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How sweet is too sweet? Measuring sweet taste preferences and liking in familiar and unfamiliar foods amongst Dutch consumers

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ABSTRACT

Sweet taste preference and liking have been assessed with various methods, yet there is no consensus in the literature on which method is most sensitive across a range of foods. The current studies explored several methods to assess sweet taste preference, liking and perceived intensity across various familiar and unfamiliar foods in Dutch consumers. In experiment 1, five different sweet foods, each with five sweetness concentration levels were evaluated on preference, liking and perceived intensity, using two methods for measuring liking and preference: ranking ($n = 10$), rating ($n = 10$); one for measuring perceived intensity: rating ($n = 10$); and one combining preference, liking and perceived intensity: structured napping ($n = 10$). The ranking method, despite having the highest discriminative power, gave no indication of inter-sample spacing nor absolute scores. In subsequent studies, ranking was thus combined with rating as "Ranking on a scale" (RoS). Experiments 2 ($N = 31$), 3 ($N = 28$) and 4 ($N = 28$) tested the RoS method across various familiar and unfamiliar foods and/or food forms. In Experiments 2 and 4, inverted-U-shaped hedonic responses were observed for all foods, and differences in preference for different sweetness concentration levels were detected. Experiments 3 and 4 showed that familiar foods were more liked than unfamiliar ones across all sweetness levels (Experiment 3 ($F(1,1322) = 14.8$, $p < .001$); Experiment 4 ($F(1,803) = 38.1$, $p < .001$)). Hence, RoS seems to be a viable method for assessing sweet taste preferences in both familiar and unfamiliar foods, among consumers. In future work we will apply this method to better understand the role of sweet taste exposure on preferences for a range of sweet foods.

1. Introduction

Sweet taste intensity perception is a process that results from the interaction of taste receptors with chemicals dissolved in saliva. The activation of the receptor cells triggers a specific and taste-related cascade of events eventually reaching the nervous system ultimately leading to conscious percept of taste (Pallante et al., 2021). Intensity perception is commonly measured with rating, where panellists rate perceived sweetness intensity on a numerical scale, such as 0–100 scale (Trumbo et al., 2020). Sweet taste liking, by comparison, is a hedonic response on whether an individual likes the taste, such as a rating of 80 out of a 100, while sweet taste preference is a discrete choice by an individual showing preference for one sweetness level over another. Studies on people's liking and preference for sweet taste tend to use the terms "liking" and "preference" interchangeably, even though they have distinct meanings (Petty et al., 2020) and can lead to different results.

Studies investigating sweet taste liking, preference or intensity perception often differ in methodological approach. There is a great deal of variation in the methods and food stimuli used, which contributes to inconsistent findings, such as when investigating determinants of sweet taste preferences (see Venditti et al. (2020), for a review). For instance, most studies are limited to the use of one or two model foods or water solutions (Appleton, Tuorila, et al., 2018; De Graaf & Zandstra, 1999; Liem & de Graaf, 2004; Petty et al., 2020; Venditti et al., 2020), even though it is known that optimal sweetener concentrations depend on the type of food and its matrix (Drewnowski et al., 2012; Urbano et al., 2016). Additionally, the type of sweet-tasting compound that is added to the model food varies, although sucrose is most commonly used (Iatridi et al., 2019). Studies also differ in the sweetness concentrations tested and in the number of concentration levels used, ranging from a single to multiple concentration levels (Venditti et al., 2020). To get a comprehensive understanding of sweet taste liking, preference and intensity

Abbreviations: BMI, Body mass index; LMM, Linear Mixed Model; LMS, Labelled magnitude scale; RoS, Ranking on a cale; VAS, Visual Analogue Scale.

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perception, these should be evaluated across a range of foods and beverages, and across a wide range of concentration levels that reflect the dynamic perceptual range in the food supply.

The choice of measurement scale also varies widely between studies investigating sweet taste liking, preference and intensity perception. Most commonly used methods include category scaling (e.g. n-point category scales) (De Jong et al., 1996; Kleifield & Lowe, 1991; Martin et al., 2011; Pomerleau et al., 1991; Urbano et al., 2016; Zandstra et al., 1999), line scaling (e.g. Visual Analogue Scale (VAS)) (Bolhuis et al., 2016; de Bruijn et al., 2017; Mooney et al., 2020), direct magnitude scaling (e.g. the labelled magnitude scale (LMS)) (Keskitalo et al., 2007; Wise et al., 2016), ranking (Balthazar et al., 2018; Desor & Beauchamp, 1987; Liem & de Graaf, 2004), and rapid descriptive sensory methods, such as napping (Dehlholm et al., 2012; Nestrud & Lawless, 2010; Risvik et al., 1994). These methods rely on the observer to report liking, preference for a specific food and/or the intensity of a sensation. Common limitations of the aforementioned scales include, no information of the absolute intensity (line scaling), only rank-order data (ranking and category scaling) and the incompatibility of verbal intensity descriptors with other languages and cultures (direct scaling, LMS) (Trumbo et al., 2020). All in all, currently, there is lack of consensus about the most sensitive method for assessing sweet taste liking, preference and intensity perception. More importantly, when choosing a particular measurement scale, the purpose of the study, the culture, context and range of sweetness concentrations among stimuli should be taken into consideration (Heymann & Ebeler, 2017; Kemp et al., 2018; Trumbo et al., 2020).

The current work aimed to develop a comprehensive and sensitive methodology to assess sweet taste liking, preference and intensity perception across a range of foods appropriate for use in the context of the Dutch food supply. The developed methodology was intended for use as primary (sweet taste liking and preference) and secondary outcome (perceived intensity) measures in a randomized clinical trial to assess the effect of dietary sweet taste exposure on sweet taste liking and perception. The methodology was developed within the context of the Sweet Tooth project (ClinicalTrials.gov ID no. NCT04497974, (Cad et al., 2022)), aimed at assessing the effect of dietary sweetness exposure on liking and preference for sweet foods and eating behaviour and health. However, the developed methodology can be applied in a broader context, such as new product development, to identify the most preferred sweetness level in a sample. In this context, the methodology could provide useful insights into consumer preferences and aid in the development of new products.

Overall, the objective of this research was to establish an effective methodology for evaluating hedonic assessments of sweet taste, using a best-case scenario. The rationale behind this pursuit stems from the lack of consensus regarding the most suitable approach, particularly when considering various food matrices and levels of familiarity. The work was conducted across four Experiments and was inspired by a study of Urbano et al. (2016) that developed and described an extensive procedure to assess basic taste perception and preferences in the French cultural food environment. The aim of Experiment 1 was to assess the efficacy of multiple measurement scales in evaluating sweet taste liking, preferences, and intensity perceptions and select the most effective method to proceed with. This evaluation was conducted on a range of test foods, encompassing different concentration levels, allowing for a comparison between (a) ranking, (b) rating and (c) structured napping. Building on the findings from Experiment 1, the aim of Experiment 2 was to refine the selected method to enhance the sensitivity of the measurement scales, by combining ranking and rating as Ranking on a Scale (RoS) and optimize the test foods and their quantities for assessing liking and preferences. Additionally, Experiment 2 included salty samples to assess the methodology's efficacy in evaluating liking, preferences and intensity perception for both sweet and salty foods. Consequently, the aim of Experiment 3 was to expand on the assessment of the developed methodology's efficacy by comparing suitability for familiar and unfamiliar sweet and salty test foods and further optimize the test foods. With the insights gained from previous experiments the aim of Experiment 4 was to optimise the sample type, sample quantity and sensitivity of the methodological approaches to assess sweet taste liking, preference and intensity perception. In Experiments 2, 3 and 4, we tested foods that varied in salt taste intensity so that potential effects of dietary sweetness exposure (the Sweet Tooth project) on salt taste can also be investigated. Uncommonly consumed (unfamiliar) foods were added in Experiments 3 and 4, as it is possible that detecting shifts in sweet taste liking and preferences, after long-term dietary sweetness exposure (aim of the Sweet Tooth project), in commonly eaten foods, might be less evident, compared to shifts in unfamiliar foods, because there is no sweetness level associated with them.

2. Methods

2.1. Sensory panels

The sensory panels consisted of untrained assessors recruited among staff and students of Wageningen University, the Netherlands. For each experiment new participants were recruited. Potential participants were contacted through email or social media and were informed that the studies would involve evaluation of sweet and salty tasting foods. Participants were all healthy and some had previous experiences with participating in sensory studies, but they were not trained. Forty participants participated in Experiment 1 (July 2019), 31 in Experiment 2 (September 2019), 28 in Experiment 3 (November 2019) and 28 in Experiment 4 (June 2020). These sample sizes were based on previous studies in this field from our laboratory (Hogenkamp et al., 2012; Hogenkamp et al., 2011). All participants provided written informed consent in advance of their participation. Ethical approval for the study was provided by the Wageningen University Medical Ethical Review Board as part of a broader study protocol covering sensory and behavioural studies of eating behaviour (NL51747.081). All study procedures were run in accordance with the Declaration of Helsinki.

2.2. Test foods

The test foods in all experiments ranged from low sweet/salt to high sweet/salt intensity, across five concentration levels (so-called L-2, L-1, L-0, L + 1, L + 2); the middle level (L-0), initially based on the quantity present in the commercial products or recipes, representing the optimal sweetness/saltiness level. Test foods were prepared a maximum of 72 h in advance and served at room temperature (approx. 22 °C) or cold (approx. 5 °C), depending on the type of food. The test foods were served on small plastic trays or in plastic cups and labelled with random three-digit codes.

2.2.1. Experiment 1: Familiar sweet foods

The test foods used in Experiment 1 were sweet and commonly consumed in the Netherlands, that is orange juice, whipped cream, apple sauce, soft cheese and plain cake. Sweetener concentration levels were manipulated with sucrose and liquid non-nutritive sweetener and were based on the work of Urbano et al. (2016). Non-nutritive sweetener was added as high concentrations of sucrose can impact the texture of products such as cake. The quantity of non-nutritive sweetener was limited to minimize the introduction of off-tastes potentially brought by the non-nutritive sweetener. An overview of the test foods and their sweetener concentration levels per intensity level is presented in Table 1.

2.2.2. Experiment 2: Familiar sweet and salty foods

Test foods used in Experiment 2, and their concentration levels, are presented in Table 2. The test foods were sweet and salty familiar foods, all differing across five concentration levels. Recipes and concentration levels were based on the original work of Urbano et al. (2016), but some

Table 1
Test foods used in Experiment 1 with sweetener concentration levels (sucrose + non-nutritive sweetener) % by weight, for each level.

Test food	Food form	Serving size	Serving temperature	Sweetener concentration (sucrose [a] + non-nutritive sweetener [b]) (% by weight)				
				L-2	L-1	L-0	L + 1	L + 2
Orange juice	Liquid	20 ml	22 °C	0.0 + 0.0	1.4 + 0.0	2.5 + 0.0	4.9 + 0.0	9.4 + 0.0
Whipped cream	Semi-Solid	15 g	5 °C	0.0 + 0.0	3.8 + 0.0	10.7 + 0.0	26.4 + 0.0	41.8 + 0.0
Apple sauce	Semi-Solid	20 g	22 °C	0.4 + 0.0	2.1 + 0.0	8.00 + 0.0	14.8 + 0.0	25.8 + 0.0
Soft white cheese (quark)	Semi-solid	20 g	5 °C	0.5 + 0.0	1.9 + 0.0	6.54 + 0.0	14.8 + 0.0	21.8 + 0.0
Plain Cake	Solid	20 g	22 °C	9.1 + 0.0	16.7 + 0.0	18.3 + 0.9	17.7 + 4.2	16.4 + 11.1

[a] Sucrose, Kristal sugar, Van Gilse, the Netherlands.
[b] Liquid sweetener based on cyclamate and saccharin (Rio Zoetstof, Sweet Life AG, Switzerland).

Table 2
Test foods used in Experiment 2 with sweetener (sucrose + non-nutritive sweetener) and salt (NaCl) concentration levels % by weight, for each level.

Test food	Food form	Serving size	Serving temperature	Sweetener concentration (sucrose[a] + non-nutritive sweetener[b]) (% by weight)				
				L-2	L-1	L-0	L + 1	L + 2
Orange juice	Liquid	20 ml	22 °C	0.0 + 0.0	0.5 + 0.0	2.5 + 0.0	4.9 + 0.0	9.4 + 0.0
Soft white cheese	Semi-solid	20 g	5 °C	0.5 + 0.0	1.9 + 0.0	6.5 + 0.0	14.9 + 0.0	21.9 + 0.0
Plain Cake	Solid	20 g	22 °C	9.1 + 0.0	16.7 + 0.0	18.2 + 0.9	17.6 + 4.2	16.9 + 8.2
				Salt concentration (NaCl) (% by weight)				
				L-2	L-1	L-0	L + 1	L + 2
Tomato juice	Liquid	20 ml	22 °C	0.0	0.3	0.5	0.7	0.9
Spinach cake	Solid	20 g	22 °C	0.0	0.2	1.2	1.6	2.5

[a] Sucrose, Kristal sugar, Van Gilse, the Netherlands.
[b] Liquid sweetener based on cyclamate and saccharin (Rio Zoetstof, Sweet Life AG, Switzerland).

levels were adjusted slightly based on the results of Experiment 1. Salty foods were included as they will serve as a control in the Sweet Tooth trial to investigate the potential effects of dietary sweetness exposure on salt taste (Cad et al., 2022). Furthermore, by including salty stimuli, we were able to assess methodology's efficacy in evaluating preferences, liking and intensity perception for both sweet and salty foods.

2.2.3. *Experiment 3: Familiar and unfamiliar sweet and salty foods*

In Experiment 3, five newly developed unfamiliar foods (three sweet and two salty) and five familiar foods (three sweet and two salty) were tested (Table 3). Recipes for sample preparation of the familiar foods were derived from the research of Urbano et al. (2016) and Bolhuis et al. (2016). Unfamiliar foods were developed and prepared specifically for this experiment and were selected based on the following criteria: novel to consumers residing in the Netherlands, palatable, and comparable to familiar foods in terms of sweetness/saltiness concentrations and food form. Some unfamiliar foods were created by adding food colourings and flavours to the familiar test foods. Unfamiliar test foods were included to investigate the potential effects of dietary sweetness exposure and familiarity on sweet taste preferences and perception in the

Table 3
Test foods used in Experiment 3 with sweetener (sucrose + non-nutritive sweetener) and salt (NaCl) concentration levels % by weight, for each level.

	Test food	Food form	Serving size	Serving temperature	Sweetener concentration (sucrose [a] + non-nutritive sweetener[b]) (% by weight)				
					L-2	L-1	L-0	L + 1	L + 2
Familiar	**Orange juice**	Liquid	20 ml	22 °C	0.0 + 0.0	0.5 + 0.0	2.5 + 0.0	4.9 + 0.0	9.4 + 0.0
	Soft white cheese	Semi-solid	20 g	5 °C	0.5 + 0.0	1.9 + 0.0	6.5 + 0.0	14.9 + 0.0	21.9 + 0.0
	Plain Cake	Solid	20 g	22 °C	9.1 + 0.0	16.7 + 0.0	18.2 + 0.9	17.6 + 4.2	16.9 + 8.2
Unfamiliar	**Buco Pandan flavoured drink**	Liquid	20 ml	22 °C	0.0 + 0.0	0.5 + 0.0	2.5 + 0.0	4.9 + 0.0	9.4 + 0.0
	Grenadine flavoured soft white cheese	Semi-Solid	15 g	5 °C	0.5 + 0.0	1.9 + 0.0	6.5 + 0.0	14.9 + 0.0	21.9 + 0.0
	Tamarind flavoured cake	Solid	20 g	22 °C	9.1 + 0.0	16.7 + 0.0	18.2 + 0.9	17.6 + 4.2	16.9 + 8.2
					Salt concentration (NaCl) (% by weight)				
					L-2	L-1	L-0	L + 1	L + 2
Familiar	**Tomato juice**	Liquid	20 ml	22 °C	0.0	0.3	0.5	0.7	1.2
	Spinach cake	Solid	20 g	22 °C	0.0	0.2	0.6	1.2	2.1
Unfamiliar	**Ube flavoured pumpkin juice**	Liquid	20 ml	22 °C	0.0	0.1	0.3	0.6	1.2
	Ube flavoured spinach cake	Solid	20 g	22 °C	0.0	0.3	0.6	1.2	2.1

[a] Sucrose, Kristal sugar, Van Gilse, the Netherlands.
[b] Liquid sweetener based on cyclamate and saccharin (Rio Zoetstof, Sweet Life AG, Switzerland).

Sweet Tooth trial (Cad et al., 2022). Furthermore, by including unfamiliar test foods, we were able to assess methodology's efficacy in evaluating preferences, liking and intensity perception for both commonly and uncommonly consumed foods by the target population.

2.2.4. Experiment 4: Familiar and unfamiliar sweet and salty foods

In total, there were eight test foods utilized in Experiment 4: three familiar sweet, two familiar salty, and three unfamiliar sweet (Table 4) (recipes for test food preparations are given in Appendix C). Recipes for illustrative preparations of popular sweet foods were derived from Urbano et al. (2016). The unfamiliar sweet foods were developed especially for this study using the same principles as in Experiment 3. Amounts given in recipes for familiar, salty dishes were gathered from the internet and used to calculate level L-0. The researchers pretested four additional levels by either lowering salt level (L-1 and L-2) or raising it (L + 1 and L + 2).

2.3. Procedures

For each of the experiments, participants attended a single test session. Participants were tested individually in eating behaviour booths of the Human Nutrition Research Unit of Wageningen University, under normal lighting and odour-free conditions. Participants were not allowed to eat, drink (except water) or smoke at least one hour before the start of the test session. Participants were instructed to taste a mouthful of each presented sample and rate it on liking, preference and/or perceived intensity. Between each evaluation, participants cleansed their palate with water. Breaks of 30–60 s between stimuli tasting were implemented to minimise possible carry-over effects. The order of sample presentation was randomized across participants and responses were recorded using EyeQuestion Software (https://eyequestion.nl/, Logic8 BV, Version 5.0.7.15).

In Experiment 1, the 40 participants were randomly assigned to one of four different conditions that were spread across four days: preference ranking (n = 10), liking rating (n = 10), perceived intensity rating (n = 10), and structured napping (n = 10). In the preference ranking condition, participants were presented with five food samples each with five different concentration levels, and were instructed to rank the samples from least to most preferred, with no ties allowed. In the liking rating condition, participants rated the samples on a nine-point hedonic scale (Peryam & Pilgrim, 1957), anchored as 'Dislike extremely' at 1 and 'Like extremely' at 9. During perceived intensity rating, participants evaluated food samples on sweetness using a 100-unit VAS, anchored 'Not sweet at all' and 'Extremely sweet'. The structured napping condition combined liking and perceived intensity evaluation. Participants assigned to this condition were instructed to rate samples using a co-ordinate system, where the x and y axes represented liking and perceived intensity, respectively. Both axes had 100 units and were anchored 'hate it' and 'love it' for liking, and 'not sweet at all' and 'extremely sweet' for perceived intensity.

In Experiments 2 (n = 31), 3 (n = 28) and 4 (n = 28), liking and preference were assessed with Ranking on a Scale method (RoS) (Heymann & Ebeler, 2017; Kemp et al., 2018; Kim & O'Mahony, 1998; Sung & Wu, 2018). For this method participants were presented simultaneously with five concentration levels of the same test food, each with different intensity levels. Participants were asked to taste and swallow a mouthful of each sample in order of presentation (from left to right) and rate it on liking, using a single 100-unit VAS. The scale was end-anchored 'like extremely' and 'dislike extremely', and at the middle 'neither like nor dislike'. Participants could re-taste the samples as needed. All five samples of the same test food were rated on a single scale and ties were allowed. Consequently, responses were considered as a continuous measure of 'liking' based on the rating on the scale, and as a measure of 'preference' based on the order in which all stimuli were ranked on the scale.

In Experiments 2, 3 and 4, perceived intensity was measured using a single 100-unit VAS, end-anchored 'not sweet/salty at all' and 'extremely sweet/salty'. Participants were asked to taste each stimulus and rate its sweetness or saltiness intensity. Stimuli were presented one by one with breaks of 60 s between each sample to prevent sensory fatigue.

During Experiments 3 and 4, participants also rated the familiarity of the test foods using a 100-unit VAS with end anchors 'very unfamiliar' and 'very familiar'.

2.4. Data analysis

Initial data analyses (Experiment 1) aimed to compare different methodological approaches for assessing sweet taste liking and preference. Ranking data were analysed using a non-parametric Friedman test which compares the mean ranks of concentration levels (Lawless & Heymann, 2010). Rating data and Structured Napping data were analysed by applying Linear Mixed Model (LMM) analysis, with *concentration* (L-2, L-1, L-0, L + 1, L + 2) as a fixed factor and *participant* as a random factor. Experiments 2, 3, and 4 used the RoS method to gather data on both preference and liking. The data on preference, which were collected in ranks (1–5), were analysed using a non-parametric Friedman test. This test was used to examine the effect of concentration level on preference rankings, followed by the Nemenyi post-hoc test for multiple comparisons. Liking and intensity data, which were collected in ratings (0–100) were analysed using LMMs. LMMs were used to explore the effects of test foods and sweetness and saltiness concentration levels on liking and perceived intensity (Experiments 2, 3 and 4), with *test food* and *concentration* and an interaction between *test food* and *concentration*

Table 4
Test foods used in Experiment 4 with sweetener (sucrose + non-nutritive sweetener) and salt (NaCl) concentration levels % by weight, for each level.

	Test food	Food form	Serving size	Serving temperature	Sweetener concentration (sucrose [a] + non-nutritive sweetener[b]) (% by weight)				
					L-2	L-1	L-0	L + 1	L + 2
Familiar	**Strawberry flavoured lemonade**	Liquid	20 ml	22 °C	0.0 + 0.0	1.3 + 0.0	3.1 + 0.0	8.6 + 0.0	15.1 + 0.0
	Chocolate flavoured custard	Semi-Solid	15 g	5 °C	3.4 + 0.0	6.6 + 0.0	12.4 + 0.0	17.6 + 0.0	26.3 + 0.0
	Plain Cake	Solid	20 g	22 °C	9.1 + 0.0	16.7 + 0.0	18.2 + 0.9	17.6 + 4.2	16.9 + 8.2
Unfamiliar	**Watermelon flavoured lemonade**	Liquid	20 ml	22 °C	0.0 + 0.0	1.3 + 0.0	3.1 + 0.0	8.6 + 0.0	15.1 + 0.0
	Elderflower flavoured custard	Semi-Solid	15 g	5 °C	3.6 + 0.0	7.1 + 0.0	13.2 + 0.0	18.4 + 0.6	21.9 + 5.9
	Tamarind flavoured cake	Solid	20 g	22 °C	9.1 + 0.0	16.6 + 0.0	18.1 + 0.9	17.5 + 4.2	16.8 + 8.1
					Salt concentration (NaCl) (% by weight)				
					L-2	L-1	L-0	L + 1	L + 2
Familiar	**Gazpacho**	Liquid	20 ml	22 °C	0.1	0.2	0.3	0.7	1.5
	Butter cracker	Solid	3.5 g	22 °C	0.0	0.7	1.4	3.5	7.1

[a] Sucrose, Kristal sugar, Van Gilse, the Netherlands.
[b] Liquid sweetener based on cyclamate and saccharin (Rio Zoetstof, Sweet Life AG, Switzerland).

as fixed factors, and *participant* as a random factor. Additionally, in Experiments 3 and 4, the effect of familiarity on liking, perceived intensity and rated familiarity was investigated, using LMM analysis. Effects of familiarity on concentration-intensity (psychophysical) and intensity-liking (psychohedonic) functions were tested with *familiarity* and *concentration, and* an interaction between *concentration* and *familiarity,* as fixed factors, and *participant* as a random factor. For all LMMs, post hoc tests with Bonferroni corrections were used to test for multiple comparisons of means when the main effect was significant. Furthermore, we explored individual consistency of most preferred concentration across test foods, to test if a preferred specific concentration level in one test food was also the same preferred concentration in another test food. To evaluate this consistency, we calculated Spearman correlation coefficients between sweetener concentration levels (expressed in % by weight) and performed cross-classification analyses between most preferred concentration levels. Results were considered statistically significant at p-values < 0.05.

3. Results

3.1. Experiment 1

3.1.1. Liking and preference method comparison: ranking, rating and structured napping

When comparing results from different methods, it was evident that the ranking had the highest discriminative power between concentrations levels (L-2, L-1, L-0, L + 1, L + 2), for most test foods (orange juice ($\chi^2(4) = 13.9$, p =.008); whipped cream ($\chi^2(4) = 10.0$, p =.040); apple sauce ($\chi^2(4) = 20.8$, p <.001); soft white cheese ($\chi^2(4) = 19.8$, p =.001); cake $\chi^2(4) = 8.8$, p =.066). The other two methods, rating and structured napping, had lower discriminative power (Table 5). The mean ranking and rating scores mostly followed an inverted U-shape, as shown in Fig. 1, indicating that most participants liked and preferred the middle level (L-0) over mid (L-1, L + 1) and extreme levels (L-2, L + 2). This trend was not as pronounced for the structured napping method (Fig. 1). In summary, for assessing liking and preference, the findings from Experiment 1 indicated that the ranking method yielded the greatest discrimination between samples. However, this high discriminative power can likely be attributed to the lower between-subject variation, compared to other methods. Furthermore, it was crucial to address the limitation of the ranking method in providing absolute values for hedonic responses. To overcome this constraint, a combination of ranking and rating – RoS approach was implemented in the subsequent experiments. This approach allowed for the inclusion of both relative rankings and absolute ratings, thus ensuring a comprehensive assessment of the hedonic response.

3.1.2. Perceived intensity method comparison: rating, structured napping

As shown in Fig. 2, for both methods, rating and structured napping, the perceived intensity increased in a linear manner, over sweetness concentration levels, respectively. For all test foods this trend was confirmed (all p <.001, Table 9). In summary, for perceived intensity, both methods were found to discriminate between different concentration levels. However, considering the practical aspect, specifically the ease of understanding as reported by our participants, we made the decision to adopt the rating approach for the subsequent experiments.

3.2. Experiment 2

3.2.1. Preference

Differences in preference ranks across concentration levels (L-2, L-1, L-0, L + 1, L + 2) were observed for all test foods, as presented in Table 6. Post-hoc pairwise comparisons were conducted to further explore the nature of the differences between the concentration levels. For all test foods, except orange juice and spinach cake, middle (L-0) concentration level was the most preferred level (Table A1, Appendix 1). Additionally, individual consistencies in most preferred level across test foods were explored. The analysis of individual preferences revealed a lack of consistency among participants, as those who showed a preference for a specific concentration level, such as L-1 in orange juice, were not necessarily inclined to favour the same concentration level, L-1, in soft white cheese. Detailed results illustrating these varying preferences on an individual level can be found in Appendix A, Table A2.

3.2.2. Liking

Mean liking scores differed between concentration levels (F(4,720) = 28.3, p <.001) and between test foods (F(4,720) = 21.9, p <.001). Overall plain cake was the most liked product in the Experiment 2, with a mean of 58.4 (Table 6). Pairwise comparisons revealed differences in liking scores between some of the products, with the largest difference between tomato juice and plain cake (*contrast estimate* = 19.13, p <.001, Table A8**,** Appendix A). L-0 was the most preferred level overall (pulling

Table 5
Mean preference (rank) and mean liking (rating) scores for Experiment 1- for all test foods across five intensity concentration levels (L-2, L-1, L-0, L + 1, L + 2).

Experiment	Method (scale)	Test food	Intensity concentrations levels					p-value[3]
			L-2	L-1	L-0	L + 1	L + 2	
Experiment 1	**Ranking**[1] (1–5)	Orange juice	1.8^{a}	2.5^{ab}	4.3^{b}	3.3^{ab}	3.1^{ab}	0.008
		Whipped cream	1.9^{a}	3.6^{a}	3.8^{a}	3.2^{a}	2.5^{a}	0.040
		Apple sauce	1.4^{a}	2.2^{ab}	3.6^{b}	4.0^{b}	3.8^{b}	<0.001
		Soft white cheese	3.0^{ab}	3.8^{a}	4.3^{a}	2.4^{ab}	1.5^{b}	0.001
		Plain cake	2.5	2.6	3.9	3.7	2.3	0.066
	Rating[2] (1–9)	Orange juice	4.8 ± 1.2	4.9 ± 2.4	5.8 ± 2.1	6.4 ± 1.2	5.8 ± 2.1	0.146
		Whipped cream	4.9 ± 2.1	5.4 ± 2.3	6.3 ± 1.8	5.0 ± 2.6	4.0 ± 2.7	0.151
		Apple sauce	3.1 ± 1.9^{a}	4.2 ± 1.3^{ab}	5.9 ± 1.7^{b}	5.5 ± 2.6^{b}	4.6 ± 2.9^{ab}	0.011
		Soft white cheese	3.9 ± 1.8	4.7 ± 2.0	5.8 ± 1.9	4.6 ± 3.0	3.8 ± 2.8	0.137
		Plain cake	4.3 ± 1.9^{a}	5.3 ± 1.2^{ab}	6.7 ± 1.1^{b}	6.5 ± 1.8^{b}	5.3 ± 2.5^{ab}	0.008
	Structured napping[2] (0–100)	Orange juice	56 ± 26^{a}	66 ± 17^{a}	66 ± 16^{a}	68 ± 20^{a}	50 ± 21^{a}	0.036
		Whipped cream	34 ± 18^{a}	52 ± 26^{a}	39 ± 29^{a}	33 ± 26^{a}	22 ± 18^{a}	0.050
		Apple sauce	42 ± 27	54 ± 18	64 ± 18	54 ± 24	40 ± 18	0.082
		Soft white cheese	44 ± 25^{ab}	54 ± 24^{a}	54 ± 3.5^{a}	38 ± 25^{ab}	24 ± 21^{b}	0.039
		Plain cake	45 ± 24^{ab}	60 ± 21^{ab}	65 ± 20^{a}	51 ± 24^{ab}	40 ± 27^{b}	0.008

[a, b, c, d, e] for each row, different letters indicate statistically significant differences at p < 0.05 (For rating (liking) Bonferroni post hoc correction applied; For ranking (preference) Nemenyi post-hoc correction applied).
[1] Data analysed using non-parametric Friedman test and shown as the mean ranks.
[2] Data analysed using Linear Mixed Models and shown as mean ± SD.
[3] p-values present differences between concentration levels of the same test food.

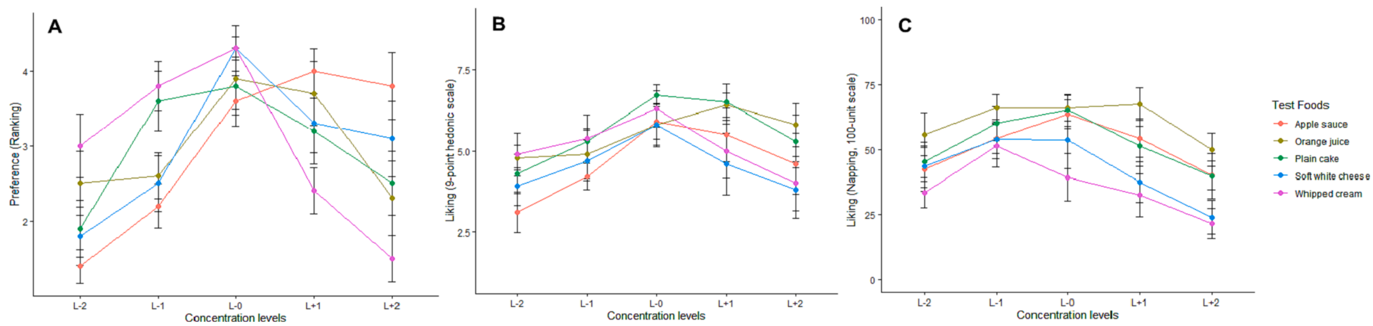

Fig. 1. For each method – ranking (A), rating (9-point hedonic scale) (B) and structured napping (100-unit Scale) (C) - the mean rated preference with SE bars, across five sweetness intensity levels (L-2, L-1, L-0, L + 1, L + 2) as a function of sweetness concentration in Apple sauce, Orange juice, Plain cake, Soft white cheese and Whipped cream (Experiment 1). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

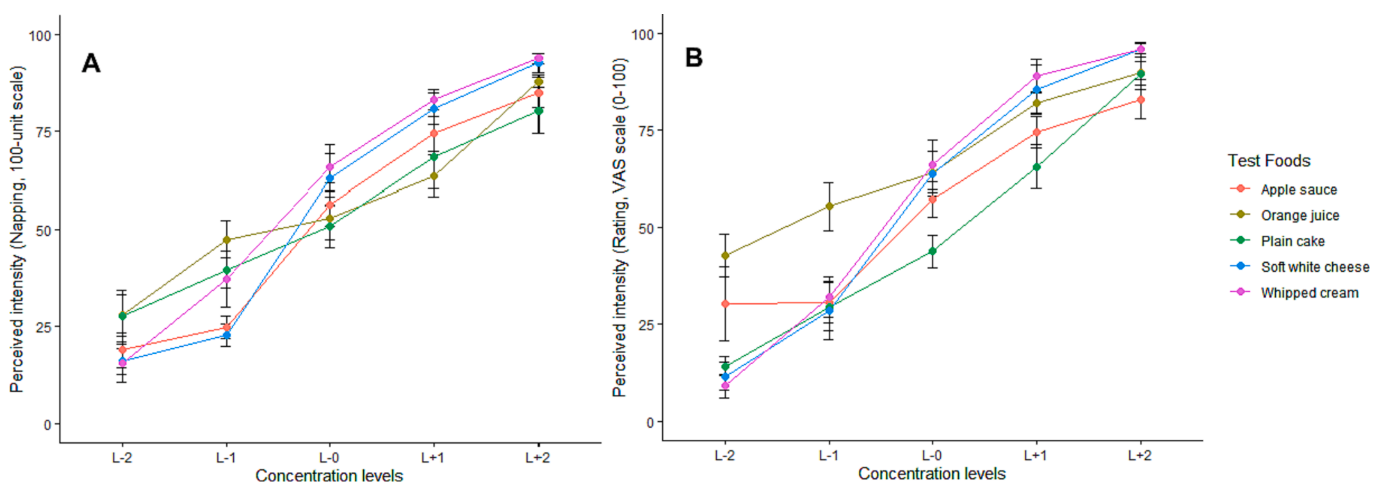

Fig. 2. For rating (A) and structured napping (B) method - the mean perceived intensity across five sweetness intensity levels (L-2, L-1, L-0, L + 1, L + 2) as a function of sweetness concentration in Apple sauce, Orange juice, Plain cake, Soft white cheese and Whipped cream (Experiment 1). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Table 6

Mean liking and preference scores for all test foods across five intensity concentration levels (L-2, L-1, L-0, L + 1, L + 2), Experiment 2 (n = 31).

Experiment	Method (domain, scale)	Test food	Liking score overall	Intensity concentrations levels					p-value[3]
				L-2	L-1	L-0	L + 1	L + 2	
Experiment 2	**Ranking on a scale**[1] (Liking, 0–100)	Orange juice	56 ± 20	49 ± 18^{a}	50 ± 21^{a}	66 ± 15^{b}	65 ± 15^{b}	51 ± 23^{a}	<0.001
		Soft white cheese	50 ± 23.	41 ± 22^{a}	49 ± 21^{ab}	64 ± 20^{b}	55 ± 22^{ab}	42 ± 28^{a}	<0.001
		Plain Cake	58 ± 23	39 ± 20^{a}	64 ± 20^{bc}	71 ± 18^{b}	63 ± 22^{bc}	55 ± 24^{c}	<0.001
		Tomato juice	39 ± 27	24 ± 21^{a}	45 ± 25^{b}	52 ± 30^{b}	41 ± 26^{bc}	35 ± 27^{ac}	<0.001
		Spinach cake	46 ± 24	45 ± 17^{a}	61 ± 22^{b}	52 ± 22^{abc}	42 ± 22^{ac}	27 ± 23^{d}	<0.001
			p <.001[4]						
	Ranking on a scale[2] (Preference, 1–5)	Orange juice		2.4^{a}	2.5^{a}	3.7^{b}	3.7^{b}	2.6^{a}	<0.001
		Soft white cheese		2.2^{a}	3.0^{ab}	3.8^{b}	3.4^{ab}	2.4^{a}	<0.001
		Plain Cake		1.5^{a}	3.1^{bc}	4.1^{b}	3.5^{bc}	2.8^{c}	<0.001
		Tomato juice		2.1^{a}	3.4^{b}	3.5^{b}	3.4^{b}	2.7^{a}	0.001
		Spinach cake		2.9^{a}	3.9^{a}	3.6^{a}	2.9^{a}	1.7^{b}	<0.001

a, b, c, d, e for each row, different letters indicate statistically significant differences at $p < 0.05$ (For rating (liking) Bonferroni post hoc correction applied; For ranking (preference) Nemenyi post-hoc correction applied).

1 Liking data (0–100) analysed using Linear Mixed Models shown as mean ± SD.

2 Preference data (1–5) analysed using non-parametric Friedman test, and shown as the mean ranks.

3 p-values present differences between concentration levels of the same test food.

4 p-values present differences between test foods overall.

data across all test foods) (M = 55.5, CI [54.7, 66.1]), followed by level L-1 (M = 53.6, CI [47.9, 59.2]), L + 1 (M = 53.4, CI [47.7, 59.1]), L-2 (M = 39.8, CI [34.1, 45.5]), and level L + 2 (M = 42.4, CI [36.7, 48.1]). More importantly, an interaction effect between concentration levels and test foods was observed ($F(16,720) = 3.4$, $p < .001$), indicating that liking scores differed across concentrations levels and test foods. For all foods tested in Experiment 2 (Table 6), except for spinach cake (preferred level L-1), the middle level (L-0) was preferred – indicating typical psychohedonic inverted U-shaped hedonic responses (Fig. 3A).

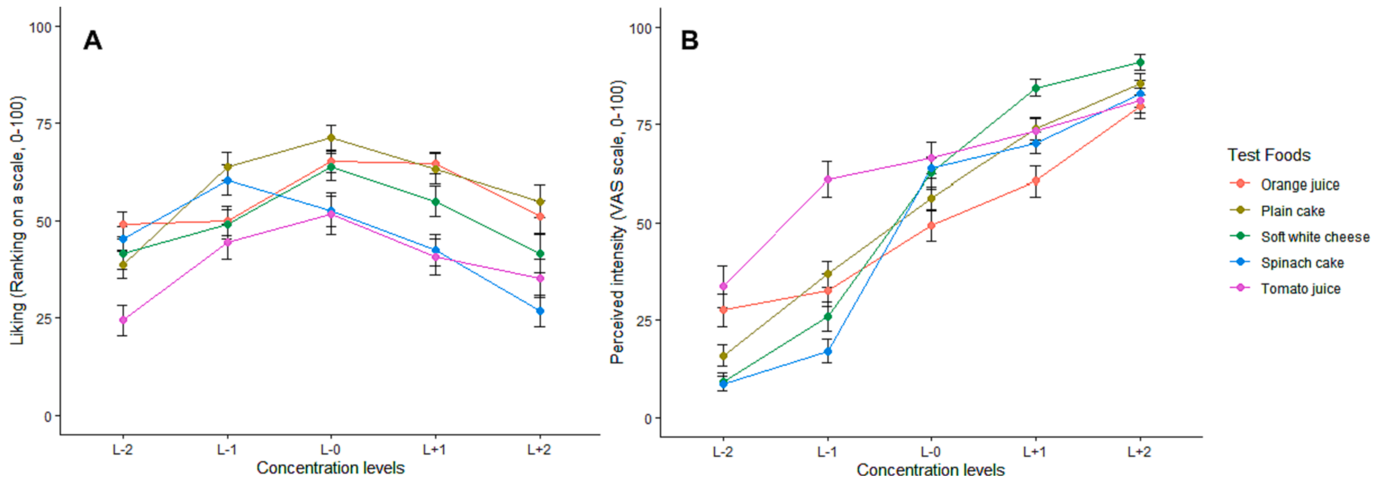

Fig. 3. Mean rated preference (A) and mean perceived intensity (B) with SE bars, across five sweetener/salt concentration levels (L-2, L-1, L-0, L + 1, L + 2) as a function of sweetener concentration in Orange juice, Plain cake, Soft white cheese, and across five salt concentration levels (L-2, L-1, L-0, L + 1, L + 2) in Spinach cake and Tomato juice (Experiment 2). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

3.2.3. *Perceived intensity*

Perceived intensity was affected by level of concentration ($F(4,722) = 358.1$, $p < .001$) and the type of test food ($F(4,722) = 16.2$, $p < .001$). Perceived sweetness and saltiness intensity increased in a linear manner over sweetness/saltiness concentration levels for all foods (Fig. 3B). However, an interaction effect was observed meaning that concentration-intensity functions were not parallel across the foods (concentration × product, $F(16,722) = 9.3$, $p < .001$) (Table 9).

In summary, the results of the Experiment 2 showed that RoS data analysed as ranks for preference (1–5) or ratings for liking (0–100) yielded similar results and demonstrate that RoS method was able to discriminate between different concentration levels for all test foods, sweet and salty. Similarly, the VAS method was also found to be sensitive for capturing perceived intensity between differing concentration levels. As a result, both the RoS and VAS methods were employed in the subsequent experiments.

3.3. *Experiment 3*

Overall, familiar test foods were perceived as more familiar than the

Table 7
Mean liking and preference scores for all test foods across five intensity concentration levels (L-2, L-1, L-0, L + 1, L + 2), Experiment 3 (n = 28).

Experiment	Method (domain, scale)	Test food	Liking score overall	Intensity concentrations levels					p-value[3]
				L-2	L-1	L-0	L + 1	L + 2	
Experiment 3	**Ranking on a scale**[1] (Liking, 0–100)	Orange juice	64 ± 19	60 ± 16	59 ± 16	66 ± 15	65 ± 23	69 ± 20	0.170
		Soft white cheese	63 ± 19	58 ± 20	62 ± 20	72 ± 16	63 ± 20	63 ± 20	0.115
		Plain Cake	65 ± 19	46 ± 15^{a}	64 ± 15^{b}	72 ± 15^{b}	75 ± 15^{b}	66 ± 19^{b}	<0.001
		Buco Pandan flavoured drink	37 ± 24	23 ± 20^{a}	26 ± 20^{ab}	42 ± 24^{bc}	48 ± 24^{c}	47 ± 22^{c}	<0.001
		Grenadine flavoured soft white cheese	34 ± 20	26 ± 20^{a}	28 ± 18^{ab}	39 ± 21^{ab}	41 ± 17^{b}	38 ± 20^{ab}	0.006
		Tamarind flavoured cake	60 ± 18	52 ± 20^{a}	61 ± 17^{abc}	68 ± 14^{b}	66 ± 13^{bc}	54 ± 19^{ac}	0.002
		Tomato juice	44 ± 24	42 ± 19	53 ± 23	47 ± 25	43 ± 25	37 ± 26	0.162
		Spinach cake	41 ± 23	44 ± 21	44 ± 21	45 ± 24	39 ± 23	31 ± 23	0.790
		Ube flavoured pumpkin juice	16 ± 16	19 ± 13	20 ± 16	14 ± 13	15 ± 17	11 ± 17	0.142
		Ube flavoured spinach cake	41 ± 21	45 ± 16^{ab}	47 ± 18^{a}	45 ± 18^{ab}	37 ± 23^{a}	32 ± 24^{b}	<0.001
			p <.001[4]						
	Ranking on a scale[2] (Preference, 1–5)	Orange juice		2.3^{a}	2.4^{ab}	3.3^{ab}	3.2^{ab}	$3^{.6b}$	0.006
		Soft white cheese		2.3^{a}	2.9^{ab}	3.7^{b}	3.0^{ab}	2.9^{ab}	0.021
		Plain Cake		1.4^{a}	2.8^{b}	3.8^{b}	4.0^{b}	2.9^{b}	<0.001
		Buco Pandan flavoured drink		2.4^{a}	2.5^{a}	3.0^{ab}	3.5^{ab}	3.7^{b}	0.004
		Grenadine flavoured soft white cheese		2.5^{ab}	2.1^{a}	3.5^{b}	3.5^{ab}	3.2^{ab}	0.001
		Tamarind flavoured cake		2.1^{a}	3.4^{bc}	3.7^{b}	3.4^{bc}	2.3^{ac}	<0.001
		Tomato juice		3.1	3.5	3.0	2.6	2.6	0.190
		Spinach cake		3.4^{a}	3.3^{a}	3.5^{a}	2.7^{ab}	2.1^{b}	0.003
		Ube flavoured pumpkin juice		3.0	3.5	2.8	2.9	2.7	0.353
		Ube flavoured spinach cake		3.1	3.3	3.4	2.7	2.4	0.098

[a, b, c, d, e] for each row, different letters indicate statistically significant differences at $p < 0.05$ (For rating (liking) Bonferroni post hoc correction applied; For ranking (preference) Nemenyi post-hoc correction applied).
[1] Liking data (0–100) analysed using Linear Mixed Models shown as mean ± SD.
[2] Preference data (1–5) analysed using non-parametric Friedman test, and shown as the mean ranks.
[3] p-values present differences between concentration levels of the same test food.
[4] p-values present differences between test foods overall.

unfamiliar test foods ($M_{familiar}$ = 72.5, CI [67.0, 77.9]; $M_{unfamiliar}$ = 37.5, CI[32.1, 43.0]; F(1,251) = 115.2, p <.001) (Figure B1, Appendix B).

3.3.1. Preference

Differences in preference ranks were observed across the concentration levels (L-2, L-1, L-0, L + 1, L + 2) for the majority of test foods (Table 7. Notably, differences were found for orange juice (χ2(4) = 14.2, p =.006), soft white cheese (χ2(4) = 11.5, p =.021), plain cake (χ2(4) = 47.9, p <.001), buco pandan flavored drink (χ2(4) = 14.9, p =.004), grenadine flavored soft white cheese (χ2(4) = 18.3, p =.001), tamarind flavored cake (χ2(4) = 22.6, p <.001), spinach cake (χ2(4) = 15.7, p =.003) but not for tomato juice (χ2(4) = 6.1, p =.190), ube flavored pumpkin juice (χ2(4) = 4.4, p =.353), and ube flavored spinach cake (χ2 (4) = 7.8, p =.098)). The optimal concentration level, which elicited the highest preference, differed among the test foods, with no systematic pattern observed across the tested foods (Table A2, Appendix A). There was also a lack of consistency in most preferred concentration level across the various test foods, except for tomato juice and spinach cake where individuals who preferred lower salt levels in tomato juice, were also more likely to prefer lower salt levels in spinach cake (Table A4, Appendix A).

3.3.2. Liking

Liking scores differed across concentration levels (F(4,1322) = 11.3, p <.001), between test foods (F(8,1324) = 79.6, p <.001) and between familiar and unfamiliar foods (F(1,1322) = 14.8, p <.001). In general, familiar foods were liked more compared to the unfamiliar ones, across all concentration levels ($M_{familiar}$ = 55.5, CI [52.9, 58.1]); $M_{unfamiliar}$ = 37.7, CI [35.1, 40.3]). The most liked product was plain cake with a mean liking score of 65.1 (CI [59.6, 70.6]), followed by orange juice with a mean score of 64.1 (CI [58.5, 69.6]) and soft white cheese with a mean score of 63.4 (CI [57.9, 69.0]). On the other hand, the least liked product was ube flavoured pumpkin juice with an mean score of 15.7 (CI [10.1, 21.2]) (overall liking scores showed in Table 7, pairwise comparisons showed in Table A8, Appendix A). L-0 was the most preferred level overall across all products (M = 51.1, CI [46.9, 55.3]), followed by level L + 1 (M = 49.3, CI [45.0, 53.5]), L-1 (M = 46.3, CI [42.1, 50.5]), L + 2 (M = 44.7, CI [40.5, 49.0]), and level L-2 (M = 41.5, CI [37.3, 45.8]). Additionally, there was a significant interaction effect between concentration level and test food (F(32,1322) = 3.5, p <.001), indicating that the same concentration levels were liked differently between test foods. No effect of familiarity on the shape of the psychohedonic function was observed (*concentration* × *familiarity*, F(4,1363) = 0.3, p =.851). These findings demonstrate that familiarity affected liking scores, but not the shape of the psychohedonic function (Fig. 5A).

Typical inverted U-shaped hedonic parabolic curves were observed for some test foods (e.g., tamarind flavoured cake), but not for others (see Fig. 4). This was further supported by the analysis which showed that liking scores did not differ between concentration levels for orange juice (F(4,135) = 1.6, p =.170); soft white cheese (F(4,135) = 1.9, p =.115); tomato juice (F(4,135) = 1.7, p =.162); spinach cake (F(4,135) = 2.0, p =.790); and for ube flavoured pumpkin juice (F(4,135) = 1.7, p =.142). For other test foods, liking scores differed across concentration level (see Table 7).

3.3.3. Perceived intensity

Perceived intensity differed between concentration levels (F (4,1322) = 453, p <.001), between test foods (F(8,1323) = 11.3, p <.001) and between familiar and unfamiliar foods (F(1,1322) = 22.9, p <.001). In general, familiar foods were rated as being more intense across all concentration levels compared to the unfamiliar foods ($M_{familiar}$ = 56.3, CI [53.9, 58.7]; $M_{unfamiliar}$ = 37.7, CI [49.2, 54.0]). Furthermore, there was a significant interaction between concentration level and test food (F(36,1322) = 5.7, p <.001), but not between concentration level and familiarity, meaning that there was no effect of familiarity on the shape of the psychophysical function (*concentration* × *familiarity*, F(4,1363) = 0.9, p =.462). Thus, familiarity affected intensity perception, but not the shape of psychophysical functions (Fig. 5B).

When looking at the test foods individually, it was observed that the concentration level impacted the perceived intensity for all foods (see Table 9). Perceived intensity increased linearly across concentration levels for most foods, but not for all (Fig. 6). For example, extreme level (L + 2) of tamarind flavoured cake was perceived less intense comped to mid-range level (L + 1), however the difference between the two samples was not statistically significant ($M_{difference}$ = 12.8, p = .383).

In summary, VAS method showed sensitivity in detecting intensity level differences for sweet, salty, familiar, and unfamiliar foods. Additionally, analysing the data from the RoS method as ranks demonstrated slightly greater discrimination between samples compared to when it was analysed as ratings. This enhanced discriminative power can likely be attributed to lower between-subject variations observed with the ranking approach. However, both methods of analysing data were able to detect differences in hedonic responses across different concentration levels for both familiar and unfamiliar foods. The large number of test foods utilized in this experiment, however, may also have impacted discriminative power. Therefore, for the subsequent experiment, we decided to maintain the same methodology but reduce the number of test foods.

3.4. Experiment 4

As in *Experiment 3*, familiar test foods were also perceived as more familiar compared to the unfamiliar test foods ($M_{familiar}$ = 77.5, CI [71.8,

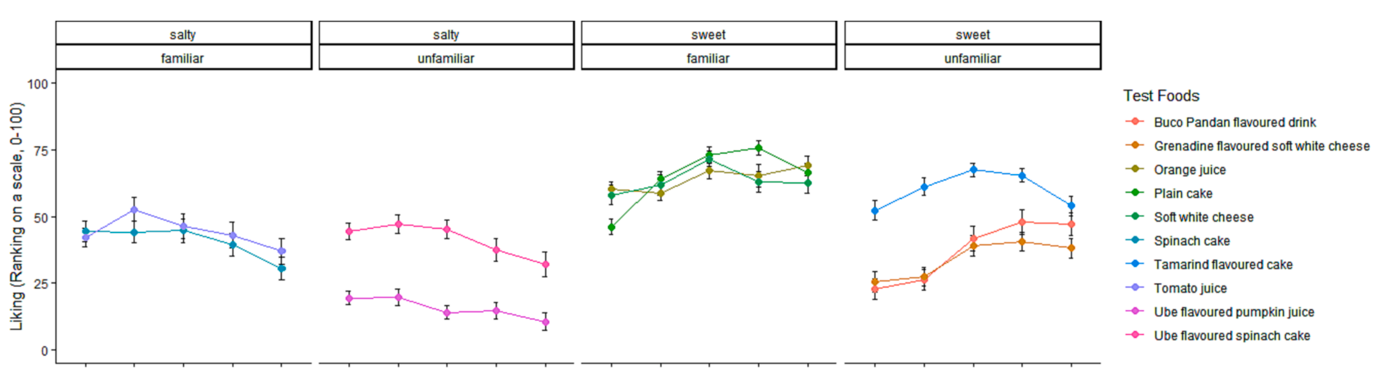

Fig. 4. Mean rated preference with SE bars, split by taste and familiarity, across five sweetener and salt concentration levels (L-2, L-1, L-0, L + 1, L + 2) in Buco Pandan flavoured drink, Grenadine flavoured soft white cheese, Orange juice, Plain cake, Soft white cheese, Tamarind flavoured cake, Tomato juice, Ube flavoured juice and Ube flavoured spinach cake (Experiment 3). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

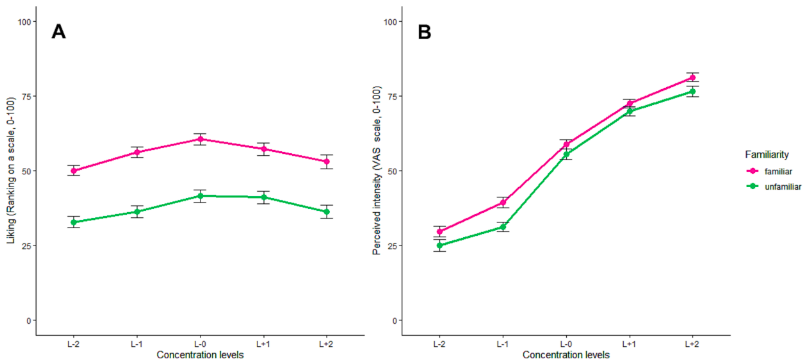

Fig. 5. (A) Effect of familiarity on psychohedonic (concentration-pleasantness) function, and psychophysical (concentration-intensity) function in familiar and unfamiliar foods (Experiment Fig. 6). Mean rated perceived intensity with SE bars, split by familiarity and taste, across five sweetener/salt concentration levels (L-2, L-1, L-0, L + 1, L + 2) in Buco Pandan flavoured drink, Grenadine flavoured soft white cheese, Orange juice, Plain cake, Soft white cheese, Tamarind flavoured cake, Tomato juice, Ube flavoured juice and Ube flavoured spinach cake (Experiment 3). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

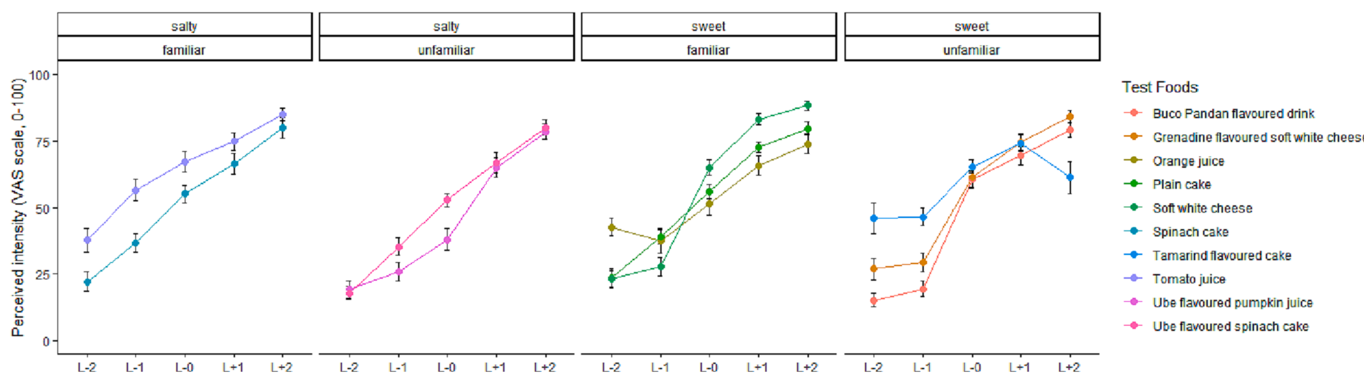

Fig. 6. Mean rated perceived intensity with SE bars, split by familiarity and taste, across five sweetener/salt concentration levels (L-2, L-1, L-0, L + 1, L + 2) in Buco Pandan flavoured drink, Grenadine flavoured soft white cheese, Orange juice, Plain cake, Soft white cheese, Tamarind flavoured cake, Tomato juice, Ube flavoured juice and Ube flavoured spinach cake (Experiment 3). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Table 8
Mean liking and preference scores for all test foods across five intensity concentration levels (L-2, L-1, L-0, L + 1, L + 2), Experiment 4 (n = 28).

Experiment	Method (domain, scale)	Test food	Liking score overall	Intensity concentrations levels					p-value[3]
				L-2	L-1	L-0	L + 1	L + 2	
Experiment 4	**Ranking on a scale**[1] (Liking, 0–100)	Strawberry flavoured lemonade	52 ± 20	53 ± 15^{ab}	54 ± 19^{a}	59 ± 15^{a}	49 ± 22^{ab}	42 ± 23^{b}	0.001
		Chocolate flavoured custard	55 ± 23	35 ± 22^{a}	49 ± 22^{ab}	57 ± 17^{b}	73 ± 16^{c}	62 ± 21^{bc}	<0.001
		Plain Cake	61 ± 22	48 ± 23^{a}	66 ± 15^{bc}	69 ± 18^{c}	69 ± 18^{c}	54 ± 26^{ab}	<0.001
		Watermelon flavoured lemonade	45 ± 21	30 ± 20^{a}	44 ± 18^{b}	56 ± 17^{c}	50 ± 20^{bc}	42 ± 21^{b}	<0.001
		Elderflower flavoured custard	41 ± 26	34 ± 22^{a}	40 ± 23^{ab}	53 ± 24^{c}	46 ± 25^{cb}	32 ± 30^{a}	<0.001
		Tamarind flavoured cake	56 ± 23	42 ± 21^{a}	54 ± 23^{b}	64 ± 21^{b}	63 ± 21^{b}	59 ± 23^{b}	<0.001
		Gazpacho	53 ± 22	50 ± 22^{ab}	53 ± 20^{ab}	54 ± 20^{ab}	60 ± 22^{a}	45 ± 25^{b}	0.024
		Butter cracker	53 ± 24 p <.001[4]	57 ± 17^{a}	57 ± 22^{a}	61 ± 18^{a}	51 ± 27^{a}	36 ± 28^{b}	<0.001
	Ranking on a scale[2] (Preference, 1–5)	Strawberry flavoured lemonade		2.7^{ab}	3.2^{ab}	3.7^{a}	3.0^{ab}	2.3^{b}	0.014
		Chocolate flavoured custard		1.6^{a}	2.5^{ab}	2.9^{b}	4.3^{c}	3.5^{bc}	<0.001
		Plain Cake		1.8^{a}	3.3^{b}	3.6^{b}	3.6^{b}	2.5^{ab}	<0.001
		Watermelon flavoured lemonade		1.9^{a}	2.9^{a}	4.0^{b}	3.5^{ab}	2.6^{a}	<0.001
		Elderflower flavoured custard		2.2^{a}	2.8^{a}	4.1^{b}	3.4^{ab}	2.6^{a}	<0.001
		Tamarind flavoured cake		1.8^{a}	2.8^{ab}	3.6^{b}	3.5^{b}	3.1^{b}	<0.001
		Gazpacho		2.8^{ab}	3.1^{ab}	2.9^{ab}	3.6^{a}	2.4^{b}	0.054
		Butter cracker		3.0^{ab}	3.1^{ab}	3.7^{b}	3.0^{ab}	2.1^{a}	0.004

[a, b, c, d, e] for each row, different letters indicate statistically significant differences at $p < 0.05$ (For rating (liking) Bonferroni post hoc correction applied; For ranking (preference) Nemenyi post-hoc correction applied).
[1] Liking data (0–100) analysed using Linear Mixed Models shown as mean ± SD.
[2] Preference data (1–5) analysed using non-parametric Friedman test, and shown as the mean ranks.
[3] p-values present differences between concentration levels of the same test food.
[4] p-values present differences between test foods overall.

83.2]; $M_{unfamiliar} = 46.4$, CI [40.7, 52.0]; $F(1,139) = 66.5$, $p < .001$) (Figure B2, Appendix B). In addition, we examined whether Dutch-speaking participants perceived familiar foods differently and found that both Dutch-speaking (n = 13) and non-Dutch-speaking (n = 15) participants rated familiar foods as more familiar than non-familiar ones (Dutch-speaking participants: $F(1,64) = 44.9$, $p < .001$, $M_{familiar} = 76.2$, CI [68.1, 84.2]; $M_{unfamiliar} = 40.8$, CI[32.7, 48.8]; non-Dutch-speaking participants: ($F(1,74) = 25.3$, $p < .001$, $M_{familiar} = 78.7$, CI [70.6, 86.6]; $M_{unfamiliar} = 51.2$, CI[43.2, 59.2]).

3.4.1. Preference

Preferences were different between concentration levels for all test foods, except for gazpacho ($\chi2(4) = 9.3$, $p = .054$), as shown in Table 8. Moreover, for majority of the test foods middle level, L-0 was the most preferred. Although for strawberry flavoured lemonade, L-1 was the most preferred level, and for chocolate flavoured custard and gazpacho, L + 1 was the preferred concentration (Table A5, Appendix A). Individual preferences demonstrated inconsistency, as participants who favoured a specific concentration level in one test food, did not necessarily hold the same preference for that concentration level in another (Table A6, Appendix A). However, significant correlations were observed between the most preferred sweetener concentration level for strawberry-flavoured lemonade and watermelon-flavoured lemonade ($r = 0.42$, $p < .05$), as well as between watermelon-flavoured lemonade and tamarind-flavoured cake ($r = 0.42$, $p < .05$).

3.4.2. Liking

Liking scores differed between concentration levels ($F(4,1053) = 25.8$, $p < .001$) and test foods ($F(7,1053) = 19.9$, $p < .001$). Overall, plain cake was the most liked product (M = 61.1, CI [54.8, 67.4]), followed by tamarind flavoured cake (M = 56.4, CI [50.1, 62.8]) and chocolate flavoured custard (M = 55.1, CI [48.8, 61.4]) (Table 8). On the other hand, the least liked product was elderflower flavoured custard with an mean score of 41.0 (CI [34.7, 47.3]). Pairwise comparisons showed that some of products differed in overall liking scores and some did not (Table A6, Appendix A). The most preferred concentration level overall (data pulled across all products) was L-0 (M = 59.2, CI [53.8, 64.5]), followed by level L + 1 (M = 57.6, CI [52.2, 62.9]), L-1 (M = 52.2, CI [46.8, 57.6]), L + 2 (M = 46.6, CI [41.2, 52.0]), and level L-2 (M = 43.8, CI [38.4, 49.2]).

Looking at the test foods, for most, liking scores followed an inverted U-shape with the middle (L-0) level being preferred over other concentration levels (Table 8). Thus, typical psychohedonic functions were observed as shown in Fig. 7. Familiarity also had an effect on liking ($F(1,803) = 38.1$, $p < .001$): in general, familiar foods were liked more compared to the unfamiliar test foods ($M_{familiar} = 65.0$, CI [52.0, 59.9]; $M_{unfamiliar} = 47.3$, CI [43.4, 51.3]). However, there was no effect of familiarity on the shape of the psychohedonic function (*concentration* × *familiarity*, $F(4,803) = 0.9$, $p = .85$). This indicates that familiarity affected liking scores, but not the shape of psychohedonic function (Fig. 8A).

3.4.3. Perceived intensity

Perceived intensity differed between concentration levels ($F(4,1053) = 533.6$, $p < .001$) and test foods ($F(7,1053) = 25.6$, $p < .001$). Additionally there was a significant interaction between concentration level and test food ($F(28, 1053) = 4.3$, $p < .001$). For all foods, perceived intensity increased in a linear manner over increasing concentration levels (Fig. 9 and Table 9). Familiarity also had an effect on perceived intensity, with unfamiliar foods on average being perceived as sweeter than familiar ones across all sweetener levels ($F(1,803) = 17.1$, $p < 0.001$). However, there were no effects of familiarity on the shape of the psychophysical functions (*concentration* × *familiarity*, $F(4,803) = 0.9$, $p = .85$). Thus, familiarity affected intensity perception, but not the shape of psychophysical functions (Fig. 8B).

In summary, results from Experiment 4 demonstrated that RoS and VAS method are practical, and are able to discriminate between different concentration levels for familiar sweet and salty, and unfamiliar sweet foods, in both hedonic and perception responses.

4. Discussion

The goal of the current work was to develop a comprehensive and sensitive approach for measuring sweet taste liking, preference and intensity perception. Such a methodology should allow the detection of changes in these perceptions over time in foods and diets that vary in their matrices, familiarity, and concentration levels. We demonstrated that RoS (ranking on a scale) is a discriminative and practical method for assessing sweet taste liking and preference in both familiar and unfamiliar foods. Additionally, we found a clear effect of familiarity on liking across experiments, along with typical psychohedonic (concentration-liking) and psychophysical (concentration-intensity) functions in both familiar and unfamiliar foods.

In the first experiment, three methods for liking and preference and two methods for perceived intensity were tested. For liking and preference, the experiment demonstrated that the ranking method had the highest discriminative power, as it allowed the participants to discriminate between different concentration levels according to their preferences. However, despite having a higher discriminative power compared to 9-point rating and structured napping, ranking gave no indication of inter-sample spacing nor the absolute liking scores. This is generally recognised as a limitation of ranking which arises from the fact that there is no predefined scale combined with ranking. To overcome this limitation, ranking can be coupled with rating, as described and tested in multiple studies (Cleaver & Wedel, 2001; Endrizzi et al., 2009; Kemp et al., 2018; Kim & O'Mahony, 1998; Kozak & Cliff, 2013; Sung & Wu, 2018; Wichchukit & O'Mahony, 2015). Therefore, in subsequent experiments, we combined ranking with rating as RoS (Ranking on a Scale) and evaluated ability to discriminative across different concentration levels in different test foods. For perceived intensity in Experiment 1, both rating and structured napping methods demonstrated discriminability for detecting differences in sweetness levels, but because structured napping is uncommon and some people find it confusing (according to our participants), we decided to adopt the rating approach in the subsequent tests.

The RoS method, incorporating both ratings for liking and rankings for preference, enabled the evaluation of data using liking scores (ranging from 0 to 100) and ranks (ranging from 1 to 5) in a comprehensive manner. The study consistently found comparable results between the two approaches. Specifically, when individuals expressed different preferences for different concentration levels (L-1, L-2, L-0, L + 1, L + 2) for various test foods, corresponding variations were observed in the liking scores across these concentration levels. In Experiment 3, ranking was found to be slightly more discriminative in detecting hedonic differences between concentration levels, which may be expected considering that liking scores (0–100) can have greater between-subject variation compared to preference scores (1–5) (Kim & O'Mahony, 1998). On the other hand, liking scores offer greater opportunities for comparing overall liking scores across different products and assessing the impact of familiarity on hedonic responses, thus clear value can be seen for considering both ranking and rating responses alongside one another.

Results of Experiments 2, 3 and 4 showed that RoS and 100-unit rating scale are viable methods for assessing sweet taste liking and preference, and perceived intensity respectively, in both familiar and unfamiliar foods. Across experiments, typical psychohedonic and psychophysical functions were observed for most test foods. We were able to replicate well-known U-shaped curve trends in liking and positive linear trends in perceived intensity (de Graaf et al., 1996; Urbano et al., 2016; Wise et al., 2016). However, for some test foods, no effect of concentration on liking and preference was observed (Experiment 3). For example, ube-flavoured pumpkin juice was equally disliked across

Table 9
Mean (±SD) perceived intensity scores for each Experiment – Experiment 1, 2 3 and 4 - for all test foods across five intensity concentration levels (L-2, L-1, L-0, L + 1, L + 2).

Experiment	Method (scale)	Test food	Intensity concentrations levels					p-value for effect level[2]	p-value for linear trend
			L-2	L-1	L-0	L + 1	L + 2		
Experiment 1	**Rating, VAS scale**[1] (0–100)	Orange juice	43 ± 17^{a}	55 ± 20^{a}	64 ± 17^{b}	82 ± 9^{b}	90 ± 13^{b}	<0.001	<0.001
		Whipped cream	9 ± 10^{a}	32 ± 17^{b}	66 ± 20^{c}	89 ± 13^{d}	96 ± 6^{d}	<0.001	<0.001
		Apple sauce	30 ± 30^{a}	31 ± 17^{a}	57 ± 15^{b}	75 ± 13^{bc}	83 ± 16^{c}	<0.001	<0.001
		Soft white cheese	12 ± 12^{a}	29 ± 24^{b}	64 ± 18^{c}	86 ± 20^{cd}	96 ± 4^{d}	<0.001	<0.001
		Plain Cake	14 ± 8^{a}	30 ± 20^{b}	44 ± 13^{c}	66 ± 18^{d}	90 ± 10^{e}	<0.001	<0.001
	Structured napping[1] (0–100)	Orange juice	28 ± 17^{a}	48 ± 15^{b}	53 ± 18^{bc}	64 ± 17^{c}	88 ± 6^{d}	<0.001	<0.001
		Whipped cream	16 ± 16^{a}	37 ± 23^{b}	66 ± 19^{c}	83 ± 8^{d}	94 ± 4^{d}	<0.001	<0.001
		Apple sauce	19 ± 14^{a}	25 ± 9^{b}	56 ± 18^{c}	75 ± 14^{d}	85 ± 12^{d}	<0.001	<0.001
		Soft white cheese	16 ± 10^{a}	23 ± 9^{a}	63 ± 20^{b}	81 ± 13^{c}	93 ± 8^{d}	<0.001	<0.001
		Plain Cake	28 ± 21^{a}	40 ± 15^{a}	51 ± 17^{ab}	69 ± 26^{bc}	80 ± 19^{c}	<0.001	<0.001
Experiment 2	**Rating, VAS scale**[1] (0–100)	Orange juice	28 ± 23^{a}	33 ± 23^{a}	49 ± 23^{b}	61 ± 22^{b}	74 ± 17^{c}	<0.001	<0.001
		Soft white cheese	9 ± 13^{a}	26 ± 20^{b}	63 ± 23^{c}	85 ± 13^{d}	91 ± 12^{d}	<0.001	<0.001
		Plain Cake	16 ± 16^{a}	37 ± 19^{b}	56 ± 16^{c}	74 ± 16^{d}	86 ± 15^{e}	<0.001	<0.001
		Tomato juice	34 ± 30^{a}	61 ± 25^{b}	66 ± 23^{bc}	74 ± 18^{bc}	81 ± 18^{c}	<0.001	<0.001
		Spinach cake	9 ± 10^{a}	17 ± 17^{a}	64 ± 15^{b}	70 ± 15^{b}	83 ± 19^{c}	<0.001	<0.001
Experiment 3	**Rating, VAS scale**[1] (0–100)	Orange juice	43 ± 18^{a}	38 ± 24^{a}	51 ± 21^{ab}	66 ± 20^{bc}	74 ± 19^{c}	<0.001	<0.001
		Soft white cheese	23 ± 16^{a}	28 ± 17^{a}	65 ± 15^{b}	83 ± 12^{c}	88 ± 9^{c}	<0.001	<0.001
		Plain cake	23 ± 19^{a}	39 ± 15^{b}	56 ± 14^{c}	72 ± 11^{d}	79 ± 14^{d}	<0.001	<0.001
		Buco Pandan flavoured drink	15 ± 14^{a}	20 ± 15^{a}	61 ± 18^{b}	70 ± 18^{bc}	79 ± 15^{c}	<0.001	<0.001
		Grenadine flavoured soft white cheese	27 ± 22^{a}	29 ± 19^{a}	61 ± 21^{b}	74 ± 18^{bc}	84 ± 12^{c}	<0.001	<0.001
		Tamarind flavoured cake	46 ± 30^{a}	47 ± 18^{a}	65 ± 13^{b}	74 ± 16^{b}	61 ± 32^{ab}	<0.001	<0.001
		Tomato juice	38 ± 24^{a}	57 ± 21.4^{b}	67 ± 21^{bc}	75 ± 18^{cd}	85 ± 12^{d}	<0.001	<0.001
		Spinach cake	23 ± 20^{a}	37 ± 19^{a}	55 ± 18^{b}	67 ± 21^{bc}	80 ± 21^{c}	<0.001	<0.001
		Ube flavoured pumpkin juice	19 ± 17^{a}	26 ± 19^{ab}	38 ± 22^{b}	65 ± 20^{c}	79 ± 15^{c}	<0.001	<0.001
		Ube flavoured spinach cake	18 ± 13^{a}	35 ± 17^{b}	53 ± 13^{c}	67 ± 20^{d}	80 ± 15^{e}	<0.001	<0.001
Experiment 4	**Rating, VAS scale**[1] (0–100)	Strawberry flavoured lemonade	26 ± 21^{a}	43 ± 21^{b}	55 ± 20^{c}	81 ± 10^{d}	88 ± 10^{d}	<0.001	<0.001
		Chocolate flavoured custard	14 ± 15^{a}	31 ± 21^{b}	50 ± 26^{c}	63 ± 17^{d}	74 ± 15^{e}	<0.001	<0.001
		Plain Cake	18 ± 15^{a}	43 ± 18^{b}	53 ± 14^{c}	73 ± 17^{d}	84 ± 9^{e}	<0.001	<0.001
		Watermelon flavoured lemonade	27 ± 24^{a}	37 ± 24^{a}	58 ± 19^{b}	76 ± 20^{c}	89 ± 8^{d}	<0.001	<0.001
		Elderflower flavoured custard	28 ± 20^{a}	49 ± 20^{b}	71 ± 13^{c}	85 ± 11^{d}	93 ± 7^{d}	<0.001	<0.001
		Tamarind flavoured cake	19 ± 17^{a}	37 ± 18^{b}	49 ± 19^{c}	72 ± 12^{d}	77 ± 13^{d}	<0.001	<0.001
		Gazpacho	47 ± 21^{a}	50 ± 20^{a}	58 ± 22^{ab}	72 ± 12^{bc}	84 ± 17^{c}	<0.001	<0.001
		Butter cracker	11 ± 11^{a}	20 ± 18^{a}	37 ± 20^{b}	74 ± 10^{c}	$90 \pm {}^{d}$	<0.001	<0.001

[a, b, c, d, e] For each row, different letters indicate statistically significant differences at $p < 0.05$ (Bonferroni post hoc correction applied).
[1] Data analysed using Linear Mixed Models and data shown as mean ± SD.
[2] Based on liner mixed model with concentration and participant as factors.

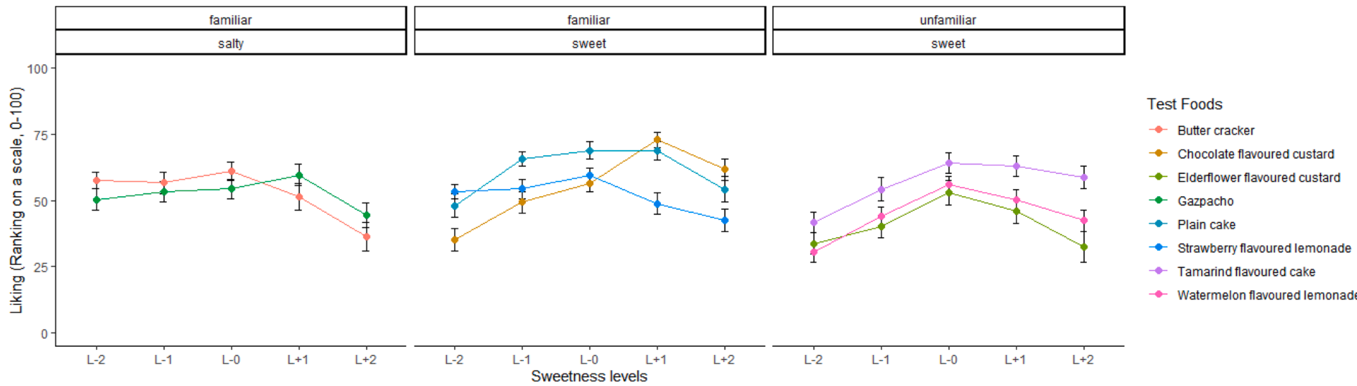

Fig. 7. Mean rated preference with SE bars, split by familiarity and taste, across five sweetness intensity levels (L-2, L-1, L-0, L + 1, L + 2) as a function of sweetness concentration in Butter cracker, Chocolate flavoured custard, Gazpacho, Plain cake, Strawberry flavoured lemonade, Tamarind flavoured cake and Watermelon flavoured lemonade (Experiment 4).

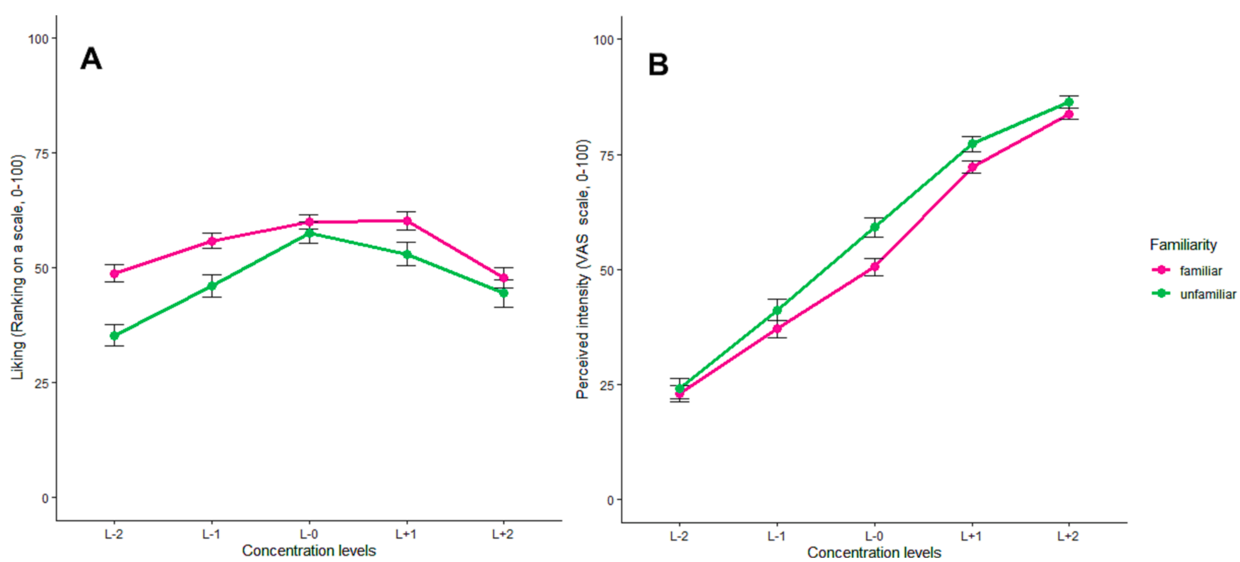

Fig. 8. (A) Effect of familiarity on psychohedonic (concentration-pleasantness) sweetness function and (B) psychophysical (concentration-intensity) sweetness function in familiar and unfamiliar foods (Experiment 4).

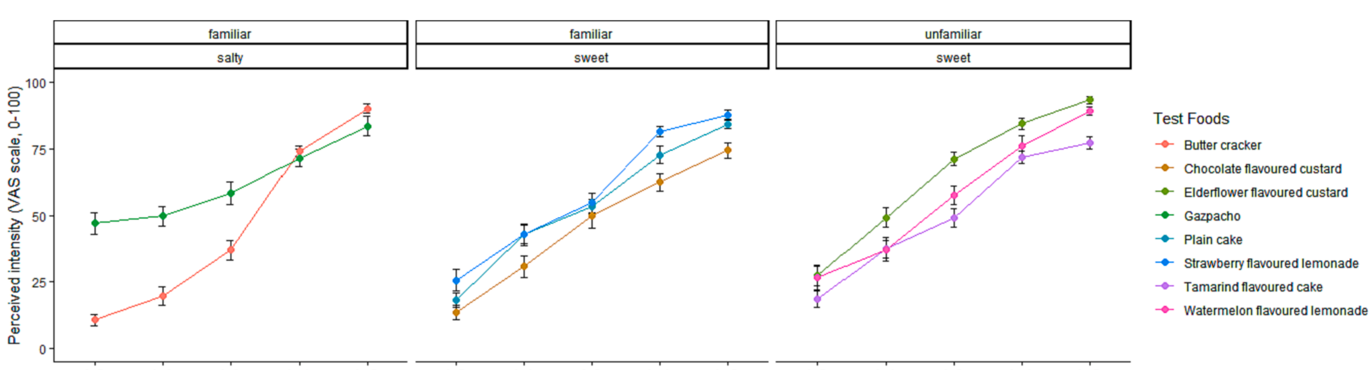

Fig. 9. Mean rated perceived intensity with SE bars, split by familiarity and taste, across five sweetness intensity levels (L-2, L-1, L-0, L + 1, L + 2) as a function of sweetener/salt concentration in Butter cracker, Chocolate flavoured custard, Gazpacho, Plain cake, Strawberry flavoured lemonade, Tamarind flavoured cake and Watermelon flavoured lemonade (Experiment 4).

all concentration levels (mean liking score between 10.5 and 19.5). One possible reason why all levels were disliked is the novelty and palatability of the food. It has been consistently shown that familiarity promotes consumer liking for foods (Grahl et al., 2020). In the current study, ube-flavoured pumpkin juice was rated as the least liked and the least familiar product. Although exposure to novel foods on a regular basis may increase liking for them, there might be no effect if the food was strongly disliked when first tried (Pliner & Pelchat, 1991; Tuorila et al., 2001). Another reason why discrimination between concentration levels was low for some foods in Experiment 3, could be context.

Including less-liked test foods in an evaluation set could create a sample context effect, thus, the ratings of other samples could be compressed toward the higher or lower end of the scale. After removing less-liked test foods from the evaluation set (Experiment 4), a clear distinction in liking and preference was observed across sweetness levels, in both familiar and unfamiliar foods. The results of Experiment 4 confirm that RoS can be practical and comprehensive, capturing both liking and preference while also discriminating hedonic responses across various concentration levels for familiar and unfamiliar foods. In the future, when using RoS to assess hedonic responses, analysing data as a continuous measure of 'liking' based on the rating scale (ranging from 0 to 100) and as a measure of 'preference' based on the order in which stimuli were ranked is advised to capture a comprehensive understanding of participants' responses.

Familiarity also affected perceived intensity. In Experiment 3, familiar test foods were rated as more intense across all concentration levels, compared to unfamiliar foods. In contrast, in Experiment 4, unfamiliar foods were perceived as more intense in terms of taste. Since different foods and flavourings were used in these two experiments, we speculate that these findings could be attributed to the flavourings added to the foods, and not familiarity per se. Research has shown that taste-flavour interactions have an effect on sweet taste perception. While fruitiness can enhance sweetness perception, other flavours such as cocoa can diminish it (Noble, 1996).

In terms of the effect of familiarity on sweet taste preference, familiar foods were preferred over unfamiliar ones in both experiments. These findings are consistent with the notion that familiarity is positively associated with food liking scores (Grahl et al., 2020; Nacef et al., 2019; Schifferstein et al., 2019; Torrico et al., 2019; Tuorila et al., 1994). However, there were no effects of familiarity on the shapes of psychophysical and psychohedonic sweetness functions – they followed the same trend. These findings appear to support the assumption that familiarity, manipulated by flavour and colour, affects sweet taste liking, preference and perhaps intensity perception, but not the shape of psychophysical and psychohedonic sweetness functions. These results suggest that the liking response to sweetness has a learning aspect and supports the idea that exposure has the potential to shape food preferences (Ahern et al., 2019; Appleton, Hemingway, et al., 2018; Pliner, 1982). However, the robustness of the psychohedonic sweetness function curves between familiar and unfamiliar foods, also indicates that optimal sweetness levels may be hard-wired, and not easily affected by factors, such as exposure.

In Experiments 2–4, an exploratory analysis was conducted to investigate individual differences in the preferred concentration levels of various test foods. The findings consistently demonstrated that, for the majority of the test foods, the middle concentration level (L-0) was the most frequently preferred. This preference was characterized by inverted U-shaped hedonic parabolic curves. Additionally, the study examined the individual consistencies in the most preferred concentration levels across different test foods. No systematic patterns were observed, indicating a lack of consistency and large variation in preferred concentration levels across the different test foods. Findings of this analyses further support the notion that preferred sweetener concentration level is product specific, emphasizing the need to assess preferences across a range of food types.

The test foods utilised in this study differed in texture, taste and familiarity (Experiments 3 and 4). In each experiment, foods were selected based on ingredient availability, technical feasibility and the potential to discriminate between concentrations and their hedonic and intensity ratings. Familiar test foods were selected to represent foods commonly consumed by the Dutch population, were easy to prepare and were available throughout the year. Test foods which allowed discrimination between the concentration levels in intensity and liking were included in the subsequent experiments. Other test foods that did not meet these requirements were replaced or concentration levels were adjusted. For each test food, quantities of added sucrose or sodium chloride were modified to approach a normal distribution of hedonic ratings following a typical U-shaped trend. Similar to the study of Urbano et al., 2016, we observed an effect of the food matrix on intensity perception. In the current study sweet taste intensity perception was the same for strawberry lemonade and plain cake at level L-0, despite there being a 16% difference in added sucrose between the two (3% of added sucrose in strawberry lemonade and 19% in cake).

This work was conducted with consumers living in the Netherlands, with a relatively small sample size, therefore, our findings may not be generalizable and may not translate to other populations. However, the sample sizes used show sufficient statistical power to support the method development and indicate the appropriateness of the foods and scales for our method development. Furthermore, the sweetness concentration levels tested here may not translate to populations with different habitual intakes of sweet foods. For example, research on dietary patterns suggests a slightly higher intake of total sugars in the US, compared to the Netherlands (Newens & Walton, 2016; Wittekind & Walton, 2014). Therefore, some adjustments of concentrations levels might be needed in different populations. It is also possible that certain populations may not agree with the (un)familiarity of the test foods in the current study. Research has shown that Asians and Westerners differ in their familiarity and liking scores for foods (Torrico et al., 2019). Additionally, because the goal of this work was to develop methodology, demographic information of our participants was not obtained (Experiment 1 and 2). As a result, we were unable to test for variations in and effects of sex, body weight, ethnicity, or level of education. Nonetheless, others have done substantial research on the factors that influence sweet taste liking and preference (for example see Venditti et al. (2020), for a review). Furthermore, it would be valuable to explore the association between preferences for aqueous solutions and diverse food matrices. While previous studies have predominantly employed aqueous solutions to investigate preferences, the comparability between preferences for sweet foods and sweet aqueous solutions is not always consistent (Tuorila et al., 2017). Future research, with more diverse samples would not only contribute to a better understanding of the relationship between aqueous solutions and different food matrices but could also provide insights into potential cross-cultural variations in sweet liking.

To better understand the effect of sweet taste liking, preference and intensity perception on health-related outcomes, sensitive and reliable methods are needed. Importantly, reliable methods could help shed light on the widespread and long-standing belief that a high sweet diet leads to changes in sweet taste liking and intensity perception, which in turn leads to overconsumption, obesity and related comorbidities. The methodology developed in this study is now being used in a randomized controlled trial aimed primarily at assessing the effects of long-term low, regular and high dietary sweetness exposure on preferences for sweet foods and beverages (Cad et al., 2022). Moreover, this trial aims to assess the effect of dietary sweetness exposure on sweet taste intensity perception, dietary behaviour, body composition and health-related outcomes.

5. Conclusion

The current work confirms that RoS is a practical tool for determining consumer liking and preference for sweet taste in both familiar and unfamiliar foods. Additionally, our findings show that familiarity has a substantial effect on liking and preference, but not on psychophysical or psychohedonic sweetness functions. Besides looking into individual variables that can influence sweet taste liking and preference, a next step is to apply this methodology to assess whether and how exposure to dietary sweetness affects sweet taste liking, preference and intensity perception. By doing this, the relationship between sweet taste exposure and health would also become clearer. Future applications of the methods developed and evaluated in the current work could include contrasting liking, preference and intensity distributions between age and ethnic groups.

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CRediT authorship contribution statement

E.M. Čad: Conceptualization, Methodology, Investigation, Data curation, Formal analysis, Visualization, Writing – original draft, Writing – review & editing, Project administration. **C.S. Tang:** Investigation, Data curation, Writing – review & editing, Project administration. **M. Mars:** Supervision, Methodology, Writing – review & editing. **K. M. Appleton:** Supervision, Methodology, Writing – review & editing. **K. de Graaf:** Conceptualization, Methodology, Supervision, Writing – review & editing.

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: MM has received research funding from Royal Cosun (sugar beet refinery) and Sensus (inulin producer), and has received expenses from ILSI Europe. KMA has received research funding from Unilever R&D Vlaardingen, NL and ILSI-North America, and the International Sweeteners Association, BE; KMA has received speaker's expenses from the International Sweeteners Association, BE, PepsiCo and ILSI-North America. KdG is a member of the Scientific Advisory Board of Sensus (inulin producer); and is a member of the Global Independent Nutrition Advisory Board of the Mars company. KdG has received travel, hotel and speaker renumeration from ISA (International Sweeteners Association), and received speaker expenses (travel, hotel) from ILSI North America.

Data availability

Data will be made available on request.

Appendix A

Table A1–A9

Table A1
Frequency of preferred sweetness concentration level per food product, Experiment 2 (n = 31).

Test food	L-2	L-1	L-0	L + 1	L + 2
Orange juice	3	4	8	9	7
Plain Cake	0	5	13	8	5
Soft white cheese	2	5	15	4	5
Spinach cake	3	14	9	4	1
Tomato juice	5	3	9	7	6

Note: The table shows the frequency of preferred sweetness concentration level per test food, based on data collected from 31 participants.

Table A2
Pearson correlation coefficients and cross-classification from the comparison of the most preferred concentration level of sweet test food and salty test foods (n = 31).

Comparison		Cross-classification		
	Pearson Correlation Coefficient [a]	Same preferred concentration level, % [b]	Moderately different preferred concentration level, % [b]	Highly different preferred concentration level, % [b]
Orange juice vs. Soft white cheese	0.03	29.0	32.3	38.7
Orange juice vs. Plain cake	0.18	25.8	48.4	25.8
Soft white cheese vs. Plain cake	−0.13	25.8	38.7	35.5
Tomato juice vs. Spinach cake	−0.09	20.0	30.0	50.0

[a] Pearson Correlation Coefficients estimated between most preferred sweet and salt concentration levels for each product, expressed in % by weight. Values between −1 and 1, where −1 indicates a perfect negative correlation, 0 indicates no correlation, and 1 indicates a perfect positive correlation. * indicates a significant correlation.

[b] The term "Same preferred concentration level" refers to when participants preferred the same level of sweetness across two test foods. When participants' preferred levels differing for only one concentration level (for example, L-0 and L + 1), this is referred to as "Moderately different preferred concentration level." Finally, if the two most preferred concentration levels differed by more than one level, with at least one level in between (for example, L-1 and L + 1), this is referred to as "Highly different preferred concentration level."

Table A3
Frequency of preferred sweetness concentration level per test food, Experiment 3 (n = 28).

Test food	L-2	L-1	L-0	L + 1	L + 2
Orange juice	3	2	6	5	11
Soft white cheese	2	6	7	4	3
Plain cake	0	3	9	12	4
Buco Pandan flavoured drink	3	4	4	9	8
Grenadine flavoured soft white cheese	6	3	6	8	5
Tamarind flavoured cake	0	8	9	8	2
Tomato juice	9	5	8	3	3
Spinach cake	7	6	7	4	3
Ube flavoured pumpkin juice	6	9	4	4	5
Ube flavoured spinach cake	6	6	4	6	6

Note: The table shows the frequency of the most preferred sweetness concentration level per test food, based on data collected from 28 participants. For some test foods, there was a tie, meaning participants had no clear preference for a single concentration level. Hence, those instances were excluded from the frequency table of the most preferred concentration.

Table A4
Pearson correlation coefficients and cross-classification from the comparison of the most preferred concentration level of sweet test food and salty test foods, Experiment 3 (n = 28).

Comparison		Cross-classification		
	Pearson Correlation Coefficient [a]	Same preferred concentration level, % [b]	Moderately different preferred concentration level, % [b]	Highly different preferred concentration level, % [b]
Orange juice vs. Soft white cheese	−0.001	14.8	40.8	44.4
Orange juice vs. Plain cake	−0.02	33.3	33.3	33.3
Orange juice vs. Buco Pandan flavoured drink	−0.04	18.5	44.4	37.1
Orange juice vs. Grenadine flavoured soft white cheese	−0.2	22.2	37.0	40.8
Orange juice vs. Tamarind flavoured cake	−0.2	19.2	30.8	50.0
Soft white cheese vs. Plain cake	0.03	17.9	53.6	28.5
Soft white cheese vs. Buco Pandan flavoured drink	0.03	28.6	28.7	42.7
Soft white cheese vs. Grenadine flavoured soft white cheese	−0.07	17.9	35.7	46.4
Soft white cheese vs. Tamarind flavoured cake	−0.05	14.8	48.2	37.0
Plain cake vs. Buco Pandan flavoured drink	−0.05	25.0	39.3	35.7
Plain cake vs. Grenadine flavoured soft white cheese	0.03	17.9	46.4	35.7
Plain cake vs. Tamarind flavoured cake	0.02	37.0	37.0	26.0
Buco Pandan flavoured drink vs. Grenadine flavoured soft white cheese	0.04	25.0	32.1	42.9
Buco Pandan flavoured drink vs. Tamarind flavoured cake	−0.07	11.1	51.8	37.1
Grenadine flavoured soft white cheese vs. Tamarind flavoured cake	0.06	22.2	40.7	37.1
Tomato juice vs. Spinach cake	0.6*	48.2	22.2	29.6
Tomato juice vs. Ube flavoured pumpkin juice	0.09	21.4	35.8	42.8
Tomato juice vs. Ube flavoured spinach cake	−0.06	10.7	42.9	46.4
Spinach cake vs. Ube flavoured pumpkin juice	0.02	37.0	18.5	44.5
Spinach cake vs. Ube flavoured spinach cake	0.3	29.6	33.3	37.1
Ube flavoured pumpkin juice vs. Ube flavoured spinach cake	0.1	21.4	17.9	60.7

[a] Pearson Correlation Coefficients estimated between most preferred sweet and salt concentration levels for each product, expressed in % by weight. Values between −1 and 1, where −1 indicates a perfect negative correlation, 0 indicates no correlation, and 1 indicates a perfect positive correlation. * indicates a significant correlation.

[b] The term "Same preferred concentration level" refers to when participants preferred the same level of sweetness across two test foods. When participants' preferred levels differing for only one concentration level (for example, L-0 and L + 1), this is referred to as "Moderately different preferred concentration level." Finally, if the two most preferred concentration levels differed by more than one level, with at least one level in between (for example, L-1 and L + 1), this is referred to as "Highly different preferred concentration level.".

Table A5
Frequency of preferred sweetness concentration level per test food, Experiment 4 (n = 28).

Test food	L-2	L-1	L-0	L + 1	L + 2
Strawberry flavoured lemonade	3	9	7	6	3
Chocolate flavoured custard	1	2	2	16	7
Plain Cake	0	7	9	9	3
Watermelon flavoured lemonade	2	5	11	5	5
Elderflower flavoured custard	2	3	13	4	5
Tamarind flavoured cake	2	2	9	8	7
Gazpacho	3	4	5	10	5
Butter cracker	5	5	7	6	4

Note: The table shows the frequency of the most preferred sweetness concentration level per test food, based on data collected from 28 participants. For some test foods, there was a tie, meaning participants had no clear preference for a single concentration level. Hence, those instances were excluded from the frequency table of the most preferred concentration.

Table A6
Pearson correlation coefficients and cross-classification from the comparison of the most preferred concentration level of sweet test food and salty test foods, Experiment 4 (n = 31).

Comparison		Cross-classification		
	Pearson Correlation Coefficient [a]	Same preferred concentration level, % [b]	Moderately different preferred concentration level, % [b]	Highly different preferred concentration level, % [b]
Strawberry flavoured lemonade vs. Chocolate flavoured custard	0.21	14.3	39.3	46.4
Strawberry flavoured lemonade vs. Plain Cake	0.14	14.3	57.1	28.6
Strawberry flavoured lemonade vs. Watermelon flavoured lemonade	0.42*	32.1	39.4	28.5
Strawberry flavoured lemonade vs. Elderflower flavoured custard	0.15	14.8	55.6	29.6
Strawberry flavoured lemonade vs. Tamarind flavoured cake	0.15	25.0	42.8	32.2
Chocolate flavoured custard vs. Plain Cake	0.09	17.8	46.5	35.7
Chocolate flavoured custard vs. Watermelon flavoured lemonade	0.32	21.4	53.6	25.0
Chocolate flavoured custard vs. Elderflower flavoured custard	0.21	22.2	40.7	37.1
Chocolate flavoured custard vs. Tamarind flavoured cake	0.01	32.1	39.3	28.6
Plain Cake vs. Watermelon flavoured lemonade	0.11	50.0	25.0	25.0
Plain Cake vs. Elderflower flavoured custard	0.29	33.3	48.1	18.6
Plain Cake vs. Tamarind flavoured cake	0.27	42.9	35.7	21.4
Watermelon flavoured lemonade vs. Elderflower flavoured custard	0.27	25.9	44.4	29.7
Watermelon flavoured lemonade vs. Tamarind flavoured cake	0.42*	39.3	42.8	17.9
Elderflower flavoured custard vs. Tamarind flavoured cake	0.21	22.2	37.0	40.8
Butter cracker vs. Gazpacho	0.19	30.8	30.8	38.4

[a] Pearson Correlation Coefficients estimated between most preferred sweet and salt concentration levels for each product, expressed in % by weight. Values between −1 and 1, where −1 indicates a perfect negative correlation, 0 indicates no correlation, and 1 indicates a perfect positive correlation. * indicates a significant correlation.

[b] The term "Same preferred concentration level" refers to when participants preferred the same level of sweetness across two test foods. When participants' preferred levels differing for only one concentration level (for example, L-0 and L + 1), this is referred to as "Moderately different preferred concentration level." Finally, if the two most preferred concentration levels differed by more than one level, with at least one level in between (for example, L-1 and L + 1), this is referred to as "Highly different preferred concentration level.".

Table A7
The estimated differences between products based on pairwise comparison of mean liking scores, Experiment 2 (n = 31).

	Orange juice	Plain Cake	Soft white cheese	Spinach cake	Tomato juice
Orange juice	–	−2.4	5.8	10.5*	16.7*
Plain Cake	2.4	–	8.2*	12.9*	19.1*
Soft white cheese	−5.8	−8.2*	–	4.7	10.9*
Spinach cake	−10.5*	−12.9*	−4.7	–	6.2
Tomato juice	−16.7*	−19.1*	−10.9*	−6.2	–

Note: * show significant differences between test food pairs, at a $p < 0.05$. The Bonferroni method was used to adjust the confidence level for multiple comparison.

Table A8
The estimated differences between products based on pairwise comparison of mean liking scores, Experiment 3 (n = 28).

	Buco pandan flavoured drink	Grenadine flavoured soft white cheese	Orange juice	Plain cake	Soft white cheese	Spinach cake	Tamarind flavoured cake	Tomato juice	Ube flavoured pumpkin juice	Ube flavoured spinach cake
Buco pandan flavoured drink	–	3.0	−26.9*	−27.9*	−26.2*	−3.4	−22.9*	−7.0	21.5*	−4.1
Grenadine flavoured soft white cheese	−3.0	–	−29.9*	−30.9*	−29.3*	−6.4	−25.9*	−10.0*	18.5*	−7.1
Orange juice	26.9*	29.9*	–	−1.0	0.7	23.5*	4.0	19.8*	48.4*	22.7*
Plain cake	27.9*	30.9*	1.0	–	1.7	24.5*	5.0	20.8*	49.4*	22.8*
Soft white cheese	26.2*	29.3*	−0.7	−1.7	–	22.8*	3.3	19.2*	47.7*	22.1*
Spinach cake	3.4	6.4	−23.5*	−24.5*	−22.8*	–	−19.5*	−3.6	24.9*	−0.6
Tamarind flavoured cake	22.9*	25.9*	−4.0	−5.0	−3.3	19.5*	–	15.8*	44.4*	18.8*
Tomato juice	7.0	10.0*	−19.8*	−20.8*	−19.2*	−3.6	−15.8*	–	28.5*	−2.9
Ube flavoured pumpkin juice	−21.5*	−18.5*	−48.4*	−49.4*	−47.7*	−24.9*	−44.4*	−28.5*	–	−25.6*
Ube flavoured spinach cake	4.1	7.1	−22.7*	−22.8*	−22.1*	0.6	−18.8*	2.9	25.6*	–

Note: * show significant differences between test food pairs, at a $p < 0.05$. The Bonferroni method was used to adjust the confidence level for multiple comparison.

Table A9
The estimated differences between products based on pairwise comparison of mean liking scores, Experiment 4 (n = 28).

	Butter cracker	Chocolate flavoured custard	Elderflower flavoured custard	Gazpacho	Plain cake	Strawberry flavoured lemonade	Tamarind flavoured cake	Watermelon flavoured lemonade
Butter cracker	–	−2.5	11.6*	0.1	−8.5*	0.9	−3.8	8.0*
Chocolate flavoured custard	2.5	–	14.1*	2.6	−6.0	3.4	−1.3	10.5*
Elderflower flavoured custard	−11.6*	−14.1*	–	−11.4*	−20.1*	−10.6*	−15.4*	−3.5
Gazpacho	−0.1	−2.6	11.4*	–	−8.6*	0.8	−3.9	7.9*
Plain cake	8.5*	6.0	20.1*	8.6*	–	9.5*	4.7	16.5*
Strawberry flavoured lemonade	−0.9	−3.4	10.6*	−0.8	−9.5	–	−4.8	7.1
Tamarind flavoured cake	3.8	1.3	15.4*	3.9	−4.7	4.8	–	11.8*
Watermelon flavoured lemonade	−8.0*	−10.5*	3.5	−7.9*	−16.5*	−7.1	−11.8*	–

Note: * show significant differences between test food pairs, at a $p < 0.05$. The Bonferroni method was used to adjust the confidence level for multiple comparison.

Appendix B

Figs. B1 and B2

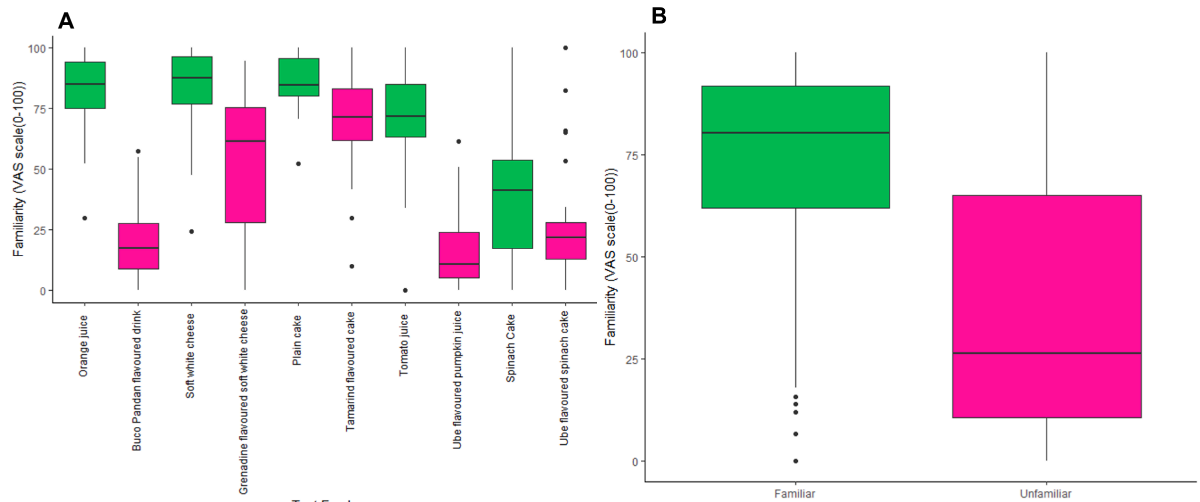

Fig. B1. Mean familiarity scores with SE bars, for individual test foods (A) (Buco Pandan flavoured drink, Grenadine flavoured soft white cheese, Orange juice, Plain cake, Soft white cheese, Tamarind flavoured cake, Tomato juice, Ube flavoured juice and Ube flavoured spinach cake), on the left; and overall pulled mean familiarity scores for familiar and unfamiliar test foods with SE bars (B) on the right (Experiment 3).

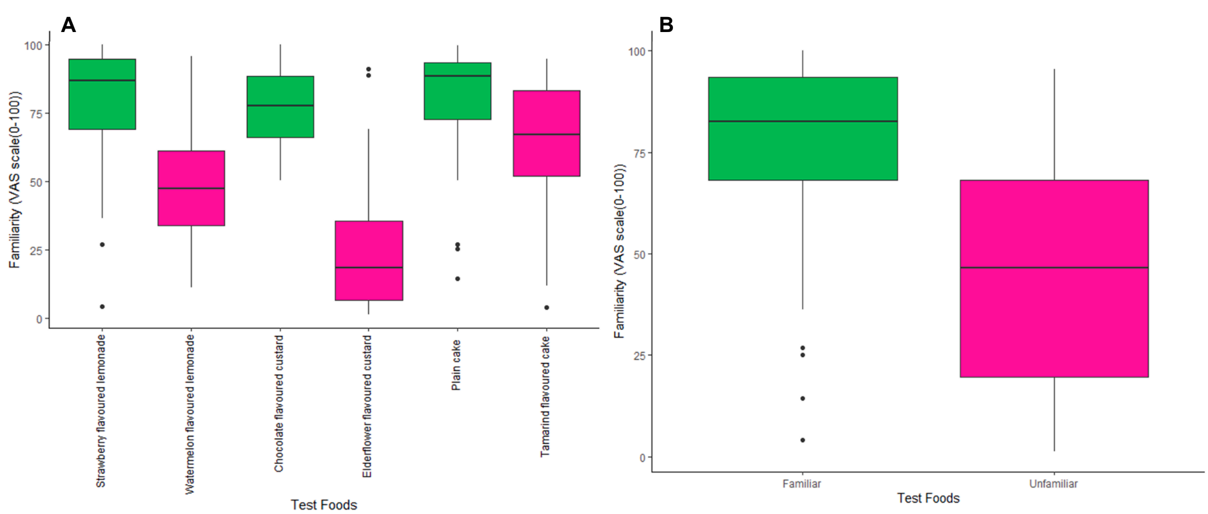

Fig. B2. Mean familiarity scores with SE bars, for individual sweet test foods (A) (Chocolate flavoured custard, Plain cake, Strawberry flavoured lemonade, Tamarind flavoured cake and Watermelon flavoured lemonade) on the left; and overall pulled mean familiarity scores for familiar and unfamiliar test foods with SE bars (B), on the right (Experiment 4).

Appendix C

Strawberry flavoured lemonade

Table C1
Strawberry flavoured lemonade ingredient list and sweetness concentration level (by weight (%) for each concentration level.

Ingredients	Product	L-2	L-1	L-0	L+1	L+2
Water (g)	Tap water	250	250	250	250	250
Strawberry Syrup (g)	Karvan Cévitam Siroop aardbei	11.9	11.9	11.9	11.9	11.9
Sugar (g)	Van Gilse	0.0	3.3	8.3	24.5	46.4
Sweetness concentration across levels by weight (%)		**0.0**	**1.3**	**3.1**	**8.6**	**15.1**
3-digit random code		539	682	251	836	382

Method

Product Preparation: 30 min.

1. Weigh ingredients in sufficient quantity for the expected number of participants.
2. For each level, pour the syrup into the required amount of water. Add sugar and mix well (use a shaker or agitator for 2 min if you have one). Keep blends in labelled bottles to facilitate the service.

Preparation of samples and Service: 30 min.

Serve 20 ml of syrup per level and per person into labelled cups. This can be done in advance, let at room temperature.

Watermelon flavoured lemonade

Table C2
Watermelon flavoured lemonade ingredient list and sweetness concentration level (by weight (%) for each concentration level.

Ingredients	Product	L-2	L-1	L-0	L+1	L+2
Water (g)	Tap water	250	250	250	250	250
Lemon Syrup (g)	Karvan Cévitam Siroop citroen	9.5	9.5	9.5	9.5	9.5
Sugar (g)	Van Gilse	0.0	3.3	8.3	24.5	46.4
Watermelon flavouring (0.30%)	Watermelon Flavouring, Meilleur du Chef	1.0	1.1	1.1	1.1	1.2
Sweetness concentration across levels by weight (%)		**0.0**	**1.3**	**3.1**	**8.6**	**15.1**
3-digit random code		167	201	813	402	387

Method

Product Preparation: 30 min.

1. Weigh ingredients in sufficient quantity for the expected number of participants.
2. For each level, pour the syrup into the required amount of water. Add sugar and mix well (use a shaker or agitator for 2 min if you have one). Keep blends in labelled bottles to facilitate the service.

Preparation of samples and Service: 30 min.

Serve 20 ml of syrup per level and per person into labelled cups. This can be done in advance, let at room temperature.

Chocolate flavoured custard

Table C3
Chocolate flavoured custard ingredient list and sweetness concentration level (by weight (%) for each concentration level.

Ingredients	Product	L-2	L-1	L-0	L+1	L+2
Corn starch (g)	Duryea Maizena	6	6	6	6	6
Cocoa	Blooker Cacaopoeder	19.2	19.2	19.2	12.8	9.6
Milk (g)	De Zaanse Hoeve Halfvolle	240.0	240.0	240.0	160.0	120.0
Sugar (g)	Van Gilse	9.4	18.7	37.4	38.0	48.5
Sweetness concentration across levels by weight (%)		**3,4**	**6.6**	**12.4**	**17.5**	**26.3**
3-digit random code		982	625	596	930	327

Method

Preparation of chocolate custard (the day before the session): 60 min.

1. Weigh ingredients in sufficient quantity for the expected number of participants.
2. For each level, dilute the corn starch into the milk and add cocoa, sugar and sweetener.
3. Place the pan on heat and stir the mixture doing « 8 », on low to medium temperature. When bubbles appear on top of the preparation, stir for 30 s and then remove from heat.
4. Reserve into a bowl and cover the surface of the custard with cling wrap.

Note: Cooking time may be different in function of the different levels.

5. Identify the bowl with the code and the manufacturing date. Place in the fridge.

Preparation of samples and Service: 45 min.

Eliminate the "superficial skin" and then homogenized custard.

Serve custard in labelled cups (15 g per cup).

Film with cellophane and place in the fridge. Get out from just before the service.

Note: possible preparation of all the samples in one time for all sessions of the day.

Elderflower flavoured custard

Table C4
Elderflower flavoured custards ingredient list and sweetness concentration level (by weight (%) for each concentration level.

Ingredients	Product	L-2	L-1	L-0	L+1	L+2
Corn Starch (g)	Duryea Maizena	8.0	8.0	8.0	8.0	8.0
Milk (g)	De Zaanse Hoeve Halfvolle	228.6	228.6	228.6	228.6	228.6
Sugar (g)	Van Gilse	9.0	18.0	36.1	54.1	72.2
Sweetener (g)	Rio Sweetener liquid	0.0	0.0	0.0	1.9	19.4
Food Flavouring (Elderflower) 0.40%	Elderflower Natural Flavouring, Meilleur du Chef	1.0	1.0	1.1	1.2	1.3
Sweetness concentration across levels by weight (%)		**3.7**	**7.1**	**13.2**	**19.1**	**27.8**
3-digit random code		476	837	697	709	528

Method

Preparation of elderflower custard (the day before the session): 60 min.

1. Weigh ingredients in sufficient quantity for the expected number of participants.
2. For each level, dilute the corn starch into the milk and add flavouring, sugar and sweetener.
3. Place the pan on heat and stir the mixture doing « 8 », on low to medium temperature. When bubbles appear on top of the preparation, stir for 30 s and then remove from heat.
4. Reserve into a bowl and cover the surface of the custard with cling wrap.

Note: Cooking time may be different in function of the different levels.

5. Identify the bowl with the code and the manufacturing date. Place in the fridge.

Preparation of samples and Service: 45 min.

Eliminate the "superficial skin" and then homogenized custard.

Serve custard in labelled cups (15 g per cup).

Film with cellophane and place in the fridge. Get out from just before the service.

Serve one sample by level and participant.

Note: possible preparation of all the samples in one time for all sessions of the day.

Gazpacho

Table C5
Gazpacho ingredient list and sweetness concentration level (by weight (%) for each concentration level.

Ingredients	Product	L-2	L-1	L-0	L+1	L+2
Passata (g)	Jumbo Tomaten Gezeefd Passata	200	200	200	200	200
Water (g)	Tap water	80.0	80.0	80.0	80.0	80.0
Onion Powder (g)	Verstegen	1.1	1.1	1.1	1.1	1.1
Garlic Powder (g)	Verstegen	0.3	0.3	0.3	0.3	0.3
Paprika powder (g)	Verstegen	1.3	1.3	1.3	1.3	1.3
Basil Powder (g)	Verstegen	0.3	0.3	0.3	0.3	0.3
Sherry Vinegar (g)	A L'Olivier	3.2	3.2	3.2	3.2	3.2
Sugar (g)	Van Gilse	1.6	1.6	1.6	1.6	1.6
Salt (g)	JOZO	0.1	0.4	0.9	2.1	4.3
Saltiness concentration across levels (%)		**0.0**	**0.1**	**0.3**	**0.7**	**1.5**
3-digit random code		807	234	614	542	718

Method

Important: this recipe calls for preparation of each salt level separately, as salt is incorporated during product preparation and not after.

Preparation of the product: 20 min.

1. Weigh ingredients in sufficient quantity for the expected number of participants.
2. Put all ingredients into blender to blend until smooth.
3. Identify the soups with their codes and the manufacturing date and place them in the fridge.

Preparation of samples and Service: 10 min.

Serve 20 ml of soup per level and per person into coded cups. This can be done in advance, let at room temperature.

Butter Cracker

Table C6
Butter cracker ingredient list and sweetness concentration level (by weight (%) for each concentration level.

Ingredients	Product	L-2	L-1	L-0	L+1	L+2
Flour (g)	AH	75	75	75	75	75
Butter (g)	AH	26.7	26.7	26.7	26.7	26.7
Water (g)	Tap water	37.1	37.1	37.1	37.1	37.1
Sugar (g)	Van Gilse	6.0	6.0	6.0	6.0	6.0
Salt (g)	JOZO	0.0	1.0	2.0	5.3	11.0
Saltiness concentrations across levels (%)		**0.0**	**0.7**	**1.4**	**3.5**	**7.0**
3-digit random code		597	903	357	430	713

Method

Important: this recipe calls for preparation of each salt level separately, as salt is incorporated during product preparation and not after.

Product Preparation: 45 min.

1. Weigh ingredients in sufficient quantity for the expected number of participants. 25 g flour makes dough baked that gives about 12 pieces of crackers.
2. Preheat oven to 232 °C (moisture level 0%, baking setting).
3. Sift all dry ingredients into food processor to mix.
4. Add in butter and blend until butter is fully incorporated.
5. While the food processor blade is running slowly, add water and blend until dough is smooth.
6. Divide the dough into equal size pieces.
7. Lightly flour work surface and roll out dough pieces thinly (standard thickness: 0.1 cm).
8. Use a round cookie cutter to cut the dough into equal sized crackers (standard diameter: 4 cm).

9. Bake crackers on baking tray lined with baking paper until lightly brown and crisp, for approx. 5 min. Warning: baking times must be adapted to the used oven.

10. Take out from the oven immediately once finished.

11. Transfer to a cooling rack and allow to cool fully.

Preparation of samples and Service: 5 min.

Store butter crackers with varying salt levels into separate air-tight containers with their codes.

Take the crackers from each air-tight container with their codes for serving.

Note: Crackers can be prepared in advance and stored in the deep freezer.

Plain cake

Table C7
Plain cake ingredient list and sweetness concentration level (by weight (%) for each concentration level.

Ingredients	Product	L-2	L-1	L-0	L+1	L+2
Flour (g)	AH	250	250	250	250	250
Oil (g)	AH Zonnebloemolie	200	200	200	200	200
Eggs (g)	AH	250	250	250	250	250
Baking powder (g)	Dr. Oetker	9.8	9.8	9.8	9.8	9.8
Salt (g)	JOZO	0.9	0.9	0.9	0.9	0.9
Sugar (g)	Van Gilse	71.4	142.9	160.7	160.7	160.7
Sweetener (g)	Rio Sweetener liquid	0.0	0.0	7.7	38.4	77.5
Sweetness concentrations across levels by weight (%)		**9.1**	**16.7**	**19.2**	**21.9**	**25.1**
3-digit random code		941	249	739	108	312

Method

Prepare the dough: 105 min.

1. Weigh ingredients in sufficient quantity for the expected number of participants.
2. Break the eggs into a bowl and beat with a fork.
3. For each level, put the flour, baking powder, salt, sugar, sweetener, oil and finish with eggs (the yolks should not be in direct contact with the sugar to prevent coagulation of yolks) into a mixing bowl.
4. Mix (whisk or spatula) to obtain a smooth mix.
5. Taste the products in the order of the range to check the progress.

Baking of cakes:

1. Put a drop of oil in the bottom of the pans and spread with a paper towel in the bottom and sides of the pans (even if they are non-stick). Identify pans.
2. Preheat oven to 180° C (100% moisture setting and fan to a minimum).
3. Bake the cakes for 20 to 30 min at 180° C.

Warning: the cooking time may vary in function of the used oven The more the cakes contain sugar, the more they tend quickly to color.

To check the baking, stick a knife in the center of the cake and check that there is not any mix on the blade.

Turning out of cakes:

Rest the cakes ten minutes and get out them from the pans.

Freezing:

Filming cakes with cellophane, identify with the code and manufacturing date.

Reheating:

Cakes should be removed the day before the session. Remove from the freezer and place in the fridge overnight.

Preparation of samples and Service:

Slice the cakes. Remove the crust from the cake and make small servings. Arrange portions on a film plate. When serving, put the portions on the plates of participants. Serve one quarter of a slice of cake each variant and participant. Note: you can use the same cake for all the sessions of the same day.

Tamarind flavoured cake

Table C8
Tamarind flavoured cake ingredient list and sweetness concentration level (by weight (%) for each concentration level.

Ingredients	Product	L-2	L-1	L-0	L+1	L+2
Flour (g)	AH	250	250	250	250	250
Oil (g)	AH Zonnebloemolie	200	200	200	200	200
Eggs (g)	AH	250	250	250	250	250
Baking powder (g)	Dr. Oetker	9.82	9.82	9.82	9.82	9.82
Salt (g)	JOZO	0.9	0.9	0.9	0.9	0.9
Sugar (g)	Van Gilse	71.4	142.9	160.7	160.7	160.7
Sweetener (g)	Rio Sweetener liquid	0	0	7.68	38.39	77.5
Food colouring (g) 0.25%	Royal Blue Food Colouring, Déco Relief	2.0	2.1	2.2	2.3	2.4

(*continued on next page*)

Table C8 (*continued*)

Ingredients	Product	L-2	L-1	L-0	L+1	L+2
Food flavouring (g) 0.50%	JO-LA Tamarind	3.9	4.3	4.4	4.5	4.7
Sweetness concentrations across levels by weight (%)		**9.1**	**16.6**	**19.0**	**21.7**	**24.9**
3-digit random code		158	451	195	843	603

Method
Prepare the dough: 60 min.

6. Weigh ingredients in sufficient quantity for the expected number of participants.
7. Break the eggs into a bowl and beat with a fork.
8. For each level, put the flour, baking powder, salt, sugar, sweetener, oil, food flavouring, food colouring, and finish with eggs (the yolks should not be in direct contact with the sugar to prevent coagulation of yolks) into a mixing bowl.
9. Mix (whisk or spatula) to obtain a smooth mix.
10. Taste the products in the order of the range to check the progress.

Baking of cakes:

4. Put a drop of oil in the bottom of the pans and spread with a paper towel in the bottom and sides of the pans (even if they are non-stick). Identify pans.
5. Preheat oven to 180° C (100% moisture setting and fan to a minimum).
6. Bake the cakes for 20 to 30 min at 180° C.

Warning: the cooking time may vary in function of the used oven The more the cakes contain sugar, the more they tend quickly to color.
To check the baking, stick a knife in the center of the cake and check that there is not any mix on the blade.
Turning out of cakes:
Rest the cakes ten minutes and get out them from the pans.
Freezing:
Filming cakes with cellophane, identify with the code and manufacturing date.
Reheating:
Cakes should be removed the day before the session. Remove from the freezer and place in the fridge overnight.
Preparation of samples and Service:
Slice the cakes. Remove the crust from the cake and make small servings. Arrange portions on a film plate. When serving, put the portions on the plates of participants. Serve one quarter of a slice of cake each variant and participant. Note: you can use the same cake for all the sessions of the same day.

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