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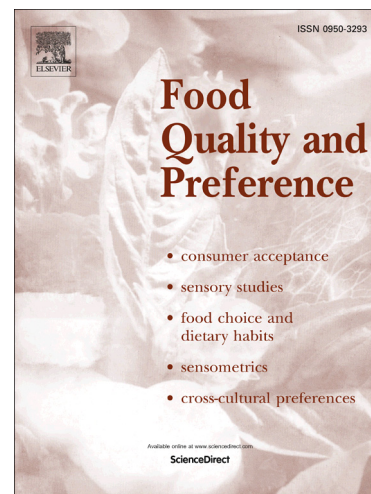
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The importance of liking of appearance, -odour, -taste and -texture in the evaluation of overall liking. A comparison with the evaluation of sensory satisfaction.

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Abstract

The response variable of *overall liking* is often used to measure consumers' overall hedonic response to food. However, little research is done to understand, if liking of all four sensory modalities; appearance, odour, taste and texture, are reflected in the evaluation of *overall liking*, or if a single sensory modality stands out and is of most importance. The term *sensory satisfaction* was recently introduced as an alternative to *overall liking* and should (at least in theory) be used by consumers as a more holistic response variable than *overall liking*. The aim of the analyses reported in the present paper were, to study the importance of the sensory modalities (liking of *appearance, odour, taste* and *texture*) in consumers' evaluation of *overall liking* and compare the findings to the importance of the sensory modalities (liking of *appearance, odour, taste* and *texture*) in consumers' evaluation of *sensory satisfaction*. The data came from a cross-over consumer case-study on apple-cherry fruit drinks (n = 67). The fruit drinks varied in: type of sweetener used, and addition of aroma and fibre. The modalities driving *overall liking* and *sensory satisfaction* were studied through slopes of a regression line relating *overall liking* and *sensory satisfaction*, respectively, to liking of the sensory modalities: *liking of appearance, -odour, -taste* and *-texture*. Results showed the steepest slope between *overall liking* and *liking of taste*, whereas the least steep slope was found for *liking of odour*. The same pattern between slopes was found for *sensory satisfaction* and *overall liking*. Therefore, it was concluded that consumers primarily paid attention to *liking of taste* (to be understood as flavour) and least attention to *liking of odour*, when evaluating *overall liking* and *sensory satisfaction*, respectively, and that consumers did not use *sensory satisfaction* as a more holistic response variable than *overall liking*.

Keywords: Sensory Satisfaction; Overall Liking; Sensory Modality; Slopes; Consumer Study.

1. Introduction

One of the most common ways to determine consumer acceptability of foods is through the measure of *overall liking*, often done via the 9-point hedonic scale developed by Peryam and Pilgrim (1957) (Lim, 2011). The term *overall liking* is scientifically understood as a holistic hedonic response, where the consumer evaluates the appeal of the sensory modalities: appearance, odour, taste as well as texture (Lawless & Heymann, 2010). Little research is done to understand, if liking of all four sensory modalities are reflected in the evaluation of *overall liking*, or if a single sensory modality stands out and is of most importance. Previous research points in the direction of *liking of taste* (understood as flavour) as the most important sensory modality for *overall liking* (Moskowitz & Krieger, 1992; 1995), indicating that the consumer do not pay equal attention to all four sensory modalities. The study of the contribution of sensory modalities in the evaluation of *overall liking* will, from a scientific perspective, help the interpretation of how participants in consumer studies utilise the term *overall liking* by answering relevant scientific questions like: When a participant says he/she likes the food, which sensory modalities are then considered? Are all sensory modalities considered equal, or do some properties drive liking more than others? A proper understanding of the most important sensory modality (or modalities) for acceptance can further guide product developers in which modalities to emphasize the most during product development.

The term *sensory satisfaction* was recently introduced as an alternative to the measure of *overall liking* when rating the sensory appeal of foods in consumer studies (Andersen, 2015; Andersen & Hyldig, 2015). The term *sensory satisfaction* has been used as a response variable in a number of studies related to the SENSWELL project (www.senswell.dk; Andersen, 2015; Andersen, Byrne, Bredie & Møller, 2017; Andersen & Hyldig, 2015; Andersen, Mielby, Viemose, Bredie, & Hyldig, 2017; Mielby, Andersen, Jensen, Kildegaard, Kuznetsova, Eggers, Brockhoff & Byrne, 2016). When measuring *sensory satisfaction*, consumers were explicitly asked to rate satisfaction based on the food's appearance, odour, taste and texture, altogether (Andersen & Hyldig, 2015). Thereby, the researcher assumes that the consumer considers all four sensory modalities; appearance, odour and texture as well as taste, and as such, the term *sensory satisfaction* can potentially be regarded a more holistic response variable than *overall liking*. Whether the response variable *sensory satisfaction* is used by consumers in the holistic way in which it is intended (incorporating an equal focus on all sensory modalities), and if the use of *sensory satisfaction* differs from *overall liking* in that regard, are not yet clarified. Such analysis will shed light on whether the measure of *sensory satisfaction* prospectively could replace the response variable *overall liking* when seeking a response variable to measure consumers' overall hedonic response to foods.

The aim of the analysis reported in this paper was to study, the importance of sensory modalities (liking of appearance, odour, taste and texture) in consumers' evaluation of *overall liking* and compare the finding to the importance of the sensory modalities (liking of *appearance, odour, taste and texture*) in consumers' evaluation of *sensory satisfaction*.

It is hypothesised that *liking of taste* is the primary sensory modality in the evaluation of *overall liking*, whereas *liking of appearance, -odour, -taste and -texture* are of equal importance in the evaluation of *sensory satisfaction*, and as such the response variable *sensory satisfaction* is used more holistically by consumers than the response variable *overall liking*.

2. Method

The data provided for the analyses in this paper comes from a consumer study focusing on acceptance of fruit drinks.

2.1 Fruit drinks

Four apple-cherry fruit drinks were used varying in: type of sweetener (sucrose vs *Stevia Rebaudiana* (Granulated Pure Circle Alpha, NP Sweet A/S, Denmark)), addition of fibres ({1-3, 1-4} PromOat® beta glucan, Sweden) and addition of lime flavour (Döhler, Germany). Product characteristics are reported in Table 1. The fruit drinks were originally developed for a series of studies on functional fruit drinks. Mielby and colleagues (Mielby, Andersen, Jensen, Kildegaard, Kuznetsova, Eggers, Brockhoff & Byrne, 2016) have presented details regarding the development of the fruit drinks. In addition to the fruit drinks described in the paper by Mielby et al (2016) a sucrose-sweetened variant was included in the present study (Suc.Fla-Fib-). The recipe for this fruit drink was, besides for the type of sweetener, the same as for the plain fruit drink sweetened with *Stevia Rebaudiana* (Stev.Fla-Fib-, Table 1).

A sensory panel conducted a descriptive analysis to clarify the sensory attributes that characterised and significantly discriminated the fruit drinks (results will be published elsewhere). For the purpose of the study reported in the present paper, we can inform that the fruit drinks were significantly different in sensory attributes related to the modalities: appearance (all $p < 0.001$), odour (all $p < 0.01$), texture (all $p < 0.001$) and flavour (all $p < 0.01$), but no significant differences was found in basic taste attributes.

Place Table 1 about here

2.2 Consumer study

A total of 67 subjects completed a randomised cross-over consumer study, 37 males and 30 females between 18 and 60 years of age. Inclusion criteria: likers of fruit drinks between 18 and 60 years of age not suffering from food allergies. Subjects should be able to participate in four sessions minimum one day apart. Fruit drinks were served as 25 ml samples in neutral plastic jars with lids. Subjects drank and evaluated all four fruit drinks four times each, once in each session. Presentation order was randomized for each session and between subjects. The fruit drinks were evaluated based on *overall liking*, *liking of appearance*, *liking of odour*, *liking of taste*, *liking of texture* and *sensory satisfaction*, in the order presented here, with the possibility of re-tasting between each evaluation. *Overall liking* was rated by asking “How much do you like the fruit drink?” and questions about liking of sensory attributes followed the form “how much do you like the ... (e.g. the appearance)?”. The variables were rated on a 9-point categorical scale labelled at the anchor points 1: “do not like at all” and 9: “like extremely”. *Sensory satisfaction* was evaluated by asking “considering the fruit drink’s appearance, odour, taste and texture altogether, how satisfied are you then?”. Ratings were collected on a 9-point categorical scale labelled at the anchor points 1: “not at all satisfied” and 9: “extremely satisfied”. The order of the questions followed the general recommendations for good practice when creating questionnaires in sensory and consumer science (Lawless, H.T. & Heymann, H., 2010) which includes; 1. To go from general to specific. As such, the question about *overall liking* was asked before asking about liking of single sensory properties. 2. To follow the logical order of perception. As such, the question about *liking of appearance* was asked before asking about *liking of odour*, *-taste* and *-texture*, respectively. 3. To check for satisfaction at the end. As such, the question about *sensory satisfaction* was asked last while taking into account the total sensory experience.

In addition to the hedonic evaluation of sensory properties, the study included questions about post-ingestive sensations after intake of the fruit drinks. These results are outside of the scope of this paper but are reported in the paper by Andersen, Mielby, Viemose, Bredie and Hyldig (2017). As the questions about post-ingestive sensations were presented in separate questionnaires answered after intake, it is unlikely that these questions had an impact on the hedonic ratings conducted during intake.

2.3 Statistical analyses

Initially, mixed models were applied to the data to study session and sample effects for each of the six variables; *overall liking*, *liking of appearance*, *-odour*, *-taste* and *-texture* respectively, and *sensory satisfaction*. Consumers were treated as random effect. Session and samples were treated as fixed effects.

The relative importance of the sensory modalities (appearance, odour, taste and texture) in consumers' evaluation of *overall liking* and *sensory satisfaction*, respectively was investigated via three steps of analyses.

In step one, the relation between liking of a sensory modality and *overall liking* and *sensory satisfaction*, respectively, was analysed. The analysis was repeated for the four sensory modalities: appearance, odour, taste and texture. To analyse the relations between liking of a sensory modality and *overall liking* and *sensory satisfaction* respectively, individual slopes of a regression line were calculated based on four corresponding (x,y) observations, one for each sample. Y was either *overall liking* or *sensory satisfaction*, and X was *liking* of one of the four sensory properties: *appearance*, *odour*, *taste* and *texture*. In all cases the observations were mean across sessions. From the individual slopes the mean slope was calculated between liking of a sensory modality and *overall liking* and *sensory satisfaction* respectively. T-tests were applied to analyse, if the respective mean slopes differed from 0. To interpret which sensory modality consumers' primarily paid attention to, relative slopes were calculated; Relative slope = "absolute value of raw modality slope" / "sum of all raw modality slopes". The relative slopes added up to 1.0. If consumers paid equal attention to liking of all four modality likings each variable had a relative slope mean of 0.25. The closer the variable lie to 1 the more attention the consumers paid to that modality liking.

In step two, it was investigated if the relation between liking of one sensory modality and *overall liking* differed from liking of another modality and *overall liking*. In this case, the slopes were compared through paired t-test to analyse if the relations differed. Comparisons were made for all possible combinations and repeated for *sensory satisfaction*.

In step three, it was investigated if the relation between liking of a sensory modality and *overall liking* differed from liking of the same sensory modality and *sensory satisfaction*. This analysis should clarify, if a sensory modality was equally considered when asking consumers to rate *overall liking* and *sensory satisfaction*. Paired t-tests were applied to compare the slopes.

All statistical analyses were conducted using R (R Core Team, 2014). For the mixed model analysis the R-packages *lme4* (Bates, Maechler, Bolker & Walker, 2014) and *lmerTest* (Kuznetsova, Brockhoff & Christensen, 2017) were used. All statistical tests were carried out with $\alpha = 0.05$.

3. Results

3.1 Product differences

No main effect of session was found for any of the variables, whereas significant main sample effect was found for all six variables: *overall liking*, *liking of appearance*, *-odour*, *-taste* and *-texture*, and *sensory satisfaction* (all p-values < 0.001). Mean hedonic scores and standard deviations can be seen from Table 2.

Place Table 2 about here

3.2 The importance of sensory modalities (appearance, odour, taste and texture) in consumers' evaluation of overall liking and sensory satisfaction, respectively.

The slopes between liking modality and *overall liking* and *sensory satisfaction*, respectively, all differed significantly from 0 (Table 3). The steepest slope between liking of a sensory modality and *overall liking* was found for *liking of taste*, whereas the least steep slope was found for *liking of odour* (Table 3). For the relation between liking of a sensory modality and *sensory satisfaction*, the steepest slope was likewise found for *liking of taste* and the least steep slope for *liking of odour* (Table 3).

Pairwise comparisons of liking of each modality in their relation to *sensory satisfaction* and *overall liking*, respectively, showed that the slope between *liking of taste* and *overall liking* and *sensory satisfaction*, respectively, differed significantly from relations between the other modality liking and *overall liking* and *sensory satisfaction*, respectively (all p-values < 0.05, results not illustrated). *Liking of appearance*, *-odour* and *-texture* did not differ in their relation to *overall liking* and *sensory satisfaction*, respectively (all p-values > 0.05, results not illustrated).

Paired t-test showed that the slope between *liking of appearance* and *overall liking* did not differ from the slope between *liking of appearance* and *sensory satisfaction* (p > 0.05, results not illustrated) The same tendency was found for the remaining three modalities; odour, taste and texture (all p-values > 0.05, results not illustrated).

Place Table 3 about here

4. Discussion

4.1 The importance of sensory modalities (*appearance, odour, taste and texture*) in consumers' evaluation of *overall liking* and *sensory satisfaction*, respectively.

The overall aim of the analyses reported in this paper were to study, the importance of liking of the sensory modalities (*appearance, odour, taste and texture*) in consumers' evaluation of *overall liking* and *sensory satisfaction*, respectively.

The relative slopes (Table 3) were used to interpret the importance of *liking of appearance, -odour, -taste and -texture* in consumers' evaluation of *overall liking* and *sensory satisfaction*. It was found that the consumers did not pay equal attention to all sensory modalities. Consumers primarily paid attention to *liking of taste*, and least attention to *liking of odour*. Therefore, the pre-analysis hypothesis of *liking of taste* being the primary sensory modality in the evaluation of *overall liking* was accepted. These results support the findings of Moskowitz and Krieger (1992; 1995), who likewise found that *liking of taste* was the primary modality determining *overall liking*. However, in the studies by Moskowitz and Krieger (1992; 1995) the response variable *liking of odour* was not included, so a direct comparison is not possible for this modality.

In the studies by Moskowitz and Krieger as well as in the present study, it is emphasised that *taste* should be understood as *flavour*, which is a combined perception of aroma and taste (and trigeminal inputs e.g. Spence, 2015). The importance of *taste* being used as *flavour* becomes evident when interpreting the results from the sensory descriptive analysis in combination with the results from consumer study. In the sensory descriptive analysis, no difference between samples was found for the basic taste attributes whereas significant differences were found for the flavour attributes (section 2.1). In the consumer study, a significant sample effect was found for *liking of taste* (section 3.1). As the conditions during the studies were the same, a difference in *liking of taste* was likely, if the basic taste attributes were different (per se or via interaction

effects) or, if the consumers' interpretation and/or use of the term *taste* differed from the sensory panels' interpretation and use of the term. As products did not differ in basic taste attributes, the study shows that consumers interpret and/or use the term *liking of taste* different from its scientific meaning (liking of basic taste attributes). Instead, the consumers interpret and/or use the term as *liking of flavour*, by combining *aroma* and *taste* in their hedonic evaluation.

Further, the study illustrates the importance of discriminating retronasal aroma perception (oral) from orthonasal aroma perception (snif) in olfaction and when studying drivers of *overall liking* (and *sensory satisfaction*). During consumers' evaluation of *liking of odour*, aroma compounds were perceived orthonasally by sniffing. In consumers' oral evaluations (liking of taste) not only basic taste compound were perceived, but also aroma compounds perceived retronasally contributed to the overall impression of flavour. In the consumer study, *overall liking* (and *sensory satisfaction*) was found mainly to be driven by *liking of taste* relative to *liking of odour*, Table 3. These results should be interpreted as, *liking of odour* equals *liking of orthonasal odour perception*, whereas the main driver of *overall liking*, *liking of taste*, equals *liking of basic taste* and *retronasal aroma perception*, and their interactions.

4.2 Sensory satisfaction a more holistic response variable than overall liking?

The results showed the same pattern between slopes for *sensory satisfaction* and *overall liking*, meaning that regardless of whether consumers were explicitly asked to consider appearance, odour, taste and texture altogether (*sensory satisfaction*) or not (*overall likings*), it did not cause a shift in how much attention the different modalities were allocated. *Liking of taste* was the primary important modality regardless of rating *overall liking* or *sensory satisfaction*. Therefore, it cannot be assumed that consumers use *sensory satisfaction* as a more holistic response variable than *overall liking* and, the present study do not give rise to a recommendation of replacing the measure of *overall liking* with the measure of *sensory satisfaction* when measuring consumers' overall acceptance of a food's sensory properties. However, in order to be able to generalise the result, more research is needed focusing on other types of products within the beverage category and other food categories.

4.3 General strengths and limitations

4.3.1 Using slopes, not correlation coefficients

Within sensory science, correlation coefficients are often used to study drivers of a variable. Correlations measure the strength of linear relationship between the two variables. Using only the correlation coefficient could result in not being able to distinguish between relationships of varying steepness that could appear with similar correlations. Therefore using correlation analysis could lead to different conclusions about the drivers of overall liking/sensory satisfaction than using slope analysis. The use of slopes to illustrate relations between variables have been applied in previous studies, and found useful for identifying sensory drivers of overall liking (Moskowitz & Krieger, 1992; 1995). Therefore, in the linear equation where liking of each sensory modality is related to *overall liking* and *sensory satisfaction* respectively, the slope of the equation measures the importance of the modality; the steeper slope the higher importance.

4.3.2 Differences between subjects

The results of the relation between liking of a sensory modality and *overall liking* (and *sensory satisfaction*) (section 3.2, Table 3) are, due to the sample size, presented as means across consumers, and as such

individual variation in modality liking mainly driving *overall liking* (and *sensory satisfaction*) is not shown. However, this does not necessarily mean that all subjects behave similar. To increase the interpretation of the results from the present study, and to indicate if individual differences can be expected in future studies (with a larger consumer groups), individual differences in liking modality driving liking (and *sensory satisfaction*) was analysed. In the analyses of individual differences, the relative slopes were calculated and ranked as described in section 2.3. Further, the percentage of consumers mainly emphasising *liking of odour*, *appearance*, *taste* and *texture* respectively, in their evaluation of *overall liking*, was calculated. The results showed that for 42% of the subjects, *liking of taste* was the most important sensory modality when evaluating *overall liking*. For 19% of the subjects the most *liking of appearance* was most important, and for 18% *liking of odour* and *texture*, respectively was most important. For 9% of the subjects *liking of taste* was the least important modality, whereas for 24%, 30% and 19% of the subjects the least important modality was *liking of appearance*, *-odour* and *-texture*, respectively. These findings show that individual differences were present and should be expected in future studies, though for the majority of subjects *liking of taste* was the primary driver of *overall liking* (and *sensory satisfaction*).

4.3.3 Generalisability of results

The results presented in the current paper come from a study using four apple-cherry fruit drinks varying in sensory characteristics (Table 2, section 2.1). Apple-cherry fruit drinks represent a narrow product category, and therefore, generalisability of the results to products with greater sensory differences can be questioned. To conclude about the generalisability of results across the broad range of fruit drinks or even the broader range of beverages, future studies will need to include more samples from the whole beverages category and analyse for consistency of results across different types of beverages. To the authors knowledge such analyses have not been conducted, besides the analyses done by Moskowitz and Krieger (1995) which, in alignment with the present study, found *liking of taste* to be the most important driver for *overall liking*.

4.3.4 Presentation order of questions in questionnaire

The fixed presentation order of the questions could potentially be regarded a limitation of the study, as the presentation order per se could have affected the relation between liking of the sensory modalities and *overall liking* and *sensory satisfaction*, respectively. One could argue that by asking about *overall liking* first and by asking about *sensory satisfaction* after liking of each of the sensory modalities, you increase the likelihood of driving the subjects attention to all sensory properties when evaluating *sensory satisfaction*. However, the phrasing of the question about *sensory satisfaction* per se should draw the subject's attention to all attributes, and therefore a biasing effect of presentation order becomes irrelevant. To elucidate if question presentation order prompt a potential bias on the results, future research could randomise the questions and study potential differences.

5. Conclusion

The present research adds to our scientific understanding of whether consumers use the response variable *overall liking* in the holistic way in which it is intended by incorporating all four sensory modalities; appearance, odour, taste and texture in their evaluation, or if the recently introduced term *sensory satisfaction* can be considered a more holistic response than *overall liking*. It was found that consumers did not pay equally attention to all sensory modalities in their rating of *overall liking* and *sensory satisfaction*, respectively. To conclude, consumers primarily paid attention to *liking of taste* (to be understood as flavour) and least attention to *liking of odour* (to be understood as orthonasal aroma perception). However, future

research will have to clarify, if this finding can be generalised across individuals, products and food categories. The relative importance of the sensory modalities (appearance, odour, taste and texture) did not differ between the evaluation of *overall liking* and *sensory satisfaction*. Therefore, it can be concluded that consumers did not use *sensory satisfaction* as a more holistic response variable than *overall liking*.

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ACCEPTED MANUSCRIPT

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Table 1. Fruit drink characteristics

Product	Sweetener	Level of added lime flavour	Level of added fibre
Suc.Fla-Fib-*	Sucrose, (26g/L)	0g	0g
Stev.Fla-Fib-*	Stevia, (0.09g/L)	0g	0g
Stev.Fla+Fib-*	Stevia, (0.09g/L)	1ml/L	0g
Stev.Fla+Fib+*	Stevia, (0.09g/L)	1 ml/L	10g/L

*Product name interpretation. Suc. = Sucrose, Stev. = Stevia, Fla.=Flavour, Fib = Fibre, “-” = none, and “+” = present
E.g. Suc.Fla-Fib- = A sucrose sweetened fruit drink with no added lime flavour and no added fibres

Table 2. Mean hedonic scores and standard deviations for fruit drinks across sessions. Means with common superscripts (^{a, b}) within a row do not differ significantly ($p > 0.05$).

	Stev.Fla-Fib-*	Stev.Fla+Fib-*	Stev.Fla+Fib+*	Suc.Fla-Fib-*
Overall liking	6.5 (± 1.2) ^a	6.1 (± 1.6) ^{ab}	5.6 (± 1.8) ^b	6.6 (± 1.4) ^a
Liking appearance	6.7 (± 1.2) ^a	6.7 (± 1.2) ^a	5.7 (± 1.5) ^b	6.7 (± 1.2) ^a
Liking odour	6.3 (± 1.2) ^{ab}	6.0 (± 1.5) ^{ab}	5.7 (± 1.8) ^b	6.4 (± 1.1) ^a
Liking taste	6.5 (± 1.5) ^a	6.1 (± 1.7) ^{ab}	5.6 (± 1.8) ^b	6.6 (± 1.4) ^a
Liking texture	6.8 (± 1.1) ^a	6.7 (± 1.2) ^a	5.7 (± 1.8) ^b	6.9 (± 1.1) ^a
Sensory satisfaction	6.3 (± 1.5) ^a	6.0 (± 1.7) ^{ab}	5.4 (± 1.8) ^b	6.4 (± 1.5) ^a

*Product name interpretation. Suc. = Sucrose, Stev. = Stevia Rebaudiana, Fla.=Flavour, Fib = Fibre, “-” = none, and “+” = present E.g. Suc.Fla-Fib- = A sucrose sweetened fruit drink with no added lime flavour and no added fibres

Table 3. Raw and relative mean slopes between liking of: appearance, odour, taste and texture respectively, and sensory satisfaction and overall liking respectively. Slopes differed from 0, when $p < 0.05$

	t	Sensory satisfaction				t	Overall liking			
		95% CI	p-value	Raw mean slope	Relative mean slope		95% CI	p-value	Raw mean slope	Relative mean slope
Appearance	5.01	0.33 – 0.76	< 0.000	0.54	0.23	4.58	0.29 – 0.73	< 0.000	0.51	0.21
Odour	2.33	0.06 – 0.72	= 0.023	0.39	0.16	2.85	0.12 – 0.67	= 0.006	0.40	0.17
Taste	11.11	0.72 – 1.03	< 0.000	0.88	0.37	16.54	0.77 – 0.98	< 0.000	0.87	0.36
Texture	4.02	0.28 – 0.83	< 0.000	0.55	0.23	4.83	0.36 – 0.86	< 0.000	0.61	0.25

Highlights

- The importance of sensory modalities in overall liking have been understood
- The importance of sensory modalities in sensory satisfaction have been understood
- Consumers primarily paid attention to liking of taste (understood as flavour)
- Overall liking and sensory satisfaction are used equally holistic by consumers

ACCEPTED MANUSCRIPT