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ORIGINAL ARTICLE

Salt reduction in vegetable soup does not affect saltiness intensity and liking in the elderly and children

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Abstract

Study background: Reduction of added salt levels in soups is recommended. We evaluated the impact of a 30% reduction of usual added salt in vegetable soups on elderly and children's saltiness and liking evaluation.
Methods: Subjects were elderly and recruited from two public nursing homes (29 older adults, 79.7 ± 8.9 years), and preschool children recruited from a public preschool (49 children, 4.5 ± 1.3 years). This study took place in institutional lunchrooms. Through randomization and crossover, the subjects participated in two sensory evaluation sessions, on consecutive days, to assess perceived saltiness intensity (elderly sample) and liking (elderly and children samples) of a vegetable soup with baseline salt content and with a 30% salt reduction. Elderly rated perceived liking through a 10 cm visual analogue scale ['like extremely' (1) to 'dislike extremely' (10)] and children through a five-point facial scale ['dislike very much' (1) to 'like very much' (5)].
Results: After 30% added salt reduction in vegetable soup, there were no significant differences in saltiness noted by the elderly ($p = 0.150$), and in perceived liking by children ($p = 0.160$) and elderly ($p = 0.860$).
Conclusions: A 30% salt reduction in vegetable soup may be achieved without compromising perceived saltiness and liking in children and the elderly.

Keywords: *elderly*; *preschool children*; *salt*; *hedonic evaluation*; *soup*

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High sodium intake has been associated with the etiology and pathogenesis of hypertension (1) and cardiovascular diseases (CVD), which is the leading cause of mortality and morbidity worldwide (2).

The World Health Organization (WHO) recommends the consumption of less than 2,000 mg sodium per day for adults and the adjustment of 2,000 mg sodium downward based on the energy requirements of children (2). In this global scenario, the reduction of population sodium intake is one of the most urgent strategies to put into practice (3). However, in Portugal, the intake levels are well above these recommendations, reaching an average of 4,800 mg per day in adults (4), and children and the elderly are two important population subgroups to target for lower sodium intake (5).

Since most sodium is consumed in the form of sodium chloride, which is table salt (approximately 40% sodium), the European Salt Framework established a benchmark of a minimum of 16% salt reduction over 4 years for all food products, also encompassing salt consumed in restaurants and catering, including vegetable soup (6). In Portugal, the amount of salt in a 100 g portion of vegetable soup may reach 1,073 mg in nursery homes, and 1,098 mg in kindergarten, and one of the key approaches to decrease sodium intake is to target added salt in soup preparation (7). In order to achieve this goal, a reduction benchmark of 16% against the individual baseline food levels was established by the European Commission (8), but strong controversy exists regarding the choice of cutback levels in each food group. In France (3), United Kingdom (3), United States (9), and Czech Republic (6), the targets for sodium reduction in soups are 7, 15, 8, and 50%, respectively. Therefore, the establishment of a sodium reduction benchmark for vegetable soup should be worked on a country level with highest priority in order to accomplish a significant reduction of sodium intake without compromising sensorial characteristics, such as liking and saltiness perception, which may compromise food

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acceptance (10). It has been reported that the reduction of added sodium to foods ranging between 10 and 48% of baseline levels may not be detected by taste receptors (11–15); however, the large majority of these studies involves trained panelists, and commercial soups or soups with salt substitutes. On the other hand, the new directions to help consumers to eat healthier focus on training in food preparation practice, including in the catering sector, to reduce salt usage in their kitchens. In this scenario, different benchmarks of salt reduction should be tested across the life cycle, in order to significantly reduce sodium intake without affecting consumer acceptability (10, 11, 13, 15, 16).

Thus, the objective of this study was to assess the perceived saltiness intensity and liking of a vegetable soup after 30% reduction of the usual sodium content, in a sample of institutionalized elderly and community preschool children.

Materials and methods

Sampling

Elderly

Elderly subjects ($n = 35$) who attended from two public nursing homes (NH1 and NH2) were invited to participate in the study, and interviewed through a structured questionnaire about general health conditions. Subjects with renal diseases or hyponatremia were excluded ($n = 6$), resulting in 29 elderly subjects remaining. Cognitive status was evaluated using the mini-mental state examination (MMSE) (17), and all had MMSE ranked >18. The elderly provided written informed consent.

Children

All children from a public preschool were also invited to participate ($n = 75$). Letters were distributed to all parents outlining the aims of the study along with a consent form. Forty-nine parents signed and returned the filled-out form, and all of these children gave verbal consent, therefore the sample consisted of 49 children.

Study design

Each set of participants – elderly and children – was randomly divided into one of two groups to perform the saltiness and liking evaluation of vegetable soups in two sessions on separated days.

Each group tasted and evaluated the soups following a crossover design, in which the subjects were randomly assigned to two different arms of the study, one consuming a vegetable soup with baseline sodium content and the other having the soup with 30% salt reduction, switching the soups with the two different levels of sodium content afterwards. Other ingredients in the soups besides salt were the same in both groups. The study was also single blinded such that the subjects were unaware of the salt content of the soup they were assessing.

The sensory evaluation took place in the usual lunchrooms at the institutions, in order to minimize the effects due to changes in the physical environment, and at the typical lunch period – between 12:00 and 13:00 am – which is also the time when participants are most alert to perform sensory testing. Furthermore, the researchers visited the institutions several times before the test so that participants became familiar with them.

Salt composition of vegetable soups

According to our previous experiences (7), no specific amount of added salt is used for different kinds of vegetable soups, and the added quantities widely vary even for a soup with the same recipe. Hence, for the estimation of the baseline sodium content of soup, we computed the mean sodium content of the consecutive days prior to the trial (7 consecutive days in nursing home and 5 days in kindergarten), and estimated the added salt reduction of 30% in order to obtain a soup in the trial.

To estimate baseline sodium content, four samples of soup were collected, two samples before adding salt in confection by a food handler and two samples after added salt, in each day. Baseline added salt was calculated subtracting average sodium before adding salt (sodium from vegetables) to average sodium after added salt, and the average sodium content of the 7 days/5 days was considered as the baseline.

Sodium content was determined using flame photometry method, the intern reference method to analyze sodium in food matrices (18). Samples preparation procedure was adapted to soups from one validated method proposed to quantify sodium content in bread (19). All soup samples were stored in plastic containers at 4°C until analysis. After homogenization of each soup (Robot 300 IX, Taurus, Oliana, Spain), 2 g was sampled and 2 ml of nitric acid was added. The mixture was shaken during 90 min to allow the food matrix's to complete hydrolysis. Then, 20 ml of water was added, and the mixture was again homogenized using an electric homogenizer (Ultra Turrax blender T25, Sotel, Staufen, Germany). Volume was completed up to 40 ml and shaken for 30 min, followed by centrifugation (4,000 rpm, 15 min; Labofuge 6000® Haerus model, Burladingen, Germany). Finally, 1 ml of aqueous supernatant was diluted up to 40 ml of deionized water before reading in the flame photometer (Model PFP7, JenWay, Staffordshire, England).

For sensory evaluation, the vegetable soups were presented in a white ceramic plate at 68–72°C. Soups were served with nectar consistency and stored in the first day for the second refrigerated at 4°C, without added salt. Before the test soups were heated, soups were divided in two groups: in one group, the amount of added salt corresponded to the usual amount in baseline soups, and

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in the other group of soups, the amount of added salt was reduced by 30% compared to baseline. For the vegetable soups prepared for the elderly, a traditional recipe was selected, consisting of 1.5 kg of potatoes, 2.0 kg of white cabbage, 1.5 kg of Portuguese cabbage, 0.5 kg of onions, and 1.0 kg of carrots. For preschool children, the usual recipe for the soup was prepared with 7.0 kg of potatoes, 1.3 kg of onions, 2.3 kg of carrots, 2.5 kg of leek, and 30 g of garlic.

Sensory evaluation

A sensory description of the two soups with the two different sodium contents was performed; elderly evaluated saltiness and liking using a visual analogue scale (VAS) with 10 cm line scale [from 'extremely' (1) to 'not at all' (10) for salt perception and 'like extremely' (1) to 'dislike extremely' (10) for hedonic perception], and children evaluated liking through perceived liking ranking using a five-point facial scale (FS), by means of smiles icons that express feelings from 'dislike very much' (1) to 'like very much' (5). Given the low educational attainment in the elderly, a prior explanation of how to fulfill the VAS was given by a trained researcher.

Sociodemographic and anthropometric data

A questionnaire was applied to elderly and to the children's parents in order to collect data on age, and the highest education qualification completed. Weight and height measurements were performed in the elderly using standardized procedures (20); in the case of children, these anthropometric measures were reported by parents. Body mass index (BMI) was calculated as weight (kg) divided by the square of height (m). Elderly were classified as overweight if their BMI exceeded 25 kg/m^2 and obese if their BMI exceeded 30 kg/m^2, and children were classified as at risk of overweight if BMI at or above the 85th percentile and lower than the 95th percentile and obese if BMI at or above the 95th percentile for children of the same age and sex according to United States Centers for Disease Control and Prevention criteria (21).

Statistical analysis

Mean and standard deviations (SD) were used to describe continuous variables with normal distribution; otherwise, medians, minimum and maximum were presented.

Data analysis was performed with SPSS (version 17, Chicago, IL). The Shapiro–Wilk test was used to assess the assumption of normality, as VAS and FS variables did not reach normality, its median scores were compared using a non-parametric test for paired data, the Wilcoxon signed rank test. Spearman correlation coefficient was used to measure the degree of the association between pairs of variables. A p value of <0.05 was regarded as significant.

The impact of reduced added salt level on sensory evaluation is described separately for children and elderly.

Results

Elderly subjects ($n=29$, 20 females) were 79.7 ± 8.9 years old with BMI of 25.7 ± 3.9 kg/m^2 (41.4% overweight and 13.8% obese); 62.1% had basic education (1–4 years) and 34.5% could not read or write. Children ($n=49$, 26 girls) were 4.5 ± 1.3 years old with a BMI of 16.0 ± 1.5 kg/m^2 (16.3% overweight and 12.2% obese). Almost half (49%) of the children's parents reported to have attained a high education level; however, 18.3% had nine or less schooling years.

The baseline sodium concentrations in soups from each institution are shown in Table 1. The values of added sodium to soups (mg of sodium/100 g of soup) were 300.7 ± 6.6 mg in NH1, 206.7 ± 7.3 mg in NH2, and 147.0 ± 8.5 mg in preschool.

The sensory evaluation of the two soups (one with baseline salt content and another with 30% added salt reduction) is presented in Table 2. There were no significant differences in saltiness and liking between the two soups. Furthermore, no significant correlation was found between saltiness and liking in the elderly ($\rho = -0.714$, $p=0.475$).

Discussion

The overweight and obesity prevalence values found in the elderly and children samples were similar to values reported in the same age groups in Portugal (22, 23).

A 30% added salt reduction did not change the saltiness and liking perception of a vegetable soup in both preschool children and elderly subjects. These results encourage for achieving higher sodium reductions than those typically advised, namely with decreases between 4 and 10% per year (9), without affecting hedonic response, particularly among children and the elderly. Nevertheless, these results should be considered with caution, and this reduction ought to be tested in soups with other vegetables, since optimum added sodium levels to increase saltiness or sweetness, or decrease bitterness, (24) may vary according to vegetable ingredients. Previous studies (10, 14, 25, 26) addressed sodium reductions and the combinations of extra aroma and salt replacers to substitute sodium (11) in adults although more research is needed to understand and control the human liking for salt (27), particularly among children and the elderly. Malherbe et al. found similar results in adults and conclude that it is possible to reduce the sodium content in soup by about 30% without significantly changing acceptability and pointed to the masking of other ingredients, partial adaptation, as well as the decreased absolute sensitivity and increased differential sensitivity as possible reasons (13).

Table 1. Sodium content in vegetable soups (mg sodium/100 g soup)[a]

		Before adding salt				After adding salt				Salt added during the cooking process			
		Mean ± SD	Med	Min	Max	Mean ± SD	Med	Min	Max	Mean ± SD	Med	Min	Max
NH1	Soup day 1	4.5 ± 0.1				212.4 ± 4.6				207.9 ± 4.5			
	Soup day 2	5.5 ± 1.6				315.2 ± 23.7				309.7 ± 22.1			
	Soup day 3	1.3 ± 1.2				290.8 ± 12.2				289.5 ± 11			
	Soup day 4	5.5 ± 1.5				308.3 ± 11.4				302.8 ± 9.9			
	Soup day 5	17.2 ± 2.6				334.4 ± 1.9				317.2 ± 0.7			
	Soup day 6	7.4 ± 4.2				267.8 ± 12.3				260.4 ± 8.1			
	Soup day 7	2.7 ± 0.8				420.0 ± 12.3				417.3 ± 11.5			
	Mean of the 7 days soups	6.3 ± 4.6	4.6	1.3	17.2	307.0 ± 11.2	308.3	212.4	420.0	300.7 ± 6.6[b]	302.8	207.9	417.3
NH2	Soup day 1	2.4 ± 0.6				358.1 ± 10.2				355.7 ± 9.6			
	Soup day 2	13.5 ± 2.9				185.4 ± 4.1				171.9 ± 1.2			
	Soup day 3	33.9 ± 2.0				166.4 ± 10.2				132.5 ± 8.2			
	Soup day 4	18.9 ± 0.2				175.3 ± 14.2				156.4 ± 14.0			
	Soup day 5	21.4 ± 1.3				204.9 ± 5.0				183.5 ± 3.7			
	Soup day 6	130.1 ± 1.0				300.9 ± 6.5				170.9 ± 5.5			
	Soup day 7	0.6 ± 0.4				226.9 ± 9.1				226.3 ± 8.7			
	Mean of the 7 days soup	31.5 ± 6.2	15.7	0.6	130.1	231.1 ± 13.5	212.5	166.4	300.9	206.7 ± 7.3[b]	196.8	132.5	355.7
PS	Soup day 1	3.0 ± 1.1				164.6 ± 3.5				161.6 ± 2.4			
	Soup day 2	3.0 ± 0.5				107.6 ± 2.9				104.6 ± 2.5			
	Soup day 3	3.0 ± 0.5				110.2 ± 8.4				107.2 ± 8.0			
	Soup day 4	18.5 ± 0.9				67.2 ± 5.9				48.7 ± 5.0			
	Soup day 5	18.5 ± 0.9				318.0 ± 19.5				299.5 ± 18.6			
	Mean of the 5 days soup	9.2 ± 0.7	6.1	3.0	18.5	153.5 ± 8.0	131.9	67.2	318.0	144.3 ± 7.3[b]	125.8	48.7	299.5

[a]Sodium obtained using flame photometry methodology; vegetable soups included four vegetables and potatoes.
[b]Values used to perform a 30% salt reduction.
SD = standard deviation; Med = median; Min = minimum; Max = maximum; NH1 = Nursing Home 1; NH2 = Nursing Home 2; and PS = preschool.

Strong concerns about the consumption of salt in vegetable soup exist in Portugal. The soups analyzed to establish the baseline (7 days in institutionalized elderly and 5 days for preschool children) take part in the usual menu cycle in both institutions, and regardless of the recipe, they are usually composed of four vegetables plus potatoes. Thus, the soup used in the trial symbolizes a general traditional vegetable composition of any of the soups analyzed in the baseline, with no expected significant variations in the nutritional composition, other than added sodium. The latter may vary according to the food handlers/cookers since no standardized amount of added sodium is established for each recipe.

Accordingly, in our study, salt added in soups during the cooking process (Table 1) varies widely between different collection days and between institutions, probably because the sodium added to soups varied according to intrapersonal and interpersonal food preparation prac-

Table 2. Evaluation tests according to the salt content in the soup (hedonic and perceived salt ratings)

		Vegetable soups with usual added salt		Vegetable soups with 30% reduction of added salt		
	Hedonic perception	Mean ± SD	Median (Min; Max)	Mean ± SD	Median (Min; Max)	*p*
Elderly (*n* = 29)	Saltiness	5.7 ± 3.2	5.0 (3.4; 9.1)	6.9 ± 2.5	7.8 (4.9; 9.3)	0.150
	Liking	2.1 ± 2.8	0.8 (0.2; 2.7)	2.2 ± 2.9	0.7 (0.3; 4.0)	0.860
Preschool children (*n* = 49)	Liking	4.4 ± 0.5	4.0 (4.0; 5.0)	4.41 ± 0.54	4.0 (4.0; 5.0)	0.160

SD = standard deviation; Min = minimum; Max = maximum.

tices without standardization (7). Moreover, the levels of salt found in the set of days used as 'baseline' are similar, or even lower than others reported in the literature (7, 28). For that reason, it is not expected that soup used in the trial was 'over-salted'.

According to a study that evaluated the sodium content of Portuguese vegetable soups in NH, elementary schools and kindergartens, subjects eating two portions of soup per day may reach 67% of the upper limit of sodium intake, when considering the mean values of sodium in vegetable soups (7) and the values found in this study were similar to ours. Given the low content of sodium in non-processed vegetables, nutrition education approaches to target sodium reduction should focus on training in cooking practice to significantly decrease added salt (according to the present study, about one third reduction in relation to usual levels may be acceptable) in vegetable soups produced both at home and in catering industries. A major challenge is to ensure that salt reductions do not exceed consumer expectations from a hedonic perspective which is a difficult task considering that bliss point depends on the individual and on his hedonic relation with a particular food (29), with some products largely punished on their hedonic evaluation even with small sodium reductions (9). However, sensitivity, perception of the intensity, preference and hedonic response to salt are independent measures; thus even individuals who are able to detect salt reduction may still maintain high ranking hedonic responses (30). Our results suggested that in vegetable soup, it is possible to moderately decrease the added salt without affecting both the consumer salty perception and the hedonic value attributed.

Salt is used in the food industry and during the cooking process due to its capacity to improve sensory properties of food (31), and each food preparation process or technology of processing has its own specific challenges as salt has multiple functions. In the case of soup preparation, adding salt may be a very cheap way to positively influence the taste of soup. For individuals who are used to tasting high levels of salt, its sudden reduction may cause the rejection of food (9, 32). For this reason, a small reduction of added salt, which is not detected by salty taste receptors, might be a valuable strategy to reduce sodium intake, and this study adds 30% as a possible benchmark for reduction.

Few studies have assessed the impact of a reduction of the sodium content of vegetable soup on hedonic perception of consumers in different age groups. Drewnowski et al. (33) showed that older adults prefer less salty soups than young adults; these results are also supported by Kremer et al. (34). However, it is largely assumed that people aged over 70 may have suffered changes in the function of ion channels and receptors of taste buds, with a consequent decrease of the threshold for detection and identification of flavor (35). Accordingly, Murphy and Withee have shown that the elderly have difficulty in detecting sweet and salty tastes (36), leading to an increased preference for salt (37), which could result in a higher sodium intake with the associated adverse health consequences. However, our findings showed that the elderly and children did not differently evaluate the soups with different sodium contents, which may be a good indicator for the process of reduction of added salt in vegetable soups in these age groups, leaving soup as a perfect vehicle of micronutrients. Vegetable soup is part of the food culture in southern Europe (38), being a culinary preparation with a suitable consistency for anyone with weak dentition (common in the elderly and children populations), with easy digestibility, high content of vitamins, minerals and fiber, that may also contribute to lower risk of overweight and obesity (39, 40). The nutritional and metabolic advantages of vegetable soup intake may further include hydration and anti-inflammatory properties (41), being strongly advised to consume it twice a day, in order to counteract the low intake of vegetables in Portuguese adults (42) and children (43) and prevent non-communicable diseases (44).

The results of the present study should be interpreted while taking into account its strengths and limitations. The study was carried out in the habitual familiar context for participants and during the period that they usually take their meals, leaving these variables constant over the intervention. Another strength of the study was the use of a single-blinded crossover model. On the other hand, participants were institutionalized; that is, the cooking process was the responsibility of the institution. Thus, the results should not be speculated to other population groups, neither the food used to taste stimuli; the perception of sodium reduction in vegetable soup should not be generalized to other foods because the effect of salt appears to be food specific. Another limitation of this study is that salt reduction was carried out a particular kind of vegetable soup recipe; however, we can achieve other values of reduction of salt content in other types of vegetable soup with other ingredients without affecting saltiness and hedonic perception.

For that reason, in the future, it will be important to consider other vegetable ingredients and recipes, and other values for the reduction of added salt in order to formulate targeted measures to control sodium intake, and set realistic and culturally relevant goals in food policy.

In conclusion, a 30% salt reduction in soups can be achieved without affecting perceived saltiness intensity and liking among the elderly and children, considering the reported mean baseline content of sodium.

Conflict of interest and funding

The authors declare no conflict of interest.

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