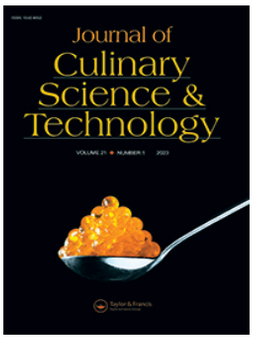

Journal of Culinary Science & Technology

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/wcsc20

# PORTUGUESE TYPICAL STARTER SOUPS: DOES SALT REDUCTION AFFECT PERCEPTION AND SENSORY QUALITY AT A UNIVERSITY CANTEEN?

**Natalie Marinho Dantas, Maria Elisabeth Machado Pinto-e-Silva, Zita Emanuela Martins, Rafaela Rodrigues Dutra, Karla Suzanne Florentino da Silva Chaves Damasceno & Olívia Pinho**

**To cite this article:** Natalie Marinho Dantas, Maria Elisabeth Machado Pinto-e-Silva, Zita Emanuela Martins, Rafaela Rodrigues Dutra, Karla Suzanne Florentino da Silva Chaves Damasceno & Olívia Pinho (2023) PORTUGUESE TYPICAL STARTER SOUPS: DOES SALT REDUCTION AFFECT PERCEPTION AND SENSORY QUALITY AT A UNIVERSITY CANTEEN?, Journal of Culinary Science & Technology, 21:1, 18-35, DOI: 10.1080/15428052.2021.1883176

**To link to this article:** https://doi.org/10.1080/15428052.2021.1883176

Published online: 12 Mar 2021.

JOURNAL OF CULINARY SCIENCE & TECHNOLOGY
2023, VOL. 21, NO. 1, 18–35
https://doi.org/10.1080/15428052.2021.1883176



# PORTUGUESE TYPICAL STARTER SOUPS: DOES SALT REDUCTION AFFECT PERCEPTION AND SENSORY QUALITY AT A UNIVERSITY CANTEEN?

Natalie Marinho Dantas[a], Maria Elisabeth Machado Pinto-e-Silva[a], Zita Emanuela Martins[b], Rafaela Rodrigues Dutra[c], Karla Suzanne Florentino da Silva Chaves Damasceno[d], and Olívia Pinho[b,e]

[a]Department of Nutrition, School of Public Health, University of São Paulo, São Paulo; [b]LAQV/REQUIMTE, Department of Chemical Sciences, Laboratory of Bromatology and Hydrology, Faculty of Pharmacy, University of Porto, Porto; [c]Nutrition Institute, Rio de Janeiro State University, Rio de Janeiro; [d]Department of Nutrition, Health Science Center, Federal University of Rio Grande do Norte, Rio Grande do Norte; [e]Faculty of Nutrition and Food Science, University of Porto, Porto

**ABSTRACT**

Controlling individuals' salt intakes from discretionary sources is one of Portugal's public health priority, to reduce factors risks for cardiometabolic diseases. Starter soups, turnip green (TG), Carrot (C) and Carrot with cabbage (CC), from a Portuguese university canteen, were evaluated by sodium content varying in salt addition, the usual amount of salt (R0); with 25% (R25), and 35% (R35) of salt reduction, respectively. One hundred and seven students participated in the research during lunchtime. Check-all-that-apply (CATA) was applied, as well as the acceptability and saltiness perception. There were no differences ($p > 0.05$) for acceptability and saltiness perception of TG and CC soups with different amounts of salt, but reduced salt samples of carrot soup were perceived to be saltier and overall more liked compared to its usual recipe. This data suggests that 35% of salt reduction is possible in complex matrices as Portuguese starter soups without a loss of acceptance by consumers.

**ARTICLE HISTORY**
Received 18 February 2020
Revised 23 January 2021
Accepted 25 January 2021

**KEYWORDS**
Salt reduction; acceptability; sodium content; saltiness perception; public health

## Introduction

The World Health Organization (WHO) has decreed a global goal of reducing salt in the diet to values lower than or equal to 5 g/day (2,000 mg of sodium) by 2025, and 30% reduction on salt consumption in the world (World Health Organization, 2013; World Health Organization. Regional Office for Europe, 2020). This measure is due to the evidence that associates high intake of sodium as a risk factor for noncommunicable diseases (NCDs), stomach cancer among other diseases (Cook, Appel, & Whelton, 2014; Davy, Halliday, & Davy, 2015; Graudal, Jurgens, Baslund, & Alderman, 2014; Kaddumukasa et al., 2017; Tan, He, & Macgregor, 2018). However, the vast majority of countries in the European Region are not on target to meet the global target of reducing salt

**CONTACT** Natalie Marinho Dantas. natiedantas@gmail.com Department of Nutrition, School of Public Health, University of São Paulo. Av. Dr. Arnaldo, 715, 01246-904. São Paulo - SP, Brazil.

intake (World Health Organization, 2019), and countries as Portugal receives between 25% and 50% of their daily salt from discretionary sources (salt added during cooking or at the table) (Bhat et al., 2020).

Sodium chloride has a major impact on food structure, which then affects both aroma release and texture perception (Guichard, Galindo-Cuspinera, & Feron, 2018). Therefore, reducing sodium content represents a complex challenge not only for the food industry, but for restaurants, chefs, and nutrition services due to its specific functionality in terms of sensory, microbiological aspects, taste and palatability associated with food (Belc, Smeu, Macri, Vallauri, & Flynn, 2019; Liem, Miremadi, & Keast, 2011; Syarifuddin, Septier, Salles, & Thomas-Danguin, 2016). However, studies involving the impact of sodium reduction on the sensory characteristics of complex food matrices are scarce in literature (Bannwart, Pinto-e-Silva, & Vidal, 2014; Bobowski, Rendahl, & Vickers, 2015; Lima, Dufauret, Benjamin, & Wooster, 2018).

Barbosa et al. (2018) reported that consumers of meals in university canteens can easily exceed the maximum daily intake for sodium. Nevertheless, any strategies against the high sodium levels must be done without causing significant changes in sensory characteristics and consumer perception (Antúnez, Giménez, Vidal, & Ares, 2018).

Few studies have focused on consumer acceptance of reduced-sodium foods in catering services (Hoppu et al., 2017). One of the approaches for reducing the salt intake in the Portuguese population is to reduce salt levels in typical dishes, such as soups (World Health Organization, 2016). According to Cardoso et al. (2019), there is a need to reduce salt content available in Portuguese food products and meals, due to its excessive daily salt intake.

As the implementation of a reduced sodium diet for the human population may result in a "less tasty" perception of the foods, it is relevant to study the impact of salt reduction on consumer perception in order to change people's inappropriate eating habits (Antúnez et al., 2019) and maintain the eating pleasure. Taking this context into consideration, the objectives of this study were (1) to reduce sodium content in starter soups served in a university canteen of Porto, Portugal and (2) to evaluate the sensory quality and saltiness perception between regular and salt-reduced recipes.

## Literature review

A feasible strategy that could deal with the high sodium intake concern is to design sensory studies based on gradual salt reduction, while studying affective responses (Herbert, Bertenshaw, Zandstra, & Brunstrom, 2014) and consumer's hedonic perception (Oliveira, Galhardo, Ares, Cunha, & Deliza, 2018). A rapid sensory profiling technique, Check-all-that-apply (CATA) is a versatile multiple-choice question format in which assessors are presented with food and a list of terms that they have to select which they consider

appropriate (Ares & Jaeger, 2013). It is easy, low cost, and has been used to study consumer-based approaches to food perceptions (Antúnez, Giménez, Alcaire, Vidal, & Ares, 2017; Vidal et al., 2019).

Salt-reduction strategies have been identified as promising in this approach, such as the use of substitute ingredients for table salt ("boosters"), foods rich in umami (e.g., onion, tomato, mushrooms and chicken) (Guinard et al., 2016; Nguyen & Wismer, 2019; Santos, Dantas, Simoni, Pontes, & Pinto-e-Silva, 2019), flavor enhancers (Rocha et al., 2020) use of other culinary salts (e.g. KCl) (Busch, Yong, & Goh, 2013; Israr, Rakha, Sohail, Rashid, & Shehzad, 2016) and also the combination of herbs and spices (Carvalho et al., 2017; Galvão, Lopes, Moura, Barretto, & Pollonio, 2014; Liem et al., 2011). Those are alternatives to reduce sodium content of food and soups in particular.

Herbert et al. (2014) considered that saltiness is influenced by representations of ideal saltiness. According to the authors, after repeated exposure on memory for the saltiness of a reduced-salt soup, most people 'recalled' them as having a higher salt concentration by drawing on a preexisting memory trace (ideal saltiness).

In a previous study, Methven, Langreney, and Prescott (2012) found that a simple exposure to the taste of a "no added salt soup" was sufficient to increase liking to a level equivalent to the initially more preferred salt level. Methven, Ghawi, Rowland, and Methven (2014) also suggest that a repeated exposure to the reduced salt soup modifies with the addition of fresh ingredients (as oregano, bay leaves, garlic and black pepper), which can significantly enhance in consumer acceptance.

Therefore, in order to reduce the salt content in foods, while maintaining consumers' liking, a number of elements must be combined to give the desired taste, flavor, texture, and aroma of foods (Inguglia, Zhang, Tiwari, Kerry, & Burgess, 2017).

Consumers of a food service can get used to the amount of salt provided (Oliveira, Dantas, & Pinto-E-Silva, 2018) and one of the World Health Organization recommendations is the implementation of integrated education and communication strategies to raise awareness about the health risks and dietary sources of salt and ultimately change behavior (World Health Organization, 2016). Besides, efforts should be done to target the use of discretionary salt added by consumers during cooking and consumption (Nowson et al., 2015).

## Material and methods

### *Participants*

The students attended the canteen of the University of Porto and were recruited after their lunch time during 3 consecutive weeks. Those who had availability to take part in the study were invited to sign the informed consent

form and to complete a small questionnaire containing information about their sociodemographic characteristics (age, gender, nationality, and frequency of consumption in the canteen during lunch and dinner). Additional information on "concern about salt" was inquired, using a 1–5 unstructured scale (1 representing "little" and 5 representing "very").

The duration of the questionnaire ranged between 5 and 8 min and was implemented using web interface (Google Doc). All participants were over the age of 18, were asked to answer all questions spontaneously and provided their written consent before participation. A convenience sample of 107 students agreed to participate in the research, and the project was submitted and approved by the Ethics Committee of the Institute of Public Health of the University of Porto (CE19107).

The study design occurred from February to May 2019.

### *Samples: soup as a starter*

Lunch meals served to students were organized in three sections: starter soup with bread, main dishes, and desserts. The menus were planned by a nutritionist of U.Porto Social Services (SASUP) and the meals prepared by a Portuguese catering company at the canteen. Three samples of starter soups were selected: turnip greens (TG), carrot (C) and carrot with cabbage (CC), from three different lunch menus provided by a canteen from University of Porto. These soups were served in 3 consecutive days in March, with the amount based in the usual quantity that was used (R0), and were repeated for a further 2 months: 3 consecutive days in April, with 25% reduction in salt (R25); and 3 consecutive days in May, with a 35% of salt reduction (R35).

### *Consumer tests*

The consumer study sessions were carried out in different days at lunch time (11h30m-14h30m). Each session took place at the eating space of the canteen, where all students received and followed the orientation for the participation. During each session, shortly after serving (a bowl of approximately 235 mL of soup), participants were asked to evaluate the soup through descriptors that most represented each sample (CATA), and to rate it for overall liking (acceptability) and salty taste intensity (saltiness perception).

#### *Application of the CATA questionnaire (Check-all-that-apply)*

The Check-all-that-apply (CATA) questionnaires including sensory attributes related to soups were applied. This methodology was used since is suitable to evaluate consumer perception while being low cost (does not require training from the tasters).

| Odour/Aroma | |
|---|---|
| Characteristic odor | □ |
| Strange smell | □ |
| Very aromatic | □ |
| Moderately aromatic | □ |
| A little aromatic | □ |
| Nothing aromatic | □ |

| Taste | |
|---|---|
| Bitter | □ |
| Tasty | □ |
| Tasteless | □ |
| Burnt taste | □ |
| Metallic taste | □ |
| Mild taste | □ |
| Not salty | □ |
| Slightly salty | □ |
| Moderately salty | □ |
| Very salty | □ |
| Extremely salty | □ |

| Texture | |
|---|---|
| Liquid | □ |
| Creamy | □ |
| Homogeneous | □ |
| Heterogeneous | □ |

| Others | |
|---|---|
| Hot | □ |
| Cold | □ |
| Pleasant | □ |
| Soothing | □ |
| Balanced | □ |
| Fatty | □ |

**Figure 1.** Check-all-that-apply (CATA) question for soup samples.

The terms used in each study were based on previous studies using soup categories and a pilot work with 30 students. The CATA lists contained 27 terms and covered multiple sensory modalities (aroma/odor, flavor/taste, texture and other sensory perception). Consumers were asked to check all of the terms they considered appropriate for describing each of the focal samples they tried (Figure 1).

### *Affective test*

In order to identify the acceptability of the usual (R0) and lower salt samples (R25 and R35), subjects were asked to rate the 9-point hedonic scale of overall liking (*How much did you like this soup?*) anchored in the expressions 1 "extremely disliked", 5 "indifferent", and 9 "extremely liked". In addition, saltiness perception (*How salty is this soup sample?*) was applied using an unstructured 10 cm scale anchored to 0 ("low salt") on the left to 10 ("very salty") on the right.

### *Sodium analysis*

Soup samples were analyzed by flame photometry, carried out according to Vieira, Soares, Ferreira, and Pinho (2012) with the analyses being carried out in triplicate (n = 3). Briefly, 2 g of sample (grounded and homogenized) were directly weighed in a 50 mL tube and 4 mL of nitric acid ($HNO_3$) (Fluka, France) were added. The mixture was shaken every 10 min for 60 min. The volume was completed up to 45 mL with deionized water and a preparation was homogenized using a Ultra Turrax blender (Ultra Turrax blender T25, Sotel, Germany). Calibration curves were established daily from standard sodium solutions with concentrations of 0.2, 0.5, 1.0, 1.5, and 5.0 μg/mL (Fluka, France).

### *Statistical treatment*

Sodium content and affective tests and were tested for residuals distribution with Shapiro–Wilk test. Sodium content was studied using a one-way analysis

of variance (ANOVA), since normal distribution was confirmed. Whenever statistical significance was found, Tukey's post hoc test was used for mean comparison, as equal variance was verified. Affective tests were studied using a Kruskal–Wallis test, since normal distribution was not confirmed. Whenever statistical significance was found, Mann–Whitney post hoc test was applied for median comparison.

To evaluate the distribution of binary responses of the CATA questionnaire during the gradual salt reduction, the Cochran's Q Test was applied. In addition, based on the frequency of terms identified in the CATA questionnaire, it was possible to create a contingency table that, in turn, was the basis for the correspondence analysis, in order to evaluate the association between attributes and samples. Terms that were not identified by the tasters or without significant difference ($p < 0.05$) among the samples were removed. Then, the independence test (Chi-square) was applied to determine if there is a significant relationship between samples and attributes. Finally, a penalty test was performed to identify the attributes with a significant mean impact on acceptability. Penalty analysis can be applied to data obtained from CATA questions when hedonic scores such as overall liking are concurrently collected. Therefore, overall liking is averaged across all observations (i.e. assessors and products) where the attribute under consideration was used to characterize the product, and across those observations where it was not. For offnotes or other negatively associated attributes, liking might decrease due to an attribute applying, resulting in a negative "penalty" (Meyners, Castura, & Carr, 2013).

All statistical treatments were performed at a 5% significance level using XLSTAT software for Windows version 2016.02 (Addinsoft, Paris, France).

## Results and discussion

### *Consumers' demographic information*

From the group of participants that took part in this study (N = 107, 87 males and 20 females), 91% were from 18 to 24 years of age and 66% were Portuguese, against 34% foreign students. Most of them had lunch at the university canteen at least 3–4 times/week (61%) and rarely had dinner there (72%). Their concern about salt was "moderate" (32%), against 34% and 35% of them who had little (1–2) or some/much (4–5) concern about salt, respectively.

### *Sodium content*

Sodium content (mg/100 g) had significant differences ($p < 0.05$) along the reduction between R0 and both R25 and R35 in all soups (Table 1). However,

**Table 1.** Sodium Content (mg/100 g) in Soup Samples

| Sample | TG | CC | C |
|---|---|---|---|
| R0 | 234.70 ± 4.64 b | 180.81 ± 3.97 b | 260.26 ± 5.41 b |
| R25 | 120.20 ± 6.53 a | 97.71 ± 3.64 a | 113.06 ± 1.94 a |
| R35 | 119.28 ± 1.69 a | 95.41 ± 4.17 a | 106.62 ± 11.82 a |
| *p*-Value | <0.001* | <0.001* | <0.001* |

Results are expressed as the mean ± standard mg/100 g of sodium. C, carrot; CC, carrot with cabbage; R0, without salt reduction; R25, 25% salt reduction; R35, 35% salt reduction; TG, turnip green. Different letters for each soup in a column show statistically significant differences ($p < 0.05$) between means. * $p$ Values from one-way ANOVA analysis. Means were compared by Tukey's, since homogeneity of variances was confirmed by Levene's test ($p > 0.05$).

no significant statistical differences were identified between the R25 and R35 samples. Samples with the usual amount of salt ranged from 180.81 ± 3.97 to 260.26 ± 5.41 mg/100 g and with the 35% of salt reduction ranged from 95.41 ± 4.17 to 119.28 ± 1.69 mg/100 g.

Significant reductions in the sodium content of soups have been achieved by stepwise reduction of salt supply, but were below those found by Gonçalves et al. (2014). According to them, sodium ranged from 147.0 to 300.7 mg/100 g after reducing 30% of salt in vegetable soups at institutional lunchrooms. However, considering the amount of sodium per weight of soups, the bread and the main courses of Portuguese lunch, sodium content can go up to near the maximum recommendation, which justifies interventions in these environments (Viegas, Torgal, Graça, & Martins, 2015).

In this work, even though same recipes were repeated and reduction levels well established, estimated salt reduction in soup preparations did not reflect sodium content measured, which was lower than expected (47–59% of sodium reduction at R35 compared to its original recipe) with greater reduction values for C samples (Table 1).

These differences could be due to the sodium content in the food ingredients (complex matrix) and also for the amount of components and the preparation techniques by the food handlers and cooks.

### *Sensory characterization: CATA terms*

According to the Cochran's Q Test (Table 2) significant differences ($p < 0.05$) among samples (R0, R25 and R35) were found in the frequency of use of the terms: "characteristic odor", "mild taste", "slightly salty", "a little aromatic", "nothing aromatic", "tasteless", "pleasant" and "not salty".

For TG soup, attributes such as "a little aromatic", "mild taste" and "slightly salty" were more frequent in samples R0 and R25, but R25 had no significant differences with R35. This behavior also occurred in the "characteristic odor", "tasty", "tasteless" and "not salty" attributes in CC soup.

Salt reduction was associated with a decrease in the frequency of use of the terms "characteristic odor" for TG soups, "pleasant" for CC soups and

**Table 2.** Terms that Showed Significant Differences at Distribution of Binary Responses of the CATA Questionnaire, According to Cochran's *Q* Test

| Attributes | R0 | R25 | R35 |
|---|---|---|---|
| | | **Turnip Green** | |
| Characteristic odor | 0.356 b | 0.195 a | 0.149 a |
| A little aromatic | 0.356 b | 0.264 ab | 0.172 a |
| Mild taste | 0.356 b | 0.264 ab | 0.184 a |
| Slightly salty | 0.287 b | 0.172 ab | 0.126 a |
| Liquid | 0.690 b | 0.299 a | 0.207 a |
| Creamy | 0.011 a | 0.138 b | 0.184 b |
| Heterogeneous | 0.276 b | 0.195 ab | 0.126 a |
| | | **Carrot with Cabbage** | |
| Characteristic odor | 0.256 ab | 0.291 b | 0.140 a |
| Nothing aromatic | 0.186 b | 0.209 b | 0.058 a |
| Tasty | 0.140 ab | 0.186 b | 0.081 a |
| Tasteless | 0.337 b | 0.256 ab | 0.140 a |
| Not salty | 0.221 ab | 0.244 b | 0.093 a |
| Liquid | 0.651 c | 0.419 b | 0.233 a |
| Creamy | 0.058 a | 0.198 b | 0.198 b |
| Heterogeneous | 0.209 ab | 0.256 b | 0.093 a |
| Hot | 0.244 a | 0.465 b | 0.326 ab |
| Pleasant | 0.419 b | 0.256 a | 0.105 a |
| | | **Carrot** | |
| Nothing aromatic | 0.247 b | 0.074 a | 0.111 a |
| Not salty | 0.346 b | 0.123 a | 0.123 a |
| Liquid | 0.630 b | 0.309 a | 0.296 a |
| Creamy | 0.037 a | 0.173 b | 0.173 b |

R0, without salt reduction; R25, 25% salt reduction; R35, 35% salt reduction; Values in bold show statistically significant differences ($p < 0.05$) between terms according to Cochran's *Q* test; Different letters for each sample at the same soup, in a line, show statistically significant differences ($p < 0.05$) between means.

"nothing aromatic" as well as "not salty" for C soups, in which the percentage of terms used for describing samples did not largely differ between samples R25 and R35. It was also evidenced that all lower salt samples (R25 and R35 soups) were considered "creamy" rather than "liquid" (R0 soups).

For turnip green soup (TG), the first dimension (D1) of the correspondence analysis explains most of the sample variation (73.79%). As shown in Figure 2, R0 and R35 samples were located to the left and right of the first dimension, respectively, and were characterized as "slightly salty" and "characteristic odor" (R0 sample) and as "nothing aromatic" and "soothing" (R35 sample). For dimension 2 of TG soup, explained with 26.21% of variance, the sensory map revealed that the 25% salt reduction soup (R25) has characteristics such as "pleasant" and "moderately salty".

Regarding to Carrot Soup with Cabbage (CC) samples, the first dimension (D1) of the sensory map also explains most of the sample variation (75.38%). As shown in Figure 3, and as well as for the TG samples, the results of R0 and R35 samples were located to the left and right of the first dimension, respectively, characterized as: "tasteless" in R0 sample and "metallic" taste in R35 sample. For dimension 2, explained with 24.62% of variance, terms such as

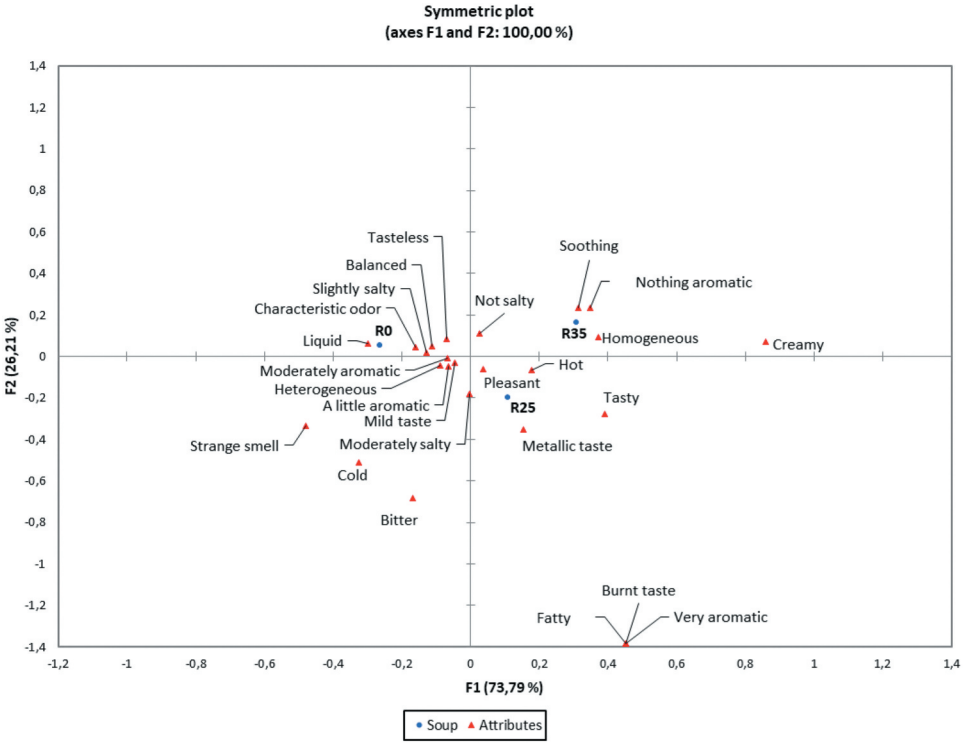


**Figure 2.** Correspondence analysis of turnip green soup.

"characteristic odor", "tasty" and moderately salty" are observed for sample R25.

Finally, for Carrot (C) soups, the first dimension (D1) of the correspondence analysis explained 90.90% of the variance, with all samples (R0, R25 and R35) in this dimension. As shown in Figure 4, samples R25 and R35 were located to the left of the first dimension, while sample R0 is to the right of this dimension. There are similarities between the R25 and R35 samples, with characteristics such as "slightly salty", "very aromatic", "characteristic odor" and "mild taste". Such salt reduction soups differ from R0 soup, characterized as "tasteless" and "nothing aromatic". The statistical treatments applied showed that there were no differences in the correspondence analysis and sodium content at salt reduction samples of carrot soups.

The common attributes that had positive impact on overall liking at the penalty test for all soup samples were as follows: "characteristic odor", "pleasant" and "a little aromatic", with and without salt reductions. Other positive attributes were: "mild taste", "liquid", "hot", "not salty" and "tasteless" for TG soups; "mild taste", "slightly salty", "hot" and "liquid", for carrot with cabbage soups; and "slightly" "salty", "hot", "liquid", "heterogeneous" and "tasteless" for carrot soups.

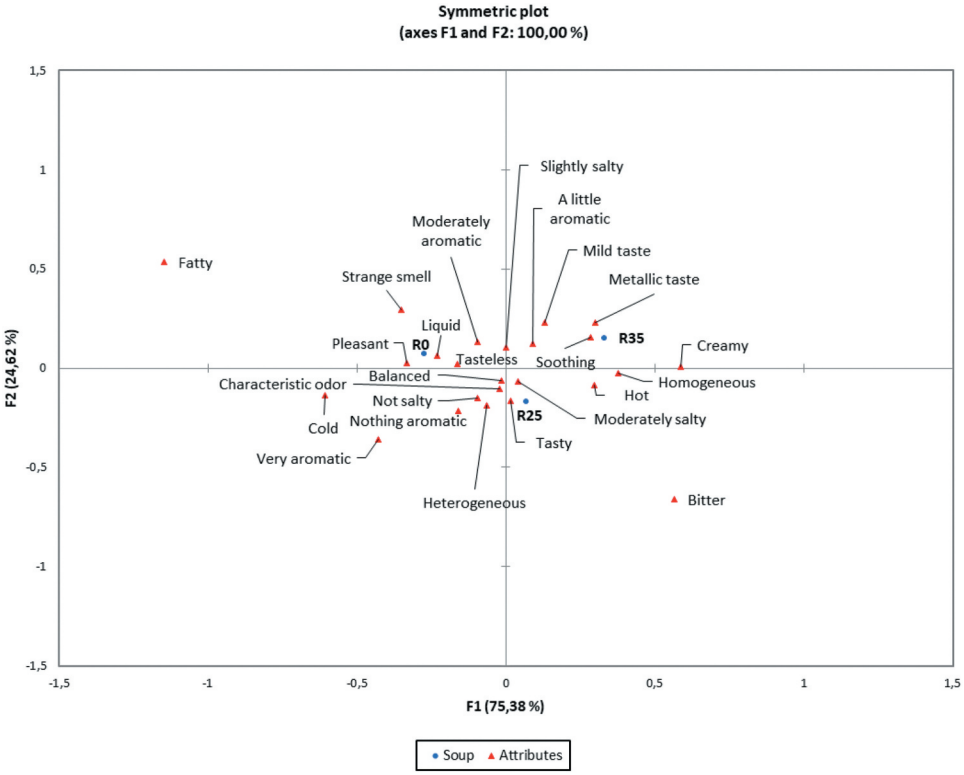


**Figure 3.** Correspondence analysis of carrot with cabbage soup.

No negative penalty term was detected in the present study, and even the attribute "tasteless" was statistically equally detected at TG soups and at higher frequency at R0 samples comparing to salt reduction samples at C soup, according to Cochran's Q Test.

### *Acceptability and saltiness perception*

For affective tests, box plots were produced to describe the distribution of responses. Results showed that there were no differences ($p > 0.05$) for overall liking and salty taste responses for TG and CC soups (Figure 5). That is, the data for acceptability and saltiness perception were statistically equivalent for those samples with and without salt reductions. For TG soup; however, salt-reduced samples (R25 and R35) showed dispersion of values with the highest concentration of acceptability ratings as well as saltiness perception (especially for R35).

Regarding CC soup samples, even there are no statistical differences between the responses, the box plots show R35 with smaller dispersion and higher grades of Acceptance and Saltiness Perception, although there are outliers. Sample R25 is biased toward lower salt intensity, granting attributes

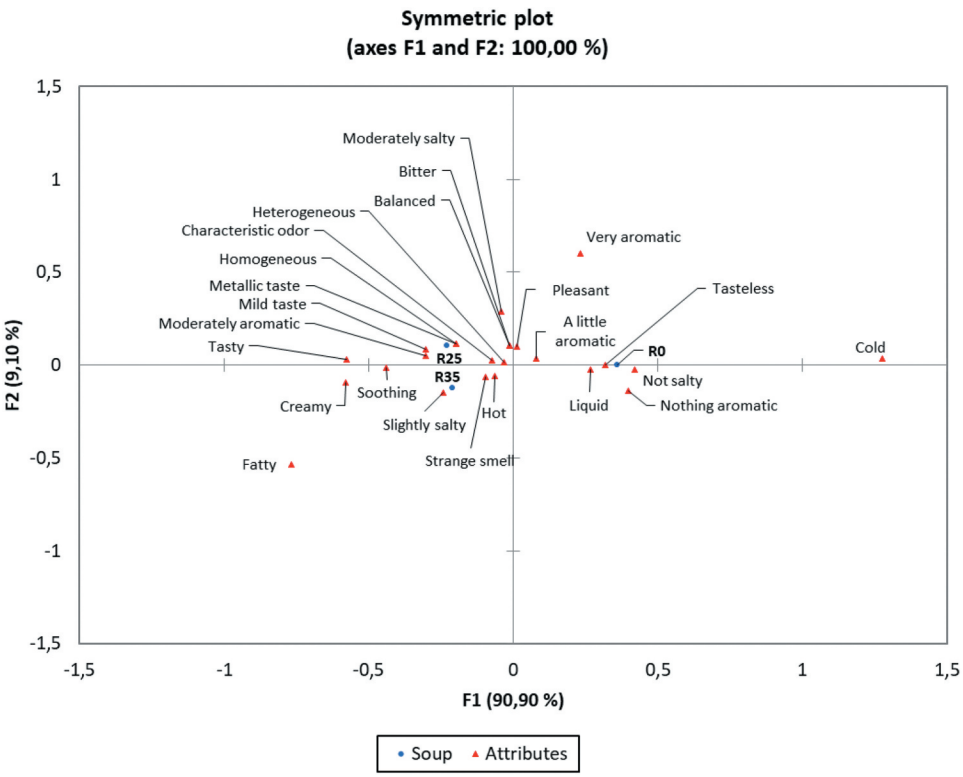


**Figure 4.** Correspondence analysis of carrot soup.

such as "tasty" and "moderately salty" as showed in the Correspondence Analysis test.

However, related to C soup, R0 differed statistically from reduced salt samples. Consumers indicated higher means for acceptability and perceived saltiness for R25 and R35 samples which tended to be saltier and overall liked compared to R0.

Consumer sensory and hedonic perception is one of the main challenges for the implementation of salt-reduction strategies (Antúnez et al., 2017) and the CATA questions correspondence analysis allowed to identify the attributes that most contributed to the differentiation of the samples along the salt reduction.

The effect of the different components in the final sensory characteristics of the starter soups was interpreted by reducing the number of variables into two principal components, as found by Kumpulainen, Sandell, and Hopia (2018). The number of sensory attributes changes at conventional and salt reduction foods can differ across dishes due to flavor interactions and/or ingredient changes required Nguyen and Wismer (2019).

According to Meyners et al. (2013), for off notes or other negatively associated attributes, liking might decrease due to an attribute applying,

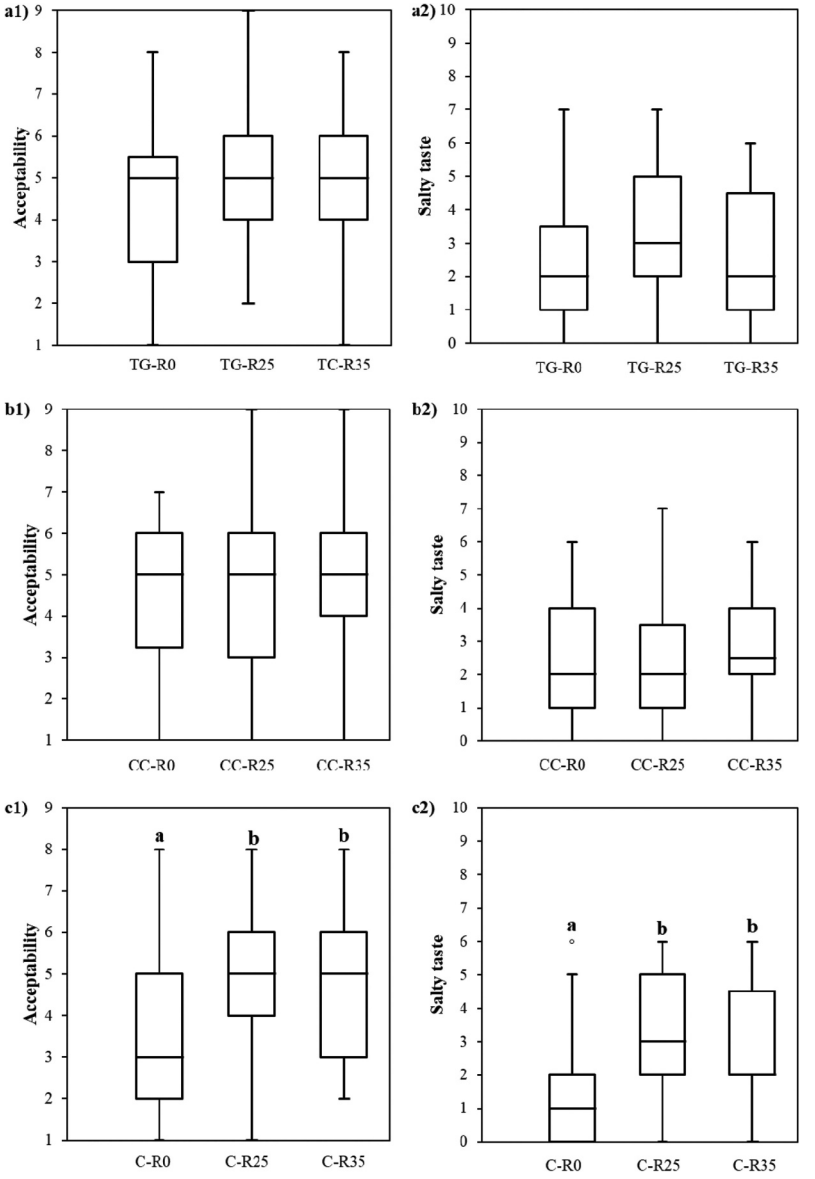


**Figure 5.** Boxplot for acceptability (1) and saltiness perception (2) for each soup and salt reduction: (a) turnip green, (b) carrot and cabbage, (c) carrot soups. *Notes*. C, carrot; CC, carrot with cabbage; R0, without salt reduction; R25, 25% salt reduction; R35, 35% salt reduction; TG, turnip green. Different letters for each soup perception show statistically significant differences ($p < 0.05$) between medians (Kruskal–Wallis analysis). Medians were compared by Dunn's test.

resulting in a negative "penalty". This is not in agreement with the present study, where the change in liking of observations had positive effects on overall liking. Bruzzone et al. (2015) suggests that intensity scales and CATA questions with penalty analysis can be a valuable alternative to gather information about consumers' perception of the sensory characteristics of foods.

In the present study, the saltiness perception of the initial vegetable soups was considered as 'low salt' for consumers, which may reflect a high salt intake as observed by Viegas et al. (2015). Regarding to acceptability, similar results were found by Gonçalves et al. (2014), who showed that is possible to reduce 30% of salt in soups without compromising consumers' perceptions. Willems, Van Hout, Zijlstra, and Zandstra (2014) also showed that a salt reduction of up to 32% in a chicken noodle soup did not affect long-term liking scores.

Interestingly, in the present study, the term "nothing aromatic" was more frequently identified in sample R0 of carrot soup, which was statistically different from salt-reduced samples R25 and R35. This suggests that carrot soup ingredients were preferred in terms of preference and taste by consumers with lower amount of salt used. Figure 6 is a graphical abstract that summarizes the main features of the work.

It is observed that it is possible to reduce the salt level even more, as the combination of fresh ingredients might be capable of enhancing flavor and aroma attributes, as suggested by Kumpulainen et al. (2018). The ingredients used in the vegetable soups of this study (e.g., onion and fresh vegetables) have flavor enhancers and high concentration of aromatic substances that, together, contribute to the flavor/aroma of the final product. Furthermore, the balance of natural ingredients as onion are rich in umami taste that can enhance the saltiness perception of culinary preparations (Santos et al., 2019).

Texture was also related to important attributes for soups and the creaminess may have enhanced saltiness perception, as it is a complex matrix that can carry ingredients that contribute to its taste. According to Malherbe, Walsh, and Van Der Merwe (2003), salt reduction in the vegetable soup (complex dish with a smooth texture) did not affect perception of saltiness significantly ($p$ = 0.14), in contrast with other dish combinations (as the beef in beef stew, the potato in mashed potatoes, and the porridge in crumbed porridge), which carries fewer number of ingredients in the recipes.

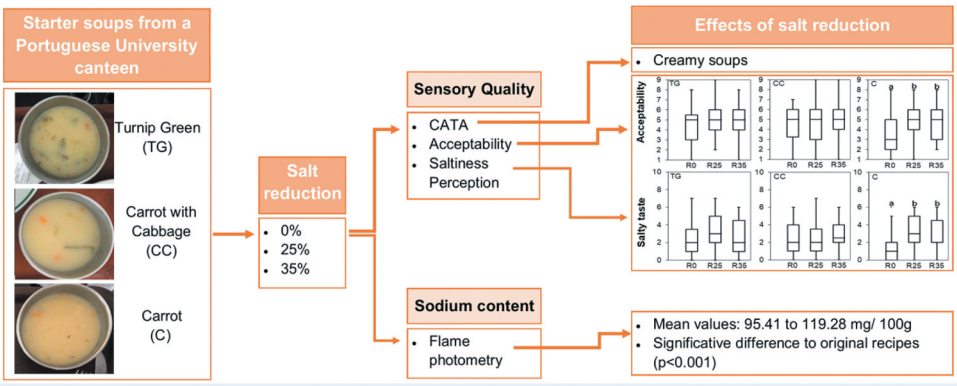


**Figure 6.** Graphical abstract of the synthesis of the work.

Analytical and sensory data presented showed that up to 35% of salt reduction at starter soups, compared to their original recipes, contributed significantly for sodium reduction without causing any major damage to its sensory quality, which confirms that it is a viable alternative for reducing sodium in preparations such as Portuguese vegetable soups. As starter soups are of daily offer in Portuguese restaurants, it is achieving international health commitments, who are requesting to accelerate salt reduction in Europe (World Health Organization, 2019; World Health Organization. Regional Office for Europe, 2020).

There is also a need to understand salt-related behavioral practices at culture-specific education and awareness campaigns on salt (Nasreddine, Akl, Al-Shaar, Almedawar, & Isma'eel, 2014), which is an important role in determining the ultimate success of the salt reduction initiative (Regan et al., 2017). In the present study, only 35% of the students have some concern about salt and there are no nutrition monitoring and dietary practices at the canteen to avoid the high salt ingestion by the students. Public concern about salt is low as many people remain unaware of their own salt intake (Grimes et al., 2017).

Finally, the research reflects the consumption of responses from university students, as it was performed in loco at the canteen.

## Conclusions

Portuguese typical starter soups at the university canteen were found to be high in sodium content. The study showed that it is possible to reduce up to 35% of discretionary salt without impairing sensory characteristics. The vegetable soups were described with attributes of odor (characteristic of the soup), texture (creaminess) and flavor (salt intensity).

The study makes a scientific contribution for the restaurants, culinary professionals, foodservice managers and overall community by providing evidence that reducing sodium supply of typical Portuguese starter soups did not show significant changes in the general acceptance and saltiness perception, which was maintained throughout the gradual reduction of salt. Considering soups as complex matrices, the combination of fresh ingredients may make major contributions to its salty taste intensity and to the flavor of foods.

This research also attends to national and international public health recommendations for reducing the discretionary use of salt as an initiative for the prevention of cardiovascular diseases. To successfully achieve those goals, it is important to focus on local consumer contexts and support initiatives to reduce the use of discretionary salt in different environments as workplaces, schools and universities, to integrate education and communication strategies to raise awareness and to involve the participation of the various

protagonists around food services, such as managers, cooks, staffs, among others.

## Funding

This work was supported by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior [001]; Fundação para a Ciência e a Tecnologia [UID/QUI/50006/2019].

## ORCID

Natalie Marinho Dantas http://orcid.org/0000-0003-1763-3472
Karla Suzanne Florentino da Silva Chaves Damasceno http://orcid.org/0000-0001-6884-1023
Olívia Pinho http://orcid.org/0000-0001-9477-8638

## References

Antúnez, L., Giménez, A., Alcaire, F., Vidal, L., & Ares, G. (2017). Consumer perception of salt-reduced breads: Comparison of single and two-bites evaluation. *Food Research International*, *100*(May), 254–259. doi:10.1016/j.foodres.2017.07.014

Antúnez, L., Giménez, A., Alcaire, F., Vidal, L., & Ares, G. (2019). Consumers' heterogeneity towards salt reduction: Insights from a case study with white rice. *Food Research International*, *121*(December), 48–56. doi:10.1016/j.foodres.2019.03.007

Antúnez, L., Giménez, A., Vidal, L., & Ares, G. (2018). Partial replacement of NaCl with KCl in bread: Effect on sensory characteristics and consumer perception. *Journal of Sensory Studies*, *33*(12441), 1–12. doi:10.1111/joss.12441

Ares, G., & Jaeger, S. R. (2013). Check-all-that-apply questions: Influence of attribute order on sensory product characterization. *Food Quality and Preference*, *28*(1), 141–153. doi:10.1016/j.foodqual.2012.08.016

Bannwart, G. C. M. D. C., Pinto-e-Silva, M. E. M., & Vidal, G. (2014). Redução de sódio em alimentos: Panorama atual e impactos tecnológicos, sensoriais e de saúde pública. *Revista Da Sociedade Brasileira De Alimentação E Nutrição*, *39*(3), 348–365. doi:10.4322/nutrire.2014.034

Barbosa, M. I., Fernandes, A., Gonçalves, C., Pena, M. J., Padrão, P., Pinho, O., & Moreira, P. (2018). Sodium and potassium content of meals served in university canteens. *Port Journal of Public Health*, 1–7. doi:10.1159/000488074

Belc, N., Smeu, I., Macri, A., Vallauri, D., & Flynn, K. (2019). Reformulating foods to meet current scientific knowledge about salt, sugar and fats. *Trends in Food Science and Technology*, *84*(2019), 25–28. doi:10.1016/j.tifs.2018.11.002

Bhat, S., Marklund, M., Henry, M. E., Appel, L. J., Croft, K. D., Neal, B., & Wu, J. H. Y. (2020). A systematic review of the sources of dietary salt around the world. *Advances in Nutrition*, *11*(3), 677–686. doi:10.1093/advances/nmz134

Bobowski, N., Rendahl, A., & Vickers, Z. (2015). Preference for salt in a food may be alterable without a low sodium diet. *Food Quality and Preference*, *39*, 40–45. doi:10.1016/j.foodqual.2014.06.005

Bruzzone, F., Vidal, L., Antúnez, L., Giménez, A., Deliza, R., & Ares, G. (2015). Comparison of intensity scales and CATA questions in new product development: Sensory characterisation

and directions for product reformulation of milk desserts. *Food Quality and Preference*, *44*, 183–193. doi:10.1016/j.foodqual.2015.04.017

Busch, J. L. H. C., Yong, F. Y. S., & Goh, S. M. (2013). Sodium Reduction: Optimizing Product Composition and Structure towards Increasing Saltiness Perception. *Trends in Food Science and Technology*, *29*(1), 21–34. doi:10.1016/j.tifs.2012.08.005

Cardoso, S., Pinho, O., Moreira, P., Pena, M. J., Alves, A., Moreira, J. L., … Gonçalves, C. (2019). Salt content in pre-packaged foods available in Portuguese market. *Food Control*, *106*, 106670. doi:10.1016/j.foodcont.2019.05.035

Carvalho, C. B., Vital, A. C. P., Carvalho Kempinski, E. M. B., Madrona, G. S., Reche, P. M., Guerrero, A., & Do Prado, I. N. (2017). Quality and Sensorial Evaluation of Beef Hamburger Made with Herbs, Spices, and Reduced Sodium Content. *Journal of Culinary Science and Technology*, 1–14. doi:10.1080/15428052.2017.1363108

Cook, N. R., Appel, L. J., & Whelton, P. K. (2014). Lower levels of sodium intake and reduced cardiovascular risk. *Circulation*, *129*(9), 981–989. doi:10.1161/CIRCULATIONAHA.113.006032

Davy, B. M., Halliday, T. M., & Davy, K. P. (2015). Sodium intake and blood pressure: New controversies, new labels … new guidelines? *Journal of the Academy of Nutrition and Dietetics*, *115*(2), 200–204. doi:10.1016/j.jand.2014.10.013

Galvão, M., Lopes, T. E., Moura, D. B., Barretto, A. C. S., & Pollonio, M. A. R. (2014). Effects of micronized sodium chloride on the sensory profile and consumer acceptance of turkey ham with reduced sodium content. *Food Science and Technology (Campinas)*, *34*(1), 189–194. doi:10.1590/S0101-20612014005000009

Gonçalves, C., Monteiro, S., Padrão, P., Rocha, A., Abreu, S., Pinho, O., & Moreira, P. (2014). Salt reduction in vegetable soup does not affect saltiness intensity and liking in the elderly and children. *Food & Nutrition Research*, *58*(1), 3–9. doi:10.3402/fnr.v58.24825

Graudal, N., Jurgens, G., Baslund, B., & Alderman, M. H. (2014). Compared with usual sodium intake, low- and excessive-sodium diets are associated with increased mortality: A meta-analysis. *American Journal of Hypertension*, *27*(9), 1129–1137. doi:10.1093/ajh/hpu028

Grimes, C. A., Kelley, S.-J., Stanley, S., Bolam, B., Webster, J., Khokhar, D., & Nowson, C. A. (2017). Knowledge, attitudes and behaviours related to dietary salt among adults in the state of Victoria, Australia 2015. *BMC Public Health*, *17*(1), 1–16. doi:10.1186/s12889-017-4451-0

Guichard, E., Galindo-Cuspinera, V., & Feron, G. (2018). Physiological mechanisms explaining human differences in fat perception and liking in food spreads-a review. *Trends in Food Science & Technology*, *74*(2018), 46–55. doi:10.1016/j.tifs.2018.01.010

Guinard, J. X., Myrdal Miller, A., Mills, K., Wong, T., Lee, S. M., Sirimuangmoon, C., … Drescher, G. (2016). Consumer acceptance of dishes in which beef has been partially substituted with mushrooms and sodium has been reduced. *Appetite*, *105*, 449–459. doi:10.1016/j.appet.2016.06.018

Herbert, V., Bertenshaw, E. J., Zandstra, E. H., & Brunstrom, J. M. (2014). Memory processes in the development of reduced-salt foods. *Appetite*, *83*, 125–134. doi:10.1016/j.appet.2014.08.019

Hoppu, U., Hopia, A., Pohjanheimo, T., Rotola-Pukkila, M., Mäkinen, S., Pihlanto, A., & Sandell, M. (2017). Effect of salt reduction on consumer acceptance and sensory quality of food. *Foods*, *6*(103), 1–12. doi:10.3390/foods6120103

Inguglia, E. S., Zhang, Z., Tiwari, B. K., Kerry, J. P., & Burgess, C. M. (2017). Salt reduction strategies in processed meat products – A review. *Trends in Food Science & Technology*, *59*, 70–78. doi:10.1016/j.tifs.2016.10.016

Israr, T., Rakha, A., Sohail, M., Rashid, S., & Shehzad, A. (2016). Salt reduction in baked products: Strategies and constraints. *Trends in Food Science and Technology*, *51*, 98–105. doi:10.1016/j.tifs.2016.03.002

Kaddumukasa, M. N., Katabira, E., Sajatovic, M., Pundik, S., Kaddumukasa, M., & Goldstein, L. B. (2017). Influence of dietary salt knowledge, perceptions, and beliefs on consumption choices after stroke in Uganda. *Journal of Stroke and Cerebrovascular Diseases*, *26*(12), 2935–2942. doi:10.1016/j.jstrokecerebrovasdis.2017.07.016

Kumpulainen, T. E. M., Sandell, M. A., & Hopia, A. I. (2018). Effect of component quality on sensory characteristics of a fish soup. *Food Science & Nutrition*, *6*(5), 1220–1228. doi:10.1002/fsn3.661

Liem, D. G., Miremadi, F., & Keast, R. (2011). Reducing sodium in foods: The effect on flavor. *Nutrients*, *3*(12), 694–711. doi:10.3390/nu3060694

Lima, A., Dufauret, M., Benjamin, R., & Wooster, T. J. (2018). Deconstructing how the various components of emulsion creamers impact salt perception. *Food Hydrocolloids*, *79*(2018), 310–318. doi:10.1016/j.foodhyd.2018.01.005

Malherbe, M., Walsh, C. M., & Van Der Merwe, C. A. (2003). Consumer acceptability and salt perception of food with a reduced sodium content. *Journal of Family Ecology and Consumer Sciences*, *31*, 12–20.

Methven, L., Ghawi, S. K., Rowland, I., & Methven, L. (2014). Enhancing consumer liking of low salt tomato soup over repeated exposure by herb and spice seasonings. *Appetite*, *81* (2014), 20–29. doi:10.1016/j.appet.2014.05.029

Methven, L., Langreney, E., & Prescott, J. (2012). Changes in liking for a no added salt soup as a function of exposure. *Food Quality and Preference*, *26*(2), 135–140. doi:10.1016/j.foodqual.2012.04.012

Meyners, M., Castura, J. C., & Carr, B. T. (2013). Existing and new approaches for the analysis of CATA data. *Food Quality and Preference*, *30*(2), 309–3019. doi:10.1016/j.foodqual.2013.06.010

Nasreddine, L., Akl, C., Al-Shaar, L., Almedawar, M. M., & Isma'eel, H. (2014). Consumer knowledge, attitudes and salt-related behavior in the Middle-East: The case of Lebanon. *Nutrients*, *6*(11), 5079–5102. doi:10.3390/nu6115079

Nguyen, H., & Wismer, W. V. (2019). A comparison of sensory attribute profiles and liking between regular and sodium-reduced food products. *Food Research International*, *123* (February), 631–641. doi:10.1016/j.foodres.2019.05.037

Nowson, C., Lim, K., Grimes, C., Halloran, S. O., Land, M. A., Webster, J., … Neal, B. (2015). Dietary salt intake and discretionary salt use in two general population samples in Australia: 2011 and 2014. *Nutrients*, *7*(12), 10501–10512. doi:10.3390/nu7125545

Oliveira, A. S., Dantas, N. M., & Pinto-E-Silva, M. E. M. (2018). Consumer acceptance and salty taste intensity of culinary preparations in a food service in the city of São Paulo. *Journal of Culinary Science and Technology*, 1–12. doi:10.1080/15428052.2018.1507857

Oliveira, D., Galhardo, J., Ares, G., Cunha, L. M., & Deliza, R. (2018). Sugar reduction in fruit nectars: Impact on consumers' sensory and hedonic perception. *Food Research International*, *107*(2018), 371–377. doi:10.1016/j.foodres.2018.02.025

Regan, Á., Kent, M. P., Raats, M. M., Mcconnon, Á., Wall, P., & Dubois, L. (2017). Applying a consumer behavior lens to salt reduction initiatives. *Nutrients*, *9*(901), 1–9. doi:10.3390/nu9080901

Rocha, R., Ribeiro, M. N., Silva, G. A., Rocha, L., Pinheiro, A., Nunes, C. A., & Carneiro, J. (2020). Temporal profile of flavor enhancers MAG, MSG, GMP, and IMP, and their ability to enhance salty taste, in different reductions of sodium chloride. *Journal of Food Science*, *85* (5), 1565–1575. doi:10.1111/1750-3841.15121

Santos, F. F., Dantas, N. M., Simoni, N. K., Pontes, L. S., & Pinto-e-Silva, M. E. M. (2019). Are foods naturally rich in glutamic acid an alternative to sodium reduction? *Food Science and Technology*, 1–7. 0101-2061 (Print) 1678-457X (Online). doi:10.1590/fst.08819

Syarifuddin, A., Septier, C., Salles, C., & Thomas-Danguin, T. (2016). Reducing salt and fat while maintaining taste: An approach on a model food system. *Food Quality and Preference*, *48*, 59–69. doi:10.1016/j.foodqual.2015.08.009

Tan, M., He, F. J., & Macgregor, G. A. (2018). Salt and cardiovascular disease in PURE: A large sample size cannot make up for erroneous estimations. *Journal of the Renin-Angiotensin-Aldosterone System,*1–5. doi:10.1177/1470320318810015

Vidal, L., Antúnez, L., Ares, G., Cu, F., Lee, P., Le, M., & Jaeger, S. R. (2019). Sensory product characterisations based on check-all-that-apply questions: Further insights on how the static (CATA) and dynamic (TCATA) approaches perform. *Food Research International*, *125* (108510), 1–11. doi:10.1016/j.foodres.2019.108510

Viegas, C. A. C. L., Torgal, J., Graça, P., & Martins, M. D. R. O. (2015). Evaluation of salt content in school meals. *Revista De Nutrição*, *28*(2), 165–174. doi:10.1590/1415-52732015000200005

Vieira, E., Soares, M. E., Ferreira, I. M. P. L. V. O., & Pinho, O. (2012). Validation of a fast sample preparation procedure for quantification of sodium in bread by flame photometry. *Food Analytical Methods*, *5*(3), 430–434. doi:10.1007/s12161-011-9247-8

Willems, A. A., Van Hout, D. H. A., Zijlstra, N., & Zandstra, E. H. (2014). Effects of salt labelling and repeated in-home consumption on long-term liking of reduced-salt soups. *Public Health Nutrition*, *17*(5), 1130–1137. doi:10.1017/S1368980013001055

World Health Organization. (2013). A global brief on Hypertension - World Health Day 2013. *World Health Organization*, 1–40. doi:10.1136/bmj.1.4815.882-a

World Health Organization. (2016). Meeting of the WHO action network on salt reduction in the population in the European Region (ESAN). *Meeting Report - Lisbon, Portugal*. Retrieved from http://www.euro.who.int/__data/assets/pdf_file/0009/325737/Salt-action-network-ESAN-Lisbon-meeting-report.pdf

World Health Organization. (2019). Meeting of the WHO action network on salt reduction in the population in the European Region (ESAN). Meeting Report - Bern, Switzerland. Retrieved from http://www.euro.who.int/__data/assets/pdf_file/0009/361989/meeting-report-esan-2017.pdf?ua=1

World Health Organization. Regional Office for Europe. (2020). *Accelerating salt reduction in Europe. A country support package to reduce population salt intake in the WHO European Region*, pp. 1–54. Retrieved from https://www.euro.who.int/__data/assets/pdf_file/0006/457611/Accelerating-salt-reduction-in-Europe.pdf