SENSORY PREFERENCE AND DETECTION THRESHOLD FOR SWEET TASTE AMONG UNDERGRADUATE STUDENTS OF HEALTH CAMPUS, UNIVERSITI SAINS MALAYSIA

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SENSORY PREFERENCE AND DETECTION THRESHOLD FOR SWEET TASTE AMONG UNDERGRADUATE STUDENTS OF HEALTH CAMPUS, UNIVERSITI SAINS MALAYSIA

By

NUR ASYIRAH BINTI AZIZ

Dissertation submitted in partial fulfilment

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CERTIFICATE

This is to certify that the dissertation entitled **SENSORY PREFERENCE AND DETECTION THRESHOLD FOR SWEET TASTE AMONG UNDERGRADUATE STUDENTS OF HEALTH CAMPUS, UNIVERSITI SAINS MALAYSIA** is the bona fide record of research work done by **MS NUR ASYIRAH BINTI AZIZ** during the period from **September 2016 to May 2017** under my supervision. I have read this dissertation and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation to be submitted in partial fulfillment for the degree of Bachelor of Health Science (Honours) (Nutrition).

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DECLARATION

I hereby declare that this dissertation is the result of my own investigations, except where otherwise stated and duly acknowledged. I also declare that it has not been previously or concurrently submitted as a whole for any other degrees at Universiti Sains Malaysia or other institutions. I grant Universiti Sains Malaysia the right to use the dissertation for teaching, research and promotional purposes.

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Date: ……..

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List of Symbols and Abbreviations

AFC	Alternative Force Choice
ASTM	American Society for Testing and Materials
BET	Best Estimation Threshold
BETg	Best Estimation Threshold Group
g	gram
MANS	Malaysian Adult Nutrition Survey
mM	milimolar
ml	mililiter
oz	ounce
% w/v	weight/volume percent
VAS	Visual analogue scale
WHO	World Health Organization

KECENDERUNGAN SENSORI DAN PENGESANAN AMBANG UNTUK RASA MANIS DALAM KALANGAN PELAJAR IJAZAH SARJANA MUDA KAMPUS KESIHATAN, UNIVERSITI SAINS MALAYSIA

ABSTRAK

Kepekaan rasa individu menentukan kecenderungan rasa dari segi keupayaan individu dalam menjangkakan kemanisan sesuatu produk makanan. Faktor utama yang menyumbang ke arah peningkatan obesiti dilihat daripada peningkatan kecenderungan rasa manis. Oleh itu, kajian ini dijalankan bagi mengetahui kecenderungan sensori dan pengesanan ambang rasa manis dalam kalangan pelajar ijazah sarjana muda di Kampus Kesihatan, Universiti Sains Malaysia. Seramai 90 orang pelajar dari tiga kumpulan etnik (Melayu, Cina dan India), berumur di antara 19 tahun hingga 26 tahun telah dipilih menjadi ahli panel untuk kajian sensori makmal. Pengesanan ambang rasa manis dijalankan menggunakan kaedah *"Three Alternative Force Choice (3-AFC)"* dengan larutan sukrosa yang standard. Kecenderungan sensori dinilai menggunakan kaedah "*9 point hedonic scale*" dalam kemanisan minuman teh. Hasil dari kajian ini menunjukkan pelajar India mempunyai pengesanan ambang rasa manis yang paling tinggi (8.526mM) berbanding pelajar Melayu (6.462mM) dan pelajar Cina (4.405mM). Pengesanan ambang rasa manis berdasarkan perbezaan jantina menunjukkan pelajar perempuan mempunyai pengesanan ambang yang lebih rendah (5.521mM) berbanding pelajar lelaki (7.211mM) yang menunjukkan bahawa pelajar perempuan adalah lebih sensitif dalam mengesan kemanisan. Manakala bagi ranking kecenderungan sensori, pelajar India dan Melayu lebih menyukai tahap kemanis yang lebih tinggi (7.5% b/v) dalam minuman teh berbanding pelajar Cina (2.5% b/v). Kecenderungan sensori berdasarkan

perbezaan jantina menunjukkan pelajar lelaki dan perempuan menyukai tahap kemanisan yang sederhana (7.5% b/v) dalam minuman teh. Etnik dan jantina pelajar tidak menunjukkan hubungan yang signifikan dalam kecenderungan sensori dan pengesanan ambang rasa manis. Tiada hubungan yang signifikan diperhatikan dalam kajian ini antara pengesanan ambang dan kecenderungan sensori yang menunjukkan bahawa individu yang mempunyai pengesanan ambang yang lebih tinggi untuk rasa manis tidak semestinya menyukai tahap kemanisan yang lebih tinggi. Namun begitu, variasi genetik serta pendedahan awal dan pengalaman ke atas rasa manis mampu mengubah tahap sensitiviti individu dan seterusnya mengakibatkan peningkatan kecenderungan tahap gula yang lebih tinggi dalam makanan.

SENSORY PREFERENCE AND DETECTION THRESHOLD FOR SWEET TASTE AMONG UNDERGRADUATE STUDENTS OF HEALTH CAMPUS, UNIVERSITI SAINS MALAYSIA

ABSTRACT

Individual taste sensitivity determined the taste preference in terms of individual's ability to perceive how sweet the food product is expected to be. Major factors contribute to the rise of obesity seen from the increased preference for sugar. Thus, this study was carried out to determine the sensory preference and detection threshold for sweet taste among Malay, Chinese and Indian undergraduate students in Health Campus, Universiti Sains Malaysia. A number of 90 students from three ethnic groups (Malay, Chinese and Indian), aged from 19 to 26 years old were conveniently selected as panellists in this sensory laboratory study. Detection threshold for sweet taste was conducted using Three-Alternative Force Choice (3-AFC) method in standard sucrose solutions. Sensory preference test was ranked using 9 point hedonic scale for sweetness in tea beverage. The results indicated that Indian students had the highest detection threshold for sweet taste (8.526mM) compared to Malay (6.462mM) and Chinese students (4.405mM). Detection threshold for sweet taste based on gender differences showed female students had lower detection threshold (5.521mM) for sweetness, compared to male students (7.211mM) that show female were more sensitive in detecting sweetness. For sensory preference ranking, Indian and Malay students preferred higher level of sweetness (7.5% w/v) in tea beverage, compared to Chinese students (2.5% w/v). Sensory preference based on gender differences showed that male and female students preferred moderate level of sweetness (7.5% w/v) in tea beverage.

Ethnicity and gender among students did not show significantly difference in the sensory preference and detection threshold for sweet taste. No significant relationship observed in our study between detection threshold and sensory preference that showed individuals with higher detection threshold toward sweet taste do not necessarily imply on higher level of sugar preference. Nonetheless, it is proposed that genetic variation and early exposure and experience could alter individual sensitivity level and led to increased preference for higher level of sugar in foods.

CHAPTER 1

INTRODUCTION

1.1 Study background

Human taste sensations can be categorized into five basic qualities: sweet, bitter, salty, sour and umami. Sugar is one of the component in sensory quality of food evaluated by the gustatory sense or known as sense of taste (Vinicius Mariano de *et al.*, 2014). Sugar elicited the sweet taste and indicates the existence of carbohydrate of calories in foodstuff (Yoshida *et al.*, 2013).

Generally, sweet taste thresholds and sensory preference had been used to evaluate the accuracy of gustation. Besides, sugars induce the hedonically positive and strongly motivating sensory quality of sweetness (Beauchamp, 2016). The taste acuity is determined using detection threshold using aqueous sucrose solution. The detection threshold is defined as the lowest concentration of a substance in a medium relating to the lowest physical intensity at which a stimulus is detected as determined by the best-estimate criterion (ASTM E679-04, 2011). The threshold value varies between individual and strongly correlated with how sweet a product is expected to be.

Meanwhile sensory preference is defined as measurement of the acceptability or pleasantness of a given stimulus (Lim, 2011). The hedonic preference of sugar have been based on taste test conducted in sensory evaluation labs, that generally ask panelists to taste and rate the flavor, texture, color and acceptability of the food products (Drewnowski, 1997). In addition, individual preferences are based on likes and dislikes

that are results from integrated qualitative of negative and positive experience by the individual.

Individual taste sensitivity determined their taste preference in term of individual ability to perceive the taste (Lanfer *et al.*, 2013). Perception of taste intensity allows the taste buds to detect different concentrations of sweet tasting compounds (Vinicius Mariano de *et al.*, 2014). The mechanism behind this is due to taste buds detect taste molecule from the ingestion of food, follow by transmission of gustatory signals to peripheral nerves which taste sensation signals transmitted to the brain (Vinicius Mariano de *et al.*, 2014). Besides, specific taste recognition is developed during the process which allowing sugars to be distinguished from other compound in foods.

Food choices are induced by the sensory taste characteristic of foods. Distinctive food patterns could be resulted from different preference of taste and in turn resulted to diet-related health outcome. Survey conducted by Wardwell *et al.* (2009) with approximately 3000 adults concluded that the taste was the predominate determinant and guides the consumers' in their food choices.

In addition, individual's preferences for sweet taste are affected by not only particular sweet food product being consumed but also by the total consumption of sweet food products. Research shows that the more often an individual is exposed to sweet foods, the higher the preference for sweet taste (Beauchamp and Moran, 1982; Holt *et al.*, 2000; Pangborn, 1970). For instance, individual are said to have a 'sweet tooth' for those that have persistent desire to eat sweet products in which preferring to particular sweet taste qualities is reliant on concentration and context (Reed and

McDaniel, 2006). Moreover, if an individual cannot detect sweet taste, then the dietary sugar intake of that individual is likely increasing.

The food intakes of sweets could potentially associated with weight gain, however the relationship between sweet taste preference and obesity has not been periodically demonstrated (Asao *et al.*, 2012). Major factors contribute to the rise of obesity usually seen from the increased preference for sugar (Ahrens, 2015; Bray, 2013; Carolina Batista Campos Vo and Elisabeth Machado Pinto e, 2012). Strong evidence revealed that calorically sweetened foods and beverages confer to obesity as their high caloric load and thus the intake of sweet foods could not produce corresponding reduction in the intake of other foods (Bray, 2013).

Study of the taste threshold and preference produced valuable data in which preference towards sweet foods not only varies on individual but also differ between gender and ethnicity. In our best knowledge, there are few studies conducted to understand human preference toward sweet food in multicultural approach in Asian (Baharuddin and Sharifudin, 2015; Jaafar and Abdul, 1989; Sia *et al.*, 2013; Thai *et al.*, 2011; Uswatun, 2014; Wong, 1991). Thai *et al.* (2011) reported that Malays have lower detection threshold for sweet taste stimuli compare to other ethnicities.

Besides, Wong (1991) compared the taste acceptance and preference among three major ethnics in Malaysia and the finding of the study revealed that Malay people prefer sweeter products compared with Chinese and Indian. Study conducted by Sia *et al.* (2013) revealed that there were ethnic difference in term of rating of preference, in addition with intake frequency and cravings were seemed to be food-specific and culturally-related with each other. Therefore it is indicated that the effect of different

food cultures among ethnic groups on the sensory perception could derived on the sweet taste preferences and sensitivity.

1.2 Problem statement

Foods that taste sweet have long been associated with dietary energy whereby increased energy in particular with greater intake of sweet, energy-dense food is thought to be one of the major contributors to the rising in global issue of overweight and obesity (Bellisle and Drewnowski, 2007; Drewnowski, 1998; Swinburn *et al.*, 2011).

Most of evidences have shown that increased of energy intake is the main driving force behind the obesity epidemic (Belinda and Aileen, 2014). The growing trend of obesity in the Malaysian population is steadily becoming a public health challenge. Serious concerns arise as obesity is a core risk factor for the development of several diet related chronic disease (Khor, 2012). Malaysia was recorded as the highest obesity prevalence for adults aged ≥ 20 years among Southeast Asian countries in 2008 based on The 2013 World Health Statistics Report in which 10.4% are among male and 17.9% are among females (WHO, 2013).

In addition, study conducted by Rampal *et al.* (2007) among 16, 127 Malaysia reported that prevalence of obesity among Malaysian females adults are higher (13.8%) compare to males (9.6%) in which Malay contributed to highest prevalence (13.6%), followed by Indian (13.5%),Chinese (8.5%), and the indigenous group of Bumiputera Sabah had the lowest prevalence of obesity (7.3%).

Evidence showed that food patterns develop during early childhood and adolescence perceived into adulthood. Some studies reported an inverse association between BMI and sweet taste sensitivity whereas a large of evidence showed that there

is no significant association between BMI and sweet taste function (Low *et al.*, 2016). On the other hand, studies have proven that low sensitivity of sweet with high preference and diet intake of sweet food and beverage (high level of sugar) have found to be associated with obesity (Ebbeling *et al*., 2006; Duffy, 2007; Raben *et al.*, 2002; Schulze *et al.*, 2004; Welsh et al., 2005).

One of the major deleterious dietary pattern occurring in Malaysia is the continued escalation of the availability of sugar and sweeteners. According to data from FAO Food balance sheet (2010), Malaysians of different ethnicities are thought to have one of the 'sweetest teeth' in the Asia Pacific region with 40.7 kg/capita/year for the Food Supply Quantity for sugar and sweeteners in 2007 which are higher compared to India (19.8) and China (8.7) but still lower compared to New Zealand (56.1) and Australia (48.2) (Thai *et al.*, 2011). This data supported the consumption of high intake of sweet product consumed by Malaysian.

It was thought that individuals were characterized by a sweet tooth, i.e. a liking for high sweetness levels in foods. Besides, individuals with high detection threshold of sweet commonly will overconsume the sweet food which consequently causing proportional rise in obesity. Study conducted by Reed and McDaniel (2006) found that obesity can be seen as feedback mechanism in influencing sweet perception. Few studies have investigated the relationship between preference for sweetness with food intake and obesity, the preference seem related to obesity however not necessarily preference for sweetness (Bartoshuk *et al.*, 2006; Sia *et al.*, 2013; Vinicius Mariano de *et al.*, 2014).

Consequently, data from Malaysian Adults Nutrition Survey (2014) reported the mean sugar intake by adults aged 18 to 59 years old were 25.52 gm/day which

equivalent to 3.65 teaspoon of serving consumed per day. Further data show men consume higher sugar intake (28.28 gm/day) compared to women (22.21 gm/day) (Institute for Public Health, 2014). Ministry of Health Malaysia reported that high intake of sugar stand for a serious public health to Malaysia which is thought to contribute to the current high prevalence of diabetes at 14.9% for adults aged ≥ 30 years and prevalence for overweight and obesity at 43.1% (Thai *et al.*, 2011).

1.3 Research objectives

1.3.1 General objective:

To determine the sensory preference and detection threshold for sweetness among Malay, Chinese and Indian students

1.3.2 Specific objective:

1. To determine the detection threshold for sweet taste among Malay, Chinese and Indian students

2. To determine sweet taste preference in food matrices among Malay, Chinese and Indian students

3. To determine the gender difference on detection threshold and sensory preference for sweet taste

4. To determine the relationship between detection threshold and sensory preference for sweet taste among Malay, Chinese and Indian students

1.4 Research questions

1. What is the detection threshold for sweet taste among Malay, Chinese and Indian students?

2. What is the sweet taste preference in food matrices among Malay, Chinese and Indian students?

3. Is there gender difference on gender difference on detection threshold and sensory preference for sweet taste?

4. How does the detection threshold of sweet taste related with sensory preference for sweet taste among Malay, Chinese and Indian students?

1.5 Research hypothesis

1) Null hypothesis: There is no significant difference between detection threshold for sweet taste among Malay, Chinese and Indian students

   Alternative hypothesis: There is significant difference between detection threshold for sweet taste among Malay, Chinese and Indian students

2) Null hypothesis: There is no significant difference between sweet taste preference in food matrices among Malay, Chinese and Indian students

   Alternative hypothesis: There is significant difference between sweet taste preference in food matrices among Malay, Chinese and Indian students

3) Null hypothesis: There is no significant gender difference on detection threshold and sensory preference for sweet taste

Alternative hypothesis: There is significant gender difference on detection threshold and sensory preference for sweet taste

4) Null hypothesis: There is no significant relationship between detection threshold and preference for sweet taste among Malay, Chinese and Indian students

Alternative hypothesis: There is significant relationship between detection threshold and preference for sweet taste among Malay, Chinese and Indian students

1.6 Significance of study

To date, there is limited research done in Malaysia to investigate the relationship between detection of threshold and sensory preference of sweetness and how its influenced by biological determinants of gender and ethnicity among young adults especially university students. Therefore in this research, we will address the process involve in taste preference by determination of detection threshold and sensory preference to characterize and compare the sensitivity towards sucrose concentration of gender and main ethnic groups in Malaysia.

Identifying taste sensitivity and preference might represent a valuable contribution to provide insight on the complexity of dietary behavior through difference in food cultural and eating habits in ethnic groups among university student. Thus, preventive effort could be developed in shaping preference of sweetness which helps to promote healthy eating and tackle obesity.

Furthermore, studies on assessing preferred concentration of sweetness with strategies in reducing the amount of sugar should be addressed among the students without affecting their acceptability. It is known that the identification of sensory

response to sugar-rich food is important as this substance had been linked to elevated risk for diabetes, obesity and metabolic syndrome.

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. Thus, finding from this study could be used in answering the relationship of sweetness preference and liking of sweet food can be directly linked to the increase prevalence of obesity in Malaysia, since the parameter could be associated with obesity.

In addition, it is useful to know about sensory preference of individuals as food preferences are important component in food behaviour. Application of this knowledge can be applied in nutrition education and food preparation with the aim of better health and greater pleasure from the food.

1.7 Conceptual framework

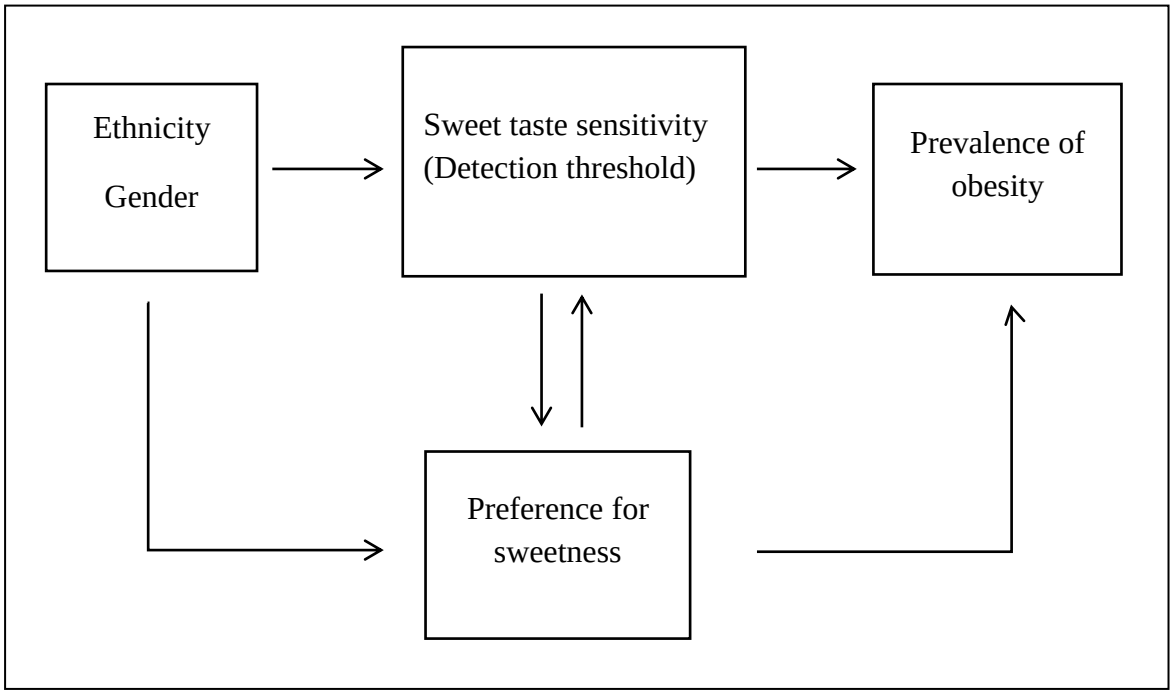

Figure 1.1: Conceptual framework

CHAPTER 2

REVIEW OF LITERATURE

2.1 Sweetness intensity in sugar

In human, sugars generate the distinctive taste quality of sweetness (McCaughey, 2008). The principal functional of sugar is their sweet taste. White refined sugar, sucrose had been used naturally occurring sweetener in the food industry and household (Clemens *et al.,* 2016). Table sugar, or pure (refined) sucrose, is a disaccharide composed of 1 molecule of glucose and 1 molecule of fructose. Sucrose, glucose and fructose are the most common sweeteners in nature. Glucose is always less sweet than sucrose, whereas the sweetness of fructose is highly dependent on temperature. Furthermore, fructose is sweeter than sucrose at low temperatures, whereas the sweetening effect decreases as the temperature rises (Clemens *et al.,* 2016).

Crystals of refined sugars (sucrose, glucose, and fructose) are white. Their solutions are colourless and transparent (Clemens *et al.,* 2016). Sucrose is the standard for the measurement of sweetness, with a relative sweetness score of 100. Sucrose is perceived to be sweetest at physiological temperatures, 32 to 38 °C, and exhibits a compression of sweetness as concentration increases (Godshall, 2007).

Glucose, also called dextrose, is a moderately sweet monosaccharide with reported relative sweetness values ranging from 50 to 70 at typical usage level concentrations. Glucose exhibits an expansion of sweetness with increasing concentration and reaches near-equivalent sweetness to sucrose at glucose concentrations around 50% (Portmann and Birch, 1995; Godshall, 2007).

Fructose is a white crystalline material in its pure form, although it is more frequently utilized as a component of high fructose corn syrup. Fructose is an attractive ingredient because of its potency as a sweetener (Colonna *et al.,* 2000). The relative sweetness of fructose is highly dependent on concentration and pH, with published relative sweetness scores ranging from 115 to 180 (Portmann and Birch 1995; Godshall, 2007; Colonna *et al.*, 2000).

The effect of concentration on sweetness intensity of a sugar is complex thus it is essential to account for the specific relationship between sweetness and concentration for each sugar when formulating to achieve a desired sweetness level. Sugars that show an increase in relative sweetness with increasing concentration are said to exhibit an expansion of sweetness, whereas sugars that show the opposite trend are said to exhibit compression of sweetness (Portmann and Birch 1995).

2.2 Sensory preference

Sensory techniques are used to assess the reactions of individual to a variety of stimuli which is useful to characterize taste perception in terms of supra-threshold responses to stimuli. At this level one have to distinguish between the intensity of the taste quality perceived and the affective value associated with that taste (Simmen *et al.*, 2004). These sensory methods permit one to assess their sensitivity, intensity, hedonic value and quality of taste sensation.

Perceptions of sweet taste differ in humans in which each individual have their own pattern of liking across concentrations. Study regarding sweetness preference and liking are complex due to variation across concentration. Example of this variation is sweet liking phenotype in ‘sweet likers’ person whereby their hedonic evaluation

showed constantly pattern of increase liking for sweet as concentration rose. Meanwhile some individual showed their pattern of liking increased to maximum and then decreased. Compare to 'sweet dislike' person, their pattern of liking increased to maximum and then decreased. (Bartoshuk *et al.*, 2006; Looy *et al.*, 1992; Looy and Weingarten, 1992).

In addition, individual varies in their ability to detect the sweet taste at low concentration and there are a few individuals who do not perceive a sweet taste from sucrose at all (Blakeslee and Salmon, 1935; Henkin, 1970; Kahn, 1951; Reed and McDaniel, 2006). Thus, it is important to considered aspect in which some individual will not able to perceive the stimuli compared with others in studies involve measuring of preference for sucrose at the low concentration.

Studies have showed that human are categorized into two groups based on the degree of preference to the sweet stimuli (Pangborn, 1970; Thompson *et al.*, 1976). Type I hedonic responder described as inverted U-shape who prefer increasing in concentration of sucrose up to medium concentration, then followed by a breakpoint in which preference decrease with increasing concentration. Type II responder will have increased preference as increases concentration and then plateaus at a certain concentration (Pangborn, 1970; Thai *et al.*, 2011; Thompson *et al.*, 1976).

2.2.1 Hedonic test

Commonly used method in measuring individual preference and liking for various product by using 9-point structure hedonic scale (Villegas-Ruiz *et al.*, 2008). The goal of hedonic test is to assess the appeal of a product to a consumer on a sensory

basis. For example, hedonic used in study to get panelist reaction on the basis of aroma, taste, and flavor of product (Lawless and Heymann, 2010a).

A 9-point hedonic scale was appropriate to use to distinguish the preference for various foods. A consumer will rate higher hedonic scale for product that they preferred most (Villegas-Ruiz *et al.*, 2008). In addition, Marchisano *et al.* (2003) stated that it is possible for consumer to rate equal hedonic scores to more than one products and still have a preference for one over the other.

Study conducted by (Drewnowski *et al.*, 1985) assessed the intensity of sweetened dairy products using 9-point hedonic scale in which the scale using intensity descriptors (such as extremely) of visual analogue scales (VAS). The intensity descriptors intended to guide the subjects in responds to their liking or disliking and also help the researcher in interpret the mean value of subject's response. This VAS scale was developed by Aitken *et al*., (1963) and can be used in measuring the intensity and preference for sweetness and other food-related stimuli (Bartoshuk *et al.*, 2006).

The reason for wide acceptance of 9-point hedonic scale is due to limited choice and categorical nature makes it easy for researchers and also study participants to use. The simplicity characteristic of 9-point hedonic scale is convenient to be used in wide range of population without required an extensive training (Lawless and Heymann, 2010b). Furthermore, the data handling is accessible for 9-point hedonic scale compare with other technique which require measuring line and the simple category in the scale are as sensitive as other scaling technique (Lim, 2011). Undoubtedly, Lim (2011) concluded that 9-point hedonic scale is simple and effective measuring device in measuring hedonic difference and acceptance among foods, beverages and consumer product.

Conversely, various limitation of 9-point hedonic scale is reported. The lack of zero point and inequality of scale intervals cause the scale not able to provide information about ratios of liking or disliking for stimuli. Thus, no meaningful comparisons of hedonic perception between individuals and groups are provided. However, this does not pose problem for measuring relative (ordinal) preferences among stimuli, which was its intended purpose (Lim, 2011; Lim *et al.*, 2009; Schutz and Cardello, 2001). Second, the 9-point hedonic scale offers little freedom for subject to express the full range of their hedonic experiences due to limited number of response categories. (Lim, 2011; Marchisano *et al.*, 2003; Villanueva and Da Silva, 2009; Villegas-Ruiz *et al.*, 2008).

2.3 Detection threshold

The methods for determination of taste threshold have been widely used in early studies of taste in human. The detection threshold is defined as the lowest concentration of a substance in a medium relating to the lowest physical intensity at which a stimulus is detected as determined by the best-estimate criterion (ASTM E679-04, 2011). Meanwhile the recognition threshold is defined as the lowest concentration in which a stimulus is recognize and specifically identified (ASTM E679-04, 2011; Uswatun, 2014). Generally, recognition threshold is higher than the detection threshold. Threshold difference is the change in concentration required to provide different in intensity that can be recognized (Uswatun *et al.*, 2014)

The detection and recognition threshold of certain food-related substances are crucial elements in sensory analysis. Concentration of a substance that produces a detectable sensation in subject may determine by using threshold measurement (Hoehl

et al., 2010). For example, relationship between stimulus and response could be used using threshold measurement procedure in order to support food product formulation. The detection threshold concentration serves as the measurement of stimulus strength and common taste outcome by important role of detection threshold which are 'objective assessments'(Barry *et al.*, 2003).

There is a difference in identification of basic tastes and its corresponding threshold that depend on the type of water in which substances are diluted. For example, Simmen *et al.* (2004) recommended the use of de-ionized water to prepare the solution under laboratory controlled situation. Besides, deionized and/or distilled water is demonstrated as it could ensure the constant composition (Lawless *et al.*, 2005; Mojet *et al.*, 2005).

Under field condition, the use of local drinking water as subjects are used to the peculiar taste of their own water sources is more realistic (Simmen *et al.*, 2004). However, some portion of minerals contained in drinking water may produce stronger taste at equal concentrations than others (Hoehl *et al.*, 2010). Study conducted by Hoehl *et al.* (2010) show sweet taste were identified better by subject than bitter, and metallic taste using tap water. Result from above study confirm that different of water qualities influence the taste sensitivity.

2.3.1 Alternative Forced Choice (AFC)

Alternative forced choice (AFC) test is defined by ASTM International as a method in which two, three or more stimuli are presented and assessors are given a criterion by which they are required to select one stimulus.(ASTM International, 2009). Example of AFC test includes 2-alternative forced choice (2-AFC) and 3-alternative

forced choice (3-AFC). Method 2-AFC is done by using a pair of samples consist of one sample contain stimulus meanwhile the other sample contain no stimulus (neutral). Otherwise, Method 3-AFC is done by using a set of consisting of one test sample and two blank samples (ASTM E679-04, 2011; Uswatun, 2014).

In the 2-AFC procedure, the panellist is asked to determine which samples contain stimulus. If the panellists answer correctly, the test is repeated on the concentration with the same stimulus. Panellist that answers correctly, the same concentration is presented again and the testing ceased after two correct answers in a row. However, if the panellist failed to answer correctly, the test is continue by using sample containing stimulus with higher concentration. The increase and decrease of concentration used is known as reversal. The reversal procedure is continued until two consecutive concentrations are answered correctly (Carolina Batista Campos Vo and Elisabeth Machado Pinto e, 2012; Uswatun, 2014).

In the 3-AFC procedure, the nature of the difference is specified. For instance, one product may be sweeter than the other two, thus the subject need to indicate the sweeter sample. During a 3-AFC test, the subject looking for the highest or lowest intensity on a sensory continuum (Dessirier and O'Mahony, 1998). During 3-AFC test, the blank and test samples are encoded so that there is no audible, visual, tactile or thermal difference between the samples other than code designators. The panellist starts at the lowest concentration step, which should be two or three concentration steps below the estimated threshold. Each sample within the set of three is compared with the other two. The panellist must indicate which of the three samples is different from the other two. Even if no difference is noted by panellist, a choice must be made in order to ensure all data can be utilized (ASTM E679-04, 2011; Uswatun, 2014).

Individual best-estimate values of threshold are derived from the pattern of correct/incorrect responses produced separately by each panellist. Group threshold are derived by geometrical averaging of the individual best-estimate threshold. The judgements test completed when the panellist either complete the evaluation of all sets of the scale or reaches a set wherein the test sample is correctly identified, then continues to choose correctly in higher concentration test sample sets (ASTM E679-04, 2011; Uswatun, 2014).

2.4 Relationship between detection threshold and sensory preference of sweetness

Taste sensitivity of sucrose is measured by the capacity to taste the stimulus and determine the quality meanwhile hedonics test are designed to determine how pleasant the stimulus and the desire to consume it. Commonly, these two types of measurement are utilized in single study to understand about element added to the sweet taste (Langwill, 1949; Lundgren *et al.*, 1978).

Most of studies had concentrated on the sweet intensity and hedonic rating of solutions or sweet foods. This is due to the reason that perceptual measures such as intensity and liking are more likely to drive liking and consumption in the individuals (Bartoshuk *et al.*, 2006).A study conducted by Uswatun (2014) reported that there is no correlation between sensory threshold with a preference in the food matrix.

Differences in the sensitivity of a person against a basic sense do not significantly difference to their preferences on the basis of taste in a food product. Mojet *et al.* (2005) reported that the higher the panelist's perceived intensity in the water, the lower the optimal preferred concentration in product. Consistent result is obtained from

study by Coldwell *et al.* (2009) that subjects who had high sucrose preference or low sugar preference did not differ in their ability to recognize sucrose at low concentration.

Similar results are shown in which there is no significant different obtained between coastal and interior subjects of Kadazandusun ethnic for sweet threshold. In addition, interior subjects reported to have lower taste threshold on sweet taste (Baharuddin and Sharifudin, 2015). However, study conducted by Uswatun (2014) show that ethnic groups have significantly affected sweet taste threshold between Nusa Tenggara and Minangese with in which Nusa Tenggara had the lowest detection threshold of sweet taste.

Moreover, Uswatun (2014) stated that there is possibility of relationship between the intensity of supra-threshold (above the detection threshold) with a preference of taste in food. Keast (2016) suggested that hedonics of sweet taste may influence intake of sweet foods, rather than the intensity or threshold of sweetness although much of the data is conflicting. Psychophysical studies conducted by Reed and McDaniel (2006) on sweet taste perception revealed that individual sensitivity in terms of recognition and detection of substance in solution as well as the intensity ratings given to a single concentration of sweet solution varies considerably. Although preference to sweet taste are universal trait as showed in studies of liking sweetness, however a large variations exist in the preferred intensity and in the type of foods or drinks that are consumed sweet (Drewnowski *et al.*, 2012). Drewnowski *et al.* (2012) explained that liking for sugar is reinforced by their nutritional effect due to sugar as source of dietary energy to the body.

2.5 Factors influence detection threshold and preference of sweet taste

2.5.1 Gender

The effect of gender on preferences to sweetness showed contradicting results. Several studies reported that men prefer higher sweet intensity compare to women. Study conducted by Katou and Ikawa (2002) shows male preferred more concentrated sucrose solution compared to females. Similar with finding that claimed American and Spanish Caucasians male preferred higher concentrations of sweet compared to women among university student (Parker *et al.*, 2003; Zellner *et al.*, 1999).

On the other hand, studies done by Katou *et al.* (2005) found females had more negative attitudes towards sugar than males did but they reported greater liking of sweet foods. Apart of that, females also reported to have positive cognition for sweetness and appreciated sweetness more than males did (Katou *et al.*, 2005). In addition, female assessed the intensity of highest sweet concentration higher than males (Michon *et al.*, 2009) and show there were a gender difference in detecting sucrose concentration.

Studies reported that gender are linked to taste preference, in which females proximately having food and taste preference which is linked to consume healthier food choices (Lanfer *et al.*, 2013). Research shown that the pleasantness of orange juices receive only low-level scoring when evaluated by women (Essed *et al.*, 2006; Luckow and Delahunty, 2004). Women are known to give lower liking scores for sweet than males of the same group and this trend may have influenced the low score seen in the research (Mahar and Duizer, 2007).

Contrarily, the current findings by Thai *et al.* (2011) revealed that Malaysian men and women did not differ in their sweetness detection threshold and preference to

sweet taste. Studies conducted by Beauchamp and Moran (1982) show that male and female infant do not differ in term of sweet preference, however men and older boys prefer higher concentrations of sweet compared with women. Chang *et al.* (2006) reported no difference between males and females in sucrose detection and may depend on age and/or characteristic of subjects. It is suggest that changes in detection threshold for sweet stimuli may tie into variation in sex hormone concentration in women, but with conflicting effects on sucrose preference (Dippel and Elias, 1980; Weizenbaum *et al.*, 1980).

2.5.2 Ethnicity

People from different cultures background differs in term of foods they eat such as ingredients, types of food eaten and the method of preparation. People connect to their ethnic group or cultural group through similar patterns. These food preferences of food likes and dislikes result in patterns of food choices within a cultural or regional group (*Food-Food and culture*, n.d).

In addition, culture is one of the factors influence our eating behaviour and this includes the frequency of consuming-sweetened foods, the acceptability and preference for sweetness. Different cultures are associated with different food and taste and such cultural entities are usually place based (Baharuddin and Sharifudin, 2015).

Norimah *et al*., (2008) stated that changing environment and increasing affluence have enlarged the behaviour of eating habits and options in consumption of sweet foods. Therefore, Coldwell *et al.* (2009) proposed that the sugar preferences are strongly influenced by habitual food intake that differs between cultures, and these cultural differences are less marked in some cities and regions than others.

Furthermore, the variation of ethnicity in threshold of sweetness and preference rating is supported by previous studies. Research done by Thai et al., (2011) conducted among three major Malaysian ethnicities by assessing their sweetness intensity perception and pleasantness ratings revealed that Malays had a lower perceived intensity of sweet stimuli compared to Chinese and Indian.

Study conducted by Abdullah (1995) revealed that Malaysian adults preferred significantly sweeter orange juice compare to Caucasians from England or Australia. These finding could be related to the high dietary sugar intakes of sweet desserts and beverages that commonly consumed in Malaysia. As supported by FAO (2010) that showed the estimated level of sugar intake in Malaysia are 96.25 g sugar/capita/day in which estimated percentage of sugar contribute of added sugar to energy intake is 13.3%

Besides, finding from Holt *et al.* (2000) show that Malaysian students which mainly Malays ethnic had significant higher sweetness perception but lower sweetness preference for high-sucrose orange juice samples, compared to their Caucasian counterparts (Holt *et al.*, 2000).

Cervellon and Dubé (2005) found that reasons for food likes and dislikes differed between Chinese and French citizens and motives for food choice varied significantly across countries in a study of consumers from four Asian countries and New Zealand (Cervellon and Dubé, 2005; Prescott *et al.*, 2002).

In addition, Schiffman *et al.* (2000) stated that ethnicity has a consistent effect with Americans of European descent (White or Caucasian) often having a lower sugar preference than Americans of African descent (Black). However, there is no race difference in the study due to the small sample size used in each ethnic group (Coldwell

et al., 2009). Study from Prescott *et al.* (1997) also found there is no differences of sweet tastes between Australian and Japanese subjects.

Previous studies also support the ethnic variability in the magnitude of sweetness detection threshold and preference. Finding show that African Americans preferred high concentration meanwhile Pima Indians preferred lower concentrations of sucrose compared to Caucasians (Salbe *et al.*, 2004; Schiffman *et al.*, 2000). Findings from study conducted by Ahrens (2015) among different European countries showed that sweet preference by country are with the smallest variation in which the lowest prevalence values in Germany and Cyprus.

2.5.3 Experience and exposure

Different factors can affect individual preference for sweetness. Two of these contributing factors are sweet taste familiarity or experience and exposure (Mahar and Duizer, 2007). Early experience or genetic may represent for sweet taste preference among ethnicity supported in studies.

Study conducted by Messer (1986) among American population in measuring the preferring of difference concentrations of sweetness in beverage by having individual look at their favoured beverage with other of known concentration. Result shows that the subjects that have been raised on sweet drinks that were 'less sweet' than the 'ordinary' range tended to dismiss higher sweetness level. Besides, Zellner *et al.* (1999) found that there were link of consistency between food liking and the degree of exposure in comparing the American and Spanish attitude toward food.

Early dietary habits influence sugar preference in studies among human infants (Beauchamp and Moran, 1982). Also, study conducted in Brazilian population among mother and children to measure sweet preference revealed significant correlation in preference of sweet taste among mother and children (Maciel *et al.*, 2001). These results show that repeated exposure and experience in perceived sweetness could alter individual sensitivity level.

Study conducted by Liem and de Graaf (2004) suggested that short period (8 days) of sweet orangeade exposure have increased children's preference for the product, meanwhile no effect were observed in young adults. However, after repeated exposure to sweet orangeade in adults, the finding shows that they decreased their consumption of this orangeade. Preference for sweet taste had been positively correlated with high consumption of sugar rich food, however study by Liem and de Graaf (2004) show that the consumption of orangeade was not related to the preference for orangeade.

Besides, 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; Mahar and Duizer, 2007). Several studies have shown that a high preference for sweet taste has a strong correlation with a high consumption of sugary foods. In addition, consumption of high energy-dense foods which commonly from sugary foods may lead to disruption to the body's energy balance, causing obesity (Vinicius Mariano de *et al.*, 2014).

CHAPTER 3

METHODOLOGY

3.1 Study design

Experimental study was adapted in this study and conducted from February to April 2017. Sensory test methods were determined by using detection threshold testing and sensory preference testing. Detection threshold testing was determined using three-alternative forced choice (3-AFC). Sensory preference testing was conducted using Hedonic test. This sensory study was conducted with small convenience sample in laboratory studies. Ethnicity and gender were two factors that are used to relate detection threshold testing and its influence toward the sensory preference of tea beverage.

3.2 Materials

The materials that were used during detection threshold testing were granulated sugars that were purchased from local supplier. The concentration of granulated sugar used was 0.91-29 mM diluted in tap water. Drinking water was used as neutralize sense of taste and the solvent of the sensory threshold testing. The water-based solutions were offered to the panellist using small cups (volume 20ml). For preference testing, tea and granulated sugars were used. An amount of 7.5g, 15g, 22.5g, 30g, 37.5g, and 45g of granulated sugar used for each 300 ml to prepare the tea beverage. The tools used for preparation of sample and testing were glass tools, analytical scales, measuring cups, spoons, trays, disposable cup 1 oz, label, and markers.