Original Article

Taste sensitivities and diet of Chinese and Indians in Singapore

Claudia Leong Shu-Fen BSc[1], Ciarán G Forde PhD[1,2], Siew Ling Tey PhD[1], Christiani Jeyakumar Henry PhD[1,3]

[1]*Clinical Nutrition Research Centre, Singapore Institute for Clinical Sciences, Agency for Science, Technology and Research (A*STAR), Singapore*
[2]*Department of Physiology, National University of Singapore, Singapore*
[3]*Department of Biochemistry, National University of Singapore, Singapore*

Background and Objectives: Taste perception plays a key role in consumer acceptance and food choice, which has an important impact on human health. Our aim was to examine the relationship between recognition thresholds for five basic tastes (sweet, salty, sour, bitter, and umami) in Chinese and Indians in relation to their dietary intake. **Methods and Study Design:** This cross-sectional study included 114 subjects (60 Chinese, 54 Indians). Taste thresholds were determined using a forced choice method and dietary intakes were assessed using an estimated three-day food diary. **Results:** Indians had significantly higher recognition thresholds for sweet, salty, sour, umami and bitter tastes compared to Chinese (all $p \leq 0.047$). Overall energy intake was not significantly different between the Chinese and Indians. Correlations between taste and diet between the Chinese and Indians were not significant ($p>0.05$). **Conclusion:** Future work is needed to further understand how differences in taste perception may influence dietary intakes between ethnic groups.

Key Words: diet, human health, Chinese, Indian, taste

INTRODUCTION

Taste perception plays a key role in consumer acceptance and food choice, which would have an important impact on human health. Food choices are made based on a variety of factors such as cultural influences, taste, smell, appearance, mood, environment, health, allergies, hunger levels and pregnancy.[1] Taste perception with special reference to taste thresholds have been studied with reference to age,[2] diseases[3] and geographical location.[4] However there is still a lack of information on the recognition thresholds of the five basic tastes in different ethnic groups.

Taste perception is related to dietary intake.[5] Individual differences in taste perception may influence dietary intake and in turn may relate to nutritional status and risk of chronic diseases.[6] Previous research has also highlighted how self-reported taste preferences predict dietary behaviours for salt; an increase in taste preference correlated with an increase in sodium consumption.[7] Improvement in nutrient intake has been proposed to be a potential modifiable risk factor for chronic diseases.[8] If taste moderates food choice and intake, it may be possible to manage chronic disease by making simple changes to the tastes and foods consumed regularly. Previous work has highlighted that simple modifications to dietary behaviours can help Asians in the management of Type II Diabetes Mellitus.[9]

No studies to date have compared the taste perception and dietary intake in Chinese and Indians, the two largest ethnicities in the world. Understanding taste perception and dietary differences within this group is critical in understanding the public health challenges encountered by different ethnic groups and for the possible design of targeted intervention programs. In Singapore, it is possible to study multi-cultural differences in taste perception and dietary behavior. Majority of Chinese and Indians in Singapore, have different diets and their prevalence of chronic diseases also differs considerably. Among the three main ethnic groups in Singapore (Chinese, Malays and Indians), diabetes was most prevalent among Indians at 17.2%, compared to Chinese at 9.7%; and prevalence of obesity was 16.9% in Indians compared to 7.9% in Chinese.[10]

This cross-sectional study aimed to investigate the taste perception of basic tastants and the potential relationship to dietary intake in Chinese and Indians. The hypothesis tested is that Chinese and Indians differ in their taste perception and these differences are also reflected in differences in dietary intake.

Corresponding Author: Christiani Jeyakumar Henry, Clinical Nutrition Research Centre, Singapore Institute for Clinical Sciences, Agency for Science, Technology and Research (A*STAR), 30 Medical Drive, Singapore 117609.
Tel: +65 6407 0793; Fax: +65 6776 6840
Email: jeya_henry@sics.a-star.edu.sg
Manuscript received 26 October 2016. Initial review completed 24 November 2016. Revision accepted 23 December 2016.
doi: 10.6133/apjcn.062017.04

PARTICIPANTS AND METHODS

Subjects

One hundred and eighteen (61 males and 57 females) healthy, non-smoking adults aged between 21 and 50 years were recruited through advertisements or word of mouth from the general public in Singapore. Four subjects were excluded as two subjects did not complete all the sensory tests given and the other two subjects were of Malay ethnicity. Thus only 114 subjects were included in the statistical analysis. This included 60 Chinese (31 males, 29 females) and 54 Indians (27 males, 27 females). The exclusion criteria were individuals who were allergic or intolerant to any of the test products and people who took medications known to alter taste function. The study was approved by the Domain Specific Review Board C of the National Healthcare Group, Singapore (Study Reference Number: 2013/00142). The study complied with the Declaration of Helsinki for medical research involving human subjects. Written informed consents were obtained from all subjects.

Procedure

All subjects were required to attend one test session between 0900 to 1800 h. Subjects were asked to avoid any food and beverages, except for plain drinking water, for at least 2 h before the test session. Anthropometric measurements were carried out. Standing height and weight were measured using a stadiometer and electronic scales (SECA 764, United Kingdom). The body mass index (BMI) was calculated using weight (kg) divided by the height squared (m^2). Percent body fat was measured using bioelectric impedance analysis (TANITA BC-418). Waist circumference was measured at the narrowest point between the lower costal border and the top of the iliac crest using SECA measuring tape.[11] All measurements were carried out in duplicates and the average values were used for statistical analysis.

Taste tests

Sample solutions for the basic tastants were prepared using sucrose, salt (NaCl), citric acid, caffeine and monosodium glutamate (MSG) dissolved in distilled water, using a silverson mixer (L5M-A, Silverson Machines, Massachusetts, USA) at 3000 rpm for 4 minutes to ensure homogeneity. All the solutions were then portioned in 10 mL volumes and served in small disposable plastic cups at room temperature.

Subjects were seated in individual sensory booths. Subjects were presented the tastants in a sequential monadic ascending order, separated by the appropriate inter-stimulus interval. Seven increasing concentrations of each tastant were prepared accordingly: Sucrose (5 mM–50 mM); NaCl (5 mM–75 mM); Citric Acid (0.05 mM–1.20 mM); Caffeine (0.05 mM–0.80 mM); and MSG (1 mM–10 mM).

Adapting the taste test procedure from Stewart et al., 2010[12] using a force choice method, subjects selected from one of three options to indicate no sensation, detection or identification: (1) the solution tastes like water; (2) the solution tastes like something other than water, but I am uncertain of the taste; or (3) the solution has a specific taste.[12] If the subject wrote (3), he/she would have to identify the taste (sweet, salty, sour, bitter or umami). The recognition threshold was defined as the concentration at which the subject correctly identified the type of taste. The threshold values stated in this study were reported as best estimated thresholds (BET). That is, each individual BET is the geometric mean (the square root of the product of the two values) of the first concentration with a correct choice, with all higher concentrations also correct, and the next lower step.[13]

Dietary intake

Dietary intake was assessed using three-day food diaries, based on estimates of household measures, on two weekdays and one weekend day.[14] On the test session day, subjects were briefed on how to fill in the diary with sample pictures and sample of a recorded day included in the food diary template given to the subject to fill in. The subjects were then given the option to scan or mail back the completed food diary. Upon receiving the food diary, the researcher would go through the food diary and call up the subject if any clarifications were required. Nutrient analysis was performed using Dietplan6 (Forestfield Software Ltd, West Sussex, UK) analysis program with the local food database.[15] The dietary outcomes examined were total energy, macronutrients (carbohydrate, fat, and protein), sodium, potassium, fiber and total sugars. The dietary data of the subjects were further categorized in EXCEL into dietary variety (adapted from Savige et al, 1997).[16]

Statistical analysis

Data were analyzed with SPSS, version 22.0 (IBM Corp. Released 2013. IBM SPSS Statistics for Windows, Armonk, NY: IBM Corp). Independent sample *t* tests were used to detect ethnic differences on continuous variables such as taste thresholds and dietary intake. Pearson correlation was used to determine the relationships between taste thresholds and dietary intake. All tests were performed at the 2-sided 0.05 level.

RESULTS

Subject characteristics and body composition

Subject characteristics and body composition measures were summarized in Table 1. There were no significant differences in BMI between Chinese and Indians. However, Indians had a higher percent body fat than Chinese (p=0.02) (Table 1).

Taste recognition thresholds

Indians had significantly higher recognition thresholds for sweet, salty, sour, umami and bitter tastes compared to Chinese (all $p\leq0.047$) (Figure 1). A greater recognition threshold indicates that Indians require a higher concentration of the tastant in order to recognize the taste of the specified tastant.

Dietary intake and pattern

A total of 101 subjects (57 Chinese) returned the completed food diary and were available to be contacted to clarify what they recorded in their food diary. Energy intake was not significantly different between Chinese and Indians (Table 2). Chinese had higher energy intake

Table 1. Characteristics of the subjects

	Total	(n=114)	Chinese	(n=60)	Indians	(n=54)	Ethnicity
	Mean	SEM	Mean	SEM	Mean	SEM	(*p*-value)
Age (years)	26.6	0.6	26.6	0.9	26.6	0.8	0.99
Height (cm)	166	0.9	167	1.1	165	1.4	0.39
Weight (kg)	62.3	1.2	61.7	1.5	63.0	1.8	0.56
BMI (kg/m^2)	22.5	0.3	22.2	0.5	23.0	0.5	0.20
Fat (%)	24.5	0.8	22.8	1.2	26.4	1.0	0.02
Waist circumference (cm)	75.1	1.0	74.7	1.4	75.5	1.5	0.69

SEM: standard error of the mean.

Table 2. Nutrient intake, energy contribution and dietary variety in Chinese and Indians

	Total	(n=101)	Chinese	(n=57)	Indians	(n=44)	Ethnicity
	Mean	SEM	Mean	SEM	Mean	SEM	(*p*-value)
Energy (kcal)	1780	50.3	1830	64.5	1710	79.4	0.24
CHO (g)	229	6.6	222	7.4	237	11.7	0.29
Energy from CHO (%)	51.9	0.8	49.1	0.9	55.5	1.1	<0.001
Protein (g)	72.5	3.0	82.1	3.8	60	4.0	<0.001
Energy from Protein (%)	16.2	0.4	17.9	0.5	14.1	0.7	<0.001
Total Fat (g)	62.7	2.3	67.1	3.2	57.1	3.1	0.03
Energy from Fat (%)	31.4	0.5	32.6	0.8	30	0.7	0.02
SFA (g)	22.1	1.0	24.3	1.5	19.4	1.1	0.01
MUFA (g)	21.2	0.9	23.2	1.3	18.7	1.2	0.01
PUFA (g)	11.1	0.5	12.1	0.6	9.8	0.7	0.02
Fibre (g)	16.2	0.7	15.8	0.9	16.8	1.3	0.52
Total sugars (g)	55.7	2.6	56.2	3.4	55	4.2	0.83
Sodium (mg)	2783	106	3110	145	2360	130	<0.001
Potassium (mg)	1610	75.4	1720	105	1470	105	0.10
% Energy for breakfast	18.6	1.0	18.6	1.3	18.7	1.6	0.98
% Energy for lunch	31.5	1.0	31.2	1.5	31.9	1.4	0.74
% Energy for dinner	33.4	1.0	34.6	1.4	31.8	1.3	0.16
% Energy for snacks	16.5	1.2	15.6	1.7	17.7	1.7	0.40
Dietary variety score	6.6	0.2	7.2	0.2	5.8	0.2	<0.001

SEM: standard error of the mean; CHO: carbohydrate; SFA: saturated fat; MUFA: monounsaturated fat; PUFA: polyunsaturated fat.

from protein and fat but lower from carbohydrate compared to the Indians (Table 2). In addition, Chinese had significantly greater sodium intake compared to the Indians ($p<0.001$). Correlations between taste thresholds and dietary intake were not significant (all $p>0.05$; data not shown).

To further describe the diet, the authors then looked at the percent of energy consumed during the different meal times (breakfast, lunch, dinner and snacks). No significant differences were observed between Chinese and Indians with the percent of energy consumed during the different meal times (all $p\geq0.16$). The dietary variety score was then calculated by scoring one point for every different food that appears over the 3-day food diary, as adapted from Savige et al, 1997.[16] In general, the average dietary variety was found to be 6.6±1.8 food items per day (Table 2), with Chinese (7.2±1.8) having a higher average dietary variety score compared to the Indians (5.8±1.6, $p<0.001$).

DISCUSSION

Taste recognition thresholds

Previous studies have concentrated on understanding taste perception in different ethnic groups in African Americans and Asian Americans;[17] Japanese and Australians;[18] and Koreans and Americans.[19] However, limited studies exist on comparison of taste perception in different ethnic groups in Asia, notably in Chinese and Indians.

In the current cohort, Indians had significantly higher recognition thresholds for sweet, salty, sour, umami and bitter tastes compared to Chinese (all $p\leq0.047$) (Figure 1). This is in contrast to some other study findings which reported no significant differences between Japanese and Americans in umami taste sensitivity.[20] The difference is proposed to be from the different ethnicities used in both studies and also Yamaguchi determined detection thresholds while the current study is on recognition thresholds. In Koreans, recognition thresholds for sweet, salty, sour and umami were 21.2 mM, 22.8 mM, 0.22 mM and 8.7 mM respectively.[21] These values are comparable to this cohort's Chinese recognition threshold for sweet, salty and sour of 22.8 mM, 33.3 mM and 0.4 mM respectively. However, the Koreans' recognition threshold for umami is more comparable to this cohort's Indian recognition threshold of 7.2 mM.

Relationships between taste perception and dietary intake

The percentage of energy contributed by macronutrients was 51.9% is from carbohydrate, 16.2% from protein and 31.4% from fat which is consistent with the Singapore's National Nutrition Survey (NNS) 2010 (52.1% from carbohydrate, 15.3% from protein and 31.4% from fat).[22]

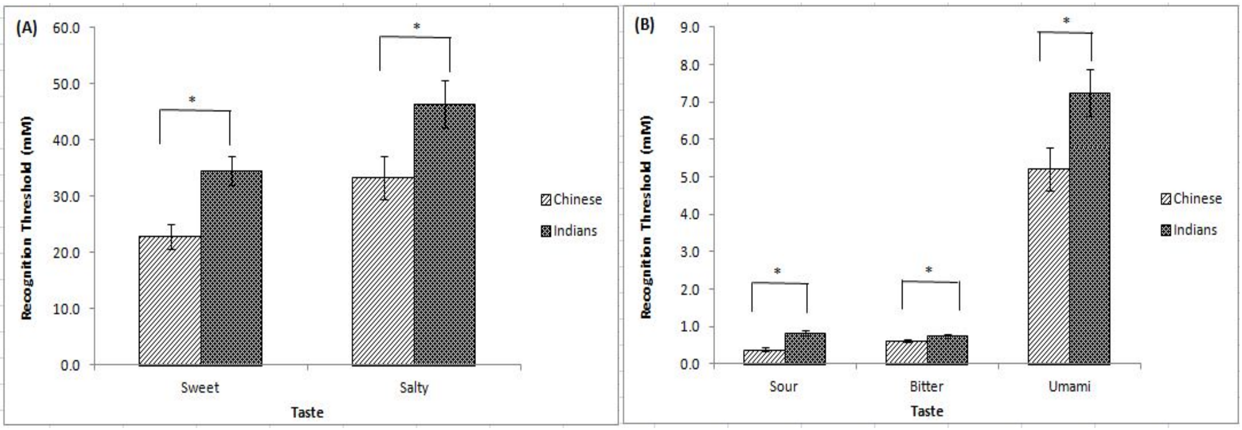

Figure 1. Recognition thresholds (mM) of Sweet and Salty (A) and Sour, Bitter and Umami (B) tastes in Chinese (n=60) and Indians (n=54).

Looking at ethnic differences, according to the NNS, Indians (355.6 g) consumed more carbohydrates than Chinese (331.7 g). Chinese (9.3%) were also more likely to add salt or sauces before tasting the food compared to Indians (6.1%).[22]

A twin study suggests that recognition threshold for sourness is primarily due to genetic factors while saltiness is mainly influenced by the environment.[23] Chinese had a significantly greater sodium intake compared to the Indians (p<0.001) (Table 2). The high sodium intake may be attributed to the greater amount of soy sauce used in Chinese cuisine. This is also reflected in the Chinese and Indians prevalence of hypertension. The Singapore National Health Survey (2010)[10] showed that the prevalence of hypertension was higher among Chinese compared to Indians (23.4% vs 19.3% respectively).[10] These results support the hypothesis that living in an environment with higher salt intake would make one more sensitive to salt taste and hence would have a lower recognition threshold which is shown in Figure 1. Given that both Chinese and Indians in Singapore have distinctively different genetics and environment, future work should investigate the role of each of these factors plays in taste perception.

In this study, total sugar was not correlated to sweet taste threshold (p>0.05), and this is similar to the study by Cicerale et al, 2012[24] and Leong et al, 2016 in press,[25] who determined dietary intake from two 24-hour recalls, and reported that sweetness intensity did not appear to play a role in dietary intake in adults.[24,25]

The present study showed that there were no differences in the percent of energy consumed during breakfast, lunch and dinner between Chinese and Indians. A diet that is high in total food variety score is essential in order to achieve nutrient adequacy.[16] Chinese had significantly lower taste thresholds of the five basic tastants and greater food variety score compared to the Indians. However, correlations performed on taste thresholds and dietary intakes were not significant (p>0.05). Another study found that dietary intake only seemed important for salt taste acuity in older European adults, but in general diet was not a predictor of taste acuity.[26]

Limitations

This study measured taste perception via taste thresholds only. Future work can also look at taste intensities and preferences in different food items; not just the basic taste solution itself.

CONCLUSION

This study has demonstrated for the first time that Indians had significantly higher recognition thresholds for sweet, salty, sour, bitter and umami tastes than Chinese. Moreover, Chinese and Indians had no differences in energy intake but energy derived from carbohydrate, protein and fat differed significantly. There were no correlations between taste and diet in Chinese and Indians. Future work is needed to further understand how differences in taste perception may influence dietary intakes between ethnic groups. This is critical in understanding the public health challenges encountered by different ethnic groups and in the design of targeted intervention programs.

ACKNOWLEDGEMENTS

The authors would like to thank the volunteers for their participation in the study, Mr Alex Toh and Ms Wang Dexin for assisting in the preparation of the samples and Ms Davina Lee for her assistance to enter all dietary records.

AUTHOR DISCLOSURES

The authors declare no conflict of interest. This study was supported by the Singapore Institute for Clinical Sciences (SICS). It was designed, executed and reported solely by the authors without any external influence. Its content is solely the responsibility of the authors and do not necessarily represent the official views of SICS.

REFERENCES

1. Feeney E, O'Brien S, Scannell A, Markey A, Gibney ER. Genetic variation in taste perception: does it have a role in healthy eating? Proc Nutr Soc. 2011;70:135-43.
2. Mojet J, Heidema J, Christ-Hazelhof E. Taste perception with age: Generic or specific losses in supra-threshold intensities of five taste qualities? Chem Senses. 2003;28: 397-413.
3. Gomez FE, Cassis-Nosthas L, Morales-de-Leon JC, Bourges H. Detection and recognition thresholds to the 4 basic tastes in Mexican patients with primary Sjogren's syndrome. Eur J Clin Nutr. 2004;58:629-36.
4. Baharuddin AR, Sharifudin MS. The impact of geographical location on taste sensitivity and preference. Int Food Res J. 2015;22:731-8.

5. Drewnowski A. Taste preferences and food intake. Annu Rev Nutr. 1997;17:237-53.
6. Garcia-Bailo B, Toguri C, Eny KM, El-Sohemy A. Genetic variation in taste and its influence on food selection. OMICS. 2009;13:69-80.
7. Takachi R, Ishihara J, Iwasaki M, Ishii Y, Tsugane S. Self-reported taste preference can be a proxy for daily sodium intake in middle-aged Japanese adults. J Acad Nutr Diet. 2014;114:781-7.
8. Tam CY, Hislop G, Hanley AJ, Minkin S, Boyd NF, Martin LJ. Food, beverage, and macronutrient intakes in postmenopausal caucasian and Chinese-Canadian women. Nutr Cancer. 2011;63:687-98.
9. Zhang G, Malik VS, Pan A, Kumar S, Holmes MD, Spiegelman D et al. Substituting brown rice for white rice to lower diabetes risk: a focus-group study in Chinese adults. J Am Diet Assoc. 2010;110:1216-21.
10. Singapore Ministry of Health. Singapore National Health Survey 2010. Singapore: Singapore Ministry of Health; 2010.
11. Gibson RS. Principles of nutritional assessment. 2nd ed. New York: Oxford University Press; 2005.
12. Stewart JE, Feinle-Bisset C, Golding M, Delahunty C, Clifton PM, Keast RSJ. Oral sensitivity to fatty acids, food consumption and BMI in human subjects. Br J Nutr. 2010; 104:145-52.
13. Lawless HT. A simple alternative analysis for threshold data determined by ascending forced-choice methods of limits. J Sens Stud. 2010;25:332-46.
14. Allison DB, Baskin M. Handbook of assessment methods for eating behaviors and weight related problems: measures, theory, and research. 2nd ed. California: Sage Publications; 2009.
15. Singapore Health Promotion Board. Energy & nutrient composition of food. In: Singapore Health Promotion Board, editor. Singapore: Health Promotion Board; 2011.
16. Savige GS, Hsu-Hage B, Wahlqvist ML, Craig LH, Simons L. Food variety as nutritional therapy. Curr Ther. 1997;38: 57-69.
17. Choi SE. Racial differences between African Americans and Asian Americans in the effect of 6-n-propylthiouracil taste intensity and food liking on body mass index. J Acad Nutr Diet. 2014;114:938-44.
18. Prescott J, Bell GA, Gillmore R, Yoshida M, O'Sullivan M, Korac S et al. Cross-cultural comparisons of Japanese and Australian responses to manipulations of sourness, saltiness and bitterness in foods. Food Qual Prefer. 1998;9:53-66.
19. Hong JH, Yoon EK, Chung SJ, Chung L, Cha SM, O'Mahony M et al. Sensory characteristics and cross-cultural consumer acceptability of Bulgogi (Korean traditional barbecued beef). J Food Sci. 2011;76:S306-13.
20. Yamaguchi S. Basic properties of umami and effects on humans. Physiol Behav. 1991;49:833-41.
21. Hong JH, Chung JW, Kim YK, Chung SC, Lee SW, Kho HS. The relationship between PTC taster status and taste thresholds in young adults. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2005;99:711-5.
22. Singapore Health Promotion Board. Report of the National Nutrition Survey 2010. In: Singapore Health Promotion Board, editor. Singapore: Health Promotion Board; 2010.
23. Wise PM, Hansen JL, Reed DR, Breslin PAS. Twin study of the heritability of recognition thresholds for sour and salty taste. Chem Senses. 2007;32:749-54.
24. Cicerale S, Riddell LJ, Keast RS. The association between perceived sweetness intensity and dietary intake in young adults. J Food Sci. 2012;77:H31-5.
25. Leong C, Forde CG, Tey SL, Henry CJ. Taste perception and diet in people of Chinese ancestry. Asia Pac J Clin Nutr. 2018;27:478-86. doi: 10.6133/apjcn.052017.08.
26. Simpson EEA, Rae G, Parr H, O'Connor JM, Bonham M, Polito A et al. Predictors of taste acuity in healthy older Europeans. Appetite. 2012;58:188-95.