Short Communication

Evaluation of taste acuity by the filter-paper disc in Japanese young women: the relationship with micronutrients status

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The aim of the present study is to investigate the taste acuity in Japanese young women in relation to their micronutrient status. Thirty-eight healthy young women (mean age; 21.3, range; 19-27 years) were enrolled. Gustatory thresholds were estimated for four basic tastes: sweet (sucrose), salty (sodium chloride), sour (tartaric acid), and bitter (quinine hydrochloride) by a filter-paper disk method. Various concentrations at each taste were serially scored from disc number 1 (lowest) to number 5 (highest). The lowest concentration at which the quality of the taste was correctly identified was defined as the recognition threshold. The mean of three measurements for each test on three different days was calculated. We divided our participants into normal taste and hypogeusia groups based on the mean threshold disc numbers, ≤3.5 and >3.5, respectively, according to previous literature using the same method. We also measured serum concentrations and dietary intakes of micronutrients including zinc, iron, copper, and selenium. The numbers of participants belonging to the hypogeusia group were 24 (63.2%) for sweet, 19 (50.0%) for sour, 17 (44.7%) for bitter, and 16 (42.1%) for salty taste. Although the hypogeusia group exhibited significantly lower serum iron concentrations, except for the salty taste, the other three micronutrients concentrations did not show any association with the four taste acuities. Dietary micronutrient intake did not show any association with the four taste acuities. This study indicates that in addition to zinc status, iron status should be considered in the study of taste acuity.

Key Words: Japanese young women, taste acuity, filter-paper disc method, micronutrient, dietary record

INTRODUCTION

Taste disorders have been well recognized in various clinical conditions including Sjögren's syndrome,[1] liver cirrhosis,[2] diabetes mellitus,[3] and cancer chemotherapy.[4] The prevalence and characteristics of taste disorders were previously evaluated in patients referred to chemosensory clinics[5] or admitted to a ward of internal medicine.[6] However, recent changes in people's diets such as the frequent intake of fast food may result in an increase of taste disorders, even in apparently healthy individuals.[7,8] Although the studies on the prevalence of taste disorders in apparently healthy individuals are limited, previous reports indicated prevalence from 2.5 to 20%.[9-11] This wide disparity is mainly due to differences either in the tests used for the determination of taste acuity or the study population. As the underlying mechanism for taste impairment, it has been well verified that micronutrient status plays a pivotal role. Among various micronutrients, zinc deficiency is well correlated with taste impairment,[12,13] and supplementation of zinc in zinc-deficient patients was associated with improvement of their taste acuity.[14,15] In contrast, information on the effect of other micronutrients on taste acuity is relatively limited.[16,17]

Therefore, the aim of the present study is to evaluate the taste status in Japanese young women by a filter-paper disc (FPD) method in relation with various micronutrient status, including: iron, zinc, copper, and selenium, as measured by serum concentrations and dietary intake records.

MATERIALS AND METHODS

Subjects

Forty students at Nara Women's University were initially recruited to participate in the present study. After two students were excluded as they had taken medicine during the past one month, thirty-eight students (mean age; 21.3, range; 19-27 years) were finally enrolled. None of the participants had self-reported chronic disorders including otolaryngological diseases. They had never smoked. We obtained written informed consent from all participants beforehand. This study was approved by the ethical committee for epidemiological study at Nara Women's University.

Testing method for taste acuity

The FPD method was used for evaluating gustatory func-

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tions. The gustatory tests were carried out in the morning during fasting state by a single well-trained dietitian. During the tests, the participant's mouth was rinsed with distilled water before testing the next concentration. Test discs of 5 mm in diameter (Taste Disc, Sanwa Chemical Inc., Nagoya, Japan) were placed on the left lateral part of the tongue at approximately 2 cm from the proglossis, which is thought to be innervated by the chorda tympani nerve. The substances and concentrations used to test the four tastes were as follows: sweet (sucrose; 8.8, 74, 292, 584, 2336 mM), salty (sodium chloride; 51.4, 214, 856, 1710, 3420 mM), sour (tartaric acid; 1.3, 13.3, 133, 266, 532 mM) and bitter (quinine hydrochloride; 0.025, 0.5, 2.5, 12.5, 100 mM).[18] The concentrations at each taste were serially scored from disc number 1 (lowest) to number 5 (highest). When the subject could not detect the taste at the highest concentration, a score of 6 was given. The lowest concentration at which the quality of the taste was correctly identified was defined as the recognition threshold. The mean of three measurements for each test performed on three different days during one week was regarded as the recognition threshold.

Procedures of additional examinations

Fasting blood samples were drawn in the morning for the measurement of micronutrients, including: zinc, iron, copper, and selenium. To evaluate serum zinc levels, blood was collected in trace-element-free tubes, and put on ice immediately. Serum zinc and selenium levels were determined by an atomic absorption method. Serum iron and copper levels were determined by a colorimetric method. The assays were done by Mitsubishi Chemical Medience Corporation (Tokyo, Japan). The reference values of four micronutrients were established by the company using more than several hundreds of healthy adult volunteers. We asked the participants to keep dietary records for 7 consecutive days.[19] The estimation of nutrient intake was done using "Excel Eiyoukun Ver. 5.0" (Kenpakusha, Tokyo, Japan). This software was developed based on "Standard Tables of Food Composition in Japan-Fifth Revised and Enlarged Edition-" (Ministry of Education, Culture, Sports, Science and Technology) and "Dietary Reference Intakes for Japanese, 2010" (Health, Labor and Welfare Ministry).

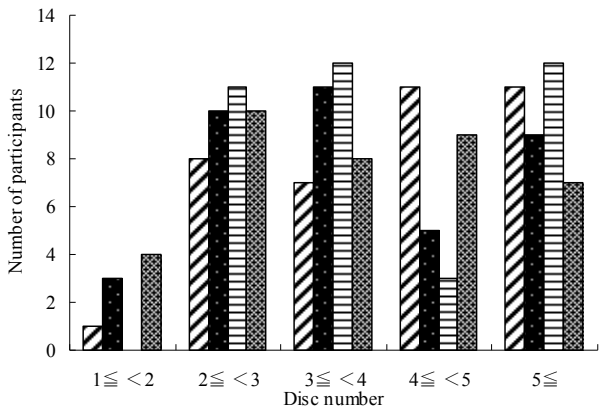

Figure 1. Histograms of taste recognition thresholds in healthy young women as measured by the filter-paper disc (FPD) method. Four different tastes are indicated as follows: Sweet ( ), Salty ( ), Sour ( ), and Bitter ( ).

Statistical analysis

Differences in the serum concentrations or dietary intake of micronutrients between the normal taste and hypogeusia groups were analyzed by the Mann-Whitney U test. A *p*-value less than 0.05 is considered significant. All statistical analyses were carried out on a personal computer using "StatMate" version III software (ATMS, Tokyo, Japan).

RESULTS

Evaluation of taste acuity by the filter-paper disc method

Figure 1 shows the histogram plots of the recognition threshold as determined by the FPD method. The mean disc numbers of the recognition threshold in all participants and their corresponding actual concentrations at each taste are; 3.7 and 510 mM for the sweet taste, 3.3 and 1050 mM for the salty taste, 3.6 and 200 mM for the sour taste, and 3.2 and 2.9 mM for the bitter taste. Since we do not have our own reference data, further analysis was done based on the data in a previous reports using the same FPD method. We divided our participants into normal taste and hypogeusia groups based on the mean threshold disc numbers, ≤3.5 and >3.5, respectively.[5] Consequently, the percentage in the hypogeusia group was highest for the sweet taste (24; 63.2%), followed by the sour taste (19; 50.0%), the bitter taste (17; 44.7%), and the salty taste (16; 42.1%).

Association between taste acuity and serum micronutrient concentration

We examined the serum concentrations of zinc, iron, copper, and selenium, which have been reported to be associated with taste acuity (Table 1). The mean concentrations of the four micronutrients in all participants fell in the reference range. In a comparison between the normal taste and hypogeusia groups, serum iron concentrations were significantly higher in the former group except for the salty taste. In contrast, no differences were found between the two groups for the other three micronutrients (Table 1).

Association between taste acuity and micronutrient dietary intake

Next, we tried to examine the association between taste acuity and the dietary intake of micronutrients as measured by a 7-day diet record. With the software we used, intake of selenium could not be measured. Table 2 indicates that there was no difference in the intake of iron, zinc, and copper between the two groups in any of the four tastes.

DISCUSSION

Taste perception is an important part of an individual's dietary life. Because of the subjective nature of taste perception, it is sometimes difficult to evaluate the taste acuity of a given individual objectively. Several methods including the FPD method,[18] the taste strips method,[20] the whole-mouth method,[21] and electrogustometry[22] have been developed for evaluating taste acuity. Taste strips are unfortunately not available in Japan. Simplicity is an advantage of the whole-mouth method, but it is impossible to determine the localization of taste acuity.[21] Elec-

Table 1. Comparison of the taste acuity and serum concentrations of four micronutrients

	Iron (40-180)[†]	Copper (70-132)	Zinc (64-111)	Selenium (10.6-17.4)
Mean (μg/dL)±SD[‡]	85.2±40.0	90.5±13.5	91.8±11.4	11.4±2.8
Sweet	101.1 vs 80.1[§] (0.038)[*]	88.2 vs 91.8 (0.39)	89.0 vs 93.4 (0.22)	10.9 vs 11.6 (0.48)
Salty	92.4 vs 81.7 (0.21)	90.0 vs 91.1 (0.81)	92.0 vs 91.5 (0.89)	12.2 vs 10.9 (0.15)
Sour	100.3 vs 75.4 (0.02)	91.8 vs 89.2 (0.56)	90.3 vs 93.3 (0.43)	11.7 vs 11.1 (0.55)
Bitter	102.3 vs 69.9 (0.008)	89.5 vs 91.7 (0.63)	91.3 vs 92.4 (0.78)	10.8 vs 12.1 (0.20)

[†] Numbers in parentheses indicate the reference values for each micronutrient.
[‡] The mean concentrations and SD of all participants (n=38) are shown.
[§] The numbers on the left and right side in each column indicate the mean concentrations of serum micronutrients in the normal- and hypogeusia groups, respectively.
[*] Numbers in parentheses indicate *p*-values as determined by the Mann-Whitney U test.

Table 2. Comparison of the taste acuity and dietary intakes of three micronutrients

	Iron	Copper	Zinc
Mean (mg/day)±SD[†]	6.2±2.2	0.85±0.26	6.3±1.7
Sweet	6.4 vs 5.6[‡] (0.21)[*]	0.87 vs 0.82 (0.59)	5.9 vs 6.4 (0.46)
Salty	6.0 vs 6.5 (0.53)	0.82 vs 0.89 (0.48)	6.3 vs 6.2 (0.48)
Sour	5.7 vs 6.7 (0.13)	0.78 vs 0.92 (0.09)	6.0 vs 6.6 (0.20)
Bitter	5.8 vs 6.6 (0.29)	0.81 vs 0.90 (0.26)	6.1 vs 6.5 (0.45)

[†] The mean intakes and SD of all participants (n=38) are shown.
[‡] The numbers on the left and right side in each column indicate the mean intake per day of micronutrients in the normal- and hypogeusia groups, respectively.
[*] Numbers in parentheses indicate *p*-values as determined by the Mann-Whitney U test.

trogustometry is thought to be the most objective method, but the elicited taste is recognized as metallic making it difficult to discriminate four major tastes.[22] Although the FPD is useful in evaluating the taste acuity of different locations on the tongue, the test takes a long time to be completed.[18] Since there are advantages and disadvantages of each method as described above, we had chosen the FPD method for the assessment of taste acuity.

The exact evaluation of our data on taste acuity was difficult, since basic quantitative reference data for taste acuity are not available in our laboratory. In the present study, therefore, we used a cut-off value of 3.5 mean disc numbers for the recognition threshold, as presented by Hamada *et al.*. [5] Consequently, we found that approximately 63.2% and 50% of the participants had values more than 3.5 for sweet and sour tastes, respectively. The results may indicate taste impairment, especially for the sweet taste, in the present cohort.

Taste impairment has been reported to be associated with demographic and lifestyle features including older age, male gender, smoking, alcohol consumption[20,23,24] and obesity.[25,26] From a nutritional aspect, several reports have indicated that zinc deficiency was associated with taste impairment.[12-14] Gustin, the major zinc-binding protein in human saliva, plays an important role in taste acuity.[27] Thus, zinc treatment is thought to upregulate taste acuity through an increase of gustin.[28] Since there are several methods of assessment for zinc in clinical settings,[12] the use of methods other than serum zinc levels may be necessary for further delineating a role of zinc in the taste acuity. Abnormal taste sensation was also found to be associated with other micronutrients including iron, copper, and selenium.[16,17,29] Particularly in 25 patients with hypogeusia, Osaki *et al.* demonstrated that a deficiency of iron but not of zinc or copper was accompanied by the elevation of taste thresholds.[17] Our data also indicated that serum iron concentrations were generally lower in the hypogeusia group for all four tastes. Based on dietary iron intake, however, no such difference was found. This discrepancy may be partly explained by individual differences in the dietary iron bioavailability.[30] Similarly serum zinc concentration and dietary zinc intake were only found to be significantly correlated in vegetarians, but not in non- vegetarians.[31] Therefore, when we want to use a dietary record as an indicator of micronutrients status, we should take factors of absorption into consideration.

There are several limitations in the present study. First, as indicated above, we did not have our own reference values for each test of taste acuity. Therefore, we performed our analysis based on the data from a previous report which used the same method. Considering the psychological aspect of tests for taste acuity, it is necessary to establish our own standard values. Second, the participants were collected not by random selection but using an application process. Therefore, we cannot rule out the possibility that the participants were a biased cohort who had a special interest in taste perception. Finally, the menstrual status of the participants was not taken into consideration at all. Frye *et al.* have reported changes of taste acuity during the menstrual cycle.[32] However, a contradictory report demonstrated that the effect of menstrual period on taste acuity, if any, is quite marginal.[33] At any rate, since the association between menstrual blood loss and iron deficiency has been well established,[34] the effect of menstruation on taste acuity is regarded as a confounding factor and should be evaluated in the further study.

In conclusion, a high percentage of Japanese young women were found to have impaired taste acuity, especially sweet taste acuity. In the study of the relation be-

tween taste acuity and four micronutrients status, the hypogeusia groups exhibited significantly lower serum iron concentrations except for the salty taste. Although the exact mechanism for these findings remain uncertain, our study indicates that in addition to zinc status, iron status should be considered for evaluating the taste acuity.

AUTHOR DISCLOSURES

There is no conflict of interest in this article. This study did not receive any funding.

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以圓盤濾紙評估日本年輕女性的味覺敏銳度：與微量營養素狀況的相關性

本研究目的為探討日本年輕女性的味覺敏銳度與微量營養素狀況之相關。總共有 38 名健康年輕女性(平均年齡 21.3 歲，範圍為 19-27 歲)參與此研究。味覺閾值是以圓盤濾紙法測試 4 種基本味道：甜(蔗糖)、鹹(氯化鈉)、酸(酒石酸)及苦(鹽酸奎寧)。每種味道以圓盤編號 1(最低)到 5(最高)的不同濃度，按順序測試記分。可正確辨識的最低濃度，定義為該味道的認知閾值。以 3 天測試的 3 次測量計算平均閾值。依據之前的文獻使用的相同方法，將參與者按照平均閾值 ≤3.5 及>3.5 分別歸為正常味覺組及味覺遲鈍組。另外也測量參與者微量營養素的血清濃度及飲食攝取，包含鋅、鐵、銅及硒。被歸類在味覺遲鈍組的參與者在甜味有 24 人(63.2%)、酸味有 19 人(50.0%)、苦味有 17 人(44.7%)及鹹味有 16 人(42.1%)。除了鹹味外，味覺遲鈍組顯示有較低的血清鐵濃度，而其它 3 種微量營養素血清濃度對 4 種味覺敏銳度則沒有顯示任何相關性。飲食微量營養素與 4 種味覺敏銳度沒有任何相關。此研究指出，除了鋅之外，鐵營養狀況應該在味覺敏銳度研究中一併被考量。

關鍵字：日本年輕女性、味覺敏銳度、圓盤濾紙法、微量營養素、飲食紀錄