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The Brazilians' sensorial perceptions for novel food – cookies with insect protein

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RESEARCH ARTICLE

Abstract

The efforts for entomophagy and the consumption of food products containing insect protein to become mainstream need to overcome a number of consumer barriers in western countries. A low willingness to purchase a novel food product containing alternative protein sources, particularly insects, requires a clear understanding of a product's attributes to improve its acceptance. A sensory analysis of a cookie made with mealworm (*Tenebrio molitor*) flour was carried out. A mixed methods approach was used to collect and analyse data from a group of 25 panellists who participated in a taste testing session at the sensory laboratory in Brazil. Gender did not appear to determine the product's preference regarding the sensory descriptors colour, smell, texture and taste. Yet, taste attracted the most positive attitude towards the cookie and also generated the most customer willingness to try. This was followed by texture (crunchiness). Familiarity with existing products on the market seemed also to be relevant for potential consumers. The participants generally demonstrated a willingness to eat a novel food such as an insect-based cookie when it reaches the market.

Keywords: entomophagy, consumer behaviour, novel foods, sensory attributes

1. Introduction

Since the Palaeolithic Age, insects have been part of the human diet as either an essential source of protein, fat, minerals, as a staple food or as a treat (Costa-Neto, 2013; Ramos *et al.*, 2018; Ramos-Elorduy *et al.*, 2009). Currently, entomophagy and the consumption of food products containing insect protein has been deemed to have great potential in fulfilling the future protein demand gap. Nonetheless, following the recommendation of the Food and Agriculture Organisation (FAO), the production and consumption of insects for humans could contribute to food security in the future (Van Huis, 2013). Hence, the FAO has been promoting and supporting the environmental, nutritional and social advantages of producing insects when compared to protein derived from traditional animal-dependent models.

Furthermore, traditional protein production methods have attracted criticism and posed challenges regarding some detrimental social and environmental practices. To counter this, Taylor (2020) pointed out the food industry, including some large meat processing companies, has invested in R&D to bring to market products containing alternative protein sources such as plants, algae and cultured tissue, as well as insects. Yet, often some food innovations can be rejected by consumers as they struggle to categorise products into 'edible' and 'non-edible' because this might be seen as too disruptive or a radical innovation.

According to the Oslo innovation manual (OECD/Eurostat, 2018) the concept of product innovation allows for the use of raw materials which would change a product's functional characteristics such as the inclusion of edible insects in new foods. These would increase a food's protein, vitamin and mineral content thus significatively distinguishing itself from those in the market. Furthermore, product innovation could be understood as marketing innovation since a differentiated product would cause repositioning among its competitors. It would also allow for change in

design and packaging considering new flavours, formats and tastes. As such, the changes would be characterised as radical or disruptive innovation since their introduction in the market could be transformative. As in other countries, in Brazil the legislation on edible insects is not clear. Yet, in the EU regulation 2015/2283 (EC, 2015) edible insects were classed as novel food according to foods or food substances that could be considered for human consumption either as raw, partially or fully processed.

he adoption of entomophagy as a food habit and an alternative source of protein by the population can be challenging, particularly in western countries. The number of insect varieties consumed have become limited throughout the centuries. The occasions have also been confined to festivities along the calendar year or as food complement during the lean months (Van Huis, 2016). This has led to a situation where in various western societies consumers to naturally avoid it. Moreover, consumers' perception of entomophagy is usually associated by it being a primitive habit by many (Sogari *et al.*, 2018; Van Huis, 2013). The inclusion of insect protein as an ingredient in food preparations can evoke repugnant feelings and provoke rejection (Deroy *et al.*, 2015; Landhuis, 2018; Looy *et al.*, 2014; Lucchese-Cheung and Moraes, 2016; Luchese-Cheung *et al.*, 2020).

As a result, the opportunities regarding the production of insect-based protein are fraught with challenges. On the one hand, it could become a viable alternative source of protein due to its cleaner production methods which avoids land degradation, deforestation, water and air pollution. Taylor (2020) predicted that the insect protein market would be worth US$8 billion by 2030 from US$ 1 billion in 2019. Taking advantage of this, some food manufacturers have already launched commercial insect-based products such as protein bars, flour, insect whole as savoury snacks, cookies, pasta, etc. Yet, on the other hand, the willingness to eat insect-based products varies from country to country (Gómez-Luciano *et al.*, 2019), and many in the food supply chain would also have to adapt when considering alternative and innovative types of protein production systems, not to mention consumers' adoption. Therefore, it is clear that entomophagy is a disruptive innovation proposition for many westerners.

The literature review focused on consumers' perceptions and intentions to consume. Particular attention was paid regarding the consumers' resistance to consume with respect to their eating habits and cultural traditions as well as overall psychology, anthropology and sociology of food. The purpose of this study was to test the acceptability of a novel food, a cookie, which included among its ingredients insect protein flour made from beetle larvae (*Tenebrio molitor*) in Brazil. In that country, despite entomophagy being practiced by indigenous people and in remote locations (Costa-Neto, 2013; Lucchese-Cheung *et al.*, 2020) it is actually not a widespread habit among its urban population. Furthermore, bearing in mind the inexistence of similar commercial products in that country, the study assessed the extent to which such a disruptive food innovation would be accepted or not, using a sensory panel to establish the likely attitudes. Both qualitative and quantitative techniques were used to analyse the extent a novel food product was perceived. Gender differences were also analysed regarding the willingness to eat and to buy a novel food. Specifically, this study attempted to answer the following questions:

- Would the different attitudes and individual behaviours of the panellists affect the perception for colour, smell, taste and texture against the gender split and the willingness to buy a novel food?
- Would the changes in the consumers' pre-existing mindsets be beneficial or not?

2. Literature review

In spite of insects being recognised as rich in nutrients and as an important food staple in some cultures, the majority of western consumers no longer consider them edible. In most of the cases, entomophagy has generated anxiety, provoked declarations of fear, and triggered reactions of general aversion, danger and disgust (Looy *et al.*, 2014; Rozin and Fallon, 1980; Ruby *et al.*, 2015). When talking about consumer food anxiety, Fischler (1990) explained that such a feeling was common among omnivores who, in order to keep fit and well, depended on a variety of foods in their diets. Hence, omnivores organised foods into two mental categories: edible and non-edible. Such a categorisation helped, according to Fischler (1990), to minimise anxiety caused by limitless ingestion possibilities particularly regarding the novel and unknown. Thus, what was not recognised as familiar, or non-edible, could be rejected.

In addition, unfamiliar foodstuffs could also be considered taboo (Gullan and Cranston, 1994) particularly in some religions as the practice of entomophagy has been considered 'unclean'. Consequently, as seen in many parts of the western world, entomophagy has been rejected and the most frequent adjectives used have been primitive, barbaric, strange, dirty or repugnant (Dobermann *et al.*, 2017; Fischler, 1990; Gere *et al.*, 2017; House, 2016; Landhuis, 2018; Mignon, 2002; Van Huis, 2013) to name a few.

Looy *et al.* (2014) proposed the current rejection of insects as food to be attributed to the process of food industrialisation which helped the dominant omnivores' food culture to intrinsically determine what was accepted or rejected as edible. That has then permeated through the communities in which consumers had grown up and lived in, thus further reinforcing their food choices. Therefore, according to Cantarero (2007) it was understandable why grasshoppers

could be accepted as food in a country such as Thailand and rejected in Finland. Whilst in Europe insects have been 'banned' from most of the so-called more civilised tables, with some exceptions (Manunza, 2018; Palmieri *et al.*, 2019).

Van Huis (2013) proposed that the lack of familiarity actually acted as a barrier for individuals to consider insects as food, which was still the case, for example, in Europe. Despite this, consumer rejection has been deemed an important limiting factor faced by food manufacturers as well as policy makers who would like to expand the provision of insect protein worldwide in the future. It has been recognised that the consumer general rejection towards insects needed to be overcome. Lucchese-Cheung *et al.* (2020) explored the complexities of consumer attitudes towards entomophagy and found that the perceived behavioural control and subjective norm had opposing effect on consumers' intention to consume, and acted as the most influential constructs in the intention to consume insects too. This is particularly relevant for both the food sector and organisations such as the FAO aimed at developing initiatives about food innovation in nutrition transition situations worldwide (FAO, 2013).

Food culture plays a fundamental role in determining the cognitive mechanism of individuals regarding the classification of foods into edible and non-edible. Therefore, it would be difficult to introduce unfamiliar novel foods into one's individual food repertoire. According to Rozin and Fallon (1980) there were three main motivations in the general western culture that guided an individual's decision to reject a food by considering it inedible: sensorial properties (bitter taste, green colour in meats); the capacity to anticipate the negative effect something might cause (nausea, allergy and illness); and the ability to judge something which could not be considered ideal to be consumed (taboo, morality and belief).

In the light of this, Pliner *et al.* (1993) recognised that the potential to reject a food would be justified by the assessment an individual made in relation to taste, unpleasant smell, or repugnant texture. In addition, Palmieri *et al.* (2019) proposed that consumers also tended to be suspicious towards insects which could provoke allergies and cause illness. Therefore, a negative attitude towards novel food technologies was an important consideration against adopting insects in individual diets. Therefore, in the case of insects, for those who tended to not categorise them as food, there were more negative emotional responses associated to entomophagy than positive ones. Hence, that posed challenges to companies behind the current introduction of novel foods containing insects as many products could fail because of rejection. As such, familiarity has been recognised by those in the fields of food anthropology and sociology as one of the main criterion in the human preference choice (Fischler, 1990; Lahlou, 1998) and key in breaking an individual's biased mindset (Castro and Chambers, 2019; Cicatiello *et al.*, 2016; La Barbera *et al.*, 2018; Rumpold and Langen, 2019; Sogari *et al.*, 2018).

Gallen *et al.* (2018) studied French consumers' cognitive mechanisms with regard to the willingness to accept disruptive innovative food products such as edible insects. According to them, insects could be considered a disruptive innovation because they tended to be a novelty to the average French consumer, as well as the fact that insects have not been part of the dominant current French culinary culture. They concluded that when consumers considered entomophagy, the thought of it caused a rupture with their previously developed mental representations as well as challenging them to change their established food model. Therefore, Gallen *et al.* (2018) pondered whether it would be pertinent to question consumers about whether they would be prepared to accept new foods in their diet. Furthermore, they also explored the extent to which the changed behaviour would be beneficial or detrimental to the consumers.

Hartmann and Siegrist (2017) identified the Europeans' disposition towards eating insects in the literature. They found that those who considered insects as a potential alternative protein source were particularly more worried about issues around sustainability and food security. However, by only just communicating the environmental benefits that insect production could contribute to sustainability, in relation to other traditional protein production methods, that was deemed insufficient to guarantee the consumption and preference for such a type of protein (Deroy *et al.*, 2015). Furthermore, product quality and environmental benefits have been highlighted by many authors as consisting of strategic motivations to increase the acceptability of insects as foods. Established chefs have helped by supporting positive actions that have contributed to enhance the interest in insects in food products. The chefs working with insects as ingredients in exotic food preparations around visualisation cues as well as taste and texture food attributes have been successful in changing the consumers' pre-established negative mindset (Caparros Megido *et al.*, 2014; Lensvelt and Steenbekkers, 2014; Looy *et al.*, 2014; Mlcek *et al.*, 2014; Oonincx *et al.*, 2010; Rumpold and Schlüter, 2013; Tan *et al.*, 2015; Van Huis, 2013; Verbeke *et al.*, 2015). Start-up businesses that have produced and commercialised dried insects as flavoured snacks, flour, cookies and cereal bars have also contributed to reduce overall aversion.

Furthermore, the pleasant taste and the inclusion of insect protein into familiar foods would minimise the overall rejection (Rumpold and Langen, 2019). Yet, Deroy *et al.* (2015) concluded that some insect species could face more barriers to consumption than others. This would be the case, for example, of cockroaches which, despite being edible,

could cause negative reactions such as disgust and aversion by individuals who associated them with being unhealthy, dirty, impure, and harmful to health. Furthermore, Tan *et al*. (2015) identified other barriers to adoption such as: the inability of individuals to include insects on a daily food preparation routine; the lack of having a mental reference price of how much an insect-based product would cost; ignorance about the place of production (origin); the feeling of being (negatively) judged by those close to the individuals about their acts of ingesting insects.

Therefore, Gallen *et al*. (2018) posited that the more an innovative food was processed to resemble a familiar one, thus matching consumers' pre-established mindsets, the easier it would become for individuals to consider the novel food as something that could be consumed. Furthermore, consumers would assess the food they would be willing to consume through sensory descriptors such as taste, smell and texture, and not simply by visual cues. Yet, when insects were presented whole or were minimally processed they usually tended to be considered as 'non-edible', thus conforming to one's cultural norm. The addition of some more familiar taste markers could lead consumers to having a more positive attitude towards a novel food (Gallen *et al*., 2018; Hartmann *et al*., 2015). Hence, this would increase the intention to consume a product. In addition, it would be also necessary to consider affective behavioural attitude components such as sensory information, images and endorsements to improve the acceptance in the cases of disruptive food innovation products.

Gallen *et al*. (2018) investigated a French sample regarding which cognitive mechanisms reacted in relation to accepting a disruptive novel food such as edible insects. In that case, insects were considered as a disruptive food innovation because they were both a novelty to French consumers and did not belong to the current French food culture. The authors proved that the act of thinking about eating insects was already provocative enough to cause a rupture with the set of mental representations the respondents had and incited changes in their established food model.

3. Methods

Data collection

This study was carried out in Dourados located in the centre-western region in Brazil. It is a medium sized city with an estimated population of 223,000 characteristically of a young profile. The mealworm was purchased from a local producer and samples were taken for the purpose of microbiological analysis regarding Staphylococcus, Coliforms and *Escherichia coli*. The analyses were carried out at SENAI laboratories (Dourados, Brazil). The cookies were made following a recipe developed by the researchers at SENAI development kitchen which contained ground mealworms. Since it was a new recipe, it was submitted to the Brazilian Patent Office (INPI) for intellectual property purposes under submission BR10.2018.075637.0.

Since the product tested was a novel food, for the purpose of an affective heuristic recruitment (Pham, 1998) a test with consumers was a requirement for sensory analysis which needed to include between 25 to 50 panellists (Drake, 2007). Since the aim was to test the acceptability of an unfamiliar product containing insect protein, and to evaluate the panellists' attitudes towards hedonic and sensory characteristics of a product, by using the affective test it was possible to assess a product on its own.

The sensory laboratory at SENAI was used which enabled sensory taste testing with a group of panellists. In total, a group of 25 male and female participants all who were over 18 years of age and presenting a mean age of 35 years were selected. These were characteristic of the demographic profile of the city (IBGE, 2019). Prior to the taste testing, it was established that the participants were willing to taste cookies containing mealworm flour. The participants filled out a consent form which was collected after the introduction. Each participant was given a questionnaire type of survey composed of both open and closed questions. Of the total 25 questionnaires, one was deemed invalid.

Question 1 tried to capture the panellists' acceptance for a novel food according their sensory perception regarding four main attributes: colour, smell, taste and texture. For that a structured hedonic scale from 1 to 9 (1 'liked very much' to 9 'disliked very much') was used because of variability of personal choice.

After tasting the cookie, the panellists were asked to choose the descriptors which best represented their sensorial experience. Based on Tan *et al*. (2015) eighteen sensorial descriptors related to flavour, odour and texture were presented as possible answers (crunchy, burnt, melts in the mouth, smell of mould, without fat, without sugar, buttery, taste of cacao, smell of flour, aerated, delicious, lacking in chocolate, caramelised, bad when touched, smell of brownie, homemade, wholesome, humid). Question 3, particularly addressed the intention to purchase and consume the cookie using a structured hedonic scale from 1 to 5 (1 = 'certainly would buy it'; 2 = 'probably would buy it'; 3 = 'couldn't answer'; 4 = 'possibly wouldn't buy it'; and 5 = 'would not buy it').

This study consisted of a mixed research and the techniques are explained below.

Qualitative study

Corpus-based content analysis model was used (Wolk and Marasek, 2014). Ramos *et al*. (2018) and Camargo and Justo

(2013) proposed that correspondence and hierarchical classification could be established allowing for providing meaning to the vocabulary used by the respondents which would then could be organised into characteristic context classes. This helped to address the main objective of the study and to investigate the likely interrelationships among indicators of context. Furthermore, Reinert (1979) posited the individuals' hierarchical classification acted as a means, not end. Therefore, the end result could be achieved by the profile description of the individual's classes supported by the indicators. Some individuals could share two classes and could also swap them without affecting the profile of the classes. Nonetheless, the classes were assumed to be formed by a distinct group of responses, independent from each other, thus supporting the choice of a descending procedure to obtain them.

The building of a hierarchy happened through the approximation of the responses which were calculated by the chi-squared value of the indexes. Each index measure correlated to one individual's participation (Hair *et al.*, 2005). Yet, the cut off of the classes corresponding to each participant took place by maximising the moment of second order and, consequently looking for representative classes of the variables associated to that cut (Reinert, 1979). After the hierarchical classification, a correspondence factor analysis, which allowed for the representation of the cluster on the factor plan formed by the characteristic texts of the classes were found. Therefore, it was clear the degree of interrelationships between the variables according to the distances provided by the calculation of the chi-squared (Camargo and Justo, 2013). The analysis of similitude was used, and according to Camargo and Justo (2013) it highlighted those trees generated must be taken as a set of variables which were strongly linked. That would depend of the connection between them according to a set of evoked words. The data treatment was subject to the software IRAMUTEQ as proposed by Camargo and Justo (2013).

Quantitative study

Non-parametric tests were used as a method to compare categories (colour, smell, taste and texture) between genders and between those individuals classed as 'willing to purchase' and those classed as 'indifferent and not willing to purchase'. It is highlighted here that, according to the answers from the questionnaire scores were given to define the respondents' own willingness to purchase a cookie containing insect flour, as follows: 1 = 'certainly would purchase'; 2 = 'probably would purchase'; 3 = 'indifferent'; 4 = 'probably would not purchase it'; and finally 5 = 'certainly would not purchase it'. Since only one observation was attributed to score 5, and no observation was attributed to score 4, it was decided to merged score 5 with score 3 thus resulting in the creation of a new set 'indifferent and not willing to purchase' as well as to merge those belonging to scores 1 and 2 into a new set 'willing to purchase'.

Parametric methods of estimation and hypothesis tests are generally used when the data presents a normal or binomial distribution. When faced with a small sample, non-parametric methods are valid and robust (Rosner, 2015). For example, Vitti *et al.* (2020) used non-parametric tests (chi-square) to analyse guava production and Holmes *et al.* (2016) used (Kruskal-Wallis) in a study with black soldier fly eggs. Lehtovaara *et al.* (2017) also used these tests to compare the efficiency of different compositions of diets administered to edible insects (*Ruspolia differens*).

The Wilcoxon (Mann-Witney) test was used to determine whether two independently selected samples of the population have the same distribution (Larson and Farber, 2010). It was used to evaluate the equivalence of the scores colour, smell, taste and texture. These categories were compared against the gender classes as well as two classes of willingness to purchase cookies made with insect flour: 'willing to purchase' and 'indifferent or not willing to purchase'. The Wilcoxon was carried out considering the scores of the participants within each situation i.e. A and B (below), and for all tests from 1 to 8. The hypotheses considered in each test were:

- Null hypothesis (H_0) that there is no difference between the scores (Sample 1 compared to Sample 2).
- Alternative hypothesis (H_a) that there was a difference between the scores.

Initially a two-tail test was carried out, and in case such a test was positive a one-tail test was also carried out only when Sample 1 was smaller or larger than Sample 2. The software used for the purpose of the analysis was R Program (R Core Team, 2018). As a result, eight Wilcoxon tests were carried out to ascertain the core differences between the respondents, as follows:

- Situation A: category comparison (colour, smell, taste and texture) between males and females:
  - Test 1. scores for colour: males vs females;
  - Test 2. scores for smell: males vs females;
  - Test 3. scores for taste: males vs females;
  - Test 4. scores for texture: males vs females;
- Situation B: category comparison (colour, smell, taste and texture) between sets 'willing to purchase' and 'indifferent or unwilling to purchase':
  - Test 5. scores for colour: 'willing to purchase' vs 'indifferent or unwilling to purchase';
  - Test 6. scores for smell: 'willing to purchase' vs 'indifferent or unwilling to purchase';
  - Test 7. scores for taste: 'willing to purchase' vs 'indifferent or unwilling to purchase';
  - Test 8. scores for texture: 'willing to purchase' vs 'indifferent or unwilling to purchase'.

The score values for the four categories were obtained from the aforementioned questionnaire. The values obtained and used in the eight tests are presented in Table 1 and Table 2.

4. Results and discussions

The first text corpus analysed was generated from all the responses collected about the terms that best characterised the cookie. Using the hierarchical classification technique, five classes of words and two important branches allowed for consideration (Figure 1).

Overall, the cookie was well accepted by the respondents, therefore it was not rejected. The dendrogram (Figure 1) shows that the classes of the first branching (5, 2 and 1) carry positive observations in the respondents' attempts to attribute the novel product a more familiar character. When the descriptors as proposed by Tan *et al.* (2015) such as 'it looks like a wholesome product' or 'it looks like shortbread' were chosen it could be inferred that the cookie was considered tasty due to 'chocolate taste', 'it melted in the mouth', 'it looked homemade' or 'it could even contain more chocolate chips'. The overall positive attitude coincided with the work of Deroy *et al.* (2015). It was also observed that the respondents were eager to constantly justify the acceptance of the product by making comparisons with other cookies. It could thus be inferred here the extent to which the respondents were eager to establish familiarity links with the new product, as mentioned in the literature.

At the second branching (classes 4 and 3), the descriptors chosen were 'a taste similar to brownie', 'buttery' and it 'it looks like it's been toasted'. Whilst 'similar to brownie' and 'buttery' thus reinforce the taste attribute, smell is another important product characteristic. The visual cue of the cookies being toasted could be attractive too.

Following that, a correspondence factorial analysis was carried out to verify whether the approximations and distancing of the textural contents on the factorial plan could be visualised (Figure 2). This technique allows for expressing the opposing axis on the factorial plan regarding the words in each of the classes on the plan. The first opposing pair found was the one manifested by respondents was 'toasted' and 'it looked like shortbread'. That was in contrast with the more hedonic product declarations which were, as expected, more representative. Those consisted of the words that were shown on a larger scale on the factorial plan such as 'lacking chocolate chips'. Yet, the second opposing pair represented the attempt to establish comparisons and associations with product familiarity. In addition, words that evaluated the insect-based cookie as 'homemade' or that 'it melted in the mouth'. No negative declarations which could diminish the willingness to consume were observed.

Table 1. Scores given by the respondents, according to gender, male and female (Samples 1 and 2).

Individual	Test 1 Category: colour		Test 2 Category: smell		Test 3 Category: taste		Test 4 Category: texture	
	Male Sample 1	Female Sample 2	Male Sample 1	Female Sample 2	Male Sample 1	Female Sample 2	Male Sample 1	Female Sample 2
1	8	9	8	8	9	7	8	8
2	9	4	9	6	9	7	9	7
3	4	8	7	7	7	5	8	7
4	7	8	4	8	4	8	7	8
5	10	7	8	5	8	1	10	2
6	8	8	6	6	6	7	6	8
7	9	9	9	8	8	9	7	8
8	9	7	8	2	9	2	9	7
9	–	8	–	8	–	9	–	8
10	–	8	–	6	–	7	–	8
11	–	7	–	8	–	9	–	9
12	–	3	–	3	–	3	–	3
13	–	9	–	8	–	8	–	8
14	–	9	–	8	–	8	–	8
15	–	7	–	7	–	9	–	9
16	–	8	–	8	–	8	–	7
Sample size (n_i)[1]	8	16	8	16	8	16	8	16

[1] The total sample contains 24 observations, of which 8 are male and 16 female. Therefore, n_i = sample size, being i = 1 for males (n_1) and i = 2 for female (n_2).

Table 2. Scores given by the respondents, according to 'purchase willingness' (WTP) and 'indifference and non-willingness to purchase' (NWTP) (Samples 1 and 2).

Individual	Test 5 Category: colour		Test 6 Category: smell		Test 7 Category: taste		Test 8 Category: texture	
	WTP Sample 1	NWTP Sample 2	WTP Sample 1	NWTP Sample 2	WTP Sample 1	NWTP Sample 2	WTP Sample 1	NWTP Sample 2
1	8	9	8	8	9	7	8	8
2	4	8	6	7	7	5	7	7
3	8	7	8	5	8	1	8	2
4	9	8	8	6	9	7	8	8
5	7	8	2	6	2	7	7	8
6	9	7	9	4	9	4	9	7
7	8	8	8	8	9	8	8	7
8	7	–	8	–	9	–	9	–
9	4	–	7	–	7	–	8	–
10	3	–	3	–	3	–	3	–
11	9	–	8	–	8	–	8	–
12	9	–	8	–	8	–	8	–
13	10	–	8	–	8	–	10	–
14	7	–	7	–	9	–	9	–
15	8	–	6	–	6	–	6	–
16	9	–	9	–	8	–	7	–
17	9	–	8	–	9	–	9	–
Sample size (n_i)[1]	17	7	17	7	17	7	17	7

[1] The total sample contained 24 observations of which 17 correspondent to those 'willing to purchase' and 7 of those declared 'indifferent or not willing to purchase'. Therefore, n_i = size of the sample, where i = 1 for those individuals 'willing to purchaser' (n_1) and i = 2 for those 'indifferent or not willing to purchase' (n_2).

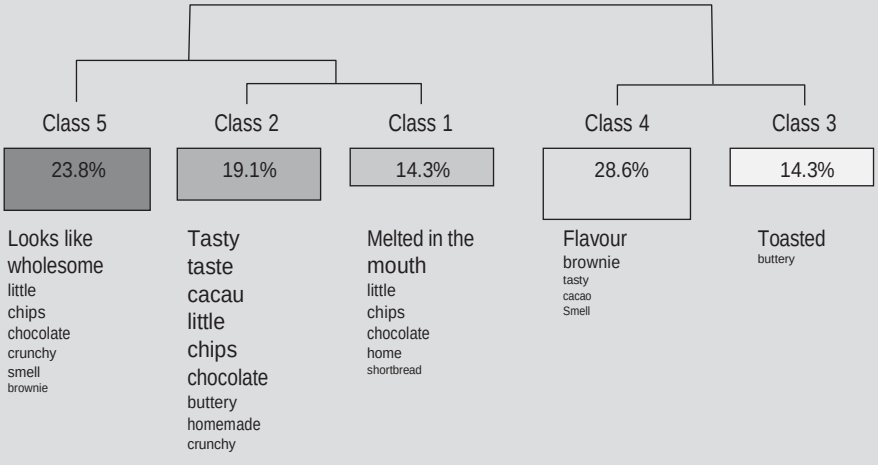

Figure 1. Dendrogram of the descending hierarchical classification showing percentage of answers for each class regarding the terminology used for the categorisation of the cookie.

The similitude analysis carried out using the interface R for multidimensional analysis (IRAMUTEQ) resulted in more relevant attribute definitions which could better characterise the insect-based cookie (Figure 3). Despite the previous cookie's descriptors serving as classification terms being valid such as 'taste of chocolate' and the 'need for more chocolate chips', when the panellists were asked about what they liked the most about the product, the

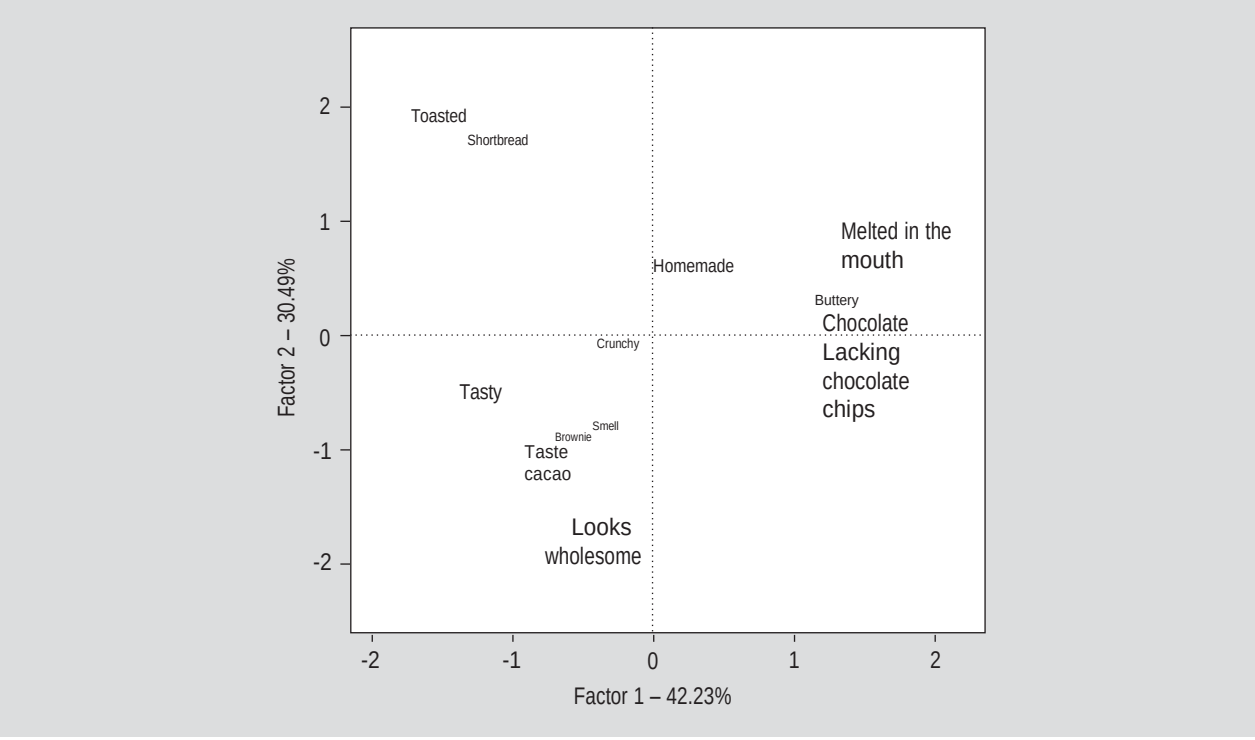

Figure 2. Factorial plan obtained from the correspondence factorial analysis and textual content of the classes distributed on the plan.

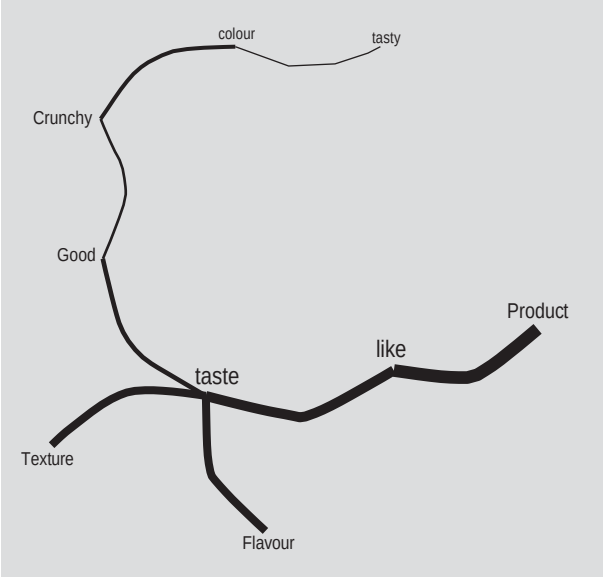

Figure 3. Analysis of similitude.

attributes for taste and texture (crunchy) were those that best represented their opinion.

The results obtained agreed to those found by Gallen *et al.* (2018), Verbeke *et al.* (2015) and Caparros Megido *et al.* (2014). The panellists did not find it difficult to eat the novel food (cookie made with insects) and went further, by attempting to establish some familiarity with the product. Further to the cookie being overwhelmingly accepted, it was compared to other non-insect based commercial products. Therefore, the market to be developed for edible insect-based products would be dependent on efficient marketing actions that would help minimise the barriers to consumption or the rejection of those more food neophobic consumers.

The results of the non-parametric tests are shown in Table 3 and Table 4. These complement the qualitative sensory analysis when comparisons of the scores of the individuals between the two samples were made according to four categories (colour, smell, taste and texture).

From Table 3, it could be observed that for all categories (colour, smell, taste and texture) the scores were equivalent between males and females, therefore the null hypothesis (H_0) was not rejected. This means there was evidence of similarity of the score for the genders. However, despite that, in the literature, there not being a consensus regarding the distinct opinions between males and females for accepting or rejecting edible insects, in this study it was found to coincide with what Caparros Megido *et al.* (2014) found regarding gender difference.

According to Table 4, it was observed that as for the categories colour, smell and texture, the null hypothesis (H_0)

Table 3. Results of the Wilcoxon test, according to gender (independent samples, being A_1 Sample 1 for males for each test and A_2 Sample 2 for females in each test).[1]

Test/category	R	Test bi-tail H_0: $A_1 = A_2$ H_A: $A_1 \neq A_2$		Test un-tail H_0: $A_1 = A_2$ H_A: $A_1 > A_2$	
		P-value	Conclusion	*P*-value	Conclusion
1 (colour)	79.5	0.8468#	Not reject H_0	–	–
2 (smell)	81.5	0.2719#	Not reject H_0	–	–
3 (taste)	75.0	0.5098#	Not reject H_0	–	–
4 (texture)	75.0	0.4990#	Not reject H_0	–	–

[1] # not significative (above 10% significance).

Table 4. Results of the Wilcoxon Tests according to the willingness to purchase (independent samples, being A_1 Sample 1 for 'willing to purchase' for each test and A_2 Sample 2 for 'indifferent or not willing to purchase' for each test).[1]

Test/category	R	Test bi-tail H_0: $A_1 = A_2$ H_A: $A_1 \neq A_2$		Test un-tail H_0: $A_1 = A_2$ H_A: $A_1 > A_2$	
		P-value	Conclusion	*P*-value	Conclusion
5 (colour)	64.5	0.7655#	Not reject H_0	–	–
6 (smell)	83.0	0.1232#	Not reject H_0	–	–
7 (taste)	95.5	0.0208**	Reject H_0	0.0104**	Reject H_0
8 (texture)	83.0	0.1245#	Not reject H_0	–	–

[1] ** 5% significance; # not significative (above 10% significance).

of the equivalent of scores between individuals 'willing to purchase' and those 'indifferent or not willing to purchase' could not be rejected. This means the scores are equivalent for these two sets of individuals. Yet, for the category 'taste' the null hypothesis was rejected in the two-tail test. Hence, the difference between the scores is evidenced here between those 'willing to purchase' and individuals who are 'indifferent or not willing to purchase'. In addition, the data was subject to the uni-tail test and the results show that the scores were higher for those individuals 'willing to purchase'. Deroy *et al* (2015) posited that taste, more than any other food sensory descriptor, was a key determinant in the willingness to eat a food product. Therefore, for novel or unfamiliar food products, taste was even stronger in determining intention.

Figure 4 and Figure 5 represent boxplot graphs for the pair of the samples (1 and 2) used in each test for two situations (gender and willingness to purchase). This analysis shows an evaluation of the sampling data using descriptive statistics.

It was observed that the scores attributed to the respondents for both Sample 1 and Sample 2 regarding tests 1, 2 and 3 (Figure 4) and test 7 (Figure 5) showed variabilities which were practically similar. As for the other tests, the scores of the samples showed visible variability. This is because the data assume asymmetric distribution for the majority of the charts. There are some outliers or symmetry in the case of Sample 1 (male) in the tests 3 and 4 as well as in Sample 1 for the willingness to purchase for tests 5, 7 and 8. Furthermore, it is worth mentioning that the asymmetric distribution of the mean could be higher or lower than the median as it was the case in some of the samples identified in the boxplot in Figures 4 and 5. Such a feature might be relevant for the mean but not necessarily for the median. Moreover, the mean value is more sensitive to outliers, and when these are non-existents (Andersson *et al*, 2016). Hence, since the analysis carried out in this study was based on a non-parametric test (Wilcoxon) based on the use of the median value as a measure for the central tendency (Larson and Farber, 2010), the results are characterised as consistent for the analysis in question.

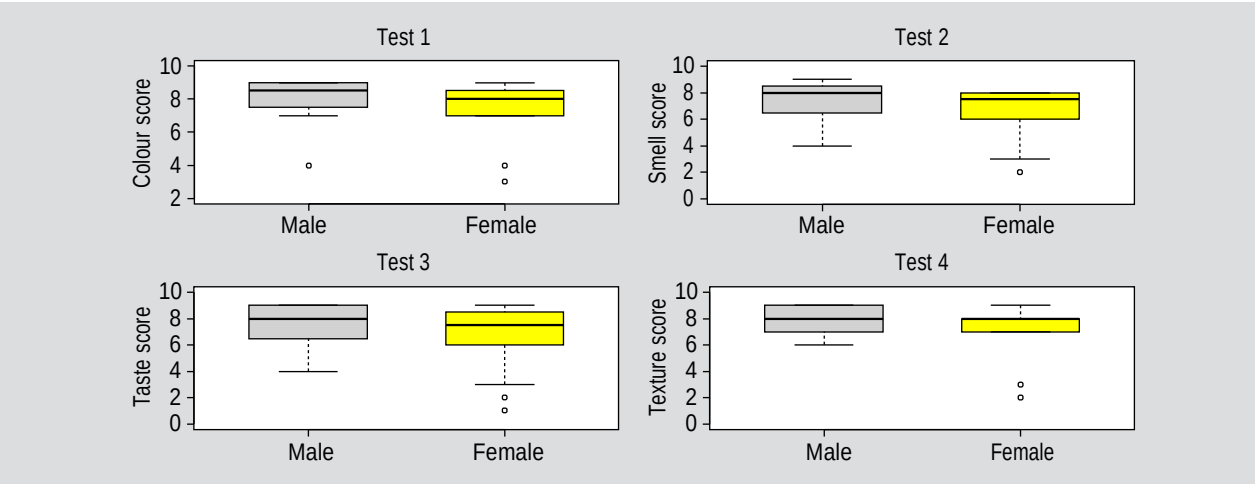

Figure 4. Boxplot for independent samples (Sample 1 and Sample 2, according to gender), considered in Tests 1 to 4.

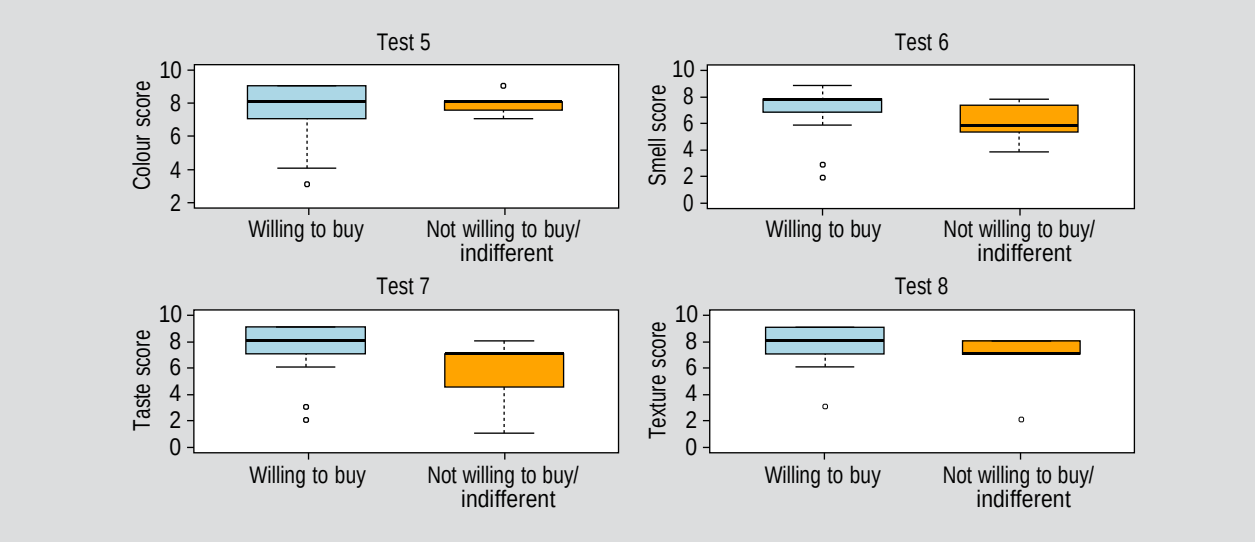

Figure 5. Boxplot for the independent samples (Sample 1 and Sample 2, according to availability of purchase), considered in Tests 5 to 8.

5. Conclusions

When using sensory analysis, it is possible to reveal the extent to which some sensory attributes act as determinants in the individuals' intention to choose and consume a food product. It can be concluded from the sensory analysis that the qualitative results regarding the categories colour, smell, taste and texture indicated there were no significative differences between the genders male and female. This confirms the notion that when the presence of insects is disguised in a novel food product, there is a greater chance for such a product to be accepted. When this is the case, the sensorial descriptors chosen associated with the product tended to be those more positive for both genders. The panellists liked the most those product attributes regarding taste and texture (crunchiness). Among the sensory descriptors analysed, taste was deemed to be the most determinant in the opinion of those participants who were willing to eat an insect-based cookie when such a product reaches the market. From the quantitative analysis 'taste' was the attribute that generated the most trust.

In spite of not being able to find significative differences between the individuals willing to purchase the cookies, those who were not willing to do so, or those who were indifferent for colour, smell and texture, the null hypothesis was rejected for the taste category. It was also observed that the scores attributed by those willing to purchase a cookie made with insects were not significatively higher than those by the individuals who were classed as indifferent or not willing to purchase the cookie. Thus, the intention to purchase a novel food product was largely motivated by taste.

Alternative protein sources such as that from insects represent a topic of global interest both for animal and human consumption. It could be a solution for a more sustainable protein production system as well as a valuable source in the future. Despite the fact that commercialisation of insect-based foods could still be fraught with consumers' acceptance barriers, no negative declarations which could diminish the willingness to consume were observed in this study. Furthermore, to establish comparisons and associations of an insect-based product with some equivalent familiar cookie in the market seemed to help with acceptance. Thus, by increasing the familiarity of an insect-based food product to one equivalent, the results show that the overall consumers' perception was positive. In the case of novel and disruptive foods attributing familiarity to a new product helps reduced food neophobia, thus cookies made with insect flour as ingredient was accepted by a group of panellists who have never been exposed to a similar product before. Words used to describe the experience such as the insect-based cookie felt like 'homemade' or that 'it melted in the mouth' also helped to establish further positive results. Therefore, the market opportunities are promising for those food companies which take the challenge to bring an insect-based food product to market.

This study is also in agreement with other published data, that when the food industry remove the insect whole and present it as an ingredient such as flour in food formulations, the consumers' barriers are lowered. Therefore, those in the food industry need to pay attention to what most pleases the consumers. Such a positive perception towards the cookie was linked to its agreeable taste. Hence, marketing actions that promote those stronger sensory elements which would reduce the rejection and aversion is considered the most important one. Therefore, the market to be developed for edible insect-based products would be dependent on efficient marketing actions that would help minimise the barriers to consumption or the rejection of those more food neophobic consumers.

Since taste was the sensorial descriptor that motivated the panellists the most, in future studies it is suggested that packaging and packaging imagery regarding the extent they can communicate attributes to consumers should be investigated. As for marketing innovation, design plays an important role in reducing rejection and enhancing adoption when a novel product reaches the market. It is suggested that further research on the topic should compare other alternative proteins and consider environmental, moral and ethical issues associated with habit of eating animal protein.

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Conflict of interest

The authors declare no conflict of interest.

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