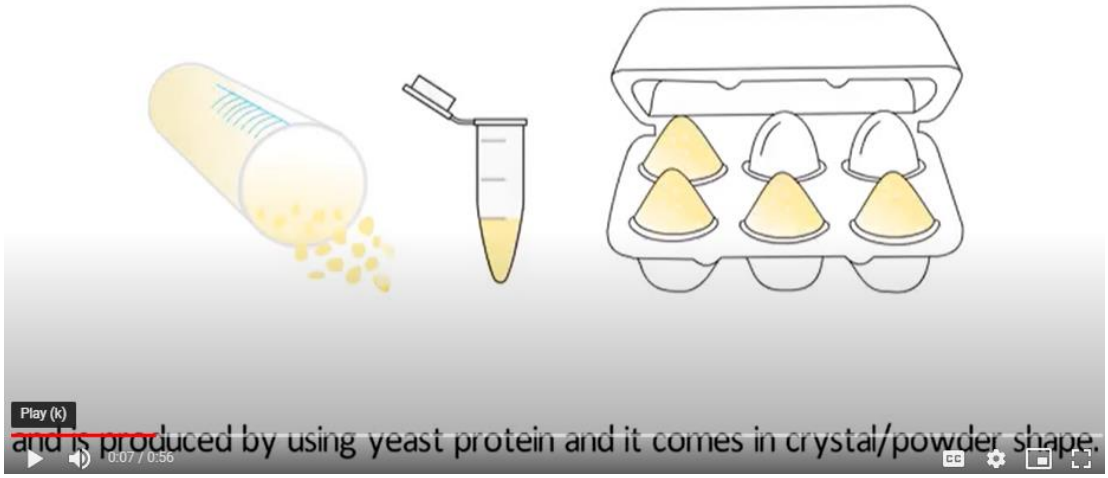


Download: **https://drive.google.com/file/d/1l2rDPQYk3Uctx5NAoVav3QDc33879h9J/view?usp=sharing**

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: The Mann U Test shows 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

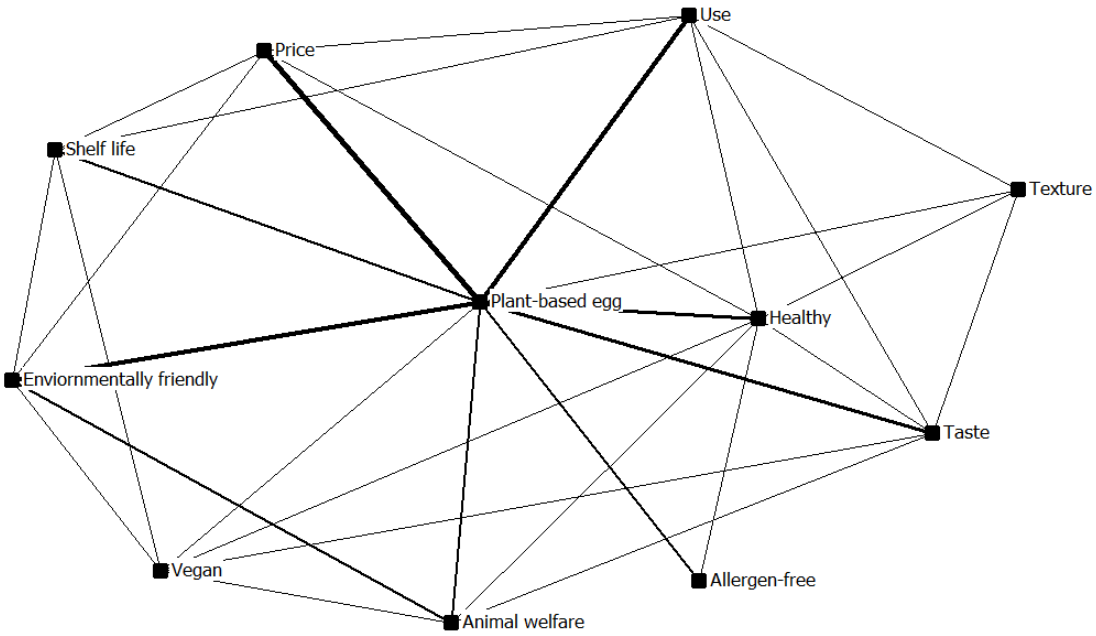


Fig. F.1 - Network of the Top-10 associations with the aggregated plant-based eggs from both countries.

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