

# Sweet and Salt Pleasantness Are Not Related to Nutritional Status

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**Abstract** The aim of this study was to investigate the relationship among nutritional status, taste sensitivity and pleasantness in overweight individuals. Threshold sensitivity of salt and sweet was determined by a two-alternative forced choice question involving each compound present at five different concentrations. Subjects received concentrated orange juice containing five different concentrations of sucrose (1%, 3%, 5%, 7% and 9% w / w). Pleasantness of salt was evaluated using mashed potato prepared at five different concentrations of salt 0%, 0.5%, 1.0%, 1.5% and 2.0% (w / w). A difference for sweet taste was observed between the groups studied, with lower sweet taste sensitivity thresholds detected in overweight subjects.

**Keywords** Sweet, Salt, Overweight

## 1. Introduction

Obesity affects more than 300 million humans worldwide [1] and is a major risk factor for diabetes mellitus, hypertension, dyslipidemia, arteriosclerosis and certain types of cancer [2-4]. In addition to overeating and lifestyle, taste perception has been extensively studied in an attempt to better understand the factors influencing obesity [5]. Research indicates that obese individuals have a stronger implicit attraction toward sweet which might stem from taste differences determined by both genetic and environmental factors [6].

Increased preference for fat and sugar may play a role in the development of overweight and obesity [7]. MACDIAR MID et al. [8] found a positive relationship between body mass index (BMI) and consumption of sugary foods in women.

Differences in taste perception associated with nutritional status have also been observed.

However, there is discordance in the literature regarding the nature of the relationship between sweet taste perception and obesity [9]. While some investigations show that obese and normal-weight individuals have the same taste sensitivity for sweet [10-12], others have found that obese individuals have lower sensitivity for this taste [9].

Salt sensitivity has also been related to nutritional status. Salt thresholds were reported as being lower in obese adolescents and children [13]. Monneuse et al. [14] found no significant link between taste recognition thresholds and

body mass index in obese adolescents. Donaldson et al. [5] observed that overweight women have a greater implicit desire for salt than normal-weight women.

Given that taste is a major determinant of dietary choices, identifying taste sensitivity among the obese represents a valuable contribution to provide insights on the complexity of dietary behavior in this group.

The objective of the present study was to investigate the relationship among nutritional status, taste sensitivity and pleasantness in overweight individuals.

## 2. Material and Methods

A total of 123 volunteers (93 women and 30 men, between 20 and 58 years of age) were recruited, via the Internet from among students and staff of the School of Public Health—University of Sao Paulo (USP) and the Geraldo Horacio de Paula Souza Health Center, both located in Sao Paulo, Brazil. Individuals aged younger than 20 years or older than 60 years, pregnant, with food allergies, colds or use of medicines that could change sensory perception, were excluded.

Subjects were asked to state their age and gender.

Weight measurements were taken using a Tanita® digital balance with a capacity of 200kg, accurate to 200g. Subjects were weighed in light clothing without footwear. To measure height, individuals stood erect with their arms alongside their body and heels, calves, hips, shoulders and head against the wall, with head positioned according to Frankfort's plan: eyes fixed on the horizontal plane parallel to the ground. The measurement was performed in duplicate, and difference between values did not exceed 1.5 mm [15]. A stadiometer accurate to 0.1 cm was used.

BMI was calculated by dividing weight in kilograms by

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height in meters squared, using reference values of the WHO [16] for group classification (BMI <25.0 kg/m<sup>2</sup> - normal-weight group; or ≥25.0 kg/m<sup>2</sup> - overweight group).

## 2.1. Procedure

### 2.1.1. Taste Test

Threshold sensitivity was determined by a two-alternative forced choice question, with concentrations presented in ascending order [17]. Two taste qualities (salt and sweet) were studied with one compound per taste, and each compound was present at five different concentrations. Briefly, the test consisted of 10 aqueous solutions of sodium chloride (0.09, 0.18, 0.37, 0.75, 1.5 g/L) and likewise of sucrose (0.5, 1, 2, 4, 8 g/L). The concentrations chosen were based on pretests. Subjects received 20 mL of each stimulus in a disposable 50 mL plastic cup. For each solution, subjects had to swirl the full sample around their mouth, evaluate the taste and then expectorate.

When the subject chose incorrectly, the subsequent trial took place at the next highest level. When the subject chose correctly, the same concentration was presented again. Testing ceased after two correct answers in a row. The geometric mean of the last and penultimate concentrations was calculated and taken as the individual threshold [18].

At the start of each session, and before each new taste quality was introduced, subjects were instructed to rinse out their mouth with tap water and to expectorate. Each session lasted 20 minutes with 5-minute breaks between two taste quality series [18].

### 2.1.2. Pleasantness

The sugar and salt concentrations employed were determined based on pre-tests.

Subjects received concentrated orange juice, diluted according to the manufacturer's instructions by adding 100 mL juice to 300 mL water. Samples containing five different concentrations of sucrose (1%, 3%, 5%, 7% and 9% w / w) were prepared based on results of extensive pretests. Subjects received 20 mL of each concentration at 8°C [19].

To determine the pleasantness of salt, mashed potato was prepared according to the manufacturer's instructions by adding 50 g of instant dry potato to 250 mL of boiling water and 200 mL of skimmed milk. Samples containing five different concentrations of salt (0%, 0.5%, 1.0%, 1.5% and 2.0% (w / w)) were prepared, also based on results of pretests. Fresh samples were prepared on the day of the test. The mashed potato was offered in 30 g portions at a temperature of 45°C [19-20]. The order of presentation of the different concentrations was random, ensuring that neither minimum nor maximum was presented first [21]. All samples were offered in white, odorless, plastic cups, coded with randomly chosen three-digit numbers. Subjects rinsed out their mouth with tap water between the stimuli.

Orange juice and mashed potato were chosen because these food types are familiar to the population, and both are

convenient vehicles for manipulating the intensity of several attributes.

Individuals were instructed to rate pleasantness on a seven-point category scale (1 = dislike extremely, 4 = neither like nor dislike, 7 = like extremely).

The tests were performed at the Laboratory of Sensory Analysis of the School of Public Health -USP, Sao Paulo – Brazil.

Subjects performed taste tests during one session and pleasantness tests during another, with the separate sessions run on two non-consecutive days.

### 2.1.3. Statistical Analysis

The Statistical Package for the Social Sciences (version 17.0 for Windows, 2008, SPSS Inc, Chicago, IL) was used for all data analyses.

Results are expressed as mean, standard deviation, median, and minimum and maximum values.

Nonparametric analyses of repeated ordinal categorical data were performed to verify the relationship among age, gender, nutritional status and pleasantness [22]. A value of  $p < 0.05$  was adopted to indicate statistical significance.

The study was approved by the Research Ethics Committee of the School of Public Health, USP. All subjects gave written informed consent.

## 3. Results and Discussion

### 3.1. Subject Characteristics

A total of 123 individuals, predominantly female (76%), aged between 20 and 40 years, participated in the study (Table 1).

**Table 1.** Gender, age and BMI of subjects

Characteristic	N	%
<i>Gender</i>		
Female	93	76
Male	30	24
<i>Age</i>		
20-40	81	74
41-60	32	26
<i>BMI</i>		
<25.0	63	51
≥25.0	60	49

### 3.2. Threshold Sensitivity

**Table 2.** Mean, standard deviation, median and magnitude of threshold (g/L) in water by normal-weight and overweight individuals

Compounds	Normal weight		Overweight		p
	Mean (SD)	Median (magnitude)	Mean (SD)	Median (magnitude)	
Sucrose	0.9 (0.4)	0.7 (0.5-2.1)	0.7 (0.3)	0.6 (0.4-2.1)	0.00*
NaCl	0.2 (0.1)	0.2 (0.1-0.5)	0.2 (0.1)	0.2 (0.0-0.5)	0.38

\* $p < 0.05$

No effects for age or gender on thresholds of the compounds evaluated were detected ( $p>0.05$ ).

A difference for sweet taste ( $p=0.00$ ) was observed between the groups studied, with lower sweet sensitivity thresholds detected among overweight subjects (see Table 2), a finding also seen by other authors.

Studies have shown that low sucrose sensitivity is associated with overeating and obesity [23-25] and weight loss improves sweet taste sensitivity in obese individuals [26].

Donaldson et al. [5] observed that sweet perception has been linked to increased BMI, with a reduced threshold observed in obese children.

Sartor et al. [6] verified that overweight and obese adults perceived sweet and salty tastes as less intense and are more implicitly attracted to sweet than normal weight subjects.

### 3.3. Pleasantness

No effects for age or gender on the reported pleasantness of the products evaluated were found. In addition, no association between nutritional status and pleasantness was found in the study (see Table 3 ( $p>0.05$ )).

**Table 3.** Mean, standard deviation, median and magnitude of pleasantness (g/L) in orange juice and mashed potato by normal-weight and overweight individuals

Compounds	Normal weight		Overweight		P
	Mean (SD)	Median (magnitude)	Mean (SD)	Median (magnitude)	
Sucrose (%)					
1	2.6 (1.6)	2.0 (1.0-7.0)	2.5 (1.5)	2.0 (1.0-7.0)	
3	4.0 (1.8)	4.0 (1.0-7.0)	3.6 (1.7)	3.0 (1.0-7.0)	
5	4.5 (1.5)	5.0 (1.0-7.0)	4.3 (1.8)	5.0 (1.0-7.0)	0.62
7	4.3 (1.5)	5.0 (2.0-7.0)	4.8 (1.8)	5.0 (1.0-7.0)	
9	3.4 (1.8)	3.0 (1.0-7.0)	4.2 (2.1)	5.0 (1.0-7.0)	
Salt (%)					
0	2.7 (1.5)	2.0 (1.0-7.0)	2.9 (1.6)	3.0 (1.0-7.0)	
0.25	4.2 (1.5)	4.0 (1.0-7.0)	3.6 (1.8)	3.0 (1.0-7.0)	0.69
0.5	4.8 (1.5)	5.0 (2.0-7.0)	4.7 (1.6)	5.0 (2.0-7.0)	
1.0	4.8 (1.4)	5.0 (2.0-7.0)	4.5 (2.0)	5.0 (1.0-7.0)	
1.5	3.3 (1.8)	3.0 (1.0-7.0)	3.8 (1.8)	4.0 (1.0-7.0)	

With regard to sugar, the highest means were observed for the concentrations 5 and 7% whereas for salt, the highest acceptance was found for the concentrations 0.5 and 1.0%. Nutritional status had no influence on the ratings assigned and no statistically significant difference in acceptance of the different concentrations of sugar and salt was found.

Sensory feedback from foods is one important factor that may influence the food choice and consumption. Characteristics of a food, such as appearance, taste, texture, and mouthfeel, are perceived differentially among individuals and likely affect the types of foods people find palatable

[27-28]. In general, salt, sugar and fat increase food palatability, which can potentially lead to an increase of food intake [28] and contribute to the development of overweight.

In the present study, and also that of PASQUET et al. [13], overweight individuals were found to have a significantly lower sucrose taste detection threshold. This sensitivity difference for sweet taste may constitute a stimulus for greater intake of sweet foods, contributing to weight gain.

Despite reports in the literature showing greater preference for sweet foods among the obese, the results of the present study indicated that this group were not overly responsive to high sucrose concentrations, corroborating the findings of FRIJTERS and RASMUSSEN-CONRAD [29] and MALCOLM et al. [30], who found no difference in sweet taste threshold or sweet taste hedonics in obese women.

Identifying sensory responses to sugar-rich foods is vital, given that this ingredient had been linked to elevated risk for obesity, metabolic syndrome, diabetes and arterial hypertension [31]. Studies on commonly consumed foods and preparations containing free sugars should be conducted, assessing preferred concentrations and allowing the definition of strategies for reducing the amount of added sugar without impacting acceptability. Based on the results of the present study, no difference in acceptance of preparations containing lower levels of sugar and salt was evident.

Little is known about the relationship between perception of salt and body mass index [5], yet identifying the salt taste detection threshold is crucial given that sensitivity to salt can directly influence its consumption [32]. The consumption of high levels of salt is associated with high blood pressure, cardiovascular disease, stroke and other pathologies [33-35]. For many reasons, contemporary diets are high in salt and daily sodium intakes excessive [36], due to the tendency to consume processed foods and the use of added salt.

Preferences for sweet, salty and fatty foods are related to their exposure. Sartor et al. [6] suggested that regular consumption of soft drinks might raise the taste threshold for sweet and potentially alter perception of both intensity and pleasantness. A short period (8 days) of sweet orangeade exposure increased children's preference for the product, an effect not seen in young adults [37]. Brownell et al. [38] also suggested that high intake of soft drinks may have chronic adverse effects on taste preferences and food acceptance.

Although dietary habits can contribute to excessive sugar and salt intake, as evidenced by the present study, levels of salt in preparations can be reduced while preserving acceptability, a measure that will have positive repercussions on public health.

Drake et al. [39] verified that liking scores for low sodium cottage cheeses did not differ to high sodium products when consumers were informed of reduced sodium and its health benefits before tasting tests.

The difference in sensitivity for sweet taste seen in overweight participants of the present study may be related to this group's dietary habits, rendering the obese more adept at detecting this taste quality more quickly. Studies investigating the correlation between taste sensitivity and dietary

habits are warranted in a bid to provide evidence elucidating the interaction among sensory aspects of foods and dietary intake.

Sensory aspects of foods that exert a direct effect on dietary intake and contribute to excessive weight gain remain unclear. Similarly, the role of preference for foods containing high levels of sugar in the development of obesity has yet to be confirmed. The findings of this study provide valuable insights into the dietary behavior of adults, but a larger sample could lead to more conclusive results.

It is noteworthy that the mechanisms influencing human dietary behavior are complex, and that besides sensory aspects, psychological, social and economic aspects also play a key role in response to foods. Knowledge on these determinants of dietary intake represents a valuable tool toward preventing and changing high risk behaviors and promoting healthier ingestive behaviors [40].

## 4. Conclusions

In conclusion, overweight adults showed a lower taste sensitivity threshold for sweet but not salt. The results of the present study showed no relationship between nutritional status and pleasantness. Knowledge of sensory responses attributed to foods, and optimal ways of managing these responses, represents a valuable tool in the dietary guidance process, aimed at reducing the level of added sugar and salt in foods without affecting their acceptability.

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