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Methodology

Differences in subjective taste between Japanese and Sri Lankan students depending on food composition, nationality, and serum zinc

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SUMMARY

Background & aims: Taste is a very important factor affecting nutritional intake and compliance. Subjective taste may differ among nationalities. In the present study we examined differences in subjective taste according to food composition and nationality. **Methods:** Twelve Japanese and 4 Sri Lankan students took part in the study. Food samples of 3 different mixtures of chicken and rice were tasted: Food 1, 3 g chicken/10 g rice; Food 2, 6 g chicken/10 g rice; Food 3, 9 g chicken/10 g rice. The sweet, salty, sour, bitter, and astringent taste of each of the food samples, as well as their deliciousness, were scored subjectively on a scale of 0–5. Results were compared between the 3 types of food samples, as well as between nationalities. In addition, concentrations of blood micronutrients were measured.

Results: Across all 3 types of food, the change in subjective taste of salty, sweet, and sour differed significantly between Japanese and Sri Lankan students ($P = 0.022$, $P = 0.008$, and $P = 0.025$, respectively). However, bitter and astringent taste, as well as the perceived overall deliciousness of the foods, was comparable

Abbreviations: ONS, oral nutritional supplement; IQR, interquartile range.

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between the 2 groups. Serum zinc levels were significantly lower in Sri Lankan than Japanese students ($P = 0.004$).

Conclusions: Subjective assessment of taste differs according to food composition and nationality, and it is important to consider taste preferences according to nationality when promoting oral nutritional support.

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1. Introduction

As with other organisms, humans require nutrition and hydration to survive [1]. Therefore, if appropriate nutrition cannot be taken, nutritional support is required. When considering nutritional support, it must first be decided whether enteral or parenteral nutrition is more appropriate, depending on gut function. If gut function is working, enteral nutrition is generally the first choice, based on the principle that “if the gut works, use it!” [2,3]. There are various methods for providing enteral nutrition, such as via a nasogastric tube or gastrostomy, but US and European nutritional guidelines recommended that oral food intake and/or oral nutritional supplement (ONS) be performed if possible [4,5]. For oral nutrition, taste is a very important factor affecting nutritional intake and compliance. In mammals, taste is generally divided into 5 basic qualities, namely salty, sweet, bitter, sour, and umami, as well as overall “deliciousness” [6,7]. Previous studies have elucidated that these tastes are affected by various factors, including age [8], systematic diseases, decreased salivary flow, nutrition (including micronutrient deficiency) [9,10], oral hygiene [11], and differences in dietary habits due to country of residence [12,13].

In the present study we investigated differences in taste sensations depending on food composition and nationality between Japanese and Sri Lankan students of the same age. In addition, we examined the effects of the background of participants and micronutrient status on taste sensations.

2. Materials and methods

2.1. Participants

Twelve Japanese students of the Department of Nursing, School of Health Sciences Faculty of Medicine, Niigata University, and 4 Sri Lankan students of the Faculty of Allied Health Sciences, University of Peradeniya, took part in the present study. All participants were female and non-smokers. Six Sri Lankan students had come to Niigata University School of Medicine at the beginning of October 2016 to study for a short 6-month period; 2 of these 6 students did not participate in the present study because of religious considerations. The study was performed in the middle of December 2016, at which time the Sri Lankan students had spent more than 2 months in Japan and had become familiar with Japanese life. Despite this, their daily diet was almost the same as in Sri Lanka because the students were able to purchase ingredients at the supermarket and cook for themselves.

This study was approved by the Institutional Review Board for Clinical Research of Niigata University (#2016-2657). All participants provided verbal consent after the purpose, methods, potential risks, and benefits of the study had been explained to them.

2.2. Participants' background

The background of each participant was investigated using questionnaires. All participants were instructed to complete a baseline questionnaire recording their age, religious practices, most preferred

food type, preferred level of spicy taste, effect of food appearance on taste, and drinking habits. In addition, participants were asked to indicate their preferred levels of “salty”, “sweet”, “sour”, “bitter”, “astringent”, and “deliciousness” based on usual food habits.

2.3. Laboratory examination of micronutrients

Non-fasting venous blood samples were collected from each participant, and a 0.5-mL sample of whole blood was stored separately in EDTA-containing tubes (SRL, Tokyo, Japan) for vitamin B₁ analysis. The remaining blood samples from each of the participants were centrifuged at $3000 \times g$ for 20 min at 4 °C, and the serum obtained was collected into trace element-free cryogenic vials (SRL) for zinc and vitamin B₁₂ analysis. All samples were stored at –70 °C until analysis. Blood vitamin B₁ concentrations in each participant were determined by liquid chromatography/tandem mass spectrometry (LC/MS/MS), whereas serum vitamin B₁₂ and zinc concentrations were measured using a chemiluminescent enzyme immunoassay and atomic absorption spectrometry, respectively. All blood sample measurements were performed by SRL.

2.4. Food and taste

In the present study, “Yu-rin-chii bento”, which is available commercially from Seven-Eleven Japan stores and consists of chicken seasoned with sweet soy sauce and rice, was used as the test food. There were 3 different food samples evaluated in the present study with different ratios of chicken to rice: Food 1, 3 g chicken/10 g rice; Food 2, 6 g chicken/10 g rice; Food 3, 9 g chicken/10 g rice. Participants were also asked to taste and assign scores, on a scale of 0–5 (with increments of 0.5), to the sweet, salty, sour, bitter, and astringent taste of the food, as well as its “deliciousness”. Comparisons were made between the 3 types of food samples and scores according to nationality.

2.5. Statistical analysis

Statistical analyses were performed using SPSS Statistics version 22 (IBM Japan, Tokyo, Japan). Categorical variables are presented as frequencies. In the case of continuous variables, those with a normal distribution are expressed as the mean \pm SD, whereas those without a normal distribution are reported as median values with the interquartile range (IQR). The significance of differences between groups was examined using the Mann–Whitney *U*-test for continuous variables, and Fisher's exact test for categorical variables. Repeated-measures analysis of variance (ANOVA) and Friedman test with Bonferroni's post hoc correction were used to analyze group differences. $P < 0.05$ was considered significant.

3. Results

3.1. Participants' background

All study participants were women aged in their 20s who were in their final year at their respective institutions. The Japanese students were significantly younger than the Sri Lankan students ($P = 0.001$; [Table 1](#)). There was no significant difference between the Japanese and Sri Lankan students with regard to ‘most preferred food type’, ‘preferred level of spicy taste’, and ‘effect of food appearance on taste’; however, a significantly greater proportion of Sri Lankan students was religious ($P = 0.003$) and did not drink ($P = 0.008$; [Table 1](#)).

3.2. Preferred tastes in usual food habits

The results of preferences regarding the “salty”, “sweet”, “bitter”, “sour”, and “astringent” tastes and the “deliciousness” of usual foods are given in [Table 2](#). Preferences for “salty”, “sweet”, “bitter”, “sour”,

Table 1
Characteristics of the Japanese and Sri Lankan students.

Factor	Japanese students (n = 12)	Sri Lankan students (n = 4)	P-value
Mean (IQR) age (years)	22.0 (21.0, 23.0)	25.5 (25.0, 26.0)	0.001
Religious beliefs			0.008
Yes	2	4	
No	10	0	
Most preferred food type			0.245
Solid	10	2	
Intermediate	2	2	
Liquid	0	0	
Preferred level of spicy taste			0.288
Low	5	0	
Moderate	3	1	
High	4	3	
Influence of food appearance on taste			0.156
Strong	7	4	
Moderate	4	0	
None	0	0	
Alcohol consumption			0.003
Yes	11	0	
No	1	4	

Unless indicated otherwise, data show the number of students in each group. IQR, interquartile range.

and “astringent” tastes of usual foods were comparable between the Japanese and Sri Lankan students. Students in both group preferred moderate levels of “salty” and “sweet” tastes, with a lower preference for “bitter”, “sour”, and “astringent” tastes. However, the preference for “deliciousness” was greater among Sri Lankan than Japanese students ($P = 0.016$).

3.3. Food and taste examination

The results of subjective assessment of each of the 5 tastes in the 3 different food samples are shown in Fig. 1. Among Foods 1–3, the change in “salty” taste differed significantly between the Japanese and Sri Lankan students ($P = 0.022$); specifically, the Sri Lankan students reported an increase in the “salty” taste as the amount of chicken increased (Fig. 1a). The change in “sweet” taste also differed significantly between the Japanese and Sri Lankan students ($P = 0.008$): although both groups reported an increase in the “sweet” taste as the amount of chicken increased, the Sri Lankan students reported a more rapid increase in the “sweet” taste (Fig. 1b). Similarly, changes in the “sour” taste were significantly different between the Japanese and Sri Lankan students ($P = 0.025$), with Japanese students reporting an increase in the “sour” taste as the amount of chicken increased, whereas this taste was almost stable across Foods 1–3 among Sri Lankan students (Fig. 1c). Despite Japanese students reporting an increase in the “bitter” and “astringent” tastes as the amount of chicken increased and no linear increase being observed for these tastes among Sri Lankan students, there was no significant difference between the 2 groups regarding changes in these tastes (Fig. 1d, e; $P = 0.406$ and $P = 0.780$, respectively). “Deliciousness”, which encompassed an overall evaluation of all 5 separate tastes, exhibited a linear increase with increasing chicken content in both the Japanese and Sri Lankan student groups, and was comparable between the 2 groups ($P = 0.144$; Fig. 1f). Bonferroni’s post hoc correction did not reveal any significant differences in the individual tastes of the 3 food samples in the Japanese student group. However, in the case of Sri Lankan students, a significant difference was observed for the “sour” taste between Foods 1 and 3.

3.4. Blood micronutrient levels

Blood micronutrient levels are given in Table 3. Serum zinc concentrations were significantly higher in Japanese than Sri Lankan students ($P = 0.004$). However, blood vitamin B₁ and vitamin B₁₂ concentrations were comparable between the two student groups (Table 3).

Table 2
Taste preferences in usual food.

Taste	Japanese students (n = 12)	Sri Lankan students (n = 4)	P-value
Salty			>0.999
Not at all	0	0	
A little	0	0	
Moderate	7	3	
Rather	5	1	
Extremely	0	0	
Sweet			0.815
Not at all	1	0	
A little	3	0	
Moderate	5	3	
Rather	3	1	
Extremely	0	0	
Sour			0.815
Not at all	1	1	
A little	3	1	
Moderate	7	2	
Rather	1	0	
Extremely	0	0	
Bitter			0.435
Not at all	4	3	
A little	6	1	
Moderate	2	0	
Rather	0	0	
Extremely	0	0	
Astringent			0.251
Not at all	6	4	
A little	4	0	
Moderate	0	0	
Rather	0	0	
Extremely	0	0	
Deliciousness			0.016
Not at all	0	0	
A little	0	0	
Moderate	8	0	
Rather	4	2	
Extremely	0	2	

4. Discussion

The profile of Japanese and Sri Lankan students was quite different. Sri Lankan students were significantly older than the Japanese students, but this was due to differences between the Japanese and Sri Lankan educational systems. In Japanese universities, students in the final year are generally around 22 years of age, whereas in Sri Lankan universities final-year students are generally around 25 years of age. However, we do not think that the age difference affected the results of the present study. There was a significant difference between Japanese and Sri Lankan students with regard to religion: all Sri Lankan students had their own religion, whereas most Japanese students were not religious. It is presumed that this difference affected the drinking habits of the students, because the religion of the Sri Lankan students forbids the consumption of alcohol. Although smoking habits have been shown to have a significant effect on taste [14,15], all participants in the present study were non-smokers.

There was no significant difference in most preferred food type or the preferred level of spicy taste, but these results may be due to the small number of participants in the present study, particularly with regard to preferred levels of spicy taste: although there was no significant difference between the 2 groups, many of the Sri Lankan students answered that they like a high level of spicy taste, whereas most Japanese students preferred low levels. Sri Lankan students in the present study were eating similar foods to those eaten in Sri Lanka because they did their own cooking and their daily meals were primarily Sri Lankan-style curries, which are well known in Southeast Asia as extremely spicy (i.e.

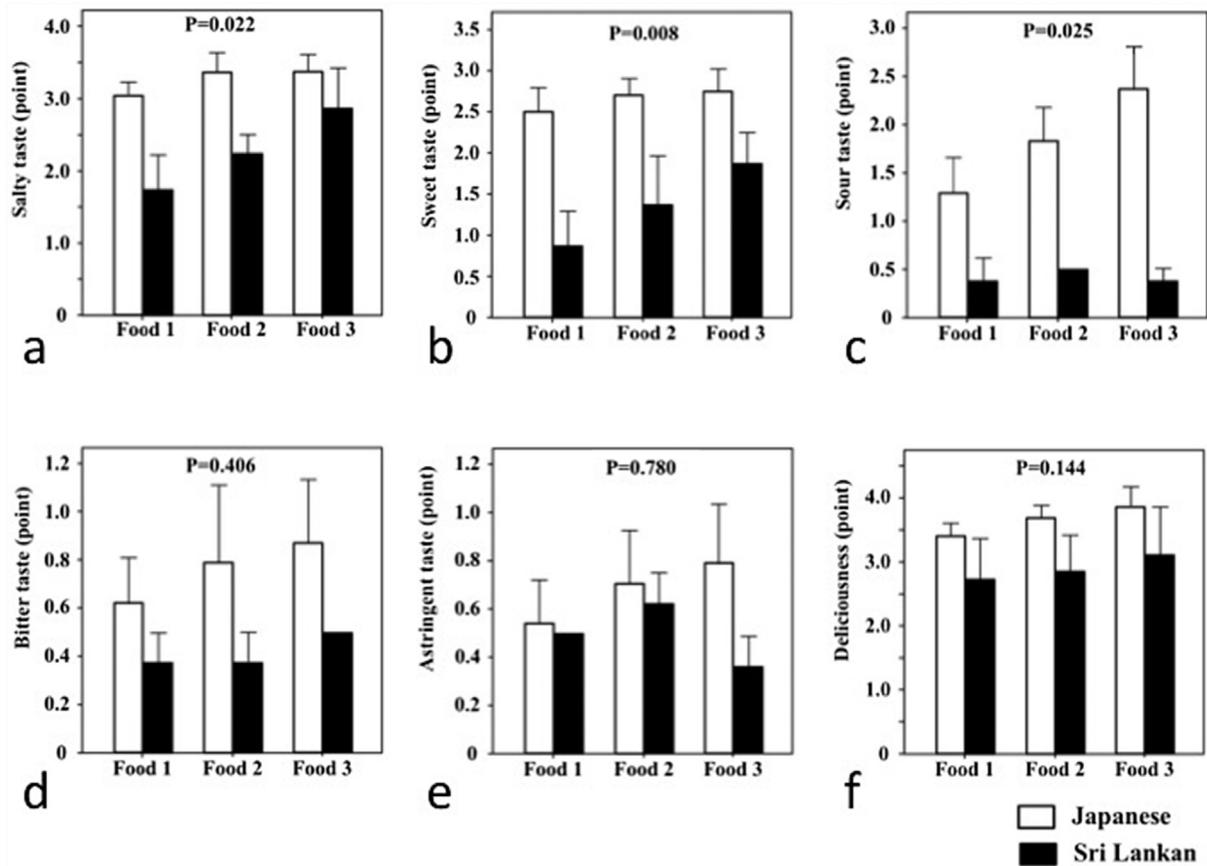


Fig. 1. Changes in the subjective assessment of each of the five tastes in Japanese and Sri Lankan students following the intake of 3 different mixtures of chicken and rice: Food 1, 3 g chicken/10 g rice; Food 2, 6 g chicken/10 g rice; Food 3, 9 g chicken/10 g rice. **a** salty, **b** sweet, **c** sour, **d** bitter, and **e** astringent tastes, as well as **f** the overall deliciousness of the food, were scored subjectively on a scale from 0 to 5.

Table 3
Blood zinc and vitamin B₁ and B₁₂ concentrations.

Micronutrient	Japanese students (n = 12)	Sri Lankan students (n = 4)	P-value
Zinc (µg/dL)			0.004
Median (IQR)	81.0 (76.3, 84.8)	60.5 (59.3, 61.0)	
Mean ± SD	81.0 ± 5.9	60.3 ± 1.0	
Vitamin B ₁ (ng/mL)			0.225
Median (IQR)	38.0 (32.5, 41.0)	34.0 (30.0, 37.3)	
Mean ± SD	37.00 ± 131.61	33.75 ± 3.78	
Vitamin B ₁₂ (pg/mL)			0.090
Median (IQR)	307.5 (254.5, 435.3)	251.0 (190.3, 295.3)	
Mean ± SD	351.33 ± 5.92	245.5 ± 55.2	

IQR, interquartile range.

“extremely hot”). As indicated in Table 2, the preferred tastes of usual food were comparable between the Japanese and Sri Lankan students, except for “Deliciousness”. The findings indicate that Sri Lankan students are seeking more “delicious” tastes than Japanese students.

The present study examined participants' subjective evaluation of the taste of food. Although previous studies have evaluated taste using chemical substances such as phenylthiocarbamide, 6-n-propylthiouracil [16–18], sodium chloride, citric acid, and sucrose [19,20], most studies were performed to examine threshold and sensitivity of taste to compare tasters and non-taster using a quantitative approach. The present study used a qualitative approach to clarify how to evaluate the taste of food as a sensation, and to examine how tastes and “deliciousness” change with changes in the ratio of chicken to rice in prepared test meals. In the present study, participants were asked to evaluate the taste of a test meal that is based on a daily meal. Japanese students reported smaller changes in “salty” and “sweet” tastes with increases in the proportion of chicken in the test meals, whereas Sri Lankan students reported a linear increase in these tastes with increasing chicken content. Conversely, “sour”, “bitter”, and “astringent” tastes increased linearly in the Japanese student group, with Sri Lankan students reporting less of a change in these tastes. These differences between Japanese and Sri Lankan students were significant for the “salty”, “sweet”, and “sour” tastes, whereas the “bitter” and “astringent” tastes were comparable between the 2 groups. We suppose these discrepancies could be due to seasonings commonly used in the diet: seasonings that are “salty”, “sweet”, and “sour” are very common, but it is rare to use “bitter” and “astringent” seasonings. The test meals used in the present study contained a standard seasoning, therefore participants in both groups found it difficult to identify “bitter” and “astringent” tastes in the test meals. Finally, “deliciousness”, as an overall sense of the taste of the test meal, increased linearly with increasing chicken content of the meals.

In the present subjective evaluation of tastes, the Japanese students allocated higher scores than the Sri Lankan students for all tastes. This could be due to differences in the taste of the usual food consumed daily. The Sri Lankan students primarily ate very spicy Sri Lankan-style curries every day, and the habit of eating spicy food possibly lowers the sensitivity of taste [13]. Another possible explanation for the lower taste scores among the Sri Lankan students in the present study could be related to blood zinc concentrations. Serum zinc concentrations were significantly lower in Sri Lankan than Japanese students, with the mean zinc concentration in Sri Lankan students (60.3 µg/dL) lower than the reference value of 65–110 µg/dL in Japan. We cannot explain the reason for the low zinc concentrations in Sri Lankan students, but low serum zinc concentrations have been reported to impair taste [21]. The effect of serum zinc on taste remains contentious; some studies have reported a negative relationship between serum zinc concentrations and taste [22,23], whereas other studies have reported that zinc supplementation effectively improves taste [24,25]. Furthermore, because recent studies have found a relationship between ethnicity and taste sensitivity [19,26], the findings in the present study of a lower taste score among Sri Lankan students may be due to genetic differences or polymorphism of taste-related receptors between Japanese and Sri Lankan people [27,28].

Whether people feel taste subjectively is related to various factors, such as individual differences and race or nationality, even among healthy people. Therefore, this should be kept in mind when proposing meals and ONS for nutritional support, and further studies are needed to clarify this issue.

5. Limitations

The main limitation of the present study is the small number of participants. At the time of the study, there were 6 Sri Lankan students at Niigata University, and 2 of these students could not participate in the study because of religious considerations. Therefore, there were only 4 Sri Lankan students in the present study. The small number of participants may have been insufficient to demonstrate significant differences between Japanese and Sri Lankan students in several of the results.

6. Conclusions

Subjective assessment of taste differs according to food composition and nationality. Therefore, it seems important to consider taste according to national traits when promoting oral nutritional support.

Statement of authorship

YK, MU, AO, and SDP designed the research; YK, SDP, TO, and AO conducted the research; YK, AO and MU collected the data; AI and NO analyzed the data; YK summarized the data; SDP and YK wrote the manuscript and YK had primary responsibility for the final content. All authors read, checked and approved the final manuscript, and none have any conflict of interest to declare.

Conflict of interest

The authors declare that they have no conflict of interest.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.yclnex.2018.10.006>.

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