Effect of product properties and context on the perception of sweetness and liking: a case study with butter cookies

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Running title: Multisensory approach in sweet products

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HIGHLIGHTS

- Sweetness perception of butter cookies, using a 40% sugar reduction, was studied
- A multimodal approach, context and labeling were assessed for sugar reduction
- Vanilla was added to sugar-reduced samples without decreasing liking
- No significant differences were found between contexts (taste room *vs* home)
- A 'low in sugar' label had higher impact on liking than reformulation and context

ABSTRACT

Consumption context has been shown to significantly contribute to food acceptance, probably because of affecting food attributes' perception. The present study investigated the influence of multisensory reformulation on the acceptance and perceived sweetness of butter cookies in two contexts (Central Location Test, CLT *vs.* Home Use Test, HUT). The objective was to determine whether the use of some natural aromas could trigger a sweet-taste-like emotional response in a confectionery product, and if consumption in a real context could aid in masking the reformulation. Results showed that a 40%-reduction in sugar content did not affect overall liking in the at-home-context (HUT), unless a 'low in sugar' message was shown in the sample. Reformulation was perceived in the CLT: the 'sugar-reduced' sample was less liked, but the 'Sugar-reduced+vanilla' sample was as liked as the original sample. These results demonstrated that a multisensory approach could contribute to reformulation even when perceived by consumers.

PRACTICAL APPLICATIONS

The insights collected during this research sums to the understanding of the relationship among sweet stimuli-context-perception and could be used for industry to reformulate and reduce sugar content in specific bakery products. A multisensory approach could be a useful approach to reformulate sweet products, because acceptance has been shown to be kept even in controlled and focused contexts. Labeling with a "low in sugar" message would not be recommended unless other messages related to taste or flavor are included. In addition, results contribute to the general understanding of sweet products perception and consumption, useful information for the design of healthy food eating environments and to promote healthy food choices among for the general population.

1. INTRODUCTION

Sugar has become the world's principal sweetener, and the consumption of processed foods and beverages with added sugar has noticeably increased during the last years (Popkin & Nielsen, 2003). Although sugar is an important nutrient and an indispensable ingredient for many foods, overconsumption of caloric sweeteners has been related to weight gain and diet-related non-communicable diseases (NCDs), contributing to the increase in obesity and overweight, also called "the modern plague" (Al Jawaldeh et al., 2018; Yadav, 2002). To help battle this issue, the World Health Organization (WHO) released a series of recommendations to promote reducing sugars to less than 10% of daily total energy intake (WHO, 2015). Different countries have launched government policies and actions to endorse this sugars' reduction and follow WHO's recommendations, such as United Kingdom (Public Health England, 2015), Eastern Mediterranean Region (Al Jawaldeh et al., 2018), and Spain (AECOSAN, 2018) among others.

During the last decade, new consumer profiles have emerged, people characterized by their increasing awareness of health-related issues, the active seek for more natural and sustainable foods, but also exigent when it comes to maintaining their demands regarding the satisfaction and the hedonic aspects related to eating (Oliveira et al., 2018). Most consumers are not willing to compromise the sensory enjoyment of foods in exchange for healthier products, therefore, reformulation strategies should depend on an integrated approach of Nutrition & Health, Food Technology, Legislations, and Consumer Perspectives to meet consumers' tastes and expectations, and succeed in the market (Alcaire et al., 2017; van Gunst et al., 2018).

The main strategies for reducing sugar content of foods can be summarized in 4 categories: the use of sugar substitutes, multisensory integration, innovation in food structure, and gradual sugar reduction (Di Monaco et al., 2018; Hutchings et al., 2018). Regarding multisensory integration, it has been reported that the human brain has the ability to combine and relate different sensory stimuli (visual, olfactory, taste ...) that the person has tested together in the foods to which they have been

exposed to (Spence, 2013). Olfactory stimuli that have regularly been paired with sweet, bitter, salty, or sour-tasting foods could enhance the associated taste quality, even when they are presented at a sub-threshold level (Spence, 2015). Therefore, the use of natural aromas in the reformulation of products could increase sweetness perception, as long as the olfactory stimuli had been previously associated with the sweet taste. Previous co-exposure is key to taste enhancement, but this can vary with participants from different cultural backgrounds. For example, vanilla has been found to enhance the intensity of sweetness perception in several studies from different countries (Alcaire et al., 2017; Bertelsen et al., 2020; Oliveira et al., 2021; Velázquez et al., 2020). Using a multisensory integration approach could be combined with any of the other reformulation strategies and could help in easing a gradual sugar reduction intake.

Besides modifying intrinsic properties of the product (e.g., with reformulation), products' perception can be also affected by its extrinsic properties. Packaging has been shown to exert a remarkable influence on consumers' perception and behavior (Velasco & Spence, 2019). Food packaging often includes labels and claims on nutritional information and health benefits that shape expectations, and impact overall product perception (Carrillo et al., 2012). Sugar-related claims, such as "reduced sugar", influenced consumers to perceiving products as healthier than regular counterparts, but also as less tasty, less sweet, and to being less preferred (Prada et al., 2021).

Context has been defined as the specific physical, social, and circumstantial conditions in which food and beverages are consumed (Meiselman, 2006). Consumers are repeatedly exposed to a multisensory environment every time they consume food and beverages (Velasco & Obrist, 2020). Therefore, it is important to recognize that, beyond the food itself, the environment to which people are exposed while eating or drinking can also influence their multisensory tasting experiences. As an alternative to classic studies carried out in tasting rooms or laboratories (also called Central-Location-Tests), some authors such as Jaeger and Porcherot (2017) have described other approaches closer to a real consumption context such as Home-Use-Tests. Some examples are real context studies (Meiselman

et al., 2000; Nijman et al., 2019), living labs (Galiñanes Plaza et al., 2019), immersive contexts (Bangcuyo et al., 2015; Hannum et al., 2019), evoked contexts (Dorado et al., 2016; Jaeger et al., 2020), and virtual reality (Chen et al., 2020). These investigations have shown that location significantly contributes to the appreciation of particular food attributes and to overall acceptability.

The main hypothesis of the present study was that using natural aromas in the reformulation of confectionery products could trigger a similar sweetness perception than sugar, maintaining acceptance of a reformulated product, and therefore consumers' adherence to products reformulated decreasing the added sugar content. Thus, the main aim of the present study was to determine the impact of reformulation, using a multisensory approach, on the acceptance and flavor perception of a sweet product, using butter cookies as a case study. As secondary objectives, two different contexts (central location *vs* real context home-use-test) and the addition of a label ("low in sugar") were assessed to study a potential contribution of these effects on the perception of the reformulation. Different contexts could allow a significant reformulation of the products because changes in the product would go unnoticed as the more complex and distracting the consumption context is. Emotions and sweetness perception were also studied as potentially influenced by the diverse environments, formulas, and label. Besides conducting the corresponding consumer tests, the products were characterized using instrumental texture and objective sensory analyses.

2. MATERIAL AND METHODS

The protocol and procedures used in this study were approved by the Basque Culinary Center scientific committee (BCC20/1102), which stated a waiver consent. All articles from the Declaration of Helsinki and the 2016/679 EU Regulation on the protection of natural persons regarding the processing of personal data and on the free movement of such data were met. The experimental procedure was explained and a written consent indicating voluntary participation was obtained from each participant prior to beginning the study.

2.1. Samples

With the aim of choosing an appropriate product sample, an online survey was conducted on sweet/confectionery products consumption, including Check-All-That-Apply questions such about 'preferred sweet products', 'aromas related to sweet products', and 'context of consumption' of these kind of products for Spanish population. The survey was shared to the Basque Culinary Center (BCC) (Donostia-San Sebastián, Spain) consumers' database and only results from adults (+18 years old) who were regular consumers of sweet products (e.g.: cookies, pastries, bakery products, etc., at least 5 times a week) were considered (n = 180; 70% female; mean age = 39.1, SD = 13.2 years old). Results from this survey showed that among sweet and confectionary products, the most frequently mentioned was cookies/biscuits (42%) and the aromas/flavors associated to this type of products were chocolate (60%), vanilla (53%), and cinnamon (50%). Butter cookies were chosen as sample for this study because, besides being the most cited, they are easy to transport and preserve, important factors in the Home Use Test condition.

The process of making the butter cookies samples was as follows: powdered sugar and butter were manually mixed during 10 min until getting a homogeneous paste. Then, the flour was added and manually mixed during 10 min; the dough was rolled into a cylinder form and chilled in a refrigerator at 5 ºC for approximately 1 hour. The chilled dough was then cut into pieces of 16 g (± 1 g) and baked at 190 ºC for 10-11 minutes (RATIONAL SCC 61 oven, RATIONAL Aktiengesellschaft, Germany). Four different samples were made following this procedure (all % in w/w):

- (i) standard/original cookies -O- (50% plain flour, 35% butter, 15% powdered sugar),
- (ii) cookies with 40% sugar reduction -SR- (59% plain flour, 35% butter, 6% powdered sugar). A 40% sugar reduction was chosen after characterizing samples with a 10% to 50% sugar reductions in preparatory stages of the research (data not shown).
- (iii) cookies with 40% sugar reduction and vanilla aroma to enhance sweetness perception -SRV- (59% plain flour, 35% butter, 6% powdered sugar; the butter had previously been aromatized with 0.1% vanilla beans. The weighted butter and vanilla beans were sealed in a

vacuum plastic bag (PA/PE, Lanbitek S.L., Spain) and let in a water bath at 65 ºC for 3 hours; after this time, the aromatized butter was attempered to room temperature before making the samples.

- (iv) cookies with 40% sugar reduction and a 'low in sugar' message clearly shown in the package -SRM-.

Once attempered, the samples were vacuum packed (80% vacuum) in 5-units bags, until tested. The 3 different formulas (all but the one with the message) were characterized using physico-chemical and objective sensory tests.

2.2. Characterization of the samples

2.2.1. Instrumental texture

The conditions reported in Stable Micro Systems Ltd. (Godalming, UK) for "hardness measurements of biscuits by cutting" were used to determine the hardness of the samples. Butter cookies were cut with an HDP/BSK blade set probe (Warner-Bratzler with rectangular slot blade) in a Texture Analyzer Aname (Microstable system, UK) to measure force in compression mode. The load cell was calibrated to 295 N and the cut was made at a speed of 2 mm s^{-1}. Peak cutting force was considered as the first peak force in g. A total of 10 replications were carried out for each sample.

2.2.2. Difference from control test

A Difference from Control (DFC) test was conducted to determine the magnitude of the difference between the Sugar Reduced (SR) and Sugar Reduced with Vanilla (SRV) samples *vs* control sample (Original). Twenty trained assessors took part of this test. All subjects were similarly familiar with the test performance and the use of the scale (Carpenter et al., 2000).

Panelists were presented with an identified control and a series of 3 samples (SR, SRV, hidden-control) to be rated on a 15-cm scale, indicating the degree of the difference ("not different" to "extremely different") of each sample with the control. Panelist were also asked to indicate the sensory descriptor for which they considered the sample to be different from control, if there were

any sensory attributes that they clearly identified as different. Each sample consisted of 2 cookie halves of the same sample batch served on disposable plates. Samples were coded with three-digit random numbers and served in a randomized order. Also, the panelists had been properly informed that some hidden controls could be found within the sample series (Carpenter et al., 2000; Muñoz, 2013).

2.3. Consumer study

2.3.1. Questionnaires and participation criteria

Data were collected using RedJade® software (RedJade Sensory Solutions, LLC, Palo Alto, USA) via personal mobile phones or tablets. For each test condition, Home-Use-Test (HUT) and Central-Location-Test (CLT), the same questionnaire was used. This questionnaire consisted of 4 sections: an overall liking question measured on a 9-point hedonic scale (1 = dislike extremely, 5 = neither like-not dislike, 9 = like extremely); Just-About-Right questions (1 = too much light, 5 = Just About Right, 9 = too much intense) for sweetness, texture, color, and overall flavor; and finally, the emotional response using the SEFrOS lexicon developed by Romeo-Arroyo et al. (2021) for measuring emotions evoked by food-related odors. This lexicon includes 25-terms with six groups of feelings ('Joyful', 'Passionate', 'Disgusted', 'Hungry', 'Melancholic', 'Relaxed') and uses a 10 cm-scale (300 px in RedJade software) to assess the intensity of the group of feelings associated to the tested stimuli, anchored in the extremes with "not at all intense" to "very intense". The question on the odor-related emotional response was added to study if the presence of vanillin in the samples could elicit a different emotional reaction than the original or SR cookies on consumers, because it has been demonstrated that some of the most well-known drivers of emotions, capable of influencing consumers' behavior, are odors and aromas (Chrea et al., 2009; Ferdenzi et al., 2011).

The selection criteria for being recruited and participate in the study were: being adult (over 18 years old), regular consumer of sweet products (e.g.: cookies, pastries, bakery products, etc., at least 5 times a week), and participating in the groceries purchase of the home.

194 *2.3.2. Study 1. CLT*

195 A total of 75 consumers (65% females, mean = 29.2 years, SD = 7.1) were recruited from BCC
196 consumers' database and participated in the test, which was conducted in a taste room with individual
197 booths and controlled temperature and relative humidity (21 ± 2 °C; 55 ± 5% RH); the illumination
198 was a combination of natural and nonnatural light (fluorescent). Before starting the tasting,
199 participants were asked to think of an occasion when they normally consume butter cookies.
200 Following the instructions reported by Dorado et al. (2016), consumers were asked: "Think about an
201 occasion when you were eating a cookie. Clearly imagine you are experiencing this occasion. Now,
202 write down a detailed description of the occasion you are imagining. Please, take your time and
203 provide a description that is as complete as possible". Then, participants assessed the 4 samples,
204 coded with three-digit random numbers, and served in disposable plates, in 4 different tasting
205 sessions.

206 *2.3.3. Study 2. HUT*

207 A total of 89 consumers (70% females, mean = 45.8 years, SD = 13.4) were recruited from the BCC
208 consumers' database for this condition. The HUTs took place during four consecutive weeks. Each
209 week, participants received a box containing a small bag of 5-vacuum packed butter cookies and
210 written instructions with a QR code to access the questionnaire at their homes. They were free to taste
211 the product whenever they wanted, and together with family and/or friends, but they were instructed
212 not to soak the butter cookies in any liquid that could alter flavor.

213 **2.4. Data analysis**

214 One-way analysis of Variance (ANOVA) followed by a post-hoc test (Tukey HSD) was carried out
215 on texture and DFC results of O, SR and SRV samples. Responses to each emotional category elicited
216 by samples and liking were inputted in a two-ways ANOVA test as dependent variables and using
217 'sample' and 'location' as factors. Post-hoc tests were conducted using Tukey's HSD. Significant
218 differences were determined with a significance level of 0.05 unless stated otherwise.

A Principal Component Analysis (PCA) was performed on the average ratings of each emotional category to explore the relationships between emotional categories and samples. The PCA was constructed from a correlation matrix generated from Pearson's correlation coefficient to avoid considering the scale effect. Liking was used as a supplementary (non-active) variable in the analysis. XLSTAT was used for the statistical analyses (XLSTAT Version 2018.7, Addinsoft, USA) (Addinsoft, 2019).

3. RESULTS

3.1. Samples characterization

Texture seemed to be affected by the sugar reduction process of the butter cookies, and significant differences were found in the hardness of the samples O and SRV (Sugar-Reduced Vanilla) with the sample SR (Sugar-Reduced) (Table 1). Although both SRV and SR samples had the same main ingredients, slight differences during the making process (butter infusion with vanilla beans) could have led to some differences in the texture of the samples, making the texture of the SRV sample similar to the one of the O sample, but the one of the SR sample softer than both.

ANOVA results from DFC test showed significant differences between the O sample and the SR and SRV samples (Table 1), showing that a trained panel was able to detect the reformulation. Both SRV and SR butter cookies were perceived different from the O sample, although data suggested that the SRV sample was more different from O than the SR sample. Seventy percent of panelists (14/20) mentioned that the SR sample was “less sweet” than the O sample. The formula of the SRV sample differed from the Original (O) one in both sugar content and added vanilla; only 50% (10/20) of the panelists mentioned that the SRV sample was “less sweet” than the O sample; 40% of the panelists (8/20) mentioned “vanilla flavor” when tasting the SRV sample.

3.2. Consumer study

Significant differences were found among samples on liking and JAR questions in each location, although, in general, no significant differences were found among locations and neither on the

interaction ‘sample*location’ in the two-way ANOVA. CLT results showed significant differences among samples for liking, ‘passionate’ emotional group, and JAR-sweetness, JAR-color, JAR-flavor, and JAR-texture (Table 2). The SR and SRM samples were significantly less liked than the O sample, but SRV liking scores were not significantly different from the other samples, suggesting that the effect of the multimodal reformulation was positive. Appropriateness of sweetness, color, and flavor intensities (JAR results) was similar in all samples but the SRM, which was perceived as significantly less sweet, less dark, and less flavorful than the O sample. These results suggested that the added message ‘low in sugar’ had a great effect on the perception of the different properties of the samples, because the SR sample (same formula but without message) was rated with similar scores to the other samples. Finally, texture was perceived significantly different in the O sample than all the reformulated ones, which were considered slightly softer than the O formula, although instrumental data did not support this data. The question related to ‘evoked context’ confirmed the results from initial survey: the majority of consumers (81%) found ‘home’ as the most common location for consuming butter cookies.

Results from the ANOVA test on liking, emotional response, and JAR questions of the 4 different samples evaluated at HUT showed significant differences among samples for liking, ‘joyful’, and JAR-sweetness, JAR-color, and JAR-flavor (Table 3). SRM samples were significantly less liked than O samples. SR and SRV liking scores were not significantly different from the ones of the O sample, suggesting that the message had a higher impact on liking than the reformulation. JAR results showed that all samples were similarly appreciated regarding texture perception. SR, SRV, and SRM samples were rated as significantly less sweet and less dark than the O sample (JAR-sweetness and JAR-color). Flavor of the samples was perceived significantly different in O and SR-SRM samples, being perceived as significantly less sweet in the reformulated samples, but no differences were detected between O and SRV samples, suggesting a positive effect of the multimodal reformulation.

Figure 1 shows a Principal Component Analysis (PCA) biplot of the results from the emotional response elicited by the butter cookies in the different locations. The first two Principal Components (PCA) explained 88.5% of the variance of the data. PC1 seemed to group the samples by context, being samples tested in the HUT environment positively correlated with liking and the positive emotions, whereas samples tested in CLT were positively correlated with more neutral emotions such as the ones included in the 'melancholy' group. The SR and SRM, were positively correlated with negative emotions such as the ones included in the 'disgusted' group. PC2 seemed to segment samples by its properties, being the SRM samples the ones with a lower correlation with liking and closer to the 'disgusted' group. No clear relationship was observed among the SRV sample (the one with an additional scent) and some specific emotions group.

4. DISCUSSION

The general purpose of this study was to assess the influence of a multimodal reformulation and some modifications on the extrinsic attributes of butter cookies (e.g.: labeling) on consumers' liking and sweetness perception of the product. In particular, the combination of three aspects was studied: 1) the modification of the butter cookies' recipe using a multimodal approach (intrinsic); 2) the eating location (context/extrinsic); and 3) the addition of a nutritional claim (extrinsic).

A taste/aroma multimodal correspondence was used as the reformulation strategy, using the relationship suggested by consumers during a survey developed to choose the samples. Vanilla was mentioned by over 50% Spanish consumers as an aroma related to sweet products, suggesting that the Spanish population has somehow linked these stimuli. Results of the consumer test conducted both in CLT and HUT showed that vanilla was an effective aroma to maintain, or even enhance, sweetness perception in butter cookies, even when the formula included a notable reduction of the added sugar. Reducing sugar up to 40% did not affect overall liking and the elicited emotions of the butter cookies in the HUT context, unless the message 'low in sugar' was indicated. CLT with evoked context showed that the reformulation was perceived by consumers and the sugar-reduced samples

(SR and SRM) were less liked than the original formula (O). SRV sample was similarly liked than O, demonstrating that adding a 0.1% of natural vanilla could mask the reformulation even in a lab-type context without having a specific impact on the emotions elicited by the samples. In a previous study, Oliveira et al. (2021) found that reducing sugar content up to 25% with the addition of at least 0.2% vanilla flavor did not compromise yogurts' acceptance. Alcaire et al. (2017) found that the combination of vanilla flavor and starch addition increased sweetness perception in vanilla milk desserts with a 40-60% sugar reduction. Bertelsen et al. (2020) found that vanilla was the most promising aroma to promote sweetness enhancement, as long as it had been previously paired with sweet foods. Although different strategies have been proposed to effectively reduce sugar in bakery products, such as the replacement or supplementation with bulking agents in combination with artificial sweeteners, or the use of sweet proteins as sugar replacers, no data has been reported up to date for a taste/aroma multimodal approach in this product category (Sahin et al., 2019). Therefore, the use of a natural 'sweet' aroma, such as vanillin, was useful to diminish the negative effect of sugar reduction on acceptance, maintaining consumers' standards. The effect of the 'low in sugar' message had more impact on acceptance than the reformulation itself. Perception depends not only on the intrinsic properties of products, but also on extrinsic features such as claims and labels of packaging. The effect of the extrinsic properties of foods seems to be variable depending on individual interests as shown by Oliveira et al. (2018) and Reis et al. (2017), and further studies would be needed to further characterize the Spanish population and its relationship with sweets/rewarding-related products. Without any contextual variables (CLT context), to focus the attention on the sugar-reduction claim of the SRM samples, could have exerted a negative effect on the perception of the sample, making the modifications of the formula more evident than when tested in the HUT context. Also, it is possible that the perception of the SRM product properties was completely influenced by the label; because no O samples were labeled as 'low in sugar' and included in the study, it is impossible to conclude if that was the case. Sütterlin and Siegrist (2015) showed the misleading effect

318 that a claim can exert on consumers, because perception of healthiness of the same product changed
319 solely by changing labeling and adding the word 'fruit', even though the nutritional information was
320 the same. Carrillo et al. (2012) showed the importance of health claims and the nutritional information
321 provided about biscuits on consumers' expectations, who frequently linked negative sensory and
322 hedonic associations with the perception of healthy claims (e.g.: "no added sugar" with "insipid").
323 As in that research, the message in the present research was not embedded in the packaging design,
324 it was a sticker adhered to the product packaging. Further research should examine the effect of the
325 same message, but including other packaging variables such as color, font type, shapes, etc. Garaus
326 and Lacilic (2021) have recently reported, in a study conducted on online dessert recipes, that the
327 negative effect of health claims could be eliminated when adding a second taste-related label.
328 Therefore, it is possible that by modifying packaging, or including additional messages related to the
329 hedonic and tasty character of the product, the acceptability of the SR cookies will increase. As for
330 now, gradually reducing sugar content without consumer awareness seems like a feasible strategy to
331 favor a positive perception of the product, but further studies should be developed comparing
332 consumer segments driven by different food-choice reasons.
333 In general, the emotional response did not help addressing the differences between samples or
334 contexts. The sample with added vanilla, although including an aroma which has been related to relax
335 feelings (e.g.: Chrea at al., 2009; Romeo-Arroyo et al., 2021), did not elicit higher scores in this
336 emotional group. It is possible that the amount of vanilla used in the present research was not enough
337 to elicit a different emotional response, or that the emotions generated by this product category is not
338 driven by the presence of a single aroma. Regarding the lack of differences on the emotions elicited
339 by the different contexts, this result could be partially explained by the fact that the chosen real context
340 (HUT), matched the evoked scenario by most consumers in CLT: "at home". Therefore, the evoking
341 scenario technique could have been suitable to mimic the emotions related to butter cookies without
342 being consumed in their habitual context (Dorado et al., 2016; Piqueras-Fiszman & Jaeger, 2014a;

Piqueras-Fiszman & Jaeger, 2014b). Jaeger et al. (2020) suggested that the use of evoked contexts could help give products a fuller meaning, even though their results did not sustain its use. Significant differences in emotions were found only within the same context: 'joyful' was significantly different for O_HUT and SR_HUT samples, and 'passionate' for O_CLT and SRM_CLT samples. Previous studies have shown that generic lexicons were not powerful enough to capture subtle differences in the emotional response elicited by similar products (van Zyl, 2016). SEFrOS is a lexicon developed for measuring the emotional response evoked mainly by food odors for the Spanish population, and the samples tested during the present study were pretty similar in odor, except the sample with the added vanilla. A specific emotional lexicon for bakery products, or a different approach to capture the emotional response, should be used to identify subtle differences among samples, and also to determine if emotions are useful to characterize these kinds of products for the Spanish population.

The choice of a suitable consumption context profoundly depends on the type of product. HUT was tested in the present study and butter cookies were chosen as samples because consumers reported that “at home + biscuits/cookies” were the most suitable combination. Although no significant differences were found between CLT and HUT evaluations, suggesting that evoking a context in CLT was a useful methodology to assess butter cookies perception, some slight but significant differences were identified among samples in each context, showing that CLT results provided higher discrimination among samples. CLT has been reported to have some advantages (time / money / resources) over real context studies (Lee & Lee, 2021), but HUT test allowed to recreate a more natural and real consumption context. In addition, HUT can be used at these times when other types of studies are not feasible, such as the situation of blockage that some countries suffered due to Covid-19 in 2020. Results of the present study corroborated previously reported results, showing that scores collected in CLT were generally lower than in HUT, but still both locations led to the same conclusion (Boutrolle et al., 2005; Wendin et al., 2015).

5. CONCLUSIONS

The use of natural aromas traditionally used in sweet foods, such as vanillin, have showed to be useful to diminishing the negative effect of sugar reduction strategies on acceptance, and therefore maintaining consumers demands. Even when consumers perceived butter cookies as less sweet, acceptance of the samples did not decrease, making it possible to reduce sugar up to a certain level without compromising product's acceptability by using a multimodal approach. The main effect was on labeling ('low in sugar'), which significantly decreased acceptance of the cookies. Further research should be conducted to study other sweet taste-aroma combinations in different cultures and different product categories, promoting confectionery and rewarding-related products reformulations without compromising the hedonic character of these foods. The negative effect of a health-related claim has been shown, as proved by previous investigations, suggesting that to highlight the healthy properties of a product may play a negative role in promoting its selection to consumers. CLT context helped to differentiate more between samples, it has demonstrated having a greater discriminative capacity than HUT. Despite this, depending on the product and the aim of the research, an approximation to the real context in which the final product will be consumed may be more interesting. Insights collected from the understanding of the relationship between sweet stimuli, context, and perception could be used to develop tools and recommendations for industry, restaurants, and the hospitality sector in general, in order to promote healthier food choices for the general population without compromising the enjoyment of food.

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