Article

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Consumer perception and acceptability of microalgae based breadstick

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Abstract

The demand for sustainable and healthy food is increasing. Therefore, it is necessary to find new sources of functional ingredients for design of novel food products. Microalgae are reliable sources of functional ingredients, ready for exploitation with purpose of production of human food. This work explores consumers' acceptance of novel foods based on microalgae. To achieve natural and realistic eating location, sensory analysis was conducted in a real restaurant in Universitat Politècnica de València. A check-all-that-apply questionnaire and hedonic scale registered the consumers' expectations ($N = 85$), perceptions and acceptance, before and after taste of typical Valencian breadsticks. Food neophobia can affect acceptability of novel foods, thus, participants completed a test designed to measure their attitudes towards new food. Microalgae breadsticks have distinctive characteristics compared to control breadsticks, such as colour, flavour and odour, because of microalgae presence. Still, those breadsticks were as acceptable as the control breadsticks according to the consumer preferences. Consumers expected more differences amongst both breadsticks before tasting, but they lowered the differences in perception after trying them. Consumers consider that the product is healthier, and they would understand if it had greater expense. We believe this information can be useful for selling / marketing this novel product.

Keywords

Microalgae, consumers' expectations, perceptions and acceptance, neophobia, realistic location, check all that apply questionnaire

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INTRODUCTION

Bakery products are one of the most consumed foods in the world (Kadam and Prabhasankar, 2010). 'Rosquilleta' is the name given to a typical Valencian breadstick, a low moisture baked product served before meals in restaurants or consumed as a snack between meals. According to annual reports of the Spanish Ministry of Agriculture (Ministerio de agricultura y pesca, Alimentación y Medio Ambiente, Spain (MAPAMA), 2017), dry industrial bread is the only bread whose consumption value and volume grew between 2014 and 2016. Although commercialised in Spain, their sale is spreading to other countries, including the USA, China, Japan, Italy and France. Further development of breadstick flavours (cheese, soy, algae, and chocolate) has also been introduced.

This emergence of products with new features is related to the need of the food industry to innovate for survival in global markets, and to increase their competitiveness. Developing attractive products for consumers is an adverse factor in this process.

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One way to innovate food products can be to use functional ingredients in traditional foods. Microalgae shows high potential as a natural, functional ingredient (Plaza et al., 2008) useful for innovative products. According to Kadam and Prabhasankar (2010), bakery products could be a source for incorporating marine functional ingredients. Therefore, these authors believe testing microalgae viability as a new ingredient in breadstick production is valuable.

Investigation of microalgae's use as a food ingredient started in the 1950s for its high protein content. Nowadays, the use of microalgae in food products is raising, and has use in pastas, snacks, biscuits, candies, gums, yoghurts, drinks and bread (Fradique et al., 2010; Gouveia et al., 2007, 2008a, 2008b; Rodríguez de Marco et al., 2014). Use of microalgae can improve nutritional characteristics, change the colour and change the flavour (Mohamed et al., 2013) of food.

Chlorella and *Spirulina* microalgae species are popular choices for use as food supplements or food ingredients. However, in 2013 the European Union accepted *Tetraselmis chuii* as a novel food. This species has similar characteristics to *Chlorella*, regarding protein, essentials amino acids and mineral contents. However, the main marketing aim is a marine flavour in food (AESAN, 2013).

Sensory evaluation is a useful tool in market research, quality control and development of products. However, before a new product launch, it is important to evaluate the consumers' concept of the product and not only its sensory characteristics. Researchers have used flexible and cheaper methodologies for sensory analysis in recent years, e.g. check-all-that-apply (CATA) questionnaires (Ares and Jaeger, 2013; Meyners and Castura, 2014) that explore specific attribute evaluations (Ares et al., 2013) with no measurement of intensity being required. CATA questionnaires are valid, simple and reproducible; besides are easier and more natural for consumers to understand, compared to intensity scales (Adams et al., 2007). Compared to descriptive analysis, they show great similarity (Cadena et al., 2012). Recent published articles show the study of sensory features in food products using CATA questionnaires with consumer panels (Ares et al., 2013; Hernández-Carrión et al., 2015; Tárrega et al., 2017). Nevertheless, authors have suggested primacy and order bias as CATA questionnaires' limitations (Krosnick, 1999; Sudman and Bradburn, 1992). Ares and Jaeger (2013) suggested an order bias linked to the dynamics of sensory perception. Castura (2009) and Lee et al. (2013) divided the total number of terms in a CATA questionnaire to several shorter modality-specific lists to mitigate primacy bias.

Performing sensory analysis is often in a laboratory, but studies have shown an underestimate of the true product acceptability, when using this setting for liking tests (Meiselman et al., 2004). There are studies (Edwards et al., 2003; García-Segovia et al., 2015; Meiselman et al., 2000; Petit and Sieffermann, 2007) that state how the ambience can affect the evaluation of food and a trend towards a real environment or naturalistic setting in sensory analysis instead laboratory environments exists. Whilst laboratory ambience can be useful when the task is sensory, if the purpose of the study is in relation with liking, use of natural or naturalistic conditions is worth considering (Torri and Salini, 2016). Jaeger and Porcherot (2017) remark different methods are available to investigate contextual influences in product-related consumer research, keeping in mind context limitations (lack of time control, peer interference, environmental noise, consumer bias, etc.; de Graaf et al., 2005; King et al., 2007; Meiselman et al., 2000). In their review about context and ecological validity, Stelick and Dando (2018) concluded that more ecologically valid results from consumer testing can be attained when testing products within contexts similar to those in which the products are customarily consumed.

Still, the consumer's response to new food concepts depends on the consumer's individual attitudes, especially with food neophobia/neophilia. Food neophobia is the avoidance to try a new food. In contrast, food neophilia is an attitude involving an interest in novel foods, showing immense pleasure in eating a wide variety of foods, familiar and unfamiliar. The Food Neophobia Scale was developed as an instrument to measure this trend (Pliner and Hobder, 1992). Studies using this scale show that the results have internal consistency (Cronbach's α: 0.8–0.9; Fernández-Ruiz et al., 2013; Previato and Bherens, 2015; Siegrist et al., 2013). It can predict responses to novel foods and can assess the willingness to try them (Ritchey et al., 2003).

The aim of the present study is to investigate consumers' perception in two breadstick types elaborated with and without microalgae (*Tetraselmis chuii*) in a real context (restaurant setting) and to determine how food neophobia affects products' acceptability.

MATERIALS AND METHODS

Breadstick ingredients

The ingredients used in breadsticks formulation were: 400 g of strong wheat flour (Harimsa, S.L., Spain), 100 mL of sunflower oil (Hacendado, Spain), 125 mL of warm water, 45 g commercial compressed yeast (ĹHirondelle, Spain), 2.5 g of salt (Sal Bueno, Spain), and microalgae (0.5%, 1%, and 1.5% based on weight of the wheat flour). The microalgae, *Tetraselmis chuii* (Fitoplacton Marino S.L., Cadiz, Spain) was used in this study, accepted in 2013 as a novel Food in

Europe (AESAN, 2017), therefore can be produced and commercialised for human consumption.

Breadstick preparation

To prepare the dough, baker's yeast was dissolved in the warm water and mixed with the remaining ingredients (flour, oil, salt, and microalgae) using a Kenwood Chef Deluxe (Kenwood Limited, Hampshire, UK) mixer, equipped with a dough hook. A first knead of 5 min was given, producing a dough of uniform colour. A second knead of 10 min produced a homogenous dough. Dough pieces were divided and weighed at 30 g, which were rolled into cylinders and cut in 10 cm (10 g) pieces. Dough fermentation was conducted at 33 °C for 60 min. Finally, breadsticks were pre-baked at 180 °C for 4 min and baked at 160 °C for 10 min.

Sensory evaluation

Vocabulary generation. A preliminary session with 12 trained assessors was conducted, to generate the sensory and emotional attributes to include in CATA questionnaire. Each participant was presented with four breadsticks with different algae concentrations (0%, 0.5%, 1%, and 1.5%) and were asked to observe and taste the samples whilst were asked to write a complete individual sample description of any characteristics that made them similar or different (sensory/composition/nutritional characteristics, or product use). Fiszman et al. (2015) showed that this method is a simple and useful tool, allowing discovery of consumer vocabulary, without a reduction in the quality of data obtained.

Of the total terms obtained in this preliminary phase, two lists were made by consensus. One list of 21 terms associated to sensory characteristics (bitter, salty, pasty, oily, wet, greenish, crunchy, hardness, intense aroma, compact, green particles, roast, smooth texture, golden surface, off-flavour, darkened, green small bits, rough texture, vegetable flavour, algae flavour, and bread flavour). A second list of 24 terms associated to composition, nutritional characteristics and product use (addictive, expensive, with fibre, increased salt leading to high blood pressure, energy-dense, fatty (energetic), disgusting, dog food, eat in train/work/street, thirst, I wouldn't try, special meal, healthy (less fat), nutritive, fullness, breakfast/afternoon snack, meal substitute, snack, together with meal, vending machine, vegetarian snack, and only with specific food).

CATA question and liking assessment. Eighty-five clients of the restaurant (27.1% women), aged between 25 and 69 years, with a median of 39 years took part in the study. All of them were previously informed and voluntarily accepted, in writing, to take part in the test with microalgae breadsticks.

To not affect the clients' lunchtime and participation decisions, they were served, simultaneously, two breadsticks (control and 1.5% microalgae) as an appetiser before lunch.

The test was conducted in two parts. First before tasting the breadsticks, participants were asked to observe the two breadsticks and mark, how much they think they would like it, on a nine-point hedonic scale (from 1 = 'I dislike it very much' to 9 = 'I like it very much'). Also, participants were asked to describe how they would consider the breadsticks in a CATA questionnaire, with terms selected by assessors. The following questions and instructions were given to participants: 'How do you think this breadstick will be? Check all that apply' and 'Which sensations or situations would you relate with this breadstick? Check all that apply'. This part was to register the expectations of the clients, about products. When finished, they were asked to taste one breadstick and after eating it, to mark how much they liked it on a nine-point hedonic scale, also describing the product using the same CATA questions.

Neophobia test. To evaluate food neophobia/neophilia of each participant, they completed the Spanish Version (Villegas et al., 2008) Food Neophobia Scale Questionnaire (Pliner and Hobder, 1992), with yes/no (Y/N) answers. The original version of the questionnaire was modified to reduce annoyance of clients because they were questioned at their real mealtime. Total scores between 0 and 10 were calculated by adding scores from each statement where NO = 1 and YES = 0. The statements were positive or negative, with the latter recoded for the final scores (Villegas et al., 2008).

Location. The evaluation of breadsticks was conducted in a restaurant (Gauss, Valencia, Spain) between 13:00 and 15:30, lunch time in Spain. The restaurant offers local and traditional dishes. This location was selected to give a realistic environment for consumption. Realistic context studies allow elicitation for good predictors of product success in the market (Hultén et al., 2009; Meiselman, 1993).

Statistical analysis

Samples were coded as follows for statistical analysis: control breadstick (CB) and microalgae breadstick (MB) rating before eating, control breadstick (CA) and microalgae breadstick (MA) assessed after tasting.

Data analysis was conducted using XLSTAT Sensory v 17.06 (Addinsoft, 2019). Normality of liking score was assessed by the Saphiro–Wilk test

and the Nemenyi test was used to compare the different values. Cluster analysis was conducted to group the consumers according to liking using Agglomerative Hierarchical Clustering. Non-parametric Friedman analysis was applied to study the effect of the sample on liking scores and significant differences between means were calculated ($\alpha \leq 0.05$).

Cochran's Q test determined the attributes that presented the differences amongst samples and to obtain a contingency table, which was used to make the correspondence analysis (CA) using χ^2-distances. Penalty lift tests were conducted only for microalgae breadsticks and CATA questionnaires with a threshold for a population size of 10%.

RESULTS AND DISCUSSION

Liking of breadsticks and relation with neophobia

For liking scores of each sample, the Saphiro–Wilk test showed a lack of normality ($p > 0.05$). Thus, this study used a non-parametric method for differences in liking amongst breadsticks. Figure 1 shows the average liking of control and microalgae breadsticks. Results showed that the liking scores of control breadsticks evaluated, before and after their tasting, did not significantly differ ($p > 0.05$), with the same occurring for breadsticks with microalgae. However, liking scores for the control breadsticks were significantly higher (7.2 ± 0.9) than the microalgae breadsticks (6.3 ± 1.7), evaluated before tasting. However, there is a lack of difference between the control (6.8 ± 1.1) and microalgae breadsticks scored after tasting (6.3 ± 1.6). Although consumers had lower expectations for the microalgae than for the control breadstick, when they tasted them, there was no significant difference in liking. Observed in a previous study (El-Baky et al., 2015), microalgae are an ingredient that can improve palatability of the product. Batista et al. (2017) obtained good sensory scores in cookies produced with microalgae. Fradique et al. (2010) reported that the incorporation of microalgae in pasta had greater acceptance scores by the panellists, than the control pasta.

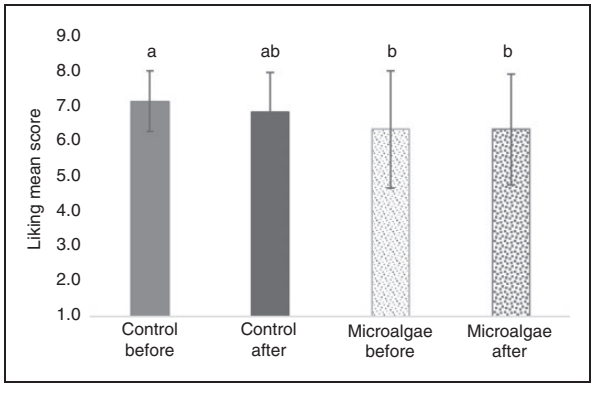

Figure 1. Liking scores mean (SD). Different letters indicate statistical differences according to Nemenyi's procedure ($p < 0.05$).

Previous conceptions of a new product can influence hedonic and sensory perception of the products before consumers tasted them (Jaeger et al., 2017; Stolzenbach et al., 2013). Regarding means of the overall liking results shown in Figure 1, when the consumers ate the breadsticks, they were more similar than they expected. The changes in the evaluation of overall liking can be related to the concept associations that the panellists had after they tasted the breadsticks.

Cluster analysis helps us better understand the consumer response when tasting the breadsticks, to show if the consumers' response to breadsticks with microalgae was related to the individual attitude of consumers to new products, therefore allowing the calculation of the neophobic degree. A mean of 5.6 ± 0.9 (out of 10) in the neophobia test was obtained, showing the panellists of this study to be neophilic. This may be because of the modifications made in the food neophobia test (altering to a Yes / No choice). This result may be anomalous, or the result of people who agreed to take part in the tasting is neophilic. Therefore, it was difficult to make groups of consumers based on neophobia. However, the differences in the average neophobic score between the groups of consumers obtained by cluster analysis were comparable.

Average liking values are shown in Table 1 for the breadsticks evaluated before and after tasting and the average neophobia score for each group of consumers. The first group ($n = 38$) gave better scores for breadsticks with microalgae (MA) compared to the control (CA), when they tasted them ($p < 0.05$). This first group presenting a lower neophobia score showed they are prone to try new foods; therefore, they have good expectations for the microalgae breadstick. In contrast, the second group ($n = 26$) gave lower scores to the microalgae breadsticks (MB and MA) compared to the control breadsticks (CB and CA). The average liking when they assessed the concept of a microalgae stick (MB) was low, but when they tasted them (MA), liking increased; however, the differences were not significant ($p > 0.05$). This group showed the highest value of neophobia, and were less willing to try new foods; therefore, they had bad expectations for this new product concept. In the third group ($n = 21$), there are no significant differences in the score between CB, CA, and MB, but the group scored the microalgae breadstick worse, after they ate them (MA). However, this bad score cannot be justified with the neophobia index.

Table 1. Mean liking values grouped according to cluster analysis and neophobia values

Group	*n*	CB	CA	MB	MA	Neophobia*
1	38	7.1 ± 0.9a	6.2 ± 1.3b	7.3 ± 0.9a	7.2 ± 1.2a	5.21 z
2	26	7.3 ± 0.8a	7.2 ± 1.2a	5.0 ± 1.8b	6.4 ± 1.2b	5.73 y
3	21	7.1 ± 0.8a	7.1 ± 0.a	6.2 ± 1.4a	4.8 ± 1.2b	5.32 z

CB: control breadstick; MB: microalgae breadstick rating before eating; CA: control breadstick; MA: microalgae breadstick assessed after tasting.
Values not sharing letters within a row are significantly different ($p < 0.05$) according to Nemenyi's procedure.
*Mean values were calculated after groups were created by cluster analysis. Different letter in column denotes significant differences.

Clusters 1 and 3 had the same level of neophobia but different behaviour of overall liking. Thus, whilst in groups 1 and 3, consumers had a good expectation for MB breadstick, the score for microalgae breadsticks after tasting (MA) was significantly lower in group 3.

The results of overall liking and neophobia show that over 75% of consumers (group 1 and 2) maintained or improved their assessment of the overall liking scores of microalgae breadsticks after they ate them (MA). This may be interesting for the food industry because it shows that this product would be well accepted if consumers were able to try it.

Consumer's description of breadsticks with microalgae

Table 2 shows the results of Cochran's *Q* test for sensory attributes. There were only 4 of 21 attributes without significant differences ($p > 0.05$) between samples (wet taste, hardness, smooth and rough texture). The results of the remaining attributes show that the differences were stronger between breadstick types (with and without microalgae) than between the test time (before or after taste). For example, 'bitter, oily, with fibre, roast, golden surface, greenish darkened, green particles, off-flavour, vegetal, algae and bread flavour' are sensory attributes showing differences between control breadsticks and those with microalgae. These results were expected because adding microalgae changes the colour, aroma and flavour of the breadsticks, indicated by authors in recent studies. Batista et al. (2017) stated that the use of *Tetraselmis suecica* changes the colour and flavour of cookies, whilst Isleten-Hosoglu (2018) analysed aroma compounds of different microalgae, finding that most of them are odour-active. Results of the 'salty' adjective indicate that the consumers expected both products would be saltier than they were.

Table 3 shows the same results for ideas-related where 4 of 23 concepts had *p* value >0.05. Likewise, there are different ideas/sensations that were checked, pointing out the differences between breadstick types; 'addictive, expensive, green small pieces, energy dense, disgusting, thirst, special meal, healthy (less fat), nutritive, breakfast / afternoon snack, vending machine, and vegetarian snack, I wouldn't try'. These results show that consumers relate the microalgae breadsticks with vegetarian food, higher price, and with healthier and nutritive properties. However, show a minor trend in trying them and seeing this product in vending machines. This can be useful for future marketing of

Table 2. Results of Cochran's *Q* test for sensory attributes

Sensory attributes	*p* value	CB	CA	MB	MA
Taste					
Bitter	0.009	1	2	9	9
Salty	<0.001	58	27	47	17
Pasty	0.025	6	18	11	16
Oily	0.027	21	23	12	13
Wet	0.282	1	5	6	4
Texture					
Smooth	0.134	17	18	13	9
Rough	0.815	2	4	4	3
Crunchy	0.001	58	52	36	45
Hardness	0.076	21	16	15	9
Compact	0.003	21	32	14	26
With fibre	0.000	8	7	25	15
Colour					
Roast	<0.001	42	28	22	19
Golden surface	<0.001	28	18	6	5
Greenish	<0.001	2	1	63	59
Darkened	0.001	1	0	7	10
Green particles	<0.001	0	0	38	17
Odour					
Intense	0.001	6	4	18	14
Off-flavour/foreign	<0.001	4	7	23	24
Vegetable	<0.001	6	2	44	34
Algae	<0.001	3	1	51	40
Bread	<0.001	62	65	21	30

CB: control breadstick; MB: microalgae breadstick rating before eating; CA: control breadstick; MA: microalgae breadstick assessed after tasting.

Table 3. Results of Cochran's *Q* test for ideas-related

Ideas-related	*p* value	CB	CA	MB	MA
Sensations					
Addictive	0.017	10	10	3	3
Expensive	<0.001	5	5	33	17
Higher salt to blood pressure	<0.001	23	9	12	5
Energy-dense	<0.001	19	25	5	14
Fatty (energetic)	0.006	6	13	2	7
Disgusting	0.045	0	0	4	3
Thirst	0.021	32	32	20	22
Healthy (less fat)	<0.001	18	11	33	29
Nutritive	<0.001	9	5	23	24
Fullness	0.015	14	21	10	10
When eat					
Special meal	0.015	0	1	6	3
Eat in train/work/street	0.005	27	24	14	17
Breakfast/afternoon snack	<0.001	39	43	28	26
Snack	0.016	60	54	50	46
Vegetarian snack	<0.001	11	10	47	43
Vending machine	<0.001	39	41	19	26
Meal substitute	0.323	11	8	11	6
Together with meal	0.392	27	21	21	25
Only with specific food	0.689	7	8	10	10
Other					
Green small pieces	<0.001	0	1	21	9
Dog food	0.066	3	2	9	6
I wouldn't try	0.045	0	0	3	4

CB: control breadstick; MB: microalgae breadstick rating before eating; CA: control breadstick; MA: microalgae breadstick assessed after tasting.

the breadsticks with microalgae, since, as stated by Stolzenbach et al. (2013), the product information and the advertisements can influence liking, concept associations and sensory properties of the consumers. Therefore, knowing the perceptions which products induce in consumers; focus on the sale of products can be directed to specific population groups. The remaining attributes (pasty, crunchy, intense aroma, compact, increased salt leading to high blood pressure, fatty, eat at train/work/street, fullness, and snack) did not show obvious differences between samples. But the consumers expected more differences between both breadstick types than they found after tasting, also observed in overall liking (Figure 1).

CA of the contingency table obtained by CATA questions helped to better visualise the relationship between the samples and the attributes. Attributes or ideas without significant differences ($p > 0.05$) or with less than 10% of checks were eliminated from this analysis (wet, hardness, smooth texture, rough texture, disgusting, dog food, I wouldn't try, special meal, meal substitute, together with meal, and only with specific food). Figure 2 shows the graphical representation of the two first factors, which explain the 97.15% of the inertia (86.95% and 10.20%, for F1 and F2, respectively), showing high quality analysis.

A separation in breadsticks with and without microalgae (Figure 2) indicated by the first factor (F1), relates to the presence or absence of microalgae. This factor explains the 86.95% of variability, confirming that the ingredient had more impact on the consumers' choice than when they did the test. On the left of the axis, the samples with microalgae were described before and after being tasted (MB and MA) with higher frequency of terms 'green particles, green small pieces, greenish, darkened, vegetal, algae flavour, expensive, bitter, addictive, and golden surface'. Samples without microalgae (CB and CA) are on the right side with higher frequency of attributes 'oily, bread flavour, crunchy and golden surface'. The second factor (F2) separated the samples evaluated before-tasting (on the bottom) with higher frequency of term 'salty' and associated with 'increased salt leading to high blood pressure' from the samples described after-tasting (on the top) with higher frequency of terms 'pasty and compact' and associated with the ideas 'fatty and energy-dense'.

Drivers for liking and disliking of microalgae breadsticks

Penalty lift analysis shows which attributes or sensations had a considerable influence on liking, determined by calculating, how much liking values varied when an attribute was present in the product versus it was not present (Meyners and Castura, 2014). Two separate penalty tests helped to better visualise the effects: one with the results of evaluation before the consumers ate the breadsticks with microalgae; and a second with the results of the evaluation after consumers ate microalgae breadsticks. Figure 3(a) shows the attributes that affected the liking for the 'concept' of the product or the expectation. When consumers considered the product as 'eat in train/work/street, salty, and breakfast/afternoon snack', liking increased by about one point. Liking was worse for one attribute, 'off-flavour' which shows a reduction in liking by 1.70 points. Figure 3(b) shows that when consumers tasted the breadsticks, the important influence of the attributes on liking changed. Attributes, that when marked, improved the overall liking (between 0.73 and 1.43 points), were 'salty, snack, breakfast/afternoon snack, nutritive, eat in train/work/street, crunchy, healthy (less fat), and vegetable'. Only the 'off-flavour' attribute influences

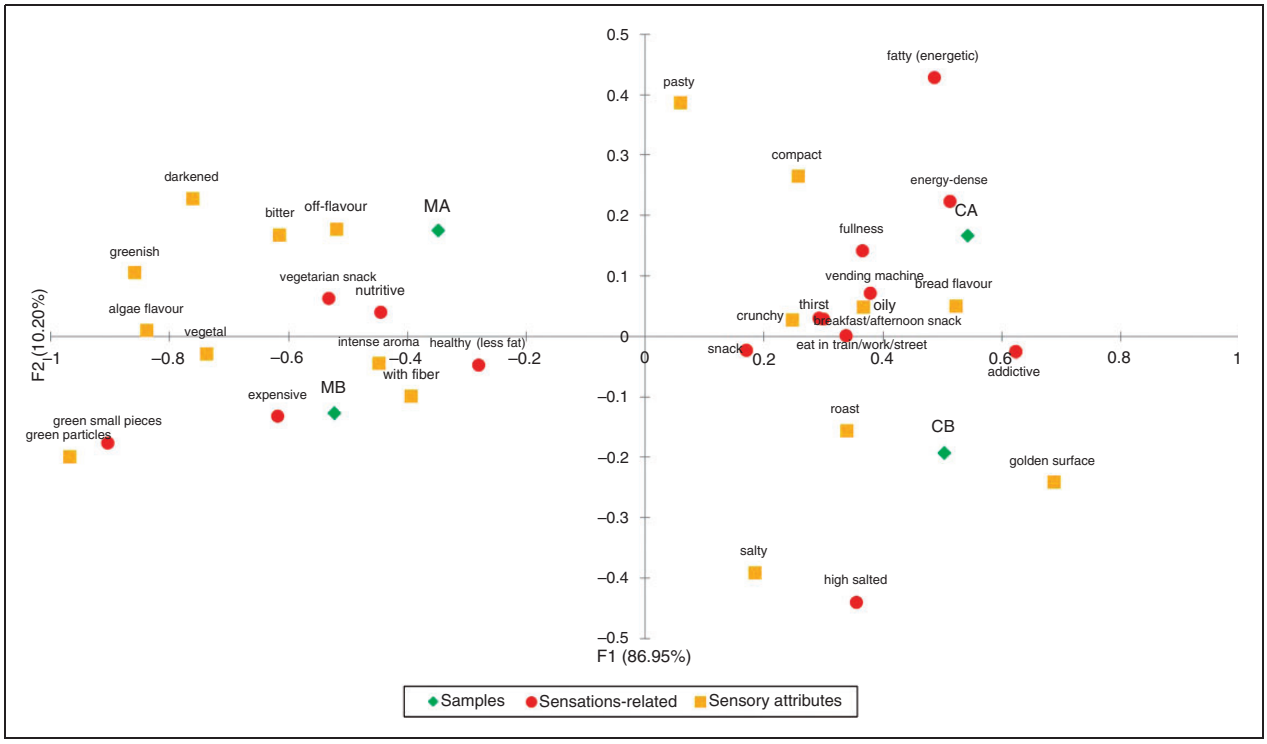

Figure 2. Scatter plot of the correspondence analysis made with the contingency table obtained in CATA questions.

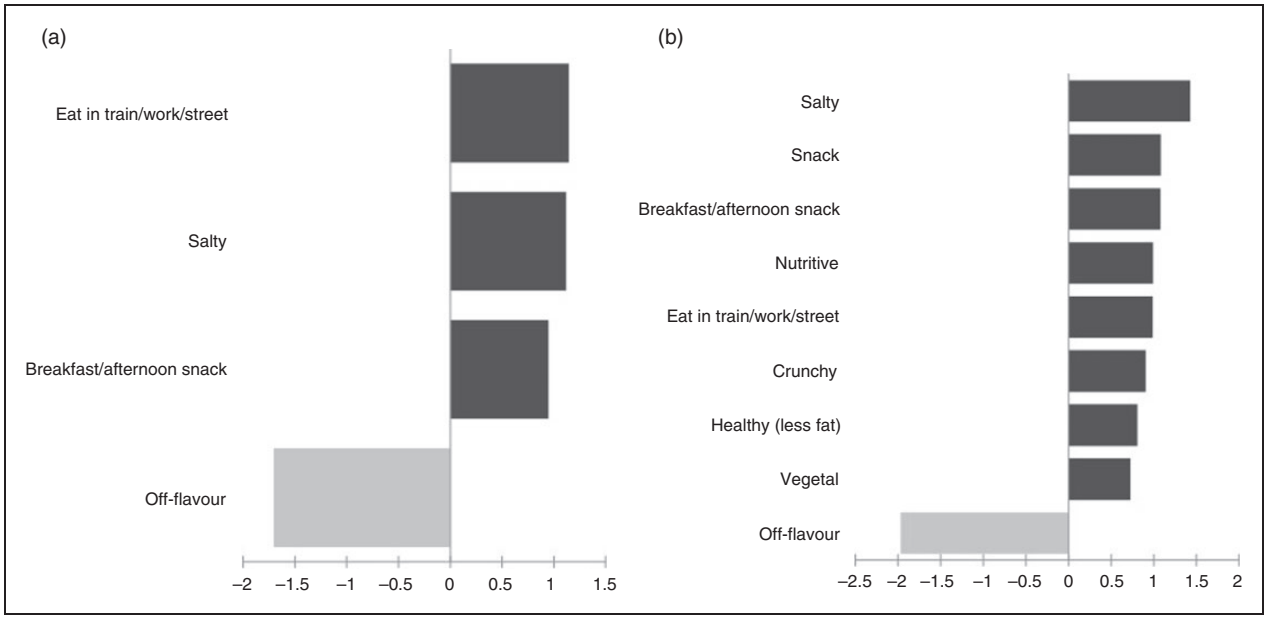

Figure 3. Penalty lift analysis. (a) Consumers' response before tasting microalgae breadsticks. (b) Consumers' response after tasting microalgae breadsticks.

negative feeling (−1.97), also confirming the bad influence of this parameter after consuming breadsticks with microalgae.

Results indicated that the attributes influencing the liking of the product 'concept', also influenced the liking of the real product. Consumers checked more attributes with a positive influence on liking after they ate the breadsticks. The presence of 'off-flavour' was the most penalising attribute, but was still expected, because there is a positive influence of flavour

enhancement on liking food (Pouyet et al., 2015) and vice versa. According to Table 2, consumers selected 'off-flavour' 23 times for microalgae breadsticks but four times for control breadsticks. Therefore, consumers relate this parameter as a strange flavour, because they dislike the microalgae taste.

It is interesting that 'snack, breakfast/afternoon snack, and eat in train/work/street' attributes related to an increased liking, because this may help us focus the sale of products in this direction (Table 3). Attributes 'nutritive and healthy (less fat)' deserve special mention because the consumers were not informed about the nutritional composition of the breadsticks. Still, they thought the breadsticks with microalgae were nutritive and healthy, making the breadsticks more acceptable. It is also interesting that the 'vegetal' attribute relates to an improvement in acceptability, linking the belief that the product is healthier if you add microalgae.

CONCLUSIONS

Considering the minor difference in liking scores between breadsticks, here the conclusion is that products with microalgae have different colour, flavour and odour characteristics because of the presence of this ingredient, but the microalgae breadstick is just as acceptable as the breadstick without microalgae. Consumers expected more differences between both breadsticks before taste, but differences perceived were lower after trying them. Regarding the attributes, which had more influence on overall liking; consumers prefer breadsticks that are 'crunchy, salty, to consume as snack in the house or in the street' and without 'off-flavour'. In addition, a proportion of the consumers consider that the product is healthier, and they would understand that it was more expensive. This information is useful for selling / marketing the product, since focus of the advertisements can target certain sectors of the population. For future research, the amount of microalgae inclusion should be reduced, keeping the functional characteristics of this ingredient, but with less sensory perception, influencing product choice.

LIMITATIONS

This study has some limitations to consider. One limitation of the study is the restaurant's location within a university building. The university location was likely limited participants to mainly university students, professors and staff. It would be important to test results in other locations with more diverse clientele. Secondly, questionnaires were anonymous during data collection, but researchers have no reason to suspect that some participants participating twice. Future research should test whether the study results are the same using other concentrations of microalgae on breadsticks.

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DECLARATION OF CONFLICTING INTERESTS

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ETHICAL APPROVAL

All protocols performed in this study were in accordance with ethical standards of the sponsoring university's institutional review board. Informed consent was obtained from all subjects who participated in this study.

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