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Application of the CATA methodology with children: Qualitative approach on ballot development and product characterization of innovative products

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ABSTRACT

There is an increasing importance of the role of children and adolescents in the food market and to successfully develop food products intended for them, it is necessary to apply proper sensory evaluation methodologies. Although children can execute traditional methods for food liking and preference evaluation, traditional sensory descriptive methods may not be suitable for them and it is necessary to assess their ability to perform novel sensory profiling methods. Thus, this study aimed to assess children's acceptance of an innovative food product – cookies incorporating fermented grass pea (*Lathyrus sativus*) flour – and their ability to describe a sensory profile using a Check-All-That-Apply (CATA) approach. Two different types of cookies (salty and sweet) were developed, differing in the level of substitution of wheat flour by fermented grass pea flour (between 0 and 40%). The cookies were evaluated by two sensory panels of 60 children (8–12 years), who assessed the overall liking using a 7-point facial hedonic scale and the sensory profile of the samples using a CATA ballot with 21 sensory terms previously developed through focus groups with children. Children showed the ability to discriminate the different samples with the hedonic scale and according to their sensory profile. Results revealed that the focus-group with children is an adequate way to generate CATA ballots and that the CATA approach is adequate to evaluate how children discriminate the sensory profile of food products. Furthermore, the food neophobia level of the children negatively impacted their acceptance of the food products.

1. Introduction

Children and adolescents are groups of consumers presenting an increasing importance in the food market, having a great influence in the purchase of food products, either through direct influence on their parents' purchase decisions or even by buying the products themselves (Laureati & Pagliarini, 2018; Laureati, Pagliarini, Toschi, & Monteleone, 2015; Popper & Kroll, 2011). It is therefore essential that food manufacturers optimize the products intended for children and adolescents, by matching the sensory expectations of these particular consumers.

Involving children in product development can also play a significant role in reducing obesity and malnutrition through a better understanding of the main processes influencing the acquisition of eating patterns (WHO, 2012). Reflecting this, most studies published in the 21st century about consumer perception and sensory analysis with young consumers have dealt with healthy eating habits (Laureati et al., 2015). Childhood obesity is one of the most serious public-health crisis of the 21st century, and children's eating habits are major factors in the development of these diseases (Lobstein, Baur, & Uauy, 2004). The unhealthy food habits of children and adolescents are related to several risk factors such as marketing of foods rich in fat, sugar and salt (Kelly et al., 2010) and individual food preferences (Birch, 1999).

Abbreviations: CATA, check-all-that-apply; CFNS, child food neophobia scale.

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Sensory analysis of products intended for children should be performed with them and not with adults, as adults and children have different sensory perceptions and preferences. These two groups have reported differences in sweet and sour taste as well as texture discrimination and preference (Laureati et al., 2015; Sune, Lacroix, & Huon de Kermadec, 2002). These differences may be related to different perceptions of texture and slower or reduced flavor release which impacts products' liking (Rose, Laing, Oram, & Hutchinson, 2004). However, the complexity of the applied sensory evaluation method or the stimuli can also play a significant role (Popper & Kroll, 2011). These differences are less noticeable in the evaluation of appearance since children can generate and evaluate attributes related to appearance at an adequate level (Rose et al., 2004; Sune et al., 2002). Regarding odor abilities, although no-marked differences in olfactory thresholds have been reported in literature, children are less capable of describing the odors (Lehrner, Glück, & Laska, 1999).

Children make their food choices mostly based on liking, considering sensory properties, mostly sweet taste, appearance and texture, as crucial points on this decision process (Laureati et al., 2015). This is evident on children's rejection of healthy foods such as fruits, vegetable and fiber-enriched products because although they are able to differentiate between healthy and unhealthy food (Varela & Salvador, 2014), they still reject these kinds of food due to bitter or unfamiliar tastes and textures which are not easily controllable in the mouth (Zeinstra, Koelen, Kok, & de Graaf, 2010).

Individual characteristics of the children can also influence their food preferences. One of these characteristics can be food neophobia, which is a psychological construct that describes a person's tendency to reject or avoid eating unfamiliar foods or foods from other cultures (Pliner, 1994). High scores in children food neophobia have been associated with a less diversified and healthy diet, with low preferences for healthy foods (and in particular fruits, vegetables and legumes) (Gomes, Barros, Pereira, Roberto, & Mendonça, 2018; Howard, Mallan, Byrne, Magarey, & Daniels, 2012; Russell & Worsley, 2008). Furthermore, high levels of food neophobia have also been associated with a preference for softer textures (Laureati et al., 2020) and decreased acceptance of fiber-enriched products (Proserpio et al., 2020; Proserpio, Lavelli, Gallotti, Laureati, & Pagliarini, 2019). Children's neophobia may also affect the parents' attitudes regarding children food habits, since they tend to offer less uncommon or healthy foods when their children are more neophobic (Coulthard & Blissett, 2009; Koivisto & Sjödén, 1996).

Sensory analysis with children can be a demanding task, since the choice of a suitable method is related to the children' cognitive abilities, which are different from adults. Children as young as 4–5 years old, have shown to be able to use hedonic scales in order to assess differences in liking regarding different products (Caporale, Policastro, Tuorila, & Monteleone, 2009; Olsen, van Belle, Meyermann, & Keller, 2011). Although several scales have been applied, the most used are five and seven-point facial hedonic scales (Laureati et al., 2015).

Regarding sensory profiling, traditional descriptive methods may not be suitable for children due to their complexity (Laureati et al., 2015). These methods require training for the correct and objective use of scales. Their suitability may also be jeopardized due to children behavior, which are mostly irrational and spontaneous, and changing through time, since it is in childhood that children acquire most of the rules related not only with the food but also with life (Birch, Savage, & Ventura, 2007).

In last years, several new techniques have been developed which are intended for naïve consumers and could also be used with children, such as Projective Mapping (Mitterer-Daltoé et al., 2017) or structured sorting (Varela & Salvador, 2014). Check-All-That-Apply (CATA) methodology is also a recent technique, which allows the sensory profiling of food products through the selection of attributes presented in a ballot, and has been extensively used with adults (Ares, Barreiro, Deliza, Giménez, & Gámbaro, 2010; Dooley, Lee, & Meullenet, 2010; Ribeiro et al., 2019). Due to the simplicity of the process and low-cognitive effort that is required, this method has already been applied with children not only to obtain sensory (Laureati & Pagliarini, 2018) but also emotional profiles (De Pelsmaeker, Schouteten, & Gellynck, 2013).

Regarding sensory profiles, CATA questions have been performed with children as young as 6 years old (Lima, Ares, & Deliza, 2018; 2019) and with several different products: apple purées (Laureati et al., 2017), grape nectar (Lima et al., 2018; 2019), biscuits (Schouteten, De Steur, Lagast, De Pelsmaeker, & Gellynck, 2017; Verwaeren, Gellynck, Lagast, & Schouteten, 2019) and fruit juices (Cardinal, Zamora, Chambers, Carbonell Barrachina, & Hough, 2015). Regardless age and type of product, children have been able to perform this methodology and to differentiate samples according to their sensory profile and even give additional insights (e.g. food products characterization and sensory drivers of liking) not available with the use of other traditional methods (Lima et al., 2018). One of the main challenges of performing CATA questions with children is the development of the ballot, since the sensory attributes used should be suitable for children. So far, most studies carrying out this methodology with children have used free listing questionnaires (Laureati et al., 2017) or focus groups (Schouteten et al., 2017; Verwaeren et al., 2019).

In the case of emotional profiling, although lists of words representing emotions have been utilized (De Pelsmaeker et al., 2013; Gallo, Swaney-Stueve, & Chambers, 2017) most studies have used ballots with Emojis (Gallo et al., 2017; Schouteten et al., 2017; Schouteten, Verwaeren, Gellynck, & Almli, 2019; Schouteten, Verwaeren, Lagast, Gellynck, & De Steur, 2018).

The main goal of this work was to assess children's ability to evaluate innovative food product (cookies incorporating grass-pea based tempeh flour), validating their ability to participate in the generation of a Check-All-That-Apply ballot and to perform this methodology. Furthermore, the impact of children's characteristics (age, sex and food neophobia) on the overall liking was evaluated and the sensory drivers of liking were identified.

2. Material and methods

2.1. Samples formulation and elaboration

A traditional grass pea (*Lathyrus sativus* L.) variety produced by a local farmer (Simões & Ramos Lda.) from Alvaiázere region, was used in this study. Due to its relatively low input requirements compared to major crops and its interesting nutritional profile, grass pea is considered a model grain legume crop for sustainable agriculture (Vaz Patto, 2006). In Portugal, it is part of the traditional heritage of dryland communities, representing an important source of revenue for some local economies (Vaz Patto & Araújo, 2016) Nonetheless, consumption of grass pea is uncommon and it is an ingredient unfamiliar to the majority of Portuguese consumers. Furthermore, its processing from fermentation into flour and further incorporation into bakery products has never been performed.

Grass pea-based tempeh was developed through a fermentation process adapted from Tibbott (2004). Briefly, grass pea seeds were soaked in demineralized water at room temperature overnight. After draining, the soaked seeds were pressured cooked for 5 min, cooled to 30 °C, dehulled and dried between absorbent paper sheets. Then, 400 g of cooked grass pea seeds were mixed with 10 mL of vinegar, inoculated with *Rhizopus microsporus* var. *oligosporus* (10^5 spores/g of grass pea seeds) isolated from a commercial tempeh starter (TopCultures, Zoersel, Belgium) and spread on polyethylene bags perforated with a sewing needle in a grid pattern with approximately 1–1.5 cm intervals. The bags were sealed and pressured to distribute the grass pea seeds in a uniform layer 2 cm thick. Tempeh containers were placed in a ventilated incubator over a rack to aid air circulation and incubated for 36 h at 30 °C, until the grass pea seeds were bound into a firm compact cake by a dense, uniform white mycelium permeating the entire cake. Tempeh

cake was sliced and dried in a ventilated oven at 95 °C for 3 h. To obtain a flour-like powder from grass pea based tempeh, the dehydrated tempeh slices were milled and sieved to a size particle less than 2 mm in a Pulverisette 14 Premium (Fritsch), and kept at room temperature in a closed container, with silica gel and protected from light, until use. The grass pea-based tempeh flour was used for incorporation in two different basic recipes of cookies, salty and sweet. For each type of cookies, five different formulations were developed, differing in the level of substitution of wheat flour by grass pea-based tempeh flour. Sweet cookies formulation was adapted from Fradinho, Nunes, and Raymundo (2015) with the addition of grass pea tempeh flour at 10%, 20%, 30% and 40% (w/w) incorporation by replacing a corresponding amount of flour. Salty cookies formulation was adapted from Batista et al. (2019) with the addition of grass pea tempeh flour at 5%, 10%, 20% and 30% (w/w) incorporation by replacing a corresponding amount of flour. For both typologies, a control sample with no grass pea-based tempeh flour was used.

2.2. Experimental design

In order to achieve the proposed research goals, two different phases were carried out, with a week difference between them. In the first phase, children were invited to participate in a focus groups aiming to generate a list of attributes for the development of a CATA ballot. In the second phase, two children' panels rated their overall liking and performed the sensory profiling of the samples.

2.3. Phase 1: CATA ballot development

2.3.1. Focus groups

In order to develop the CATA ballot for the sensory profiling of the cookie samples, focus groups were performed. In total, four focus groups, with 5 children each, were performed. The groups were selected based on sex (boys and girls) and age (8 to 10 years old and 11 to 12 years old). Recruitment was based on the previous identification of adult consumers from Sense Test's (a sensory evaluation and consumer tests company) consumer database with children at their households. Children willing to participate were identified and each participation was fully authorized. Parents gave their informed consent for their children participation, in accordance with the ASTM E2299-13 Standard Guide for Sensory Evaluation of Products by Children and Minors.

Focus groups discussions took place at Sense Test's focus group room, during August 2018, and had a duration of approximately 30 min. All the sessions were conducted by the same experienced researcher, one of the first authors, to ensure consistency in interviewing style (Partridge, Edwards, & Thorpe, 2010). The moderator was assisted by other co-authors to deal with video recording and some important annotations about participants' behavior.

The focus group guide was based on the work of Rose et al. (2004). After an initial icebreaker introduction, the task was split into three main phases: (i) exercise contextualization - children were asked to describe some geometric solids, namely to describe "how do they look?" and "what did they think that is important in the figures?"; (ii) exercise with food – children were asked to indicate how do apples look, smell and taste, and then they were invited to find the best words (from the ones elicited) to describe the apples; (iii) product description – children were asked to describe the cookies samples (appearance, smell, texture and taste), and then they were invited to indicate which characteristics better fit the cookies.

The focus group sessions were video recorded for accuracy of transcription and analysis (following participants' informed consent). All the recordings were anonymously transcribed verbatim.

2.3.2. Data analysis

The focus group transcriptions were analyzed, and themes were developed by the researchers, based upon the core themes of the focus group guide, considering similarities and differences of participants' responses (Bardin, 1977). In this specific work, the core themes were sensory dimensions and the characteristics that children perceived in each dimension. To illustrate the analysis, direct quotes by the participants were transcribed, serving as a description of the topic explored. For each elicited term, an absolute frequency was calculated. Due to the similarity of terms and in order to have a more comprehensive ballot, a common list for both cookies was created for the CATA ballot.

Data analysis was performed using the XL-STAT 2019® (Addinsoft 2019) and Statistical Package for Social Sciences (SPSS) – version 25® software.

2.4. Phase II: Evaluation of the samples with different grass pea-based tempeh flour incorporation

2.4.1. Sensory evaluation

Considering the previously established ballot, two panels of 60 children (between 8 and 12 years old) were invited to evaluate the different samples described in Section 2.1. Recruitment was based on the previous identification of adult consumers from Sense Test's consumer database with children at their households. Children willing to participate were identified, with each participation being authorized. All parents gave their written informed consent for their children participation, in accordance with the ASTM E2299-13 Standard Guide for Sensory Evaluation of Products by Children and Minors.

The panel for sweet cookies evaluation had an average age of 10.3 (±1.5) years and had a proportion of 52% girls. The panel for salty cookies had an average age of 10.2 (±1.4) years and had a proportion of 53% girls.

For each sample, children were asked to score their overall liking, using a 7-point facial hedonic scale (ASTM, 2003), ranging from 1 – "very bad" to 7 – "very good", before evaluating the CATA ballot, as a way to avoid potential hedonic score bias (King, Meiselman, & Carr, 2013). The CATA terms were presented in a random order between participants and between samples (Ares et al., 2013) and divided by sensory modalities to reduce the cognitive effort of the participants (Ares & Jaeger, 2013).

The tests were performed at Sense Test's sensory evaluation lab, in a special room with individual tasting booths equipped in accordance with ISO 8589:2007 – Sensory analysis – General guidance for the design of test rooms. Prior to the evaluation of the samples, the general procedure and the attributes in the CATA ballot were explained to each child individually by an experienced researcher and afterwards children practiced the evaluation procedure with a dummy sample (unsalted cracker). For each sample evaluation, children were provided with two cookies from the same formulation on plastic plates identified by a three-digit random number, under normal white lighting. Two cookies were provided to ensure that children had a representative amount of the sample to perform both liking and Check-All-That-Apply methods.

All samples were presented following a monadic balanced order of presentation, according to the Latin square design, to counterbalance possible carry-over effects (Macfie, Bratchell, Greenhoff, & Vallis, 1989). Participants were provided with a porcelain spittoon, a glass of bottled natural still water and unsalted crackers and were asked to chew a piece of cracker and to rinse the mouth with water between each sample, to rinse the palate. Tasting was performed under the surveillance of the researchers and all children willingly followed the test instructions, without any major difficulty.

2.4.2. Children food neophobia

In order to assess the food neophobia level of the participants, the children's parents answered the 10-item Children Food Neophobia Scale – CFNS (Pliner, 1994). This questionnaire consists of five neophobic and five neophilic statements regarding food consumption. Parents answer the level of agreement in a 7-point scale, ranging from "strongly disagree'' to "strongly agree", when considering their own children's

eating behavior. After reversing the scores given to the neophilic statements, the CFNS scores were calculated as the sum of the ratings in each statement, ranging from 10 to 70 with higher scores corresponding to higher levels of Food Neophobia.

2.4.3. Data analysis

Regarding the CFNS scale, the panel was divided into three groups (Table 1) according to the frequency distribution of the CFNS scores: class 1 (children in the lowest quartile, CFNS score lower than 21.5), class 2 (children in the second and third quartile, CFNS score between 21.5 and 40) and class 3 (children in the last quartile, CFNS score greater than 40). Children were also divided according to age – group 1 (8–10 years old) and group 2 (11 and 12 years old) - and sex. The results of overall liking were evaluated with descriptive statistics (mean and standard error of the mean) and with a 4-way ANOVA, where age, sex, neophobia class and level of replacement were used as main factors, followed by the LSD (Least Significant Difference) multiple comparison test. The second order interactions of this factors were also evaluated at a 95% confidence level.

To analyze CATA questions, frequency of use of each term was determined by counting the number of consumers who have used each attribute to describe the samples and a Cochran Q test at a 95% confidence level was initially used to identify significant differences perceived by consumers between samples for each of the terms (Parente, Manzoni, & Ares, 2011).

In order to obtain a two-dimensional representation of the samples, a correspondence analysis (CA) was applied from the previously determined contingency table. This analysis provides a sensory map of the samples, allowing the determination of similarities and differences between samples as well as the features that characterize its attributes (Ares, Varela, Rado, & Giménez, 2011). A multidimensional alignment (MDA) was also applied to assess the degree of multidimensional association between products and attributes presented on the perceptual map (Meyners & Castura, 2014; Meyners, Castura, & Carr, 2013). Both the CA and MDA analyses were performed with only the attributes that differentiated the samples according to the Cochran Q test. Additionally, to have a deeper understanding of the impact of each sensory attribute (evaluated on the CATA ballot) on liking, a penalty analysis was applied. Indeed, for each type of cookie, the impact of each significant sensory attribute (retained with the application of Cochran's test) on liking scores was measured, evaluating if the presence of the attribute represents a significant penalty or an added-value for sample liking (Ares et al., 2014).

Table 1
Socio-demographic characteristics, average FNS score and n (number of children) in each CFNS class.

CFNS class	Characteristics	Sweet cookies	Salty cookies
Class 1 - Low neophobia level	n	14	15
	Age – years (± S. D)	10.0 (± 1.6)	9.9 (± 1.5)
	FNS (± S.D)	17.3 (± 2.9)	17.7 (± 2.9)
	Sex (M/F %)	36/64	40/60
Class 2 - Intermediate neophobia level	n	30	29
	Age – years (± S. D)	10.4 (± 1.3)	10.2 (± 1.3)
	FNS (± S.D)	33.6 (± 4.7)	34.1 (± 4.6)
	Sex (M/F %)	63/37	55/45
Class 3 – High neophobia level	n	13	15
	Age – years (± S. D)	10.4 (± 1.6)	10.3 (± 1.3)
	FNS (± S.D)	47.9 (± 7.4)	47.1 (± 6.7)
	Sex (M/F %)	23/77	33/67

3. Results

3.1. CATA ballot development

Children elicited a total of 60 sensory attributes for the sweet cookies and 57 for the salty cookies and for both types of cookies most of the attributes were related to appearance (23 for sweet cookies and 21 for salty cookies). On the other hand, the sensory dimension that had fewer attributes was texture, with only five different attributes being elicited for sweet cookies and eight for salty cookies. Although children elicited a great number of attributes related to appearance, in the final list only 3 attributes were chosen for appearance. This is explained by the great number of redundant elicited attributes (e.g. tires, wheels, round, different types of wheels) and/or low frequency of mention. To have a broader applicability, the same ballot was utilized for both typologies of cookies, salty and sweet, with two specific taste attributes for each: salty -'water & salt cookie' and 'salty taste'-; sweet -'sweet taste' and 'Maria cookie'-.

The final CATA ballot (Table 2) was comprised of 21 attributes divided by sensory dimensions – appearance (3), odor (5), texture (4) and taste (9).

3.2 Overall liking - effects of sample and children's traits and characteristics

For the sweet cookies, it was possible to see that the sample with the highest overall liking had a 10% wheat flour substitution by grass-pea based tempeh flour (Table 3), with no significant differences with the 20% of flour substitution sample or control sample. However, with 30% and 40% of flour substitution, the samples had the lowest scores in overall liking, with the sample with 40% of flour substitution having significant differences in overall liking scores for all the other samples.

For the salty cookies, the control sample had the highest score in overall liking, with significant differences for the samples with 5%, 20% and 30% of flour substitution (Table 2). The samples with 10% flour substitution had the second highest overall liking score, although with no significant differences for any other sample.

Regarding the individual characteristics of the children, only the CFNS class had a significant impact on the overall liking of both types of cookies (Table 3), while age group ($p = 0.266$ for sweet cookies; $p = 0.255$ for salty cookies) and sex ($p = 0.248$ for sweet cookies; $p = 0.2828$ for salty cookies) had no significant impact. Additionally, the interactions between samples and children's characteristics -age group ($p = 0.672$ for sweet cookies; $p = 0.598$ for salty cookies), sex ($p = 0.681$ for sweet cookies; $p = 0.573$ for salty cookies) and CFNS class ($p = 0.586$ for sweet cookies; $p = 0.818$ for salty cookies), had no significant impact on the overall liking for both types of cookies. Furthermore, the interaction 'CFNS class × sex' had a significant impact on the overall liking of the sweet cookies ($F(2, 255) = 6.435$; $p = 0.002$), with neophobia level having a more significant impact for boys than for girls.

Similar behaviors were observed when analyzing the impact of the CFNS class on overall liking for each type of cookie, given that the most neophobic group (class 3) gave the lowest overall liking scores with a significant difference from the other groups (classes 1 and 2) (Table 3).

3.2. Sensory profile

Results yielded different levels of discrimination for each type of cookies, with the panel for sweet cookies identifying 71,4% of the attributes (15/21) as discriminant and the panel for salty cookies identifying 42.9% of the attributes (9/21) as discriminant (Table 2). The main differences between the two types of cookies were observed for the attributes related to taste, since in the evaluation of salty cookies only 2 out of 9 attributes differentiated the samples ('salty' and 'toasted'), while in the evaluation of sweet cookies 8 out of 9 had that effect ('*Maria* cookie, 'water & salt cookie', 'sweet', 'cereals', 'unpleasant', 'unpleasant aftertaste', 'wholegrain cookie', 'toasted'). For other sensory dimensions, differences were found for the attributes 'crunchy' (only

Table 2
List of sensory attributes utilized in CATA ballot. Attributes that statistically differentiated the samples (*p*-value below 0.050 on Cochran's test) are represented in bold.

Appearance			Odor			Texture			Taste		
	Sweet	Salty		Sweet	Salty		Sweet	Salty		Sweet	Salty
Wholegrain cookie	**<0.001**	**<0.001**	Toast	**<0.001**	**<0.001**	Crumbles easily	0.385	0.361	Water & salt cookie	**0.021**	0.052
Dark color	**<0.001**	**<0.001**	Raw dough	0.646	**0.007**	Dry	0.615	0.064	Wholegrain cookie	**0.030**	0.064
Tempting	**<0.001**	**<0.001**	Water & salt cookie	**0.022**	**0.045**	Crunchy	**0.023**	0.511	Unpleasant taste at the end	**0.017**	0.093
			Odorless	**0.001**	0.178	Easy to chew	0.945	0.182	Cereals	**0.027**	0.219
			Wholegrain cookie	0.065	**0.045**				Toasted	**<0.001**	**0.009**
									Maria cookie	**<0.001**	0.736
									Sweet	**<0.001**	0.104
									Salty	0.539	**0.007**
									Unpleasant	**0.010**	0.121

Table 3
Mean overall liking, based on 7-point facial hedonic scale, (± SD) according to type of cookie for different levels of incorporation of fermented grass pea flour and for different CFNS classes. F-values from the 4-way ANOVA, with age, sex, neophobia class and samples as factors on overall liking.

Sweet cookies			Salty cookies		
	Mean (±SD)	F ($df_{(level, error)}$); p		Mean (±SD)	F ($df_{(level, error)}$); p
Control	5.9 (± 1.2)^{a,b}	F (4,255) = 8.199; $p <$	Control	5.9 (± 0.9)^{a}	F (4,265) = 2.415; $p =$
10%	6.1 (± 1.2)^{a}	0.001	5%	5.2 ± (1.5)^{b}	0.049
20%	5.9 (± 1.2)^{a,b}		10%	5.6 ± (1.4)^{a,b}	
30%	5.7 (± 1.1)^{b}		20%	5.2 ± (1.5)^{b}	
40%	4.9 (± 1.4)^{c}		30%	5.3 ± (1.5)^{b}	
CFNS class	Mean (±SD)	F ($df_{(CFNS, error)}$); p	CFNS class	Mean (±SD)	F ($df_{(CFNS, error)}$); p
1	6.0 (± 1.2)^{a}	F (2,255) = 13.090; $p <$	1	5.5 (± 1.3)^{a}	F (2,265) = 3.703; $p =$
2	5.7 (± 1.2)^{a}	0.001	2	5.6 (± 1.3)^{a}	0.026
3	5.2 (± 1.3)^{b}		3	5.0 (± 1.7)^{b}	

a,b,c- homogeneous groups in accordance with the LSD test ($p < 0.050$).

discriminant for sweet cookies), odor of 'raw dough' and 'wholegrain cookie' (only discriminant for salty cookies) and 'odorless' (only discriminant for sweet cookies). For the attributes related to appearance, all the attributes presented in the ballot differentiated the samples for both types of cookies.

The Correspondence Analysis of the CATA frequencies (Fig. 1) and the MDA (Fig. 2 and Fig. 2) allowed to better understand how the addition of grass pea-based tempeh flour affected the sensory profiling of sweet and salty cookies by children. For sweet cookies (Fig. 1a and Fig. 2), it is possible to see that the samples with the highest incorporation (30 and 40% flour substitution) were associated with 'dark color', 'wholegrain' appearance, 'toast' odor, 'toasted' taste, 'unpleasant' taste, 'unpleasant aftertaste', and taste of 'wholegrain cookie'. On the other hand, the control sample and cookies with 10 and 20% flour substitution had different sensory profiles. Both the control and cookies with 10% flour substitution were associated with a 'sweet' taste, 'crunchy' texture and tempting appearance. The addition of grass pea-based tempeh flour made the samples with 10% and 20% flour substitution to be associated with a 'cereals' taste, while the association with 'odorless', odor of 'water & salt' cookie, taste of 'water & salt' cookie and '*Maria* cookie' taste was weaker than for the control sample.

Concerning the attributes that were identified through penalty analysis as having a significant impact on the overall liking of sweet

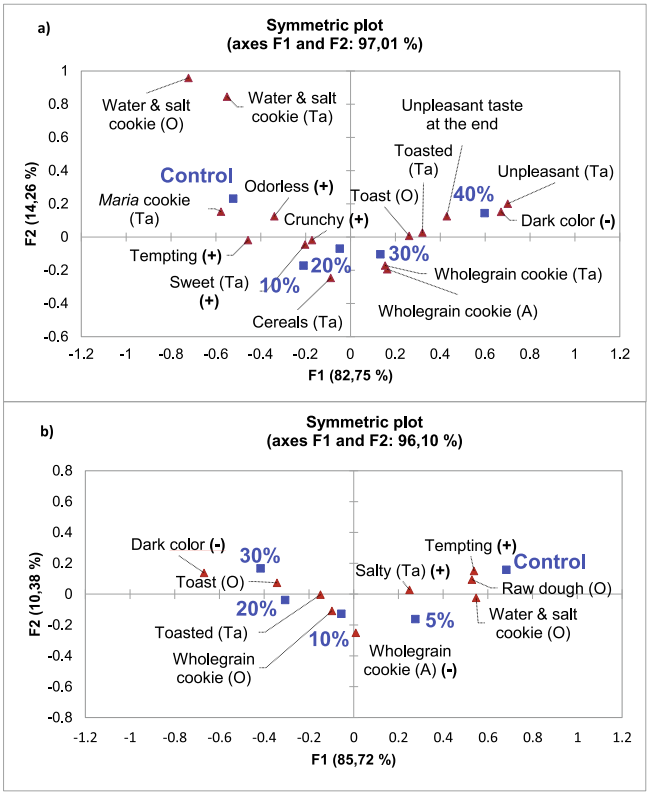

Fig. 1. Correspondence Analysis of CATA frequencies containing only the attributes related to appearance (A), texture, odor (O) and taste (Ta) that significantly differentiated the sweet cookies (graph a) and the salty cookies (graph b) samples (according to the Cochran Q test at 95% significance level). Attributes represented with symbols (+) or (-), were identified as having a significant impact on the overall liking of the sweet cookies (a) and salty cookies (b) through Penalty Analysis.

cookies, it was found that 'tempting' appearance, 'crunchy' texture, 'sweet' taste and 'odorless' had a positive impact and were mostly associated with the control sample and cookies with 10% flour substitution. On the other hand, 'dark color' had a negative impact on overall liking and was associated with cookies with 30% or 40% flour substitution.

For the salty cookies (Fig. 1b and Fig. 3), a similar performance in the sensory profile was also observed. The samples with the highest incorporation (20% and 30% substitution), were associated with a 'dark color', 'toast' odor, 'toasted' taste and odor of 'wholegrain cookie'. The control sample (which was the sample with the highest overall liking score), was associated with a 'salty' taste, 'tempting' appearance, odor of 'raw dough' and odor of 'water & salt cookie'. The incorporation of

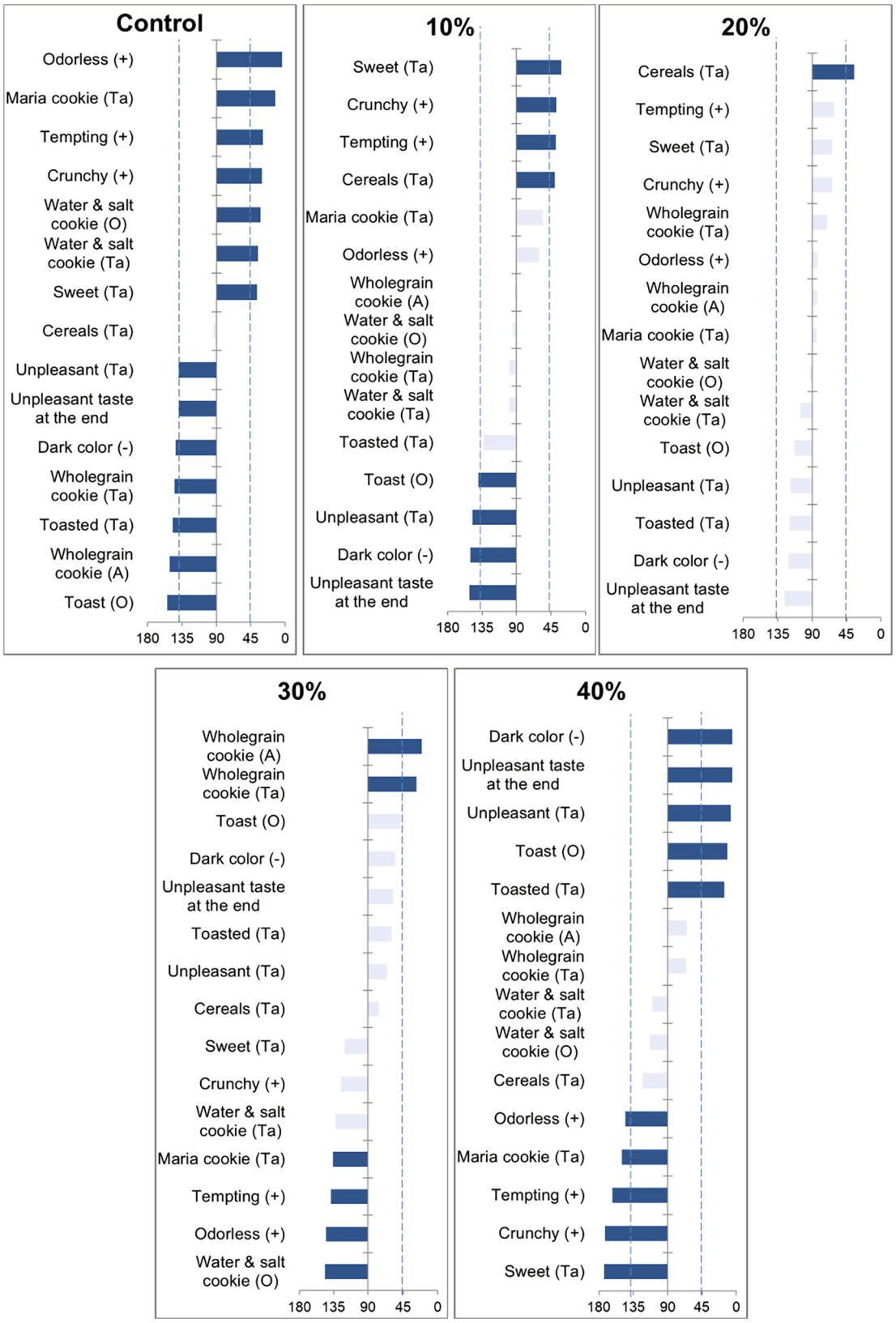

Fig. 2. Results of MDA analysis, with cosines of the angles between the samples and all the attributes that significantly differentiated the sweet cookies samples (according to the Cochran Q test at 95% significance level). Vertical dashed lines indicate the cut-off values of cos(45°) and cos(135°) – which represent positive and negative correlations between samples and attributes, respectively. Attributes represented with symbols (+) or (-), were identified as having a significant impact on the overall liking of the sweet cookies through Penalty Analysis.

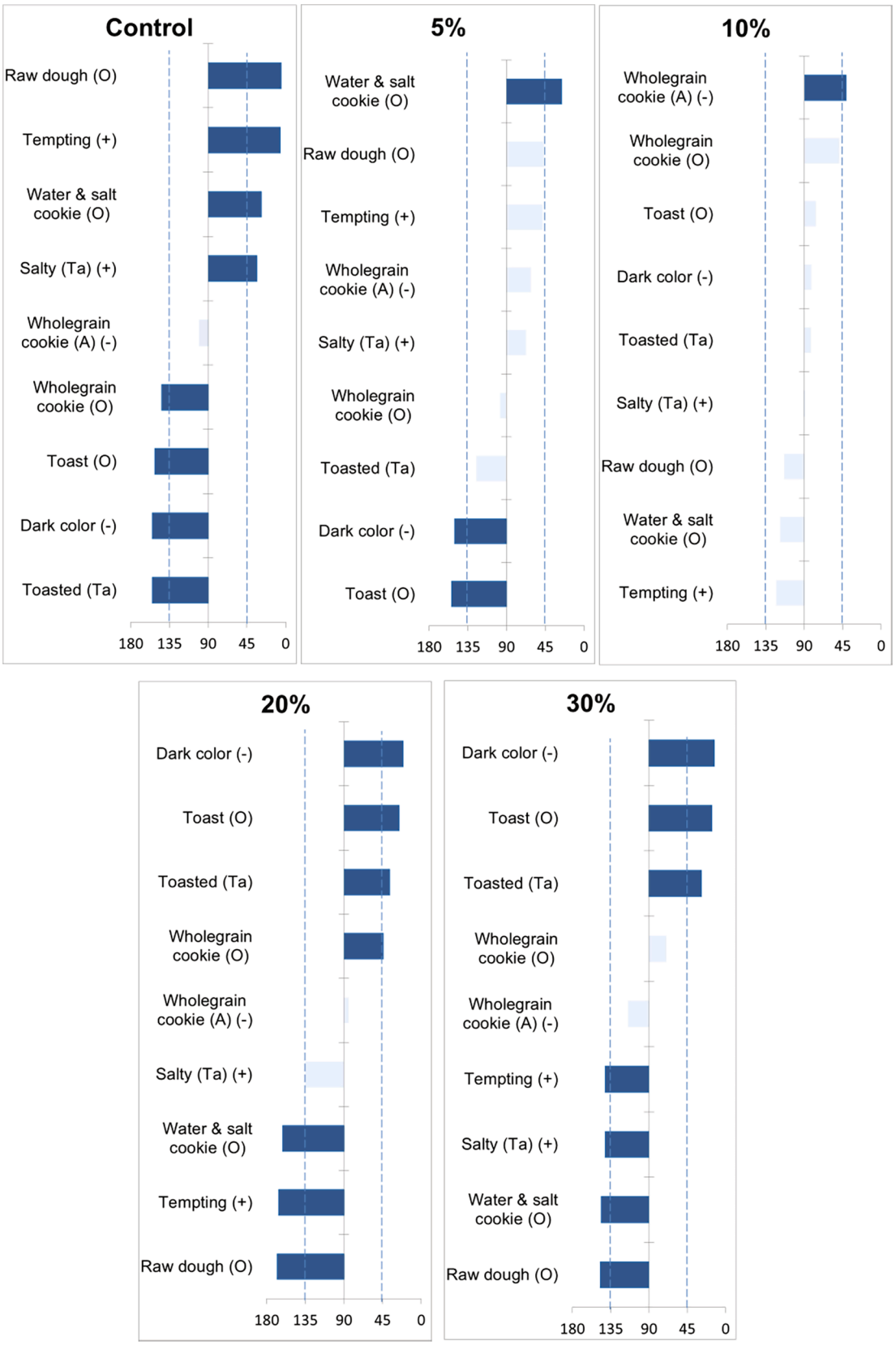

Fig. 3. Results of MDA analysis, with cosines of the angles between the samples and all the attributes that significantly differentiated the salty cookies samples (according to the Cochran Q test at 95% significance level). Vertical dashed lines indicate the cut-off values of cos(45°) and cos(135°) – which represent positive and negative correlations between samples and attributes, respectively. Attributes represented with symbols (+) or (-), were identified as having a significant impact on the overall liking of the salty cookies through Penalty Analysis

grass-pea based tempeh flour at a 5% flour substitution level lead to considerable weaker association with all those attributes except for odor of 'water & salt cookie', while at a 10% substitution level there was no correlation to odor of 'water & salt cookie' and a positive association was found to 'wholegrain' appearance and odor.

The attributes identified through penalty analysis as significantly improving overall liking of the samples were 'tempting' appearance and 'salty' taste, which were associated with the control sample and cookie with 5% flour substitution. Regarding attributes with negative impact on the overall liking, these were related to appearance ('wholegrain' and 'dark color') and were associated with the cookies with higher flour substitution (20 and 30%).

4. Discussion

In this study, children aged between 8 and 12 years old were able to differentiate different samples of salty and sweet cookies incorporating various levels of grass pea-based tempeh flour, not only in terms of overall liking but also through the sensory profile of the samples. This work further illustrates the appropriateness of using CATA questions to evaluate children's perception of sensory profile, and their ability to generate CATA ballots through the application of carefully conducted focus groups.

In this research, the application of a 7-point facial hedonic scale allowed children to discriminate different samples (Table 3), further demonstrating that children are able to correctly use these kind of scales not only to rate their overall liking but also to discriminate different samples (Laureati & Pagliarini, 2018; Laureati et al., 2015). The application of the CATA methodology was also successful in obtaining further insights into how children perceive different food products. The level of discrimination of the attributes present in the CATA ballot (Table 2) was dependent of the cookie typology – a greater discrimination was observed for sweet cookies (71%, 15/21 attributes), but the level for salty cookies was also very relevant (43%, 9/21 attributes). The ballot employed in this study had a total of 21 sensory attributes, a higher number if compared with previous studies using the same approach (Schouteten et al., 2017; Verwaeren et al., 2019). Nonetheless, the number of discriminating attributes under blind evaluation was very similar to those studies and children were able to perform the CATA methodology and to elaborate different sensory profiles.

Concerning the development of the CATA ballot, most attributes elicited by children were related to the appearance and for both salty and sweet cookies all the attributes related to appearance discriminated the samples (Table 2). In previous studies, it has been reported that most of the attributes that children elicit for food products are related to appearance and that the evaluation of these attributes is more analytical when compared to other sensory dimensions (Rose et al., 2004; Sune et al., 2002). Furthermore, it has been reported that children use vision more than adults when making their food decisions (Dovey et al., 2012). A similar evaluation was also observed for both salty and sweet cookies, since an increase in the amount of fermented grass-pea flour lead to an increase in 'dark color' and 'wholegrain' appearance and decrease in 'tempting' appearance. Moreover, the attributes related to appearance had a significant impact on the overall liking of the samples for both typologies. Previous studies performed with speculoos (a traditional cookie from Belgium and Netherlands), have also noted that products associated with a 'dark brown color' had lower overall liking scores (Schouteten et al., 2017). The importance of appearance in children's acceptance of food products can also be explained by the "visual exposure" theory, in which the simple exposure to a certain food product leads to a greater acceptance and consumption of the food product (Rioux, Lafraire, & Picard, 2018). This strategy is particularly helpful in neophobic or picky eaters, which are more prone to reject foods on mere sight (Dovey, Staples, Gibson, & Halford, 2008). Color seems to be one of the major attributes that controls food rejection in children. This happens because food categorization has been shown to be mainly color-dependent, as it provides information regarding the typicality of a certain product, unlike shape or texture (Rioux, Picard, & Lafraire, 2016). In fact, in this study the researchers found that dark color is also strongly related to disliking.

Regarding the attributes related to texture, only one attribute ('crunchy') discriminated sweet cookies while for salty cookies no attribute related to texture discriminated the samples. In the sweet cookies, the samples with highest overall liking scores were the ones associated with this attribute ('crunchy') and it had a significant impact on samples' overall liking, according to the penalty analysis. These results are in accordance with studies that have been performed with speculoos, in which the samples with the highest overall liking were associated with a crunchy texture and it had a significant impact on the overall liking (Schouteten et al., 2017; Verwaeren et al., 2019). Nonetheless, it has also been reported that children dislike crunchy or chewy textures, preferring foods with low complexity (Popper & Kroll, 2011) and that more neophobic children have a higher preference for softer textures (Laureati et al., 2020). However, the preference for crunchy textures depends on the type of food that is being consumed. In the case of pastry products, this attribute may be related to the freshness of the product (Heenan, Hamid, Dufour, Harvey, & Delahunty, 2009).

For the taste dimension, striking differences were observed for each type of cookies, given that a higher number of discriminating attributes was observed for sweet cookies than for salty cookies. This could be explained by the fact that children are more familiar with sweet-type cookies, leading to a higher discrimination for taste attributes. These differences in taste attributes discrimination could explain the higher differences that were registered for overall liking in the sweet cookies (e.g. only for sweet cookies the samples were associated with clear negative attributes such as 'unpleasant' taste and 'unpleasant aftertaste'). For sweet cookies, it was evident that the samples with the highest overall liking were associated with familiar tastes (such as 'Maria cookie' and 'Water & salt cookie', which are two of the most consumed types of cookies in Portugal, (Lopes et al., 2017)) and sweet taste. The preference and acceptance of sweet products by children is well-documented. Positive responses to sweet taste are generally inborn, and the preference for sweet taste is universal for children among the world, and only declines during mid-adolescence (Mennella, 2014). In the case of salty cookies, the only differences were found for 'salty' and 'toasted' taste, with samples with highest overall liking being linked with 'salty' taste and samples with the lowest overall liking being associated with a 'toasted' taste. Saltiness preference in children is more complex that sweet preference, but positive responses to saltiness is also inborn and there are several reports in which the overall liking of food products (including crackers) by children is increased by the addition of salt (Liem, 2017; Mennella, 2014).

The individual characteristics of the children, particularly the level of neophobia, seemed to greatly impact how children perceived the different samples (Table 3). Neophobia has been associated with reduced preferences for almost all food groups, with this effect being more prominent in healthy foods such as fruits or vegetables (Howard et al., 2012; Russell & Worsley, 2008). Therefore, it can be responsible for a less diversified diet (Gomes et al., 2018), along with a possible lack of essential nutrients (Carruth et al., 1998). In this study, it was possible to observe that the CFNS level of children was negatively associated with the samples overall liking, with the most neophobic group giving lower overall liking scores for both salty and sweet cookies, regardless of the level of inclusion of fermented grass-pea flour (even for the control samples, neophobic children gave lower scores). One possible explanation for this behavior is that neophobic/picky children have lower food discriminability capacity, given that these children do not accept new food products and thus have fewer learning opportunities with sensory attributes (Rioux et al., 2016). The results of this study are very similar to the ones reported in literature (Laureati, Bergamaschi, & Pagliarini, 2015; Laureati, Bertoli, et al., 2015; Laureati, Cattaneo, Bergamaschi, Proserpio, & Pagliarini, 2016; Proserpio et al., 2020, 2019) in which

more neophobic children gave lower overall liking scores than children who were less neophobic. However, in the work by Proserpio et al. (2019) this effect of food neophobia was more pronounced in increasingly modified samples. Additionally, it should be noted that these studies used a Food Neophobia questionnaire designed to be self-reported by children (Laureati, Bergamaschi, et al., 2015) which is different from the applied Food Neophobia questionnaire in this work (Pliner, 1994), in which parents answer the questionnaire. The use of the questionnaire developed by Pliner (1994) can have some limitations because it can underestimate the role of the child in the process (Aldridge, Dovey, & Halford, 2009) and parents may project their own behaviors onto those of their children (Mata, Scheibehenne, & Todd, 2008) and can only report about their children's behavior when they are under their control/view (Proserpio et al., 2020).

5. Conclusion

Children aged 8–12 years old were able to elaborate a CATA ballot for the evaluation of innovative food products (salty and sweet cookies incorporating fermented grass-pea flour) and to correctly employ this methodology to elaborate different sensory profiles. Attributes related to appearance, crunchy texture and sweet/salty taste were the attributes that significantly impacted children's acceptance of food products, which is in accordance with studies present in literature. Furthermore, it was also possible to observe that the level of neophobia is negatively associated with the children's sensory perception of food products, given that neophobic children consistently gave lower overall liking scores for all the tested samples.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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