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The impact of geographical location on taste sensitivity and preference

[1*]Baharuddin, A.R. and [1]Sharifudin, M.S.

[1]Faculty of Food Science and Nutrition, Universiti Malaysia Sabah, 88400, Kota Kinabalu, Sabah,Malaysia

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Abstract

This study was carried out to determine recognition threshold and taste preference for three basic tastes (sweetness, saltiness and sourness) based on location (interior and coastal) among the Kadazandusun ethnic in Sabah, Malaysia. One hundred and ninety four (194) volunteers aged 20 to 55 years were selected randomly (stratified) as subject. Three Alternative Forced-Choice (3AFC) and hedonic test were used to determine the taste threshold and preference. The interior group had lower taste threshold for all tastes; sweet (10.97 g/L ± 3.69), salty (1.14 g/L ± 0.38), sour (0.0095 g/L ± 0.011) compared to the coastal group; sweet (11.56 g/L ± 3.71), salty (1.23 g/L ± 0.39), sour (0.0012 g/L ± 0.0034). For intensity and hedonic rating, the patterns of response varied based on location for sweet and sour taste. No significant different ($p>0.05$) was observed for salty taste. However, both groups preferred the base stimulus which concentration similar to the commercially available products tested. There is a correlation between taste threshold and optimum concentration. Individuals with preferred high taste intensity tend to have higher taste threshold. Location and culture can influenced individual taste preference. However, exposure and experience to taste sensation was the major factor on individual's taste preference.

Introduction

Food is a symbol of acceptance and relation in social and culture in human life which influenced by food choice and habit. Food choice is an action by desire and aspiration caused of desperation or to have basic compound which contained protein, carbohydrate and fat for development, maintenance and other main process for supply energy to all organism activities (Verbeke, 2003). Human being not just consumed food as their essential need for survival but to fulfill their social and psychological needs in their life (Wright *et al.*, 2001).

Food preference and choice is a complex process because it includes the culture, status and also taste which can give many meaning to any institution (Furst *et al.*, 1996; Koster, 2009). Sensory attributes of food are widely considered as the main factors in food choice and consumption. In addition, marketing studies on determinants of food consumption are largely determined by taste of the particular food (Drewnowski *et al*., 1999). A number of studies revealed that people tend to have similarity in intensity discrimination from low to high levels of tastants but there are differences in the magnitude of rating between them (Laing *et al*., 1994; Prescott *et al*., 1997; Holt *et al*., 2000). The influenced of culture sets to be one of the main factor in determine human taste perception and preferences (Moskowitz *et al*., 1975; Prescott and Bell, 1995; Rozin, 1996).

Study of the perceptions and preferences for taste qualities on foods across different cultures produced valuable data. It may enhance our understanding on innate and environmental influences on individual perceptions and preferences (Prescott *et al*., 1998). An increasing attention is being given to cultural comparisons in food, eating and nutrition (Devine *et al*., 1999). There are few studies conducted to understand the variation in food choices, taste preferences and their causes among individuals, groups and culture (Zellner *et al*., 1999). Most studies focus on human physiology (aging, disease, body weight) as the main factor of variation in human taste preferences and perceptions (Laeng *et al*., 1994; Okoro *et al*., 1998; De Graaf and Zandstra, 1999; De Graaf *et al.*, 2001; Sanders and Oakes, 2002) and only scarce of knowledge focused on cultural and origins (Cervellon and Dube, 2005).

Different cultures are associated with different food and taste and such cultural entities are usually place based. We know only little about differences in liking for foods that are common to several region and cultures (Zellner *et al*., 1999). Moskowitz *et al.* (1975) compared western populations and Kartanaka labourers in India on simple sensory stimuli through basic tastes. They found out that there are significant

*Corresponding author.
Email: *a_riduan@ums.edu.my*

different between both group on sour taste. In addition, Jamel *et al.* (1996) found that people who are living in urban areas with high sugar intake preferred sweeter tea compared to people who are living in rural area. Holt *et al.* (2000) reported that Malaysians' preference of sweeter food compared to Australians is related to higher sugar intake among Malaysians. Those studies showed that there are differences in human taste perception based on culture and place. However, Prescott *et al*. (1997) found that there were no differences in the sweet tastes between Australian and Japanese subjects.

Most of cross cultural study on food focused on basic tastes in solution but not in real foods and conducted almost exclusively in western country (e.g. Lennernas *et al.*, 1997; Okoro *et al*., 1999; Zellner *et al*., 1999; Mojet *et al,* 2001; Cervellon and Dube, 2005). In contrast, to our best knowledge, only scarce studies have been done in Malaysia. Wong (1991) compared taste acceptances and preferences among three major ethnics in Malaysia; The Malays, Chinese and Indian. She found that Malay people prefer sweeter food products compared to other ethnic. In contrast, Indian subjects prefer higher sour taste compared to other ethnics while Chinese subjects always prefer medium taste intensity of all food tested. As a multiracial country, it is beneficial to study ethnic based perception and preferences in order to understand their various culture and lifestyle among Malaysian. This effort not only benefits the manufacturer and nutritionist but also to the ruler to understand and to know in depth about their peoples.

Sabah was located in the easternmost part in Borneo Island. It is the second largest and unique state in Malaysia. It shares a maritime border with the Federal Territory of Labuan on the west and Philippines to the north and northeast. In addition, the land border also shares with the province of North Kalimantan of Indonesia in the south. The state of Sabah consists of five divisions; namely, Tawau, Sandakan, Kudat, West Coast and Interior. Sabah comprise of variety of ethnic, culture and heritage. Kadazandusun is the largest ethnic in Sabah, Malaysia. It composed of 30% population of the country. Most of this ethnic population live in 3 main divisions in Sabah; West Coast Division (Penampang, Putatan, Papar, Kuala Penyu, Inanam, Menggatal, Tamparuli, dan Tuaran), Interior Division (Kundasang, Ranau dan Tambunan) and Sandakan Division (Sandakan and Lahad Datu). The location and places form another sub-ethnic in this community. It is reported that their culture, food and lifestyle were quiet similar between the sub-ethnic (Madisah, 1986). However, we hypothesized that geographical location factor may have influences to the taste acceptance and preference between the sub-ethnic and groups. Hence, this study was conducted to measure the influences of geographical location on taste sensitivity and preferences among Kadazandusun ethnic in Sabah.

Materials and Methods

Subjects

The study was conducted in the coastal and interior of Sabah, Malaysia. Malaysia is a multiracial country which Sabah itself has about 53 ethnic groups. To minimize the difference in taste preferences among the multiracial community, only the Kadazandusun ethnic was selected. One hundred and ninety four (194) peoples from coastal area (20 – 55yr; 41 males, 59 females) and interior area (20 – 55yr; 42 males, 52 females) were recruited. Based on geographical location, Kuala Penyu was selected as coastal area while Ranau were selected as interior area for this study. All selected subjects must be healthy, not pregnant, not on a therapeutic diet and live at least 5 years in that particular area.

Stimuli

Three basic tastes were studied; sweetness, saltiness and sourness. For each taste, specific compounds were chosen to represent the taste: Sucrose, Natrium Chloride (Nacl) and Citric Acid. All compounds were dissolved in distilled water (taste threshold) and commercially available products such as tea, orange juice, and mushroom soup (hedonic test). In total, subjects were given 2 sensory tests: (1) Taste threshold which using triangle test ; 1 tastant + 2 blanks (distilled water) (2) Hedonic test was conducted by utilising market products which represents the basic tastes studied; (i) chrysthemum tea– sweetness, (ii) mushroom soup – saltiness, (iii) orange juice – sourness.

Commercial products available in market vary from brand to brand for their intensity of taste compound (Sucrose, Nacl, Citric acid). Preliminary test were used to determine the level of concentration for solutions and products to be used in hedonic test (Prescott *et al*., 1997). Two stages of preliminary test were conducted by 30 subjects from both areas. In the first stage, subjects ranked taste intensities of 5 commercial brands available in the market. Brand with the lowest scores in taste intensity was used as the based sample. The based samples were manipulated to 9 different concentrations. In the second stage, subjects were rated the intensity and palatability of manipulated based product by using 9-point hedonic scale. Five samples which covered

a wide intensity range and not being unpalatable (mean rating between 3 to 7 on the 9 point hedonic scale) were chosen as sample in this study (Prescott *et al*., 1998). Final amount of added tastant for each stimuli used in the hedonic test were as follows: (1) Chrysanthemum Tea which sucrose had been added: 0 g, 17 g, 38 g, 65 g, 98 g; (2) Mushroom soup which sodium chloride had been added: 0 g, 3 g, 7 g, 12 g,16 g; and (3) Orange juice which citric acid had been added: 0 g, 2 g,5 g, 9 g, 14 g.

Likewise, stimuli concentrations for taste threshold were determined by preliminary test and also based on previous studies (e.g. Okoro *et al*., 1998; Mojet *et al*., 2001; Ng *et al*., 2004; Pasquet *et al*., 2006). Stimuli with high subjects can be detected as recognition threshold were chosen as central based. 5 concentrations (2 ascending 0.1 log steps and 2 descending 0.1 log steps from based) were administered as stimuli in this study. The central concentration for (i) sweet- 11g/L (ii) salty-1.0g/L (iii) sour – 0.13g/L.

Procedures

Subjects started to evaluate the stimulus after fasting for an hour. This study was conducted in a hall. Fifteen flexible cubicles (45 cm x 45 cm x 50 cm) were used to replace sensory set up in the laboratory to avoid subjects discussed among them while evaluating the tastants (Penfield and Campbell, 1990).

Taste Threshold

Three-alternative forced choice was used in the threshold measurement with concentration presented in ascending order. At each concentration, sample set consisted of one tasted solution and two blank samples. Each sample coded with a 3 digit number and tasted from left-centre-right order. Within each set/concentration, subjects indicated that sample which is different from the two others. If the subjects cannot readily discriminate, a guess must be made. Tests were completed when subjects' reach a set wherein the test samples correctly identified. An individual best- estimate value of threshold is the geometric mean of that concentration at which the last miss occurred and the next higher concentration detected. Group threshold are derived by averaging of the individual best-estimate thresholds (ASTM, 2004). Subjects were asked to rinse the mouth with mineral water before tasted the samples. To avoid fatigue, test divided into 3 sessions based on basic taste studied.

Hedonic test

Subjects tasted the samples and asked to observe the products/ samples on intensity of tastes (sweetness, saltiness, sourness) and degree of liking on the particular concentration/level of intensity. Then, subjects marked their rating on a separate score sheet containing scale on products they were tasted. For both scale, 9-point hedonic scale were used which anchors very weak to the left and very strong to the right on 135mm line (Prescott *et al*., 1998). 9-point hedonic scale has lower same stimulus error and a better different stimulus error compared to 5-point and 7-point hedonic scale (Park *et al*., 2003). Intensity scale used the end points of none (left) and extremely (right) together with attribute name (taste) while hedonic scale used end points of dislike extremely (left) and like extremely (right) (Aminah, 2000). Each sample coded with a 3 digit number and tasted from left-centre-right order. Subjects were told to rinse their mouth with water until no aftertaste remained before tasted another sample.

Data Analysis

Data were analysed using SPSS (version 17.0). Two-way mixed ANOVA was used to determine the main differences and interaction between each group (location). Simple effect test (Independent T-test) with bonferoni correction was used to compare different level of solutions between groups. Chi square Test was used to measure impact of location towards taste threshold. Spearman correlation was used to predict relationship between taste threshold and preferred concentration; as well as intensity rating – liking rating. Preferred concentration refers to the highest liking rating for one particular sample. In some cases, subjects will give more the one sample as the preferred concentration. The average of the concentrations will take as preferred concentrations for the subject. A p-value of 0.05 or lower is reported as significant different.

Results

Taste threshold

Sweet

Only 10% of subjects can detect the taste in the lowest concentration of stimuli given for both groups. Most of the subjects from the interior group have lower sweet taste threshold compared to coastal group respectively. Best estimation threshold (BET) for interior group was 10.97 g/L while 11.56/g/L for coastal group. However, there was no significant different between both group in their sweet threshold

(X^2=1.768, df= 5, p>0.05). Hence, the sweet threshold distribution was not influenced by geographical factor (p>0.05) for this population. In general, this Kadazandusun ethnic group sweet threshold was 11.27±3.7 g/L for this study.

Salty

The distribution of salty threshold between both groups was similar for all stimuli tested. Therefore, there is no significant difference between both groups in their salty taste threshold. In contrast, interior group subjects have a lower best estimation threshold (BET) (1.14 g/L) compared to coastal group (1.23g/L) respectively. Chi square test revealed that there is no effect of geographical factor on saltiness threshold (X^2=5.797, df= 5, p>0.05).

Sour

Only 11.5% of subjects from both groups were able to recognize sour taste at the lowest concentration of the stimuli (0.08 g/L). Subjects from interior group showed a lower threshold (0.095 g/L) compared to coastal group (0.12 g/L). There was a significant difference between both groups (p<0.05). In addition, Chi square test showed that this distribution was influenced by geographical factor (X^2 =33.828, df =5, p<0.05).

Taste preference

Sweetness

Sucrose that being added, the liking and intensity rating for each level different than previous level. Each level being significantly different to each other's (P<0.05). There was interactive effect [level x origin: (F1, 78, = 4.04; P<0.05)]. Post hoc multiple test revealed that both group significantly different at two highest additional of sucrose to the based product (65g/l and 98g/L) (Figure 1a and 1b).

(1a) (1b)

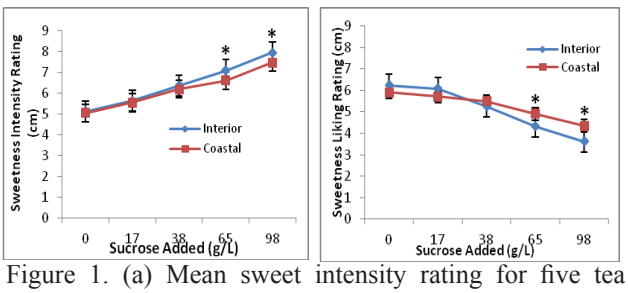

Figure 1. (a) Mean sweet intensity rating for five tea samples (*P < 0.05); (b) Mean sweetness liking rating for five tea samples (*P < 0.05)

It showed that a switch trend for both group between lower concentration and high concentration of stimuli. There was a negative correlation between intensity and liking rating for sweetness (r_s=-0.34; p<0.05).

Saltiness

The mean intensity rating for both groups showed a linear increase with additional NaCl in soups. Each level being significantly different to each other's (P<0.05). Coastal groups give a higher mean intensity rating compared to interior subjects for all concentrations studied (Figure 2a). There was no interactive effect (p >0.05) between locations. Above 3g/L added tastant, liking rate for the samples started to decrease for both groups (Figure 2b).

(2a) (2b)

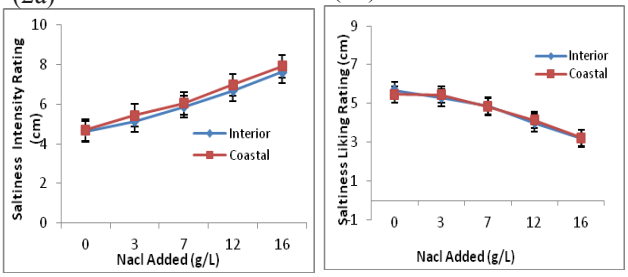

Figure 2. (a) Mean salty intensity rating for five mushroom soup samples (*P < 0.05); (b) Mean saltiness liking rating for five mushroom soup samples (*P < 0.05)

There were no significant differences between those two groups on liking rating and intensity rating (p>0.05). There was a negative correlation between intensity and liking rating for saltiness (r_s=- 0.37, p<0.05).

Sourness

Mean sourness intensity rating for both groups equally rated over the five additional citric acid levels (Figure 3a). However, each level being significantly different with each other's (P<0.05). For liking rating, addition of citric acid to the juice decreased the liking rating and fell dramatically after addition of 9g/L (Figure 3b).

(3a) (3b)

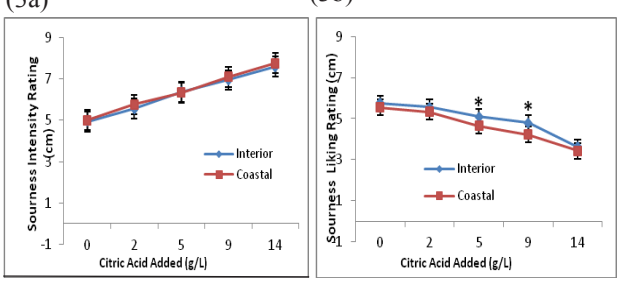

Figure 3. (a) Mean sour intensity rating for five juice samples (*P < 0.05); (b) Mean sourness liking rating for five juice samples (*P < 0.05)

Subjects from interior area have higher liking rating than subjects from coastal area. There was interactive effect between main factors (p<0.05) and

post hoc multiple showed that there are significant different between both groups at the higher of citric acid addition (5g/L and 9g/L) ($p<0.05$). There was a negative correlation between intensity and liking rating for sourness (r_s=-0.35, $p<0.05$).

Relationship between taste threshold and preferred concentration

There is a significant correlation between taste threshold and preferred concentration for all studied tastes ($p<0.05$). However, there's only weak correlation ($p<0.05$) for all tastes studied ranging from 0.2 to 0.38 respectively. It showed that subject who preferred higher concentrations of taste's substance food tend to have higher taste threshold for that particular taste.

Discussion

The threshold values for sucrose, natrium chloride and citric acid obtained in this study are similar to other studies conducted (Kellyand Meyer, 1971; Pangborn and Pecore, 1982, Okoro *et al.*, 1998). However, there was a slight different between researchers on the threshold values obtained from this study to others. Aminah (2000) reported that Malay ethnic in the West Malaysia have 2.4 g/L as their sweet threshold (sucrose) which lower than Kadazandusun ethnics taste threshold in Sabah. This difference might suggest that people in this study had high intake on sweet food compared to Malay ethnic in Malaysia. Holt *et al.* (2000) confirmed that people with more exposure and regularly consumed sweet food tend to have high preference for sweet taste. However, range of method used in determination of threshold also needs to be address as cause of differences (Okoro *et al.*, 1998).

On average, interior subjects have lower taste threshold on all tastes studied. No significant different obtained between both groups for sweet and salty taste threshold except sour taste. Previous studies had shown that signalling detection and pathway for both tastes are almost similar at lower concentration of sucrose and Nacl (Spetter *et al*., 2010). However, sour taste transduction is different compared to other taste. Sour taste sensation sharper and stronger compared to salty and sweet taste which can reflect the taste threshold distribution (McFeeters *et al.*, 2007).

Additional of compounds to the samples will effect on rating of intensity and liking of the sample. Through all taste discrimination, both subject's group showed averaged rating for intensity rating which both of them showed a linear increase with addition of compounds to the samples tested. This result showed that people will have similar interact and reflection towards taste discrimination from low to high level of taste sensation. It can be related to innate preferences for tastants (Rozin, 1996) and confirmed that each individual can discriminate intensity of sweetness from low to high (Holt *et al.*, 2000). From the result, most of the subjects preferred level of compounds added in based products which it's commercial products. So that, we can concluded that the commercial food product are familiar and acceptable by consumers.

Interestingly, liking rating for higher concentration for both groups were significantly different with interior group had lower rating compared to coastal group. This finding is different from other studies whose reported people with higher sweet food intake tend to like higher sweetness of food (Moskowitz *et al*., 1975; Pangborn and Pecore, 1982; Jamel *et al*., 1996; Holt *et al*, 2000; Mahar and Duizer, 2007). Through observation, temperatures of both locations will influence subject food habit and intake which can gave impact to taste perception. Interior had lower surrounding temperature compared to coastal. This will influence subject from interior consume a lot of hot beverages and food. Several studies confirmed that temperature had impact on taste acceptance of food which extreme temperature can lead to higher taste threshold and lower taste acceptance (liking) (Moskowitz, 1972; Schiffman *et al*.,2000;Talavera *et al.* 2007). In this study, samples were presented at room temperature. So that, subject from interior will give higher sweetness intensity rating and lower liking rating for the samples. Instead of temperature, it is suggested, experience and exposure also play important role in human taste acceptance and preference. Laing *et al*. (1994) also suggested that differences in responses of subjects from different cultures to chemosensory stimuli are restricted to reference behavior arising from experience rather than from genetically-based influences.

There were significant differences between groups in sweetness and sourness liking rating. It is suggested that difference in food frequency consumption is related to intensity and liking rating in particular taste preferences (Jamel *et al.*, 1996; Holt *et al.*, 2000; Maher and Duizer, 2007). Previous studies had shown that high dietary intake of salty will increase salty taste perception in food (Pangborn and Pecore, 1982). In the present study, result showed lower rating in saltiness rating in coastal area even they can be connected to availability of seafood and sources surround them which can make they have higher rate in saltiness rating. However, high consumption of instant and preserved food (salted

fish, instant noodles, snacks) among interior groups gives impact to this difference for both groups - data not show (Kim and Lee, 2009). This suggested that availability of specific food not the only predictor for the subjects' taste acceptance and food preference. Abundant of food product in the market and advertisement of food in the media could lead to changes of taste acceptance and food preferences among individuals (Elder and Krishna, 2010; Lanfer *et al*, 2013)

Apart from that, Duffy *et al*. (2007) suggested that oral sensation could lead to chronic diseases risk such as diabetes and hypertension through the dietary intake and food habit. Several studies have proved that high preferences and intake for high sweet food and beverages could lead to obesity and diabetes (Drewnoski, 1987; Raben *et al*., 2002; Schulze *et al.*, 2004; Welsh *et al*., 2005; Ebbeling *et al*., 2006). Even the result of this study not consistent but the trend and pattern was convinced that the relationship could be existed. Hence, study on this particular cause (taste acceptance; food intake) and effects (body weight; obesity, diabetes) seem warranted in future especially among Malaysian society.

Conclusion

The results showed that there are different on taste perception between both groups (location). However, the observed difference was unstable for means of liking ratings for some of the test stimuli. The taste acceptance differences may plausibly due to geographical structure and condition (temperature, altitude) between both locations. Location or geographical factor can affect individual/group's taste perception. However, this factor prone to be as identity of one group. Exposure, experience and food habit (caused by surrounding and culture) may give more significant impact to our taste perception.

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References

ASTM. 2004. Standard practice for determination of odor and taste by a forced-choice ascending concentration series method of limits – E679-04. USA. ASTM International.

Aminah Abdullah. 2000. Prinsip penilaian sensori, p. 72-84. Selangor. Penerbit Universiti Kebangsaan Malaysia.

Cervelllon, M. and Dube, L. 2005. Cultural influences in the origins of food likings and dislikes. Food Quality and Preference. 16: 455 – 460.

De Graaf, C. and Zandstra, E. H. 1999. Sweetness intensity and pleasantness in children, adolescents and adults. Physiology and Behavior 67: 513-20.

De Graaf, C., Zandstra, E. H. and van Staveren, W. A. 2001. Influence of health and taste attitudes on consumption of low and high-fat foods. Journal of Food Quality and Preference 12:75-82.

Devine, C.M., Sobal, J., Bisogni, C.A. and Connors, M. 1999. Food choices in three ethnic groups: Interaction of ideals, identities and roles. Journal of Nutrition Education 31(2): 86-93.

Drewnoski, A. 1987. Body weight and sensory preferences for sugar and fat. Food Science and Technology Journal 20 (5):327-330.

Drewnowski, A., Henderson, S.A., Levine, A. and Han, C. 1999. Taste and food preferences as predictors of dietary practices in young women. Public Health Nutrition 2: 513-519.

Duffy, V.B. 2007. Variation in oral sensation: Implication for diet and health. Current Opinion in Gastroenterology. 23: 171 -177.

Ebbeling, C.B., Feldman, H.A., Osganian, S.K., Chomitz, V.R., Ellenbogen, S.J. and Ludwige, D.S. 2006. Effects of decreasing sugar-sweetened beverage consumption on body weight in adolescents: a randomized, controlled pilot study. Pediatrics 117: 673–680.

Elder, R.S. and Krishna, A. 2010. The effects of advertising copy on sensory thoughts and perceived taste. Journal of Consumer Research 36 (5): 748-756.

Furst, T., Connors, M., Bisogni, C. A., Sobal, J. and Falk, L. W. 1996. Food choice: a conceptual model of the process. Appetite 26: 247 - 266.

Holt, S.H.A., Cobiac, L., Beaumont-Smith, Easton, K. and Bestand, D.J. 2000. Dietary habits and the perception and liking of sweetness among Australian and Malaysian students: a cross-cultural study. Journal of Food Quality and Preference 11: 299-312.

Jamel, H.A, Sheiham, A., Cowell, C.R. and Watt, R.G. 1996. Taste preference for sweetness in urban and rural populations in Iraq. Journal of Dental Research 75: 1879-1884.

Kelly, M. F. and Mayer, J. 1971. Rapid determination of taste threshold: a group procedure. The American Journal of Clinical Nutrition 24: 177-180.

Kim, G.H. and Lee, H.M. 2009. Frequent consumption of certain fast foods maybe associated with an enhanced preference for salt taste. Journal of Human Nutrition and Dietetics 22: 475 – 480.

Koster, E. P. 2009. Diversity in the determinants of food choice: a psychological perspective. Journal of Food Quality and Preferences 20: 70-82.

Laing, D.G., Prescott, J., Bell, G.A, Gillmore, R., Allen, S., Best, D.J., Yoshida, M., Yamazaki, K. and Ishii-Mathews, R. 1994. Responses of Japanese and Australians to sweetness in the context of different

foods. Journal of Sensory Studies 9: 131-155.

Laeng, B., Berridge, K. C. and Butter, C. M. 1994. Pleasantness of a sweet taste during hunger and satiety: effects of gender and "Sweet Tooth". Appetite 21: 247-54.

Lanfer, A., Bammann, K., Knof, K., Buchecker, K., Russo, P., Veidebaum, T., Kourides, Y., de Henauw, S., Molnar, D., Bel-Serrat, S., Lissner, L. and Ahrens, W. 2013. Predictors and correlates of taste preferences in European children: The IDEFICS study. Journal of Food Quality and Preference 27: 128-136.

Lennernäs, M., Fjellström, C., Becker, W., Giachetti, I., Schmitt, A., Remaut de Winter, A. and Kearney, M. 1997. Influences on food choice perceived to be important by nationally-representative samples of adults in the European Union. European Journal of Clinical Nutrition 51(2): 8-15.

Madisah, J. 1986. Tatacara, adat istiadat dan kebudayaan kadazandusun, p. 3-11. Kota Kinabalu. Sikuk Publication.

Mahar, A. and Duizer, L.M. 2007. The effect of frequency of consumption of artificial sweet on sweetness liking by woman. Journal of Food Science 72: S714-S718.

Mcfeeters, R. F., Da Conceicao Neta, E. R. and Johanninsmeier, S. D. 2007. The chemistry and physiology of sour taste – A review. Journal of Food Science. 72: 33-38

Mojet, J., Heidema, H. and Christ-Hazelhof, E. 2001. Taste perception with age: Generic or specific losses in threshold sensitivity to the five basic tastes? Chemical Senses 26: 845-860.

Moskowitz, H. W. 1972. Effect of solution temperature on taste perception. Physiology and Behavior 10: 289-292.

Moskowitz, H. W., Kumaraiah, V. Sharma, K. N. H., Jacobs, L. and Sharma, S. D. 1975. Cross-cultural differences in simple taste preferences. Sciences 190: 1217-1218.

Ng, K., Lo, R. and Cavadini, C. 2004. Effect of age and disease on taste perception. Journal of Pain and Symptom Management 28(1): 28-33.

Okoro, E. O., Jolayemi, E. T., Uroghide, G. R., George, O. O. and Enobakhare, C. O. 1998. Studies on taste threshold in a group of adolescents children in rural Nigeria. Journal of Food Quality and Preference 9: 205-210.

Pangborn, R.M. and Pecore, S.D. 1982. Taste perception of sodium chloride in relation to dietary intake of salt. The American Journal of Clinical Nutrition 35: 510-520.

Park, J.Y., Jeon, S.Y. , O'Mahony, M. and Kim, K-O. 2003. Induction of scaling errors. Journal of Sensory Studies 19: 261-271.

Pasquet, P., Simmen, B. and Marez, A. 2006. Relationship between taste threshold and hunger under debate. Appetite 46: 63- 66.

Penfield, M. P. and Campbell, A.M. 1990. Experimental food science, p. 51-74. London. Academic Press Limited.

Prescott, J. and Bell, G. 1995. Cross cultural determinants of food acceptability: recent research on sensory perception and preferences .Trend In Food Science and Technology 6: 201 – 205.

Prescott, J., Bell, G. A., Gillmore, R., Yoshida M., O'sullivan, M., Korac, S., Allena, S. and Yamazaki, K. 1997. Cross-cultural comparison of Japanese and Australians responses to manipulations of sweetness in foods. Journal of Food Quality and Preference 8: 45-55.

Prescott, J., Bell G. A., Gillmore, R., Yoshida M., O'sullivan, M., Korac, S., Allena, S. and Yamazaki, K. 1998. Cross-cultural comparison of Japanese and Australians responses to manipulations of sourness, saltiness and bitterness in foods. Journal of Food Quality and Preference 9: 53-66.

Raben, A., Vasilaras T.H., Moller , A.C. and Astrup, A. 2002. Sucrose compared with artificial sweeteners: different effects on ad libitum food intake and body weight after 10 week of supplementation in overweight subjects. The American Journal of Clinical Nutrition 76: 721–729.

Rozin, P. 1996. The socio-cultural context of eating and food choice. In Meiselman, H.L. and Macfie, H.J.H. Food Choice, Acceptance and Consumption, p. 83-102. London: Blackie Academic and Professional.

Sanders, O. G. and Oakes, S. 2002. Taste acuity in the elderly: the impact of threshold, age, gender, medication, health and dental problems. Journal of Sensory Studies 17: 89-104

Schiffman, S., Sattely–Miller, E.A, Brevick,G.G., Jeanette, B.L., Barbara, B.J., Desai, N. and Ihab Bishay, I. 2000. Effect of temperature, pH and ions on sweet taste. Physiology and Behavior 68: 469-481.

Schulze M.B., Manson J.E., Ludwige, D.S., Colditz G.A., Stampfer, M.J., Willett, W.C. and Hu, F.B. 2004. Sugar-sweetened beverages, weight gain, and incidence of type 2 diabetes in young and middle-aged women. The Journal of the American Medical Association 292 (8): 927–934.

Spetter, M.S., Smeets, P.A.M., De Graaf, C. and Viergever, M.A. 2010. Representation of sweet and salty taste intensity in the brain. Chemical Senses 35 (9): 831-840.

Talavera, K., Ninomiya, Y., Winkel, C., Voets, T. and Nilius, B. 2007. Influence of temperature on taste perception. Cellular and Molecular Life Sciences 64: 377-381.

Verbeke, W. 2003. Consumer acceptance of functional foods: socio-demographic, cognitive and attitudinal determinants. Journal of Food Quality and Preference 16: 45 – 57.

Welsh, J.A., Cogswell, M.E., Rogers, S., Rockett, H., Mei, Z. and Grummer-Strawn, L.M. 2002. Overweight among low-income preschool children associated with the consumption of sweet drinks: Missouri, 1999–2002. Pediatrics 115: e223–e229.

Wong, P. H. 1991. Ethno-cultural taste preference of the three main ethnic groups in Malaysia. Bangi, Malaysia: The National University of Malaysia, MSc Thesis.

Wright, L. T., Nancarrow, C. and Kwok, P. M. H. 2001. Food taste preferences and cultural influences on consumption. British Food Journal. 103(5): 348-357.

Zellner, D.A., Garriga-Trillo, A., Rohm, E., Centeno, S. and Parker, S. 1999. Food liking and craving: A cross cultural approach. Appetite 33: 61-67.