Highlights

Modified SLS classification methods were applied and four sweet liking clusters were identified

Differences in liking and emotional response to sweetness in ice tea beverage were reported across SLS

The ideal sweetness in ice tea is significantly higher for High Sweet Liker than that of Low Sweet Liker

An overall PTS effect was found but the effect is independent of sweetness level in ice tea

Sweet Liking Status and PROP Taster Status impact emotional response to sweetened beverage

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Abstract

Humans are innately predisposed to enjoy sweetness. However, excessive sugar consumption has been linked to a range of health issues. In order to develop an effective strategy to provide customised products and promote healthy eating, it is important to understand individual variation in sweetness preference. This study investigated how both Sweet Liking Status and PROP Taster Status impact on liking and emotional response to an ice tea product varying in sweetness intensity. One hundred and seventy five consumers were invited to rate liking and sweetness intensity of 5 sucrose solutions and emotional response, liking and sweetness intensity of ice tea samples varying in sweetness concentration (Low, Medium and High), and with sugar type (Sucrose and sweetener). Cluster analysis followed by validation test within each cluster group has identified 34% High Sweet Likers (HSL), 16% Medium Sweet Likers (MSL), 35% Low Sweet Likers (LSL) and 15% Unclassified group (UN). LSL had an overall heightened sweetness sensitivity than HSL for the sucrose solutions. For ice tea samples, no significant differences on liking and emotional response were observed between the two types of sugar, indicating consumers have a high acceptability when using sweetener as a sugar substitute in beverages. Overall, liking and positive emotions were rated more intensely for the Medium sweetened ice tea, whereas the opposite was found for the Low sweetened ice tea. A significant Sweet Liking Status*Concentration interaction was observed, where for High sweetened ice tea, LSL significantly disliked the sample and associated with lower positive and higher negative emotions, but an opposite trend was observed for HSL. For ideal sweetness, LSL indicated a significant lower ideal sweetness level in ice tea than HSL. Unlike Sweet Liking Status, an overall PROP Taster Status effect on both liking and emotional response was observed, but the effect was found to be independent of sweetness levels. A relative effect of Sweet Liking Status and PROP Taster Status on emotional response was also observed, where the effect of Sweet Liking Status was more pronounced in both pST and pNT group.

Key words: sweet liking status, PROP taster status, emotional response, liking, ideal sweetness

Abbreviations:

AHC: Agglomerative Hierarchical Clustering; HSL: High Sweet Likers; MSL: Medium Sweet Likers; LSL: Low Sweet Likers; UN: Unclassified Group; pST: PROP supertasters; pMT: PROP medium tasters; pNT: PROP non-tasters

1. Introduction:

Excessive consumption of sugar has been associated with increased risk of obesity, type 2 diabetes and cardiovascular disease (Lean & Te Morenga, 2016; Malik, Popkin, Bray, Després, & Hu, 2010; Rippe & Angelopoulos, 2016). Added sugar refers to all type of sugars that added to foods/beverages to sweeten, preserve, or give functional feature during preparing or processing (Sánchez-Pimienta, Batis, Lutter, & Rivera, 2016). In some countries such as Mexico, United States and Canada, added sugar food and beverages contribute to approximately 11% to 17% of total energy intake (Afeiche, Koyratty, Wang, Jacquier, & Le, 2018; Brisbois, Marsden, Anderson, & Sievenpiper, 2014; López-Olmedo et al., 2016; Powell, Smith-Taillie, & Popkin, 2016). World Health Organisation (WHO) urged global action to curtail consumption of sugary drinks to reduce obesity, type 2 diabetes and tooth decay (World-Health-Organization, 2016, 2017), resulting in the introduction of a sugar tax in a number of countries to help sugar reduction in the diet. In general, the approaches that have been taken to achieve sugar reduction mainly focus on the modification of food structure (Mosca, van de Velde, Bult, van Boekel, & Stieger, 2015), and multimodal sensory integration (Alcaire, Antúnez, Vidal, Giménez, & Ares, 2017). The most commonly used approach is using sugar substitutes to replace sugar, however this often adds bitter or metallic taste when presented at higher concentration (Calvino, Garrido, & Garcia, 2000). This is a big challenge for food manufactures, as consumers are willing to cut down their sugar consumption but they are not willing to sacrifice the sensory properties of food/beverage products. In order to more effectively shape strategies for sugar reduction, it is crucial to understand sweet preferences in foods and beverages.

It is in a human's innate nature to enjoy sweet foods. The reason draws from an evolutional perspective where sweet taste, commonly produced by sugar, signals the presence of carbohydrates, a main provider of energy (Chaudhari & Roper, 2010). In the modern world, when people do not face the risk of food crisis, individuals have started to show variations in their preferred sweetness levels in sweet foods and beverages.

Pangborn (1970) first reported that the preferred sweetness level differed across individuals. Researchers have classified individuals as sweet likers and sweet dislikers based on their hedonic responses to different levels of sweetness in sucrose solutions. As sweetness intensity increases, sweet likers typically show an increase in liking, whereas, sweet dislikers show a decline. This classification is referred as an individual's Sweet Liking Status (Garneau, Nuessle, Mendelsberg, Shepard, & Tucker, 2018; Kim, Prescott, & Kim, 2014, 2017; Methven, Xiao, Cai, & Prescott, 2016). Participants with an inverted U-shaped response curve, are either categorised as dislikers (Kim et al., 2014; Yeomans, Tepper, Rietzschel, & Prescott, 2007), as their own group (Pangborn, 1970) or removed from analysis (Kim et al., 2017; Looy, Callaghan, & Weingarten, 1992). Participants who had a neutral response regardless of sweetness levels were either categorised in their own group (Garneau et al., 2018) or removed from analysis (Looy et al., 1992). An early study reported that the classification of Sweet Liking Status is robust across different sugars, as similar patterns were observed among a range of sugar solutions such as sucrose, glucose, and fructose (Looy et al., 1992), however no study has explored artificial sweetener.

When moving from testing sucrose solutions to actual beverage products, a significant Sweet Liking Status impact was observed for many of the product categories. For example, sweet likers had a significantly higher preferred sweetness level for a strawberry beverage (Kim et al., 2014) and sweet dislikers rejected the sweetness level of orange juice at 380g/l, whereas sweet likers didn't reach a rejection threshold (Methven et al., 2016). Kim et al. (2014) also found that sweet likers self-reported to like chocolate flavoured milk, donut and coffee with artificial sweetener significantly higher than sweet dislikers.

Regarding the sweet perception, sweet likers have also been found to have an overall heightened sweetness intensity response to sucrose solutions than sweet dislikers (Looy et al., 1992; Methven et al., 2016), but other studies failed to replicate this finding (Garneau et al., 2018; Kim et al., 2014). Garneau et al. (2018) used a validated beverage food frequency questionnaire (Hedrick et al., 2012) and found that sweet dislikers consumed less sweetened juice and tea than sweet likers. In general, sweet likers self-reported to have greater energy intake from sugar-sweetened beverages compared to neutral and sweet dislikers (Garneau et al., 2018) providing evidence that Sweet Liking Status impacts food choice behaviour.

PROP Taster Status is another taste phenotype that has been studied widely since its discovery by Fox (1932). It relates to variation in individuals' ability to taste bitter compounds containing a thiourea (N-C=S) moiety, such as phenylthiocarbamide (PTC) and 6-n-propylthiouracil (PROP). Based on individual's ability to taste PTC/PROP, individuals can be

grouped as ‘supertasters’ (pST) if they are supersensitive to PTC/PROP, ‘medium-tasters’ (pMT) if they experience moderate sensitivity, and ‘nontasters’ (pNT) if they are insensitive. A number of studies have revealed that pST have a greater sensitivity to sweetness (Yeomans et al., 2007), which might affect their hedonic response to sweet tastes. Interestingly, a few studies have found that pST are more likely to be sweet dislikers, and pNT are more likely to be sweet likers (Looy & Weingarten, 1992; Yeomans et al., 2007) suggesting these two taste phenotypes might be associated.

Measuring emotion to understand and predict food choice is growing to be a popular method of data collection because it has been shown to provide additional product discrimination than hedonic response itself (Chaya et al., 2015; King, Meiselman, & Thomas Carr, 2013; Ng, Chaya, & Hort, 2013). Individual differences in emotional response to food products have been reported previously (Jaeger & Hedderley, 2013). Yang, Dorado, Chaya, and Hort (2018) suggested that emotional response measurement was a more sensitive approach to capture the differences across taste phenotypes than hedonic response itself.

In order to capture the emotional response to food and beverages, several self-reported emotion questionnaires were developed. The EsSense profile was one of the most popular used questionnaire, developed by King and Meiselman (2010) for a broad application to a wide variety of food and beverages. A truncated version, EsSense 25 was further developed by Nestrud, Meiselman, King, Lesher, and Cardello (2016) to provide a validated shorter version of the EsSense Profile. So far, only two published researches have investigated the impact of taste phenotype on emotional response elicited by food/beverage products. Kim et al. (2017) found that sweet likers expressed strong positive emotions to sweeter food/beverage products (chocolate biscuit), whereas sweet dislikers expressed strong positive emotions to low sweet products (wheat biscuits). Yang et al. (2018) reported a significant general PROP Taster Status effect on emotional response to beer that was independent of the sensory properties of beer products.

So far, different research groups have used different classification methods, which makes comparing results across studies difficult. Thus, there is an urgent need to develop a standardised Sweet Liking Status classification method. Previous studies have looked at correlations between Sweet Liking Status, PROP Taster Status, and liking/emotional response to a range of sweet foods/beverages, however, no emotional response to beverages that systematically varies in terms of sweetness and type of sugar was investigated. Thus, the first objective of this study was to develop a robust Sweet Liking Status classification methodology; and the second objective was to investigate the impact of

Sweet Liking Status and PROP Taster Status on liking and emotional response to an iced tea product varying in sweetness and sugar type using a scientifically controlled approach.

2. Material and Method:

2.1. Participants:

Healthy participants were recruited through the consumer database held at the Sensory Science Centre, University of Nottingham. Participants who have diabetes or have any medical conditions that is known to affect sensory perceptions were excluded from this study. In total, 175 participants, (age range 18-65 years; 133F, 42M) participated in this study. This study was approved by the University of Nottingham Bioscience Research Ethics Committee and all participants gave informed consent before taking part.

Participants were invited to take part in two sensory sessions lasting approximately 45 minutes each. Participants were instructed to refrain from eating and drinking any strong flavoured food one hour prior to the session.

2.2. Study 1: Taste Phenotype Screening

2.2.1. General Labelled Magnitude Scale (gLMS) training

In the first session, all participants were trained in the use of the gLMS scale. Participants completed a short gLMS scale training by writing down their own strongest sensation of any kind that they have experienced previously or the strongest sensation they could imagine experiencing, which represents the top of the scale. They were then asked to rate the intensities of 5 remembered sensations, relative to their own strongest sensations (Bartoshuk et al., 2002).

2.2.2. Sweet Liking Status Measurement

The sucrose solutions used for Sweet Liking Status classification in this study were 3%, 6%, 12%, 24% and 36% w/v sucrose solutions (Kim et al., 2014). Sucrose was dissolved in Evian water (Evian, Danone, France). Samples were prepared the day before testing, and placed on the roller bed for 15 minutes to ensure sucrose was fully dissolved.

Each participant was instructed to drink the sucrose samples provided (10ml) and rate how much they like the taste on a Labelled Magnitude Scale (LAM) (Schutz & Cardello, 2001) and the intensity of sweetness on a generalised labelled magnitude Scale (gLMS) (Bartoshuk et al., 2002). A water sample (0% sucrose) was always served first as dummy sample, followed by the 5 sucrose solutions. The presentation for the 5 sucrose solutions was randomised, without the weakest and strongest samples following each other. Two-

minute breaks were given and participants were asked to cleanse their palate with water (Evian, Danone, France) and crackers (Rakusen's crackers, Leeds, UK).

2.2.3. PROP Taster Status Measurement

A 0.32mM PROP solution was prepared by dissolving 6-n-propylthiouracil (PROP) (Sigma Aldrich, UK) in water on a low heat stirring plate. Each subject was instructed to roll a saturated cotton bud that previously dipped in the PROP solution (19 ± 2ºC) across the anterior tip of the tongue for approximately 3 second. Participants were then instructed to rate its taste intensity at its maximum using a gLMS scale. Participants were informed that the bitterness may take a few seconds to reach its maximum. After a 3 min break and using water to cleanse palate, the procedure was repeated to collect duplicate ratings. PROP taster status was defined based on mean PROP intensity ratings: pNT were defined as those rated below 'barely detectable (logged intensity of 0.15)', pMT were those rated above 'barely detectable' but below 'moderate (logged intensity of 1.23)', and pST were those rated above 'moderate' on the gLMS scale following Lim, Urban, and Green (2008).

2.3. Study 2: Emotional response to ice tea samples

2.3.1. Ice tea Sample

The ice tea base was prepared by adding 2g PG tips® instant ice tea granules (Unilever, Colworth, UK) and 20ml fresh lemon juice (Tesco, UK) in 1L boiled water (Evian, France). Two types of ice tea were prepared: 1) with natural sugar addition – sucrose (Sainsbury's, London, UK); 2) Artificial sweetener addition - Canderel sweetener including Aspartame & Acesulfame-K (Merisant, High Wycombe, UK). The concentrations were determined based on a preliminary test to provide similar sweetness intensity between sucrose and sweetener for each concentrations (Low, Medium and High). The three levels of sucrose that were added into the ice tea base were Low (30g/L), Medium (80g/L) and High (130g/L). The three levels of sweetener that added into the ice tea base were Low (5g/L), Medium (10g/L) and High (15g/L).

2.3.2. Emotional response measurement

EsSense25 Profile (Nestrud et al., 2016) was used to collect emotional response data to each ice tea samples. It consists of 16 positive (*active, adventurous, calm, enthusiastic, free, good, good-natured, happy, interested, joyful, loving, nostalgic, pleasant, satisfied, secure* and *warm*), 3 negative (*bored, disgusted* and *worried*), and 6 unclassified emotional terms (*aggressive, guilty, mild, tame, understanding* and *wild*) (Ng et al., 2013). For each emotional term, a line scale, anchored from 'not at all' to 'extremely' was used. The presentation order

of the emotion terms was randomised across participants, but the same order was kept for each consumer (King & Meiselman, 2010).

2.3.3. Test Procedure

In the second session, participants were given a dummy sample (80g/L sucrose in ice tea) to provide a mid-range sample at the beginning of the session. The remaining 6 ice tea samples were randomised across participants. All ice tea samples (30ml) were served at cold temperature (10±3°) in a 100ml plastic cup and labelled with random three digit codes. For each sample, participants were asked to rate how intensely they felt each of the emotion items for each of the ice tea using the *EsSense25 Profile*, followed by overall liking on LAM scale and sweetness intensity on gLMS scale. At the end of the second session, participants were given an additional gLMS scale to rate their ideal sweetness for the ice tea product.

Two-minute breaks were given and participants were asked to cleanse their palate with water (Evian, Danone, France) and crackers (Rakusen's crackers, Leeds, UK). All data were collected using Compusense Cloud (Compusense, Canada)

2.4. Data Analysis

For Sweet Liking Status classification, Agglomerative hierarchical clustering (AHC) using Ward's method, and dissimilarity was performed on liking data of the 5 sucrose solutions, followed by correlation test (Pearson correlation coefficient) between each individual's results and cluster means to check the validity of the cluster groups.

Dummy sample data were removed before performing any further data analysis. Chi-square was conducted to investigate associations between Sweet Liking Status, PROP Taster Status, gender and ethnic groups.

To examine the impact of Sweet Liking Status and PROP Taster Status on liking, sweetness intensity and emotional response data, a three-way Analysis of Variance (ANOVA) (concentration, Sweet Liking Status and PROP Taster Status) was conducted on liking and sweetness intensity ratings of sucrose solutions. A four-way ANOVA (concentration, sugar type, Sweet Liking Status and PROP Taster Status) was conducted on liking, intensity rating and emotional response of ice tea samples. Two-way interactions were included in the ANOVAs to determine if interactions occurred across the factors above. Where significant effects were observed, further Tukey Honest Significant Difference (HSD) multiple comparison tests were applied to identify the differences. All statistical analyses were performed using XLSTAT version 2018.01 (Addinsoft, Paris, France) at α-risk of 0.05.

3. Results:

3.1. Study 1: Taste Phenotype Screening Results

3.1.1. Overall Liking and sweetness intensity of sucrose solutions

Considering the pooled data, a significant concentration effect was observed for both liking and sweetness intensity ratings. As illustrated in Figure 1A, 12% sucrose solution was significantly more liked than 0%, 3%, 24% and 36% sucrose solutions ($p<0.01$), but not significantly different to 6% sucrose solution ($p=0.1$). However, the overall liking for 6% sucrose solution was rated significantly higher than 0%, 3% and 36% sucrose solutions ($p<0.05$). No significant difference between 6% and 24% sucrose solutions was observed ($p=0.9$). The liking score for 24% sucrose solution was rated significantly higher than 0% and 36% sucrose solutions ($p<0.05$), but not significantly different to 3% sucrose solution ($p=0.3$). In addition, liking score for 3% sucrose solution was also rated significantly higher than 36% sucrose solution, but not significantly different to 0% sucrose solution. As expected, sweetness intensity significantly differed among concentrations ($p=0.0001$). The higher concentration was rated significantly sweeter than the previous concentration ($p<0.0001$), but the two highest concentrations were not significantly different from each other ($p=0.18$) (Figure 1B).

3.1.2. Sweet Liking Status Classification

Followed by both cluster analysis (AHC) and correlation test, three cluster groups were initially identified, resulting 96 participants in Cluster 1 (correlation coefficient between each participant and Cluster 1 mean score ranged from -0.48 to 0.98), 57 participants were classified as Cluster 2 (correlation coefficient between each participant and Cluster 2 mean score ranged from -0.52 to 0.99) and 22 participants were classified as Cluster 3 (correlation coefficient between each participant and Cluster 3 mean score ranged from -0.76 to 0.98). Reclassification was implemented for those correlation coefficients that were below 0.6, and participants were regrouped into other groups if the correlation coefficient was greater than 0.6 to the other groups. After reclassification, correlation test was performed, this procedure was repeated until the correlation coefficient within each cluster group was greater than 0.6. Participants, whose correlation coefficient were lower than 0.6 in any of the three clusters were classified as a fourth group, named as Unclassified.

As shown in Table 1, 59 participants (34%) were classified as Cluster 1, named as High Sweet Likers (HSL) with correlation coefficient between 0.62 to 0.90; 29 participants (16%) were classified as Cluster 2, named as Medium Sweet Likers (MSL) with correlation coefficient between 0.60 to 0.98; 61 participants (35%) were classified as Cluster 3, named as Low Sweet Likers (LSL) with correlation coefficient between 0.61 to 0.99; and 26

participants (15%) were unclassified (UN) as their the correlation coefficient was below 0.6 in any of the three cluster groups. Chi-square test demonstrated that there is no significant association between Sweet Liking Status and gender and PROP taster Status ($p>0.05$).

3.1.3. Impact of Sweet Liking Status on overall liking and sweetness intensity of sucrose solutions

A main effect of Sweet Liking Status was observed for both liking and intensity rating, where HSL rated liking scores significantly higher than the other three groups ($p<0.0001$), and the liking scores for MSL and UN were significantly higher than that of LSL group ($p<0.0001$), but no significant difference was observed between MSL and UN ($p=0.25$), as shown in Figure 2a. For sweetness intensity rating, in general, LSL rated significantly higher than the other three groups ($p<0.05$), but no significant difference was observed between HSL, MSL and UN groups ($p>0.05$) (Figure 2b).

As expected, a significant Sweet Liking Status and sucrose concentration interaction was found for liking data ($p=0.0001$), and sweetness intensity rating approached significance ($p=0.06$). As shown in Figure 3, HSL preferred medium to high sweet solutions (12% to 36%) over the low sweet solutions (0–6%); MSL preferred the medium sweet solution (12%) over both the low sweet solutions (0-6%) and high sweet solution (36%); LSL preferred the low sweet solutions (0-6%) over the two higher sweet solutions (24-36%) ($p<0.05$). For sweetness ratings for 3% sucrose solution, LSL (mean intensity of 0.96) rated significantly higher than HSL (mean intensity of 0.78) ($p=0.008$). For 6% sucrose solution, LSL (mean intensity of 1.28) rated the sweetness significantly higher than HSL (mean intensity of 1.11) ($p=0.032$), but no significant difference was observed for other concentrations among different Sweet Liking Status phenotypes ($p<0.05$).

3.1.4. Impact of PROP Taster Status on overall liking and sweetness intensity of sucrose solution

A significant PROP Taster Status effect was observed for both liking ($p=0.04$) and sweetness intensity rating ($p=0.0001$), but no significant PROP Taster Status*Sucrose concentration interaction was observed ($p>0.05$). As illustrated in Figure 4, in general, pMT liked the sucrose solutions significantly higher than pST ($p=0.004$). For intensity ratings, pST rated the sweetness intensity significantly higher than pMT and pNT ($p<0.0001$).

3.2. Study 2: Overall Liking, Sweetness Intensity and Emotional Response to ice tea samples

3.2.1. Effect of sweetness level and sugar type

As expected, a significant concentration effect was observed on sweetness intensity ($p<0.0001$), where the higher concentration was rated significantly sweeter than the previous one. No significant difference was observed between sucrose and sweetener samples considering the pooled data ($p=0.7$). Although a significant Concentration*Sugar type interaction was found ($p=0.002$) for sweetness intensity, when looking at the interaction plot, no significant difference was observed between sucrose and sweetener at each concentration level ($p>0.05$), as illustrated in Figure 5. In addition, no significant difference between the two sugar type on overall liking was found ($p=0.96$). Since the two sugar types shared the same level of sweetness at each concentration level and did not impact on overall liking, the high, medium and low sweetened ice tea refer to data combining both sugar types (sucrose and sweetener).

A significant overall difference was found among the three concentrations ($p<0.0001$), where the Medium sweetened ice tea was most liked than the other two concentrations, and the High sweetened ice tea was significantly more liked than Low sweetened ice tea ($p<0.001$) (Figure 6).

For emotional response, no significant difference was observed between the two sugar types for all emotional terms ($p>0.05$). A significant concentration effect was observed for 23 out of 25 emotion items ($p<0.05$) (*tame* and *worried were not significant*). As illustrated in Figure 7, Low sweetened ice tea evoked significantly less positive emotions, and more negative emotions than both High and Medium sweetened ice tea ($p<0.05$). No significant differences between High sweetened ice tea and Medium sweetened samples were observed for most of the emotions ($p>0.05$), apart from High sweetened ice tea evoked significantly higher ratings for *disgusted*, *guilty* and significantly lower ratings for *mild* than Medium sweetened samples ($p<0.05$).

3.2.2. Effect of Sweet Liking Status on overall liking and emotional response to ice tea

A significant Sweet Liking Status effect was observed for liking scores ($p=0.0001$), where HSL rated overall liking higher than LSL for ice tea samples ($p=0.0001$), but the ratings for both HSL and LSL were not significantly different with MSL and UN ($p>0.05$). A significant Sweet Liking Status*Concentration interaction was observed ($p<0.0001$), where HSL, MSL and UN groups rated the Medium and High sweetened samples higher than the Low sweetened sample ($p<0.001$), and no significant difference was observed between Medium and High sweetened samples ($p>0.05$). However, LSL group rated the Medium sweetened sample significantly higher than Low and High sweetened samples ($p<0.0001$) and no significant difference was observed between Low and High sweetened samples ($p>0.05$), as shown in Figure 8.

For emotional response, a significant Sweet Liking Status effect was found for 23 emotional terms ($p<0.05$), with an additional emotional term (*interested*) approached significance ($p=0.058$), as shown in Table 2. Interestingly, it's the MSL group that rated most of the emotional response significantly higher than LSL regardless of positive, negative or unclassified emotions ($p<0.05$) (Figure 9). A significant Sweet Liking Status*Concentration interaction was observed for 8 positive and 1 negative emotions ($p<0.05$) (Table 2). Both HSL and MSL rated positive emotions including *adventurous, enthusiastic, good, happy, interested, joyful, pleased, satisfied, warm* significantly higher, and negative emotion (*disgusted)* significantly lower for the Medium and High sweetened ice tea than that of Low sweetened sample ($p\leq0.05$). Whereas, for LSL group, Medium sweetened ice tea evoked higher positive emotions including *good, happy, interested, joyful, pleasant* and *satisfied* than Low sweetened ice tea, and no significant difference was observed between High sweetened samples with Low sweetened samples. For UN group, in general, no significant difference was observed for most emotions, apart from Medium sweetened ice tea evoked significantly more *interested* and *satisfied*, but less *disgusted* emotions than Low sweetened samples ($p<0.05$). A selection of Sweet Liking Status*Concentration interaction plots are presented in Figure 10.

Interestingly, a significant difference was observed for ideal sweetness rating ($p=0.0001$), where HSL rated their ideal sweetness for the ice tea sample significantly higher than LSL, as shown in Figure 11.

3.2.3. Effect of PROP Taster Status

A significant PROP Taster Status effect was observed for liking ($p=0.008$), where pNT (mean liking = 54.1) rated liking scores significantly higher than pST (mean liking = 49.1), and pMT (mean liking = 52.5) did not differ significantly with either pST or pNT. No significant interaction between PROP Taster Status and sugar type/concentration on liking was observed ($p>0.05$).

For emotional response, significant PROP Taster Status effect was observed for 20 emotion terms including *active, enthusiastic, good, good-natured, happy, satisfied, worried, bored, disgusted, worried, aggressive* and *guilty* emotions (Table 2). As shown in Figure 12, pNT rated *active* significantly higher than pST and pMT ($p<0.05$). In addition, pNT also rated *warm* significantly more intense than pST ($p<0.05$). pST rated negative emotions such as *bored, disgusted, worried, aggressive* significantly more intense than both pMT and pNT ($p<0.05$). In addition, pMT also rated *disgusted* and *worried* significantly higher than pNT. For *guilty* emotion, both pST and pMT felt significantly *guiltier* than pNT when drinking the

ice tea samples. Although ANOVA revealed a significant PROP Taster Status group difference for *enthusiastic, good, good-natured, happy,* and *satisfied* emotions ($p<0.05$), the Tukey's post-hoc tests failed to find a significant difference.

3.3. Additional analysis on PROP Taster Status* Sweet Liking Status interactions

Due to the small sample size in PROP Taster Status groups within Unclassified (n=26) and MSL groups (n=29), only results from HSL and LSL were included to investigate Sweet Liking Status*PROP Taster Status association, and interactions for both sucrose solutions and ice tea sample. Chi-square showed that the association between PROP taster status and Sweet Liking Status was approaching significance ($p=0.06$), where pNT were more likely to be LSL, and pMT and pST were more likely to be HSL. A significant Sweet Liking Status*PROP Taster Status interaction was observed for overall liking data for sucrose solutions ($p=0.002$), where pST rated the sucrose solution significantly lower than pMT and pNT within LSL group, and no significant difference was found among PROP Taster Status groups within HSL group ($p<0.05$). No significant Sweet Liking Status*PROP Taster Status interaction was found for perceived sweetness intensity for sucrose solution ($p>0.05$).

For ice tea sample, no significant Sweet Liking Status*PROP Taster Status interaction was observed for overall liking and perceived sweetness intensity ($p<0.05$). However, a significant Sweet Liking Status*PROP Taster Status interaction was observed for 15 out of 25 emotions ($p\leq0.05$). In general, no significant difference was observed between HSL and LSL within pMT group for all emotions. Within pST group, HSL rated the emotions of *good, happy, pleasant, satisfied* and *tame* significantly higher than LSL ($p\leq0.05$), and within pNT, HSL rated the emotions of *loving, enthusiastic, free*, *active*, *worried* and *wild* significantly higher than LSL ($p\leq0.05$). A selection of interaction plots were presented in Figure 13.

4. Discussion:

4.1. Sweet Liking Status classification

The methods used for classifying Sweet Liking Status varied in different studies, thus it's not surprising that the proportion of sweet likers and sweet dislikers reported across studies varies significantly (the range of proportion of sweet likers are between 12% to 78%) (Enns, Van Itallie, & Grinker, 1979; Garneau et al., 2018; Holt, Cobiac, Beaumont-Smith, Easton, & Best, 2000; Kim et al., 2014; Pangborn, 1970). As Iatridi, Hayes, and Yeomans (2019) summarised in their review paper, in general, four types of Sweet Liking Status classification methods have been used in the literature. The first approach is to use visual pattern of hedonic response curve to classify individuals as Sweet Likers if they progressively increase their liking as sugar concentration increases, and Sweet Dislikers if the shape of the liking

curve is a continual decline or a rise and decline (Holt, Cobiac, Beaumont-Smith, Easton, & Best, 2000; Yeomans et al., 2007). The second approach is 'average rating above mid-point', where classification is based on a specific cut-off score. However, Methven et al. (2016) have found the mid-point classification method could lead to a higher proportion of misclassification. The third approach is using paired preference approach, where an optimal/rejection point can be identified during multiple paired preference (Asao et al., 2015; Mennella, Finkbeiner, Lipchock, Hwang, & Reed, 2014). There is also a fourth approach that used 'highest preference using ratings', which were most often used in medical research to understand the link between sweet liking and alcoholic, depress and certain disorders (Garbutt, Kampov-Polevoy, Kalka-Juhl, & Gallop, 2016; Goodman et al., 2018; Swiecicki et al., 2015). Some studies have adopted the first approach by using a statistical analysis technique - AHC for clustering Sweet Liking Status (Garneau et al., 2018; Kim et al., 2014, 2017; Methven et al., 2016). However, different cluster groups have been identified in different studies. For example, Kim et al. (2014) have identified three clusters, Cluster 1 showed a progressively increasing liking pattern (50% of total participants); Cluster 2 preferred the three higher concentrations (31%); and Cluster 3 has an optimal sweetness concentration in the middle, and their liking scores declined at higher concentrations (19%). Methven et al. (2016) used the same approach, identifying two cluster groups: Sweet Likers (34%) and Sweet Dislikers (66%). Kim et al. (2017) identified 5 clusters further grouping two of the five clusters together as Sweet Dislikers (32%) as both clusters preferred the low sweet sucrose solutions, and grouped another two clusters as Sweet Likers (33%) as they had a preference over the high sweet samples. They excluded one cluster as they did not follow the liking curve for either Sweet Likers or Sweet Dislikers.

So far, no standardised classification methodology has been developed, this has increased challenges when comparing results across studies. This study is the first that has adopted cluster analysis combined with correlation test to check the validity within each cluster group to achieve better consistency and reliability of Sweet Liking Status classification. By using this method, this study revealed four cluster groups who have shown to have distinct liking curves. Humans have innate preference for sweet foods, the name of Sweet Disliker may not be appropriate, thus this study has named these clusters as High Sweet Likers (HSL), who prefer very sweet solution, Medium Sweet Likers (MSL), who prefer medium sweet solution, but disliked the high sweet solution, Low Sweet Likers (LSL), who prefer low sweet solutions. In this study, a group of participants were also classified as Unclassified (UN), whose liking scores are inconsistent across the five sucrose concentrations or have no preference over different sweetness levels. In the current study, 34% of the participants were classified as HSL, 16% of the participants were classified as MSL, and 35% of the

participants were classified as LSL, this left 15% of the tested population as Unclassified. The proportion of HSL and LSL reported in the current study is similar to the proportion reported as Sweet Likers and Sweet Dislikers in the study of Kim et al. (2017). The unclassified group in this study include individuals who either do not have a preference over different levels of sweetness or show an inconsistent trend in their liking scores. The reason behind the trend observed for unclassified group is currently unclear, more studies are needed to look into repeatability of individual's liking pattern and understand their food eating behaviours to gain further insight behind the unclassified group.

4.2. The effect of Sweet Liking Status

LSL were found to have an overall higher sweetness sensitivity to sucrose solutions, however, such finding did not maintain for ice tea samples. Conflicting results were obtained from previous studies, some evidence showed that Sweet Dislikers is associated with heightened sweetness intensity ratings (Drewnowski, Henderson, & Shore, 1997; Looy & Weingarten, 1992; Methven et al., 2016; Peterson, Bartoshuk, & Duffy, 1999), but another study has failed to replicate this finding (Kim et al., 2014), which may be caused by different classification methods used. In the current study, LSL only rated 3% and 6% sucrose solutions as significantly higher than HSL, indicating the impact of Sweet Liking Status on sweetness perception is dependent on sweetness intensity (Drewnowski, Henderson, & Shore, 1997).

The HSL group showed increased liking patterns with increasing sucrose concentrations, and the pattern remained in the ice tea samples, but the liking of the High and Medium sweetened ice-tea samples were not significantly different. HSL most preferred the sucrose concentrations between 12% to 36%, and it could be that the HSL group's optimal sweetness was not reached in the concentration range (3% to 13% sucrose) used in the ice tea samples. Humans innately prefer sweet taste, and if the sweetness level in foods/beverages are below their expectations, it is likely that everyone will dislike the samples regardless of their Sweet Liking Status, this could be an innate rejection to low sugar level. The results in the present study shows that the Low sweetened ice tea (3% sucrose and 0.5% sweetener) were significantly disliked compared to Medium and High sweetened ice tea for all Sweet Liking Status groups suggesting that the low sweetness level is too low for all participants. Thus, if participants were forced to make a choice between two products that they don't like (e.g. Low and High concentration ice tea for LSL), a rejection threshold may be difficult to reach. As shown in Methven et al. (2016)'s research that the rejection threshold for sweet disliker was 380gl sucrose in Orange Juice and no rejection threshold was reached for sweet likers. .

The emotional responses aligned with liking data where higher ratings for positive emotions were found for higher liked samples. However, LSL showed a slightly different preference and emotion profile, compared to the other three Sweet Liking Status groups. LSL gave lower liking scores and lower ratings for positive emotions and higher ratings for negative emotions for the High sweetened ice tea sample, whereas the other three groups gave higher liking scores and rated positive emotions more intense to the same sample. Currently, there is only one published study investigating the impact of Sweet Liking Status on emotional response, and similar findings were reported as found here (Kim et al., 2017). Kim et al. (2017) found that sweeter food products (such as chocolate biscuit) evoked significantly higher positive emotions than less sweet food products (such as wheat biscuit) for sweet likers, whereas an opposite trend was observed for sweet dislikers. However, this trend was not observed for beverages, as Mango Juice (a highly sweet beverage) was highly liked and associated with higher positive emotional response than lower sugar beverages (such as Orange Juice) for both sweet likers and sweet dislikers (Kim et al., 2017). This could be due to the fact that the Orange Juice contained only 4.4g sugar in 100ml Orange juice compared to 14.8g sugar in 100ml Mango juice and the perceived sweetness for Orange Juice might be lower than consumers' expectation resulting in innate rejection.

This is the first study that has classified individuals into four Sweet Liking Status groups based on their response to sucrose solutions including MSL and UN groups. Although liking scores were not significantly different between MSL and UN for iced tea samples, MSL rated all emotional response significantly higher than UN, as well as HSL and LSL. The reason behind MSL's heightened emotional response regardless of emotional categories were currently unclear, and warrants further investigation.

4.3. The effect of PROP Taster Status

As expected, pST was associated with a higher sweetness sensitivity to sucrose solutions, which agrees with previous findings (Bajec & Pickering, 2008; Drewnowski, Henderson, & Shore, 1997; Yang, Hollowood, & Hort, 2014), but some studies have failed to find an effect of PROP Taster Status on sweetness perception (Drewnowski, Henderson, Shore, & BarrattFornell, 1997). Interestingly, no significant effect of PROP Taster Status on sweetness was found when testing in a more complex food matrix – ice tea, indicating pST's heightened sweetness perception is dependent on food matrix. In the current study, pST gave lowest liking scores to both sucrose solutions and ice tea samples among PROP Taster Status groups, which suggest pST's heightened sweetness sensitivity may partially contribute to overall liking.

An effect of PROP Taster Status on emotional response elicited by ice tea regardless of sweetness levels was found. The effect was pronounced for negative emotions, where pST rated negative emotions such as *bored, disgusted, worried, aggressive* and *guilty* significantly higher than pMT and pNT. The finding aligns with previous data reported by Macht and Mueller (2007) who found that pST's were associated with negative emotions after an anger-inducing film clip viewing. A recent published paper investigated the effect of PROP Taster Status on emotional response for beer products and found an overall PROP Taster Status effect regardless of the product conditions (carbonation level, temperature, bitterness). However, unlike the findings in the current study, the effect of PROP Taster Status appears more on the positive emotions (Yang et al., 2018). More research is needed to understand the variation among PROP Taster Status grounds in terms of their emotional profile, however, the data here suggest that pST are more likely to express their emotions during food consumption or film viewing.

4.4. Explorative information regarding relationship between Sweet Liking Status and PROP Taster Status

Due to small sample size in both MSL and UN groups, MSL and UN groups were excluded when investigating relationships between Sweet Liking Status and PROP Taster Status. Although MSL and UN groups were removed, the sample size is still small to fully interpret the results. This data is only presented as explorative data and caution needs to be taken when interpreting the results.

Although previous studies have shown that pST were more likely to be Sweet Dislikers, and pNT were more likely to be Sweet Likers (Looy & Weingarten, 1992; Yeomans et al., 2007), this study failed to find an association between Sweet Liking Status and PROP Taster Status phenotypes. An additional Chi-square test was conducted after excluding MSL and UG group to investigate the association between Sweet Liking Status and PROP Taster Status phenotypes. Although the association approached significance ($p=0.06$), an opposite trend was found that pNT were more likely to be LSL, which disagree with previous findings (Looy & Weingarten, 1992; Yeomans et al., 2007). In addition, no significant association between Sweet Liking Status and gender was observed. This could be due to the fact that gender was not balanced in this study. Previous studies have demonstrated gender impact on sweet liking and craving for sweet products, however the effect is dependent on nationality or age (Deglaire et al., 2015; Roininen et al., 2001; Tuorila, Keskitalo-Vuokko, Perola, Spector, & Kaprio, 2017). One of the limitations of the current study is that the link between Sweet Liking Status and craving for sweet products and their food eating behaviour was not

548 investigated, further study that balancing gender would be needed to understand the
549 relationship between gender, Sweet Liking Status and food eating behaviour.

550 A significant Sweet Liking Status*PROP Taster Status interaction on emotional response for
551 ice tea sample was found in this study, but not for overall liking, which has once again
552 demonstrated emotional response can be more discriminating than traditional hedonic
553 response (King et al., 2013; Ng et al., 2013; Spinelli, Masi, Zoboli, Prescott, & Monteleone,
554 2015;), and may be a more sensitive approach to captue differences across taste phenotype
555 (Yang et al., 2018).

556 4.5. Overall trend observed for ice tea sample

557 The findings in the present study have revealed individual variation in preferred sweetness
558 level in an ice tea product suggesting a variety of sweetness levels might be needed to meet
559 different consumer groups' satisfaction. The ideal sweetness rating in this study has further
560 proved this, where HSL rated the ideal sweetness for the ice tea sample was around 1.4 on
561 the gLMS scale, which is similar to the high sweetened ice tea (mean intensity of 1.49);
562 whereas LSL specified their ideal sweetness was 1.18 on the scale, which is close to the
563 perceived intensity of Medium sweetened sample (mean intensity of 1.23). Although HSL
564 gave the High sweetened ice tea the highest liking score and the ideal sweetness is also
565 close to the High sweetened ice tea, the liking for Medium sweetened ice tea was not
566 significantly different from the High sweetened ice tea sample. This indicates that the
567 Medium sweetened ice tea seems to be the optimal sweetness level for everyone. However,
568 it could be due to the fact that the Medium sweetened iced tea (80g/L sucrose) is similar to
569 the sucrose level found in commercial products (e.g. 69g/L sugar in Lipton Ice Tea Lemon
570 and 87g/L sugar in AriZona Lemon Iced Tea) in the UK. Experience and familiarity have
571 shown to affect food intake and preference. Cardello and Maller (1982) have suggested that
572 foods are most accepted at the condition that the food is normally served. Studies conducted
573 on serving temperature suggested that if coffee was served at ambient temperature, it
574 evoked more negative and less positive emotions than coffee served at cold/hot conditions
575 (Pramudya & Seo, 2018). Yang et al. (2018) found that when beer served at ambient and
576 low carbonation level, beer evoked more negative emotions and less positive emotions,
577 compared to beer served at cold and commercial carbonation level. Ice tea beverage is
578 commonly expected to be sweetened, therefor, it's not surprising that the Low sweetened ice
579 tea sample results in a lower liking score and evoked more negative emotions.

580 Repeated exposure in children has shown to successfully increase children's' acceptance of
581 an unfamiliar food such as vegetables (Wardle, Herrera, Cooke, & Gibson, 2003). Methven,
582 Langreney, and Prescott (2012) reported that repeated exposure has improved liking scores

for no added salt soup, which adds weights to the current evidence that familiarity play a role in hedonic response. It would be interesting to investigate the level of expected sweetness in food/beverage products and to examine if repeated exposure could improve consumer's acceptance to a lower sweetened beverage/food products, in order to validate if gradually reduce the level of sugars in food/beverage products would be an effective approach for sugar reduction (Hutchings, Low, & Keast, 2018)

Interestingly, no significant difference for liking and emotional response was observed between sucrose and sweetener in ice tea products, suggesting, in general, consumers do accept sweetener as a substitute to sucrose in their beverage. This finding agrees with Mahar and Duizer (2007)'s finding that no significant impact of type of sweetener (artificial or natural sweetener) on liking of orange juice that varies sweetness intensity was observed. It would be interesting to examine the relationship between sweetener usage and liking/emotional response to food/beverage products that sweetened using sucrose and sweeteners respectively. One of the limitations of this study is that only one beverage type was examined, it would be interesting to investigate if the effect of Sweet Liking Status are product-specific.

5. Conclusion

This is the first study that used Agglomerative Hierarchical Clustering (AHC), followed by Pearson correlation tests to check validity within each Sweet Liking Status cluster groups, which provide standardisation on the classification methodology. LSL disliked the High sweetened beverage and elicited significantly lower positive emotions, whereas an opposite trend was observed for HSL. Interestingly, everyone regardless of their Sweet Liking Status liked the Medium sweetened ice tea and disliked the Low sweetened ice tea samples, indicating familiarisation play a role in preferred sweetness level in food and beverage. Regarding the ideal sweetness rating for the beverage sample, this study provided evidence that the preferred sweetness in ice tea varied between HSL (34% of tested population) and LSL (35% of tested population) groups, where HSL preferred moderate to strong level of sweetness and LSL preferred sweetness level below moderate on the gLMS scale. The findings here suggested sugar reduction in beverage without sweetener substitution may be a promising strategy for consumers who are LSL.

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Table 1: Participants characteristics

	Total	High Sweet Liker	Medium Sweet Liker	Low Sweet Liker	Unclassified
Total n (%)		59 (34)	29 (16)	61 (35)	26 (15)
Gender n (%)					
Female	133 (76)	42 (32)	21 (16)	52 (39)	18 (13)
Male	42 (24)	17 (40)	8 (19)	9 (21)	8 (19)
Ethnicity n(%)					
Caucasian	105 (60)	37 (35)	16 (15)	34 (32)	18 (17)
Asian	59 (34)	17 (29)	11 (19)	24 (41)	7 (12)
Others	11 (6)	5 (45)	2 (18)	3 (27)	1 (10)
PTS n(%)					
ST	32 (18)	10 (31)	5 (16)	13 (41)	4 (12)
MT	107 (61)	40 (37)	19 (18)	29 (27)	19 (18)
NT	36 (21)	9 (25)	5 (14)	19 (53)	3 (8)

Table 2: Summary p-values table of ANOVA main effects and double interactions for SLS and PTS on emotional response

	SLS	***SLS * CONC***	***PTS***	***SLS*PTS***
Active	**< 0.0001**	0.171	**0.002**	**0.049**
Adventurous	**0.001**	**0.025**	0.513	0.144
Calm	**< 0.0001**	0.544	0.098	**0.050**
Enthusiastic	**< 0.0001**	**0.002**	**0.03**	**0.020**
Free	**< 0.0001**	0.167	0.13	**0.009**
Good	**<0.0001**	**0.002**	**0.026**	**0.008**
Good-natured	**< 0.0001**	0.151	**0.039**	0.468
Happy	**< 0.0001**	**0.001**	**0.019**	**0.007**
Interested	0.058	**0.0001**	0.118	0.767
Joyful	**0.003**	**0.003**	0.074	**0.029**
Loving	**0.001**	0.08	0.152	**0.023**
Satisfied	**<0.0001**	**<0.0001**	**0.016**	0.533
Pleasant	**0.033**	**0.000**	0.769	**0.021**
Satisfied	**0.016**	**< 0.0001**	0.870	**0.0001**
Secure	**0.001**	0.505	0.524	0.481
Warm	**< 0.0001**	**0.039**	**0.003**	0.083
Bored	**< 0.0001**	0.202	**< 0.0001**	0.122
Disgusted	**0.01**	**0.003**	**< 0.0001**	0.676
Worried	**< 0.0001**	0.325	**< 0.0001**	**0.001**
Aggressive	**< 0.0001**	0.146	**< 0.0001**	0.160
Guilty	**< 0.0001**	0.738	**0.004**	**0.015**
Mild	0.935	0.101	0.667	0.186
Tame	**< 0.0001**	0.997	0.135	**0.008**
Understanding	**< 0.0001**	0.377	0.274	**0.047**
Wild	**0.0001**	0.962	0.791	**0.003**

*p≤0.05 were highlighted in bold in this table. The p value for SLS*PTS interactions were obtained from data including HSL and LSL only.*

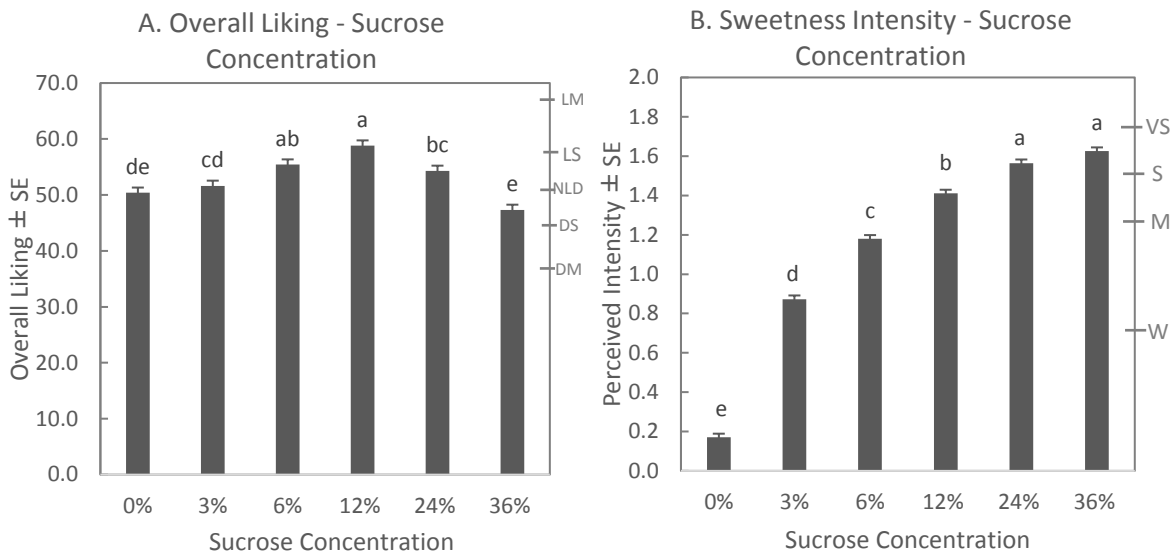

Figure 1: Effect of Sucrose concentration on a) overall liking (Mean score ± SE) and b) sweetness intensity (Mean score ± SE). Different letters indicate significant difference (p≤0.05). LM-Like moderately, LS -Like slightly, NLD- Neither like nor dislike, DS – Dislike slightly and SM- Dislike moderately. VS- Very Strong, S-Strong, M-Moderate, W-Weak.

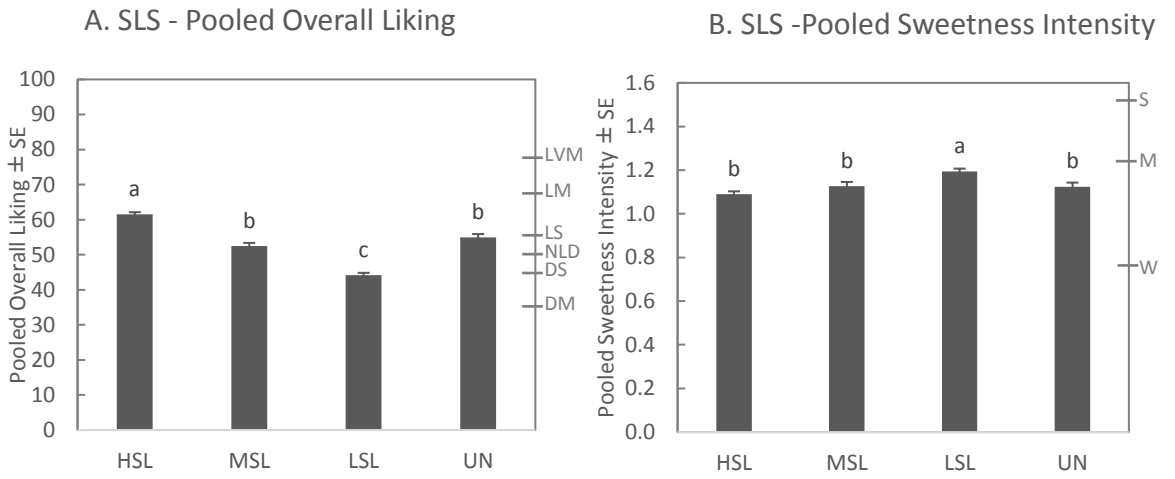

Figure 2: Effect of Sweet Liking Status on a) pooled overall liking (Mean score ± SE) and b) pooled sweetness intensity (Mean score ± SE). HSL – High Sweet Likers, MSL – Medium Sweet Likers, LSL – Low Sweet Likers, UN – Unclassified Group. LVM – Like very much, LM-Like moderately, LS -Like slightly, NLD- Neither like nor dislike, DS – Dislike slightly and DM- Dislike moderately. S-Strong, M-Moderate, W-Weak. Different letters indicate significant difference (p≤0.05).

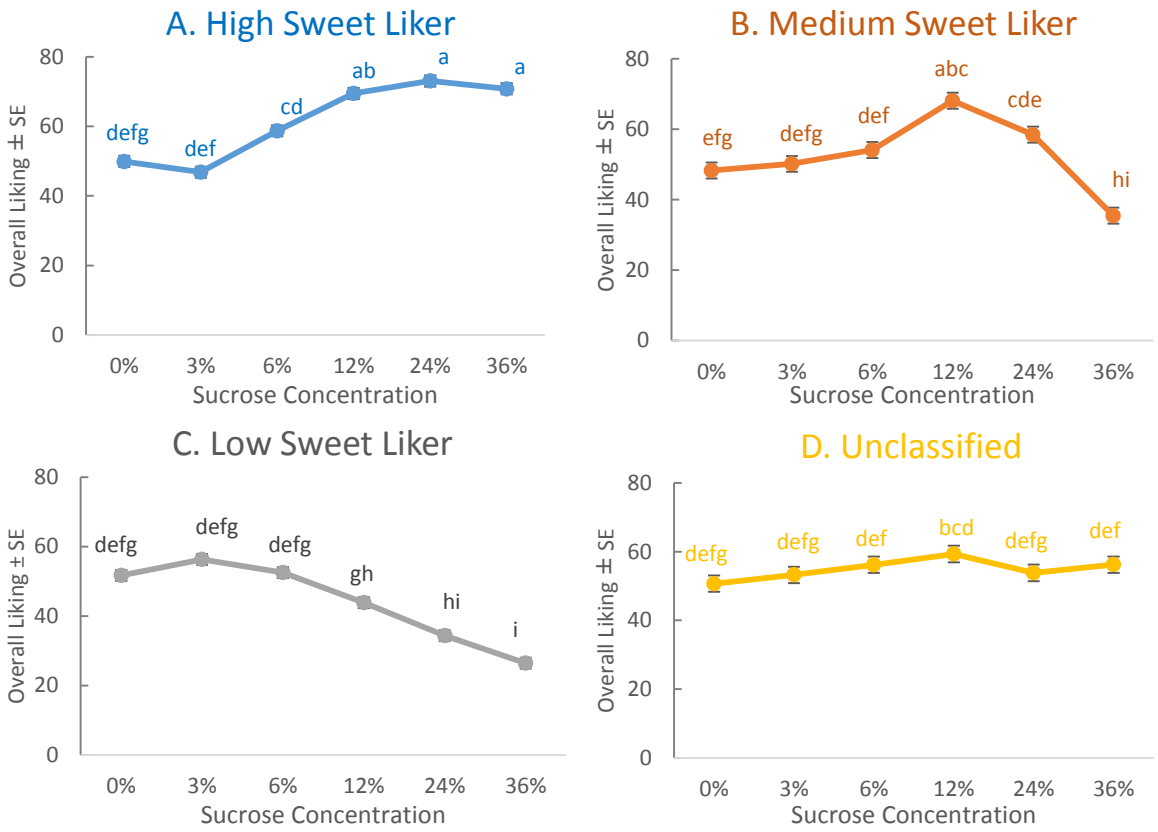

Figure 3: Overall liking for 0% (water), 3%, 6%, 12%, 24% and 36% sucrose solutions among a) High Sweet Liker, b) Medium Sweet Liker, c) Low Sweet Liker and d) Unclassified. Letters from all four figures above are obtained from the same post-hoc analysis, and different letters indicate significant difference (p≤0.05).

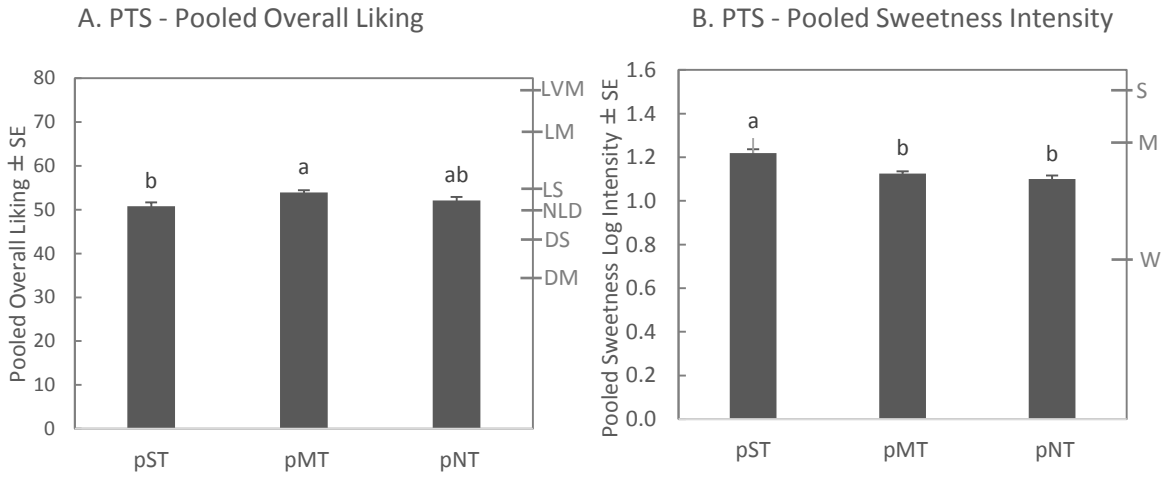

Figure 4: Effect of PROP Taster Status on a) pooled overall liking and b) pooled sweetness intensity. Different letters indicate significant difference (p≤0.05). pST – PROP supertasters, pMT – PROP medium-tasters, pNT – PROP non-tasters. LVM – Like very much, LM-Like moderately, LS -Like slightly, NLD- Neither like nor dislike, DS – Dislike slightly and DM- Dislike moderately. S-Strong, M-Moderate, W-Weak.

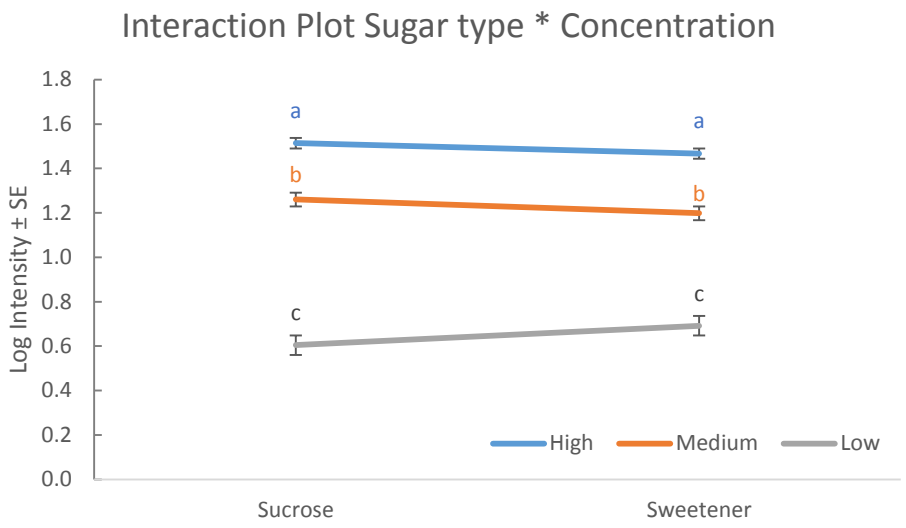

Figure 5: Interaction plot between sugar type (Sucrose and Sweetener) and sweetness concentration of ice tea sample (High, Medium and Low sweetened ice tea). Different letters indicate significant difference (p≤0.05).

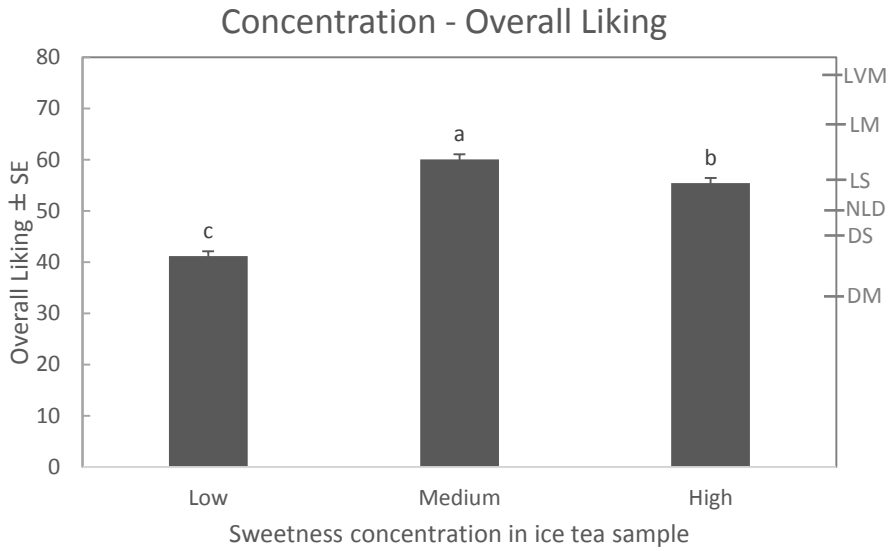

Figure 6: Effect of sweetness concentration in ice tea on overall liking. Each ice tea concentration include data for both sugar types (sucrose and sweetener). Different letters indicate significant difference (p≤0.05). LVM – Like very much, LM-Like moderately, LS -Like slightly, NLD- Neither like nor dislike, DS – Dislike slightly and DM- Dislike moderately.

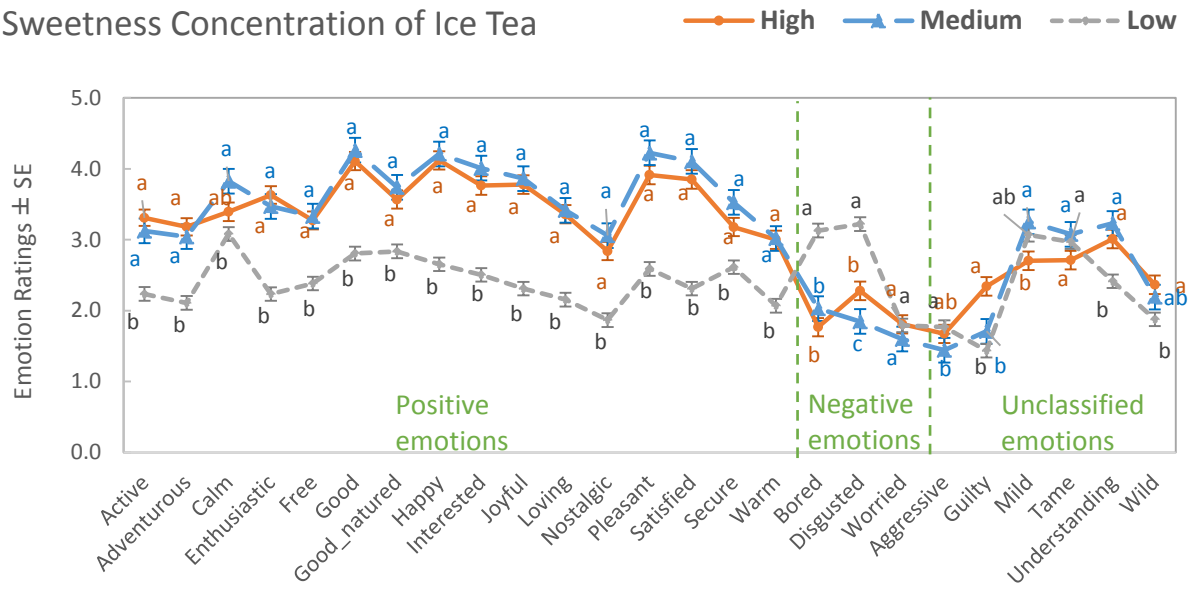

Figure 7: Effect of Sweetness concentration of ice tea on emotional response (Mean scores ± SE). Each ice tea concentration include data for both sugar types (sucrose and sweetener). Different letters indicate significant difference (p≤0.05).

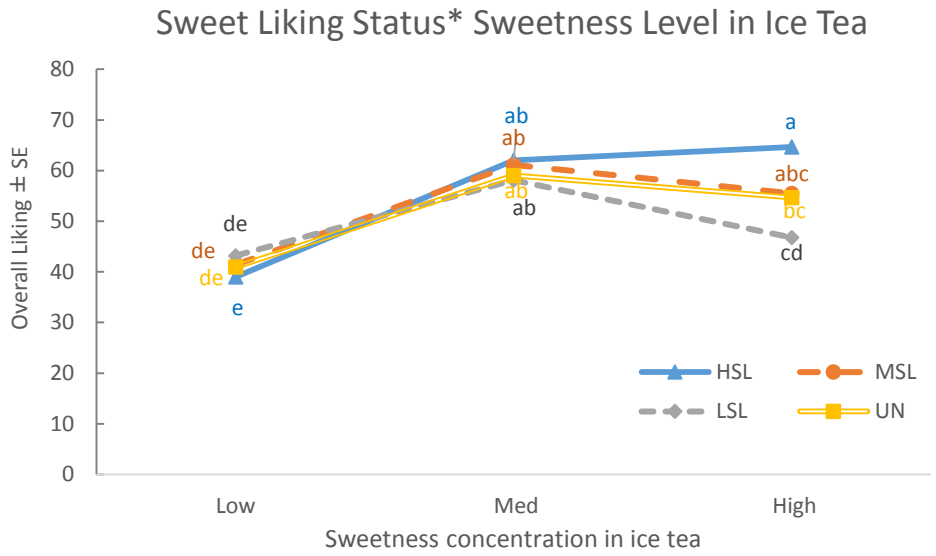

Figure 8: Interaction plot between Sweet Liking Status and Sweetness Concentration in ice tea sample. Each ice tea concentration include data for both sugar types (sucrose and sweetener). HSL – High Sweet Likers, MSL – Medium Sweet Likers, LSL – Low Sweet Likers, UN – Unclassified Group. Different letters indicate significant difference (p≤0.05).

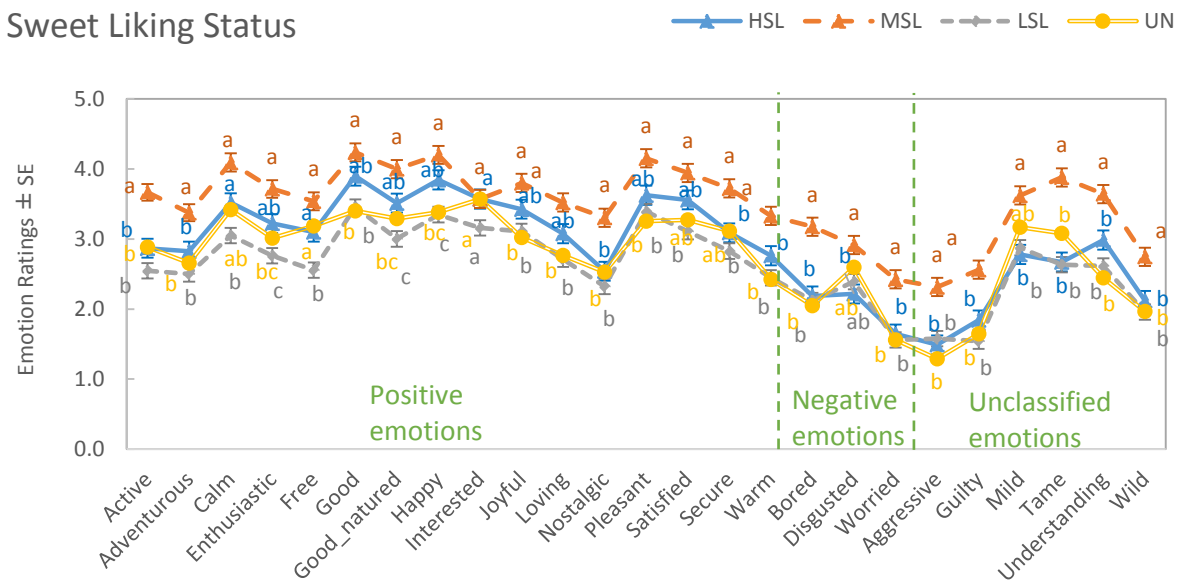

Figure 9: Effect of Sweet Liking Status on emotional response (Mean scores ± SE). HSL – High Sweet Likers, MSL – Medium Sweet Likers, LSL – Low Sweet Likers, UN – Unclassified Group. Different letters indicate significant differences (p≤0.05).

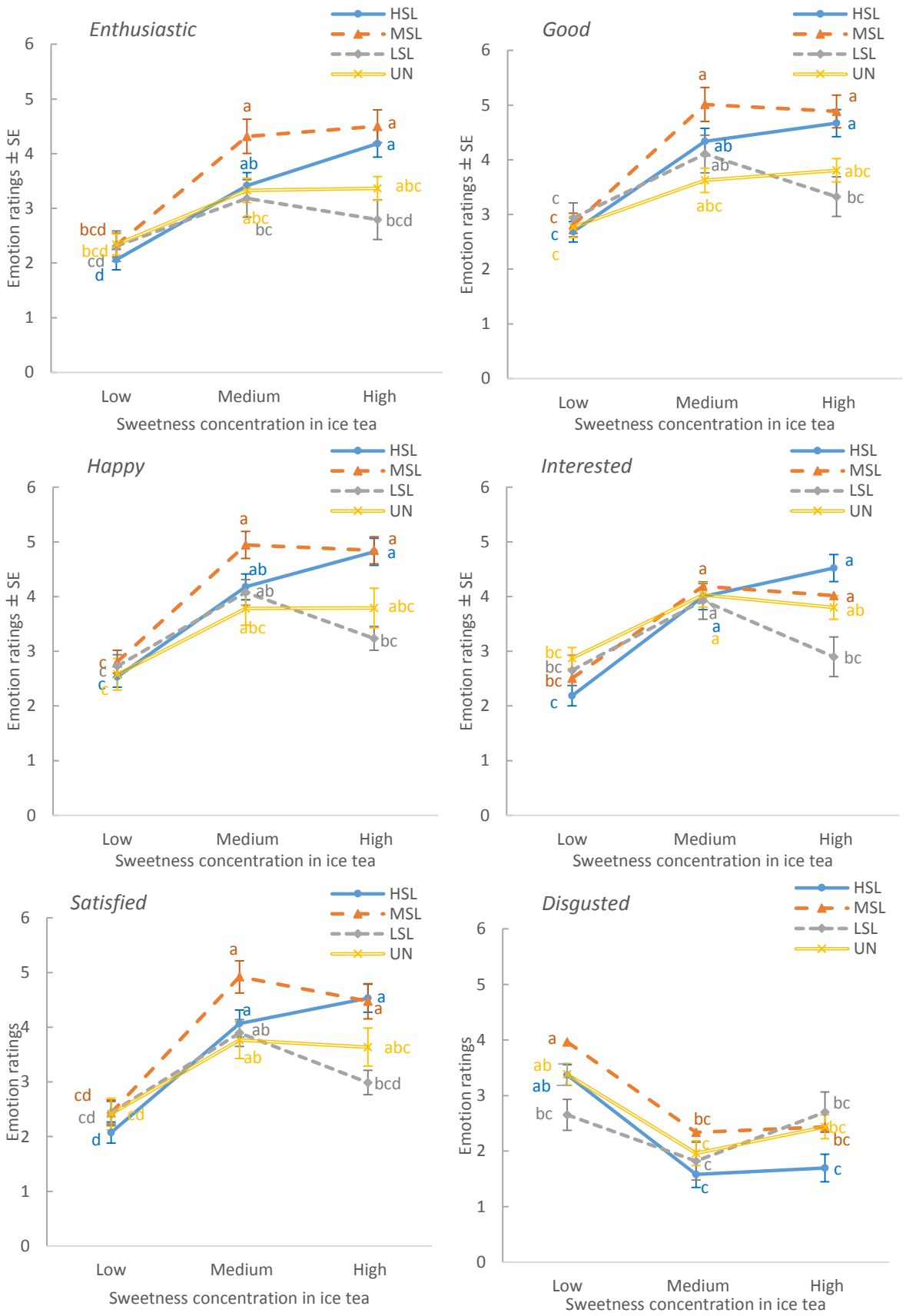

Figure 10: Interaction plot between SLS and sweetness concentration in ice tea for enthusiastic, good, happy, interested, satisfied and disgusted. HSL – High Sweet Likers, MSL – Medium Sweet Likers, LSL – Low Sweet Likers, UN – Unclassified Group. Different letters within each graph indicate significant difference (p≤0.05).

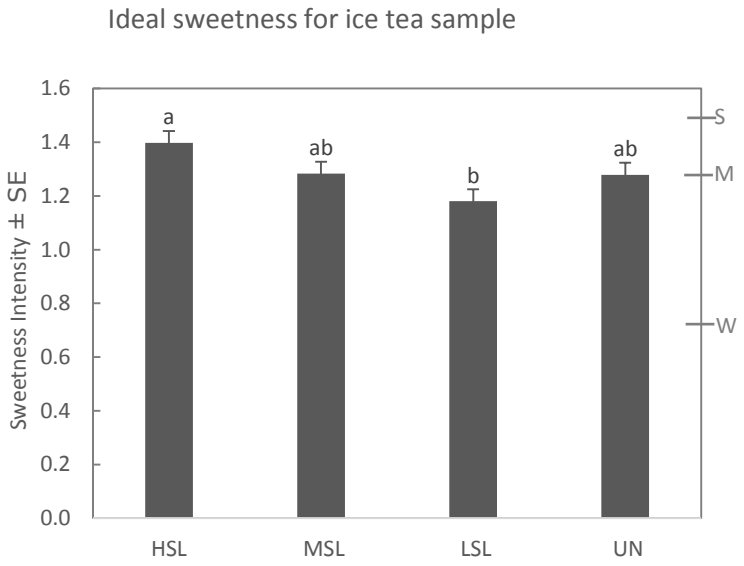

Figure 11: Effect of SLS on ideal sweetness of ice team samples (Mean score ± SE). HSL – High Sweet Likers, MSL – Medium Sweet Likers, LSL – Low Sweet Likers, UN – Unclassified Group. Different letters indicate significant difference (p≤0.05). S-Strong, M-Moderate, W-Weak.

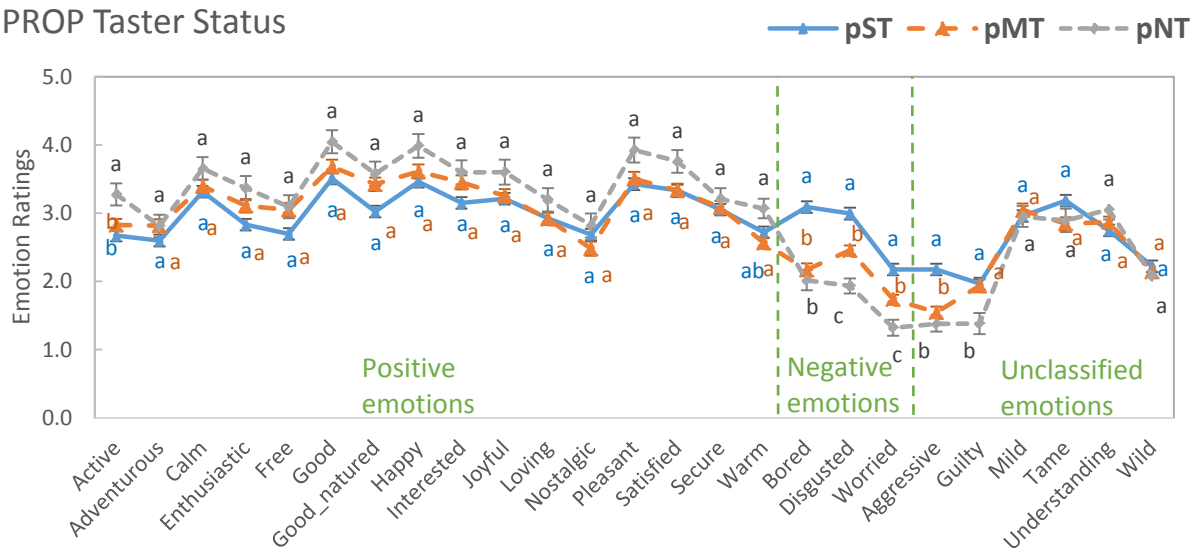

Figure 12: Effect PROP Taster Status on emotional response. pST – PROP supertasters, pMT – PROP medium-tasters, pNT – PROP non-tasters. Different letters within each emotion items indicate significant difference (p≤0.05) from Tukey's post-hoc test.

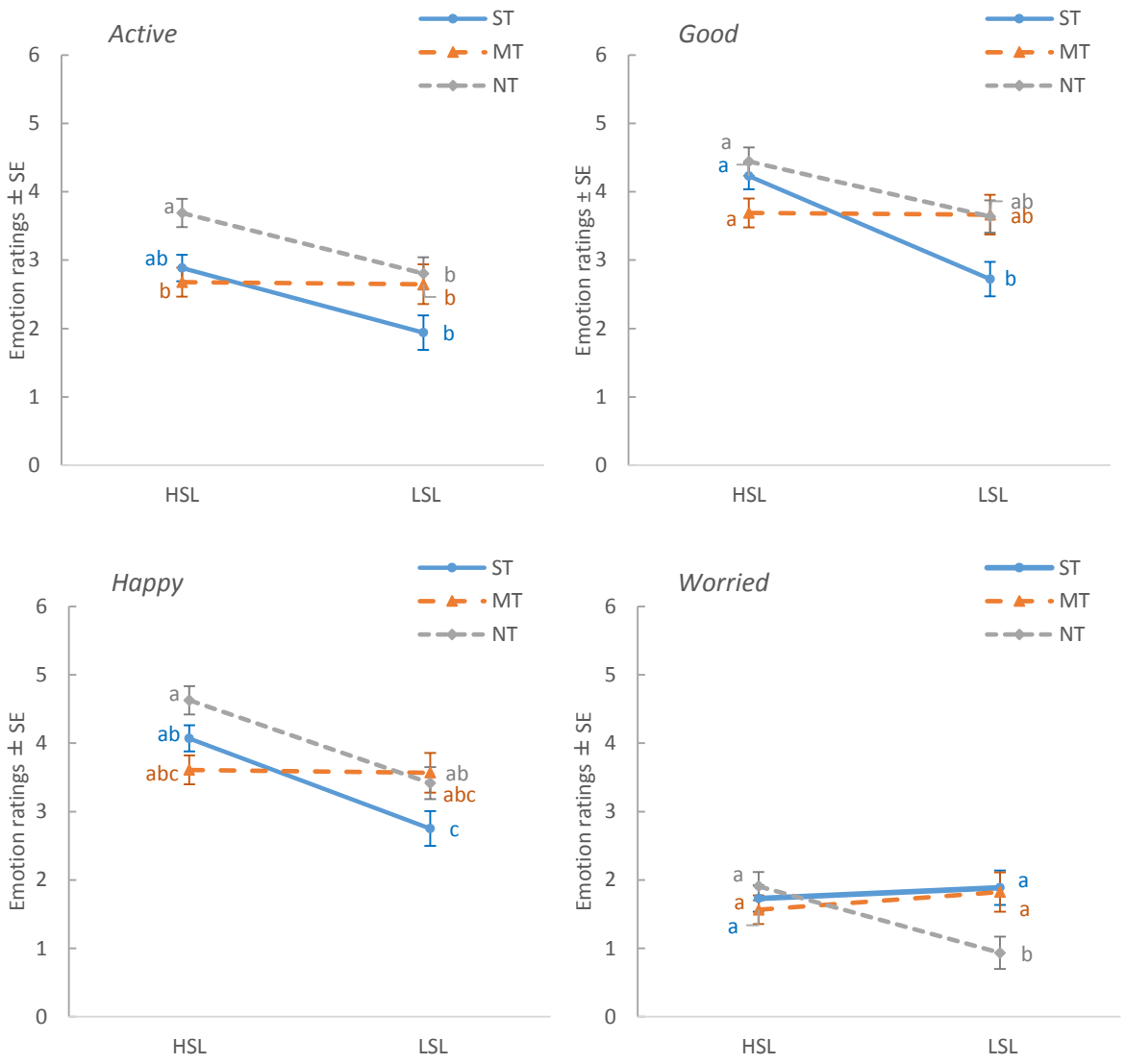

Figure 13: Interaction plots between Sweet Liking Status and PROP Taster Status for active, good, happy and worried emotions. HSL – High Sweet Likers, MSL – Medium Sweet Likers, LSL – Low Sweet Likers, UN – Unclassified Group. pST – PROP supertasters, pMT – PROP medium-tasters, pNT – PROP non-tasters. Different letters indicate significant difference at (p≤0.05).