BRAZILIAN JOURNAL OF FOOD TECHNOLOGY

ISSN 1981-6723
Online version

ORIGINAL ARTICLE

Measurement properties of an assay measuring suprathreshold intensity and acceptability for chicken broth containing different amounts of sodium chloride

Jean-François Giguère[1,2]*, Samuel-Claude Pelletier[1,2], Michel Doré[1,2], Maria-Cécilia Gallani[1,2]

[1]Université Laval, Faculté des Sciences Infirmières, Québec/QC - Canada

[2]Université Laval, Centre de Recherche de l'Institut Universitaire de Cardiologie et de Pneumologie de Québec, Québec/QC - Canada

***Corresponding Author:** Jean-François Giguère, Université Laval, Sciences Infirmières, Avenue de la Médecine, 1050, Université Laval Québec G1V 0A6, Quebec/QB - Canada, e-mail: jean-francois.giguere@fsi.ulaval.ca

Cite as: Giguère, J. F., Pelletier, S. C., Doré, M., & Gallani, M. C. (2023). Measurement properties of an assay measuring suprathreshold intensity and acceptability for chicken broth containing different amounts of sodium chloride. *Brazilian Journal of Food Technology*, *26*, e2022127. https://doi.org/10.1590/1981-6723.12722

Abstract

It was assessed the reliability of an assay aimed at measuring the suprathreshold intensity and acceptability for chicken broth containing different amounts of sodium chloride, according to the criteria of temporal stability, among adults. Both intensity and acceptability were measured using a 9-point scale ("not salty at all" to "extremely salty" for intensity and "dislike it extremely" to "like it extremely" for acceptability). Results indicated that the intensity ratings increased gradually throughout the nine concentrations ranging from 1.7 to 7.9. The highest level of acceptability corresponds to the concentration of 255 mg of Na/100ml with a rating score of 6.3. The intensity and acceptability values varied greatly among concentration and participants. The temporal stability was assessed over a period of 7 to 15 days. There was no statistically significant difference between the two sessions for the suprathreshold and acceptability scores, regardless of the concentration. The Intraclass Correlation Coefficient (ICC) was significant for one concentration in the intensity scores (ICC = 0.54) and for 4 out of 6 concentrations of the acceptability scores, varying from 0.35 to 0.64. The test covers a range of concentrations consistent with sodium levels found in commercially available products. Due to the limited number of subjects in this study, further work is needed to better describe its measurement properties.

Keywords: Taste properties; Perception; Hedonic; Salt; Sodium chloride; Reliability.

Highlights

- Suprathreshold intensity and acceptability showed great variability from one sodium concentration to another
- Maximum acceptability was attained for Campbell's 30% Less Sodium Chicken Broth
- Results inform the number of subjects needed for future studies

1 Introduction

Excessive salt (sodium chloride) intake remains a major public health problem and is the target of many organizations, such as the World Health Organization (WHO) with its global strategy on diet, physical activity, and health, for which reduction of salt remains a primary objective (Waxman, 2004; World Health Organization, 2020). The average salt intake around the world is estimated at 10 grams per day (World Health Organization, 2020), exceeding by twofold the recommended maximum intake of 5 grams/day (World Health Organization, 2012; O'Donnell et al., 2020). Excessive dietary salt intake is associated with blood pressure elevation, which is also a major risk factor for stroke and other cardiovascular pathologies as well as kidney disease and long-term mortality (Cook et al., 2016; Tagawa et al., 2021). Also, salt intake is associated with B-type natriuretic peptide levels, which may constitute a surrogate marker reflecting salt-induced heart diseases (Ohashi et al., 2021). On the other hand, a reduction in dietary salt intake leads to a considerable reduction in blood pressure, especially in hypertensive patients (He et al., 2013).

A better understanding of factors influencing salt consumption - whether at an individual or population level - is essential in developing effective interventions aimed at reducing salt intake. Among these factors, eating behavior, which includes the consumption of salty foods, is a complex phenomenon that is influenced by several factors. These factors include psychological, cultural, socioeconomic, and environmental components, as well as dietary habits, sensory properties, and acceptability/preference for certain kinds of foods. Moreover, people differ in their sensory functions due to genetic, physiological (e.g., gender, aging, hormones), and dietary/nutritional factors that contribute to the diversity of consumer preferences (Barragán et al., 2018; Chamoun et al., 2018; Dias et al., 2013; Donaldson et al., 2009; Methven et al., 2012; Noh et al., 2013; Tepper, 2008).

Interestingly, by enhancing other aromatic ingredients and reducing bitterness, sodium contributes substantially to the taste of food and increases acceptance (Dötsch et al., 2009). Human salt taste receptors can, however, adapt to low salt concentrations (Blais et al., 1986), making it possible to achieve small, stepwise reductions in sodium content in food without altering acceptance. After 2 to 3 months of sodium restriction, the acceptance of low-sodium foods increases, and the level of preferred salt in food decreases (Mattes, 1997). Achieving these results requires a deeper understanding of the complex relationship between the sensory properties of salt and its consumption.

Some studies have investigated the link between actual salt intake and sensory properties for salt taste, such as detection and recognition thresholds, suprathreshold intensity, and preference/acceptability for salty foods. Other studies have attempted to assess the impact of a modification to salt consumption on

different sensory properties. Thus, some authors have observed that a reduction in salt intake over a few months resulted in an increase in the suprathreshold for salty foods, as well as a decrease in appreciation for these same foods (Bertino et al., 1982, 1986). Bertino et al. (1986) also observed the opposite effect during an increased salt intake over a few weeks. Other authors have found that a decrease in the sodium diet over a few weeks or months resulted in an increased preference for a low-salt food, without modifications in the detection or recognition thresholds (DiNicolantonio et al., 1984; Gillum et al., 1981). However, one study failed to establish the effect of changing the salt diet on sensory properties (Bobowski & Mennella, 2019).

On the other hand, some studies have instead sought to know whether the inter-individual differences that exist in sensory properties resulted in a different salt intake. The study conducted by Cattaneo et al. (2019) demonstrated that individuals with a higher recognition threshold for salt consumed more salty foods. Cho et al. (2016) have substantiated that groups presenting higher detection and recognition thresholds, as well as an increased preference for salt, demonstrated greater salt consumption. This observation was also shown for patients with renal impairment, i.e. a positive correlation between preference for salty foods and salt consumption (Kim et al., 2016, 2018). Interestingly, high thresholds for salt perception were recently reported to be inversely associated with salt intake and blood pressure, suggesting a relationship between salt taste properties, salt consumption, and blood pressure (Kudo et al., 2021).

Other studies such as Hayes et al. (2010) highlighted the complex relationship between certain phenotypes comprising taste papillae number, sensitivity to bitterness (PROP status), suprathreshold for salt, preference for salty foods, and actual salt consumption. These authors suggest that the taste papillae number, as well as the ability to perceive bitterness positively influences the suprathreshold for salt and acceptability for salty foods, and conclusively, the consumption of salt per se.

Likewise, some researchers have suggested that individual differences in sensory properties for salt - such as detection and recognition threshold and suprathreshold intensity, as well as the acceptability/preference for salty foods could influence salt intake and thus impact blood pressure and cardiovascular disease (CVD) risk (Hayes et al., 2010; Drewnowski et al., 1996; Fischer et al., 2012; Kim et al., 2017; Pilic & Mavrommatis, 2018).

However, some studies have failed to establish a relationship between sensory properties and actual salt consumption (Drewnowski et al., 1996; Kim et al., 2017; Pilic & Mavrommatis, 2018; Inoue et al., 2017; Kubota et al., 2018). The lack of consensus may be due to insensitivity in methods used to assess sodium intake (Mattes, 1997) or in the variations of methods chosen to evaluate the salt sensitivity phenotype as well as their measurement properties. Thus, the real impact of individual sensory differences for salt, preference/acceptability for salty foods, actual salt intake, and the associated cardiovascular risk deserve to be investigated.

It is recommended that assays used to characterize sensory properties be first evaluated for their measurement properties (Köster et al., 2003). Accordingly, this study assesses the reliability based on the criteria of temporal stability of a simple and practical assay measuring both suprathreshold intensity and acceptability for chicken broth containing different sodium chloride concentrations. These tests will be useful for studies intending to explore the relationship between hedonic aspects and salt intake.

2 Materials and methods

2.1 Subjects and test conditions

Thirty nonsmoking adults participated in this study. Three subjects were excluded from the analysis because they did not receive the samples in the pre-established order during the retest. Consequently, 27 subjects were analyzed (9 males, 18 females; average age = 38.9 years, Standard Deviation (SD) = 11.8; ranging from 21 to 64). Subjects with anosmia/ageusia or problems affecting the taste function (such as flu-like syndrome) at the time of enrollment were excluded from the study. No subjects had prior involvement with the measurement of taste thresholds. Subjects completed the test–retest within 6 to 17 days (mean of 9.3 days, SD = 3.4). Before the test, subjects were advised that fasting was not necessary, but that they had to restrain from eating, drinking, chewing, or brushing their teeth at least 1 hour before the procedure; water was permitted. The tests were conducted in a quiet and private room equipped with a sensory analysis booth, in order to eliminate auditory and other sensory stimulation, as recommended in international guidelines for sensory analysis (Association Française de Normalisation, 1987). Room temperature was controlled at 22 °C. The duration of the assay, performed one subject at a time, was approximately 10 to 15 minutes.

2.2 Materials

The chloride sodium was purchased from Merck (EMPROVE® EXPERT Ph Eur, BP, JP, USP) and broth is the Campbell's chicken broth (no salt added; 27 mg of sodium/100 ml). The water used for rinsing was purchased from Puretap Water Distillers Ltd. (Mississauga, Ontario).

2.3 Acceptability (hedonic) and suprathreshold intensity for salty foods

Suprathreshold intensity and acceptability (hedonic) for salty foods were assessed using chicken broth containing six different concentrations of sodium (27 (no salt added), 140, 255, 370, 485, and 714 mg of Na/100 ml). All six concentrations were presented monadically (i.e., one at a time) to participants in a counterbalanced order. The first concentration was repeated at the end to reduce the effect of the serving order. In total, seven samples were given, yet the first one was discarded from analysis (Lawless & Heymann, 2010). The sample was the same for each participant in both sessions. Each sample contained 10 mL of preheated (70 °C) chicken broth served in 30 mL plastic cups. For each sample, participants were asked to assess the intensity of saltiness (intensity scale) and the degree of acceptability (hedonic scale) according to a 9-point category scale (Lawless & Heymann, 2010). For the saltiness intensity, the scale was graduated from “not salty at all” to “extremely salty” while the acceptability scale was graduated from “dislike it extremely” to “like it extremely”. The participants were asked to rinse their mouths with distilled water between each sample and wait 30 seconds after swallowing each solution.

2.4 Ethical aspects

This project was approved by the local ethics committee (2013-2127, 20908), and all participants provided a written informed-consent form (ICF). The participants received no financial compensation. Our study complies with the *Declaration of Helsinki for Medical Research Involving Human Subjects*.

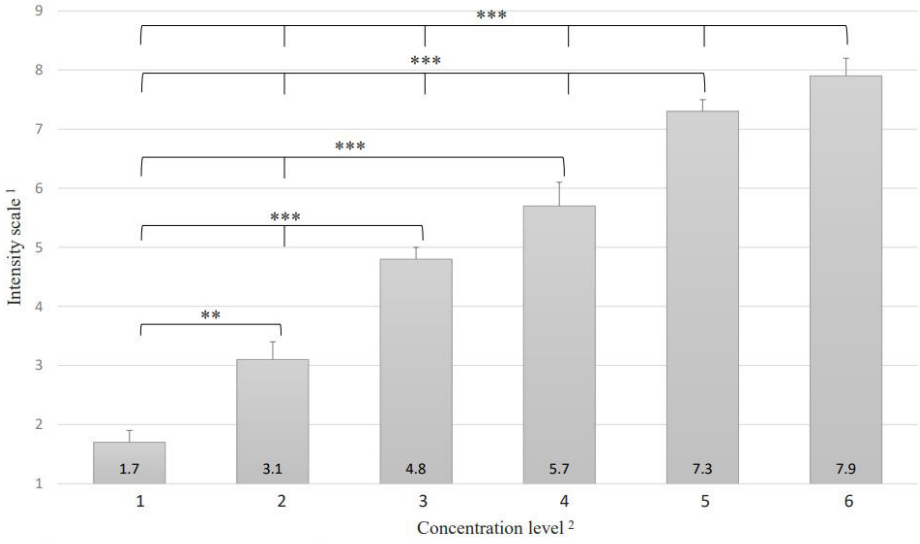
2.5 Data analysis

All the results obtained were doubly entered in a database created in the REDCap international database. SPSS statistical package, version 23, (SPSS Inc, Chicago, IL) was used to analyze the data. Data were descriptively analyzed and then the measurement properties were assessed. For the analyses, the data from the 9-point category scales were assigned values of one through nine and then analyzed using parametric statistics. The proportion of agreement between the test and retest results was estimated for both the suprathreshold intensity and acceptability using a paired t-Test to assess the difference between the means scores and Intraclass Correlation Coefficient (ICC). ICC estimates and the 95% of Confident Intervals (CI) were calculated based on a single measurement, absolute-agreement, two-way, mixed-effects model. Values less than 0.5 are indicative of poor reliability, values between 0.5 and 0.75 indicate moderate reliability, values between 0.75 and 0.9 indicate good reliability, and values greater than 0.90 indicate excellent reliability (Watkins, 2009).

3 Results

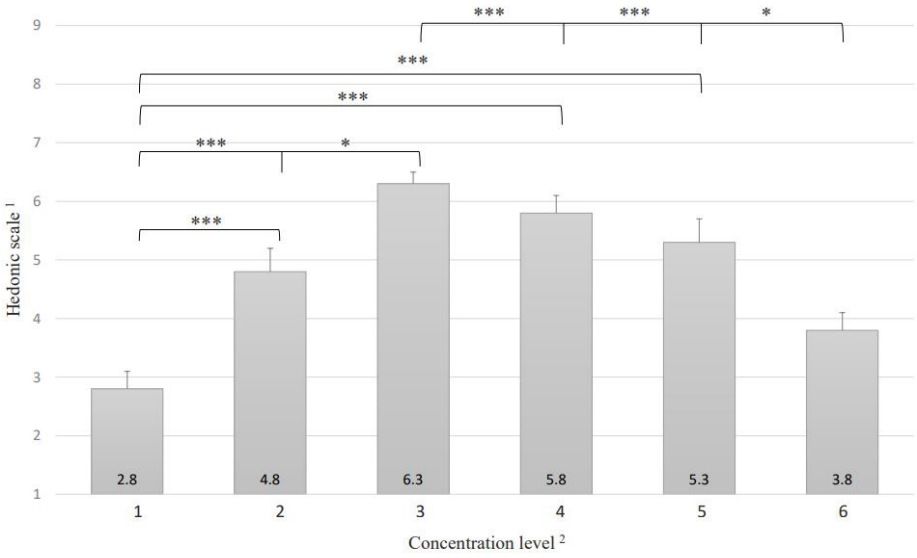
3.1 Intensity and acceptability rating

Figure 1 shows the results for perceived suprathreshold intensity (Figure 1A) and acceptability (Figure 1B) for the six chicken broth samples containing increasing sodium chloride concentration (data obtained during the first session). The perceived salt intensity increased continuously with higher salt concentrations, ranging from an average of 1.7 for the lowest to 7.9 for the highest. For acceptability, the relationship between liking and sodium concentrations forms an inverted U shape. The level of appreciation increased first to a maximum of 6.3 at a concentration of 255 mg of Na/100 ml of chicken broth and decreased thereafter.



Statistical analyses are one-way ANOVA with the Tukey-Kramer adjustment for multiple comparisons in a MIXED model due to the heterogeneity of variance. $^{**}P<0.01$; $^{***}P<0.001$.
[1] Intensity scale : 1 = "not salty at all" and 9 = "extremely salty".
[2] Concentration level : 1 = 27, 2 = 140, 3 = 255, 4 = 370, 5 = 485 and 6 = 714 mg of Na/100 ml of broth.

Figure 1A. Perceived intensity of broth's salty taste according to sample's concentration.



Statistical analyses are one-way ANOVA with the Tukey-Kramer adjustment for multiple comparisons in a MIXED model due to the heterogeneity of variance. *P<0.05; **P<0.01; ***P<0.001.
[1] Hedonic scale : 1 = "dislike it extremely" and 9 = "like it extremely" .
[2] Concentration level : 1 = 27, 2 = 140, 3 = 255, 4 = 370, 5 = 485 and 6 = 714 mg of Na/100 ml of broth.

Figure 1B. Appreciation of the broth according to the sample's concentration.

3.2 Reliability of the assay

The temporal stability was assessed for both intensity and acceptability ratings. Table 1 gives the mean ± SD of the intensity and acceptability scores for each salt concentration in sessions 1 and 2, the absolute difference of the scores between both sessions, as well as the associated ICC (95% CI) for each concentration. There was no statistically significant difference in the scores of suprathreshold and acceptability between the two sessions no matter the concentration. Regarding the ICC, for the intensity scores, it was significant only for the concentration of 255 mg of Na/100 ml (ICC = 0.54 with 95% CI = 0.21-0.76). For the acceptability scores, the agreement was confirmed for 4 out of 6 concentrations and ranges from poor to good reliability (ICC = 0.35 with 95% CI = -0.01-0.63 for the concentration of 255 mg of Na/100 ml to ICC = 0.64 with 95% CI = 0.34-0.82 for the concentration of 140 mg of Na/100 ml).

Table 1. Suprathreshold intensity and acceptability at sessions 1 and 2 and the associated Intraclass Correlation Coefficient (ICC).

Sodium concentration (mg/100ml)	Session	Suprathreshold intensity			Acceptability		
		Mean Score ± SD	Absolute difference between sessions	Intraclass Correlation Coefficient (95% CI)	Mean Score ± SD	Absolute difference between sessions	Intraclass Correlation (95% CI)
27	Session 1	1.7 ± 1.0	$\|0.3\|^{NS}$	0.21 (-0.19, 0.55)	2.8 ± 1.5	$\|0.5\|^{NS}$	0.52 (0.18, 0.75)*
	Session 2	2.0 ± 1.4			3.3 ± 2.1		
140	Session 1	3.1 ± 1.5	$\|0.2\|^{NS}$	0.29 (-0.10, 0.60)	4.8 ± 2.1	$\|0.0\|^{NS}$	0.64 (0.34, 0.82)*
	Session 2	2.9 ±1.2			4.8 ± 1.9		
255	Session 1	4.8 ± 1.2	$\|0.2\|^{NS}$	0.54 (0.21, 0.76)*	6.3 ± 1.2	$\|0.5\|^{NS}$	0.35 (-0.01, 0.63)*
	Session 2	4.6 ± 2.0			5.8 ± 1.8		
370	Session 1	5.7 ± 1.9	$\|0.1\|^{NS}$	0.13 (-0.27, 0.49)	5.8 ± 1.7	$\|0.1\|^{NS}$	0.30 (-0.10, 0.61)
	Session 2	5.8 ± 1.8			5.7 ± 1.8		
485	Session 1	7.3 ± 1.1	$\|0.7\|^{NS}$	0.05 (-0.29, 0.40)	5.3 ± 2.1	$\|0.6\|^{NS}$	0.13 (-0.25, 0.47)
	Session 2	6.6 ± 1.8			4.7 ± 1.7		
714	Session 1	7.9 ± 1.4	$\|0.3\|^{NS}$	-0.01 (-0.38, 0.37)	3.8 ± 1.8	$\|0.1\|^{NS}$	0.53 (0.18, 0.75)*
	Session 2	8.2 ± 0.9			3.7 ± 1.9		

^{NS}: Not statistically significant (p-value > 0.05). *p-value < 0.05.

4 Discussion

The purpose of this study was to develop and document the reliability of an assay aimed at measuring the perceived suprathreshold intensity and the acceptability of a chicken broth containing increasing concentrations of table salt. This assay was developed using a commercial chicken broth (Campbell's No Salt Added Ready to Use Chicken Broth) to which increasing amounts of salt were added. The resultant concentrations ranged from no-salt added (27 mg of sodium/100 mL of broth), 30% less sodium broth (255 mg of sodium/100 mL of broth), and regular sodium broth (370 mg of sodium/100 mL of broth) to levels far above those typically found in commercial products (up to 714 mg of sodium/100 mL of broth) but below the level at which salt is an oral irritant (> 0.4 M or about 900 mg of Na/100 ml) (Green & Gelhard, 1989).

We observed an increase in the perceived intensity throughout the 6 concentrations presented, ranging between 1.7 and 7.9. This indicated that the range of concentrations selected for the assay was appropriate to cover low to high salt perceived intensity. Concerning the acceptability, a past study reported that the relationship between liking and sodium concentration takes the shape of an inverted U for liquid foods such as broth: liking is initially low before rising to a peak and subsequently falling (Hayes et al., 2010). Our results corroborated this observation. Interestingly, the two concentrations at which the maximum acceptability was obtained (the third and the fourth concentrations corresponding to 255 and 370 mg sodium/100 mL, respectively) corresponded to the concentration of Campbell's 30% Less Sodium Chicken Broth and the regular Campbell's Sodium Chicken Broth products. More specifically, the concentration with the highest acceptability in our study (255 of Na/100 ml) corresponded to the WHO global sodium benchmark for soups, which reinforces the consistency of our test with the values targeted for consumption (World Health Organization, 2021).

Our data regarding repeatability indicate that the agreement is most frequently observed for the acceptability scores. The non-significance of poor to moderate ICC obtained in this study could be either due to the lack of variability among the subjects, the small number of subjects, or both in addition to the low degree of measurement agreement between the two sessions (Koo & Li, 2016). In a recent study, Wanich et al. (2018) assessed the reliability at one week interval of a 9-point category scale used for liking assessment of ten food products tasted in the laboratory. The ICC obtained in this study varied from 0.55 to 0.85. Interestingly, some authors tried to explain the reasons for the discrepancies observed between the initial impression of a product and its final appreciation (Köster et al., 2003). They first point out that this change of preference over time would be more important for new and unfamiliar products. Second, saltiness perception and acceptability/preference for salt depends on the matrix (for example, distilled water, aqueous or solid food products) to which salt is added. To be relevant, studies aimed at establishing relationships between sensory properties and salt consumption need to focus on foods widely consumed by the target population. Our trial focused on a product (chicken broth) very familiar to and frequently consumed by the study population.

This study presents notable strengths. One is the choice of the product used for the test. Chicken broth is an item consumed by most of our population, which therefore facilitates its acceptability. In addition, its matrix is a homogenous liquid simplifying the standardization of the sample preparation and presentation to participants. Furthermore, another strength point remains in the use of a counterbalanced

order method to present the samples: the six different concentrations and the repetition of the first concentration as a seventh sample while eliminating the first sample from the analysis reduces the effect of serving order (Lawless & Heymann, 2010). Lastly, the 9-point scale is very simple to use and to implement. It has been widely studied and has been shown to be useful in the hedonic assessment of foods and beverages (Lawless & Heymann, 2010).

A major limitation of this study is the insufficient number of subjects needed to compare the samples to each other. Hough et al. proposed an approach for calculating the number of subjects necessary for sensory acceptability studies in which standard error and difference in means targeted in the experiment are considered as two important parameters (Hough et al., 2006). Based on a power of 0.90 and alpha of 0.05, when using a 9-point scale, the number of subjects needed to detect a difference of 0.8 with a standard error of 1.84 is 112 subjects. In our study, differences in rating scores between samples varied from 0.5 to 3.5 on the 9-point scale, and the standard error varied from 1.2 to 2.1 (see Table 1). Thus, 27 subjects is insufficient to detect a statistically significant difference for acceptability between chicken broth containing 255 *versus* 370 mg of Na/100 ml, considering the small difference of 0.5 in the rating score and a standard error of 1.2 to 1.7 in this experiment. The results of our study, however, inform us on important parameters that will be useful in estimating the number of subjects needed for future studies. Interestingly, the results of the study demonstrate the feasibility of performing the test in a large number of subjects due to its rapidity, as well as its simplicity. These data are essential for planning future studies.

Conflicting results exist regarding the relationship between sensory functions such as detection and recognition thresholds and suprathreshold intensity, appreciation for salty foods and their actual consumption (Hayes et al., 2010; Drewnowski et al., 1996; Fischer et al., 2012). A better characterization of the psychometric properties of these tools is essential to interpret critically the results obtained. The test developed in our study is easy and quick to perform. It also measures two important properties to be considered, namely suprathreshold and acceptability of salty foods. The test covers a range of concentrations compatible with commercially available sodium levels.

5 Conclusion

The simple and easy assay to assess the hedonic aspect of salt intake by measuring the suprathreshold intensity and acceptability for chicken broth containing different amounts of salt, demonstrated initial evidence of reliability according to the temporal stability criterion. Due to the limited number of subjects in this study, further work is needed to better describe its measurement properties.

Acknowledgements

The authors acknowledge the contribution of Sébastien Tousignant for English language editing of the manuscript.

References

Association Française de Normalisation – AFNOR. (1987). *NF V09-105 1987: Analyse sensorielle –Directives générales pour l'implantation de locaux destinés à l'analyse sensorielle*. Paris: AFNOR.

Barragán, R., Coltell, O., Portoles, O., Asensio, E. M., Sorli, J. V., Ortega-Azorin, C., Gonzalez, J. I., Saiz, C., Fernandez-Carrion, R., Ordovas, J. M., & Corella, D. (2018). Bitter, sweet, salty, sour and umami taste perception decreases with age: sex-specific analysis, modulation by genetic variants and taste-preference associations in 18 to 80 year-old subjects. *Nutrients*, *10*(10), 1539. PMid:30340375. http://dx.doi.org/10.3390/nu10101539

Bertino, M., Beauchamp, G. K., & Engelman, K. (1982). Long-term reduction in dietary sodium alters the taste of salt. *The American Journal of Clinical Nutrition*, *36*(6), 1134-1144. PMid:7148734. http://dx.doi.org/10.1093/ajcn/36.6.1134

Bertino, M., Beauchamp, G. K., & Engelman, K. (1986). Increasing dietary salt alters salt taste preference. *Physiology & Behavior*, *38*(2), 203-213. PMid:3797487. http://dx.doi.org/10.1016/0031-9384(86)90155-1

Blais, C. A., Pangborn, R. M., Borhani, N. O., Ferrell, M. F., Prineas, R. J., & Laing, B. (1986). Effect of dietary sodium restriction on taste responses to sodium chloride: A longitudinal study. *The American Journal of Clinical Nutrition*, *44*(2), 232-243. PMid:3728360. http://dx.doi.org/10.1093/ajcn/44.2.232

Bobowski, N., & Mennella, J. A. (2019). Repeated exposure to low-sodium cereal affects acceptance but does not shift taste preferences or detection thresholds of children in a randomized clinical trial. *The Journal of Nutrition*, *149*(5), 870-876. PMid:31006818. http://dx.doi.org/10.1093/jn/nxz014

Cattaneo, C., Riso, P., Laureati, M., Gargari, G., & Pagliarini, E. (2019). Exploring associations between interindividual differences in taste perception, oral microbiota composition, and reported food intake. *Nutrients*, *11*(5), 11. PMid:31137674. http://dx.doi.org/10.3390/nu11051167

Chamoun, E., Mutch, D. M., Allen-Vercoe, E., Buchholz, A. C., Duncan, A. M., Spriet, L. L., Haines, J., & Ma, D. W. L. (2018). A review of the associations between single nucleotide polymorphisms in taste receptors, eating behaviors, and health. *Critical Reviews in Food Science and Nutrition*, *58*(2), 194-207. PMid:27247080. http://dx.doi.org/10.1080/10408398.2016.1152229

Cho, H., Kim, S. M., Jeong, S. S., & Kim, S. B. (2016). Comparison of salt taste thresholds and salt usage behaviours between adults in Myanmar and Korea. *Asia Pacific Journal of Clinical Nutrition*, *25*(4), 879-884. PMid:27702732.

Cook, N. R., Appel, L. J., & Whelton, P. K. (2016). Sodium intake and all-cause mortality over 20 years in the trials of hypertension prevention. *Journal of the American College of Cardiology*, *68*(15), 1609-1617. PMid:27712772. http://dx.doi.org/10.1016/j.jacc.2016.07.745

Dias, A. G., Rousseau, D., Duizer, L., Cockburn, M., Chiu, W., Nielsen, D., & El-Sohemy, A. (2013). Genetic variation in putative salt taste receptors and salt taste perception in humans. *Chemical Senses*, *38*(2), 137-145. PMid:23118204. http://dx.doi.org/10.1093/chemse/bjs090

DiNicolantonio, R., Teow, B. H., & Morgan, T. O. (1984). Sodium detection threshold and preference for sodium chloride in humans on high and low sodium diets. *Clinical and Experimental Pharmacology & Physiology*, *11*(4), 335-338. PMid:6518662. http://dx.doi.org/10.1111/j.1440-1681.1984.tb00273.x

Donaldson, L. F., Bennett, L., Baic, S., & Melichar, J. K. (2009). Taste and weight: Is there a link? *The American Journal of Clinical Nutrition*, *90*(3), 800s-803s. PMid:19571216. http://dx.doi.org/10.3945/ajcn.2009.27462Q

Dötsch, M., Busch, J., Batenburg, M., Liem, G., Tareilus, E., Mueller, R., & Meijer, G. (2009). Strategies to reduce sodium consumption: A food industry perspective. *Critical Reviews in Food Science and Nutrition*, *49*(10), 841-851. PMid:19960392. http://dx.doi.org/10.1080/10408390903044297

Drewnowski, A., Henderson, S. A., Driscoll, A., & Rolls, B. J. (1996). Salt taste perceptions and preferences are unrelated to sodium consumption in healthy older adults. *Journal of the American Dietetic Association*, *96*(5), 471-474. PMid:8621872. http://dx.doi.org/10.1016/S0002-8223(96)00131-9

Fischer, M. E., Cruickshanks, K. J., Pinto, A., Schubert, C. R., Klein, B. E., Klein, R., Nieto, F. J., Pankow, J. S., Snyder, D. J., & Keating, B. J. (2012). Intensity of salt taste and prevalence of hypertension are not related in the beaver dam offspring study. *Chemosensory Perception*, *5*(2), 139-145. PMid:22745848. http://dx.doi.org/10.1007/s12078-012-9118-8

Gillum, R. F., Prineas, R. J., Anderson, P., & Kebede, J. (1981). Lack of response of salt taste threshold and preference to dietary sodium restriction in mild hypertension. *American Heart Journal*, *102*(1), 138. PMid:7246407. http://dx.doi.org/10.1016/0002-8703(81)90430-0

Green, B. G., & Gelhard, B. (1989). Salt as an oral irritant. *Chemical Senses*, *14*(2), 259-271. http://dx.doi.org/10.1093/chemse/14.2.259

Hayes, J. E., Sullivan, B. S., & Duffy, V. B. (2010). Explaining variability in sodium intake through oral sensory phenotype, salt sensation and liking. *Physiology & Behavior*, *100*(4), 369-380. PMid:20380843. http://dx.doi.org/10.1016/j.physbeh.2010.03.017

He, F. J., Li, J., & Macgregor, G. A. (2013). Effect of longer term modest salt reduction on blood pressure: Cochrane systematic review and meta-analysis of randomised trials. *BMJ (Clinical Research Ed.)*, *346*(3), f1325. PMid:23558162. http://dx.doi.org/10.1136/bmj.f1325

Hough, G., Wakeling, I., Mucci, A., Chambers 4th, E., Gallardo, I., & Alves, L. (2006). Number of consumers necessary for sensory acceptability tests. *Food Quality and Preference*, *17*(6), 522-526. http://dx.doi.org/10.1016/j.foodqual.2005.07.002

Inoue, H., Kuwano, T., Yamakawa-Kobayashi, K., Waguri, T., Nakano, T., & Suzuki, Y. (2017). Perceived 6-n-Propylthiouracil (PROP) bitterness is associated with dietary sodium intake in female Japanese college students. *Journal of Nutritional Science and Vitaminology*, *63*(3), 167-173. PMid:28757530. http://dx.doi.org/10.3177/jnsv.63.167

Kim, C. Y., Ye, M. K., & Lee, Y. S. (2017). The salt-taste threshold in untreated hypertensive patients. *Clinical Hypertension*, *23*(1), 22. PMid:29163986. http://dx.doi.org/10.1186/s40885-017-0079-8

Kim, S. M., Kim, M., Lee, E. K., Kim, S. B., Chang, J. W., & Kim, H. W. (2016). The effect of zinc deficiency on salt taste acuity, preference, and dietary sodium intake in hemodialysis patients. *Hemodialysis International. International Symposium on Home Hemodialysis*, *20*(3), 441-446. PMid:26833639. http://dx.doi.org/10.1111/hdi.12388

Kim, T. H., Kim, Y. H., Bae, N. Y., Kang, S. S., Lee, J. B., & Kim, S. B. (2018). Salty taste thresholds and preference in patients with chronic kidney disease according to disease stage: A cross-sectional study. *Nutrition & Dietetics: the Journal of the Dietitians Association of Australia*, *75*(1), 59-64. PMid:28791790. http://dx.doi.org/10.1111/1747-0080.12374

Koo, T. K., & Li, M. Y. (2016). A guideline of selecting and reporting intraclass correlation coefficients for reliability research. *Journal of Chiropractic Medicine*, *15*(2), 155-163. PMid:27330520. http://dx.doi.org/10.1016/j.jcm.2016.02.012

Köster, E. P., Couronne, T., Léon, F., Lévy, C., & Marcelino, A. S. (2003). Repeatability in hedonic sensory measurement: A conceptual exploration. *Food Quality and Preference*, *14*(2), 165-176. http://dx.doi.org/10.1016/S0950-3293(02)00075-7

Kubota, Y., Higashiyama, A., Sugiyama, D., Nishida, Y., Kubo, S., Hirata, T., Kadota, A., Miyamatsu, N., Wakabayashi, I., Miyamoto, Y., & Okamura, T. (2018). Association between impairment of salty taste recognition and masked hypertension based on home blood pressure in Japanese residents: The KOBE study. *Hypertension Research*, *41*(9), 756-762. PMid:30054590. http://dx.doi.org/10.1038/s41440-018-0074-9

Kudo, A., Kitamura, A., Imano, H., Cui, R., Umesawa, M., Yamagishi, K., Ohira, T., Muraki, I., Hayama-Terada, M., Kiyama, M., & Iso, H. (2021). Salt taste perception and blood pressure levels in population-based samples: The Circulatory Risk in Communities Study (CIRCS). *British Journal of Nutrition*, *125*(2), 203-211. PMid:32814612. http://dx.doi.org/10.1017/S0007114520002640

Lawless, H. T., & Heymann, H. (2010). *Sensory evaluation of food: principles and practices.* New York: Springer. http://dx.doi.org/10.1007/978-1-4419-6488-5.

Mattes, R. D. (1997). The taste for salt in humans. *The American Journal of Clinical Nutrition*, *65*(2, Suppl.), 692s-697s. PMid:9022567. http://dx.doi.org/10.1093/ajcn/65.2.692S

Methven, L., Allen, V. J., Withers, C. A., & Gosney, M. A. (2012). Ageing and taste. *The Proceedings of the Nutrition Society*, *71*(4), 556-565. PMid:22883349. http://dx.doi.org/10.1017/S0029665112000742

Noh, H., Paik, H. Y., Kim, J., & Chung, J. (2013). Salty taste acuity is affected by the joint action of alphaENaC A663T gene polymorphism and available zinc intake in young women. *Nutrients*, *5*(12), 4950-4963. PMid:24317554. http://dx.doi.org/10.3390/nu5124950

O'Donnell, M., Mente, A., Alderman, M. H., Brady, A. J. B., Diaz, R., Gupta, R., López-Jaramillo, P., Luft, F. C., Lüscher, T. F., Mancia, G., Mann, J. F. E., McCarron, D., McKee, M., Messerli, F. H., Moore, L. L., Narula, J., Oparil, S., Packer, M., Prabhakaran, D., Schutte, A., Sliwa, K., Staessen, J. A., Yancy, C., & Yusuf, S. (2020). Salt and cardiovascular disease: Insufficient evidence to recommend low sodium intake. *European Heart Journal*, *41*(35), 3363-3373. PMid:33011774. http://dx.doi.org/10.1093/eurheartj/ehaa586

Ohashi, N., Takase, H., Aoki, T., Matsuyama, T., Ishigaki, S., Isobe, S., Fujikura, T., Kato, A., & Yasuda, H. (2021). Salt intake causes B-type natriuretic peptide elevation independently of blood pressure elevation in the general population without hypertension and heart disease. *Medicine*, *100*(19), e25931. PMid:34106662. http://dx.doi.org/10.1097/MD.0000000000025931

Pilic, L., & Mavrommatis, Y. (2018). Genetic predisposition to salt-sensitive normotension and its effects on salt taste perception and intake. *British Journal of Nutrition*, *120*(7), 721-731. PMid:30105963. http://dx.doi.org/10.1017/S0007114518002027

Tagawa, K., Tsuru, Y., Yokoi, K., Aonuma, T., & Hashimoto, J. (2021). Albuminuria intensifies the link between urinary sodium excretion and central pulse pressure in the general population: the wakuya study. *American Journal of Hypertension*, *34*(8), 851-857. PMid:33893813. http://dx.doi.org/10.1093/ajh/hpab057

Tepper, B. J. (2008). Nutritional implications of genetic taste variation: The role of PROP sensitivity and other taste phenotypes. *Annual Review of Nutrition*, *28*(1), 367-388. PMid:18407743. http://dx.doi.org/10.1146/annurev.nutr.28.061807.155458

Wanich, U., Sayompark, D., Riddell, L., Cicerale, S., Liem, D. G., Mohebbi, M., Macfarlane, S., & Keast, R. (2018). Assessing food liking: Comparison of food liking questionnaires and direct food tasting in two cultures. *Nutrients*, *10*(12), 10. PMid:30544892. http://dx.doi.org/10.3390/nu10121957

Watkins, M. P. (2009). *Foundations of clinical research: applications to practice*. Philadelphia: Nova Jersey.

Waxman, A. (2004). WHO global strategy on diet, physical activity and health. *Food and Nutrition Bulletin*, *25*(3), 292-302. PMid:15460274. http://dx.doi.org/10.1177/156482650402500310

World Health Organization (2020). *Salt reduction.* Retrieved in 2022, November 19, from https://www.who.int/news-room/fact-sheets/detail/salt-reduction.

World Health Organization. (2012). *Guideline: sodium intake for adults and children.* Geneva: World Health Organization.

World Health Organization. (2021). *WHO global sodium benchmarks for different food categories.* Geneva: World Health Organization.

Funding: Fondation Institut Universitaire de Cardiologie et de Pneumologie de Québec (MOP-114820)

Received: Nov. 19, 2022; **Approved:** July 11, 2023

Associate Editor: Deborah dos Santos Garruti