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The Factors Affecting Sweet Taste Sensitivity and Preference of the Korean Middle-Aged Females

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ABSTRACT

Sensory factors are important determinants of appetite and food choices but little is known about factors affecting taste acuity and preference of Koreans. Any factors causing deficits in sweet taste perception may lead to over consumption of simple sugar, which is related to several chronic diseases. This study was conducted to determine factors affecting sweet taste sensitivity and preference. Subjects were 30 government employees who were serving as school dietitians or in the area of public health while they were studying in the program for the qualification to become nutrition teachers. Sweet taste threshold and the optimally-preferred sweetness of omija jelly were determined by a sensory evaluation and general characteristics, health-related lifestyles, dietary habits and food preferences were determined using a self-administered questionnaire. For the subjects of this study, detection threshold concentration of sucrose solution was 0.184 ± 0.06% and optimally-preferred sucrose concentration of omija jelly was 13.88 ± 2.28% and there was no significant correlation between the sweet taste sensitivity and preference. Subjects who had higher (≥ 4 out of 10) physical or psychological stress and who had late getting-up time (after 7am) tended to have lower sweet taste threshold (higher sensitivity) than their counterpart. The sweet taste preference determined by optimally-preferred sucrose concentration of omija jelly tended to be lower in the subjects who eat slowly. Those who answered in the questionnaire to prefer sweet foods did have significantly higher optimally-preferred sucrose concentration of omija jelly. Further research is required to determine whether decreased sensitivity and increased preference for sweetness can increase the actual intake of simple sugar. (*J Community Nutrition* 8(2): 107~113, 2006)

KEY WORDS: sweet taste threshold · dietary habits · preference for sweet taste.

Introduction

Many countries, as well as WHO, have dietary guidelines which recommend less consumption of sugar and sweet foods, concerning the linkage to various health problems such as dental caries, obesity and elevated blood lipids (Tee 2006). These foods are generally placed at the tip of the pyramid or comprise the smallest portion of the food plate to be consumed the least. Added sugar has been recommended to no more than 5% or 10% of total energy intake.

Chung (2006) recently presented that total sugar intake of the average Korean was 62g a day according to 2001 Korean NHANES (National Health and Nutrition Examination Survey). Although it is only 45% of that in US, which is 134g, consumption of simple sugar has been increasing every year in this country. For example, the Food Balance Sheet shows that daily sugar intake of 2004 was 57.98g per capita in this country (Korea Rural Economic Institute 2005), which marks a 12 times increase from 4.8g in 1962.

As important determinants of appetite and food choices, taste sensitivity and preference have been topics of many studies around world, in relation to gender difference (Frye, Demolar 1994), age and aging (James et al. 1997; Mojet et al. 2005), seasonal difference (Arbisi et al. 1996), menstruation cycle (Curtis et al. 2005; Kanarek et al. 1995) and eating disorder (Eiber et al. 2002).

Genetic and environmental factors are implicated in the sweet taste preferences of humans and mice (Purtkin et al.

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2000). In both genders, taste acuity has been reported to increase gradually up to 16−20 years of age and then decrease rapidly (Pepino, Mannela 2005). James et al. (1997) reported that the ability of 8−9-year-old children to detect sweet taste was inferior to that of girls even though their general development was superior to their counterpart. Preference for sweet taste has been reported higher in childhood than in adolescence and higher in adolescence than in adulthood (Graaf 1999).

New knowledge about the factors affecting sweet taste sensitivity and preference may suggest strategies to overcome sugar over consumption induced diseases in the modern society which is struggling with obesity and diabetes. While there have been several studies reporting on salty taste sensitivity and preference in relation to blood pressure (Choi et al. 1997; Kim 1994) and stress state (Jun, Choi 2004), almost nothing has been reported on sweet taste perception of the Korean subjects. Therefore, this study was conducted to determine factors affecting detection threshold and preference for sweet taste such as health-related lifestyles, dietary habits and food preferences of the applicants for nutrition teachers, who comprise a highly homogeneous group in that they share the same gender, age group, occupation and educational background.

Subjects and Methods

1. Subjects

Subjects of this study were 30 government employees who served as school dietitians or in the area of public health while studying in the program for the qualification to become nutrition teachers. None wore dentures and were smokers. All subjects completed the questionnaire and sensory evaluation including sweet taste threshold and preference for sweet taste. The self-administered questionnaire contained questions regarding general characteristics, self diagnosis of stress, health-related lifestyles, dietary habits and food preferences. General characteristics of the subjects are shown in Table 1. Those who had more than 4 points out of 10 stress symptoms were grouped as the stressed(Korean Health and Welfare Administration 1999). The participants were instructed to refrain from eating or drinking anything but water for at least 2h prior to being tested. Survey and sensory evaluations were conducted between September and October in 2005.

Table 1. General characteristics of the subjects

	n = 30
Age (year)	35.67 ± 5.15 (30−47)[1]
Symptoms of stress[2]	
Physical	3.63 ± 1.75 (1−7)
Behavioral	2.73 ± 1.86 (0−7)
Psychological	4.50 ± 1.20 (1−8)

[1] Mean ± standard deviation (range)
[2] Number of symptoms out of 10 questions according to self assessment by Korean Health and Welfare Administration; point lower than 4 is considered as the unstressed

2. Methods

1) Determination of sweet taste sensitivity

The concentration of sucrose solution for the determination of detection threshold of sweet taste was 0.03%, 0.06%, 0.09%, 0.12%, 0.15%, 0.2%, 0.25% and 0.3%. Sucrose solution was made in de-ionized water and allowed to stand to reach room temperature after storage at 4℃. The taste thresholds were obtained by three-alternative forced choice trials modified from that of other authors (Hong et al. 2005; Kim 1993). Subjects were required to taste two de-ionized waters and one sucrose solution, starting from the lowest concentration and choose one from a choice of three. The lower concentration was recorded as threshold concentration when the subjects succeeded in two consecutive trials. The detection threshold concentration was considered 0.3% sucrose concentration, in case the subjects could not detect different tastes among three cups even at the highest sucrose concentration, 0.3%. Rinsing mouth with de-ionized water was required before tasting each test cup.

2) Determination of sweet taste preference

All the omija was purchased at once in the large-size retail market in Seoul in September 2005. Omija juice was extracted by soaking 60g of washed omija, in a refrigerator for 18 hours, in 1L of de-ionized water which was cooled after boiling. For omija jelly containing 10% sucrose, 14 g of gelatin and 60mL of omija juice were added to the boiled mixture of 376mL of de-ionized water and 50g of sugar before stirring at the rate of about 90 beats per minute for complete mixing. For the solution of 12%, 14%, 16% and 18% sucrose concentration, 60g, 70g, 80g and 90g of sugar was added, respectively at the expense of water. After sealed and hardened in a plastic container, omija jelly was cut in the size of 2cm × 2cm × 2cm and presented to the subjects to choose the omija jelly with the optimally-preferred sucrose concentration. Ri-

nsing the mouth with de-ionized water was required before tasting each sample. Omija flavor was chosen in the determination of the optimally-preferred sweetness because other popular flavors such as orange and strawberry were not commercially available as unsweetened.

3) Statistical analysis

Collected data were processed for significance by using SPSS 12.0K for Windows. Age, stress symptom, detection threshold concentration and the optimally-preferred sucrose concentration were shown as mean ± standard deviation. Significant difference between the two means was tested by Student's t-test and that among the three means was tested by Duncan's multiple range test after analysis of variance. Correlation between detection threshold concentration and the optimally-preferred sweetness was analyzed by Pearson's correlation coefficient. Statistical significance was marked at $p < 0.05$.

Results

Table 1 shows that the age of the subjects was 35.67 ± 5.15 years and average scores of physical, behavioral and psychological stress was 3.63, 2.73 and 4.50 respectively.

The subjects of this study had the detection threshold sucrose concentration of 0.184 ± 0.096% and the optimally-preferred sucrose concentration of 13.9 ± 2.29% and there was no significant correlation between the detection threshold sucrose concentration and the optimally-preferred sucrose concentration (correlation coefficient = −0.001, p = 0.997).

Sweet taste detection threshold of subjects who had higher (≥ 4 out of 10) physical stress or psychological stress

Table 2. Sweetness threshold and optimally-preferred sweetness according to general characteristics

	Sweet taste detection threshold (%)		Optimally-preferred sucrose concentration (%)	
Regular physical examination				
Yes	0.192 ± 0.098 (20)[1]	.512[2]	13.70 ± 2.08 (20)	.581
No	0.167 ± 0.095 (10)		14.20 ± 2.74 (10)	
Self awareness of own health				
Fair	0.146 ± 0.974 (8)	.132	13.75 ± 2.49 (8)	.983
Average	0.212 ± 0.919 (18)		13.89 ± 2.22 (18)	
Bad	0.130 ± 0.844 (4)		14.00 ± 2.83 (4)	
Number of physical sign of stress[3]				
<4	0.210 ± 0.094 (17)	.087	14.12 ± 2.18 (17)	.501
≥ 4	0.149 ±0.092 (13)		13.54 ± 2.47 (13)	
Number of behavioral sign of stress				
<4	0.198 ± 0.090 (20)	.256	14.20 ± 2.24 (20)	.266
≥ 4	0.149 ± 0.092 (10)		13.54 ± 2.47 (10)	
Number of psychological sign of stress				
<4	0.223 ± 0.087 (11)	.091	14.00 ± 2.19 (11)	.813
≥ 4	0.161 ± 0.096 (19)		13.79 ± 2.39 (19)	
Weight change for the past 5 years				
Gained	0.170 ± 0.106 (17)	.381	14.24 ± 2.22 (17)	.612
Keeping	0.221 ± 0.073 (9)		13.33 ± 2.65 (9)	
Lost	0.158 ± 0.096 (4)		13.50 ± 1.91 (4)	
Family history of diabetes mellitus				
Yes	0.210 ± 0.088 (12)	.227	14.17 ± 2.17 (12)	.566
No	0.166 ± 0.100 (18)		13.67 ± 2.40 (18)	
Having acquaintance with diabetes mellitus				
Yes	0.173 ± 0.091 (12)	.613	13.50 ± 2.11 (12)	.483
No	0.191 ± 0.101 (18)		14.11 ± 2.42 (18)	

[1] Mean ± standard deviation (number of subjects)
[2] p value
[3] Number of symptoms out of 10 questions according to self assessment by Korean Health and Welfare Administration; point lower than 4 is considered as the unstressed

tended to be lower (higher sensitivity) than their counterpart without statistically significance, while psychological stress did not affect neither the sweet taste sensitivity nor preference.

Table 2 also shows that regular physical examination, self awareness of own health, weight change for the past 5 years, family history of diabetes mellitus, or having acquaintance with diabetes mellitus, did not significantly affect the sweet

Table 3. Sweetness threshold and optimally-preferred sweetness according to health-related lifestyle practice

	Sweet taste detection threshold (%)		Optimally-preferred sucrose concentration (%)	
Sound sleep				
Yes	0.193 ± 0.090 (26) [1]	.159 [2]	14.00 ± 2.26 (26)	.425
No	0.120 ± 0.122 (4)		13.00 ± 2.58 (4)	
Time to go to bed				
Before midnight	0.190 ± 0.100 (24)	.481	13.83 ± 2.43 (24)	.876
After midnight	0.158 ± 0.081 (6)		14.00 ± 1.79 (6)	
Time to get up				
Before 7am	0.201 ± 0.092 (23)	.075	13.83 ± 2.48 (23)	.864
After 7am	0.127 ± 0.093 (7)		14.00 ± 1.63 (7)	
Hours for sleeping				
< 8	0.190 ± 0.090 (24)	.481	13.83 ± 2.20 (24)	.876
≥ 8	0.158 ± 0.125 (6)		14.00 ± 2.83 (6)	
Constipation				
Yes	0.175 ± 0.123 (4)	.851	13.00 ± 2.58 (4)	.425
No	0.185 ± 0.094 (26)		14.00 ± 2.26 (26)	

[1] Mean ± standard deviation (number of subjects), [2] p-value

Table 4. Sweetness threshold and optimal sweetness according to dietary habits of the subjects

	Sweet taste detection threshold (%)		Optimally-preferred sucrose concentration (%)	
Skipping meals more than 3 meals a week				
Yes	0.182 ± 0.106 (16) [1]	.915 [2]	14.25 ± 2.05 (16)	.335
No	0.186 ± 0.088 (14)		13.43 ± 2.53 (14)	
Speed of eating				
Fast	0.167 ± 0.095 (9)	.245	13.78 ± 2.54 (9)	.098
Average	0.173 ± 0.100 (16)		14.50 ± 2.00 (16)	
Slow	0.250 ± 0.070 (5)		12.00 ± 2.00 (5)	
Type of breakfast				
Traditional	0.182 ± 0.108 (10)	.511	14.40 ± 2.27 (10)	.199
Bread/milk/cereal	0.159 ± 0.096 (10)		14.40 ± 2.27 (10)	
Uncooked food/rice cake	0.210 ± 0.086 (10)		12.80 ± 2.15 (10)	
Having dessert at breakfast				
Often	0.205 ± 0.098 (6)	.456	14.33 ± 1.51 (6)	.467
Sometimes	0.164 ± 0.104 (17)		13.41 ± 2.62 (17)	
Seldom	0.213 ± 0.072 (7)		14.57 ± 1.90 (7)	
Having dessert at lunch				
Often	0.205 ± 0.098 (6)	.107	13.68 ± 1.50 (6)	.467
Sometimes	0.164 ± 0.104 (17)		13.41 ± 2.62 (17)	
Seldom	0.213 ± 0.072 (7)		14.57 ± 1.90 (7)	
Having dessert at supper				
Often	0.206 ± 0.096 (13)	.403	13.85 ± 2.76 (13)	.348
Sometimes	0.149 ± 0.097 (9)		13.11 ± 1.76 (9)	
Seldom	0.213 ± 0.072 (8)		14.75 ± 1.83 (8)	

[1] Mean ± standard deviation (number of subjects), [2] p-value

taste threshold concentration or the optimally-preferred sucrose concentration.

Sweetness threshold and optimal sweetness according to health-related life-style practices are shown in Table 3. Those who get up before 7 o'clock tended have a higher sweet taste threshold than those who get up after 7 o'clock. The effects of smoking and drinking on the sweet taste perception could not be examined since only one subject was currently drinking and none were smoking. Regular exercise, sleep quality, bed time, sleep duration and bowel habits did not significantly affect sweet taste sensitivity nor optimal sweetness of omija jelly.

Table 4 shows the effects of dietary habits of the subjects on the sweet taste threshold and optimal sweetness. The subjects who eat slowly tended to have lower optimal sweetness determined with omija jelly than their counterpart ($p = 0.098$). Skipping meals, type of breakfast and having dessert at each respective meal did not significantly affect sweet taste threshold nor optimal sweetness determined with omija jelly.

Preferences for certain food groups such as plant source vs. animal source, vegetable vs. fruits and fish vs. meat did not significantly affect sweet taste threshold and optimal sweetness (Table 5). The subjects who answered in the questionnaire to have a high preference for sweet food, did have significantly higher optimal sweetness determined with omija jelly than those who did not answer that they like sweet taste (15.7 vs. 13.1, $p = 0.004$), while it was not significantly different according to the other taste preferences answered by the subjects.

Table 5. Sweetness threshold and optimal sweetness according to dietary preference of the subjects

	Sweet taste detection threshold (%)		Optimally-preferred sucrose concentration (%)	
Favorite dessert				
Fruits	0.213 ± 0.078 (12)[1]	.377[2]	14.17 ± 2.89 (12)	.842
Tea/coffee	0.167 ± 0.107 (17)		13.65 ± 1.90 (17)	
Others	0.120 (1)		14.00 (1)	
Food source				
Prefer plant	0.182 ± 0.117 (6)	.842	14.33 ± 1.97 (6)	.796
Prefer animal	0.169 ± 0.105 (9)		14.00 ± 2.00 (9)	
Same	0.193 ± 0.088 (15)		13.60 ± 2.64 (15)	
Favorite plant food source				
Prefer vegetable	0.175 ± 0.087 (13)	.227	14.31 ± 1.97 (13)	.421
Prefer fruits	0.212 ± 0.092 (13)		13.23 ± 2.65 (13)	
Same & others	0.120 ± 0.127 (4)		14.50 ± 1.92 (4)	
Favorite animal food source				
Prefer fish	0.215 ± 0.090 (13)	.293	13.54 ± 2.47 (13)	.761
Prefer meat	0.166 ± 0.090 (12)		14.00 ± 2.09 (12)	
Same	0.146 ± 0.121 (5)		14.40 ± 2.61 (5)	
Like sweet foods				
Yes	0.144 ± 0.089 (8)	.504	15.75 ± 1.98 (8)	.004***[3]
No	0.191 ± 0.100 (22)		13.18 ± 2.01 (22)	
Like sour foods				
Yes	0.186 ± 0.107 (14)	.915	13.71 ± 2.81 (14)	.739
No	0.182 ± 0.089 (16)		14.00 ± 1.79 (16)	
Like salty foods				
Yes	0.190 ± 0.101 (4)	.890	14.50 ± 1.91 (4)	.561
No	0.183 ± 0.098 (26)		13.77 ± 2.35 (26)	
Like spicy foods				
Yes	0.181 ± 0.100 (14)	.878	14.29 ± 1.90 (14)	.357
No	0.186 ± 0.096 (16)		13.50 ± 2.58 (16)	

[1] Mean ± standard deviation (number of subjects)
[2] p-value
[3] ***Significantly different at $p = 0.005$

Discussion

In the present study, the threshold concentration and the optimally-preferred sweetness were determined at least 2 hours after the subjects had eaten breakfast and asked not to have a snack from meal to test time, since the relationship between taste thresholds and hunger is under debate, although Pasquet et al. (2006) reported no significant difference in taste recognition thresholds between hunger and satiety.

For the subjects of the present study, the detection threshold of the sucrose solution was 0.184% and the optimally-preferred sucrose concentration of omija jelly was 13.88%. Compared to 0.148% and 13.44%, respectively for the sweet taste threshold concentration and the optimally-preferred sucrose concentration of the young female students, the subjects in the present study had lower sensitivity and similar preference, suggesting that aging may affect sweet taste sensitivity more profoundly than preference for sweet foods.

The subjects of the present study were shown to be even less sensitive to sweet taste compared to those of the report by Hong et al. (2005) which presented 0.108% and 0.32% for the detection threshold and recognition threshold of sucrose concentration, respectively for Korean young adults, supporting the report by Mojet et al. (2001) which observed a significant decrease in taste sensitivity with aging. Detection threshold and recognition threshold are two kinds of taste threshold to evaluate taste acuity; the former is the lowest concentration to differentiate sucrose solution from distilled water and the latter is the lowest sucrose concentration to recognize sweetness.

It is also widely assumed that loss of sensory acuity inevitably leads to a preference for stronger flavored/tasting products (De Graaf et al. 1996). Our results suggest that an individual's lower sensitivity may not necessarily mean one's higher preference for sweet food, since there is no significant correlation between threshold and the optimally-preferred sweetness. Absence of significant correlation between sensitivity and preference for taste has been reported in salty taste of children in an institution (Kim 1994) and healthy adults (Drewnowski 1996) and was also supported by other authors (Mojet et al. 2005) who concluded that the optimally-preferred concentration was unrelated to threshold sensitivity. However, this lack of significant correlation is not surprising when one bears in mind that hedonic ratings often show an inverted u-shaped function (Moskowitz 1977), i.e. the liking increases first, then peaks, and subsequently diminishes with increasing concentration.

The results of this study is consistent with the previous study (Lee 2006) on female university students by the same laboratory in that both physical stress and psychological stress tended to affect sweet taste threshold while behavioral stress did not, but is inconsistent in that the effect of physical stress and psychological stress on the threshold concentration was increasing for female university students and decreasing for the subjects in the present study.

Higher optimally-preferred sweetness of the subjects who answered to prefer sweet food may present the credibility of the analysis method which was used in this study. On the other hand, university female students who answered that they like sweet foods did not have significantly higher optimal sweetness in the previous study from this laboratory (Lee 2006), suggesting that subjects in this study may have more objective understanding their own taste preference or, at least, that understanding their own taste preferences may be age-dependent, i.e. improvement with aging (35.67 ± 5.15 vs. 20.98 ± 1.63).

The results of the present study could not support the observation of the previous study in which having ice cream as a favorite dessert tended to decrease sensitivity and significantly increased preference for sweet taste, since ice cream was the favorite dessert for none of the subjects in this study. Decreased sensitivity in the subjects who prefer animal to plant food source, which was observed in the previous study, was not seen in this study. The reason for this difference remains to be clarified in the further study, whether it results from the age difference of subjects between two studies (20.98 vs. 35.67 years) or not.

Fast eating as a cause of obesity has been well established (Otuska 2006). Slow eating tended to decrease sweet taste preference without any effect on sweet taste sensitivity in the subjects of this study. This is not consistent with the results of the previous study on female university students, in that slow eating tended to increase sensitivity to sweet taste without affecting preference for sweet taste. Regardless of the difference in the results between the two studies, those from both studies altogether provide another reason to discourage fast eating.

Summary and Conclusion

Those who answered the questionnaire to prefer sweet foods did have significantly higher optimally-preferred sucrose concentration of omija jelly. There was no significant correlation between sensitivity and the preference, supporting other authors reporting that lower sensitivity to sweet taste does not inevitably mean higher preference for the sweet foods.

Further studies, including a large number of well-controlled subjects, are essential to obtain the effects of smoking, drinking, gender difference, age etc. on the sweet taste threshold and the optimally-preferred sweetness. The reasons why those who had more stress physically or psychologically and get up late tended to have higher sensitivity (lower threshold) and those who eat slowly tended to have lower preference for sweetness than their counterparts also remain to be cleared in future study. Accompanied with the study on the relation between sensitivity or preference for sweet taste and the actual intake of simple sugar, the results of the present study will provide some strategies to overcome over consumption of simple sugar or sweet foods.

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