Evaluating consumer emotional response to beverage sweeteners through facial expression analysis

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ABSTRACT

Emotional processing and characterization of internal and external stimuli is believed to play an integral role in consumer acceptance or rejection of food products. In this research three experiments were completed with the ultimate goal of adding to the growing body of research pertaining to food, emotions and acceptance using traditional affective sensory methods in combination with implicit (uncontrollable) and explicit (cognitive) emotional measures. Sweetness equivalence of several artificial (acesulfame potassium, saccharin & sucralose) and natural (42% high fructose corn syrup and honey) sweeteners were established to a 5% sucrose solution. Differences in consumer acceptability and emotional response to sucrose (control) and four equi-sweet alternatives (acesulfame potassium, high fructose corn syrup, honey, and sucralose) in tea were evaluated using a 9-point hedonic scale, check-all-that-apply (CATA) emotion term questionnaire (explicit), and automated facial expression analysis (AFEA) (implicit). Facial expression responses and emotion term categorization based on selection frequencies were able to adequately discern differences in emotional response as it related to hedonic liking between sweetener categories (artificial; natural). The potential influence of varying product information on consumer acceptance and emotional responses was then evaluated in relation to three sweeteners (sucrose, ace-k, HFCS) in tea solutions. Observed differences in liking and emotional term characterizations based on the validity of product information for sweeteners were attributed to cognitive dissonance. False informational cues had an observed dampening effect on the implicit emotional response to alternative sweeteners. Significant moderate correlations between liking and several basic emotions supported the belief that implicit emotions are contextually specific. Limitations pertaining to AFEA data collection and emotional interpretations to sweeteners include high panelist variability (within and across), calibration techniques, video quality, software sensitivity, and a general lack of consistency concerning methods of analysis. When used in conjunction with traditional affective methodology and cognitive emotional characterization, AFEA provides an additional layer of valued information about the consumer food experience.

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Table of Contents

List of Figures

List of Tables

Chapter 1: Introduction

There has been a dramatic increase in consumer awareness concerning the nutrition and safety of foods and beverages in the past couple of years. This has been due to several factors including recent legislation concerning the food supply (i.e. the Food Safety Modernization Act of 2011), an increased amount of reported foodborne outbreaks and resulting illnesses, and the growing obesity epidemic. On a global scale, the number of overweight and obese individuals has more than doubled since the year 1980 and continues to be a huge problem to this day (WHO 2012). According to the Centers for Disease Control and Prevention (CDC), in 2010 it was noted that 35.7% of U.S. adults were obese (Ogden, Carrol, Kit & Flegal, 2012). That percentage is roughly equivalent to 78 million individuals, not including children. That same year, it was estimated that approximately 17% (or 12.5 million) U.S. children and adolescents were obese. Obesity rates have varied among states but have continued to increase; furthermore, the rate of obesity in America is not slowing down. Predictions for the future show an increase in the percentage of obese individuals being as high as 43% within the next two decades (WHO 2012).

Problems and risks associated with overweight and obese individuals range from mild to severe and can include the following: sleep breathing irregularities, cardiovascular diseases, diabetes, musculoskeletal disorders, hypertension, osteoarthritis, and a decreased quality of life (Kissebah, Freedman, & Peiris 1989). A number of these health risks associated with obesity are among the top five causes for death globally (WHO, 2012). Factors attributed to the origin and continued prevalence of obesity mainly include unhealthy eating habits and an inactive lifestyle (Kissebah, et al., 1989). Several food and beverage products have come under public scrutiny for being major contributors to the obesity epidemic in the United States. A majority of these products have been categorized in one of the following groups: fast food, high calorie processed snack foods or sugar sweetened beverages (SSB). The SSB category has received extensive media attention in the past few years.

Several studies have shown that added sugars, especially in beverages, are linked to an increase in overall weight gain (Malik, Schulze, & Hu, 2006), obesity and other health-related problems (Malik, Popkin, Bray, Despres, & Hu, 2010; Schulze, Liu, Rimm, Manson, & Willett, 2004). Other studies have shown that the total consumption of SSB has dramatically increased over the past 30 years in the United States (Dennis, Flack & Davy, 2009; Han & Powell, 2013; Nielsen & Popkin, 2004). Both of these findings contribute to the broadly held conclusion that SSB, etc. are among the leading contributors of the obesity epidemic in the United States (Woodward-Lopez, Kao, & Ritchie, 2010). In fact, there has been so much media sensationalism about the linkage between SSB and obesity that various local and state government administrations have begun to tackle the problem by implementing laws designed to help reduce the obesity epidemic. One of the most notable government actions occurred in September 2012 in New York City and implemented a ban on the sale of sugary drink containers greater than 16 ounces (Grynbaum 2012). More recently, a new bill entitled the “Sugar-Sweetened Beverages Tax Act of 2014” or the “Sweet Act” was created in Congress (DeLauro, 2014). The purpose behind both of these actions is ultimately to reduce the prevalence of obesity and all associated health risks (and economic costs) in the country by discouraging overall consumption of sugar sweetened beverages. However, sugar sweetened beverages in general are not the entire problem; the use of specific sweeteners and the companies that use them are starting to be questioned by consumers and media proponents alike.

Sweet taste has been linked to positive affective responses across individuals (de Graaf & Zandstra, 1999; Rozin & Vollmecke, 1986; Steiner, Glaser, Hawilo & Berridge, 2001). Sucrose (or table sugar) is the standard sweetener with which all other sweeteners are compared. Due to its inherent sweetness and many functional properties, it quickly became the standard in the beverage world also (Knehr, 2005; Mitchell, 2006). However, numerous alternative sweeteners were introduced to the market as a result of several factors including economics (production prices), flavor compatibility, heat stability, volume of production and others (Anonymous 2009). Among these alternative sweeteners are high fructose corn syrup, honey, acesulfame potassium, aspartame, saccharin and sucralose, to name a few. These sweeteners have been used for several decades with great success in the food and beverage industry due to their sweetness intensities, functionality, as well as other factors. Until recently, their usage in the beverage market had not really been questioned. With the growing obesity epidemic and sweetened beverages continually being linked together, specific sweetener choices have come into question and with that consumer awareness and perception of such sweeteners has changed.

High fructose corn syrup is a prime example. In a 2004 study, Bray, Nielsen & Popkin (2004) claimed that high fructose corn syrup could be directly linked to the obesity epidemic in the United States due to the assumption that fructose was metabolized differently in the body than all other sugars. The findings did not sit well with consumers and mainly served as a point of confusion (Bray, Nielsen, & Popkin, 2004). A negative consumer perception of the sweetener developed immediately following the article publication and continued due to affiliated media sensationalism despite scientific studies claiming otherwise (Borra, 2009). Confusion about the use of high fructose corn syrup by the beverage industry and its functional and nutritional role as a sweetener continues today (Cogent Research, 2006; IFIC, 2013; White, 2014). Other alternative sweeteners, specifically artificial or high-intensity sweeteners, have also received bad reputations due to their chemical nature and associated safety concerns.

In spite of obtaining generally recognized as safe (GRAS) approval by the FDA and the many positive aspects associated with non-nutritive sweeteners, some artificial sweeteners are still negatively perceived by consumers as food additives. Two of the artificial sweeteners with well-known consumer negative perceptions include saccharin and aspartame. Saccharin was among the first artificial sweeteners to be synthesized and was discovered in 1878 by researcher Ira Remsen (Hicks 2010). Two clinical studies in the 1970s linked consumption of saccharin to the prevalence of bladder cancer in rats. Shortly after the findings were published, the FDA removed saccharin from the GRAS list and a ban on the sweetener was issued a few years later but was eventually removed (Hicks 2010). This ban forced the food industry to search for other alternative sweeteners to use in both food and beverages. Among those discovered was aspartame and not long after its discovery, controversy about its safety followed much in the same manner as saccharin. Claims about the health detriments of aspartame continue to create a negative perception of the sweetener in the public eye in spite of the fact that no scientific evidence supports such claims. The consumption of aspartame is associated with one potential health risk for those that have phenylketonuria (PKU).

With the growing obesity epidemic and negative consumer perceptions of many current sweeteners on the market, a demand is created for new, more nutritive and "natural" alternative sweeteners in the beverage industry (Devcich, Pedersen, & Petrie, 2007; Dickson-Spillmann, Siegrist, & Keller, 2011; Rozin, et al., 2004). The challenge from an industry perspective then becomes creating new food products (beverages) using sweeteners that meet consumer perceptions of being "healthy" and natural without compromising the product taste or expected taste (Koster, 2002). Being able to determine consumer perceptions and attitudes about these products is valuable to the companies that make and sell them, not only because it helps them to develop better products but also because it might help to improve associated marketing strategies.

Researchers believe that consumer emotions have a huge impact on food product acceptance, purchasing habits and ultimately, brand loyalty (Cardello, 1994; Gibson, 2006; Lindstrom, 2005). In the past, consumer-food interaction research has largely been focused on consumer preferences for and/or acceptance of one product over another. In the food industry, there are several well established sensory techniques utilized, which can be broken down into three main categories: discrimination, descriptive and affective tests (Meilgaard, Civille & Carr, 2007). While data collected using these techniques is useful, very little research has been completed to explore the role that consumer emotions and perceptions have on acceptance and decision making when it comes to food products. Defining emotions and characterizing consumer emotional responses to stimuli has been highly debated in the psychological and consumer studies fields.

Methods developed to measure emotional responses have been categorized into verbal (explicit) or nonverbal (implicit) techniques (Desmet, 2004). Applications of several explicit methods, such as the EsSense Profile (King & Meiselman, 2010), are gaining popularity in the industry; however, one of the major limitations involved with explicit techniques is that consumers are expected to be cognitively aware of their emotions and self-report to the researcher. Implicit techniques can include the measurement of physiological, neurological and/or expressive reactions (Desmet, 2004). Automated facial expression analysis (AFEA) is a relatively new nonverbal technique that has the potential to capture minute, rapidly-occurring changes in consumer emotions that are otherwise missed during self-reporting. One such tool, FaceReader (Noldus Information Technology, Wageningen, The Netherlands), evaluates consumer emotional responses using AFEA based on Ekman's six basic emotions (happy, sad, surprised, angry, scared and disgust) and neutral. The use of AFEA has only been applied to consumer food interaction in a few recent studies (Danner, Haindl, Joechl, & Duerrschmid, 2014; Danner, Sidorkina, Joechl, & Duerrschmid, 2013; De Wijk, He, Mensink, Verhoeven, & De Graaf, 2014; De Wijk, Kooijman, Verhoeven, Holthuysen, & De Graaf, 2012; Garcia-Burgos & Zamora, 2015).

The following research project explored the role emotions play on consumer food acceptance through measurement of both explicit (CATA emotion ballot) and implicit (AFEA) measures. Findings of this research project have a very practical and economic application in the real world due to the potential value in establishing a new methodology for examining and understanding consumer perceptions, attitudes and emotions about food products. Three studies were conducted, which included the following topics: (1)

sweetness equivalency of sucrose to natural and artificial sweeteners; (2) acceptability of sweeteners in tea and influence of emotional response using both AFEA and CATA emotion ballot methods; (3) implications of information and/or media messaging on acceptability and emotional response of sweeteners.

Objectives

1) Determine the concentration of each alternative sweeteners (4 artificial; 4 all-natural) needed to achieve the same perceived sweetness intensity of a 5% sucrose concentration in water.
2) Evaluate the relationship of consumer acceptability and emotional response of sweeteners in tea using a 9-point hedonic scale, an emotion term questionnaire (explicit), and a facial expression response (implicit).
3) Evaluate if and how the overall acceptance and emotional response (measured explicitly using a check-all-that-apply (CATA) emotion term questionnaire and implicitly using an automated facial expression response (AFEA) to two alternative sweeteners (ace-K & HFCS) and sucrose in cold tea changed when consumers were given varying product information (none; true; false).

References

Anonymous. The functional properties of sugar. (2009). Nordic Sugar [Brochure].

Borra, S.T. & Bouchoux, A. (2009). Effects of science and the media on consumer perceptions about dietary sugars. *Journal of Nutrition, 139,* 1214S-1218S.

Bray, G.A., Nielsen, S.J. & Popkin, BM. (2004). Consumption of high-fructose corn syrup in beverages may play a role in the epidemic of obesity. *American Journal of Clinical Nutrition, 79*(4), 537-543.

Cardello, A.V. (1994). Consumer expectations and their role in food acceptance. In *Measurement of Food Preferences.* (pp. 253-297). Springer, U.S.

Cogent Research, LLC (Cambridge, MA). 2006. High fructose corn syrup: consumer communications. Report and at-a-glance executive summary. Washington (DC): International Food Information Council (IFIC).

Danner, L., Haindl, S., Joechl, M., & Duerrschmid, K. (2014). Facial expressions and autonomous nervous system responses elicited by tasting different juices. *Food Research International*, *64*(2014), 81-90.

Danner, L., Sidorkina, L., Joechl, M., & Duerrschmid, K. (2013). Make a face! Implicit and explicit measurement of facial expressions elicited by orange juices using face reading technology. *Food Quality and Preference*, *32*(Part B), 167-172.

De Graaf, C. & Zandstra, E.H. (1999). Sweetness intensity and pleasantness in children, adolescents, and adults. *Physiology & Behavior*, *67*(4), 513-520.

DeLauro, R. Sugar-Sweetened Beverages Tax Act of 2014, HR. 113th Cong. (2014). Retrieved from http://cspinet.org/images/sweetactbill.pdf. Last accessed: 9 February 2015.

Dennis, E.A., Flack, K.D., & Davy, B.M. (2009). Beverage consumption and adult weight management: A review. *Eating Behaviors, 10*(4), 237-246.

Desmet, P.M.A., & Schifferstein, H.N.J. (2008). Sources of positive and negative emotions in food experience. *Appetite, 50*(2-3), 290-301.

Devcich, D.A., Pedersen, I.K., & Petrie, K.J. (2007). You eat what you are: modern health worries and the acceptance of natural and synthetic additives in functional foods. *Appetite, 48*(3), 333-337.

De Wijk, R. A., He, W., Mensink, M. G., Verhoeven, R. H., & de Graaf, C. (2014). ANS responses and facial expressions differentiate between the taste of commercial breakfast drinks. *Plos One*, *9*(4), e93823.

De Wijk, R.A., Kooijman, V., Verhoeven, R.H.G., Holthuysen, N.T.E., & de Graaf, C. (2012). Autonomic nervous system responses on and facial expressions to the sight, smell and taste of liked and disliked foods. *Food Quality and Preference, 26*(2), 196-203.

Dickson-Spillmann, M., Siegrist, M., & Keller, C. (2011). Attitudes toward chemicals are associated with preference for natural food. *Food Quality & Preference, 22*(1), 149-156.

Garcia-Burgos, D., & Zamora, M.C. (2015). Exploring the hedonic and incentive properties in preferences for bitter foods via self-reports, facial expressions and instrumental behaviours. *Food Quality and Preference, 39*, 73-81.

Gibson, E.L. (2006). Emotional influences on food choice: sensory, physiological and psychological pathways. *Physiology and Behavior, 89*(1), 53-61.

Grynbaum, M. (2012, September 13). Health panel approves restriction on sale of large sugary drinks. *The New York Times.* Retrieved from http://www.nytimes.com/2012/09/14/nyregion/health-board-approves-bloombergs-soda-ban.html?_r=0. Last accessed: 9 February 2015.

Han, E. & Powell, L.M. (2013). Consumption patterns of sugar sweetened beverages in the united states. *Journal of the Academy of Nutrition and Dietetics, 113*(1), 43-53.

Hicks, J. (2010). The pursuit of sweet: A history of saccharin. Chemical Heritage Magazine 28(1). Retrieved from http://www.chemheritage.org/discover/media/magazine/editions/28-1-spring-2010.aspx.

International Food Information Council Foundation (IFIC). (May 2013). [Survey of consumer attitudes toward food safety, nutrition & health]. Retrieved September 26, 2014, from the International Food Information Council Foundation website: http://www.foodinsight.org/articles/2013-food-and-health-survey.

King, S.C. & Meiselman, H.L. (2010). Development of a method to measure consumer emotions associated with foods. *Food Quality and Preference, 21*(2), 168-177.

Kissebah, A.H., Freedman, D.S. & Peiris, A.N. (1989). Health risks of obesity. *The Medical Clinics of North America, 73*(1), 111-138.

Koster, E.P. (2002). The psychology of food choice: some often encountered fallacies. *Food Quality and Preference, 14*(5-6), 359-373.

Knehr, E. (2005, May 1). *Carbohydrate sweeteners*. Retrieved from http://www.foodproductdesign.com/articles/2005/05/carbohydrate-sweeteners.aspx. Last accessed: February 2013.

Lindstrom, M. (2005). *Brand Sense: Build Powerful Brands Through Touch, Taste, Smell, Sight and Sound.* New York, NY: Free Press.

Malik, V.S., Schulze, M.B. & Hu F.B. (2006). Intake of sugar-sweetened beverages and weight gain: a systematic review. *American Journal of Clinical Nutrition*, *84*(2), 274-288.

Malik, V.S., Popkin, B.M., Bray, G.A., Despres, J.P. & Hu, F.B. (2010). Sugar-sweetened beverages, obesity, type 2 diabetes mellitus, and cardiovascular disease risk. *Journal of the American Heart Association, 121(?),* 1356-1364.

Meilgaard, M., Civille, G.V. & Carr, B.T. (2007). *Sensory Evaluation Techniques.* (4th ed.). Boca Raton: Taylor & Francis Group, LLC. (pp. 448).

Nielsen, S.J. & Popkin, B.M. (2004). Changes in beverage intake between 1977 and 2001. *American Journal of Preventive Medicine*, *27*(3), 205-210.

Ogden, C., Carrol, M., Kit, B. & Flegal, K. (2012). U.S. Dept. of Health and Human Services. *Prevalence of obesity in the United States, 2009-2010* (82). National Health and Nutrition Examination Survey.

Rozin, P., Spranca, M., Krieger, Z., Neuhaus, R., Surillo, D., Swerdlin, A., & Wood, K. (2004). Preference for natural: instrumental and ideational/moral motivations and the contrast between foods and medicines. *Appetite, 43* (2), 147-154.

Rozin, P. & Vollmecke, T.A. (1986). Food likes and dislikes. *Annual Review of Nutrition 6*, 433-456.

Schulze, M.B., Liu, S., Rimm, E.B., Manson, J.E., Willett, W.C. & Hu F.B. (2004). Glycemic index, glycemic load, and dietary fiber intake and incidence of type 2 diabetes in younger and middle-aged women. *Am J Clin Nutr,* (80),348-356.

Steiner, J.E., Glaser, D., Hawilo, M.E., & Berridge, K.C. (2001). Comparative expression of hedonic impact: affective reactions to taste by human infants and other primates. *Neuroscience and Biobehavioral Reviews, 25*(1), 53-74.

White, J.S. (2014). Sucrose, HFCS, and Fructose: History, Manufacture, Composition, Applications, and Production. In J.M. Rippe (Ed.), *Fructose, HFCS, Sucrose & Health* (pp. 13-33). New York, NY: Springer.

WHO Media Center. (2012). *Obesity and overweight* [Fact Sheet]. Retrieved from: http://www.who.int/mediacentre/factsheets/fs311/en/.

Woodward-Lopez, G., Kao, J. & Ritchie, L. (2010). To what extent have sweetened beverages contributed to the obesity epidemic? *Public Health Nutrition, 14*(3), 499-509.

Chapter 2: Literature Review

Sucrose and imparted sweetness

Carbohydrates are a necessary component in everyone's diet. They are used to fuel metabolic processes within the body and they provide energy to maintain activity (CDC, 2012). The building blocks of carbohydrates are sugars, which can be further classified in one of four groups: monosaccharides, disaccharides, oligosaccharides or polysaccharides (Tymoczko, 2010). These are organic compounds composed solely of carbon, hydrogen and oxygen atoms. In nature, the most abundant are simple carbohydrates (monosaccharides and disaccharides) and examples include glucose, fructose, glyceraldehydes, sucrose, maltose and lactose. Sucrose is made up of two monosaccharides, glucose and fructose, and is the most abundant disaccharide found in plants. It has become the standard sweetener in the food and beverage industry.

When comparing potential applications of various sweeteners in the food industry it is important to consider several different aspects of these additives. Those that are most important in the beverage industry include sweetness intensity, measured intensity over time, solubility, volume/mouth feel, interaction with other tastes/flavors and shelf life (Anonymous, 2009). Sucrose has always been considered the standard against which all other sweetener alternatives were compared due to its clean flavor profile and abundance in nature (Nabors, 2012).

Alternatives to sucrose and acceptance

In the United States, several sucrose alternatives have been used over the years due to economics, health benefits associated with the sweeteners, flavor components, and application factors specific to each sweetener that are better than or equal to sucrose. In the past, beverage industry products could be broken into two groups based mainly on the type of sweetener used. These two groups could be classified as diet drinks (artificial, nonnutritive) or full calorie drinks (natural, nutritive).

Artificial (nonnutritive) sweeteners

Artificial, or non-nutritive, sweeteners have gained in popularity over the years with the ever-increasing obesity epidemic. The main advantage of such sweeteners includes their ability to provide a similar sweetness profile to that of sucrose when used in beverages while contributing virtually little to no calories due to their high intensity nature. In the U.S., only five artificial, high intensity sweeteners have been approved for use in the food and beverage market. These include acesulfame potassium (ace-K), aspartame, saccharin, sucralose and neotame (IFIC & USFDA, 2010). Table 1, which has been modified from the Journal of the American Dietetic Association (ADA, 2004), shows the commercial names, functionality in beverage systems, caloric contents, relative sweetness equivalencies to sucrose, and various nutritional benefits associated with these five alternative sweeteners.

Table 2-1. Nonnutritive sweeteners that have been approved by the FDA. Includes commercial and market names, nutrition information and sweetness equivalence to sucrose. Modified from ADA (2004).

Type	**Commercial Name**	**kcal/g**	**Description**
Acesulfame-K	Sunett, Sweet One	0	200x sweeter than sucrose, no glycemic response
Aspartame	Nutrasweet, Equal	4	160-220x sweeter than sucrose, limited glycemic response
Neotame	N/A	0	8,000x sweeter than sucrose, no glycemic response
Saccharin	Sweet 'N Low	0	200-700x sweeter than sucrose, no glycemic response
Sucralose	Splenda	0	600x sweeter than sucrose, no glycemic response

Each of these sweeteners have profile and application differences when it comes to foods and beverages; however they all are similar in that they all give a higher sweetness intensity than that of sucrose, with ranges for ace-K, aspartame, saccharin and sucralose ranging between 200 and 700 (Nabors, 2012; Wiet & Beyts, 1992). Numerous studies have investigated the sensory characteristics associated with alternative sweeteners in comparison to sucrose. In addition to their high potency, some alternatives have been characterized as having secondary taste attributes such as an associated bitterness as a function of increased intensity (Wiet & Beyts, 1992). In particular, aspartame, ace-k and saccharin have been identified (Mitchell 2006; Nabors, 2012; Wiet & Beyts, 1992).

Recently, there has been an increase in health concerns associated with using synthetic ingredients in spite of the caloric advantages provided by various nonnutritive sweeteners. Public misunderstandings related to dose sensitivity and food safety (Rozin, Ashmore, & Markwith, 1996; Rozin, Spranca, Krieger, Neuhaus, Surillo, Swerdlin & Wood, 2004) have largely been influenced by media proponents (Borra & Bouchoux, 2009). However, criticisms associated with the use of specific artificial sweeteners are not new; in particular, aspartame and saccharin have had a tumultuous history in the public eye. Immediately following a nation-wide marketing campaign to increase sales of aspartame, consumer reporting of adverse health effects led to an investigation by the CDC (Nabors, 2012). Increased rates of brain tumors and incidences of leukemia and lymphoma were among some of the health complaints and allegations associated with increased consumption of aspartame, which were disproved later (Nabors, 2012).

There has also been controversy surrounding the safety of human consumption of saccharin. Most notably, evidence from a rat study showing increased bladder tumors as a direct result of consuming high doses of sodium saccharin led to an FDA ban on saccharin in 1977 (Nabors, 2012). The ban was finally lifted in 1991 after safety reviews of the sweetener found that the bladder tumor instance was an issue that only occurs in rats (Nabors, 2012). Regardless, studies have shown that these negative perceptions, warranted or not, have led to an increased preference for “natural” products among consumers (Devcich, Pedersen, & Petrie, 2007; Dickson-Spillman, Siegrist, & Keller, 2011). As a result, the food industry has started focusing on using more natural products, containing simple ingredients that are readily found in nature.

Natural (nutritive) sweeteners

In the beverage industry, these negative perceptions and trends have consumers demanding products with more diverse flavor profiles and that are more nutritionally beneficial (Himmelspach, Berry, Foster, Gan, & Decker, 2012; Zink, 1997). One of the easiest ways for companies to achieve this has been to alter the sweeteners used for beverages. Traditional nutritive sweeteners include honey, agave, and corn syrup blends (such as high fructose corn syrup) among others. All are relatively similar in composition, with varying concentrations of glucose and fructose, and slight differences in application.

Honey is one of the world's oldest sweetening agents used in beverages (Bogdanov, Jurendic, Sieber, & Gallmann, 2008) and is one of the only that does not need to be processed before use (White, 1978). Its three main components include fructose, glucose and water, making liquid honey relatively equivalent to dried sucrose on a sweetness intensity level (National Honey Board, 2005). Honey is characterized by two factors, color and floral type, and in the United States, there are approximately twenty types of single source and blends that are produced commercially (White, 1978). There are many perceived functional characteristics associated with honey, which include flavor enhancement, a relatively low glycemic index (depending on the percentage of fructose), and nutritional benefits in relation to antioxidant properties (Bogdanov et al., 2008).

Agave nectar is considered to be one of the world's more familiar nutritive beverage sweeteners. It is harvested from the Agavaceae plant, which is native to warmer climates such as the Mediterranean, Central and South America (Tomasik, 2004). The agave plant has many applications within the food industry and is typically used to either make alcoholic beverages or the nectar is processed for use as a beverage sweetener (Narváez-Zapata & Sánchez-Teyer, 2009). High levels of fructose are found in agave nectar as inulin, with ranges comparable to high fructose corn syrup, and give the nectar its sweetening power (White, 2009). Since agave nectar originates from a plant, the sweetener is considered to be "natural" and is therefore associated with the common misconception of being "healthier" by consumers. Tomasik (2004) describes the agave plant as being a rich source for several vitamins and minerals (calcium and magnesium), which also contributes to the positive perception of agave nectar as an alternative sweetener.

Contrary to the positive perception elicited by honey and agave as sweeteners, high fructose corn syrup has had a very different history with the beverage industry. High fructose corn syrup (HFCS) was first introduced in the late 1950s but didn't become a major player in the food industry as a beverage sweetener until the 1970s after production processes were fully established (Parker, Salas, & Nwosu, 2010). From an industrial perspective, HFCS has many advantages as a sweetener. Corn is one of the leading crops produced in the United States and as a result it is the main ingredient used to create HFCS. Production costs are relatively cheap due to the availability of corn in the U.S. which accounts for the high occurrence of HFCS as a sweetener in the U.S. food industry (Duffey & Popkin, 2008; Nabors, 2012). Three variations of HFCS exist in the marketplace and their differences are based on their specific applications in the food industry. These variations are defined by the fructose to glucose ratio and include HFCS-42, HFCS-55 and HFCS-90, which is mainly used to produce HFCS-42 and HFCS-55; for example, HFCS-42 contains 42% fructose and 58% glucose. The differing concentrations of fructose and glucose used to produce HFCS have an important effect on its perceived sweetness intensity. For this reason, HFCS can be identified as having a range of sweetness intensity from 0.92 to 1.17 when compared to a sucrose value equal to 1.0 (Hazen, 2012).

High fructose corn syrup, sugar sweetened beverages and the obesity epidemic

Advantages of using sweeteners labeled as "all-natural" differ depending on the sweetener being used. However true this may be, most are associated with an overall positive consumer perception of the product. However, some of these traditional sweeteners have been criticized in the past, especially high fructose corn syrup. In the United States, the replacement of sucrose with HFCS as the main beverage sweetener could be attributed to its availability, consistency and clean flavor profile among other factors (Nabors, 2012). This shift began gradually and then increased rapidly between the 1980’s and early 2000’s (Haley, Reed, Lin, & Cook, 2005).

Simultaneously, over the past twenty years, there has been an overwhelming increase in the number of overweight and obese individuals in the United States (Han & Powell, 2013). Associated health risks can include an increased predisposition for diabetes, cardiovascular diseases and an overall decrease in quality of life among many others (Kissebah, Freedman, & Peiris, 1989). In 2014, the CDC estimated that over one-third of the adult population was obese (Centers for Disease Control [CDC], 2014); however some studies are showing that while rates are still high in many countries, they are not increasing in children or adolescents (Olds et al., 2011). Proposed links to obesity prevalence in the United States include an overall increase in consumption paired with a decrease in activity (exercise). In particular, sugar sweetened beverages (SSBs) have become scrutinized by researchers and media proponents alike.

Many studies have shown a similar pattern between increased SSB consumption and the dramatic increase in obesity prevalence (Dennis, Flack, & Davy, 2009; Han & Powell, 2013). Other researchers have shown that consuming beverages (and foods) with added sugars can lead to weight gain (Malik, Schulze, & Hu, 2006). As a result, there is a widely held belief among consumers that SSBs are a leading contributor to the obesity epidemic (Woodward-Lopez, Kao, & Ritchie, 2010). This perception was supported by findings from researchers Bray, Nielsen, & Popkin (2004), who claimed that HFCS, which is the most frequently used sweetener in the beverage industry, had a direct link to obesity and its associated health problems. Skeptics later showed that there were discrepancies in the study and an overall lack of evidence to support the claims made against HFCS (Klurfeld, Foreyt, Angelopoulos, & Rippe, 2013).

Despite this, negative consumer perceptions and confusion surrounding the sweetener persist. Borra & Bouchoux (2009) suggested that a majority of consumer health understanding is related to the media. In 2006, the International Food Information Council (IFIC), collected survey data about consumer perceptions surrounding high fructose corn syrup. Results from the study suggested that most consumers were not well informed about the sweetener, although they believed it and other sweeteners to be associated with weight gain (Cogent Research, 2006). Researchers Rozin, Ashmore, & Markwith (1996) found evidence further supporting consumer confusion related to health and food; they called it the “monotonic mind” belief, meaning that if something had negative health effects when consumed at lower levels, most consumers would believe it to be harmful at high levels as well (Rozin, et al., 1996). As such, there has been a demand for new sweeteners that are beneficial health-wise and tend to be processed more naturally than their artificial sweetener counterparts. New all-natural sweeteners that have become more popular in the past few years include Stevia, coconut palm, and Monk fruit extract (Himmelspach, et al., 2012).

New natural substitutes & high-potency sweeteners

The constant search for better, more “natural” alternatives to sucrose in the food and beverage industry yielded two relatively new sweeteners that are still gaining in popularity. Coconut palm sugar has been nicknamed the new “agave” and was even featured on the Dr. Oz show in February 2012 for proclaimed health benefits (Oz, 2012). Coconut sugar in the granulated form is made from coconut tree buds and is relatively new to the U.S. food industry (Feder, 2012). It is most commonly marketed as an organic, all natural, non-GMO, gluten-free and kosher alternative for brown sugar. With fructose content less than 50%, coconut palm sugar is slightly lower in sweetness intensity when compared to sucrose and has a reportedly unique flavor profile characterized by caramel flavor (Mogea, Seibert, & Smits, 1991).

Another major difference is that unlike other alternative sweeteners, coconut palm sugar retains many of its other health nutrients throughout processing. In 2000, the Philippine Food and Nutrition Research Institute performed a comparative nutritional analysis of a variety of sweeteners, including coconut palm sugar, honey, agave syrup, maple syrup, and brown and refined white sugar (Philippine Food and Nutrition Research Institute, 2000). The data suggested that coconut palm sugar contained a significantly higher amount of macro and micronutrients related to elevated health benefits when compared to most of the other sweeteners. The most notable were high levels of nitrogen, potassium, magnesium and vitamin C. Consumption of these nutrients have been linked to reducing the risk of cardiovascular diseases, improved regulation of blood sugar, cholesterol and weight management, and increased brain stimulation.

Another new and upcoming all-natural sweetener with applications in the beverage industry is monk fruit extract. Monk fruit extract acts almost like a high-intensity artificial sweetener but its origins are from the natural Chinese gourd plant *Siraitia grosvenorii* (Hazen, 2012). Also known as luo han guo, monk fruit extract derives its intensely sweet nature from a variety of five different mogrosides (II, III, IV, V and IV) (Liu, Liu, Rong, & Rong, 2011). Mogrosides are a group of naturally occurring, zero-calorie sweeteners classified as cucurbitane-type triterpene glycosides. Some studies have shown that sweeteners in this class potentially have anti-cancer properties (Takasaki, et al., 2003). The sweetener has also been used in China to aid with the common cold and flu-like symptoms such as a sore throat (Feder, 2012).

Tomasik reported that the main sweetening agent of monk fruit extract, mogroside V, is approximately 250 times sweeter than a 10% aqueous solution of sucrose (Tomasik, 2004). Other researchers have claimed monk fruit extract sweetness equivalence to be as low as 150 times sucrose (Lee, 1975) and as high as 425 times sucrose concentrations (Kinghorn, Soejarto, & Inglett, 1986). Reports of a licorice aftertaste have been associated with the mogroside sweetener (Lee, 1975; Tomasik, 2004). All of the associated properties of monk fruit extract as a sweetener point towards it having many future applications in the U.S. food and beverage industry.

Many studies have been conducted on the characteristics, applications and sweetness equivalency of the above-mentioned high-intensity artificial sweeteners as well as high fructose corn syrup and honey. However, very few scientific studies have been carried out which explore the consumer acceptance and/or preference for these two new all-natural sweeteners. Also, many studies focusing on sweetness equivalency and associated hedonics used water as the beverage medium of choice; several studies have applied and compared these sweeteners in more complex beverage systems such as carbonated sodas, milk or tea, but very few have explored acceptance and emotional response of sweeteners in complex beverage systems. There is definitely a need to examine the degree of acceptance or liking for these various all-natural and artificial sweeteners in a similar beverage in which they would be applied.

Taste perception and acceptance

Sweet taste

Imparted sweetness is considered to be widely acceptable and elicit positive affective reactions across species, cultures and ages (De Graaf & Zandstra, 1999; Greimel, Macht, Krumhuber, & Ellgring, 2006; Rozin & Vollmecke, 1986; Steiner, 1979; Steiner, Glaser, Hawilo, & Berridge, 2001). One study conducted by Barr, Pantel, Young, Wright, Hendricks & Gravel (1999) showed that imparted sweetness elicited the same degree of "calmness" (and effectively reduced crying) among infants whether it was due to sucrose or an equi-sweet concentration of aspartame; results suggest that acceptance is not based on the ability to physiologically differentiate between artificially and naturally derived sweeteners (Barr et al., 1999). While inherent sweetness acceptance has been established, studies have shown that variations exist in the degree of taste perception across individuals and species. For example, the sweet taste modality is not created "equal" across mammalian species; one study showed that cats cannot detect sweet at all (Li, et al., 2006); another study showed that there are major disparities in sweet detection between New and Old World monkeys based on the sweetener used (Nofre, Tinti, & Glaser, 1996).

In humans, it has been argued that the perception and acceptance of various tastes is influenced by a combination of genetic factors and environment experiences (Reed, Tanaka, & McDaniel, 2006). From a biological perspective, the T1R gene family, which includes T1R1, T1R2 and T1R3 proteins, is directly responsible for sweet and umami detection in mammals (Li, Inoue, Reed, Hugue, Puchalski, Tordoff, Ninomiya, Beauchamp, & Bachmanov, 2001; Li, Staszewski, Xu, Durick, Zoller & Adler, 2002; Nelson, Hoon, Chandrashekar, Zhang, Ryba & Zuker, 2001). The T1R2 and T1R3 proteins form a G-complex when a sweetener binds to the taste receptor in the taste cell, regardless of its natural or artificial derivation (Birch, 1987; Chandrashekar, Hoon, Ryba, & Zuker, 2006; Li, et al., 2002; Nie, Vigues, Hobbs, Conn, & Munger, 2005). Once the taste cell has been activated, a neurotransmitter (taste signal) is carried by one of three cranial nerves to the gustatory complex (insula) in the brain (Garrett, 2014). Several areas of the brain are involved in taste perception and evaluation upon successful arrival of the sensory signal (Garrett, 2014). The somatosensory & frontal cortex are directly involved in the conscious perception of taste, the amygdala and hypothalamus are involved in the emotional quality of taste, and the hippocampus is associated with taste memory (Garrett, 2014; Reed, et al., 2006).

However, the manner in which taste modalities are encoded and "read" by the brain are not well understood (Reed, et al., 2006; Schoenfeld, Neuer, Tempelmann, Schüßler, Noesselt, Hopf, & Heinze, 2004). In fact, Schoenfeld, et al. (2004) showed that high variation in brain patterns exists among individuals when examining responses to basic taste stimuli. It has been shown that expectations associated with varying properties of a food stimuli, such as temperature (Zellner, Stewart, Rozin, & Brown, 1988), information (Stein, Nagai, Nakagawa, & Beauchamp, 2003; Stubenitsky, Aaron, Catt, & Mela, 1999), and taste (Woods, Lloyd, Kuenzel, Poliakoff, Dijksterhuis & Thomas, 2011) have a strong association with consumer acceptance, which could potentially explain altered processing in the brain.

Other studies have even suggested that brain processing may be affected by the type of sweetener being consumed. Results from a neurological study conducted by Frank, Oberndorfer, Simmons, Paulus, Fudge, Yang & Kaye (2008), showed that nutritive sweeteners activated some taste pathway areas in the brain that nonnutritive sweeteners did not. Green & Murphy (2012) suggested that this could be caused by the beverage consumption frequency of the individual. They found that the reward processing system in the brain differed for individuals who regularly consumed diet beverages from individuals who did not (Green & Murphy, 2012). Other factors such as sweetener concentration, pH, sample temperature and additional flavor components can all play a role in consumer perception of sweetness intensity. Most frequently, the additional flavor compounds associated with the sweetener or beverage medium affect the overall taste sensation.

Bitter taste

Water has generally been shown to elicit neutral responses (Steiner, 1979; Steiner, et al., 2001) but more complex beverages can alter this acceptance or response. After water, tea is the second most frequently consumed beverage in the world (Tea Association of the USA, 2013). Tea aroma and taste has been characterized by a number of extractable, nonvolatile flavor compounds, which have been known to impart bitter tastes when the leaves are oxidized (Balentine, Wiseman & Bouwens, 1997; Sanderson & Graham, 1973; Tea Association of the USA, 2013).

Bitter taste perception is much more complex than other tastes due to the large family of bitter receptors in taste cells and the multiple brain signal pathways proposed (Chandrashekar, et al., 2006; Reed, et al., 2006). It is generally accepted that bitter taste is undesirable (Fischer, Griffin, England, & Garn, 1961; Gibson, 2006; Reed, et al., 2006; Steiner, 1979), however some bitter foods and beverages are regularly consumed and enjoyed (coffee, cruciferous vegetables, etc.). It has been suggested that the acceptance of bitter foods is associated with sensitivity of taste, exposure over time and the presence of specific personality traits among individuals (Mattes, 1994). Some research studies have shown that human conditioning via repeated exposure can influence and change taste acceptance over time (Stein, et al., 2003; Stubenitsky, et al., 1999). When deciding to use an alternative sweetener for a beverage system, it is important for the developer to consider all of these factors in relation to the sweetener of interest, especially alternative sweeteners, such as saccharin and ace-K, which can be characterized by bitter aftertastes (Wiet & Beyts, 1992).

Taste preferences

Food liking (or disliking) begins with the ability of an individual to perceive basic tastes in the mouth (Drewnowski, 1997). Evolutionarily, it has been argued that humans have a predisposition to like sweet tastes and dislike bitter tastes (Fischer, et al., 1961; Rozin & Vollmecke, 1986). An evaluation of the taste stimuli, also recognized as a hedonic (affective) response, occurs immediately following this detection (Rozin & Vollmecke, 1986). A consumer report recently found that consumers believe taste to be among the most important factors when making consumption decisions about food products (IFIC, 2013). In the industry, several well established techniques including discrimination, descriptive and affective testing methods have been used to determine consumer liking and preferences through ratings and taste tests (Meilgaard, Civille, & Carr, 2007). Affective methods, which have traditionally been broken into two groups based on the type of data collected (quantitative versus qualitative), have proven useful for a variety of purposes including product development, assessment of the current market success of a product or potential market success in the future, among others. As a result, there is a belief that food preferences can be derived directly from food liking, although many studies have shown that this is an oversimplification.

From a biological perspective, it has been shown that the ability to detect and distinguish between tastes can change over time across and within individuals due to physiological changes such as aging (Drewnowski, 1997; Mojet, Christ-Hazelhof, & Heidema, 2001) and/or the emotional state of the individual (Canetti, Bachar, & Berry, 2002; Nakagawa, Mizuma, & Inui, 1996). It is also generally believed that acceptance of a new or disliked food product can be altered in a positive manner upon mere exposure, especially if product familiarity increases over time. Supporting evidence for this conclusion has been provided by several studies investigating generally disliked foods such as vegetables and acceptance among children (Wardle, Herrera, Cooke, & Gibson, 2003), or the acceptance of bitter beverages among individuals (Mattes, 1994; Stein, et al., 2003). Even so, the formation of consumer product expectations pre-consumption and the impact those expectations then have on subsequent behavior has been of interest to marketing and consumer behavioral researchers for a while.

Product expectations, informational cues & memory

Aside from the many sensory attributes associated with a product (taste, smell, appearance, packaging, temperature, etc.), consumers are influenced by any number of additional factors when assessing food products. These can include motivational factors such as the bodily state of the individual (hunger, thirst, etc.), expectations associated with the product, its package, or any other information, learning based on previous experiences with the product, or other cultural, social, psychological & environmental influences (Cardello, 1994). Rozin & Vollmecke (1986) suggested that there are three basic motivations involved in acceptance or rejection of a food product. These include sensory affect (or degree of pleasantness), anticipated effects (health benefits or consequences), and ideational motivations (morally or aesthetically pleasing/disgusting). Thus, it is important for researchers to consider all influencing factors when assessing consumer acceptance, preferences, and consumption behavior of food products.

Product expectations were defined by Olson and Dover (1979) as "pre-trial beliefs about a product." Deliza and MacFie (1996) went further to suggest that these expectations have a huge impact on the numerous decisions consumers make on a daily basis, whether realized or not. The total food quality model was first proposed by researchers Grunert, Larsen, Madsen, & Baadsgaard in 1996 (as cited in Grunert, 2002) as a framework for studying the various factors driving consumer decisions about food products. Based on the model, it is assumed that consumers use a variety of intrinsic (product taste, texture, aroma, etc.) and extrinsic (price, brand and other product informational cues) quality cues in order to form expectations pre-consumption, which in turn influences behavior (Grunert, 2002).

Numerous sensory studies have investigated the effects of individual differences such as genetic diversity (Reed et al., 2006) and age (De Graaf & Zandstra, 1999) and intrinsic product cues such as taste intensity (Woods et al., 2011) and temperature (Zellner et al., 1988) on food acceptance and preferences. Extrinsic cues such as price, label information, advertising and branding also play an integral role in generating consumer perceptions and expectations (Deliza & MacFie, 1996; Schifferstein, Fenko, Desmet, Labbe, & Martin, 2013). As mentioned previously, consumer perceptions of products drive the directionality of the food industry market (Zink, 1997). It is thought that these perceptions can be changed based on the type and amount of informational cues derived from the product (Grunert, 1986; Hoegg & Alba, 2007).

When considering the sheer abundance of extrinsic cues upon which consumers can base their expectations, Cox (1967) suggested the existence of a "sorting method" where an individual becomes more selective and gives higher values to reliable informational cues. Thus, it is assumed that cue reliability is evaluated by the consumer and quality cues, assigned with higher values, are more predictive of acceptance (Cox, 1967). Grunert (2002) said that information cue dimensions could be divided into three categories: search, experience and credence. Information cues found within the "search" dimension include those that can be evaluated by the consumer immediately pre-purchase. For example, price is an extrinsic cue with which most consumers are familiar and one that is used frequently and easily to differentiate between similar products (Jacoby, Olson, & Haddock, 1971). One study showed that reliability of cereal quality perception using price as an indicator varied by culture (Krutulyte, Costa, & Grunert, 2009). It has been suggested that other extrinsic credence cues, such as label/nutrition information and branding, are becoming increasingly more important during the consumer decision making process (Grunert, 2002). However, Cox (1967) argued that it is actually the confidence value (or consumer certainty in understanding the cue) assigned and not a higher predictive value of quality that determines behavior.

Studies investigating the impact of label information on hedonic liking have found conflicting results. One study found evidence supporting the belief that provided information generally increases overall acceptance of new and familiar food products (Tuorila, Meiselman, Bell, Cardello, & Johnson, 1994), while another found conflicting results suggesting that general liking and purchasing habits were not affected by nutritional information provided on the label (Shepherd, Sparks, Bellier, & Raats, 1992). Evidence showing prevalence of consumer misconceptions related to food, nutrition and nutritional claims are numerous (Roe, Levy, & Derby, 1999; Rozin, et al., 1996; van Trijp & van der Lans, 2007). Results from the above mentioned studies suggest support for the predictive nature of Cox's confidence value in relation to expectation.

Consumers overall understanding of food and nutrition and their ability to evaluate the reliability of specific health claims are being further confounded by advertisements and brand marketing. In the past, consumer studies involving food advertisements have mostly focused on their impact on snack and food eating behaviors in children (Coon, Goldberg, Rogers, & Tucker, 2001; Harris, Bargh, & Brownell, 2009) and how brand priming can affect consumer food attitudes (Boush, 1993; Lamote, Hermans, Baeyens, & Eelen, 2004). Recently, increased media coverage over the obesity epidemic and contributing foods and beverages has impacted consumer perceptions of various ingredients and food products (Borra & Bouchoux, 2009). In an attempt to effectively communicate with and appeal to the higher proportion of health-aware consumers, the industry has started using several unregulated food buzzwords and phrases (Devcich et al., 2007; Dickson-Spillmann, et al., 2011). “Natural” and “all-natural ingredients” are among the most frequently used on food packages and in advertisements.

However, a major criticism in regard to the food industry using these food related buzzwords is that it has added to consumer health confusion and created a false sense of health for specific products (Northup, 2014). In fact, consumer studies exploring the role of learning, memory, trust and validity have shown that once primed, repeated exposure (or familiarity) to a claim will enhance the claim credibility in the eyes of the consumer (Cronley, Kardes, & Hawkins, 2006). This is also known as the “illusory truth effect” (Hawkins & Hoch, 1992) and when consumers are presented with misleading information, it often leads to higher consumer confusion regarding food products (Alpert, 2014). One study investigated the effect deceptive advertising had on consumption patterns of weight loss products and found that some gender disparities associated with determining advertisement credibility and ultimately consumption patterns existed (Cawley, Avery, Eisenberg, 2011). Following those initially formed product expectations, the experience of interacting with the product and subsequently formed memories can influence consumer perception, expectation and behavior with the same or similar products in the future. Koster (2003) has argued that taste memory (and its influence on expectation) is among the most important of these factors when evaluating familiar food products. A major risk associated with relying too heavily on food product memories to evaluate products include individual taste inconsistencies (Hoegg & Alba, 2007), which can lead to disconfirmed expectancies (Carlsmith & Aronson, 1963).

Cognitive dissonance

Cognitive dissonance theory, first defined by Carl Festinger in 1957, is known as the mental stress or discomfort an individual experiences when confronted with information that conflicts with their current beliefs (as cited in Cardello & Sawyer, 1992). In relation to food acceptance, dissonance (or disconfirmation) is closely related to the degree of expectation an individual assigns to a particular product based on informational and contextual cues (Cardello & Sawyer, 1992). Disconfirmation can be a positive or negative experience and based on the associated expectations, four theoretical models have been recognized (Cardello & Sawyer, 1992). These include “assimilation” (Hovland, Harvey, & Sherif, 1957), “contrast” (Hovland, et al., 1957), “assimilation-contrast” (Deliza & MacFie, 1996; Hovland, et al., 1957) and “generalized negativity” (Carlsmith & Aronson, 1963). These cognitive influences (informational cues, expectations, etc.) can ultimately affect consumer reporting of product acceptability and underlying emotional responses.

Emotions and food

Emotions play an integral role in almost every aspect of the daily lives of humans and consumer-food interaction is no different (Scherer, 2000). Studies have shown that numerous outside factors (environmental, neural, cognitive and physiological) can have various positive and negative effects on consumers’ emotions (Baumeister, DeWall, Vohs, & Alquist, 2010; Cohen, Pham, & Andrade, 2008). A growing body of research is also suggesting that emotional states have an effect on not only how consumers approach the eating experience but also how consumers' emotions can be altered because of the eating experience (Canetti, et al., 2002; Gibson, 2006; Macht, 2008). However before consumer emotional responses can be explored on a scientific level, emotion and the associated states must first be defined. This has proven to be a very difficult task for behavioral researchers over the years due to the sheer complexity and various interpretations involved, especially when differentiating between attitudes, affective feelings, mood and emotion (Cohen, et al., 2006; Scherer, 2000). In spite of this, several researchers strived to develop a universal definition for all emotions but with two different approaches.

Definitions and theories

One definition that is gaining acceptance was proposed by researchers Ortony, Clore and Collins (1988) who went into great detail and determined that simply put, an emotion is a positive or negative (valenced) reaction (arousal; bodily reaction) to an individual's perception of reality. Robbins & Judge (2013) differentiated emotions from definitions for similar terms (attitude, mood, etc.), stating that they occur very quickly (microseconds) and generally have a short duration (seconds to minutes at most). Once defined, the manner in which two or more emotions are distinguished has become a highly debated issue among psychologists. There are two fundamental emotion theories (discrete versus dimensional), both of which have been extensively researched over the years (Gendron & Barrett, 2009).

Discrete emotion theory states that upon receiving an emotion-producing stimulus, all individuals experience one or more basic emotions resulting from a physiological response (McGinley, 2014). Some scientists have argued that the emergence of such emotions could have resulted out of evolutionary necessity (Richins, 1997) and/or the need for a social signaling system (Scherer, 2000). The James-Lange theory, which is included under the discrete theory ‘umbrella,’ attributed different emotions to varying patterns of arousal (Garrett, 2014). In contrast the dimensional emotion theory, also referred to as the circumplex model of affect, proposes that physiological arousal contributes to intensity while emotional response is based on an individual’s cognitive assessment of varying contextual factors related to the product itself (Garrett, 2014; McGinley, 2014; Posner, Russell, & Peterson, 2005). This theory supports evidence from more recent consumer studies investigating the impact of informational cues on appraisal and consumer product behavior patterns (Cox, 1967; Grunert, 2002).

Neither theory has proven to be superior when interpreting emotion response(s) to the consumption experience (Garrett, 2014). In fact, when measuring and interpreting consumer emotional responses to foods, both theories have been applied (Richins, 1997). Many researchers have emphasized the occurrence of 8-10 basic emotions from which it is believed that all others (more complex and/or basic emotion combinations) stem (Richins, 1997). Izard (2007) stated that in order to define an emotional response, one must make the distinction between basic emotions (involving feelings) compared to behaviors and emotion schemas, which incorporate a cognition component. Several explicit and implicit methods have been developed to capture emotional response to food stimuli; however the characterization of emotional response is highly variable depending on the approach used (Desmet, 2004).

Measuring consumer emotional responses

Development and use of consumer emotional responses to a food product has the potential to change how the food industry interacts with and is perceived by the public. Emotional responses evoked by a food product provide an additional piece of information, which hedonic information and current qualitative methods currently do not provide in an effective manner. This can potentially allow manufacturers to see their commodity more accurately and therefore enable them to make the necessary changes to ensure success (or acceptance) of the product by a wider audience. Methodology developed to measure emotions has traditionally been rooted in the fields of psychology and sociology. It has only been in the past 10-20 years that techniques have been developed to measure consumer responses for advertising, marketing, computer science and other fields (such as food science). Such methodologies can be segmented into two categories: verbal and nonverbal emotional response measurements (Desmet, 2004).

Verbal (explicit) emotional collection methods and responses

Verbal methods for collecting and interpreting emotional responses have to be self-reported; in this way they are very similar to current qualitative sensory techniques. Describing emotional responses in relation to food stimuli is not an easy task and as a result, several different tools have been developed in order to accurately characterize them. Among some of the earliest methods were Plutchik's Emotions Profile Index and the pleasure-arousal-dominance (PAD) scale which was first described by Mehrabian and Russel (as cited in Richins, 1997). Plutchik's index used 62 emotion pairs to characterize eight basic emotions while the PAD method attempted to assess the three perceived dimensions in the context of the environment. Richins (1997) noted several shortcomings of these existing methods, which included list content and length. In particular, the use of emotional terms that seemed unfamiliar and/or unrelated to the consumption experience was listed as a major limitation. Two additional tools aimed to characterize moods, Profile of Mood States (POMS) and Multiple Affect Adjective Check List (MAACL), have been used extensively in clinical psychiatry (as cited in King & Meiselman, 2010). Similar to the Emotions Profile Index and the PAD method, both mood lists consist of a lengthy amount of terms (POMS uses 65 terms; MAACL uses 66).

In the past, a majority of studies have focused on the negative emotional aspects of food, often investigating how pre-determined emotion states affect eating behavior (Cardello, Meiselman, Schutz, Craig, Given, Lesher, & Eicher, 2012). In spite of this, recent research suggests that most food-related experiences can be described in positive terms (Desmet & Schifferstein, 2008; Gibson, 2006; King & Meiselman, 2010). This is reflected by the various emotional term check-all-that-apply lists that have been developed for food and other consumption fields more recently. Among these are tools aimed to characterize emotions related to odors such as the Geneva Emotion Scale (GEOS) (Chrea, et al., 2009) and the modified version of GEOS (Porcherot, Delplanque, Raviot-Derrien, Le Calve, Chrea, Gaudreau, & Cayeux, 2010) and emotions related to foods such as the EsSense Profile™ (King & Meiselman, 2010). Such lists are similar in that the goal is to effectively characterize the emotional response to foods, all have a predominance of positive terms, and in that they consist of a shorter but still fairly lengthy number of emotional terms (GEOS consists of 36 terms; EsSense has 39 terms)(Cardello et al., 2012; Porcherot et al., 2010).

Self-reported (explicit) data collection requires that consumers be consciously aware of the emotional state elicited by a stimulus, which provides some limitations. Participants may not necessarily be in tune with their emotional side and could therefore over think (or post-rationalize) their answer; therefore, reported emotions may be confounded by previous interactions with said stimulus (and subsequent expectations), especially if they are familiar with the product (Zajonc, 1980). Unfamiliarity with emotion terms and/or meaning provides another interesting limitation when using emotion term checklists. Linguistic relativity theory (LRT) as defined by Whorf (1956) states that "language intrinsically shapes how people perceive, categorize, and experience reality." When put in the context of food consumption and reported emotional response, LRT suggests that there is a potential for individual bias simply due to the emotion terms found within the checklist (Lindquist, Barrett, Bliss-Moreau, & Russell, 2006). In a separate study, researchers Gendron, Lindquist, Barsalou & Barrett (2012) showed that the ability of an individual to perceive and detect emotions in others can be affected by priming said individual with related or unrelated emotion words and/or facial expressions. In this way, the understanding and recognition of an emotion by an individual can be perceptually changed due to the emotion words used (Gendron et al., 2012). Even so, there are many potential advantages of this technique in the food and beverage industry when coupled with other emotion measures or traditional sensory methods.

Nonverbal (implicit) emotional collection methods and responses

Nonverbal techniques for measuring consumer emotional responses are comprised of two different components: physiological and expressive reactions (Desmet, 2004).

Many physiological reactions are associated with emotional states and can include a variety of measures. These can include changes in heart rate, brain waves and skin responses (coloration, temperature changes and/or moisture production), which are all measured by appropriate instruments designed for the mechanism being observed. Facial movements, changes in posture and/or vocal changes (volume, pitch, etc) make up the various categorical expressive changes that can potentially take place or be observed during an experiment.

Measuring (ANS) brain responses

The cognitive and autonomic brain mechanisms involved in the emotional responses have long been of interest to neuroscientists, behavioral, and sensory scientists (Garrett, 2014). The neural basis for emotional processing elicited from various stimuli (visual, auditory, taste, etc.) has been studied extensively using positron emission tomography (PET) and functional magnetic resonance imaging (fMRI) methods (Damasio, Grabowski, Bechara, Damasio, Ponto, Parvizi, & Hichwa, 2000; Phan, Wager, Taylor, & Liberzon, 2002). It has been proposed that several brain regions including the cortical, limbic, and paralimbic are involved emotional processing of various stimuli (Garrett, 2014; McGinley, 2014; Phan, et al., 2002) and that specific areas have specialized functions for emotional input processing and emotional responses (Bush, Luu, & Posner, 2000; Reed, et al., 2006; Rolls, 2000). Brain areas included in this general belief are the amydala, anterior cingulate cortex, hippocampus, hypothalamus, prefrontal cortex, orbitofrontal cortex, and somatosensory cortex (Bush et al., 2000; Garrett, 2014; Phan et al., 2002; Rolls, 2000).

Several psychological studies have suggested that brain lateralization plays a role in emotional processing and response (Alves, Fukusima, & Aznar-Casanova, 2008; Garrett, 2014; Heller, Nitschke, & Miller, 1998; Tomarken, Davidson, & Henriques, 1990); two models of emotional processing in the brain have been proposed. The right hemisphere hypothesis states that the left hemisphere is solely involved in cognition and associated processes while the right hemisphere is associated with emotions (Alves et al., 2008; Garrett, 2014; Heller et al., 1998). Two additional hypotheses, known as the negative/positive model and approach/withdrawal model, evolved after several psychiatric studies revealed that damages to one hemisphere resulted in different affect responses (Alves et al., 2008; Davidson, Ekman, Saron, Senulis, & Friesen, 1990). The two models are very similar; however differences exist in relation to the classification of emotions (Alves et al., 2008). The positive/negative groups emotions based on valence (positive emotions: happy and surprise; negative: anger, disgust, fear and sadness). The approach/withdrawal model categorizes emotions based on behavioral motivations driving the individual towards or away from a stimulus (Alves et al., 2008; Davidson et al., 1990). Approach emotions include anger, happy and surprise; withdrawal emotions include disgust, fear and sadness. Both models, positive/negative and approach/withdrawal, were used to interpret emotional response to taste stimuli.

In relation to basic tastes and food stimuli, several researchers have started investigating the relationship between ANS responses, perceived emotion and hedonic liking. Rousmans, Robin, Dittmar and Vernet-Maury (2000), found that differentiated autonomic responses were associated with the hedonic value of each basic taste. Sweet taste, associated with pleasant affective responses, was found to elicit the weakest responses of all taste stimuli (Rousmans et al., 2000). One group of researchers proposed that the weak ANS responses associated with sweet taste merely reflected habitual use or preference for sweet rather than a lack of pleasure or response (Leterme, Brun, Dittmar, & Robin, 2008). This interpretation is supported using the psychological perspective that emotions are motivational forces to maintain homeostasis within an individual (McGinley, 2014). More recently, scientists have started using autonomic nervous system responses in conjunction with other measures, such as facial expressions in order to assess the predictive nature of emotions on hedonic liking.

Measuring facial expressions

Due to the variation of definitions and overall number of basic emotions, several different nonverbal facial expression systems have developed over the years. However, one thing that all of the methods have in common is that specific facial expressions or movements are linked to one or more emotions (Ekman, 1994). Two separate behavioral researchers, Ekman and Izard, laid the groundwork for facial expression methodology to take place. The two most well-known facial expression measurement systems developed in the late 1970's include the Facial Action Coding System (FACS; Ekman & Friesen, 1978) and the Maximally Discriminative Facial Moving Coding System (MAX; Izard, 1979). The main differences between Ekman & Friesen's FACS and Izard's MAX are based upon the selectivity of the program (Ekman & Rosenberg, 2005). FACS is an observational system that measures all visible facial movement and classifies those movements according to a baseline of 44 action units. Each of the 44 unique action units is associated with a specific number, which then encodes for a specific muscle movement; examples include "lip bite," "lip corner pulled," "brow lowered," etc.

Whereas FACS captures virtually all facial movements, MAX captures only those facial movements that have been pre-selected as being indicative of or associated with a specified emotion.

Using FACS, several researchers have investigated the correlation between specific action units and associated emotion with affect (degree of pleasantness) to a stimulus. In one study, researchers Kohler, Turner, Stolar, Bilker, Brensinger, Gur, & Gur (2004) found that four basic emotions (happy, sad, angry and scared) were associated with characteristic patterns of action units. Degree of association was assessed based on frequency of expression (Kohler et al., 2004). Wendin, Allesen-Holm & Bredie (2011) assessed the interpretation of pleasantness and emotions from facial expressions using varying basic taste intensities. Results supported other findings suggesting that facial expressions may aid in identification and differentiation of liking among varying taste stimuli (Wendin et al., 2011). The impact of facial expression stimuli on pleasantness ratings and emotional response in adults has also been studied (Greimel et al., 2006). Results suggested that while induced facial expressions were not indicative of emotion response reactions, they were predictive of subsequent pleasantness ratings (Greimel et al., 2006).

Advantages of such facial movement systems include the ability for observations to be completely independent of language and the participants' emotional self-assessment. Gaps with the technology of these programs in the past included a limited number of readily available/affiliated basic emotions as well as a failure to report mixed emotions. Another limitation includes the extensive time commitment for researchers to become trained and adjust to using the program in general. As such, while facial expression software programs have continued to be developed for applications in other industries such as security, education, robotics and observing autism patients among other things, applications for the food industry were put on hold until recently.

Automated facial expression analysis (AFEA)

Currently there are several commercially available automated facial expression analysis (AFEA) software programs, which include Affdex (Affectiva, Inc., Waltham, MA), Computer Expression Recognition Toolbox (CERT; Emotient, Inc., San Diego, CA), FaceReader (Noldus Information Technology Institute, The Netherlands), nViso (nViso, SA, Lausanne, Switzerland) and PrEMO (SusaGroup). PrEMO is slightly different from the other programs in that it allows consumers to characterize their own (basic or combination of) emotions using images and animations as opposed to words (How does PrEMO work?, 2014). All of the other programs are founded on Ekman's facial action coding system (FACS) and use 3-dimensional facial imaging capture changes in emotion via expression through real time (Affectiva, 2013; Noldus, 2010; nViso, 2011). The CERT program created by Emotient also has the option for researchers to integrate measures for eye tracking, EEG, and survey questions (Computer expression recognition toolbox, 2014). Potential food industry applications of these programs include interpreting emotional responses evoked by food stimuli. The fully automated approach addresses time constraint limitations associated with original methods interpreting facial expressions, such as FACS. This technology has the potential to change sensory evaluation techniques in the entire field of food science. FaceReader, version 5, was used for the experiments later described; as such this will be the only AFEA program discussed in depth for the purpose of this literature review.

FaceReader™ was first developed and released in 2001 by Noldus (Noldus Information Technology, Wageningen, The Netherlands); it was created to measure facial expression changes based off of the FACS system to observe and interpret emotional responses (Cohn & Sayette, 2010). The program essentially works by tracking the movements of over 491 points on the human face and assigning an emotional response (in the form of one out of seven possible emotion choices including happy, sad, angry, surprised, scared, disgusted and neutral) for a designated time period (Noldus Information Technology, 2010). FaceReader addresses the failure of FACS to adequately report mixed emotion and several emotional states can, in fact, be recorded.

In spite of its development, very few studies have investigated the use of FaceReader when interpreting emotional responses to food stimuli (Danner, Haindl, Joechl, & Duerrschmid, 2014; Danner, Sidorkina, Joechl, & Duerrschmid, 2013; De Wijk, He, Mensink, Verhoeven, & de Graaf, 2014; De Wijk, Kooijman, Verhoeven, Holthuysen, & de Graaf, 2012; Garcia-Burgos & Zamora, 2013). Of the few studies that have used AFEA, no apparent protocols for interpreting emotions or participant responses evoked by foods exist. In previous studies using FaceReader or other AFEA programs, individual variation of emotional responses have been identified but not sufficiently explained or accounted for in calibration settings.

Little research has been performed on the potential functionality of FaceReader in consumer sensory testing (Lewinski, den Uyl, & Butler, 2014). However numerous limitations regarding the software sensitivity and accurate capture and interpretation of emotions exist. Of these, ability of the software to recognize a face based on individual position and environmental settings such as lighting have been identified (Fasel &

Luettin, 2003). Occlusion of the face via glasses and/or facial hair has also been proposed as limiting (Arnade, 2013). The impact of consumer expectations related to specific ingredients and/or product information on emotions has yet to be investigated.

References

Affectiva. (2013). "*Exploring the emotion classifiers behind affdex facial coding.*" (White paper). Affective, Inc. Retrieved from http://www.affectiva.com/wp-content/uploads/2014/09/Whitepaper___Exploring_Affdex_Classifiers.pdf. Last accessed February 2015.

Alpert, P.T. (2014). Imposter foods. *Home Health Care Management & Practice, 25*(1), 29-31.

Alves, N.T., Fukusima, S.S., Aznar-Casanova, J.A. (2008). Models of brain asymmetry in emotional processing. *Psychology & Neuroscience, 1*(1), 63-66.

Anonymous. The Functional Properties of Sugar. (2009). Nordic Sugar [Brochure].

American Dietetic Association (ADA), (2004). Position of the American Dietetic Association: Use of Nutritive and Nonnutritive Sweeteners. *Journal of the American Dietetic Association, 104*(2), 255-275.

Arnade, E.A. (2013). Measuring consumer emotional response to tastes and foods through facial expression analysis. Master's Thesis (Major Professor: S.E. Duncan), Virginia Polytechnic Institute and State University, Blacksburg, VA.

Balentine, D.A., Wiseman, S.A. & Bouwens, L.C.M. (1997). The chemistry of tea flavonoids. *Critical Reviews in Food Science and Nutrition*, 37(8), 693-704.

Barr, R. G., Pantel, M. S., Young, S. N., Wright, J. H., Hendricks, L. A., & Gravel, R. (1999). The response of crying newborns to sucrose: Is it a "sweetness" effect?. *Physiology & Behavior*, *66*(3), 409-417.

Baumeister, R. F., DeWall, C. N., Vohs, K. D., & Alquist, J. L. (2010). Does emotion cause behavior (apart from making people do stupid, destructive things). In C.R. Agnew, D.E. Carlston, W.G. Graziano, & J.R. Kelly (Eds.), *Then a Miracle Occurs: Focusing on Behavior in Social Psychological Theory and Research* (pp. 12-27). New York: Oxford University Press.

Birch, G.G. (1987). Sweetness and sweeteners. *Endeavour, 11*(1), 21-24.

Bogdanov, S., Jurendic, T., Sieber, R., & Gallmann, P. (2008). Honey for nutrition and health: A Review. *Journal of the American College of Nutrition, 27*(6), 677-689.

Borra, S.T., & Bouchoux, A. (2009). Effects of science and the media on consumer perceptions about dietary sugars. *The Journal of Nutrition*, *139*(6), 1214S-1218S.

Boush, D. M. (1993). How advertising slogans can prime evaluations of brand extensions. *Psychology & Marketing*, *10*(1), 67-78.

Bray, G. A., Nielsen, S. J., & Popkin, B. M. (2004). Consumption of high-fructose corn syrup in beverages may play a role in the epidemic of obesity. *The American Journal of Clinical Nutrition*, *79*(4), 537-543.

Bush, G., Luu, P., & Posner, M.I. (2000). Cognitive and emotional influences in anterior cingulate cortex. *Trends in Cognitive Sciences*, *4*(6), 215-222.

Canetti, L., Bachar, E., & Berry, E. M. (2002). Food and emotion. *Behavioural Processes*, *60*(2), 157-164.

Cardello, A. V. (1994). Consumer expectations and their role in food acceptance. In *Measurement of Food Preferences* (pp. 253-297). Springer US.

Cardello, A. V., Meiselman, H. L., Schutz, H. G., Craig, C., Given, Z., Lesher, L. L., & Eicher, S. (2012). Measuring emotional responses to foods and food names using questionnaires. *Food Quality and Preference*, *24*(2), 243-250.

Cardello, A. V., & Sawyer, F. M. (1992). Effects of disconfirmed consumer expectations on food acceptability. *Journal of Sensory Studies*, *7*(4), 253-277.

Carlsmith, J. M., & Aronson, E. (1963). Some hedonic consequences of the confirmation and disconfirmation of expectances. *The Journal of Abnormal and Social Psychology*, *66*(2), 151-156.

Cawley, J., Avery, R., & Eisenberg, M. (2011). *The effect of advertising and deceptive advertising on consumption: the case of over-the-counter weight loss products*. Working Paper. 2011 http://www. iza. org/conference_files/riskonomics2011/cawley_j6697. pdf. Last accessed February 2015.

Centers for Disease Control and Prevention, CDC (2012). Nutrition for everyone: basics: Carbohydrates [Fact Sheet]. Retrieved from http://www.cdc.gov/nutrition/everyone/basics/carbs.html. Last accessed February 2015.

Centers for Disease Control and Prevention, CDC (2014). Overweight and obesity [Fact Sheet]. Retrieved from http://www.cdc.gov/obesity/data/facts.html. Accessed on January 5, 2015.

Chandrashekar, J., Hoon, M. A., Ryba, N. J., & Zuker, C. S. (2006). The receptors and cells for mammalian taste. *Nature*, *444*(7117), 288-294.

Cogent Research, LLC (Cambridge, MA). 2006. High fructose corn syrup: consumer communications. Report and at-a-glance executive summary. Washington (DC): International Food Information Council (IFIC).

Chrea, C., Grandjean, D., Delplanque, S., Cayeux, I., Le Calvé, B., Aymard, L., Velazco, M.I., Sander, D., & Scherer, K. R. (2009). Mapping the semantic space for the subjective experience of emotional responses to odors. *Chemical Senses*, *34*(1), 49-62.

Cohen, J. B., Pham, M. T., & Andrade, E. B. (2008). The nature and role of affect in consumer behavior.In C.P. Haugtvedt, P. Herr, & F. Kardes (Eds.). *Handbook of Consumer Psychology* (pp. 1-80). Sussex, UK: Psychology Press.

Cohn, J.F. & Sayette, M.A. (2010). Spontaneous facial expression in a small group can be automatically measured: An initial demonstration. *Psychonomic Society Publications*, 42(4), 1079-1086.

Computer Expression Recognition Toolbox (CERT). (2014). Retrieved from http://www.emotient.com/cert.

Coon, K. A., Goldberg, J., Rogers, B. L., & Tucker, K. L. (2001). Relationships between use of television during meals and children's food consumption patterns. *Pediatrics*, *107*(1), e7-e7.

Cox, D.F. (1967). The sorting rule model of the consumer product evaluation process. *Risk Taking and Information Handling in Consumer Behavior* (pp.324-368). Boston: Harvard University.

Cronley, M. L., Kardes, F. R., & Hawkins, S. A. (2006). The illusory truth effect: exploring implicit and explicit memory influences on consumer judgments. *Advances in Consumer Research*, *33*, 247.

Damasio, A. R., Grabowski, T. J., Bechara, A., Damasio, H., Ponto, L. L., Parvizi, J., & Hichwa, R. D. (2000). Subcortical and cortical brain activity during the feeling of self-generated emotions. *Nature Neuroscience*, *3*(10), 1049-1056.

Danner, L., Haindl, S., Joechl, M., & Duerrschmid, K. (2014). Facial expressions and autonomous nervous system responses elicited by tasting different juices. *Food Research International*, *64*(2014), 81-90.

Danner, L., Sidorkina, L., Joechl, M., Duerrschmid, K. (2013). Make a face! Implicit and explicit measurement of facial expressions elicited by orange juices using face reading technology. *Food Quality and Preference*, *32*(Part B),167-172.

Davidson, R.J., Ekman, P., Saron, C.D., Senulis, J.A., & Friesen, W.V. (1990). Approach-withdrawal and cerebral asymmetry: emotional expression and brain physiology I. *Journal of Personality and Social Psychology*, *58*(2), 330-341.

De Graaf, C. & Zandstra, E.H. (1999). Sweetness intensity and pleasantness in children, adolescents, and adults. *Physiology & Behavior*, *67*(4), 513-520.

Deliza, R., & MacFie, H. J. (1996). The generation of sensory expectation by external cues and its effect on sensory perception and hedonic ratings: a review. *Journal of Sensory Studies*, *11*(2), 103-128.

Dennis, E.A., Flack, K.D., & Davy, B.M. (2009). Beverage consumption and adult weight management: A review. *Eating Behaviors, 10*(4), 237-246.

Desmet, P. (2004). Measuring emotion: Development and application of an instrument to measure emotional responses to products. In: M.A. Blythe, K. Overbeeke, A. Monk, P.C. Wright(Ed.), *Funology: From Usability to Enjoyment* (pp. 111-124). Netherlands: Kluwer Academic Publishers.

Desmet, P. M., & Schifferstein, H. N. (2008). Sources of positive and negative emotions in food experience. *Appetite*, *50*(2), 290-301.

Devcich, D.A., Pedersen, I.K., & Petrie, K.J. (2007). You eat what you are: Modern health worries and the acceptance of natural and synthetic additives in functional foods. *Appetite,* 48(3), 333-337.

De Wijk, R. A., He, W., Mensink, M. G., Verhoeven, R. H., & de Graaf, C. (2014). ANS responses and facial expressions differentiate between the taste of commercial breakfast drinks. *Plos One*, *9*(4), e93823.

De Wijk, R.A., Kooijman, V., Verhoeven, R.H.G., Holthuysen, N.T.E., & de Graaf, C. (2012). Autonomic nervous system responses on and facial expressions to the sight, smell and taste of liked and disliked foods. *Food Quality and Preference, 26*(2), 196-203.

Dickson-Spillmann, M., Siegrist, M., & Keller, C. (2011). Attitudes toward chemicals are associated with preference for natural food. *Food Quality and Preference*, *22*(1), 149-156.

Drewnowski, A. (1997). Taste preferences and food intake. *Annual Review of Nutrition*, *17*(1), 237-253.

Duffey, K.J. & Popkin, B.M. (2008). High-fructose corn syrup: is this what's for dinner? *American Journal of Clinical Nutrition,88*(6), 1722S-1732S.

Ekman, P. 1994. Strong evidence for universals in facial expressions: A reply to Russell's mistaken critique. *Psychological Bulletin, 115*(2), 268-287.

Ekman, P. & Friesen, W.V. (1978). *Facial Action Coding System: A technique for the Measurement of Facial Movement.* Palo Alto: Consulting Psychologist Press.

Ekman, P., Rosenberg, E.L. (2005). *What the Face Reveals: Basic and Applied Studies of Spontaneous Expression Using the Facial Action Coding System (FACS).* 2nd edition. Oxford: Oxford University Press. 639 p.

Fasel, B., & Luettin, J. (2003). Automatic facial expression analysis: a survey. *Pattern Recognition*, *36*(1), 259-275.

Feder, D. (2012). How sweet it is. *Prepared Foods*, 61-73.

Fischer, R., Griffin, F., England, S., & Garn, S.M. (1961). Taste thresholds and food dislikes. *Nature*, *191*,1328.

Frank, G. K., Oberndorfer, T. A., Simmons, A. N., Paulus, M. P., Fudge, J. L., Yang, T. T., & Kaye, W. H. (2008). Sucrose activates human taste pathways differently from artificial sweetener. *Neuroimage, 39*(4), 1559-1569.

Garcia-Burgos, D., & Zamora, M. C. (2013). Facial affective reactions to bitter-tasting foods and body mass index in adults. *Appetite*, *71*, 178-186.

Garrett, B. (2014). *Brain & Behavior: An Introduction to Biological Psychology*. Thousand Oaks, California: Sage Publications.

Gendron, M. & Barrett, L.F. (2009). Reconstructing the past: a century of ideas about emotion in psychology. *Emotion Review*, *1*(4), 316-339.

Gendron, M., Lindquist, K. A., Barsalou, L., & Barrett, L. F. (2012). Emotion words shape emotion percepts. *Emotion*, *12*(2), 314-325.

Gibson, E.L. (2006). Emotional influences on food choice: sensory, physiological and psychological pathways. *Physiology and Behavior, 89*(1), 53-61.

Green, E., & Murphy, C. (2012). Altered processing of sweet taste in the brain of diet soda drinkers. *Physiology & Behavior, 107*(4), 560-567.

Greimel, E., Macht, M., Krumhuber, E., & Ellgring, H. (2006). Facial and affective reactions to tastes and their modulation by sadness and joy. *Physiology & Behavior, 89* (2), 261-269.

Grunert, K. G. (1986). Cognitive determinants of attribute information usage. *Journal of Economic Psychology*, *7*(1), 95-124.

Grunert, K.G. (2002). Current issues in the understanding of consumer food choice. *Trends in Food Science & Technology, 13*(8), 275-285.

Haley, S., Reed, J., Lin, B-H., & Cook, A. (August 2005). Sweetener consumption in the United States. [Electronic Outlook Report]. Washington (DC): United States Department of Agriculture (USDA).

Han, E. & Powell, L.M. (2013). Consumption patterns of sugar sweetened beverages in the United States. *Journal of the Academy of Nutrition and Dietetics, 113*(1), 43-53.

Harris, J. L., Bargh, J. A., & Brownell, K. D. (2009). Priming effects of television food advertising on eating behavior. *Health Psychology*, *28*(4), 404-413.

Hawkins, S. A., & Hoch, S. J. (1992). Low-involvement learning: Memory without evaluation. *Journal of Consumer Research*, 212-225.

Hazen, C. (2012). Optimizing Flavors and Sweeteners. *Food Product Design, 22*(11), 1-8.

Heller, W., Nitschke, J.B., Miller, G.A. (1998). Lateralization in emotion and emotional disorders. *Current Directions in Psychological Science*, *7*(1), 26-32.

Himmelspach, J., Berry, D., Foster, R.J., Gan, R., & Decker, K. (2012). Sweeteners for the future. *Food Product Design, 22*(3), 6-39.

Hoegg, J. & Alba, J.W. (2007). Taste perception: more than meets the tongue. *Journal of Consumer Research, 33*(4), 490-498.

How does PrEMO work? (2014, November 23). Retrieved from http://www.susagroup.com/tools-to-measure-emotions/premo/.

Hovland, C. I., Harvey, O. J., & Sherif, M. (1957). Assimilation and contrast effects in reactions to communication and attitude change. *The Journal of Abnormal and Social Psychology*, *55*(2), 244-252.

International Food Information Council Foundation (IFIC). (May 2013). [Survey of consumer attitudes toward food safety, nutrition & health]. Retrieved September 26, 2014, from the International Food Information Council Foundation website: http://www.foodinsight.org/articles/2013-food-and-health-survey.

International Food Information Council (IFIC) and U.S. Food and Drug Administration. (2010). *Food Ingredients and Colors* [Fact Sheet]. Retrieved from: http://www.fda.gov/food/foodingredientspackaging/ucm094211.htm. Last accessed February 2015.

Izard, C.E. (2007). Basic emotions, natural kinds, emotion schemas and a new paradigm. *Perspectives on Psychological Science, 3*(2), 260-280.

Izard, C.E. (1979). *The Maximally Discriminative Facial Movement Coding System (MAX).* Newark: Instructional Resources Centre, University of Deleware.

Jacoby, J., Olson, J. C., & Haddock, R. A. (1971). Price, brand name, and product composition characteristics as determinants of perceived quality. *Journal of Applied Psychology, 55*(6), 570-579.

King, S.C. & Meiselman, H.L. (2010). Development of a method to measure consumer emotions associated with foods. *Food Quality and Preference, 21*(2), 168-177.

Kinghorn, D.A., Soejarto, D.D., & Inglett, G.E. (1986). Sweetening agents of plant origin. *Critical Reviews in Plant Sciences, 4*(2), 98.

Kissebah, A.H., Freedman, D.S. & Peiris, A.N. (1989). Health risks of obesity. *The Medical Clinics of North America, 73*(1), 111-138.

Klurfeld, D. M., Foreyt, J., Angelopoulos, T. J., & Rippe, J. M. (2013). Lack of evidence for high fructose corn syrup as the cause of the obesity epidemic. *International Journal of Obesity (2005), 37*(6), 771.

Kohler, C.G., Turner, T., Stolar, N.M., Bilker, W.B., Brensinger, C.M., Gur, R.E., Gur, R.C. (2004). Differences in facial expressions of four universal emotions. *Psychiatry Research, 128*(3), 235-244.

Koster, E. P. (2003). The psychology of food choice: some often encountered fallacies. *Food Quality and Preference, 14*(5), 359-373.

Krutulyte, R., Costa, A. I., & Grunert, K. G. (2009). A cross-cultural study of cereal food quality perception. *Journal of Food Products Marketing, 15*(3), 304-323.

Lamote, S., Hermans, D., Baeyens, F., Eelen, P. (2004). An exploration of affective priming as an indirect measure of food attitudes. *Appetite, 42*(3), 279-286.

Lee, C.H. (1975). Intense sweetener from Lo Han Kuo (*Momordica grosvenori). Experientia, 31*(5), 533-534.

Leterme, A., Brun, L., Dittmar, A., & Robin, O. (2008). Autonomic nervous system responses to sweet taste: Evidence for habituation rather than pleasure. *Physiology & Behavior*, *93*(4), 994-999.

Lewinski, P., den Uyl, T. M., & Butler, C. (2014). Automated facial coding: Validation of basic emotions and FACS AUs in FaceReader. *Journal of Neuroscience, Psychology, and Economics, 7*(4), 227-236.

Li, X., Inoue, M., Reed, D.R., Huque, T., Puchalski, R.B., Tordoff, M.G., Ninomiya, Y., Beauchamp, G.K., & Bachmanov, A.A. (2001). High-resolution genetic mapping of the saccharin preference locus (*Sac*) and the putative sweet taste receptor (T1R1) gene (*Gpr70*) to mouse distal Chromosome 4. *Mammalian Genome, 12*(1), 13-16.

Li, X., Li, W., Wang, H., Bayley, D. L., Cao, J., Reed, D. R., Bachmanov, A.A., Huang, L., Legrand-Defretin, V., Beauchamp, G.K., & Brand, J. G. (2006). Cats lack a sweet taste receptor. *The Journal of Nutrition*, *136*(7), 1932S-1934S.

Li, X., Staszewski, L., Xu, H., Durick, K., Zoller, M., & Adler, E. (2002). Human receptors for sweet and umami taste. *Proceedings of the National Academy of Sciences of the United States of America*, *99*(7), 4692-4696.

Lindquist, K. A., Barrett, L. F., Bliss-Moreau, E., & Russell, J. A. (2006). Language and the perception of emotion. *Emotion*, *6*(1), 125-138.

Liu, C., Liu, J., Rong, Y., & Rong, L. (2011). Preparation of productive and highly purified mogrosides from Siraitia grosvenorii. *African Journal of Biotechnology*, *10*(36), 7021-7025.

Macht, M. (2008). How emotions affect eating: a five-way model. *Appetite*, *50*(1), 1-11.

Malik, V.S., Schulze, M.B. & Hu F.B. (2006). Intake of sugar-sweetened beverages and weight gain: a systematic review. *American Journal of Clinical Nutrition*, *84*(2), 274-288.

Mattes, R. D. (1994). Influences on acceptance of bitter foods and beverages. *Physiology & Behavior*, *56*(6), 1229-1236.

Meilgaard M., Civille G.V. & Carr B.T. (2007). *Sensory Evaluation Techniques.* 4^{th} ed. Boca Raton: Taylor & Francis Group, LLC. 448 p.

McGinley, J. (2014). *Emotion* [PowerPoint slides]. Retrieved from https://scholar.vt.edu/portal/site/nsbfall2014. Last accessed: 20 August 2014.

Mitchell, H. (2006). *Sweeteners and Sugar Alternatives in Food Technology*. Oxford: Blackwell Publishing Ltd.

Mogea, J., Seibert, B., Smits, W. (1991). Multipurpose palms: the sugar palm (*Arenga pinnata*). *Agroforestry Systems*, *13*, 111-129.

Mojet, J., Christ-Hazelhof, E., & Heidema, J. (2001). Taste perception with age: generic or specific losses in threshold sensitivity to the five basic tastes?. *Chemical Senses*, *26*(7), 845-860.

Nabors, L.O. (2012). *Alternative Sweeteners.* 4^{th} edition. Boca Raton, FL: CRC Press LLC.

Nakagawa, M., Mizuma, K., & Inui, T. (1996). Changes in taste perception following mental or physical stress. *Chemical Senses*, *21*(2), 195-200.

Narváez-Zapata, J. & Sánchez-Teyer, L. (2009). Agaves as a raw material: recent technologies and applications. *Recent Patent on Biotechnology, 3*(3), 185-191.

National Honey Board. (2005). *Honey Reference Guide* [Fact Sheet]. Date Accessed: October 2012. Retrieved from: http://www.honey.com/images/uploads/general/refguide.pdf.

Nelson, G., Hoon, M. A., Chandrashekar, J., Zhang, Y., Ryba, N. J., & Zuker, C. S. (2001). Mammalian sweet taste receptors. *Cell*, *106*(3), 381-390.

Nie, Y., Vigues, S., Hobbs, J. R., Conn, G. L., & Munger, S. D. (2005). Distinct contributions of T1R2 and T1R3 taste receptor subunits to the detection of sweet stimuli. *Current Biology, 15*(21), 1948-1952.

Nofre, C., Tinti, J. M., & Glaser, D. (1996). Evolution of the sweetness receptor in primates. II. Gustatory responses of non-human primates to nine compounds known to be sweet in man. *Chemical Senses*, *21*(6), 747-762.

Noldus. (2010). "*FaceReader Methodology"* (White paper). Noldus Information Center.

Noldus Information Technology (2012). *FaceReader 5.0™ Reference Manual.* Noldus Information Technology, Wageningen, The Netherlands. Available from http://www.noldus.com. Last accessed October 28, 2014.

Northup, T. (2014). Truth, lies and packaging: how food marketing creates a false sense of health. *Food Studies: An Interdisciplinary Journal, 1*(3), 9-18.

nViso. (2011). "*3D Facial imaging software and emotion."* (White paper). www.nviso.ch/technology.html.

Olds, T., Maher, C., Zumin, S., Péneau, S., Lioret, S., Castetbon, K., de Wilde, J., Hohepa, M., Maddison, R., Lissner, L., Sjoberg, A., Zimmerman, M., Aeberli, I., Ogden, C., Flegal, K., & Summerbell, C. (2011). Evidence that the prevalence of childhood overweight is plateauing: data from nine countries. *International Journal of Pediatric Obesity*, *6*(5-6), 342-360.

Olson, J. C., & Dover, P. A. (1979). Disconfirmation of consumer expectations through product trial. *Journal of Applied psychology*, *64*(2), 179.

Ortony, A., Clore, G.L., & Collins, A. (1988). *The Cognitive Structure of Emotions.* Cambridge: Cambridge University Press. 26 p.

Oz, Dr. (Producer). (2012). *Coconut palm sugar: Best new sugar alternative.* [Web video]. Retrieved from http://www.doctoroz.com/videos/coconut-palm-sugar-best-new-sugar-alternative.

Parker, K., Salas, M., & Nwosu, V. (2010). High fructose corn syrup: Production, uses and public health concerns. *Biotechnology and Molecular Biology Review*, *5*(5), 71-78.

Phan, K.L., Wager, T., Taylor, S.F., & Liberzon, I. (2002). Functional neuroanatomy of emotion: a meta-analysis of emotion activation studies in PET and fMRI. *NeuroImage*, *16*(2), 331-348.

Philippine Food and Nutrition Research Institute. 2000. *Comparison of the elemental content of 3 sources of edible sugar.* [Fact Sheet]. Retrieved from: http://coconutpalmsugar.com/Nutritional_Information.html

Porcherot, C., Delplanque, S., Raviot-Derrien, S., Le Calvé, B., Chrea, C., Gaudreau, N., & Cayeux, I. (2010). How do you feel when you smell this? Optimization of a verbal measurement of odor-elicited emotions. *Food Quality and Preference*, *21*(8), 938-947.

Posner, J., Russell, J.A., & Peterson, B.S. (2005). The circumplex model of affect: an integrative approach to affective neuroscience, cognitive development, and psychopathology. *Development and Psychopathology, 17*(3), 715-734.

Reed, D. R., Tanaka, T., & McDaniel, A. H. (2006). Diverse tastes: Genetics of sweet and bitter perception. *Physiology & Behavior*, *88*(3), 215-226.

Richins, M.L. (1997). Measuring emotions in the consumption experience. *Journal of Consumer Research*, *24* (2), 127-146.

Robbins, S.P., & Judge, T.A. (2013). Emotions and moods. In *Essentials of Organizational Behavior* (pp. 258-297). Upper Saddle River, NJ: Prentice Hall.

Roe, B., Levy, A.S., & Derby, B.M. (1999). The impact of health claims on consumer search and product evaluation outcomes: results from FDA experimental data. *Journal of Public Policy & Marketing*, *18*(1), 89-105.

Rolls, E. T. (2000). On the brain and emotion. *Behavioral and brain sciences*,*23*(02), 219-228.

Rousmans, S., Robin, O., Dittmar, A., & Vernet-Maury, E. (2000). Autonomic nervous system responses associated with primary tastes. *Chemical Senses*, *25*(6), 709-718.

Rozin, P., Ashmore, M., & Markwith, M. (1996). Lay American conceptions of nutrition: dose insensitivity, categorical thinking, contagion, and the monotonic mind. *Health Psychology*, *15*(6), 438-447.

Rozin, P., Spranca, M., Krieger, Z., Neuhaus, R., Surillo, D., Swerdlin, A., & Wood, K. (2004). Preference for natural: instrumental and ideational/moral motivations, and the contrast between foods and medicines. *Appetite*, *43*(2), 147-154.

Rozin, P. & Vollmecke, T.A. (1986). Food likes and dislikes. *Annual Review of Nutrition 6,* 433-456.

Sanderson, G.W., & Graham, H.N. (1973). On the formation of black tea aroma. *Journal of Agricultural Food Chemistry, 21*(4), 576-584.

Scherer, K.R. (2000). Emotion. In M. Hewstone & W. Stroebe (Eds.). *Introduction to Social Psychology: A European Perspective* (3rd ed., pp. 151-191). Oxford: Blackwell.

Schifferstein, H. N., Fenko, A., Desmet, P. M., Labbe, D., & Martin, N. (2013). Influence of package design on the dynamics of multisensory and emotional food experience. *Food Quality and Preference*, *27*(1), 18-25.

Schoenfeld, M. A., Neuer, G., Tempelmann, C., Schüßler, K., Noesselt, T., Hopf, J. M., & Heinze, H. J. (2004). Functional magnetic resonance tomography correlates of taste perception in the human primary taste cortex. *Neuroscience*, *127*(2), 347-353.

Shepherd, R., Sparks, P., Bellier, S., & Raats, M. M. (1992). The effects of information on sensory ratings and preferences: the importance of attitudes.*Food Quality and Preference*, *3*(3), 147-155.

Stein, L. J., Nagai, H., Nakagawa, M., & Beauchamp, G. K. (2003). Effects of repeated exposure and health-related information on hedonic evaluation and acceptance of a bitter beverage. *Appetite*, 40(2003), 119-129.

Steiner, J.E. (1979). Human facial expressions in response to taste and smell stimulation. *Advances in Child Development and Behavior, 22*, 257-295.

Steiner, J.E., Glaser, D., Hawilo, M.E., & Berridge, K.C. (2001). Comparative expression of hedonic impact: affective reactions to taste by human infants and other primates. *Neuroscience and Biobehavioral Reviews*, *25*(1), 53-74.

Stubenitsky, K., Aaron, J. I., Catt, S. L., & Mela, D. J. (1999). Effect of information and extended use on the acceptance of reduced-fat products. *Food Quality and Preference*, *10*(4), 367-376.

Takasaki, M., Konoshima, T., Murata, Y., Sugiura, M., Nishino, H., Tokuda, H., Matsumoto, K., Kasai, R., & Yamasaki, K. (2003). Anticarcinogenic activity of natural sweeteners, cucurbitane glycosides, from *Momordica grosvenori*. *Cancer Letters, 198,* 37-42.

Tea Association of the USA. (2013). Tea Fact Sheet [Fact Sheet]. Retrived from http://www.teausa.com/14655/tea-fact-sheet. Last accessed: 5 Feb 2015.

Tomarken, A. J., Davidson, R. J., & Henriques, J. B. (1990). Resting frontal brain asymmetry predicts affective responses to films. *Journal of Personality and Social Psychology*, *59*(4), 791-801.

Tomasik, P. (2004). *Chemical and Functional Properties of Food Saccharides*. Boca Raton: CRC Press LLC. 426 p.

Tuorila, H., Meiselman, H. L., Bell, R., Cardello, A. V., & Johnson, W. (1994). Role of sensory and cognitive information in the enhancement of certainty and linking for novel and familiar foods. *Appetite*, *23*(3), 231-246.

Tymoczko, J.L., Berg, J.M., & Stryer, L. (2010). *Biochemistry: A Short Course*. 1st ed. New York: W.H. Freeman and Company. 720 p.

United States Department of Agriculture (USDA). (2005). Sweetener consumption in the United States.

van Trijp, H.C.M & van der Lans, I.A. (2007). Consumer perceptions of nutrition and health claims. *Appetite, 48*(3), 305-324.

Wardle, J., Herrera, M. L., Cooke, L., & Gibson, E. L. (2003). Modifying children's food preferences: the effects of exposure and reward on acceptance of an unfamiliar vegetable. *European journal of clinical nutrition*, *57*(2), 341-348.

Wendin, K., Allesen-Holm, B. H., & Bredie, W. L. (2011). Do facial reactions add new dimensions to measuring sensory responses to basic tastes?. *Food quality and preference*, *22*(4), 346-354.

White, J.W. (1978). Honey. *Advances in Food Research, 24*, 287-374.

White, J. (2009). Misconceptions about high-fructose corn syrup: is it uniquely responsible for obesity, reactive dicarbonyl compounds, and advanced glycation endproducts. *The Journal of Nutrition, 139,* 1219-1227.

Whorf, B.L. (1956). *Language, Thought and Reality.* Cambridge, MA: Technology Press of Massachusetts Institute of Technology.

Wiet, S. G., & Beyts, P. K. (1992). Sensory characteristics of sucralose and other high intensity sweeteners. *Journal of Food Science*, *57*(4), 1014-1019.

Woods, A. T., Lloyd, D. M., Kuenzel, J., Poliakoff, E., Dijksterhuis, G. B., & Thomas, A. (2011). Expected taste intensity affects response to sweet drinks in primary taste cortex. *Neuroreport*, *22*(8), 365-369.

Woodward-Lopez, G., Kao, J. & Ritchie, L. (2010). To what extent have sweetened beverages contributed to the obesity epidemic? *Public Health Nutrition, 14*(3), 499-509.

Zajonc, R.B. (1980). *Feeling and Thinking: The Role of Affect in Social Cognition*. Paris: Cambridge University Press.

Zellner, D. A., Stewart, W. F., Rozin, P., & Brown, J. M. (1988). Effect of temperature and expectations on liking for beverages. *Physiology & Behavior*, *44*(1), 61-68.

Zink, D.L. (1997). The impact of consumer demands and trends on food processing. *Emerging Infectious Diseases*, *3*(4), 467-469.

Chapter 3: Determining sweetness equivalency of eight alternative sweeteners to sucrose (Research Note)

Abstract

There are increased public concerns about the relationship between sugar sweetened beverages (SSBs) and the current obesity epidemic in the United States. Consumer attitudes and preferences for artificial or natural sweeteners are driving formulation changes in the beverage industry; however the search for alternative sweetening agents that are naturally derived while still providing fewer calories and meeting taste (sweetness) expectations is challenging. Researchers believe that measuring consumer emotional responses may provide key insights pertaining to behavior and purchasing decisions post-consumption. The purpose of this study was to determine the concentration of each alternative sweetener (n=8) needed to achieve the same perceived sweetness intensity of a 5% sucrose concentration in water. Results from this study served to eliminate potential taste biases concerning sweetness intensity perceptions when collecting acceptance and emotional response data in subsequent research studies (Chapters 4, 5).

Participants (Trial 1: n≥83; Trial 2: n≥74; Trial 3: n=48) evaluated sweetness intensity of eight alternative sweeteners (4 natural; 4 artificial) compared to a 5% sucrose concentration in water via multiple two-sided, forced choice paired comparisons. Testing days (N=5; n=2 for each Trial, except for Trial 3) were divided by sweetener category (natural; artificial). Panelists were instructed to select the sample that they perceived to be "MORE SWEET." Comparisons were analyzed using the chi-squared method for equivalence to sucrose (α=0.05-0.10; β=0.05).

Relative equivalence ($p>0.05$) was found for five (Natural: high fructose corn syrup, honey; Artificial: acesulfame potassium, saccharin, sucralose) of the eight alternative sweeteners. Perceived differences in sweetness intensity between sucrose and the remaining alternatives (aspartame, coconut palm sugar, monk fruit extract) were attributed to flavor profiles and were not used in subsequent studies (Chapters 4, 5) as a result. Four sweeteners (high fructose corn syrup, honey, ace-K & sucralose) with established equivalence were selected for use in the ensuing emotion studies.

Introduction

Sugar sweetened beverages (SSBs) have come under major scrutiny in the United States over the past few years as a result of the linkage between consumption and increased health risks including obesity, type 2 diabetes, and cardiovascular diseases among adolescents and adults (Dennis, Flack & Davy, 2009; Malik, Popkin, Bray, Després, Willett & Hu, 2010; Malik, Schulze & Hu, 2006; Wang, Bleich & Gortmaker, 2008). These beverages contain natural, energy-providing sweeteners such as sucrose, high fructose corn syrup or fruit juice concentrates. Honey and high fructose corn syrup (HFCS) are probably the two most widely recognized naturally-derived sweeteners in the industry; honey is one of the oldest sweeteners in the world (Bogdanov, Jurendic, Sieber, & Gallmann, 2008) and HFCS is one of the most frequently used in the beverage industry (White, 2008). With that being said, one major disadvantage of using HFCS currently is the negative perception in the media and among consumers (Parker, Salas, & Nwosu, 2010; Anonymous, 2012). Recently, government legislation limiting the sale of sugary beverages exceeding 16 ounces in addition to new taxation laws have been implemented as a means of reducing overall consumption and increasing health (Grynbaum, 2012;DeLauro, 2014).

Common alternative (aka “high-intensity,” “artificial” and “non-nutritive”) sweeteners, including acesulfame potassium (ace-K), aspartame (asp), saccharin (sac), and sucralose (sucral), have been used in the industry as a means of reducing the overall intake of calorie-rich beverages. One major advantage of artificial sweeteners is that they are non-nutritive due to their high sweetness intensities and therefore contribute no additional energy to a consumer. Major disadvantages include off-flavors, especially a lingering and/or bitter aftertaste, which is associated with many artificial sweeteners including aspartame, ace-K, and saccharin (Mitchell, 2006; Nabors, 2012; Wiet & Beyts, 1992). Other disadvantages include health concerns and public misconceptions about the safety of using artificial sweeteners as additives in food products (Devcich, Pedersen & Petrie, 2007; Dickson-Spillmann, Siegrist & Keller, 2011; Grenby, 1991; Rozin, Spranca, Krieger, Neuhaus, Surillo, & Swerdlin, 2004).

Sucrose has always been the standard to which all new sweeteners are compared due to many of its qualities and applications in the food and beverage industry (Nabors, 2012). Human taste receptors recognize all sweeteners in the same manner, regardless of whether they are artificially or naturally derived (Birch, 1987; Nelson, Hoon, Chandrashekar, Zhang, Ryba & Zuker, 2001; Li, Inoue, Reed, Huque, Puchalski, Tordoff, Ninomiya, Beauchamp, & Bachmanov, 2001; Li, Staszewski, Xu, Durick, Zoller & Adler, 2002). Numerous studies have determined the sweetness intensities and investigated the qualities of most alternative sweeteners (both artificial and natural) as they compare to sucrose in food and beverage systems (Moraes, Barbosa, Bolini, &

Andre, 2010; Tunaley, Thomson, & McEwan, 1987). As a result, developers are left with many options when choosing the optimal sweetener for a product; consumer taste preferences and perceptions about specific sweeteners often become the deciding factor.

Some researchers studying the gustatory (taste) processing of natural and artificial sweeteners in the brain have suggested that the reward system between the two (natural *v* artificial) stimuli is different (Green & Murphy, 2012). Evidence from these studies may have implications for the emotional response of participants who regularly consume diet beverages versus those who do not. The purpose of this study was to determine the concentration of each alternative sweetener (n=8) needed to achieve the same perceived sweetness intensity of a 5% sucrose concentration in water. Results from this study served to eliminate potential taste biases concerning sweetness intensity perceptions when collecting acceptance and emotional response data in subsequent research studies.

Materials and Methods

Samples & sample preparation

Sweetener-water solutions were prepared approximately 24 hours prior to testing. A 5% (w/w) sucrose in water solution was chosen based on the Sensory Spectrum and Hill Top Research taste Intensity Scale for Descriptive Analysis (Meilgaard, Civille, & Carr, 2007). Concentrations for each of the all-natural and artificial sweeteners were initially chosen based on sweetness equivalency values determined in the literature (Table 1). The all-natural sweeteners chosen for this experiment included coconut palm sugar (Big Tree Farms; Ashland, OR), high fructose corn syrup (HFCS; Tate & Lyle;

London, UK), honey (Kroger brand, Cincinnati, OH) and monk fruit extract (Tate & Lyle; London, UK). The artificial sweeteners chosen for this experiment included acesulfame potassium (ace-k; Wego Chemical & Mineral Co.; Great Neck, NY), aspartame (Wego Chemical & Mineral Co.; Great Neck, NY), saccharin (Sweet ‘N Low; Kroger; Cincinnati, OH) and sucralose (Tate & Lyle; London, UK). Specific characteristics of each sweetener (ace-K, aspartame, coconut palm sugar, high fructose corn syrup, monk fruit extract & sucralose) based on ingredient profile sheets are shown in the appendix (Appendix D, Figures 1-6).

Each sweetener was weighed using a food grade scale and then thoroughly mixed with distilled water (w/w) (Kroger brand, Cincinnati, OH) in a large pot. All-natural sweetener solutions (except Monk fruit extract) were gently heated on a stovetop with stirring to ensure thorough mixing, while the artificial sweeteners were mixed at room temperature. After sweetener solutions were completely dissolved, solutions were transferred to a large pitcher and carefully poured into several labeled wine bottles (750 mL each). Samples were capped with pourers, which dispense one ounce aliquots, and stored in a refrigerator (4 °C) overnight. On the morning of each testing day, sweetener solutions were allowed to reach room temperature in order to ensure temperature uniformity across samples. Prior to testing, sweetener-water solutions (approximately 1-ounce each; 30 mL) were poured into 2-ounce sample cups labeled with randomly selected 3-digit codes, which were used to identify treatments.

Table 3-1. Calculated equi-sweet concentrations of alternative sweeteners[1] to sucrose.

Category	**Sweetener**	**Determined Equi-sweet Concentration (g/mL)**
Control	Sucrose	0.05
Natural	Coconut Palm Sugar	-
	High fructose corn syrup (42%)	0.085
	Honey	0.062
	Monk fruit extract	-
Artificial	Acesulfame potassium	2.6×10^{-4}
	Aspartame	-
	Saccharin	3.7×10^{-3}
	Sucralose	9.5×10^{-5}

(n=85 for all natural trial 1; n=83 for artificial trial 1) (n=85 for all natural trial 2; n=74 for artificial trial 2) (n=48 for trial 3); [1]Sweeteners grouped based on category (natural; artificial)

Participant recruitment

Virginia Tech (VT) Institutional Review Board (IRB) approval (IRB #12-792)(Appendix A) was obtained prior to executing sensory testing of sweetness equivalency using human subjects. Participant recruitment methods included advertising on the VT news notices and calendar, emailing over several listservs and through word of mouth. Individuals from the local community as well as students, faculty and staff at Virginia Tech were invited to participate if they were at least 18 years of age and had no known allergies or sensitivities to the artificial or natural sweeteners being used. More specifically, individuals with phenylketonuria (PKU), sensitivities to sulfonamides or individuals with a cold were asked not to participate. Participants were asked to complete an online demographic survey (Appendix C-1), which also included questions surrounding their attitudes, preferences and usage of specific sweeteners and tea (Appendix C-2).

Two trials were initially conducted within two weeks of each other; a third trial (one test per day) was conducted a few months later to refine sweetness equivalence to sucrose for one sweetener (HFCS). Each trial had two testing days (one for natural sweeteners; one for artificial sweeteners) in order to limit the number of samples and avoid sensory fatigue. Between forty-five and eighty individuals (Trial 1: n=85 for all natural testing; n=83 for artificial testing; Trial 2: n=85 for all natural testing; n=74 for artificial testing; Trial 3: n=48) participated on each testing day in the Sensory Evaluation Laboratory in the Food Science Building on campus at Virginia Tech.

Experimental trials, testing environment & data collection

A two-sided, forced-choice paired comparison sensory test was conducted for the sweetness equivalency study. Each alternative sweetener was compared to a sucrose sample in order to determine which sample was 'MORE sweet.' Sensory Information Management System (SIMS; Sensory Computer Systems, Berkeley Heights, New Jersey) software program was used to develop the test design, balanced order of presentation across panelists, and sequence of sample sets to each panelist. Participants were presented with four sets of two samples for the first trial and three sets of two samples during the second trial (two testing days per trial; 4 days total). The third trial contained two sample sets, both containing sucrose and high fructose corn syrup (low and high concentration). Sample order was balanced within each pair across panelists; order of sample sets was randomized across panelists so that each pair of samples was presented in each position (set 1, 2, 3, or 4) an equal number of times.

At the beginning of each test day, each participant was directed to a booth in the sensory evaluation laboratory (Food Science Building, Rm 127; Virginia Tech) and given a consent form (Appendix B) to review and sign. After consent was received, 3-digit coded samples (sets of 2 samples) were presented to the participant in a balanced incomplete block design. Red lighting was used to minimize visible color differences from the alternative sweeteners. Participants were directed to taste and evaluate the sweetness intensity of each set of paired sweetener solutions. Each paired sample set included one sample of an all-natural (testing day 1) or artificial sweetener (testing day 2) solution compared to that of a sucrose solution (5%). Panelists were directed to taste samples from left to right, taking a sip of water between samples and then identify which sample was MORE SWEET on the touch screen monitor. Between each sample set, participants were encouraged to take a bite of unsalted crackers (Kroger brand, Cincinnati, OH) and rinse their mouth with water in order to cleanse the palate.

Panelist compensation was estimated at $2 for trial 1, provided as snack foods as an expression of gratitude for participation. For the second and third trials, participants had the alternate option to donate $2 worth of shelf stable food in lieu of a snack, purchased by the sensory evaluation laboratory, to the local food bank in Christiansburg, VA.

Statistical analysis

The project and test objectives were to establish that relatively no difference in sweetness intensity existed between 5% sucrose and each of the alternative sweeteners (similarity testing) with the expectation that results for each comparison would show no significant difference ($p>0.05$). The initial statistical parameters chosen for this test were as follows: $n = 120$, α-level = 0.10, β-level = 0.05, $\rho_{max} = 65\%$; however, adjustments were made to allow for a smaller population in each trial (i.e. Trial 1: $n=86$; $\alpha = 0.05$, $\beta =$

0.05 and ρ_{max} = 70%). Sweetener intensity results from each testing day (sweetener category) and trial (n=3) was collected from the SIMS software database and stored on a password protected external thumb drive. Immediately following data collection, the results were analyzed using Chi-squared (Microsoft Excel, Redmond, WA) to determine whether differences ($p<0.05$) existed between the concentrations selected for each alternative sweetener and sucrose (5% w/w) in water.

Results and Discussion

Trial 1: Establishing equivalence for Ace-K & Honey

A lower number of panelists (n=84) completed the first trial than the target (n=120) for the set statistical parameters (α-level = 0.10, β-level = 0.05, ρ_{max} = 65%). In order to control for type I & II errors in the analysis, we adjusted the proportion of discriminators from 65% to 70% (n=86; α = 0.05, β = 0.05 and ρ_{max} = 70%). Results for the first trial established that the initial concentrations chosen for acesulfame potassium (Ace-K; p=0.15) and honey (p=0.82) were relatively equivalent ($p>0.05$) in perceived sweetness to a 5% sucrose concentration in water (Table 2). Ace-K and honey were removed from their respective sample sets for the second trial in order to reduce the number of paired comparisons each panelist was expected to evaluate. Results for the coconut palm sugar and sucrose comparison showed that perceived sweetness was almost relatively equivalent (p=0.056). The calculated p-value was very close to approached significance and therefore, ‘achieved’ equivalence was not accepted (Table 2). In contrast to the other alternatives, little to no research has been conducted on the sweetness intensity and/or the flavor profile of coconut palm sugar when compared to sucrose in a beverage application. As such, the significant difference in sweetness intensity was not completely unexpected.

Concentrations for the remaining sweeteners were not equivalent to sucrose based on the outcomes of the first trial (panelists were able to detect differences in sweetness intensity) and were therefore adjusted appropriately based on the directionality of the responses. On the natural sweetness intensity testing day, high fructose corn syrup (HFCS) was significantly less sweet than sucrose and Monk fruit extract (MFE) was perceived as being significantly sweeter than sucrose (Table 2). On the artificial sweetness intensity day, aspartame (Asp) and sucralose (Sucral) were significantly sweeter than sucrose; saccharin (Sac) was significantly less sweet than sucrose (Table 2).

It was unexpected to find differences in perceived sweetness intensity between sucrose and some of the alternative sweeteners (HFCS, aspartame, saccharin & sucralose) due to the extensive body of research work completed in this area showing established equi-sweet concentrations in various liquid solutions (Mitchell, 2006; Nabors, 2012; Wiet & Beyts, 1992). Saccharin, however, was purchased from a local supermarket in the form of Sweet 'N Low, which contains fillers (dextrose and cream of tartar). The inclusion of these fillers most likely affected the perceived sweetness intensity of this sweetener when compared to sucrose in a water solution. Mogrosides V & VI are the known sweetening agents found in *T. grosvenorii*, which is the fruit used to make monk fruit extract. Reported sweetness intensities ranged from approximately 150 times that of sucrose (Lee, 1975) to anywhere between 200-425 times sweeter than sucrose (Kinghorn, Soejarto & Inglett, 1986), although this was not supported by results from trial 1. A lingering licorice aftertaste has been associated with mogroside V (Lee, 1975; Tomasik, 2004), while bitter tastes have been associated with some other constituents (mogrosides II & III) of the fruits depending on ripeness (Li, Ikeda, Huang, Liu, Nohara, Sakamoto, & Nonaka, 2007). The additional flavor profile may have played a role in perceived sweetness intensity due to the untrained nature of the panel.

Table 3-2. Alternative sweetener concentrations (trial 1) used to establish equivalence to sucrose

Sweetener	**Concentration (g/mL)**	**# participants that selected alternative as "MORE sweet"**	**Calculated p-value**	**Established sweetness equivalence?**
Sucrose (control)	0.05	--	--	--
Coconut palm sugar (CPS)[1]	0.052	27	0.056	No
High fructose corn syrup (HFCS)	0.067	6	2.41×10^{-15}	No
Honey	0.062	44	0. 829	Yes
Monk fruit extract (MFE)	4×10^{-4}	67	1.07×10^{-7}	No
Acesulfame potassium (Ace-K)	2.6×10^{-4}	35	0.154	Yes
Aspartame (Asp)	3.2×10^{-4}	58	0.0001	No
Saccharin (Sac)[2]	1.8×10^{-4}	1	N/A	No
Sucralose (Sucral)	8.8×10^{-5}	61	1.86×10^{-5}	No

(n=85 for all natural; n=83 for artificial); Concentrations of bolded sweeteners were determined to be relatively equivalent in sweetness intensity to 5% sucrose concentration in water.

[1]Coconut palm sugar p-value suggested equivalence but was very close to 0.05

[2]Saccharin was perceived as being significantly less sweet than sucrose; no appropriate statistical test applied

Trial 2: Establishing equivalence for Saccharin & Sucralose

Chi squared analysis using data from both testing days of the second trial showed no significant differences ($p>0.05$) in sweetness intensity between sucrose and two artificial sweeteners (Table 3). Statistical parameters remained the same for the natural sweetener testing day, but had to be adjusted ($\alpha = 0.10$, $\beta = 0.05$ and $\rho_{max} = 70\%$) for the artificial testing day due to lower panelist participation (n=74). By increasing the alpha level, we were able to keep the same proportion of discriminators and reduce the risk of a type II error. Relative equivalence to sucrose was established for saccharin ($p=0.25$) and sucralose ($p=0.16$). The selected concentration of the last remaining artificial sweetener, aspartame, was closer to relative equivalence ($p=0.0116$) than any of the concentrations from the natural sweetener testing day. Panelists perceived differences ($p<<0.05$) in sweetness intensity between sucrose and the selected concentrations for coconut palm sugar (CPS), high fructose corn syrup (HFCS), and monk fruit extract (MFE)(Table 3). Concentrations selected for HFCS and MFE appeared to change in the correct direction, but panelists detected a greater difference in sweetness intensity between CPS and sucrose during the second trial than the first.

Some factors that may be confounding the experiment are related to the flavor profile and aftertastes associated with monk fruit extract (mentioned previously) and coconut palm sugar. While little information exists in the literature describing the unique flavors associated with coconut palm sugar, a distinctive caramel flavor profile has been previously reported that may be directly contributing to the perceived differences in sweetness intensity (Mogea, Seibert, & Smits, 1991). Also, CPS is most commonly used as a sugar substitute in baked goods not as a beverage sweetener (Feder, 2012).

Table 3-3. Alternative sweetener concentrations (trial 2) used to establish equivalence to sucrose

Sweetener	Concentration (g/mL)	# participants that selected alternative as "MORE sweet"	Calculated p-value	Established sweetness equivalence?
Sucrose (control)	0.05	--	--	--
Coconut palm sugar (CPS)	0.056	17	3.17×10^{-8}	No
High fructose corn syrup (HFCS)	0.073	10	1.78×10^{-12}	No
Monk fruit extract (MFE)	2×10^{-4}	22	8.70×10^{-6}	No
Aspartame (Asp)	2.6×10^{-4}	27	0.012	No
Saccharin (Sac)	3.7×10^{-3}	32	0.245	Yes
Sucralose (Sucral)	9.5×10^{-5}	43	0.163	Yes

(n=85 for all natural; n=74 for artificial) Concentrations of bolded sweeteners were determined to be relatively equivalent in sweetness intensity to 5% sucrose concentration in water.

Trial 3: Establishing equivalence for HFCS

Relative equivalence for one more natural sweetener was needed in order to move forward with the study; HFCS was selected due to the media controversy surrounding its usage in both foods and beverages. Two HFCS concentrations ("low"; "high") were chosen to be compared to sucrose in a water solution based on concentrations used in previous trials and benchtop tastings (unreported data). Results showed that no significant difference in detected sweetness intensity existed between the "low" HFCS concentration and sucrose (Table 4). Challenges in achieving equivalence between 42% HFCS and sucrose for this study are not well understood.

A majority of the relative sweetness studies found in the literature used a 10% sucrose concentration base for comparison to alternative sweeteners (White, 2014). Published ranges for relative sweetness of sucrose (relative sweetness=100) to 42% HFCS, 55% HFCS or its respective components (fructose and glucose), are reported to be between 60 and 150 (Hull, 2010; Nabors, 2012; Tunaley, et al., 1987; White, 2008; White 2014). Tunaley, Thomson and McEwan conducted a study to determine the relative sweetness of nine alternative sweeteners to a 5% sucrose concentration. Using their reported values for glucose and fructose, an estimated equi-sweet concentration for 42% HFCS was calculated to be approximately 6.84 g per 100mL. The determined relative sweetness equivalence value for 42% HFCS in this study (8.5g/100mL) did not match ranges previously found in the literature (Tunaley, et al., 1987; White, 2008). In fact the relative equivalence found (based on weight) was closer to values published for glucose to sucrose comparisons, suggesting that the 42% HFCS used actually contained a higher ratio of glucose to fructose than stated on the specification sheet (Appendix D-4). This speculation is supported by evidence from a study conducted by Ventura, Davis & Goran (2011); researchers observed deviations in the reported sugar content, specifically fructose composition, on the labels of beverages from several well-known brands.

Table 3-4. "Low" and "High" concentrations of high fructose corn syrup (HFCS) (trial 3) used to establish equivalence to sucrose

Sweetener	**Concentration (g/mL)**	**# participants that selected alternative as "MORE sweet"**	**Calculated p-value**	**Established sweetness equivalence?**
Sucrose (control)	0.05	--	--	--
"Low" HFCS	0.085	28	0.248	Yes
"High" HFCS	0.10	36	0.0002	No

(n=48); Concentrations of bolded sweeteners were determined to be relatively equivalent in sweetness intensity to 5% sucrose concentration in water.

Challenges in achieving relative sweetness equivalency

Pangborn (1963) attributed high variations in published relative sweetness values comparing sweeteners to sucrose to several factors. These included sweetness intensity used for comparisons, a diverse number of sensory techniques, and the chosen beverage medium (water versus more complex beverages). Any of these, coupled with other factors such as temperature, number of samples and participant taste sensitivity may have played an important role in the challenge to achieve relative equivalence.

Relative sweetness equivalence comparisons have been studied for sucrose intensities ranging from threshold concentrations (1%) to 20% and higher (Cardello, Da Silva, & Damasio, 1999; Kim, Prescott & Kim, 2014; Moraes et al., 2010; Moskowitz, 1971; Pangborn, 1963; Tunaley, et al., 1987). Preferences for specific intensities have been reported to vary across individuals and cultures but reach a peak around 10-12% (Cardoso & Bolini, 2007; Pfaffman, 1980). One limitation of this study was that we did not test for intensity preferences or group participants into “sweetener liker” or “sweetener disliker" categories. In separate studies, Kim et al. (2014), Moraes et al. (2010) and Pangborn (1963) observed that relative sweetness equivalence of alternative sweeteners can also vary due to the selected beverage medium. A potential indirect limitation of the current study was that the equi-sweet concentrations were determined using water as the medium and then applied in a tea medium for subsequent emotion studies.

Sensory tests previously used to determine equi-sweet concentrations include paired comparisons (Pangborn, 1963), threshold determinations (Fabian & Blum, 1943; Lichtenstein, 1948), and various scaling techniques such as category, line and magnitude estimations (Cardello, et al., 1999; Cardoso & Bolini, 2007; Kim, et al., 2014; Moraes, et al., 2010; Moskowitz, 1970; Tunaley, et al., 1987). Lichtenstein (1948) described the advantages and disadvantages of using the comparison method when compared to threshold testing. He argued that threshold method allows for rapid determination; however threshold values change over time, for varying substances and across individuals (Meilgaard et al., 2007).

For this study, a forced choice paired comparison was chosen instead of threshold testing, magnitude scaling, paired preference or pairwise ranking for its simplicity and so that we could determine relative equivalence of one attribute (sweetness) between only sucrose and each alternative sweetener at the desired concentration (5%) (Meilgaard et al., 2007). The two-sided nature of the test also allowed for sensitivity in terms of directionality so that concentration adjustments could be made in future trials. One limitation of using the paired comparison method was that comparisons could not be made across alternative sweeteners since relative equivalence was only established to sucrose. This was an important distinction for interpreting data from the subsequent emotional response studies (Chapters 4, 5).

Conclusions

Relative sweetness equivalence to a 5% sucrose concentration in water was achieved for five alternative sweeteners; two natural (Honey, HFCS) and three artificial

(Ace-K, Saccharin, Sucralose). The equivalency values of four of these alternative sweeteners were selected for the next experiment, which investigated the acceptance and emotional response to alternative sweeteners in tea (Chapters 4, 5). We selected four sweeteners (2 natural: honey, HFCS; 2 artificial: ace-K, sucralose) in order to have a balanced number of samples on each testing day. These four specific sweeteners were chosen due to the established relative equivalency of each alternative to sucrose and their usage history as beverage sweeteners in addition to other factors related to consumer emotions. In particular, two sweeteners were chosen for their potential role in the elicitation of the disgust emotion. HFCS was selected due to the increasingly negative perception portrayed by media and public proponents; ace-K was selected due to its associated bitter flavor.

Equi-sweet concentrations for three alternative sweeteners (monk fruit extract, coconut palm sugar, and aspartame) remain to be found; although, extensive research has been conducted pertaining to the sweetness perception and intensity of aspartame. The main purpose of this experiment was to establish equivalency to sucrose in order to remove biases associated with sweetness intensity differences for the next study; however establishing equivalence for the remaining natural sweeteners may prove useful in future studies.

References

Anonymous. (2012, December). What sways sweetener choices. *Food Product Design: Custom Special Report*, 1-9.

Birch, G.G. (1987). Sweetness and sweeteners. *Endeavour*, *11*(1), 21-24.

Bogdanov, S., Jurendic, T., Sieber, R., & Gallmann, P. (2008). Honey for nutrition and health: A review. *Journal of the American College of Nutrition*, *27*(6), 677-689.

Cardello, H., Da Silva, M., & Damasio, M. (1999). Measurement of the relative sweetness of stevia extract, aspartame and cyclamate/saccharin blend as compared to sucrose at different concentrations. *Plant Food for Human Nutrition*, *54*, 119-130.

Cardoso, J.M.P., & Bolini, H.M.A. (2007). Different sweeteners in peach nectar: ideal and equivalent sweetness. *Food Research International*, *40*(/), 1249-1253.

DeLauro, R. Sugar-Sweetened Beverages Tax Act of 2014, HR. 113th Cong. (2014). Retrieved from http://cspinet.org/images/sweetactbill.pdf.Last accessed: 9 February 2015.

Dennis, E. A., Flack, K. D., & Davy, B. M. (2009). Beverage consumption and adult weight management: A review. *Eating Behaviors*, *10*(4), 237-246.

Devcich, D. A., Pedersen, I. K., & Petrie, K. J. (2007). You eat what you are: Modern health worries and the acceptance of natural and synthetic additives in functional foods. *Appetite*, *48*(3), 333-337.

Dickson-Spillmann, M., Siegrist, M., & Keller, C. (2011). Attitudes toward chemicals are associated with preference for natural food. *Food Quality and Preference*, *22*(1), 149-156.

Fabian, F.W. & Blum, H.B. (1943). Relative taste potency of some basic food constituents and their competitive and compensatory action. *Food Research*, *8*, 179-193.

Feder, D. (2012). How sweet it is. *Prepared Foods*, 61-73.

Green, E., & Murphy, C. (2012). Altered processing of sweet taste in the brain of diet soda drinkers. *Physiology & Behavior*, *107*(4), 560-567.

Grenby, T. H. (1991). Intense sweeteners for the food industry: an overview. *Trends in Food Science & Technology*, *2*, 2-6.

Grynbaum, M. (2012, September 13). Health panel approves restriction on sale of large sugary drinks. *The New York Times.* Retrieved from http://www.nytimes.com/2012/09/14/nyregion/health-board-approves-bloombergs-soda-ban.html?_r=0. Last accessed: 9 February 2015.

Kim, J.Y., Prescott, J., & Kim, K.O. (2014). Patterns of sweet liking in sucrose solutions and beverages. *Food Quality and Preference*, 36, 96-103.

Kinghorn, D.A., Soejarto, D.D., & Inglett, G.E. (1986). Sweetening agents of plant origin. *Critical Reviews in Plant Sciences, 4*(2), 98.

Lee, C.H. (1975). Intense sweetener from Lo Han Kuo (*Momordica grosvenori). Experientia, 31*(5), 533-534.

Li, D., Ikeda, T., Huang, Y., Liu, J., Nohara, T., Sakamoto, T., & Nonaka, G. I. (2007). Seasonal variation of mogrosides in Lo Han Kuo (Siraitia grosvenori) fruits. *Journal of Natural Medicines*, *61*(3), 307-312.

Li, X., Inoue, M., Reed, D.R., Huque, T., Puchalski, R.B., Tordoff, M.G., Ninomiya, Y., Beauchamp, G.K., & Bachmanov, A.A. (2001). High-resolution genetic mapping of the saccharin preference locus (*Sac*) and the putative sweet taste receptor (T1R1) gene (*Gpr70*) to mouse distal Chromosome 4. *Mammalian Genome, 12*(1), 13-16.

Li, X., Staszewski, L., Xu, H., Durick, K., Zoller, M., & Adler, E. (2002). Human receptors for sweet and umami taste. *Proceedings of the National Academy of Sciences of the United States of America*, *99*(7), 4692-4696.

Lichtenstein, P.E. (1948). The relative sweetness of sugars: sucrose and dextrose. *Journal of Experimental Psychology, 38*(5), 578-586.

Malik, V.S., Schulze, M.B., & Hu F.B. (2006). Intake of sugar-sweetened beverages and weight gain: a systematic review. *American Journal of Clinical Nutrition 84*(2), 274-288.

Malik, V. S., Popkin, B. M., Bray, G. A., Després, J. P., Willett, W. C., & Hu, F. B. (2010). Sugar-sweetened beverages and risk of metabolic syndrome and Type 2 Diabetes A meta-analysis. *Diabetes Care*, *33*(11), 2477-2483.

Meilgaard M., Civille G.V. & Carr B.T. (2007). *Sensory Evaluation Techniques*. 4th ed. Boca Raton: Taylor & Francis Group, LLC. 448 p.

Mitchell, H. (2006). *Sweeteners and Sugar Alternatives in Food Technology*. Oxford: Blackwell Publishing Ltd.

Mogea, J., Seibert, B., Smits, W. (1991). Multipurpose palms: the sugar palm (*Arenga pinnata*). *Agroforestry Systems, 13*, 111-129.

Moraes, T., Barbosa, P. C., Bolini, H., & Andre, M. (2010). Different sweeteners in beverages prepared with instant and roasted ground coffee: Ideal and equivalent sweetness. *Journal of Sensory Studies*, *25*(s1), 215-225.

Moskowitz, H.R. (1970). Ratio scales of sugar sweetness. *Perception & Psychophysics, 7*(5), 315-320.

Moskowitz, H.R. (1971). The sweetness and pleasantness of sugars. *American Journal of Psychology, 84*(3), 387-405.

Nabors, L.O. (2012). *Alternative Sweeteners.* 4th edition. Boca Raton, FL: CRC Press LLC.

Nelson, G., Hoon, M. A., Chandrashekar, J., Zhang, Y., Ryba, N. J., & Zuker, C. S. (2001). Mammalian sweet taste receptors. *Cell*, *106*(3), 381-390.

Pangborn, R.M. (1963). Relative taste intensities of selected sugars and organic acids. *Journal of Food Science*, *28*(6), 726-733.

Parker, K., Salas, M., & Nwosu, V.C. (2010). High fructose corn syrup: Production, uses, and public health concerns. *Biotechnology and Molecular Biology Review, 5*(5), 71-78.

Pfaffman, C. (1980). Wundt’s schema of sensory affect in the light of research on gustatory preferences. *Psychological Research, 42* (1-2), 165-174.

Rozin, P., Spranca, M., Krieger, Z., Neuhaus, R., Surillo, D., Swerdlin, A., & Wood, K. (2004). Preference for natural: instrumental and ideational/moral motivations, and the contrast between foods and medicines. *Appetite*, *43*(2), 147-154.

Schiffman, S.S., Booth, B.J., Carr, B.T., Losee, M.L., Sattely-Miller, E.A., & Graham, B.G. (1995). Investigation of synergism in binary mixtures of sweeteners. *Brain Research Bulletin, 38*(2), 105-120.

Tomasik, P. (2004). *Chemical and Functional Properties of Food Saccharides*. Boca Raton: CRC Press LLC. Page 426.

Tunaley, A., Thomson, D. M. H., & McEwan, J. A. (1987). Determination of equi-sweet concentrations of nine sweeteners using a relative rating technique. *International Journal of Food Science & Technology*, *22*(6), 627-635.

Ventura, E.E., Davis, J.N., & Goran, M.I. (2011). Sugar content of popular sweetened beverages based on objective laboratory analysis: focus on fructose content. *Obesity, 19*(4), 868-874.

Wang, Y. C., Bleich, S. N., & Gortmaker, S. L. (2008). Increasing caloric contribution from sugar-sweetened beverages and 100% fruit juices among US children and adolescents, 1988–2004. *Pediatrics*, *121*(6), e1604-e1614.

White, J. S. (2008). Straight talk about high-fructose corn syrup: what it is and what it ain't. *The American Journal of Clinical Nutrition*, *88*(6), 1716S-1721S.

White, J.S. (2014). Sucrose, HFCS, and Fructose: History, Manufacture, Composition, Applications, and Production. In J.M. Rippe (Ed.), *Fructose, HFCS, Sucrose & Health* (pp. 13-33). New York, NY: Springer.

Wiet, S. G., & Beyts, P. K. (1992). Sensory characteristics of sucralose and other high intensity sweeteners. *Journal of Food Science*, *57*(4), 1014-1019.

Chapter 4: Characterizing consumer emotional response to sweeteners using an emotion terminology questionnaire and facial expression analysis

Footnote: This chapter has been submitted to the Journal of Food Research International Special Edition on food, mood and emotion. At the time of thesis defense the manuscript was in review.

Abstract

Concerns associated with sugar-sweetened beverages (SSBs) have led to an increased consumer demand for sweetener alternatives that are functionally (and taste) equivalent to sucrose without the associated health risks. Measuring consumer emotions has the potential to aid the industry in subsequent ingredient decision-making. The purpose of this study was to evaluate the relationship of consumer acceptability and emotional response of sweeteners in tea using a 9-point hedonic scale, an emotion term questionnaire (explicit), and a facial expression response (implicit).

Participants (n=30) evaluated a water sample (baseline), two (5%) sucrose-tea samples (control), and four equi-sweet alternative sweetener-tea samples (ace-k, sucralose, high fructose corn syrup and honey), divided by category (artificial; natural). Sessions (4 total, spread over 2 days) were divided by category and emotional response tool in a cross-over design. Facial expression responses were recorded in the first session of both days using FaceReader 5.0 and individual participant videos were analyzed per sample for 5-sec post-consumption (α=0.05) in the continuous analysis setting using automated facial expression analysis software. Emotional term responses were collected in the second session of each day and count frequencies of each term per sample were tabulated and analyzed. Hedonic acceptability was rated in all sessions on a 9-point scale.

Alternative sweeteners were all rated 'acceptable' (score of 5 or higher), except for honey in one session. Only one alternative in each category was statistically different ($p<0.05$) in liking from sucrose. Facial analysis showed minimal differences in emotion elicited across sweetener categories. Time series analysis was more robust in showing differences ($p<0.05$) than baseline comparisons. Emotional term selection using a CATA questionnaire showed four unique terms (disgusted, good, mild, steady) for natural sweeteners and two unique terms (bored, good-natured) for artificial sweeteners. More research exploration related to emotions and food is needed in order to accrue a more accurate picture of consumer product preferences.

Keywords:

Emotion, Facial Expression Analysis, Sweetener, Consumer

Introduction

Sucrose is the standard sweetener to which all other sweeteners are compared in the beverage industry. This is largely attributed to its inherent sweetness, which studies have shown elicit positive affective responses in humans (de Graaf & Zandstra, 1999; Rozin & Vollmecke, 1986; Steiner, Glaser, Hawilo & Berridge, 2001), paired with its clean flavor profile, texture, color, shelf-life and ubiquitous abundance in nature (Mitchell, 2006). Sucrose alternatives, traditionally chosen for cost reduction and/or consumer weight control, include those readily found in nature and sweeteners artificially produced in a laboratory setting (Nabors, 2012).

Taste, whether expected or remembered through conveyed information on packaging, is one of the most important factors when making product choices (International Food Information Council, 2013; Koster, 2002; Schifferstein, Fenko, Desmet, Labbe, & Martin, 2013); however, most U.S. consumers believe that sugar consumption is associated with weight gain and should therefore be avoided (IFIC, 2013). The use of alternative sweeteners in beverages, consequently, is advantageous for health conscious consumers. Recent consumer reports have shown that there is a gap in knowledge concerning the relationship between (1) sugar intake and consumer health and (2) the difference in functionalities between specific sweeteners (such as high fructose corn syrup) (Cogent Research, 2006; IFIC, 2013). Evidence from peer-reviewed literature addressing food-health concerns has shown that consumer beliefs heavily influence their acceptance or rejection of food products and ingredients (Dickson-Spillmann, Siegrist, & Keller, 2011; Rozin, Ashmore, & Markwith, 1996). Increasing popularity surrounding food products that are organic, non-GMO, 'natural', and have "clean labels", etc. is largely attributed to the perceived and/or expected health benefits of these products rather than their functionality (Devcich, Pedersen & Petrie, 2007; Rozin, Spranka, Krieger, Neuhaus, Surillo, Swerdlin, & Wood, 2004). Thus, industry response has focused on creating products that are ‘healthier’ and meet the high taste expectations that have been previously established in the original products.

Success is not solely driven by taste; consumer attitudes and perceptions of the product, its ingredients and all associated branding have an effect that is often hard to quantify. The challenge in sensory science lies in developing a more complete understanding of drivers of consumer preferences. Consumer emotions contribute to purchase habits and, more importantly, brand and product loyalty (Lindstrom, 2005). Emotions occur very quickly (microseconds) and have a short duration (seconds to a few minutes) (Robbins & Judge, 2013). Preferences for one product over another are often attributed to a combination of several internal and external factors. Measuring emotions evoked by food are consequently due to an exponential number of confounding factors, although most recent research suggests that food related experiences are often described in positive terms (Desmet & Schifferstein, 2008; Gibson, 2006; King & Meiselman, 2010).

New methods exploring the role of consumer emotions and perceptions of foods include collecting both explicit and implicit measures. Explicit methods rely on participant cognition of and ability to recognize (emotional) response, much like traditional sensory methods already in use by the industry for acceptance or preference. Limitations involving emotions research can include high panelist to panelist variation, within panelist inconsistency and a lack of emotion term understanding especially in the context of food liking and preferences (Booth, 1994; Köster, 2002). The application of methods measuring subconscious (or implicit) responses that cannot be controlled, typically neurological or physiological, may augment assumptions made in explicit approaches. Several studies in the psychology field show that expressed emotions can be categorized as positive/negative or approach (meaning "towards stimuli") or withdrawal ("away from stimuli"). Approach emotions include angry, happy and surprised and withdrawal emotions include disgusted, sad and scared based on brain asymmetry (Alves, Fukusima, & Aznar-Casanova, 2008; Davidson, Ekman, Saron, Senulis, & Friesen, 1990). Implicit measures include temperature & sweat changes, heart rate, electroencephalography, and functional magnetic resonance imaging to evaluate the relationship to food stimuli (de Wijk, Kooijman, Verhoeven, Holthuysen, & de Graaf, 2012; Hu, Player, McChesney, Dalistan, Tyner, & Scozzafava, 1999). Manual facial coding, such as Facial Action Coding System (Ekman & Friesen, 1978), as well as automated facial expression analysis (AFEA) tools (FaceReader™, PrEmo, Affdex) are less invasive; however, they can be time consuming, and the software reliability and accuracy related to food stimuli is not well understood. Of the very few studies using facial expression analyses (Danner, Sidorkina, Joechl, & Duerrschmid, 2013; Danner, Haindl, Joechl, & Duerrschmid, 2014; De Wijk et al., 2012; Garcia-Burgos & Zamora, 2015), most have focused solely on measuring single or dominant emotions at a set time period.

The purpose of this project was to compare natural and artificial sweeteners to the traditional standard, sucrose, for acceptability as well as implicit and explicit emotional responses. The specific objective was to evaluate the relationship of consumer acceptability and emotional response of sweeteners in tea using a 9-point hedonic scale, an emotion term questionnaire (explicit), and a facial expression response (implicit).

Materials and Methods

Samples & sample preparation

Acesulfame potassium (ace-k; Wego Chemical & Mineral Co.; Great Neck, NY), high fructose corn syrup (HFCS; Tate & Lyle; London), honey and sucrose (Kroger; Cincinnati, OH) and sucralose (Sucral; Tate & Lyle; London) were received by donation or purchased at the local supermarket. Preliminary testing established sweetness equivalence of alternative sweeteners to a 5% sucrose in water solution (w/w). Five sweetened tea solutions, using alternative sweeteners and sucrose (control), were made approximately 24 hr prior to each sensory testing day. Each batch solution of tea (Lipton Tea, Unilever, Englewood Cliffs, NJ) was prepared based on package instructions (Southern Sweet Tea, n.d.). Drinking water (Kroger brand, Cincinnati, OH) was brought to a simmer (~99 ºC). Tea leaves (~4g), bundled in cheesecloth, were placed in a heatproof container, heated water (355 mL/4 g tea leaves) was added to packaged tea, steeped (covered) for 3-5 minutes, then tea leaves were removed. Pre-measured sweeteners were added to the appropriate volume of tea (Table 1). Sweetener-tea solutions were mixed, then transferred into pre-labeled 750mL wine bottles, covered and stored overnight (4°C). Sweetener-tea solutions were poured into color-coded sample cups (2 oz. plastic; Solo brand) with caps prior to testing.

Table 4-1. Final alternative sweetener concentrations established to be sucrose-equivalent

Category	Sweetener	Concentration (g/mL)
Control	Sucrose	0.05
Natural sweeteners	HFCS	0.085
	Honey	0.062
Artificial sweeteners	Ace-K	2.6×10^{-4}
	Sucralose	9.5×10^{-5}

Participant recruitment & pre-screening study

Virginia Tech (VT) Institutional Review Board (IRB) approval was obtained prior to beginning the study. Informed consent and consent for the video recording were obtained prior to data collection. Recruited panelists were screened based on consumption of tea beverages (invited participants consumed tea on a weekly basis or greater), use of various sweeteners (invited participants reported using either “natural” or “non-nutritive” sweeteners with beverages) and facial features (facial hair, glasses) that might interfere with video capture for facial expression analysis. A preliminary video trial was used to evaluate participant (n=65; 47 females) adherence to training instructions to limit risk of failed video. All captured videos were run through the automated facial expression software program (FaceReader 5.0™, Noldus Information Technology, Wageningen, The Netherlands) and assessed for video success. Thirty-one individuals (Virginia Tech students, faculty, staff and community members; age range 20-60: 72% female) were invited to continue in the study.

Experimental cross-over design

On each testing day (n=2), participants completed two sessions. Sessions were divided based on sweetener category (natural; artificial) and the emotional collection tool used (video capture of facial expression response, FER; emotional term selection, ETS) (Figure 1). Video capture of their face occurred in the first session of the evaluation on each day. In the second evaluation session, participants characterized their emotional response by selecting emotional terms from a check-all-that-apply (CATA) list. In each session, participants tasted and rated overall acceptability of tea-sweetener samples (2 artificial + sucrose; 2 natural + sucrose; 6 samples each day; total of 12 samples over a 2-day testing period) on a 9-point hedonic scale (1= dislike extremely; 5= neither like nor dislike; 9= like extremely). The order of natural and artificial sweetener sessions was reversed on the second day.

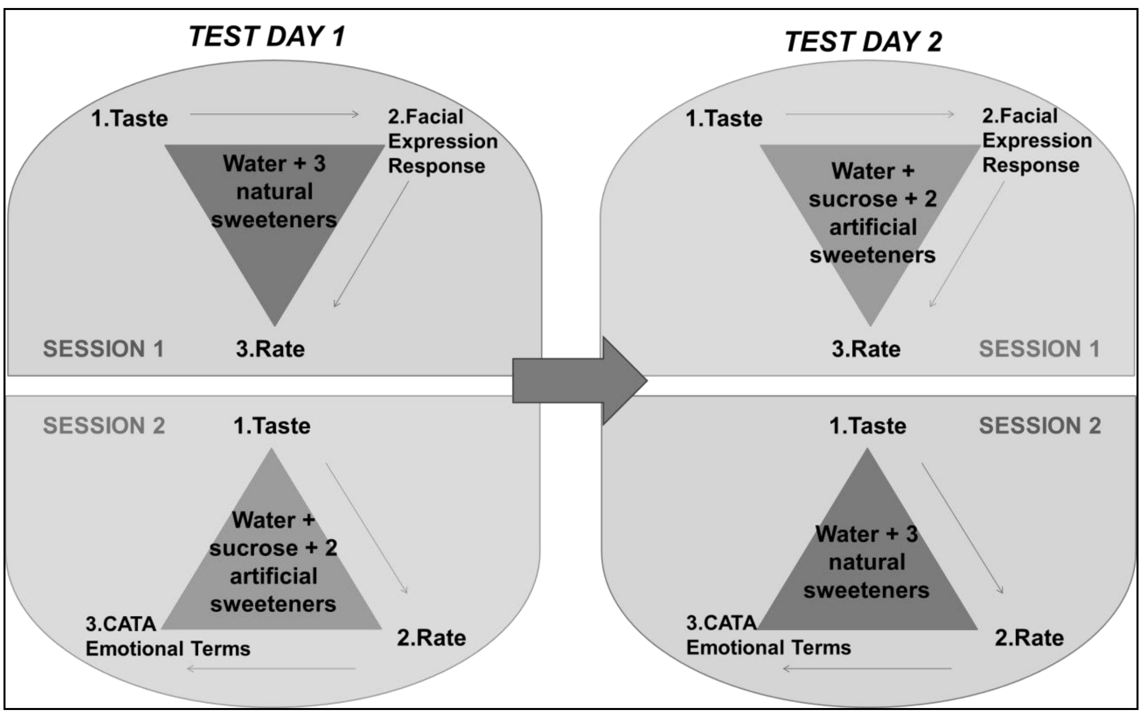

Figure 4-1. Cross-over experimental design.

Experimental environment, testing sequence & data management

Session 1: FER & sweetener acceptance

In order to best control and standardize FER video capture, one sensory booth was used for all participants; each participant was scheduled with individual sessions. White lighting in the booth and incidental lighting from overhead lights and from the booth's touch screen monitor illuminated the face. A webcam (Microsoft 2.0 megapixel LifeCam NX-6000, Redmond, WA), attached to the bottom of the touch screen monitor, was positioned for each participant to best capture the face; the webcam was connected to a laptop (Latitude Essio, Dell, Inc., Round Rock, TX) on the researcher side of the hatch. This also allowed the researcher to provide further instructions to ensure better video capture, as suggested by Arnade (2013). The webcam was preset to capture 30 frames/sec with set frame dimensions (640w x 480h) while recording; video recording began at the start of each testing session and captured the entire first session of each testing day using Microsoft Movie Maker (2011). Videos were saved as Windows media video (.wmv) files.

During the first testing session, the participant was seated in the booth and presented simultaneously with a water sample (Drinking water, Kroger brand, Cincinnati, OH) and 3 color-coded sweetened tea samples. While being video recorded, they first tasted the water sample in order to elicit a neutral emotional response, which established a video baseline. The expectation was that this preliminary water tasting would help to reduce as much "emotional" noise as possible and give the researcher a standard response from each panelist. The remaining three samples (two sessions per day; two days) were randomized in a balanced complete block design. Panelists were not informed which sweeteners were used in each sample or the ‘sweetener category’ used in each session. Each panelist evaluated samples under white lighting, from left to right; water and unsalted soda crackers were provided to cleanse the palate between samples.

Panelists held up a uniquely colored index card (placed on top of each sample and coded for samples specific to a category), prior to tasting, to provide a video record of the sample being evaluated. Panelists were instructed to take the whole sample (30mL) into their mouth, swallow and sit for a “wait period” of 30 sec, which was programmed into the management software (Sensory Information Management System, SIMS; version 6, Sensory Computer Systems, Berkeley Heights, NJ). This ensured that the amount of time allotted for panelists to respond emotionally was the same per sample. Acceptability scores (1= dislike extremely; 5= neither like nor dislike; 9= like extremely) were collected via touchscreen monitor and the data was stored on the computer server until completion of the study at which point all responses were transferred to an electronic data spreadsheet (Microsoft Excel, Microsoft Corporation, Inc., Redmond, WA) for further analysis.

All video files were batch analyzed using the facial expression analysis software with continuous face calibration setting, which is one of three (default, continuous, & individual) calibration settings (FaceReader 5.0™, Noldus Information Technology, Wageningen, The Netherlands). The goal is to reduce variation for each elicited emotion across participants. The default setting utilizes an internal software library with which to base the mean intensities for each emotion. In contrast, both continuous and individual settings actively eliminate participant bias by applying a correction factor while running the analysis; however the individual calibration requires a “baseline” image/video (minimum of 10 secs) for all participants in order to remove personal bias(es). Unpublished results from our lab group suggest that the continuous setting produces a higher sensitivity in determining emotional response differences than the Version 5.0 software default setting and is less involved than the individual calibration setting. Each recording was then event marked for a period of 5 sec post-consumption, based on when the hand holding the sample cup fell below the chin, in order to identify the relevant data for all samples (including water; 8 total per panelist). Log files for each panelist were exported and compiled into an electronic spreadsheet for further analysis. R code (R 3.1.1, R Core Team, 2014) was created to identify and extract the desired facial expression data for each sample per panelist for statistical analysis. Facial expression data for water was analyzed as a 'sample' in comparison to the sweetened tea samples in each category and also as a baseline, where its post-consumption mean was subtracted from the other mean samples using R.

Session 2: ETS & sweetener acceptance

Immediately following the first session, panelists were guided into a separate room and directed to a seat with a trifold board to simulate a sensory booth. Upon arrival, participants completed 2 questionnaires (a demographic and beverage intake questionnaire; Hedrick, Comber, Estabrooks, Savla, & Davy, 2010), given only on the first testing day.

All participants were presented with one water sample and three color-coded tea-sweetener samples under white florescent lighting. Samples were presented at the same time and participants were asked to evaluate each color coded sample one at a time from left to right, consuming water and unsalted soda crackers (Kroger brand, Cincinnati, OH) between each to cleanse the palate. Immediately following consumption of the sweetened tea samples, panelists were directed to rate their acceptability score at the top of the modified EsSense™ paper ballot (King & Meiselman, 2010) and select all applicable emotional terms from the list of 43 provided (38 of the original 39 terms used). One term (glad) was removed due to its similarity in meaning to the term "happy" and five terms (angry, content, fearful, sad and safe) were added to the ballot that more directly correlate to the emotions represented in the facial expression software program. All panelist demographic, hedonic and emotion term data from session 2 was recorded.

Statistical analyses

Sweetener acceptance

Mean hedonic scores for each sweetener within both categories (natural; artificial) and data collection tools (facial expression; CATA emotional term list) were calculated (Microsoft Corporation, Inc., Redmond, WA). Distribution normality was tested using the Shapiro-Wilk goodness-of-fit test (JMP *vs* 9.2, SAS, Cary, NC) for each sweetened tea sample. Nonparametric one-way analyses of variances (ANOVAs) using the Kruskal-Wallis test were conducted (JMP *vs* 9.2, SAS, Cary, NC) to determine differences ($p<0.05$) among mean hedonic scores within each sweetener category for both collection methods.

Facial expression response

Emotion intensity means, each scaled 0-1 (0=not expressed; 1=fully expressed) for all participants and samples, 5 sec post-consumption, were generated from FaceReader™ output using R. Repeated one-way ANOVAs were conducted within emotion state (sad, surprised, happy, scared, angry, disgusted and neutral), across sweeteners (water, sucrose, HFCS, honey, ace-k, and sucralose) and within sweetener, across emotions using Tukey's HSD multiple comparison of means in R. Significance was determined with critical values less than 0.05. The relationship between mean facial expression intensity values of emotions and hedonic score (liking) for each sweetened tea sample was evaluated using a liner regression analysis (JMP SAS, Cary, NC). Coefficients of determination (R^2 values) were found and used to obtain correlation values (R values) within each sweetener category.

The time series data for each emotion were collected at 20Hz. The start times for each sample were adjusted to zero, t-tests, paired by panelist, evaluated the mean difference for each emotion at each time step (Spivey, Grosjean & Knoblich, 2005) between the sweetener and water over the 5 sec interval. Signs of the mean difference (sweetener – water, data not shown) were used to evaluate whether the sweetener or water had the stronger emotional response. P-values (Figures 2 and 3) were used to evaluate statistical significance ($p<0.05$) and duration of emotional differences.

Emotional term selection

Count frequencies for each emotion term (43 total) were calculated for all sweeteners in both categories (natural; artificial). We defined terms that were selected with 20% frequency for at least one sweetener-tea sample were classified as "frequently selected" (Arnade, 2013) within both sweetener categories and graphed to compare for overall similarities and differences. "Shared" terms across sweetener comparisons were identified from frequently selected terms and had less than 8% difference between sample frequencies. Frequently selected terms with greater than 10% difference in frequency between two sweeteners were identified as "unique" terms. Penalty-lift analysis (Meyners, Castura & Carr, 2013) and a Cochran's Q test for significance (α=0.05) were used to assess the significance of frequently selected terms and the relationship to mean hedonic scores within each sweetener category.

Results and Discussion

There are a number of physiological (taste) and neurological (perception/cognition, emotion and memory/expectation) processes involved when capturing consumer acceptance and response to food products. This creates a complex problem when measuring implicit and explicit emotions. From a biological perspective, research studies have shown that nutritive and non-nutritive sweeteners activate the same taste receptors (T1Rs) on the tongue (Birch, 1987; Nelson, Hoon, Chandrashekar, Zhang, Ryba & Zuker, 2001; Li, Inoue, Reed, Hugue, Puchalski, Tordoff, Ninomiya, Beauchamp, & Bachmanov, 2001; Li, Staszewski, Xu, Durick, Zoller & Adler, 2002). While little individual variation in the ability to detect sweet taste may exist, Nie, Vigues, Hobbs, Conn & Munger (2005) showed evidence that non-nutritive sweeteners may bind to taste receptors with a higher affinity than their nutritive counterparts. Neurological studies suggest that the pleasantness/reward system in the brain differs across sweetener types (Frank, et al., 2008) and frequency of consumption for an individual (Green & Murphy, 2012).

These physiological responses, in conjunction with many social, environmental and psychological factors, influence the emotional processing of food products in the brain (Cardello, 1994; Gibson, 2006). The characterization of individual emotional responses can differ greatly depending on the type of measurement (verbal, nonverbal) used. We attempted to address these differences by collecting implicit emotions through facial expression responses and cognitive responses through acceptance as well as explicit emotions through a verbal check-all-that-apply ballot.

Acceptability of sweeteners in tea

It has been well established that imparted sweetness via sucrose or alternative sweeteners is inherently acceptable and elicits positive emotions across cultures and ages (De Graaf & Zandstra, 1999; Greimel, Macht, Krumhuber, & Ellgring, 2006; Rozin & Vollmecke, 1986; Steiner et al., 2001); water has also been shown to produce neutral emotions via facial expressions (Steiner, 1979; Steiner et al., 2001). This general acceptance can be altered when sweeteners are added to a more complex beverage such as black tea, which is characterized by bitter flavors from the effects of nonvolatile and volatile compounds extracted from tea leaves during brewing (Balentine, Wiseman, & Bouwens, 1997). Results showed that most sweetened tea samples were well liked with acceptability scores falling between "like slightly" to "like moderately." Any influence on acceptability due to the imparted bitterness from tea was assumed to be consistent across all sweeteners.

Honey and ace-k had mean values significantly lower ($p<0.05$) than sucrose with scores falling between "dislike slightly" to "neither like nor dislike" (Table 2). Lower acceptability in honey was unexpected since it is among the oldest sweetening agents (White, 1978) and is generally added to tea-based beverages. Data suggests that there were two participant user groups (honey users and non-users); left skews were observed for all other sweetened samples in both sessions. Hedonic scores for all samples were not normally distributed. Lowered acceptability of ace-K was not unexpected due to its association with bitter flavor, which is generally viewed as an inherently aversive taste (Fischer, Griffin, England, & Garn, 1961; Rozin & Vollmecke, 1986). We speculated that bitter flavor may have been compounded by the combination of ace-K and tea, resulting in lowered acceptance.

Panelist reliability is suggested by sucrose (control) comparisons ($p>0.05$) within and across categories (natural; artificial) (Table 2). No differences ($p>0.05$) existed between mean scores of each alternative sweetener across the two sessions (FER; ETS), further supporting panelist reliability. We concluded that any differences in liking for alternative sweeteners were attributed to other factors such as sweetener flavor profile, consumer perception and/or emotions.

Table 4-2. Mean hedonic scores[1] for natural and artificial sweeteners in cold tea

Natural Session								
	FER[2]				**ETS[2]**			
Sweetener	Mean	SD	95% CI	Median	Mean	SD	95% CI	Median
Sucrose	6.7^{aA}	1.2	6.3-7.2	7.0	6.4^{aA}	1.4	5.9-6.9	7.0
HFCS	6.5^{aA}	1.1	6.1-6.9	6.0	6.1^{aA}	1.4	5.6-6.6	6.0
Honey	5.5^{bA}	1.6	4.9-6.1	5.5	4.7^{bA}	1.6	4.1-5.3	4.0

Artificial Session								
	FER[2]				**ETS[2]**			
Sweetener	Mean	SD	95% CI	Median	Mean	SD	95% CI	Median
Sucrose[3]	6.8^{aA}	1.3	6.3-7.3	7.0	6.6^{aA}	1.4	6.1-7.1	7.0
Ace-K	5.9^{bA}	1.3	5.4-6.4	6.0	5.3^{bA}	1.9	4.6-6.0	6.0
Sucralose	6.5^{abA}	1.6	5.9-7.1	7.0	6.3^{aA}	1.7	5.7-6.9	7.0

[a, b, c] Means in each sweetener row and session category column (natural; artificial) with different letters are significantly different across treatments at $p<0.05$.
[A,B] Means in each sweetener row with different letters are significantly different within treatments at $p<0.05$.
[1]n=30; 1= extremely dislike; 9= extremely like.
[2]Sessions: FER= Facial expression response session; ETS= Emotional term selection session.
[3]Artificial sweetener session included sucrose as the standard control.

Characterizing explicit emotional responses to sweeteners in tea

In order to distinguish differences among those factors, frequently selected verbal emotion responses were identified for each sweetener type. A similar proportion of emotion terms, approximately 40% (17-18 out of 43 terms), were classified as frequently selected in both sweetener categories (natural; artificial). Reported differences across categories were demonstrated when comparing the two sucrose (control) samples, which shared only six terms across both sessions (Figure 2a). Three shared terms (good-natured, peaceful, pleasant) were identified among the natural sweeteners. Five shared terms (content, friendly, good, pleased, quiet) were identified among the three sweeteners in the artificial session. Two terms differentiated honey (disgusted, p=0.002; mild, p=0.028) based on Cochran's Q test (Figure 2b). In addition, based on our pre-defined category of "unique", the term good was selected more frequently for HFCS and steady was selected more frequently for honey compared to sucrose; the term bored was selected more for ace-k and good-natured was selected more for sucralose compared to sucrose. These results further support the hedonic score data, which showed a significant decrease in liking for honey in the natural category.

Penalty-lift results in this study showed that two terms, bored (ranging between -0.27 and -1.64) and mild (ranging between -0.19 and -0.81) had negative penalty towards hedonic scores when selected for sweeteners in both categories (Figure 3). In the natural category, the negative penalty was driven by sucrose and honey, respectively. One additional term, disgusted (-2.37), showed a high negative penalty only for the natural category and was uniquely associated with honey.

A majority of the terms in the natural category (9 out of 14 positive terms) showed minimal positive mean differences, with ranges between 0 and 1, while a majority of the terms (10 out of 15 positive terms) showed higher positive differences (1-1.5 range) for the artificial category (Figure 5). The highest positive differences for sweeteners were seen in the terms pleased (1.22) and happy (1.20) in the natural session, and pleased (1.67) and good (1.53) in the artificial session (Figure 3). Interestingly, both pleased and happy were driven by sucrose and HFCS in the natural session, as neither term was frequently selected for honey. The positive penalty makes sense when comparing it to the hedonic scores of these sweeteners.

Previous studies investigating the relationship between product acceptability and emotion scores (King & Meiselman, 2010; Porcherot, Delplanque, Raviot-Derrien, Le Calve, Chrea, Gaudreau, & Cayeux, 2010) have conflicting results. In a study conducted by King and Meiselman (2010), consumers categorized specific terms associated with the eating experience into one of three groups: positive, negative or unclear. Correlations between overall liking and positive or negative terms were shown; however when examining product differences, acceptability and emotion score data was variable. Similar conclusions can be drawn from results in this study. In general, liked sweeteners (sucrose, HFCS, sucralose) were associated with neutral to positive terms, while neutrally liked to disliked sweeteners (honey and ace-k) were uniquely associated with negative terms. Evidence for these conclusions were supported by the Cochran's Q test as well as penalty lift results. It is interesting to note that emotion term selection patterns elicited by artificially categorized sweeteners were more closely related than that of their nutritive counterparts (Figure 2b & 2c).

Studies investigating the linguistic relativity theory (Whorf, 1956) have shown that the ability to detect and perceive emotions within oneself can be greatly influenced by language (Gendron, Lindquist, Barsalou & Barrett, 2012; Lindquist, Barrett, Bliss-Moreau, & Russell, 2006). This evidence suggests that there was potential for participant response bias due to the unbalanced nature of positive (34) and negative (9) emotion terms used in the CATA ballot. Furthermore, panelists were not trained in their understanding of the emotion words and could have easily misinterpreted term meaning(s) or selected specific terms as way of post-rationalizing an affective experience to a sweetener. In this way, the emotional response may have been misdirected due to the prompted emotional terms on the ballot.

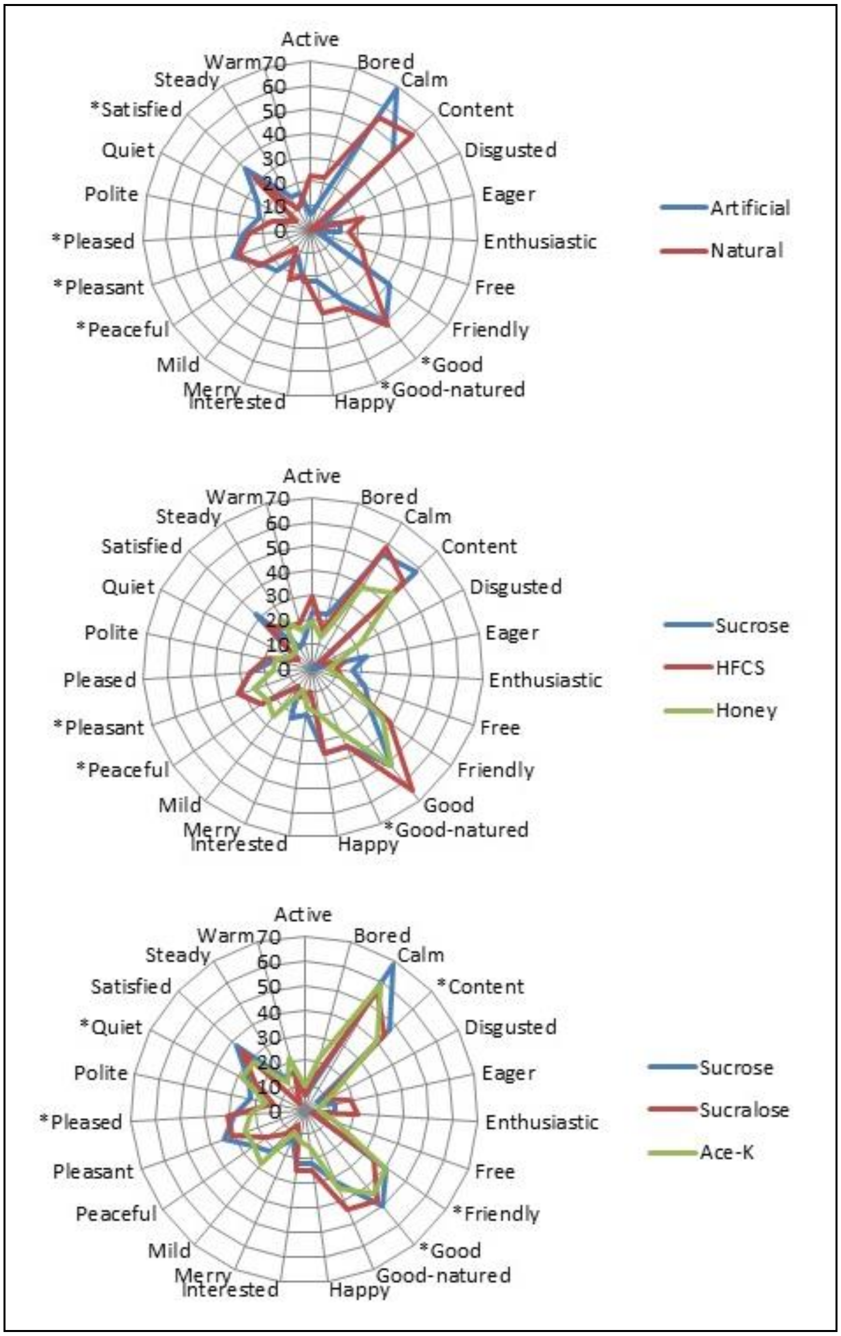

Figure 4-2. Comparison of frequently selected emotion terms from emotion term selection sessions for sweeteners in cold tea; (a) sucrose in natural and artificial sessions; (b) natural session; (c) artificial session. (n= 30) The displayed emotion terms (23/43) were selected based on a 20% or greater selection frequency for at least one of the samples being compared. Terms were ordered clockwise alphabetically. Shared terms, having 20% or greater frequency among samples and a difference equal to or less than 8% are denoted with an asterisk.

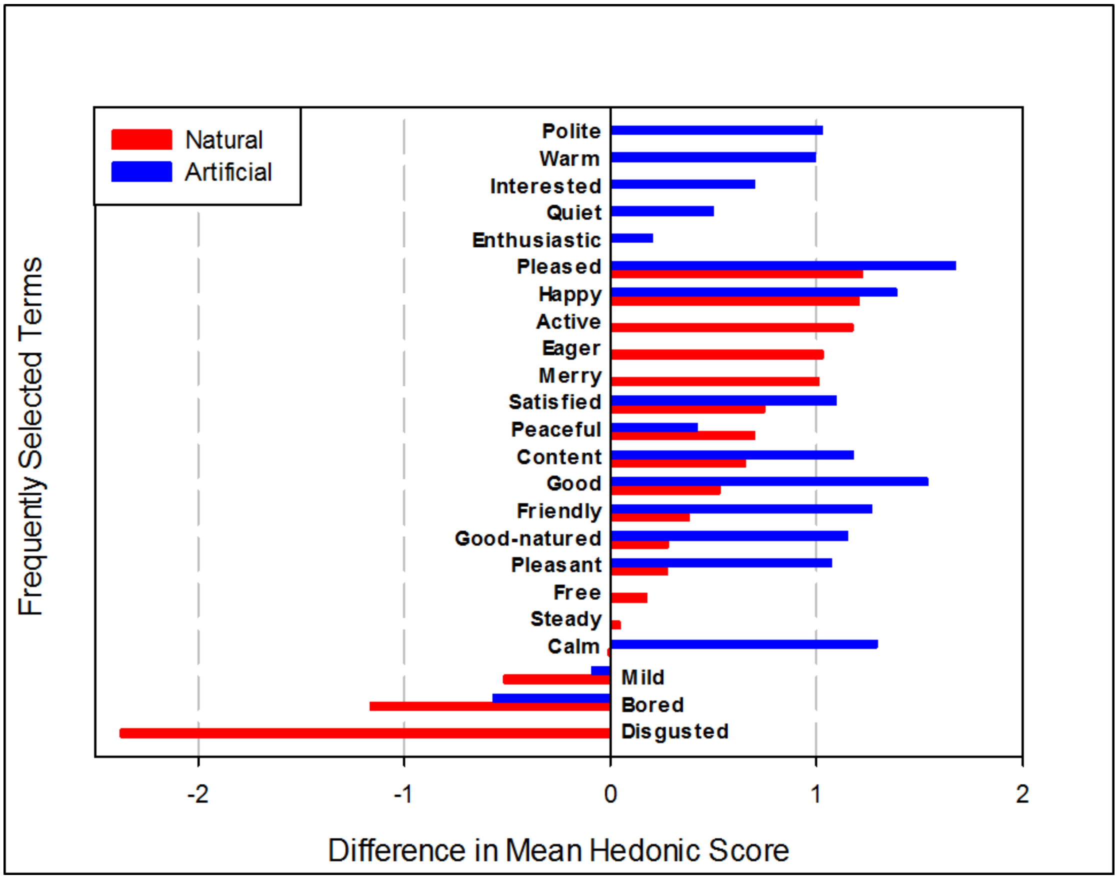

Figure 4-3. Penalty-lift analysis for natural & artificial sweeteners in cold tea (n= 62 total observations; n= 31 for natural sweeteners; n= 31 for artificial sweeteners). Differences in mean acceptability scores for all sample conditions were found for the 'frequently selected' terms (>20% selection; natural: 18 terms; artificial: 17 terms) and between participants who selected and did not select the term.

Characterizing implicit emotional responses to sweeteners in tea.

It is debated whether affect precedes cognition or vice-versa and what role emotions play in the decision making process (Zajonc, 1980). ANS (automatic nervous system) responses, such as facial expressions, are believed to capture subtle discrepancies in emotion that are otherwise missed when participants self-report. Pleasant affective responses to stimuli have been shown to elicit specific action unit facial movements ("Cheek raiser" and "lip corner puller"), which uniquely correspond to "happy" (Ekman, Friesen, & Ancoli, 1980; Kohler, et al., 2004). As such, it was believed that sweeteners with higher hedonic scores would glean higher mean intensities for “happy” and lower mean intensities for “disgust” with the opposite being true for disliked sweeteners (ace-k and honey).

No statistical ($p>0.05$) differences were seen within emotion across any sweetener samples in their respective categories (Tables 3, 4). Repeated one-way ANOVAs within samples (in each category separately) across each of the 6 emotions (sad, surprised, happy, scared, angry and disgusted) and neutral state did show some statistical differences ($p<0.05$) suggesting small (weak) differences in overall response. A similar intensity pattern (ordered highest to lowest) for the six basic emotions and neutral was revealed; neutral was elicited with the highest intensity, followed by sad for all sweeteners. Coefficients of determination were very small and showed little to no correlation between emotions and hedonic score (liking).

The lack of significant correlations between emotional response and hedonic score (liking) was unexpected. A study conducted by de Wijk et al. (2012), showed significantly higher facial expression responses upon seeing and tasting disliked foods when compared to liked foods. Results suggesting negative emotions are more intensely expressed with disliked samples, while samples falling somewhere between neutral and positive on the liking scale are more likely to elicit smaller degrees of positive emotion, were supported by findings of Danner et al. (2013), Danner et al. (2014), Wendin, Allesen-Holm, & Bredie (2011) and Zeinstra, Koelen, Colindrews, Kok, & de Graaf (2009). These conclusions were not fully supported by mean results from this study. It has also been suggested that happy is rarely expressed through facial expressions outside of social settings (De Wijk, He, Mensink, Verhoeven & De Graaf, 2014; Parkinson, 2005).

One proposed explanation involving the low emotional mean intensity responses to sweet taste in tea (and water) is that the inherent acceptance and habitual consumption of sweetened products in general is related (Leterme, Brun, Dittmar, & Robin, 2008). Other studies examining ANS responses to basic tastes found that sucrose elicited weaker responses overall using the six basic emotions compared to the other tastes and especially bitter (Robin, Rousmans, Dittmar, & Vernet-Maury, 2003; Rousmans, Robin, Dittmar, & Vernet-Maury, 2000).

Another potential explanation for the lack of differences was the high variation in emotional response across all panelists for one sweetener and within individual panelists across all sweeteners. This variation could be due to differing responses from the reward system in the brain associated with sweetener consumption patterns across individuals as suggested by Green & Murphy (2012). Danner et al. (2013) attributed high variance in facial expressions to unnatural laboratory settings. Environmental factors such as poor lighting conditions, unoptimized camera angles and partial face occlusion may have contributed to poor video capture resulting in response variation. Kotsia, Buciu & Pitas (2008) found supporting evidence stating that partial occlusion of the mouth especially affects the interpretation of anger and fear emotions, whereas partial eye occlusion affected disgust and surprise.

Other studies have proposed using baseline measures such as water or neutral facial expression (Garcia-Burgos & Zamora, 2015) to eliminate individual biases. Calculated mean intensity scores, using neutral as a correction factor against other emotions, showed lack of robust differences across sweeteners in our study. Further exploration of panelist to panelist facial expression variance is needed, although it has been suggested that neutral state may not be the best measurement when making comparisons (Somerville, Kim, Johnstone, Alexander & Whalen, 2004).

Differences in expressed intensity and sequence of emotions across sweeteners in relation to the 5 sec post-consumption time period were observed when compared to a water baseline (Figures 4, 5). Between 1 and 2.5 sec post-consumption, there appeared to be significant differences ($p<0.05$) in expressivity of disgust (withdrawal emotion) for the water-sucrose (natural session) comparison and the water-honey comparison (Figure 4). Both sweeteners (sucrose, honey) appeared to elicit less disgust than water, evidenced by the disgust curves (Figures 4b, 4c) falling below the dotted significance line ($p=0.05$). Sucrose exposure appeared to elicit a significantly higher amount of the approach emotion anger (as identified by AFEA) than water for approximately 2 sec post-consumption (1.5-2.5 sec; 3.5-4 sec). No significant differences between HFCS and water were observed, although spikes in two emotions (disgust & sad) appeared at similar times in relation to trends for sucrose and honey, suggesting similar emotion response within the sweetener category (Figure 4). Similar to findings in the verbal questionnaire, natural sweeteners elicited less emotions and at lower intensities over the set time period than sweeteners in the artificial category.

Three approach emotions (angry, happy and surprised) stood out as having observed intensity and time differences ($p<0.05$) across all artificial sweetener-water comparisons (Figure 5). Expression of surprised had the highest intensity with apparent significance beginning around 1 second post-consumption for all three; however, differences exist across sweeteners when interpreting elicited surprise in comparison to water. Sucrose exposure appeared to elicit less surprise in general than water, but especially so between 1.5 and 3.5 sec post-consumption (Figure 5). Both alternative sweeteners appeared to elicit more surprise than water, but at different time frames; significance for ace-k occurred around 1 second post-consumption, whereas significance for sucralose occurred between 2 and 3 sec post-consumption (Figure 5). Sequencing for elicitation of happy were similar for sucrose and ace-K, occurring around 3-4 sec post-consumption, whereas sucralose elicited happy within the first second (Figure 5). Anger was elicited at differing times across sweeteners and at minimal intensities.

Overall, significant differences ($p<0.05$) for expressed approach emotions only occurred when comparing artificial sweeteners (and sucrose) to water, which we used as our control (Figure 5); significance for expressed withdrawal emotions only occurred when comparing sweeteners from the natural category to water (Figure 4). It is important to reiterate that participant variance was very high. Spikes indicating significance were most likely due to false positives or major changes (drops/additions) in participant number due to sample pooling. The time series method of analysis has the potential to benefit interpretations of micro emotions elicited from food by adding the additional piece of information regarding time to baseline comparisons; however, over interpreting the results is a risk.

Table 4-3. Mean emotional intensity values[1] within water (baseline) and natural sweeteners[2] in cold tea

Emotion	Water	Sucrose	HFCS	Honey
Neutral	0.555^{aA}	0.553^{aA}	0.546^{aA}	0.557^{aA}
Sad	0.176^{bA}	0.174^{bA}	0.166^{bA}	0.176^{bA}
Surprised	0.057^{cA}	0.063^{cA}	0.069^{bcA}	0.049^{cA}
Happy	0.026^{cA}	0.027^{cA}	0.030^{cA}	0.049^{cA}
Scared	0.028^{cA}	0.018^{cA}	0.021^{cA}	0.011^{cA}
Angry	0.006^{cA}	0.009^{cA}	0.008^{cA}	0.007^{cA}
Disgusted	0.001^{cA}	0.001^{cA}	0.005^{cA}	0.003^{cA}

[a, b, c] Means within each column with different letters are significantly different at $p<0.05$.
[1](n=30); Mean intensity values (0-1; 0= not expressed; 1= fully expressed) based on 5 second video analysis of facial response (FaceReader 5.0, Noldus Information Technology, Wageningen, The Netherlands) post-consumption of each sample on testing "Day 1" session.
[2]High fructose corn syrup (HFCS) and honey were added at equi-sweet concentration to 5% sucrose (w/w).

Table 4-4. Mean emotional intensity values[1] within water, sucrose, and artificial sweeteners[2] in cold tea

Emotion	Water	Sucrose	Ace-K	Sucralose
Neutral	0.568^{aA}	0.569^{aA}	0.599^{aA}	0.562^{aA}
Sad	0.138^{bA}	0.132^{bA}	0.106^{bA}	0.135^{bA}
Surprised	0.048^{bcA}	0.111^{bA}	0.083^{bcA}	0.100^{bcA}
Happy	0.057^{bcA}	0.040^{bcA}	0.061^{bcA}	0.046^{bcA}
Scared	0.045^{bcA}	0.020^{cA}	0.012^{cA}	0.034^{bcA}
Angry	0.003^{cA}	0.009^{cA}	0.010^{cA}	0.009^{cA}
Disgusted	0.002^{cA}	0.002^{cA}	0.005^{cA}	0.002^{cA}

[a, b, c, d] Means within each column with different letters are significantly different at $p<0.05$.
[1](n=29); Mean intensity values (0-1; 0= not expressed; 1= fully expressed) based on 5 second video analysis of facial response (FaceReader 5.0, Noldus Information Technology, Wageningen, The Netherlands) post-consumption of each sample on testing "Day 2" session.
[2]Ace-k and sucralose were added at equi-sweet concentrations to 5% sucrose (w/w).

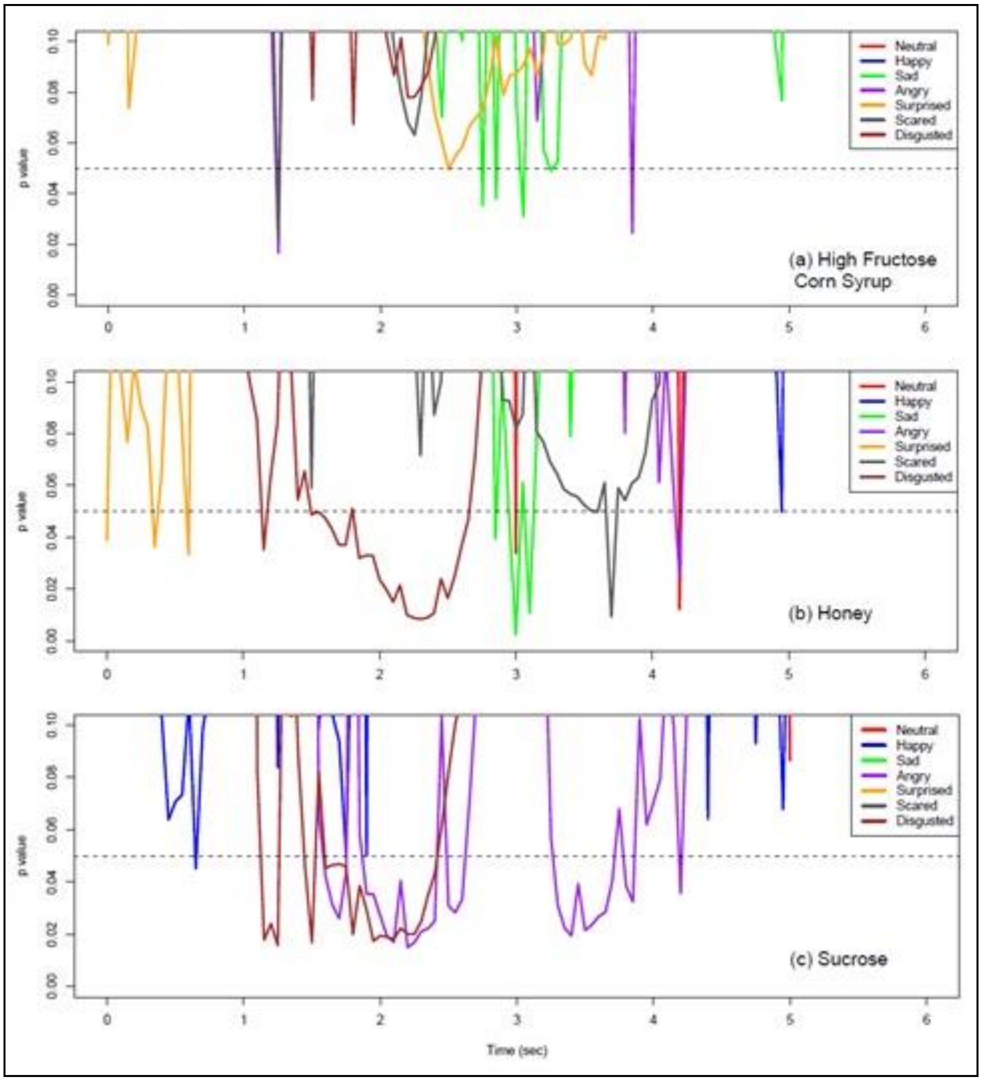

Figure 4-4. Time series analysis (5 seconds) of emotions from facial expression analysis session, comparing natural sweeteners to water baseline. Emotions with extended duration below the dotted line ($p<0.05$) are different from emotions elicited by water. (a) high fructose corn syrup; (b) honey; (c) sucrose.

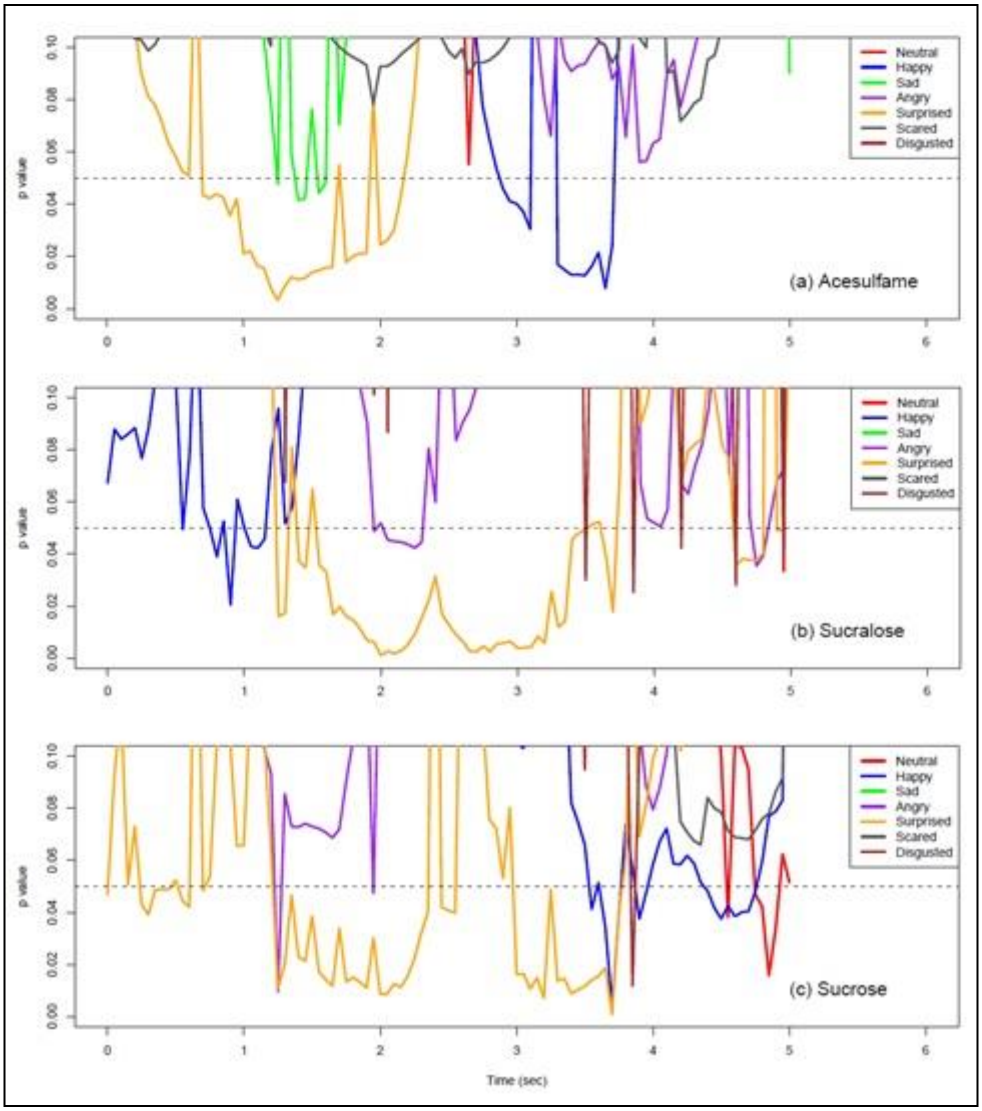

Figure 4-5. Time series analysis (5 seconds) of emotions from facial expression analysis session, comparing sucrose (control) and artificial sweeteners in cold tea to water baseline. Emotions with extended duration below the dotted line ($p<0.05$) are different from emotions elicited by water. (a) acesulfame k (Ace-K); (b) sucralose (SL); (c) sucrose (S).

Conclusions

The focus of this study was to explore whether differences in expressed emotions (implicit and explicit) exist among similar products and whether they are related to overall liking. Results showed that more emotions (and the intensity of each) were expressed by panelists due to artificial sweeteners than natural sweeteners, regardless of overall liking or the explicit/implicit tool utilized. Differentiation in liked versus disliked sweeteners (within categories) was found when using verbal responses but not facial expressions. While self-report emotion term questionnaires have begun to aid companies in understanding consumer acceptability and associated emotions, it is believed that facial expression analysis may aid in finding rapid, uncontrollable micro emotion responses that influence liking and preferences.

Limitations still exist in regards to panelist variation and AFEA software sensitivity during video capture; optimization of environmental settings is key. Exploring emotion patterns elicited by varying stimuli over time may provide additional value in understanding uncontrollable micro emotions in relation to verbal expressions of emotion and acceptability. Future research in the area of automated facial expression analysis should focus on finding subtle differences in emotion expression by product users and how/if those differences are related to product successes rather than failures in the marketplace.

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References

Alves, N.T., Fukusima, S.S. & Aznar-Casanova, J.A. (2008). Models of brain asymmetry in emotional processing. *Psychology & Neuroscience, 1*(1), 63-66.

Arnade, E.A. (2013). Measuring consumer emotional response to tastes and foods through facial expression analysis. Master's Thesis (Major Professor: S.E. Duncan), Virginia Polytechnic Institute and State University, Blacksburg, VA.

Balentine, D.A., Wiseman, S.A. & Bouwens, L.C.M. (1997). The chemistry of tea flavonoids. *Critical Reviews in Food Science and Nutrition*, 37(8), 693-704.

Birch, G.G. (1987). Sweetness and sweeteners. *Endeavour, 11*(1), 21-24.

Booth, D.A. (1994). *Psychology of Nutrition.* Bristol, PA: Taylor and Francis.

Cardello, A.V. (1994). Consumer expectations and their role in food acceptance. In *Measurement of Food Preferences.* (pp. 253-297). Springer, U.S.

Cogent Research, LLC (Cambridge, MA). 2006. High fructose corn syrup: consumer communications. Report and at-a-glance executive summary. Washington (DC): International Food Information Council (IFIC).

Danner, L., Haindl, S., Joechl, M., & Duerrschmid, K. (2014). Facial expressions and autonomous nervous system responses elicited by tasting different juices. *Food Research International, 64*(2014), 81-90.

Danner, L., Sidorkina, L., Joechl, M., & Duerrschmid, K. (2013). Make a face! Implicit and explicit measurement of facial expressions elicited by orange juices using face reading technology. *Food Quality and Preference*, *32*(Part B), 167-172.

Davidson, R.J., Ekman, P., Saron, C.D., Senulis, J.A., & Friesen, W.V. (1990). Approach-withdrawal and cerebral asymmetry: emotional expression and brain physiology I. *Journal of Personality and Social Psychology*, *58*(2), 330-341.

De Graaf, C. & Zandstra, E.H. (1999). Sweetness intensity and pleasantness in children, adolescents, and adults. *Physiology & Behavior*, *67*(4), 513-520.

De Wijk, R. A., He, W., Mensink, M. G., Verhoeven, R. H., & de Graaf, C. (2014). ANS responses and facial expressions differentiate between the taste of commercial breakfast drinks. *Plos One*, *9*(4), e93823.

De Wijk, R.A., Kooijman, V., Verhoeven, R.H.G., Holthuysen, N.T.E., & de Graaf, C. (2012). Autonomic nervous system responses on and facial expressions to the sight, smell and taste of liked and disliked foods. *Food Quality and Preference*, *26*(2), 196-203.

Desmet, P.M.A., & Schifferstein, H.N.J. (2008). Sources of positive and negative emotions in food experience. *Appetite, 50*(2-3), 290-301.

Devcich, D.A., Pedersen, I.K., & Petrie, K.J. (2007). You eat what you are: Modern health worries and the acceptance of natural and synthetic additives in functional foods. *Appetite,* 48(3), 333-337.

Dickson-Spillmann, M., Siegrist, M., & Keller, C. (2011). Attitudes toward chemicals are associated with preference for natural food. *Food Quality & Preference, 22*(1), 149-156.

Ekman, P., & Friesen, W.V. (1978). *Facial Action Coding System: A Technique for the Measurement of Facial Movement.* Palo Alto, CA: Consulting Psychologists Press.

Ekman, P., Friesen, W.V., & Ancoli, S. (1980). Facial signs of emotional experience. *Journal of Personality & Social Psychology, 39*(6), 1125-1134.

Fischer, R., Griffin, F., England, S., & Garn, S.M. (1961). Taste thresholds and food dislikes. *Nature, 191,* 1328.

Frank, G. K., Oberndorfer, T. A., Simmons, A. N., Paulus, M. P., Fudge, J. L., Yang, T. T., & Kaye, W. H. (2008). Sucrose activates human taste pathways differently from artificial sweetener. *Neuroimage*, *39*(4), 1559-1569.

Garcia-Burgos, D., & Zamora, M.C. (2015). Exploring the hedonic and incentive properties in preferences for bitter foods via self-reports, facial expressions and instrumental behaviours. *Food Quality and Preference, 39*, 73-81.

Gendron, M., Lindquist, K. A., Barsalou, L., & Barrett, L. F. (2012). Emotion words shape emotion percepts. *Emotion*, *12*(2), 314.

Gibson, E.L. (2006). Emotional influences on food choice: sensory, physiological and psychological pathways. *Physiology and Behavior, 89*(1), 53-61.

Green, E., & Murphy, C. (2012). Altered processing of sweet taste in the brain of diet soda drinkers. *Physiology & Behavior, 107*(4), 560-567.

Greimel, E., Machts, M., Krumhuber, E., & Ellgring, H. (2006). Facial and affective reactions to tastes and their modulation by sadness and joy. *Physiology & Behavior, 89* (2), 261-269.

Hedrick, V.E., Comber, D.L., Estabrooks, P.A., Savla, J., & Davy, B.M. (2010). The beverage intake questionnaire: determining initial validity and reliability. *American Dietetic Association*, *110*(8), 1227-1232.

Hu, S., Player, K.A., McChesney, K.A., Dalistan, M.D., Tyner, C.A. & Scozzafava, J.E. (1999). Facial EMG as an indicator of palatability in humans. *Physiology and Behavior, 68*(1-2), 31-35.

International Food Information Council Foundation (IFIC). (May 2013). [Survey of consumer attitudes toward food safety, nutrition & health]. Retrieved September 26, 2014, from the International Food Information Council Foundation website: http://www.foodinsight.org/articles/2013-food-and-health-survey.

King, S.C. & Meiselman, H.L. (2010). Development of a method to measure consumer emotions associated with foods. *Food Quality and Preference*, *21*(2), 168-177.

Kohler, C.G., Turner, T., Stolar, N.M., Bilker, W.B., Brensinger, C.M., Gur, R.E., Gur, R.C. (2004). Differences in facial expressions of four universal emotions. *Psychiatry Research, 128*(3), 235-244.

Köster, E.P. (2002). The psychology of food choice: some often encountered fallacies. *Food Quality and Preference, 14*(5-6), 359-373.

Kotsia, I., Buciu, I., & Pitas, I. (2008). An analysis of facial expression recognition under partial facial image occlusion. *Image and Vision Computing*, *26*(7), 1052-1067.

Leterme, A., Brun, L., Dittmar, A., & Robin, O. (2008). Autonomic nervous system responses to sweet taste: evidence for habituation rather than pleasure. *Physiology & Behavior*, *93*(4-5), 994-999.

Li, X., Inoue, M., Reed, D.R., Huque, T., Puchalski, R.B., Tordoff, M.G., Ninomiya, Y., Beauchamp, G.K., & Bachmanov, A.A. (2001). High-resolution genetic mapping of the saccharin preference locus (*Sac*) and the putative sweet taste receptor (T1R1) gene (*Gpr70*) to mouse distal Chromosome 4. *Mammalian Genome, 12*(1), 13-16.

Li, X., Staszewski, L., Xu, H., Durick, K., Zoller, M., & Adler, E. (2002). Human receptors for sweet and umami taste. *Proceedings of the National Academy of Sciences of the United States of America*, *99*(7), 4692-4696.

Lindquist, K. A., Barrett, L. F., Bliss-Moreau, E., & Russell, J. A. (2006). Language and the perception of emotion. *Emotion*, *6*(1), 125.

Lindstrom, M. (2005). *Brand Sense: Build Powerful Brands Through Touch, Taste, Smell, Sight and Sound.* New York, NY: Free Press.

Meyners, M., Castura, J. C., & Carr, B. T. (2013). Existing and new approaches for the analysis of CATA data. *Food Quality and Preference, 30*(2), 309-319.

Mitchell, H. (2006). *Sweeteners and Sugar Alternatives in Food Technology*. Oxford: Blackwell Publishing Ltd.

Nabors, L.O. (2012). *Alternative Sweeteners*. (4th ed.). Boca Raton, FL: Taylor & Francis Group, LLC.

Nelson, G., Hoon, M. A., Chandrashekar, J., Zhang, Y., Ryba, N. J., & Zuker, C. S. (2001). Mammalian sweet taste receptors. *Cell*, *106*(3), 381-390.

Nie, Y., Vigues, S., Hobbs, J. R., Conn, G. L., & Munger, S. D. (2005). Distinct contributions of T1R2 and T1R3 taste receptor subunits to the detection of sweet stimuli. *Current Biology*, *15*(21), 1948-1952.

Noldus Information Technology (2012). *FaceReader 5.0TM Reference Manual.* Noldus Information Technology, Wageningen, The Netherlands. Available from http://www.noldus.com. Last accessed October 28, 2014.

Parkinson, B. (2005). Do facial movements express emotions or communicate motives? *Personality and Social Psychology Review*, *9*(4), 278-311.

Porcherot, C., Delplanque, S., Raviot-Derrien, S., Le Calve, B., Chrea, C., Gaudreau, N., & Cayeux, I. (2010). How do you feel when you smell this? Optimization of a verbal measurement of odor-elicited emotions. *Food Quality and Preference, 21*(8), 938-947.

R Core Team (2014). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL http://www.R-project.org/.

Robbins, S.P., & Judge, T.A. (2013). Emotions and moods. In *Essentials of Organizational Behavior* (pp. 258-297). Upper Saddle River, NJ: Prentice Hall.

Robin, O., Rousmans, S., Dittmar, A., & Vernet-Maury, E. (2003). Gender influence on emotional responses to primary tastes. *Physiology & Behavior, 78*(3), 385-393.

Rousmans, S., Robin, O., Dittmar, A., & Vernet-Maury, E. (2000). Autonomic nervous system responses associated with primary tastes. *Chemical Senses, 25*(6), 709-718.

Rozin, P., Ashmore, M., & Markwith, M. (1996). Lay American conceptions of nutrition: dose insensitivity, categorical thinking, contagion, and the monotonic mind. *Health Psychology, 15*(6), 438-447.

Rozin, P., Spranca, M., Krieger, Z., Neuhaus, R., Surillo, D., Swerdlin, A., & Wood, K. (2004). Preference for natural: instrumental and ideational/moral motivations, and the contrast between foods and medicines. *Appetite, 43*(2), 147-154.

Rozin, P. & Vollmecke, T.A. (1986). Food likes and dislikes. *Annual Review of Nutrition 6*, 433-456.

Schifferstein, H.N.J., Fenko, A., Desmet, P.M.A., Labbe, D., Martin, N. (2013). Influence of package design on the dynamics of multisensory and emotional food experience. *Food Quality and Preference*, *27* (1), 18-25.

Somerville, L.H., Kim, H., Johnstone, T., Alexander, A.L., & Whalen, P.J. (2004). Human amygdala responses during presentation of happy and neutral faces: correlations with state anxiety. *Biological Psychiatry, 55*(9), 897-903.

Southern Sweet Tea. (n.d.). Retrieved April 30, 2013, from Lipton Tea website: http://www.liptontea.com/recipes/.

Spivey, M.J., Grosjean, M., & Knoblich, G. (2005). Continuous attraction toward phonological competitors. *Proceedings of the National Academy of Sciences (PNAS), 102*(29), 10393-10398.

Steiner, J.E. (1979). Human facial expressions in response to taste and smell stimulation. *Advances in Child Development and Behavior, 22*, 257-295.

Steiner, J.E., Glaser, D., Hawilo, M.E., & Berridge, K.C. (2001). Comparative expression of hedonic impact: affective reactions to taste by human infants and other primates. *Neuroscience and Biobehavioral Reviews*, *25*(1), 53-74.

Wendin, K., Allesen-Holm, B.H., & Bredie, W.L.P. (2011). Do facial reactions add new dimensions to measuring sensory responses to basic tastes? *Food Quality and Preference, 22*(4), 346-354.

White Jr, J.W. (1978). Honey. *Advances in Food Research,* 24, 287-374.

Whorf, B.L. (1956). *Language, Thought and Reality.* Cambridge, MA: Technology Press of Massachusetts Institute of Technology.

Zajonc, R.B. (1980). Feeling and thinking. Preferences need no inferences. *American Psychologist,* 35 (2), 151-175.

Zeinstra, G.G., Koelen, M.A., Colindrews, D., Kok, F.J., & de Graaf, C. (2009). Facial expressions in school-aged children are a good indicator of “dislikes”, but not of “likes”. *Food Quality and Preference, 20*(8), 620-624.

Chapter 5: Evaluating the role of true and false information on acceptability and emotional response to sweeteners in tea

Abstract

Food buzzwords and nutrition claims are everywhere; they play a role in addition to the numerous sensory, physiological, psychological, social and emotional attributes that help form consumer expectations and overall product acceptance. The purpose of this study was to evaluate if and how the overall acceptance and emotional response (measured explicitly using a check-all-that-apply (CATA) emotion term questionnaire and implicitly using an automated facial expression response) to two alternative sweeteners (ace-K & HFCS) and sucrose in cold tea changed when consumers were given varying product information (none; true; false).

Participants (n=27) evaluated a water sample (baseline, no product information), two (5%) sucrose-tea samples (control, true product information), and four equi-sweet alternative sweetener tea samples (2 high fructose corn syrup, 2 ace-K), divided by product information validity (true, false). Sessions (4 total, spread over 2 days) were divided by validity of product information and emotional response tool in a cross-over design. Facial expression responses were recorded in the first session of both days using FaceReader 5.0 and participant videos were analyzed per sample for 5-sec post-consumption (α=0.05) in the continuous analysis setting. Emotional term responses were collected in the second session of each day and count frequencies of each term per sample were tabulated and analyzed for significance (α=0.05). Hedonic acceptability was rated in all sessions on a 9-point scale.

Sweeteners were all rated “acceptable” (score of 5 or higher) across all information sessions; ace-K was the only sweetener to exhibit significant differences ($p<0.05$) in liking across information sessions. Sucrose was consistently rated significantly higher than Ace-K, and only significantly higher than HFCS for one session. Facial expression analysis showed minimal differences in emotion elicited across sweeteners and information sessions. Time series analysis showed more differences ($p<0.05$) than baseline comparisons during the true information session. Significant correlation values of moderate strength were observed for one emotion (scared), elicited from sucrose ($r= -0.49$; $0.0025<p<0.005$) during the true information session and three emotions (happy: $r= 0.44$; $0.01<p<0.02$; surprised: $r= -0.36$; $0.025<p<0.05$ & scared: $r= -0.38$; $0.02<p<0.025$) elicited by HFCS during the false information session. Emotional term selection using the CATA questionnaire showed highly variable responses across sweeteners and information sessions. Cochran’s Q test showed significance ($p=0.002$) for only one unique term, active, by sucrose during the blinded information session. More research investigating the impact of product information on emotions and acceptability is needed.

Keywords:

Emotion, automated facial expression analysis, product information, sweeteners

Introduction

Consumers are influenced by a number of internal and external factors when evaluating both new and familiar products. When it comes to foods and beverages, typical attributes evaluated on an industry level are those inherent to the product or package itself and can include appearance, taste, smell, texture, etc. (Cardello, 1994; Schifferstein, Fenko, Desmet, Labbe, & Martin, 2013). According to a national survey conducted in 2013, U.S. consumption habits of foods and beverages are mostly influenced by taste, closely followed by price and health (International Food Information Council, 2013). Acceptance of these product attributes are important for market success and can be directly measured through traditional sensory tests (Meilgaard, Civille, & Carr, 2007); however there are a number of other physiological, psychological, social and emotional influences on food choice that are not easily measured (Gibson, 2006). Several psychologists argue that it is not the product taste, but the expected taste (or taste memory) that affects consumer decisions (Köster, 2002). Other consumer studies have shown that product marketing (branding and advertisements) can also have a huge impact on the consumer decision making process, especially when a claim is repeated over time (Cronley, Kardes, & Hawkins, 2006; Harris, Bargh, & Brownell, 2009; Stein, Nagai, Nakagawa, & Beauchamp, 2003).

With the seemingly endless supply of options in the food sector, it can be difficult for a specific food product or new brand to differentiate itself from competitors and achieve market success. As a result, the product information and manner in which it is communicated to consumers becomes almost as important as the product appeal itself. Information changes the manner in which consumers are first exposed to and ultimately assess a product, regardless of whether it is conveyed through company marketing on a label, package, and/or commercial or by another means. With the growing obesity epidemic, consumers are becoming increasingly aware of how the nutrition of specific ingredients in foods and beverages can impact their overall health; however some disconnects in understanding between claims and personal health & nutrition still exist (Cogent Research, 2006; IFIC, 2013; Nocella & Kennedy, 2012; van Trijp & van der Lans, 2007).

The media has played a significant role in recent years on influencing the positive and negative consumer perceptions about certain ingredients. In turn, these perceptions have impacted how the food industry uses ingredients and ultimately markets their products. Regulations surrounding food product claims in the United States are closely monitored by government agencies, which provide certain labeling limitations for companies (Food & Drug Administration, 2013). In an effort to appeal to the minds of health-conscious consumers, the industry has taken advantage of using the four types of label claims (nutrient, health, qualified health and structure/function claims) in addition to using several unregulated food buzzwords and phrases. “Organic”, “local”, “contains probiotics,” “low-fat”, “multigrain”, “non-GMO”, “all-natural”, “diet”, “sustainable”, “free-range”, “gluten-free”, “whole” and “artisanal” are just a few examples of the types of claims being incorporated on food packages and in advertisements. In particular, use of the word “natural” and the phrase “all-natural” on labels has increased substantially in recent years due to safety and health concerns surrounding synthetic additives in food products (Devcich, Pedersen, & Petrie, 2007; Dickson-Spillmann, Siegrist, & Keller, 2011; Rozin, Spranca, Krieger, Neuhaus, Surillo, Swerdlin & Wood, 2004).

The absence of a standard legal definition of ‘natural’ and all of its derivatives in relation to food products has created some controversy among consumer and media proponents alike. In response, the USDA and National Organic Program have created a draft guidance decision tree for manufacturers in order to determine whether specific products under their mandate fit within the “natural” or “synthetic” category (United States Department of Agriculture, 2013). Despite this regulation step, numerous psychological and consumer studies on word association, implicit memory and priming have shown that once exposed to a stimuli, a certain amount of expectation exists among consumers when evaluating that product in the future (Cardello, 1994; Cronley et al., 2006; Harris et al., 2009; Lamote, Hermans, Baeyens, & Eelen, 2004). These developed product expectations based on labeling and packaging cues can often conflict with the consumers’ actual experience, also known as cognitive dissonance.

There is an existing body of literature (in the psychological and consumer studies fields) that has examined the relationship between expectation (both confirmed and disconfirmed) and food acceptability (Cardello & Sawyer, 1992; Cox, 1967, Grunert, 2002; Northup, 2014); however, very few (if any) studies have investigated the impact of product expectation on emotions and how those emotions then impact product acceptability. The purpose of this study was to evaluate if and how the overall acceptance and emotional response (measured explicitly and implicitly) to two alternative sweeteners (ace-K & HFCS) and sucrose changed when consumers were given varying product information (none; true; false). The specific objectives were two-fold: (1) determine if the key words and/or phrases used to describe the samples changed consumer acceptance for one or both of the alternative sweeteners; (2) determine if the emotional response (explicit and/or implicit) of consumers was affected by the addition of the given key words/phrases and/or the validity of such information.

Materials and Methods

Samples & sample preparation

Acesulfame potassium (ace-k; Wego Chemical & Mineral Co., Great Neck, NY), high fructose corn syrup (HFCS; Tate & Lyle, London) and sucrose (Kroger; Cincinnati, OH) were received by donation or purchased from the local supermarket. These two alternative sweeteners (and their concentrations) were selected from a previous study (Chapter 4; Leitch, 2015) in addition to a 5% sucrose (Kroger brand, Cincinnati, OH) solution (w/w) as the control. A batch solution of tea and three sweetened-tea solutions, using alternative sweeteners and sucrose (control), were made according to the same directions previously described (Chapter 4; Leitch, 2015) approximately 24 hours prior to all sensory testing days. Sweetener-tea solutions were mixed, transferred into pre-labeled 750mL wine bottles, covered and stored overnight (4 °C). At the beginning of each testing day, samples were poured into color-coded sample cups (2 oz. plastic; Solo brand) with caps.

Participant recruitment

All panelists from a previous study (Chapter 4: Emotional response) were invited to participate in the messaging portion of the experiment in order for the researchers to be able to compare all responses with messaging information to corresponding blinded responses. A total of 27 participants, (21 females; 6 males) from the acceptance study completed both testing days for this experiment; four participants from a previous study

(Chapter 4) were unable to complete this study. Participants were selected from the previous study due to the fact that they had already been screened for acceptable facial features based on software limitations and had already demonstrated "good panelist practices" in regards to training instructions. Modifications to the original IRB application (IRB# 13-244) entitled "Acceptability and Emotional Response to Alternative Sweeteners" were made to accommodate the messaging portion of this study prior to any sensory testing (Appendix A).

Experimental cross-over design

On each testing day (n=2), participants were asked to taste and evaluate the given sweetener-tea samples in the same manner as previously described (Chapter 4). The same cross-over test design was used; however sessions were divided based on the emotional collection tool used (video capture of the facial expression response (FER); emotional term selection, (ETS) and the sweetener information category (true; false), which was presented alongside each sweetened-tea sample (Table 1). Video capture of the face occurred in the first session of the evaluation each day; participants characterized their emotional response by selecting emotional terms from a check-all-that-apply (CATA) list in the second session of the day. Participants tasted and evaluated acceptability of sweetener-tea samples (3 total: sucrose, 1 natural and 1 artificial; 6 samples each day; total of 12 samples over a 2-day testing period), which were each presented with sweetener information (true; false; Table 1) on a 9-point hedonic scale (1= dislike extremely; 5= neither like nor dislike; 9= like extremely).

The validity of the information provided with each of the alternative tea-sweetener products changed depending on the testing session and testing day. Abbreviated true product descriptions for each labeled (on the ballot) sample included the following: sucrose-sweetened tea said "natural", tea with HFCS said "naturally sweetened" and tea with ace-k said "artificially sweetened." All of the samples were also accompanied by the amount of calories typically provided by the sweetener in a 12-ounce beverage. On the second day, the information for HFCS and ace-k was reversed providing a false message; the information for the sucrose product description remained true.

Table 5-1. Cross-over design. Information presented with each sweetener for both sessions and each testing day are shown.

Day 1	**Samples**	**Session 1 – True**[1] **Hedonic/FER**[2]	**Session 2 – False**[1] **ETS**[2]**/Surveys/Hedonic**
	Sugar[3]	Natural; 144 kcal/g	Natural; 144 kcal/g
	High fructose corn syrup[4]	Natural; 136 kcal/g	Artificial; 0 kcal/g
	Sweet One[5]	Artificial; 0 kcal/g	Natural; 136 kcal/g
Day 2	**Samples**	**Session 1 – False Hedonic/FER**	**Session 2 - True ETS/Surveys/Hedonic**
	Sugar[3]	Natural; 144 kcal/g	Natural; 144 kcal/g
	High fructose corn syrup[4]	Artificial; 0 kcal/g	Natural; 136 kcal/g
	Sweet One[5]	Natural; 136 kcal/g	Artificial; 0 kcal/g

[1]Information indicates the settings under which the acceptance and emotional response data was collected, not necessarily the validity of the message paired with each sweetener
[2]Emotional response tool used for each information session (FER=facial expression response; ETS=emotional term selection)
[3]Sugar (5% sucrose concentration in cold tea)
[4]High fructose corn syrup (HFCS)
[5]Sweet One (Acesulfame potassium, Ace-K)

Experimental environment, testing sequence & data management

Session 1: FER & sweetener + message acceptance

Individual sessions were scheduled for all participants using the same sensory booth from the previous emotion study (Chapter 4) in order to standardized FER video capture and lighting across testing days and studies. White lighting in the booth and lighting from overhead lights and the touchscreen monitor illuminated the faces of participants. The same webcam (Microsoft 2.0 megapixel LifeCam NX-6000, Redmond, WA) was attached to the bottom of the touchscreen monitor and attached to a laptop (Latitude Essio, Dell, Inc., Round Rock, TX) on the research side of the hatch in order to record facial movements during the session. The webcam was preset using all of the same parameters (30 frames/sec; frame dimensions = 640w x 480h) as for the previous study (Chapter 4) in order to best compare across studies. Video recording began at the start of each testing session and captured the entire first session using Microsoft Movie Maker (2011); files were saved as windows media files (.wmv) on an external hard drive.

At the beginning of the testing session, participants were seated in the booth and presented with a consent form. After signing, panelists received a water sample (Drinking water, Kroger brand, Cincinnati, OH) and 3 color-coded sweetened tea samples (30 mL each) on one tray. While being video recorded, panelists first tasted the water sample, which was used as a baseline to elicit a neutral response and reduce as much emotional noise between panelists as possible. Following the water sample, panelists were presented with the sweetener information on screen and immediately tasted the associated sweetener-tea samples one at a time. These three samples (two sessions per day; two days) were randomized in a balanced complete block design. Panelists were informed which sweeteners were used in each sample, however they were not informed of the veracity of the information provided with each sweetener in each session. Samples were presented from left to right and panelists were instructed to cleanse the palate with provided water and an unsalted soda cracker between each.

Uniquely colored index cards (placed on top of each sample and coded for samples specific to an information category) were held up prior to tasting in order to provide the researcher with a video record of the sample being evaluated. Panelists followed the same tasting protocol as described in Chapter 4 and were instructed to sit for "wait periods" of 30 sec upon swallowing each sample in full (30 mL); the waiting time was enforced through programming of the management software (Sensory Information Management System, SIMS). After the 30 sec wait period, acceptability scores (1= extremely dislike; 5= neither like nor dislike; 9= like extremely) were collected via touchscreen monitor and the data was stored on the computer server until completion of the study, when all responses were transferred to an electronic spreadsheet (Microsoft Excel, Microsoft Corporation, Inc., Redmond, WA) for further analysis.

Video files were stored on an external hard drive and batch analyzed using the facial expression analysis software with continuous face calibration. Continuous was selected from three calibration settings (default, continuous and individual) offered by the FaceReader software (Noldus, 2012) due to its ability to actively eliminate participant bias while analyzing each video without requiring a baseline recording. Unpublished results from our lab group showed that the continuous calibration setting was more sensitive than the default setting in FaceReader 5.0 and less involved than the individual calibration. Each sample/recording (including water; 8 total per panelist) was event marked for a period of 5 sec post-consumption, based on when the sample cup fell below the chin, in order to identify desired data. R code (version 3.1.1, R Core Team, 2014), which was created for a previous emotional acceptance study (Chapter 4), was used to identify and extract the event marked facial expression data for each sample per panelist for statistical analysis from the exported log files (.txt). Facial expression data for water was also analyzed as a 'sample' in comparison to the sweetened tea samples in each category in addition to being treated as a baseline using R.

Session 2: ETS & sweetener + message acceptance

Upon completion of the first session, panelists were guided to a separate classroom and directed to a seat with a trifold board simulating a sensory booth. Since all participants had completed the demographic and beverage intake questionnaire from the previous emotional acceptance study (Chapter 4; Leitch, 2015), panelists were only given a daily self-assessment questionnaire (n=2) during this session, providing information on their state of mind and general health. This also provided additional recovery time to reduce sensory fatigue between sessions.

All participants were presented with four samples simultaneously, (one water and three color-coded tea-sweetener samples) under white fluorescent lighting. Participants were instructed to read the product information while consuming the associated sweetener-tea samples. All samples were evaluated from left to right and participants were directed to consume water (Drinking water, Kroger brand, Cincinnati, OH) and/or unsalted soda crackers between each to cleanse the palate. Panelists rated their acceptance of each sweetener-tea solution on the 9-point hedonic scale at the top of the modified EsSense™ ballot (King & Meiselmann, 2010) and selected any emotional terms they associated with the sample or the provided information from the list of 43 terms. All panelist self-assessment information, hedonic and emotional term data were recorded electronically upon completion of the study. All panelists were offered a snack and given the option to accept two canned goods or donate them in accordance with our “Serving Science & Society” sensory program as compensation.

Statistical analyses

In order to make comparisons across all information types (none, true and false), data from the previous blinded study (Chapter 4; Leitch, 2015) was carried over using only active participants (n=27) from the current study. This allowed the researchers to use the data collected during the blinded experiment as a control for the influence of true and false information.

Sweetener acceptance

Mean hedonic scores for each sweetener within each information category (none; true; false) and data collection tools (facial expression; CATA emotional term list) were calculated (Microsoft Corporation, Inc., Redmond, WA). Distribution normality was tested using the Shapiro-Wilk goodness-of-fit test (JMP SAS, Cary, NC) for each sweetened tea sample. Nonparametric one-way analyses of variances (ANOVAs) using the Kruskal-Wallis test were conducted (JMP SAS, Cary, NC) to determine differences among mean hedonic scores for (1) within each sweetener across information categories and (2) within each information category across sweeteners for both data collection methods.

Facial expression response

Emotion intensity means, each scaled 0 to 1 (0=not expressed; 1=fully expressed) for all participants and samples, 5 sec post-consumption, were generated from FaceReader output using R, version 3.1.1 (R Core Team, 2014). Repeated one-way

ANOVAs were conducted in the same manner in which they were performed in the blinded study (Chapter 4). Comparisons within emotion state (sad, surprised, happy, scared, angry, disgusted and neutral), across sweeteners (water, sucrose, ace-k, and HFCS) and within sweetener, across emotions using Tukey's HSD multiple comparison of means in R were made; significance ($p<0.05$) and potential trends ($p<0.2$) were explored in relation to information provided alongside each sample. Repeated one-way ANOVAs were also made across information session, within emotion and across emotion within information session, blocking by sweetener. Time series data for each emotion were collected and mean differences between water and each sweetener were evaluated in the same manner as the blinded study (Chapter 4; Leitch, 2015). The relationship between mean facial expression intensity values and hedonic scores were also assessed using a linear regression analysis within and across information categories (JMP, SAS, Cary, NC). Regression value strength was defined using suggestions by Taylor (1990), where values less than 0.35 were considered weak, 0.36 to 0.67 were moderately strong and values between 0.68 to 1.0 were strong.

Emotional term selection

Count frequencies for each emotion term (43 total), term classifications, Cochran's Q test for significance (Gacula, Singh, Bi, & Altan, 2009) and penalty lift analysis (Meyners, Castura, & Carr, 2013) comparing term selection to liking for all samples in each information category (none; true; false) were calculated and performed in the same manner as previously described in Chapter 4 (Leitch, 2015).

Results and Discussion

Any number of internal and external factors can influence consumers when appraising the quality of a product. These factors can include any physiological, social, psychological or emotional factors in addition to the intrinsic and extrinsic components of the product itself (Gibson, 2006; Cardello, 1994; Grunert, 2002). It is believed that product expectations are formed from intrinsic and extrinsic product factors such as taste, appearance, price, and nutrition, as well as product information and branding conveyed through packaging, advertisements or word of mouth (Cox, 1967; Deliza & MacFie, 1996; Grunert, 2002). The manner in which consumers appraise such quality cues has been explored through numerous consumer and behavior studies (Jacoby, Olson, & Haddock, 1971; Krutulyte, Costa, & Grunert, 2009; Lamote et al., 2004; Lindstrom, 2005). The total food quality model (Grunert, 2002) & and the “sorting method” (Cox, 1967) have both used to explain product appraisal processing among consumers. Both models are similar but Cox (1967) argued that the consumer assigned confidence value of information cues is most important when predicting behavior.

It has been shown that consumer understanding of nutritional information is somewhat lacking, and the use of food buzzwords by the industry and media has served to further perpetuate misconceptions about specific ingredients and their incorporation in various products (Borra & Bouchoux, 2009; Devcich et al., 2007; Dickson-Spillmann et al., 2011).Very few studies have attempted to understand the impact specific key words (natural; artificial) have on the acceptance and emotional response (verbal, nonverbal) to sweeteners. We attempted to characterize implicit and explicit emotional and acceptance differences elicited from sweetener information by measuring facial expression responses and a verbal check-all-that-apply ballot when providing consumers with true and false product information.

Acceptability of sweeteners in tea with and without product information

The inherent acceptability of sweet and sweet products has been established throughout the literature (De Graaf & Zandstra, 1999; Greimel, Macht, Krumhuber & Ellgring, 2006; Rozin & Vollmecke, 1986; Steiner, Glaser, Hawilo & Berridge, 2001). However, taste is not the only factor influencing product acceptability (Gibson, 2006). Investigations related to consumer understanding and acceptance or rejection of various sweeteners have found that a certain amount of controversy exists surrounding sweetener derivation, consumption and subsequent health consequences (Rozin, Ashmore, & Markwith, 1996; Rozin et al., 2004); this is especially true for HFCS (Bray, Nielsen & Popkin, 2004). When assessing consumer acceptability of products, it is therefore important for investigators to consider the type and manner in which information is conveyed. Two food buzzwords that appear to have such an impact on consumer acceptability include “natural” and “artificial” (Devcich et al., 2007; Dickson-Spillman et al., 2011).

Hedonic scores for all sweetened tea samples in each information category (none; true; false) did not follow a normal distribution as determined by Shapiro-Wilk goodness-of-fit. Left skews were observed for nearly all sweeteners that were presented with no information (Figure 1A, 1B). A slight difference in hedonic distribution was observed for sucrose by testing day rather than information session; the distribution for testing day 1 was more spread than those observed for testing day 2 (Figure 1C & 1D, 1E & 1F). Since the information provided with sucrose was unchanged, no significant differences in reported acceptability were expected. Paired t-tests conducted within panelists for sucrose confirmed that no significant differences (p>0.05) in acceptability exist across sessions (FER, ETS; none, true, false).

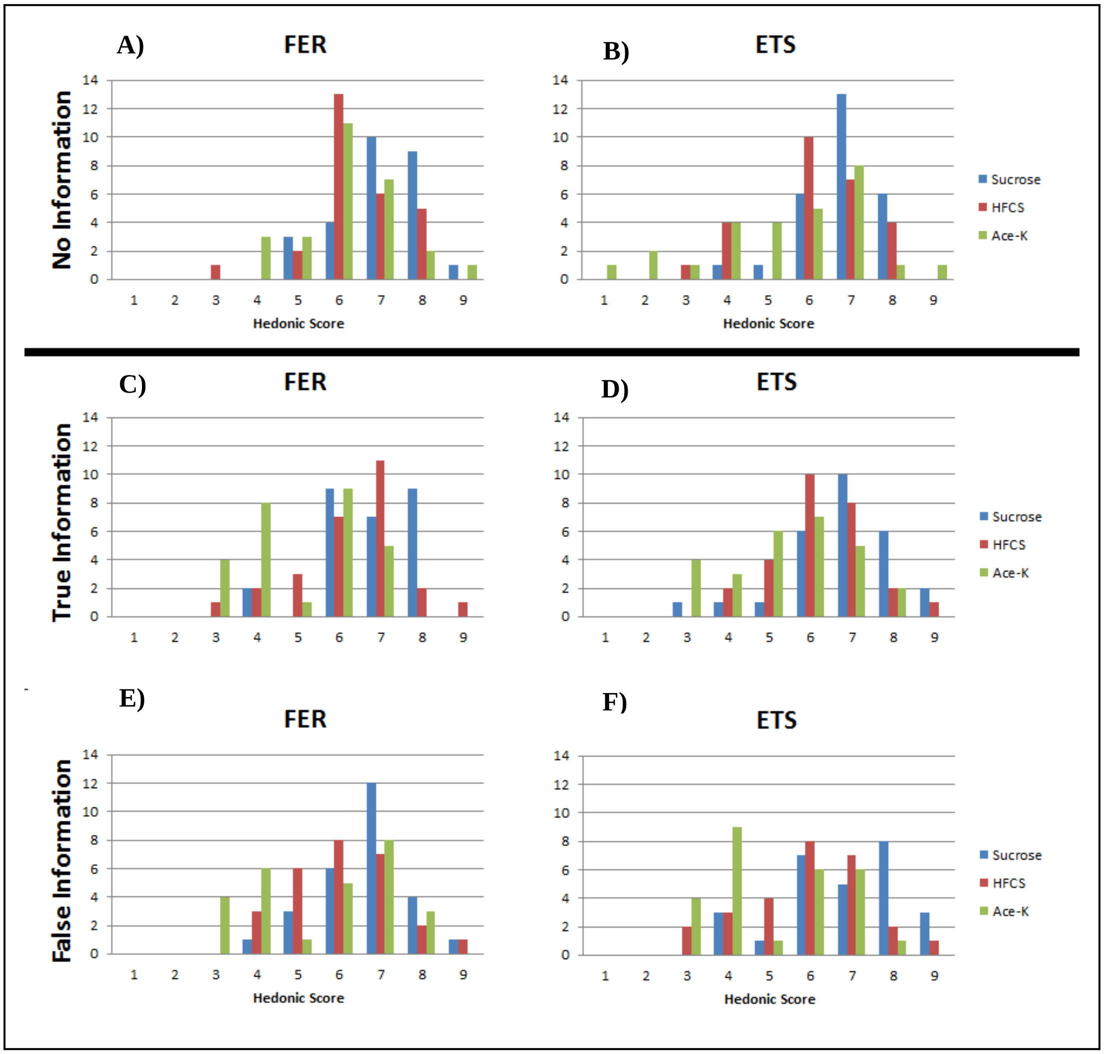


Figure 5-1. Histograms of hedonic ratings of sweeteners in tea within each information session. Population: (n=27 FER, facial expression response; n=27 ETS, emotional term selection); Participants tasted samples of each sweetener in tea in a balanced complete randomized order in six separate sessions based on the product information provided (none; true; false) and the data collection tool (FER; ETS). Participants rated each sample using a 9-point Likert scale (1=extreme dislike; 9=extremely like).

One explanation for the observed distribution differences includes contributing external factors due to a potential day effect across the “blinded” and “information provided” studies; however, this was not explored at length and only mentioned as a potential explanation for discrepancies in liking. A higher number of participants reported (self-assessment questionnaire) having lower mental health, feeling more stressed and less alert on testing day 1 than on testing day 2 during the “information study” (Table 2). Distributions for HFCS appeared to change according to the type of information provided with the sample; true information elicited higher hedonic scores than false information; however no significant differences ($p>0.05$) were detected (Figure 1C-F). Ace-k hedonic scores appeared to display bimodal distributions for all information sessions and testing days except Day 2 for true information (Figures 1C-F).

Table 5-2. Self-Assessment Questionnaire Count Summary by testing day

Testing Day 1

	Excellent (1)	Good (2)	Average (3)	Below average (4)	Poor (5)
Physical health	12	11	3	0	1
Mental health	8	15	3	1	0
	No stress (1)	Slightly stressed (2)	Moderately stressed (3)	Very stressed (4)	Extremely stressed (5)
Stress level	5	15	5	2	0
	Very alert/awake (1)	Moderately awake (2)	Borderline awake/tired (3)	Moderately tired (4)	Very tired (5)
Alertness	6	15	4	2	0

Testing Day 2

	Excellent (1)	Good (2)	Average (3)	Below average (4)	Poor (5)
Physical health	10	14	2	1	0
Mental health	12	11	4	0	0
	No stress (1)	Slightly stressed (2)	Moderately stressed (3)	Very stressed (4)	Extremely stressed (5)
Stress level	11	11	4	1	0
	Very alert/awake (1)	Moderately awake (2)	Borderline awake/tired (3)	Moderately tired (4)	Very tired (5)
Alertness	11	10	4	2	0

(n=27) Count summary of participant responses to the self-assessment questionnaire distributed during the ETS session of each testing day. Provided answers were used to interpret differences in acceptability scores and/or emotional responses.

Sucrose and HFCS samples were both well-liked with acceptability scores falling between “like slightly” to “like moderately.” Ace-K values fell between “neither like nor dislike” to “like slightly.” Mean acceptability scores revealed that ace-k in tea was liked significantly less ($p<0.05$) than sucrose, regardless of the information given in either session (Table 3). This was partially expected based on results collected during the blinded study (No information; Table 3). When presented with true information during the FER session, ace-k was liked significantly ($p<0.05$) less than when it was presented with no information but false information did not influence ratings compared to true or no information (Table 3). These results may suggest calling attention to the word “artificial” is detrimental to consumer acceptability of a product in this category; however this conclusion was not directly supported by hedonic ratings collected during the ETS sessions and may also be attributed to testing day differences.

Table 5-3. Mean hedonic scores[1] for sweeteners presented with varying information[2] in cold tea.

FER[3]	**None**	**True**	**False**
Sucrose[4]	$6.8^{Aa} \pm 1.2$	$6.8^{Aa} \pm 1.2$	$6.7^{Aa} \pm 1.1$
Ace-K	$6.0^{Ab} \pm 1.4$	$5.0^{Bb} \pm 1.5$	$5.6^{ABb} \pm 1.7$
HFCS	$6.5^{Aab} \pm 1.1$	$6.3^{Aa} \pm 1.3$	$6.1^{Aab} \pm 1.3$

ETS[3]	**None**	**True**	**False**
Sucrose[4]	$6.5^{Aa} \pm 1.3$	$6.8^{Aa} \pm 1.4$	$6.9^{Aa} \pm 1.5$
Ace-K	$5.4^{Ab} \pm 1.9$	$5.4^{Ab} \pm 1.5$	$5.1^{Ab} \pm 1.6$
HFCS	$6.1^{Aab} \pm 1.4$	$6.3^{Aab} \pm 1.2$	$5.9^{Ab} \pm 1.5$

[A,B] Means in each sweetener row with different letters are significantly different across information categories at $p<0.05$.

[a,b] Means within each information category column (None; True; False) with different letters are significantly different across sweetener treatments at $p<0.05$.

[1] n= 27; 1= extremely dislike; 9= extremely like.

[2] Information: None= Blind hedonic session (Chapter 4); True= correct information; False= Incorrect information.

[3] Tool: FER= Facial expression response tool; ETS= Emotional term selection tool.

[4] Population variance across studies (Mean scores for sucrose during the blind study reflect an average between two testing days for both tool used)

HFCS acceptability was found to be no different in comparison to sucrose or ace-k within information categories, with two exceptions (Table 3). HFCS was liked significantly less than sucrose when it was presented with false sweetener information during the ETS session ("testing day 1"), supporting the earlier conclusion that the word "artificial" has negative connotations from a consumer point of view (not supported during FER session though). Moreover, HFCS was significantly more acceptable than ace-k when both were presented with true sweetener information during the FER session ("testing day 1") (Table 3). These results, which were similar to hedonic ratings for ace-k, were not repeated across testing days.

One explanation for this could be due to the testing day in question; "day 1" was the first exposure to the information and therefore, the conflicting results may be due to panel perception of "trust-worthiness" of the information. Some studies have shown that general acceptance of new and familiar products can be enhanced by simply providing consumers with product information (Tuorila, Meiselman, Bell, Cardello, & Johnson, 1994). Results from several consumer studies have showed that word priming and repeated exposure to stimuli can impact information credibility in the eyes of the consumer (Boush, 1993; Cronley et al., 2006; Hawkins & Hoch, 1992; Lamote et al., 2004). In regards to this experiment, consumers were not asked about familiarity with the product information provided prior to testing and therefore it was assumed that participant's first exposure to the information was prior to "Day 1" during "session 1." As a result, potential day effects were not explored since appraisal differences between first exposure and later exposure to the information could not be detected.

Another potential explanation for observed differences in panelist acceptability across information sessions is the theory of cognitive dissonance. First proposed by Festinger in 1957, dissonance is defined as the amount of stress experienced by an individual when confronted with contextual information that conflicts with an internal belief system (as cited in Cardello & Sawyer, 1992). When experienced by an individual, disconfirmation can have either a positive or negative impact on acceptance (Cardello & Sawyer, 1992). In regards to the results from this experiment, dissonance can potentially explain reported liking differences for ace-K and HFCS, where truthful product information (ace-k = artificial; HFCS = natural) appeared to negatively affect scores for ace-K and positively affect those for HFCS, even when significant differences were not found (Table 3).This conclusion is supported by evidence from Carlsmith and Aronson (1963) who reported that disconfirmed expectancies related to sweet and bitter solutions resulted in lower hedonic scores.

Comparisons of mean hedonic scores for each sweetener (sucrose, ace-k, and HFCS) were not significantly different ($p<0.05$) within information category (none; true; false), across sessions (FER; ETS). These results suggest panelist reliability across studies and conflict with the potential day effect explanation since sweeteners were not provided with the same type of product information (true; false) on the same testing days. Therefore, it can be concluded that any differences in liking resulted from the exposure to and validity of the sweetener information provided.

Facial expression response

It has been well established that facial expression responses are highly correlated to acceptance or rejection of food stimuli (Danner, Haindl, Joechl & Duerrschmid, 2014;

Garcia-Burgos & Zamora, 2013; Wendin, Allesen-Holm & Bredie, 2011). Since apparent liking/disliking for sweeteners was proposed to be influenced by provided information credibility, it was predicted that the characterization of implicit emotional responses would relate closely to this as well. No statistical ($p<0.05$) or near statistical differences ($p<0.2$) were seen within emotion comparing across all sweetener samples when presented without information or with truthful sweetener information (Table 4). Statistical differences ($p<0.5$) were, however, observed for the happy and disgusted emotions when the sweeteners were presented with false product information (Table 4). Happy, an approach emotion, was expressed with significantly higher intensity ($p<0.5$) upon consumption of water when compared to sucrose, high fructose corn syrup and ace-k. It is generally thought that when used as a stimulus, water elicits neutral responses (Steiner, 1979; Steiner, et al., 2001).

Table 5-4. Mean emotional intensity values[1] within water (baseline) and sweeteners in cold tea when given varying product information[2] from facial expression analysis.

No information	Water	Sucrose	HFCS	Ace-K
Neutral	0.562^{a}	0.561^{a}	0.546^{a}	0.599^{a}
Sad	0.157^{b}	0.153^{b}	0.166^{b}	0.106^{b}
Surprised	0.053^{c}	0.087^{bc}	0.069^{c}	0.083^{b}
Happy	0.042^{c}	0.034^{cd}	0.030^{c}	0.061^{bc}
Scared	0.037^{c}	0.019^{cd}	0.021^{c}	0.012^{c}
Angry	0.005^{c}	0.009^{d}	0.008^{c}	0.010^{c}
Disgusted	0.002^{c}	0.002^{d}	0.005^{c}	0.005^{c}

True information	Water	Sucrose	HFCS	Ace-K
Neutral	0.547^{a}	0.579^{a}	0.555^{a}	0.555^{a}
Sad	0.084^{b}	0.141^{b}	0.128^{b}	0.127^{b}
Happy	0.090^{b}	0.052^{c}	0.046^{c}	0.089^{bc}
Surprised	0.045^{b}	0.050^{c}	0.065^{bc}	0.050^{bc}
Scared	0.034^{b}	0.017^{c}	0.018^{c}	0.015^{c}
Angry	0.022^{b}	0.010^{c}	0.015^{c}	0.011^{c}
Disgusted	0.003^{b}	0.001^{c}	0.005^{c}	0.006^{c}

False information	Water	Sucrose	HFCS	Ace-K
Neutral	0.567^{Aa}	0.543^{Aa}	0.567^{Aa}	0.563^{Aa}
Sad	0.150^{Ab}	0.183^{Ab}	0.152^{Ab}	0.162^{Ab}
Surprised	0.087^{Abc}	0.066^{Ac}	0.096^{Abc}	0.084^{Abc}
Happy	0.050^{Abc}	0.023^{Bc}	0.026^{Bc}	0.018^{Bc}
Scared	0.013^{Ac}	0.026^{Ac}	0.013^{Ac}	0.012^{Ac}
Angry	0.011^{Ac}	0.007^{Ac}	0.014^{Ac}	0.005^{Ac}
Disgusted	0.001^{Ac}	0.003^{ABc}	0.002^{ABc}	0.005^{Bc}

[a, b, c] Means within each sweetener column (blocked by information session) with different letters are significantly different at p<0.05.
[A, B] Means within each emotion row, across sweeteners with different letters are significantly different at p<0.05.
[1](n=27); Mean intensity values (0-1; 0= not expressed; 1= fully expressed) based on 5 second video analysis of facial response (FaceReader 5.0, Noldus Information Technology, Wageningen, The Netherlands) post-consumption of each sample.
[2]Blocked by information session; “no information” mean intensity values (same panelists) were collected in a previous study and used to compare to the “true” and “false” information sessions.

This conflicting result can potentially be explained by cognitive dissonance theory if emotions are conceptualized as the drivers of homeostatic maintenance (McGinley, 2014). False product information for the AFEA session was presented on the last testing day. Therefore the panelists had already been primed and potentially formed expectations about the sweetener-information pairs. This may have prompted panelists to experience a certain amount of confusion or cognitive dissonance when the information provided with each alternative sweetener was different from previous sessions. Water was consistently presented without information, and may have served as an emotional homeostatic "balance" resulting in a higher elicitation of happy when compared to the sweetener-information samples. This interpretation was supported by findings of Cronley et al. (2006) who investigated the impact repeated exposure of product information had on consumer ability to discern truthfulness; under subliminal conditions, they found that repeated exposure actually resulted in significantly lower credibility ratings (Cronley et al., 2006).

Disgusted (an avoidance/withdrawal emotion) was expressed with a significantly ($p<0.05$) higher intensity for tea with ace-k as compared to water and (higher intensity than sucrose and HFCS, although not significant) (Table 4). The elicitation of 'disgust' from ace-k corresponds to the low acceptability scores as compared to the other sweeteners in general as it was the least liked sweetener. It was also somewhat expected as studies have shown that bitter taste in foods, which is associated with ace-k (Wiet & Beyts, 1992), is undesirable (Gibson, 2006; Steiner, 1979). Findings were also supported by previous facial expression response studies showing that disliked samples tend to elicit higher intensities of disgust (Danner, Haindl, Joechl, & Duerrschmid, 2014; Garcia-Burgos & Zamora, 2013; Zeinstra, Koelen, Colindrews, Kok & de Graaf, 2009).

However, the lack of significance for the elicitation of disgust by ace-K during the "none" and "true" information sessions was unexpected in this regard, especially when interpreting how product information relates to acceptance. One investigation conducted by Shepherd, Sparks, Bellier & Raats (1992) found that liking for different sweetened milk samples was not influenced by product information unless consumer attitudes toward specific product attributes were taken into account. Positive attitudes towards product information resulted in higher hedonic scores as well as higher ratings for potential future purchases (Shepherd, et al., 1992). Studies have shown that in general, health-conscious consumers have preferences for more natural ingredients (Devcich et al., 2006; Dickson-Spillman et al., 2011). As a result, it was hypothesized that sweeteners paired with the term "natural" (ace-k in the "false" session) would show higher reported liking and therefore a higher elicitation of positive expressions and lower elicitation of negative emotions. This assumption was not supported by the significantly expressed emotions observed for ace-k during the false information session.

Repeated one-way ANOVAs within samples (blocking by information session) across each of the 6 emotions (sad, surprised, happy, scared, angry and disgusted) and neutral state also showed some statistical differences ($p<0.05$), suggesting differences in overall response among sweeteners alone. The intensity pattern (ordered highest to lowest) revealed that the same two emotions (neutral and sad, respectively) were elicited with the highest and second highest intensity for all sweeteners and information sessions;

however, the order of the remaining five emotions changed for two out of three sweeteners in each information session when compared to the blind session.

No statistical differences ($p<0.05$) were found within emotion across information session when blocked by any of the sweeteners (Table 5). One near statistical difference was observed for the emotion “happy” ($p=0.06$) when presented with true versus false information alongside ace-K (Table 5). Intuitively, the higher elicitation of happy does not match the corresponding hedonic score data when presented under truthful information circumstances as compared to false. However, these findings were supported by evidence from another facial expression investigation showing that disliked foods elicit higher intensities of the neutral, happy and sad emotions than liked foods (De Wijk, Kooijman, Verhoeven, Holthuysen & De Graaf, 2012).

Repeated one-way ANOVAs within information sessions (blocking by sweeteners) across the 6 emotions (sad, surprised, happy, scared, angry and disgusted) and neutral state also showed statistical differences ($p<0.05$) and numerous subtle differences (Table 5). Neutral was always expressed with the highest intensity across all product information sessions and sweeteners, however the intensity pattern (second highest to lowest) of the remaining emotions elicited by each sweetener changed with the type of product information presented. Intensity patterns for sucrose and ace-K remained the same with one exception; happy was expressed with higher intensity during the true information session than surprise (Table 5).

Table 5-5. Differences in mean emotional intensity values[1] from facial expression analysis within sweeteners in cold tea across product information session.[2]

Sucrose

	No Information[3]			
	Session 1	Session 2	True Information	False Information[1]
Neutral	0.604[a]	0.598[a]	0.579[a]	0.543[a]
Sad	0.112[b]	0.112[b]	0.117[b]	0.183[b]
Surprised	0.062[bc]	0.099[bc]	0.050[bc]	0.066[c]
Happy	0.033[bc]	0.044[bc]	0.052[bc]	0.023[c]
Scared	0.008[c]	0.005[c]	0.017[c]	0.026[c]
Angry	0.010[c]	0.011[c]	0.010[c]	0.007[c]
Disgusted	0.001[c]	0.002[c]	0.001[c]	0.003[c]

HFCS

	No Information	True Information	False Information
Neutral	0.546[a]	0.555[a]	0.567[a]
Sad	0.166[b]	0.128[b]	0.152[b]
Surprised	0.069[bc]	0.065[bc]	0.096[bc]
Happy	0.030[bc]	0.046[bc]	0.026[c]
Scared	0.021[c]	0.018[c]	0.013[c]
Angry	0.008[c]	0.015[c]	0.014[c]
Disgusted	0.005[c]	0.005[c]	0.002[c]

Ace-K

	No Information[4]	True Information	False Information
Neutral	0.599[a]	0.555[a]	0.563[a]
Sad	0.106[b]	0.127[b]	0.162[b]
Surprised	0.083[b]	0.050[bc]	0.084[bc]
Happy[5]	0.061[b]	0.089[bc]	0.018[c]
Scared	0.012[b]	0.015[bc]	0.012[c]
Angry	0.010[b]	0.011[c]	0.005[c]
Disgusted	0.005[b]	0.006[c]	0.005[c]

[a, b, c] Means within each information column (blocked by sweetener) with different letters are significantly different at $p<0.05$.

[1](n=27); Mean intensity values (0-1; 0= not expressed; 1= fully expressed) based on 5 second video analysis of facial response (FaceReader 5.0, Noldus Information Technology, Wageningen, The Netherlands) post-consumption of each sample.

[2]Information indicates the settings under which the facial expression data was collected, not necessarily the message paired with the sweetener

[3]Sessions 1 & 2 indicate that sucrose was presented as the control with natural sweeteners during session 1 and artificial sweeteners during session 2.

[4]No information approaches significance (p=0.055) between sad and disgusted for ace-K.

[5]Happy approaches a significant difference (p=0.06) between true and false sessions for Ace-K.

Facial expression analysis using time series

Paired t-test comparisons using time-step analysis showed some sweetener differences (mostly sweetener trends) in expressed intensity and sequence of emotions from baseline (using water) when blocking by information session (Figures 2, 3). Intensity and time differences ($p<0.05$)/trends ($p<0.2$) were observed for three emotions (sad, surprised and neutral) across sweetener-water comparisons in the true information session (Figure 2). Neutral was expressed with the highest intensity and duration for sucrose with observed significance between 2-5 secs post-consumption (Figure 2c). Trends ($p<0.2$) were observed for sad (avoidance/withdrawal emotion) between 0-1 sec and happy (approach emotion) between 1.5-2.5 sec post-consumption for sucrose, although findings were not as robust as neutral. Evidence from a study conducted by De Wijk et al. (2012) suggested that disliked samples elicited higher intensities of neutral, happy and sad when compared to well-liked samples. This interpretation is not supported by results from our study since sucrose was rated as the most liked sweetener; however, direct comparisons cannot be made since the acceptability of water was not evaluated.

Sad was elicited with the highest intensity and duration for high fructose corn syrup when compared to water, followed by surprised (Figure 2b). Two peaks of observed significance for sad between 0.5-1 secs and 1.5-3.5 secs post-consumption were found for HFCS; significance for surprised was observed between 1-2 secs post-consumption. Sad was the only emotion expressed with significance for ace-K when presented with truthful information as compared to water; two peaks were observed between 0.5-1.0 and 2.5-3.0 secs post-consumption (Figure 2a). When compared to water, the significance of observed emotions elicited by both alternative sweeteners under true information conditions did not match those found during the blinded study. The most plausible explanation for this discrepancy is high panelist variability.

Time series results for sweeteners presented during the false information session were not as robust as the other two information sessions (Figure 3). The same emotions (happy, sad, and neutral) were elicited by sucrose during the false sessions, however time series data showed a lack in significance when mean intensities were compared to water. One notable difference between the "true" and "false" sessions for sucrose was the time at which two emotions (happy, sad) appeared to be significantly (or approaching significance) elicited when compared to water. Spikes of happy (between 0.5-1.0 secs post-consumption) and sad (between 1.5-3.0 secs post-consumption) were elicited by sucrose in opposite sequence during the false information session when compared to the true information session (Figures 2c, 3c).

In contrast to sucrose, HFCS and ace-K elicited very different emotional responses during the two information sessions (true, false). No significant differences in expressivity of any emotions between the water baseline and HFCS were observed during the false information session (Figure 3b). Only one emotion (neutral; 2-3 secs post-consumption) was expressed with such intensity that it dipped below the dotted significance line (p=0.05) for the ace-K and water comparison (Figure 3a). Some facial expression response studies have suggested that degree of liking is associated with the elicitation of the neutral emotion (De Wijk, He, Mensink, Verhoeven & de Graaf, 2014). Spikes for one other emotion, scared (0.5-1.0), approached significance between water and ace-K during the false session (Figure 3a). Overall, differences in intensity and sequence of emotions between water and sweeteners during the false session were lacking, which supported findings from Greimel et al. (2006) when using baseline measures to compare facial responses to basic tastes. This may further support evidence for cognitive dissonance (or panelist confusion).

One major limitation of this time-series analysis was that water was always used as the baseline for comparison. In attempting to interpret the potential influences that product information has on emotional response over time, other baseline comparisons might prove to be more fruitful in providing subtle differences in facial expression. Using sucrose (control) or responses elicited by each sweetener during the blinded (no information) session are proposed for future research investigations.

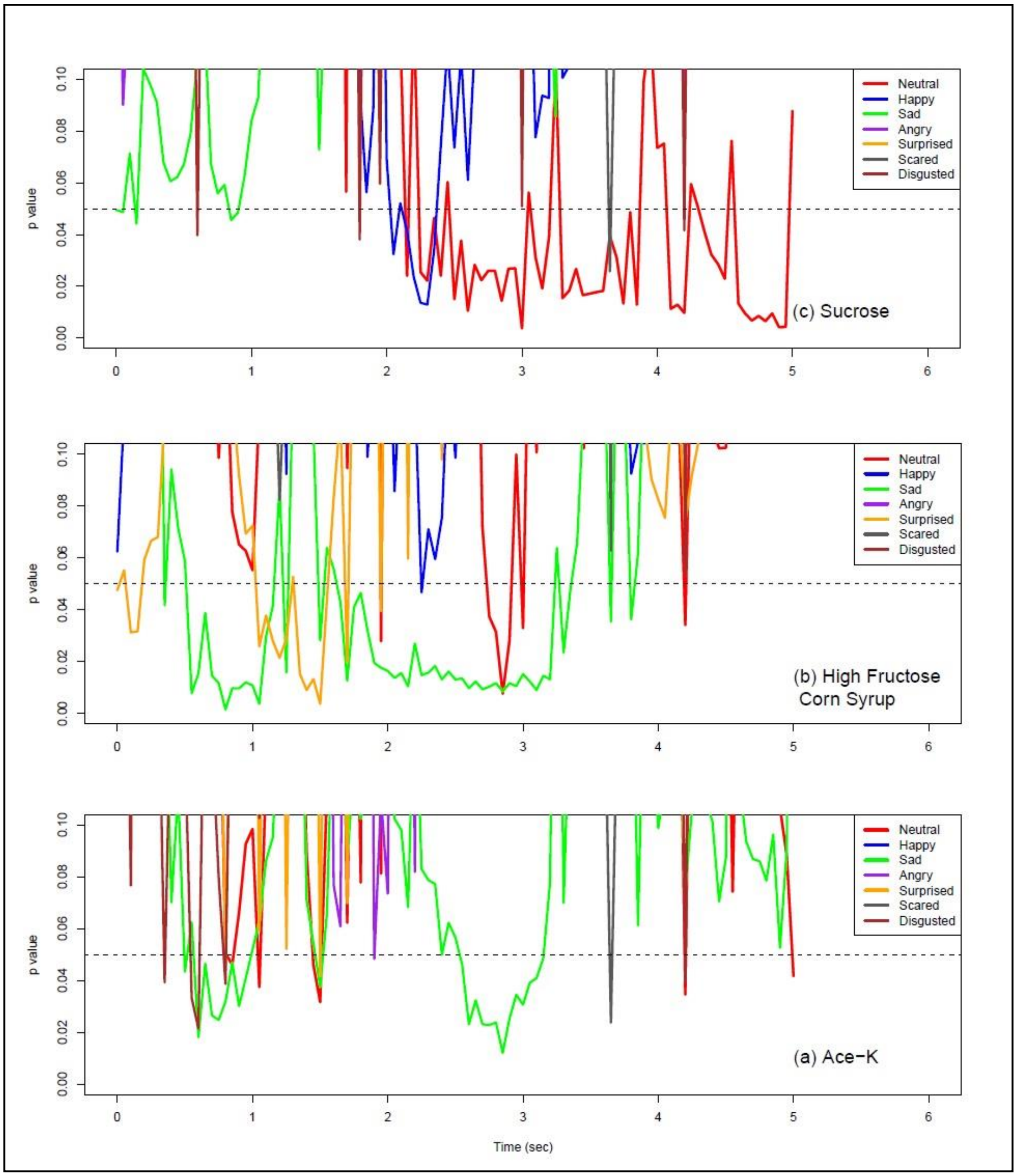


Figure 5-2. Time series analysis (5 seconds) of emotions from facial expression analysis session, comparing sweeteners presented with true information to a water baseline. Emotions elicited with extended duration below the dotted line of significance ($p<0.05$) are different from emotions elicited by water. (a) Ace-K; (b) High Fructose Corn Syrup; (c) Sucrose.

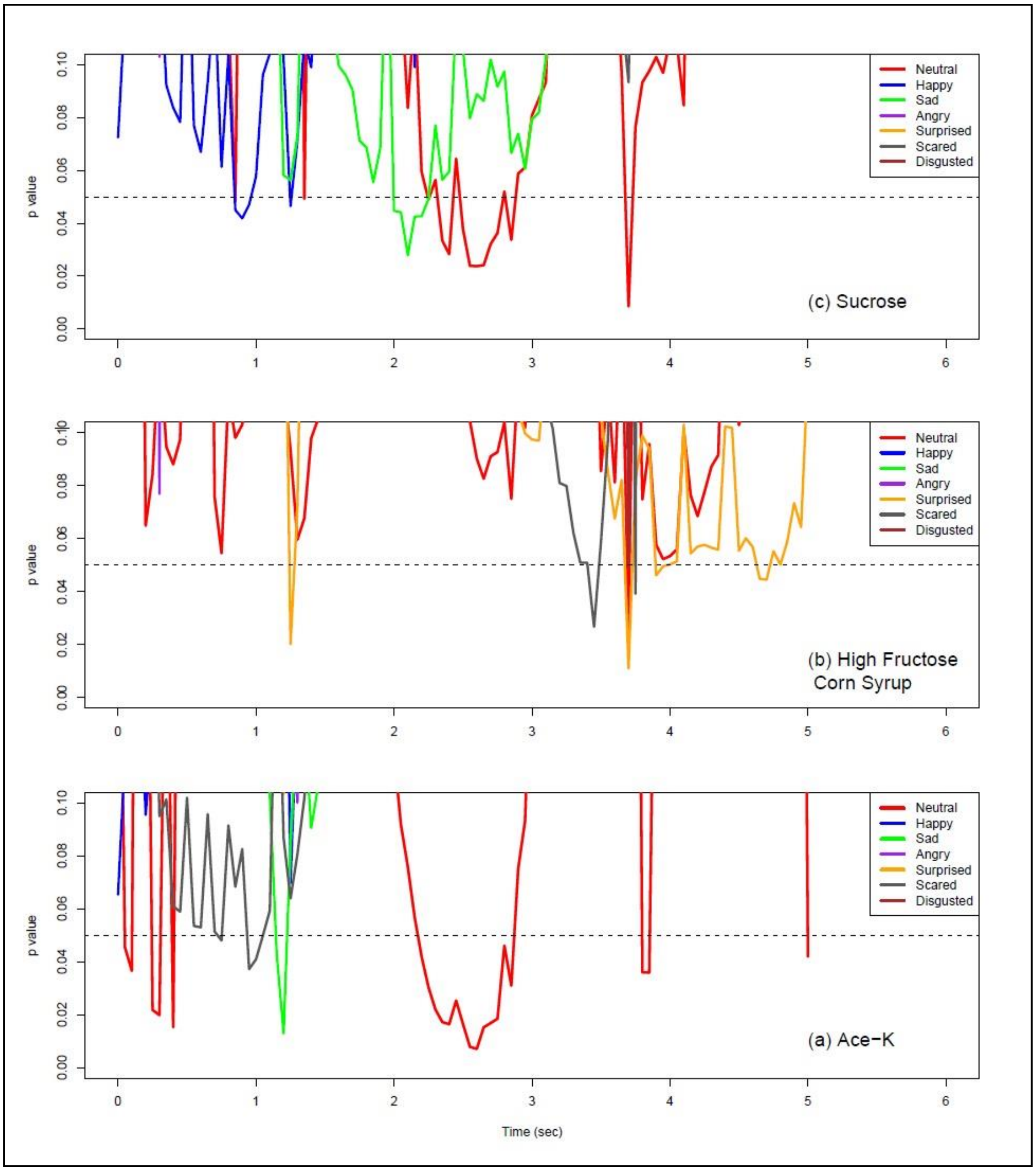


Figure 5-3. Time series analysis (5 seconds) of emotions from facial expression analysis session, comparing sweeteners presented with false information to a water baseline. Emotions elicited with extended duration below the dotted line of significance ($p<0.05$) are different from emotions elicited by water. (a) Ace-K; (b) High Fructose Corn Syrup; (c) Sucrose.

Relationship between hedonic score and facial expression responses through linear regression analysis

Linear regression analysis showed some moderate correlations between the explicit acceptability of sweeteners (hedonic rating) and the implicit emotional response (automated facial expression analysis) for the "true" and "false" information sessions. R values calculated from multiple linear regression analyses under the "no information" conditions showed little to no correlations for all sweeteners (Chapter 4). A majority of the correlation coefficients (R values) showed a weak (0 to ±0.3) positive or negative correlations between acceptability and emotion when sweeteners were paired with true and false information, however a few showed significant ($p<0.05$) moderate (±0.3 to ±0.5) correlations (Table 6). This supports previous findings of Danner et al. (2014), De Wijk et al. (2014), and Garcia-Burgos & Zamora (2013) who found moderate correlations between the neutral, disgust, happy and sad facial responses and liking.

During the true information session, a significant negative correlation was found for scared ($p<0.005$; $r=-0.50$) elicited by sucrose (Table 6). This result was in agreement with findings from Danner et al. (2014) who found that degree of liking was negatively correlated to negative emotions such as sad, disgust and angry. All other correlations during the true information session were not significant and classified as weak according to Taylor (1990). Calculated values for the multiple linear regression analyses during the false information session showed weak correlations that were not significant between acceptance and emotion for sucrose and ace-k.

Liking for HFCS under the false information session was positively associated with moderate strength for the emotion happy ($r=0.44$; $p<0.02$), which also supported previous findings from Danner et al. (2014) stating that liked samples correlate with positive emotions. In contrast to these results, a majority of other studies investigating facial responses and liking reported that well-liked samples are usually characterized by weak facial expressions in general, where “neutral” was the expressed with the highest intensity (De Wijk et al., 2014; Wendin et al., 2011; Zeinstra et al., 2009).Weak to moderately strong negative correlations were also observed between HFCS acceptance and the emotions scared ($r=-0.39$; $p<0.025$) and surprised ($r=-0.36$; $p<0.05$) (Table 6) which were further supported by the work of Danner et al. (2014).

Weaker correlations, although not significant, provided researchers with some insights about the relationship between emotion and liking when panelists were provided with specific product information. It was hypothesized that the term “natural” would generate higher hedonic scores and therefore more positive/approach emotions when paired with sweeteners regardless of truthfulness. In contrast, it was hypothesized that “artificial” when paired with sweeteners, would generate lower hedonic scores and more negative/withdrawal emotions. Weak to moderate correlation values associated with HFCS and ace-k under each information category did not reflect anticipated outcomes. Observed correlations for anger and liking associated with each sweetener under the natural information condition showed similarity in strength, but differences in direction; HFCS liking was positively correlated with anger ($r=0.29$), while liking for ace-k was negatively correlated to anger ($r=0.30$). Ace-k liking was also positively correlated to neutral ($r=0.32$), suggesting that the term “natural” was positively received for ace-k (especially compared to correlation values for “artificial”) but not HFCS. Under the “artificial” information conditions, positive correlation values for happy ($r=0.44$, $p<0.02$, HFCS; $r=0.28$, $p<0.1$, ace-k) and negative correlations for scared ($r=-0.39$, $p<0.025$, HFCS; r=-0.30, ace-k) were observed for HFCS and ace-k liking respectively. These results suggest that the word "artificial" was positively received for both sweeteners in contrast to the initial hypothesis, however only correlations for HFCS were significant ($p<0.05$).

Overall, these results were different from correlation values calculated during the blinded (no information) study (Chapter 4), suggesting that the addition of product information may have had a small effect on correlation. This interpretation is supported by consumer studies suggesting that product perceptions and subsequent behavior and liking are influenced by information; more studies are needed in order to confirm these conclusions (Grunert, 1986; Hoegg & Alba, 2007).

Table 5-6. Correlation values[1] between hedonic[2] score data and mean intensity facial expression responses[3] within sweeteners in cold tea blocked by product information session.[4]

True information

	Sucrose	HFCS	Ace-K
Neutral	0.29	-0.01	0.10
Happy	0.06	-0.11	0.28
Sad	-0.03	0.12	-0.29
Angry	-0.05	0.29	-0.16
Disgusted	-0.07	0.10	-0.08
Surprised	-0.26	-0.22	0.07
Scared	**-0.50**	-0.15	-0.30

False information

	Sucrose	HFCS	Ace-K
Neutral	0.17	0.19	**0.32**
Happy	0.06	**0.44**	0.17
Sad	0.18	0.13	-0.08
Angry	0.05	0.01	-0.30
Disgusted	0.01	-0.25	-0.19
Surprised	0.04	**-0.36**	-0.12
Scared	-0.18	**-0.39**	0.00

[1]R-values calculated from multiple linear regression analyses; Bolded values show significance ($p<0.05$).
[2](n=27); 1=extremely like; 9=extremely like.
[3]Mean intensity values (0-1; 0= not expressed; 1= fully expressed) based on 5 second video analysis of facial response (FaceReader 5.0, Noldus Information Technology, Wageningen, The Netherlands) post-consumption of each sample; emotion order based on sucrose correlation value (highest to lowest)
[4]Information indicates the settings under which the facial expression data was collected, not necessarily the message paired with the sweetener.

Lack of robust facial expression responses

The established elicitation of neutral-positive emotions through facial expressions (De Graaf & Zandstra, 1999; Greimel et al., 2006; Rozin & Vollmecke, 1986; Steiner, 1979; Steiner et al., 2001) by sweeteners and water was discussed in detail within the blinded study (Chapter 4). Results from the study found a lack of correlation between emotional response and acceptance under the "no product information condition," which was unexpected. Facial expressions were variable and lacked significance under both the "true" and "false" product information conditions of this current study for all sweeteners, but especially sucrose. This supported previous findings from Wendin et al. (2011) who observed that sweet solutions elicited weaker facial expression responses than all other basic tastes. However, weak to moderate correlations were observed in relation to the multiple linear regression r values and time series data for the alternative sweeteners. One potential explanation for this result is due to the change in product information validity across testing days for only the alternative sweeteners (HFCS; Ace-K).

Sequence of emotions provided through time series data provided insights for subtle trends in emotional expression when no significant differences existed. The characterization of implicit emotions and their influence on product acceptability is an already challenging task for the industry; exploring these relationships with the addition of external informational cues contributes to complexity when analyzing and interpreting responses. A major limitation of this study was that panelist familiarity with product information claims (natural; artificial) in relation to each sweetener was not collected prior to testing. As a result, interpretations about sweetener acceptance and emotional response in relation to the information provided are based on inference. For example, it was assumed that panelists had previously been exposed to each claim and therefore had pre-established attitudes and expectations in relation to each sweetener. Collecting panelist attitudes/beliefs/expectations about specific ingredients and/or buzzwords in relation to acceptance and emotional response would be beneficial to the industry when marketing new products to specific consumer groups.

Emotional term selection

A similar proportion of emotion terms 35-40% (15-18 out of 43 terms) were classified as “frequently selected” (count frequency ≥ 5) for all three sweeteners across information categories (no information; true information; false information). Differences in reported emotional response across sweeteners were demonstrated when comparing sweeteners within information sessions (Figure 4). Sweeteners presented with no product information had the highest proportion of terms (7) that were uniquely defined as “shared”; whereas only three shared terms (true: friendly, good, mild; false: good-natured, happy, pleasant) were observed for either information session (Figure 4).

Sucrose had the highest proportion of terms classified as “frequently selected” across information sessions (Table 7). Five shared terms (friendly, good, happy, pleased, satisfied) were identified for sucrose across information sessions (no information, true, false) and a total of seven terms were identified as “unique” for sucrose within each information session (Table 8). Three shared terms across information conditions and three unique terms within each condition were identified for HFCS; two shared terms and five unique terms were identified for ace-K (Table 8).

No significant differences were found via Cochran’s Q test for any terms identified as “unique” when selected for any sweetener under any of the information conditions, with one exception; active, when selected for sucrose under false conditions was found to be significantly different ($p=0.002$) from selection for sucrose under artificial conditions when no information was provided. Subtle differences between sweeteners and information conditions were observed for other uniquely defined terms including enthusiastic ($p=0.09$) and mild ($p=0.06$) for sucrose when comparing none and true information sessions. Calm, a unique term for both ace-K and HFCS under the no information condition, was found to approach significance ($p=0.07$) when compared to the true session for HFCS and the false session for HFCS and ace-K. Notably, happy was identified as a uniquely defined term for ace-K under false conditions. These explicit results directly conflicted with implicit mean intensities collected from the facial expression response session across sweeteners, under false conditions (Tables 7, 8). As such, the results suggest some degree of cognitive dissonance was experienced related to the term understanding, sweetener liking and paired product information.

Emotion term differentiation within sweeteners and across product information categories suggested that the type of information played some role in influencing cognitive emotional response to the product; whereas emotional differentiation across sweeteners was lacking. This interpretation was supported by previous findings by Cardello, Meiselman, Schutz, Craig, Given, Lesher & Eicher (2012) who examined the explicit emotional responses to two types of chocolate and their names. Results from their study showed that significant emotional characterization was elicited by product names rather than chocolate flavor (Cardello et al., 2012). This suggested that memory and expectations associated with the names of a product were more successful in driving emotion affect. Richins (1997) stated that emotions are contextually specific, thus indirectly supporting the proposed impact of information validity on hedonic liking and explicit emotional characterization of sweeteners. In contrast to this, researchers Ng, Chaya, & Hort (2013) found that intrinsic properties (taste, smell, etc.) of a food product are more closely related to emotional characterization than extrinsic factors.

There were several limitations related to the CATA methodology to consider when interpreting results and optimizing explicit emotional characterization in future studies; most notably were the properties of the terms listed in the ballot itself (amount of terms, ratio of positive to negative terms, term appropriateness regarding sweetener consumption). Several psychological studies have shown that language shapes our perception of reality (Gendron, Lindquist, Barsalou & Barrett, 2012; Lindquist, Barrett, Bliss-Moreau & Russell, 2006). This concept can be applied two-fold in the context of this study; once in relation to the nature and amount of emotional terms listed on the ballot and once in regards to the type of information provided with each sweetener. Again, it was assumed that panelists had pre-established expectations about the sweetener terms provided as it has been widely established that the terms “natural” and “artificial” are controversially used in the media to describe the safety and nutrition of various ingredients (references). And since consumer perceptions and attitudes towards each of the terms were not measured, there was no baseline with which to compare liking changes elicited by specific product information and sweetener pairings; also, the degree of intensity for each emotion was not measured. Incorporation of these measures could provide further insights about the influential role specific information terms have on sweeteners and other food products.

Table 5-7. Frequently selected terms for sweeteners in cold tea across information categories

Sweetener	Frequently Selected Terms
Sucrose	Active, Adventurous, **Calm**, **Content**, Energetic, Enthusiastic, **Friendly**, **Good**, Good-natured, **Happy**, Interested, Mild, Peaceful, Pleasant, **Pleased**, **Satisfied**, Steady, Warm
HFCS	**Active**, **Calm**, **Content**, Energetic, **Friendly**, **Good**, **Good-natured**, **Happy**, Mild, Peaceful, Pleasant, Pleased, Satisfied, Steady, Warm
Ace-K	Active, Bored, **Calm**, **Content**, Friendly, **Good**, **Good-natured**, Happy, Interested, **Mild**, Peaceful, Pleasant, Pleased, Quiet, Satisfied, Warm

n=27 participants; 'Frequently selected terms, exhibiting greater than or equal to 20% selection. Bolded terms were frequently selected for the specified sweetener sample across all information sessions.

Table 5-8. Shared and uniquely selected terms for sweeteners in cold tea across information categories

Sweetener	Shared Terms	Unique Term – No information	Unique Term – True information	Unique Term – False information
Sucrose	Friendly, Good, Happy, Pleased, Satisfied	Calm, Peaceful	Adventurous, Enthusiastic[2], Mild[2]	Active[1], Content
HFCS	Active, Content, Friendly	Calm[2], Happy, Peaceful	N/A	N/A
Ace-K	Content, Mild	Calm[2], Good-natured, Quiet, Satisfied	N/A	Happy

[1]Terms were found to be significantly different ($p<0.05$) when selected for sweeteners across information sessions.
[2]Terms were found to approach significance ($0.05<p<0.1$) when selected for sweeteners across information sessions.

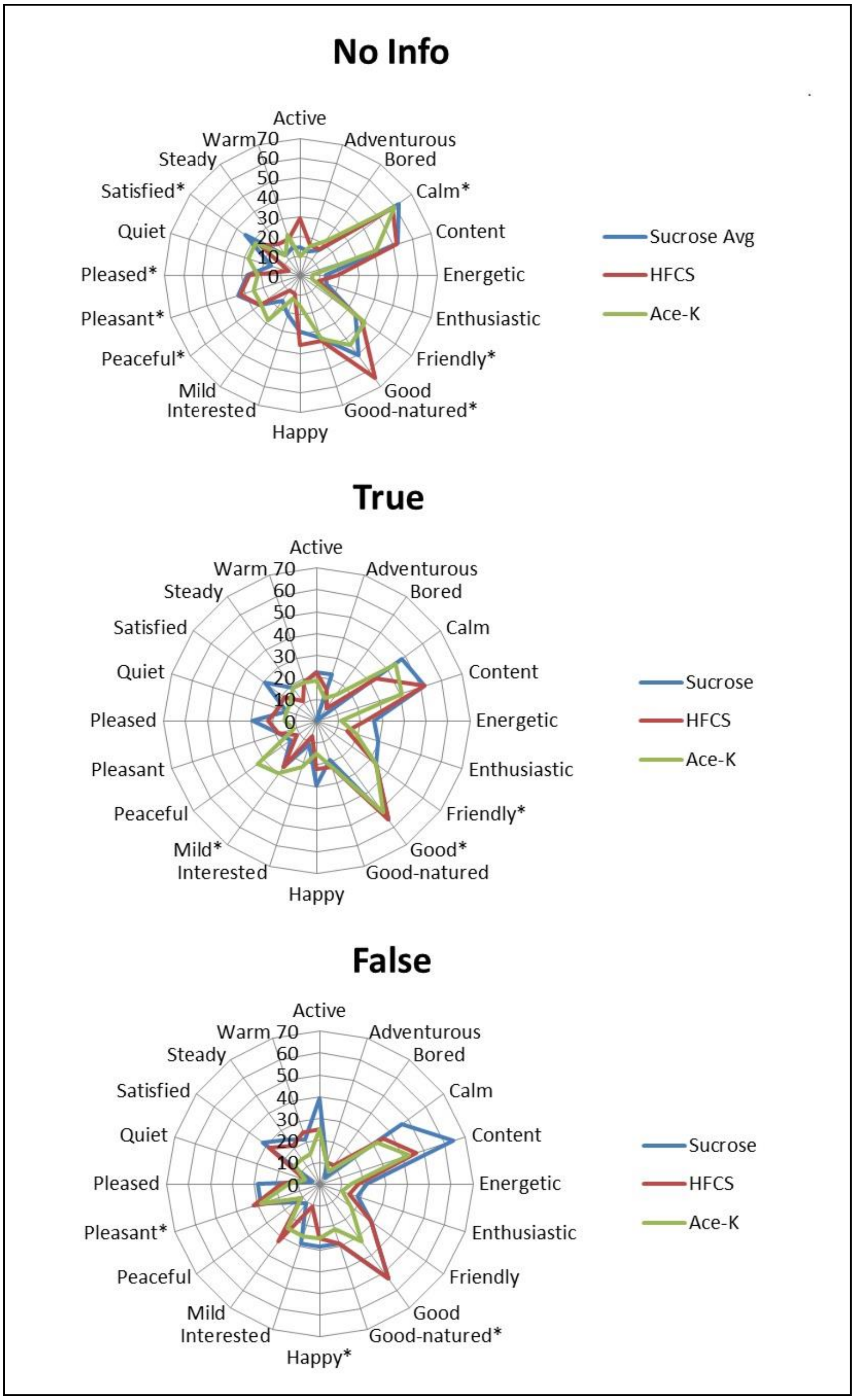


Figure 5-4. Comparison of frequently selected emotion terms from emotion term selection sessions for sweeteners in cold tea based on the amount and validity of the information provided with each sample; (a) no information given for each sweetener sample; (b) truthful information provided with each sweetener sample; (c) false information provided with HFCS and Ace-K sweetener samples. (n= 27) The displayed emotion terms (20/43) were selected based on a 20% or greater selection frequency for at

least one of the samples being compared across the information sessions. Terms were ordered clockwise alphabetically. Shared terms, having 20% or greater frequency among samples and a difference equal to or less than 10% are denoted with an asterisk.

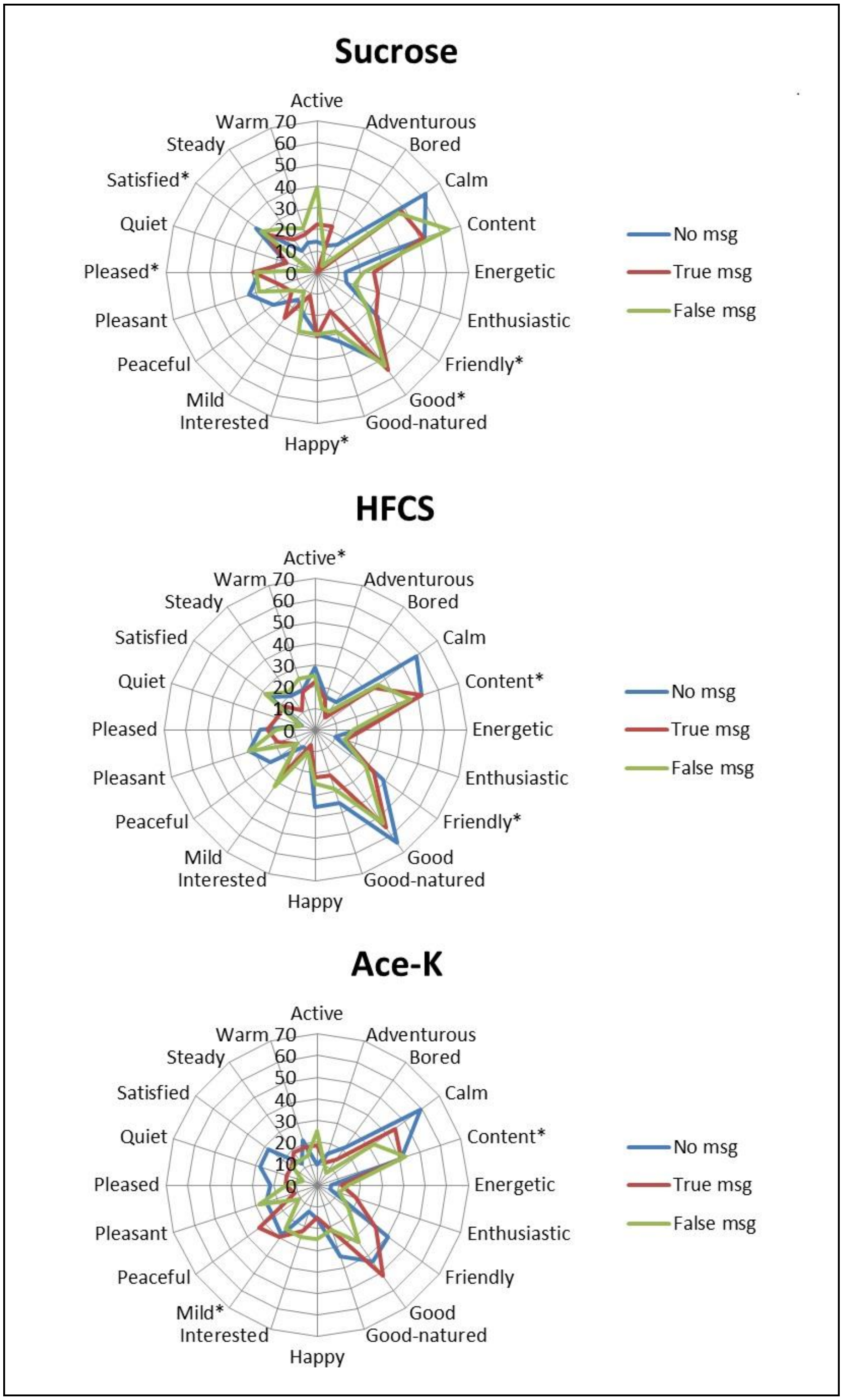


Figure 5-5. Comparison of frequently selected emotion terms from emotion term selection sessions by sweeteners in cold tea; (a) no information given for each sweetener sample; (b) truthful information provided with each sweetener sample; (c) false information provided with HFCS and Ace-K sweetener samples. (n= 27) The displayed emotion terms (20/43) were selected based on a 20% or greater selection frequency for at

least one of the samples being compared across the information sessions. Terms were ordered clockwise alphabetically. Shared terms, having 20% or greater frequency among samples and a difference equal to or less than 10% are denoted with an asterisk.

Relationship between hedonic score and emotional terminology selection

Penalty lift analysis was first developed as a means of assessing the “drivers of liking” associated with specific attributes within food products (Van Trijp, Punter, Mickartz & Kruithof, 2007). By combining traditional rating methods with intensity scaling from JAR scores, penalty lift (or drop) analysis enables researchers to determine the estimated cost in liking when specific attributes are less than ideal (Lawless & Heymann, 2010). In this way, penalty lift analysis has the added benefit of providing attribute directionality in relation to liking for product developers. Previous studies applying this method have assessed the importance of various ingredients such as cooked versus fresh herbs, degree of saltiness, and flavor on liking (Meyners, 2015). However, only a few studies have used penalty lift analysis to explore the relationship between liking and emotional response (Arnade, 2013; King & Meiselman, 2010).

Penalty-lift results in this study showed associated positive and negative mean differences in frequently selected terms (>20% selection frequency) across information sessions and sweeteners (Figure 6). The highest positive mean differences for sucrose were seen in the terms active (1.52) and energetic (1.45) during the no information session; active (1.52) and adventurous (1.52) during the true information session; good-natured (1.63) and content (1.51) for the false session (Figure 6). Only one term, mild (-0.38), showed a negative penalty when selected for sucrose during the false information session. The three terms with highest overall positive penalties for high fructose corn syrup in each respective information session include pleased (1.40; no information), satisfied for true (1.37) and satisfied for false (0.87). The highest negative penalties associated with HFCS for each information session include steady (-0.63; no information), happy (-0.83; true), good for true (-0.78) and for false (-0.58) sessions, and calm (-0.72; false) (Figure 6).

Mean differences for positive and negative penalties associated with ace-K were higher than the other sweeteners, suggesting higher variation in explicit emotional characterization for ace-k “likers” versus “dislikers.” Three terms showed negative penalties for the true or false information sessions; true showed negative penalties for interested (-0.79) and happy (-0.42); false showed a negative penalty for quiet (-0.70). The positive nature of happy and interested in the emotional characterization of terms in relation to liking has been previously established in the literature (King & Meiselman, 2010). As such, the negative penalty associated with these terms for ace-k under true conditions suggests that some degree of informational influence is taking place. Five terms (3 for no information; 1 each for true and false) exhibited positive penalties above 2 points for ace-K. Interested (2.34), calm (2.13) and quiet (2.00) showed the highest positive penalties for ace-K under the no information condition. Two additional terms, peaceful (2.00; true) and pleased (2.17; false), exhibited positive penalties for ace-K under true and false information conditions (Figure 6).

One limitation of the application of penalty life analysis to this study includes the lack of reported intensities for each emotion term. Traditional penalty lift analysis assesses hedonic liking and attribute intensity via JAR scores to help researchers modify products against the ideal (even if the ideal does not exist). Since consumers cognitively characterize emotion terms based on product liking/disliking, the effect of the analysis is not quite the same. Even so, penalty lift analysis has the potential to add value when assessing the relationship between emotions, sweetener information and liking in marketing applications.

Figure 5-6. Penalty lift analysis for each sweetener in cold tea across information categories. (n=81 total observations for each sweetener; n=27 for no information; n=27 for true information; n=27 for false information). Differences in mean acceptability scores for all sample conditions were found for the 'frequently selected' terms (>20% selection; sucrose: 18 terms; HFCS: 15 terms; ace-K: 16 terms) and between participants who selected and did not select the term.

Conclusions

The focus of this experiment was to examine the degree to which varying information influenced acceptability and emotional response (implicit and explicit) of sweeteners in tea. Differences in hedonic liking scores as they relate to the validity of information revealed that the term "artificial" resulted in lower hedonic scores for both

HFCS and ace-k. Cognitive dissonance was proposed as an explanation for observed liking differences across information sessions and during the cognitive characterization of emotions. Emotional responses via facial expressions for all sweeteners were weak and lacked significant differences; although subtle differences were observed through time series analysis. Results showed that false informational cues provided with alternative sweeteners had a dampening effect on implicit emotional responses. Some moderate correlations between liking and implicit emotional response were revealed.

Very few studies have investigated the influence of information on the relationship between product acceptance and the characterization of explicit and implicit emotional responses. Exploring the influence extrinsic product factors have on consumer acceptance and emotional response has the potential to provide insights on appraisal processes and ultimately consumer behavior. Several limitations still exist in relation to implicit emotion data capture and analysis through AFEA such as software sensitivity, calibration to minimize panelist variability, and the nonexistence of a standardized method of analysis.

References

Arnade, E.A. (2013). Measuring consumer emotional response to tastes and foods through facial expression analysis. Master's Thesis (Major Professor: S.E. Duncan), Virginia Polytechnic Institute and State University, Blacksburg, VA.

Borra, S.T., & Bouchoux, A. (2009). Effects of science and the media on consumer perceptions about dietary sugars. *The Journal of Nutrition, 139*(6), 1214S-1218S.

Boush, D. M. (1993). How advertising slogans can prime evaluations of brand extensions. *Psychology & Marketing*, *10*(1), 67-78.

Bray, G. A., Nielsen, S. J., & Popkin, B. M. (2004). Consumption of high-fructose corn syrup in beverages may play a role in the epidemic of obesity. *The American Journal of Clinical Nutrition*, *79*(4), 537-543.

Cardello, A.V. (1994). Consumer expectations and their role in food acceptance. In *Measurement of food preferences* (pp. 253-297). Springer US.

Cardello, A.V., Meiselman, H.L., Schutz, H.G., Craig, C., Given, Z., Lesher, L.L., & Eicher, S. (2012). Measuring emotional responses to foods and food names using questionnaires. *Food Quality & Preference, 24*(2), 243-250.

Cardello, A.V. & Sawyer, F.M. (1992). Effects of disconfirmed consumer expectations on food acceptability. *Journal of Sensory Studies*, *7*(4), 253-277.

Carlsmith, J.M., Aronson, E. (1963). Some hedonic consequences of the confirmation and disconfirmation of expectancies. *Journal of Abnormal and Social Psychology, 66*(2), 151-156.

Cogent Research, LLC (Cambridge, MA). 2006. High fructose corn syrup: consumer communications. Report and at-a-glance executive summary. Washington (DC): International Food Information Council (IFIC).

Cox, D.F. (1967). The sorting rule model of the consumer product evaluation process. *Risk Taking and Information Handling in Consumer Behavior* (pp.324-368). Boston: Harvard University.

Cronley, M.L., Kardes, F.R., & Hawkins, S.A. (2006). Advances in consumer research: the illusory truth effect: exploring implicit and explicit memory influences on consumer judgments. *Association for Consumer Research 33*, 247.

Danner, L., Haindl, S., Joechl, M., & Duerrschmid, K. (2014). Facial expressions and autonomous nervous system responses elicited by tasting different juices. *Food Research International*, *64*, 81-90.

Danner, L., Sidorkina, L., Joechl, M., & Duerrschmid, K. (2013). Make a face! Implicit and explicit measurement of facial expressions elicited by orange juices using face reading technology. *Food Quality and Preference*, *32*, 167-172.

De Graaf, C. & Zandstra, E.H. (1999). Sweetness intensity and pleasantness in children, adolescents, and adults. *Physiology & Behavior*, *67*(4), 513-520.

Deliza, R., & MacFie, H. J. (1996). The generation of sensory expectation by external cues and its effect on sensory perception and hedonic ratings: a review. *Journal of Sensory Studies*, *11*(2), 103-128.

Devcich, D.A., Pedersen, I.K., & Petrie, K.J. (2007). You eat what you are: modern health worries and the acceptance of natural and synthetic additives in functional foods. *Appetite*, *48*(3), 333-337.

De Wijk, R. A., He, W., Mensink, M. G., Verhoeven, R. H., & de Graaf, C. (2014). ANS responses and facial expressions differentiate between the taste of commercial breakfast drinks. *PloS one*, *9*(4), e93823.

De Wijk, R.A., Kooijman, V., Verhoeven, R.H.G., Holthuysen, N.T.E., & de Graaf, C. (2012). Autonomic nervous system responses on and facial expressions to the sight, smell, and taste of liked and disliked foods. *Food Quality and Preference, 26*(2), 196-203.

Dickson-Spillmann, M., Siegrist, M., & Keller, C. (2011). Attitudes toward chemicals are associated with preference for natural food. *Food Quality & Preference, 22*(1), 149-156.

Food & Drug Administration (FDA). (2013). *Guidance for Industry: A Food Labeling Guide (8 Claims).* Washington, DC: Author.

Gacula, M., Singh, J., Bi, J., & Stan, Altan. (2009). *Statistical Methods in Food and Consumer Research.* Burlington, MA: Academic Press, Elsevier, Inc.

Garcia-Burgos, D., & Zamora, M. C. (2013). Facial affective reactions to bitter-tasting foods and body mass index in adults. *Appetite, 71*, 178-186.

Gendron, M., Lindquist, K. A., Barsalou, L., & Barrett, L. F. (2012). Emotion words shape emotion percepts. *Emotion*, *12*(2), 314-325.

Gibson, E.L. (2006). Emotional influences of food choice: sensory, physiological and psychological pathways. *Physiology & Behavior, 89*(1), 53-61.

Greimel, E., Macht, M., Krumhuber, E., & Ellgring, H. (2006). Facial and affective reactions to tastes and their modulation by sadness and joy. *Physiology & Behavior*, *89* (2), 261-269.

Grunert, K. G. (1986). Cognitive determinants of attribute information usage. *Journal of economic psychology*, *7*(1), 95-124.

Grunert, K.G. (2002). Current issues in the understanding of consumer food choice. *Trends in Food Science & Technology*, *13*(8), 275-285.

Harris, J.L, Bargh, J.A., & Brownell, K.D. (2009). Priming effects of television food advertising on eating behavior. *Heath Psychology*, *29*(4), 404-413.

Hawkins, S. A., & Hoch, S. J. (1992). Low-involvement learning: Memory without evaluation. *Journal of Consumer Research*, 212-225.

Hoegg, J. & Alba, J.W. (2007). Taste perception: more than meets the tongue. *Journal of Consumer Research, 33*(4), 490-498.

International Food Information Council Foundation (IFIC). (May 2013). [Survey of consumer attitudes toward food safety, nutrition & health]. Retrieved September 26, 2014, from the International Food Information Council Foundation website: http://www.foodinsight.org/articles/2013-food-and-health-survey.

Jacoby, J., Olson, J. C., & Haddock, R. A. (1971). Price, brand name, and product composition characteristics as determinants of perceived quality. *Journal of Applied Psychology, 55*(6), 570-579.

King, S.C. & Meiselman, H.L. (2010). Development of a method to measure consumer emotions associated with foods. *Food Quality and Preference, 21*(2), 168-177.

Kohler, C. G., Turner, T., Stolar, N. M., Bilker, W. B., Brensinger, C. M., Gur, R. E., & Gur, R. C. (2004). Differences in facial expressions of four universal emotions. *Psychiatry research, 128*(3), 235-244.

Köster, E.P. (2002). The psychology of food choice: some often encountered fallacies. *Food Quality and Preference, 14*(5-6), 359-373.

Krutulyte, R., Costa, A. I., & Grunert, K. G. (2009). A cross-cultural study of cereal food quality perception. *Journal of Food Products Marketing, 15*(3), 304-323.

Lamote, S., Hermans, D., Baeyens, F., Eelen, P. (2004). An exploration of affective priming as an indirect measure of food attitudes. *Appetite, 42*(3), 279-286.

Lawless, H.T. & Heymann, H. (2010). Just about right scales. *Sensory Evaluation of Food* (2^{nd} ed.)(pp.339-340). Ithaca, NY: Springer.

Leitch, K.A. (2014, September). *Emotional response to sweeteners in tea.* Poster session presented at EuroSense 2014: A Sense of Life. 6^{th} European Conference on Sensory and Consumer Research, Copenhagen, Denmark.

Lindstrom, M. (2005). *Brand Sense: Build Powerful Brands Through Touch, Taste, Smell, Sight and Sound.* New York, NY: Free Press.

Lindquist, K. A., Barrett, L. F., Bliss-Moreau, E., & Russell, J. A. (2006). Language and the perception of emotion. *Emotion, 6*(1), 125.

McGinley, J. (2014). *Emotion* [PowerPoint slides]. Retrieved from https://scholar.vt.edu/portal/site/nsbfall2014. Last accessed: 20 August 2014.

Meilgaard, M., Civille, G.V., & Carr, B.T. (2007). *Sensory Evaluation Techniques.* (4^{th} ed.). Boca Raton: Taylor & Francis Group, LLC. (pp. 448).

Meyners, M. (2015). Temporal liking and CATA analysis of TDS data on flavored fresh cheese. *Food Quality & Preference.* In Press, Accepted Manuscript. doi: 10.1016/j.foodqual.2015.02.005.

Meyners, M., Castura, J. C., & Carr, B. T. (2013). Existing and new approaches for the analysis of CATA data. *Food Quality and Preference, 30*(2), 309-319.

Ng, M., Chaya, C., & Hort, J. (2013). The influence of sensory and packaging cues on both liking and emotional, abstract and functional conceptualisations. *Food Quality and Preference, 29*(2), 146-156.

Nocella, G. & Kennedy, O. (2012). Food health claims – what consumers understand. *Food Policy, 37*(5), 571-580.

Noldus Information Technology (2012). *FaceReader 5.0™ Reference Manual.* Noldus Information Technology, Wageningen, The Netherlands. Available from www.noldus.com. Last accessed October 28, 2014.

Northup, T. (2014). Truth, lies and packaging: how food marketing creates a false sense of health. *Food Studies: An Interdisciplinary Journal, 1*(3), 9-18.

Richins, M.L. (1997). Measuring emotions in the consumption experience. *Journal of Consumer Research, 24* (2), 127-146.

Rozin, P., Ashmore, M., & Markwith, M. (1996). Lay American conceptions of nutrition: dose insensitivity, categorical thinking, contagion, and the monotonic mind. *Health Psychology, 15*(6), 438-447.

Rozin, P., Spranca, M., Krieger, Z., Neuhaus, R., Surillo, D., Swerdlin, A., & Wood, K. (2004). Preference for natural: instrumental and ideational/moral motivations and the contrast between foods and medicines. *Appetite, 43* (2), 147-154.

Rozin, P. & Vollmecke, T.A. (1986). Food likes and dislikes. *Annual Review of Nutrition 6,* 433-456.

Schifferstein, H.N.J., Fenko, A., Desmet, P.M.A., Labbe, D., Martin, N. (2013). Influence of package design on the dynamics of multisensory and emotional food experience. *Food Quality and Preference, 27* (1), 18-25.

Shepherd, R., Sparks, P., Bellier, S., & Raats, M.M. (1992). The effects of information on sensory ratings and preferences: the importance of attitudes. *Food Quality and Preference, 3*(2), 147-155.

Stein, L.J., Nagai, H., Nakagawa, M., Beauchamp, G.K. (2003). Effects of repeated exposure and health-related information on hedonic evaluation and acceptance of a bitter beverage. *Appetite, 40*(2), 119-129.

Steiner, J.E. (1979). Human facial expressions in response to taste and smell stimulation. *Advances in Child Development and Behavior*, *22*, 257-295.

Steiner, J.E., Glaser, D., Hawilo, M.E., & Berridge, K.C. (2001). Comparative expression of hedonic impact: affective reactions to taste by human infants and other primates. *Neuroscience and Biobehavioral Reviews*, *25*(1), 53-74.

Taylor, R. (1990). Interpretation of the correlation coefficient: a basic review. *Journal of Diagnostic Medical Sonography*, *1*, 35-39.

Tuorila, H., Meiselman, H. L., Bell, R., Cardello, A. V., & Johnson, W. (1994). Role of sensory and cognitive information in the enhancement of certainty and linking for novel and familiar foods. *Appetite*, *23*(3), 231-246.

United States Department of Agriculture (USDA), Agricultural Marketing Service (AMS) & National Organic Program (NOP). (2013). *Draft guidance: classification of materials.* Washington, DC: Author.

van Trijp, H.C., Punter, P.H., Mickartz, F., & Kruithof, L. (2007). The quest for the ideal product: comparing different methods and approaches. *Food Quality and Preference, 18*(5), 729-740.

van Trijp, H.C.M & van der Lans, I.A. (2007). Consumer perceptions of nutrition and health claims. *Appetite*, *48*(3), 305-324.

Wendin, K., Allesen-Holm, B. H., & Bredie, W. L. (2011). Do facial reactions add new dimensions to measuring sensory responses to basic tastes?. *Food Quality and Preference*, *22*(4), 346-354.

Wiet, S. G., & Beyts, P. K. (1992). Sensory characteristics of sucralose and other high intensity sweeteners. *Journal of Food Science*, *57*(4), 1014-1019.

Zeinstra, G.G., Koelen, M.A., Colindrews, D., Kok, F.J., & de Graaf, C. (2009). Facial expressions in school-aged children are a good indicator of “dislikes”, but not of “likes”. *Food Quality and Preference*, *20*(8), 620-624.

Appendices

Appendix A. IRB#12-792 Approval Letter

VirginiaTech

Office of Research Compliance
Institutational Review Board
2000 Kraft Drive, Suite 2000 (0497)
Blacksburg, VA 24060
540/231-4606 Fax 540/231-0959
email irb@vt.edu
website http://www.irb.vt.edu

MEMORANDUM

DATE:	November 21, 2012
TO:	Susan E Duncan, Kristen Leitch, Elizabeth Amalia Arnade, Virginia C Fernandez-Plotka
FROM:	Virginia Tech Institutional Review Board (FWA00000572, expires May 31, 2014)
PROTOCOL TITLE:	Sweetness Equivalence of various alternative sweeteners in Water
IRB NUMBER:	**12-792**

Effective November 21, 2012, the Virginia Tech Institution Review Board (IRB) Chair, David M Moore, approved the Amendment request for the above-mentioned research protocol.

This approval provides permission to begin the human subject activities outlined in the IRB-approved protocol and supporting documents.

Plans to deviate from the approved protocol and/or supporting documents must be submitted to the IRB as an amendment request and approved by the IRB prior to the implementation of any changes, regardless of how minor, except where necessary to eliminate apparent immediate hazards to the subjects. Report within 5 business days to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.

All investigators (listed above) are required to comply with the researcher requirements outlined at:

http://www.irb.vt.edu/pages/responsibilities.htm

(Please review responsibilities before the commencement of your research.)

PROTOCOL INFORMATION:

Approved As:	**Exempt, under 45 CFR 46.110 category(ies) 2,6**
Protocol Approval Date:	**September 18, 2012**
Protocol Expiration Date:	**N/A**
Continuing Review Due Date*:	**N/A**

*Date a Continuing Review application is due to the IRB office if human subject activities covered under this protocol, including data analysis, are to continue beyond the Protocol Expiration Date.

FEDERALLY FUNDED RESEARCH REQUIREMENTS:

Per federal regulations, 45 CFR 46.103(f), the IRB is required to compare all federally funded grant proposals/work statements to the IRB protocol(s) which cover the human research activities included in the proposal / work statement before funds are released. Note that this requirement does not apply to Exempt and Interim IRB protocols, or grants for which VT is not the primary awardee.

The table on the following page indicates whether grant proposals are related to this IRB protocol, and which of the listed proposals, if any, have been compared to this IRB protocol, if required.

Invent the Future

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY
An equal opportunity, affirmative action institution

Appendix B: IRB#12-792 Consent Form

Virginia Polytechnic Institute and State University
Informed Consent for Participation in Sensory Evaluation

Title of Project: Paired Comparison of Sweetness Equivalence in Water

Investigators: Dr. Susan E. Duncan, Kristen Leitch, Elizabeth Arnade and Tina Plotka

I. PURPOSE OF PROJECT

You are invited to participate in a study about the sweetness equivalence of various artificial and all natural sweeteners in water as compared to table sugar (sucrose). This study will help us estimate the amount of various sweeteners needed to deliver the same level of sweetness as sucrose. We will use the outcomes of this project in future studies pertaining to consumer acceptability of and emotional response to various sweeteners and how messaging affects these responses.

II. PROCEDURES

After you sign the consent form, there will be a sensory test, which will last approximately 15-20 minutes. You will be presented with 3 sets of sweetened water samples; each set will contain 2 samples. For each set, please taste the samples from left to right, taking a sip of water in between each and identify which sample is MORE SWEET.

When tasting the samples, please follow these steps:

1. Take a generous sip and then swallow or expectorate the sample in the provided cup

Make sure to eat a few crackers and rinse your mouth with water between each sample to cleanse the palate and wait one minute between each set before evaluating the next pair of samples.

III. BENEFITS/RISKS OF THE PROJECT

There are no more than minimal risks for participants in this study. The following artificial sweeteners will be used: Acesulfame potassium (Ace-K, aka: Sunett, Sweet One), Aspartame (NutraSweet, Equal), Saccharin (NutraSweet) and Sucralose (Splenda). Due to the chemical nature of aspartame, it cannot be metabolized by people with Phenylketonuria (PKU) and may result in toxic levels in the body if consumed. Saccharin belongs to a class of compounds called sulfonamides which may trigger a response in people that are sensitive to sulfa-drugs. The following all-natural sweeteners will be used: Honey, High Fructose Corn Syrup, Coconut Palm Sugar and Luo Han Guo (Monk fruit juice). If you are aware of any allergies associated with artificial sweeteners or all-natural sweeteners (especially people that have PKU or are sensitive to sulfa-drugs), please do not participate. Your participation will provide valuable information related to the sweetness equivalence of various sweeteners in water, which will be useful to the researcher in regards to a future consumer emotional response study. If you would like a summary of the research results, please contact the researcher at a later time.

IV. EXTENT OF ANONIMITY AND CONFIDENTIALITY
The results of your performance as a panelist will be kept strictly confidential. Individual panelists will be referred to by code for analyses and in any publication of the results.

V. COMPENSATION
Snacks will be provided at the conclusion of each session as an expression of our gratitude for your participation. If you decide not to take a snack, up to $2 worth of canned goods per participant will be donated to the local food bank for each day of the sensory panel ($4 total per participant).

VI. FREEDOM TO WITHDRAW
It is essential to sensory evaluation projects that you complete this session in so far as possible. However, there may be conditions preventing your completion of the session. Examples of conditions might include short term health impairment such as a cold, chronic or acute taste disorders, allergies, sensitivities to the listed sweeteners, or concerns about interactions of sweeteners with medications. If after reading and becoming familiar with the sensory project, you decide not to participate as a panelist, you may withdraw at any time without penalty.

VII.APPROVAL OF RESEARCH
This research project has been approved by the Institutional Review Board for projects involving human subjects at Virginia Polytechnic Institute and State University and by the human subjects review of the Department of Food Science and Technology.

VIII. SUBJECT'S RESPONSIBILITIES
I know of no reason I cannot participate in this study, which will require approximately 15-20 minutes of data collection in one session. It is my responsibility to

- Taste each sample and identify the sample that is “more sweet” in each pair
- To follow the protocols as directed
- To not discuss my observations with other study participants
- Excuse myself from participation if I have any health conditions or taste disorders that are affecting my sensory perception of the taste/flavor (e.g. head cold or sinus infection) on the day of evaluation.

IX. SUBJECT'S PERMISSION
I have read the information about the conditions of this sensory evaluation project and give my voluntary consent for participation in this project. I know of no reason I cannot participate in this study.

______________________________ ________________________
Subject signature Date

____
Subject printed name

-----------------------------------For human subjects to keep---------------------------------------

Should I have any questions about this research or its conduct, I should contact:

Kristen Leitch, Master's Student 540-840-8725 kaleitch@vt.edu____
Investigator/Phone/E-Mail

Elizabeth Arnade, Master's Student 540-840-8725 elizabeth.arnade@gmail.com_
Co-Investigator/Phone/E-Mail

Tina Plotka, Research Associate 540-231-9843 tplotka@vt.edu
Co-Investigator/Phone/E-Mail

Dr. Susan E. Duncan 540-231-8675 duncans@vt.edu_____
Faculty/Investigator/Phone/E-Mail

Dr. David Moore (540)231-4991
Chair, IRB/Phone for Research Division

Appendix C: IRB#12-792 SIMS Ballots

Figure C-1: SIMS Natural Sweetener Ballot

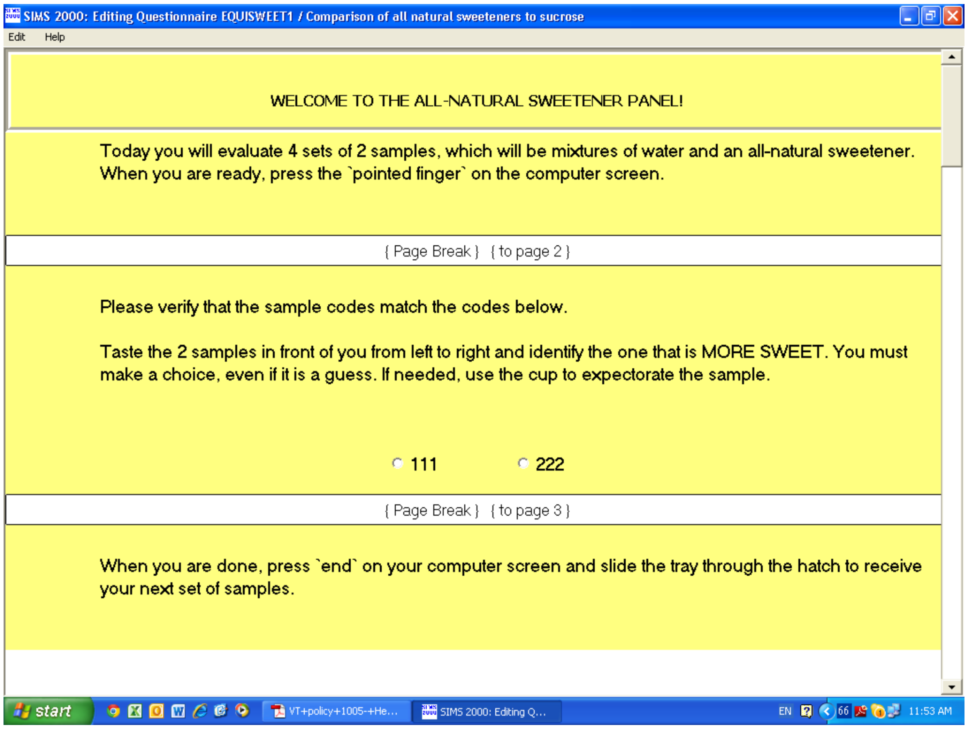
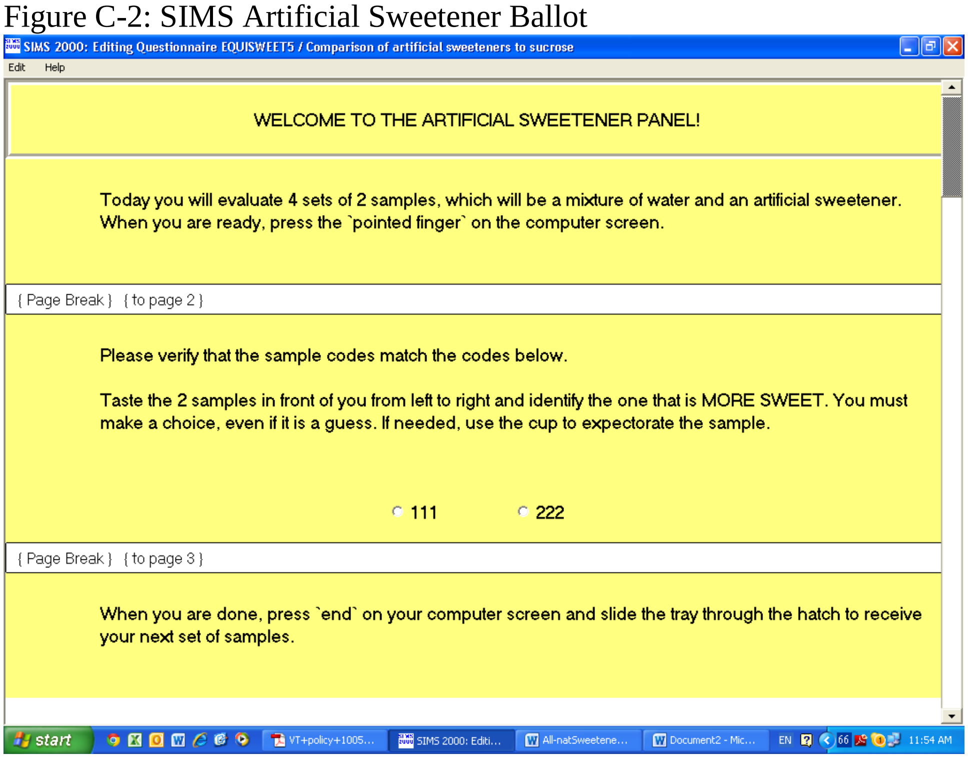


Figure C-2: SIMS Artificial Sweetener Ballot



Appendix D: Panelist Information from Online VT Survey Raw Results

Table D-1. Demographic and sweetener and tea consumption habits

Question	Options	Count	Frequency (%)
1. Select your gender.	Male	7	14%
	Female	43	86%
2. Select your age-range.	18-24	23	46%
	25-34	10	20%
	35-44	9	18%
	45-54	5	10%
	55-64	1	2%
	65 and older	2	4%
3. Please select the category that best describes you.	Undergraduate student	16	32%
	Master's/PhD student	16	32%
	Faculty	2	4%
	Staff	13	26%
	Community member	1	2%
	Other	2	4%
4. Do you have any food allergies[1] (i.e. Soy, shellfish, fish, peanut, tree nut, eggs, milk, wheat)?	No	46	92%
	Yes	3	6%
5. Do you have any food intolerances[2] (lactose, gluten, etc.)?	No	47	94%
	Yes	2	4%
6. Do you have any other health concerns associated with consuming foods/beverages containing sugar and/or caloric sweeteners (e.g. PKU associated with Aspartame, diabetes, etc.)?	No	48	96%
	Yes	2	4%
7. How often do you consume sweetened beverages (i.e. juice, soda, tea, coffee, flavored milk, etc.)?	Daily (at least once per day)	26	52%
	Weekly (1-6 times per week)	14	28%
	Monthly (1-3 times per month)	5	10%
	Rarely and/or never	5	10%

Table D-1. Demographic and sweetener and tea consumption habits (continued)

Question	Options	Count	Frequency (%)
8. What kind(s) of sweeteners do you consume in or with beverages? (Check all that apply).	Non-nutritive sweeteners (i.e. Splenda, NutraSweet/Equal, Sweet One, Sweet 'N Low, etc.)	34	68%
	All natural sweeteners (i.e. Honey, agave syrup, coconut palm sugar, etc.)?	20	40%
	High fructose corn syrup (HFCS)	16	32%
	Table sugar (sucrose)	23	46%
	None	2	4%
	Other	3	2%
9. How often do you consume tea beverages?	Daily (at least once per day)	10	20%
	Weekly (1-6 times per week)	23	46%
	Monthly (1-3 times per month)	9	18%
	Rarely and/or never	8	16%
10. Do you primarily drink caffeinated tea beverages or decaffeinated?[3]	With caffeine	34	68%
	Decaffeinated	11	22%

[1]Three participants responded 'yes' to question 4; their food allergies included ???; x participants did not respond at all.
[2]Two participants
[3]Five participants did not respond to this question and thus, were not asked to participate in the study.

Table D-2. Consumer attitudes and preferences about various sweeteners in beverages.

What is your attitude or preference toward consuming sweeteners?		
Natural sweeteners (honey, agave syrup, etc.)	Count	Frequency (%)
Negative	4	10%
Neutral	5	12%
Positive	32	78%
High fructose corn syrup (HFCS)	Count	Frequency (%)
Negative	19	53%
Neutral	13	36%
Positive	4	11%
Artificial/Non-nutritive sweeteners (Sweet 'N Low, Equal, NutraSweet, Splenda, etc.)	Count	Frequency (%)
Negative	18	43%
Neutral	8	19%
Positive	16	38%

Appendix E: Sweetener Specification Sheets

Figure E-1. Acesulfame potassium certificate of analysis & MSDS

Wego Chemical .Mineral Corp.
239 Great Neck Road
Great Neck, NY 11021
UNITED STATES
Phone: (516) 487-3510
Fax: (516) 487-3794

TECHNICAL DATA

CERTIFICATE OF ANALYSIS

Certificate Date 2/16/2010

Product Name: ACE-K FCC - 25 KG CARTON

PAGE 1

Wego Tracking Number 00019682
File Number 55485

CAS # 55589-62-3
Synonyms eligible for SPI K

ITEMS	Specifications	TEST RESULTS
Batch No 20111184		Quantity 15,000.0000 KGS
Mfg Date:	-	11/21/2012
Expiration Date	-	11/20/2016
Solubility in Water	Freely Soluble	Complies
Solubility in Ethanol	Slightly Soluble	Complies
Ultraviolet Absorption	227 +/- 2 nm	Complies
Test for Potassium	Positive	Complies
Percipitation Test	Yellow Percipitate	Complies
Assay	99.0 - 101.0%	99.75
Potassium	17.0 - 21.0%	19.1
Organic Impurities: Impurity A	0.125% max.	<0.125
Organic Impurities: Impurity B	20 mg/kg max.	<20
Fluoride	3 mg/kg max.	0.69
Heavy Metals	10 mg/kg max.	<5
Lead	1 mg/kg max.	0.1
Arsenic	3 mg/kg max.	0.23
Selenium	10 mg/kg max.	0.1
pH (1 in 100 solution)	5.5 - 7.5	6.56
Microbiological Limit		
Total Plate Count	200 cfu/g max	<20
Yeast & Mold	100 cfu/g max	<10
E Coli	Negative	Complies
Salmonella	Negative	Complies
Organic Volatile Impurities	20 ug/g max	<20
Mercury	1 ppm max	Complies
Cadmium (Cd)	1 ppm max	Complies
Appearance	White Crystals Powder	Complies

The information set forth herein is offered as a service to our customers and is not intended to relieve a customer from its responsibility to determine the suitability of the information or of the materials described herein for purchaser's purposes, to investigate other sources of information, to comply with all laws and procedures regarding safe use of these materials and to use these materials in a safe manner. No warranty is made of the merchantability or fitness of any product, and nothing herein waives any of the Seller's conditions of sale.

Material Safety Data Sheet

WEGO CHEMICAL & MINERAL CORP

239 Great Neck Road

Great Neck, NY 11021

Phone: (516) 487 3510; email: sales@wegochem.com

Date of Revision: 12/2011 **ACESULFAME K**

Section 1 - Chemical Product and Company Identification

Product/Chemical Name: Acesulfame k
Chemical Formula: $C_4H_5KNO_4S$
CAS Number: 55589-62-3
Other Designations: ACE K, 6-Methyl-1,2,3-Oxathiazin-4(3H)-One-2,2-Dioxide,Potassium Salt; Acesulfame k; acesulfame potassium
Derivation:
General Use:
Emergency Telephone: **(ChemTel)** Contract MIS0000335; **800 255-3924; INTL - 813 248-0585**

Section 2 - Composition / Information on Ingredients

Ingredient Name	CAS Number	EINECS/ELINCS	% wt or % vol
Acesulfame k	55589-62-3		100

Trace Impurities:

	OSHA PEL		ACGIH TLV		NIOSH REL		NIOSH
Ingredient	TWA	STEL	TWA	STEL	TWA	STEL	IDLH
Acesulfame k	none estab.	none estab.	none estab.	none estab.	none estab.	none estab.	none estab.

Section 3 - Hazards Identification

☆☆☆☆☆ Emergency Overview ☆☆☆☆☆

Warning! Causes respiratory tract irritation.Causes skin irritation. Causes digestive tract irritation. May cause severe eye irritation and possible injury.

HMIS	
H	1
F	1
R	0
PPE†	
†Sec. 8	

Potential Health Effects

Primary Entry Routes: Inhalation, ingestion, skin and eye contact.
Target Organs: Eyes, skin, respiratory tract.
Acute Effects
Inhalation: May cause gastrointestinal irritation.
Eye: Contact with eyes may cause severe irritation, and possible eye burns.
Skin: May cause skin irritation.
Ingestion: May cause gastrointestinal irritation if consumed in extremely large quantity.
Carcinogenicity: IARC, NTP, and OSHA do not list Acesulfame k as a carcinogen.
Medical Conditions Aggravated by Long-Term Exposure:
Chronic Effects: None known

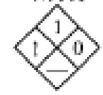
Section 4 - First Aid Measures

Inhalation: Remove from exposure to fresh air immediately. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical aid if cough or other symptoms appear.
Eye Contact: Immediately flush eyes with plenty of water for at least 15 minutes, occasionally lifting the upper and lower lids. Get medical aid immediately.
Skin Contact: Immediately flush skin with plenty of soap and water for at least 15 minutes while removing contaminated clothing and shoes. Get medical aid if irritation develops or persists.
Ingestion: If victim is conscious and alert, give 2-4 cupfuls of milk or water. Get medical aid.
After first aid, get appropriate in-plant, paramedic, or community medical support.
Note to Physicians: Treat symptomatically and supportively.

Section 5 - Fire-Fighting Measures

Flash Point: ?? °F (?? °C)
Flash Point Method: CC?, OC?, COC?
Burning Rate:
Autoignition Temperature: ?? °F (?? °C)
LEL: ??% v/v
UEL: ??% v/v

NFPA



Flammability Classification: Solid which exhibits difficult combustion or is difficult to ignite.
Extinguishing Media: Water spray or fog. Foam. Dry chemical powder. BCF (where regulations permit). Carbon dioxide.
Unusual Fire or Explosion Hazards: Avoid generating dust, particularly clouds of dust in a confined or unventilated space, as dust may form an explosive mixture with air and any source of ignition, e.g., flame or spark, will cause fire or explosion.
Hazardous Combustion Products:
Fire-Fighting Instructions: Do not release runoff from fire control methods to sewers or waterways.
Fire-Fighting Equipment: Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full face-piece operated in pressure-demand or positive-pressure mode.

Section 6 - Accidental Release Measures

Spill /Leak Procedures: Eliminate all ignition sources. Ventilate area.
Small Spills: Vacuum or sweep up material and place into a suitable disposal container. Clean up spills immediately, observing precautions in the Protective Equipment section.
Large Spills
Containment: For large spills, dike far ahead of spill for later disposal. Do not release into sewers or waterways.
Cleanup: Avoid generating dusty conditions. Provide ventilation.
Regulatory Requirements: Follow applicable OSHA regulations (29 CFR 1910.120).

Section 7 - Handling and Storage

Handling Precautions: Wash thoroughly after handling. Remove contaminated clothing and wash before reuse. Use with adequate ventilation. Avoid contact with eyes, skin, and clothing. Keep container tightly closed. Avoid ingestion and inhalation.
Storage Requirements: Store in a tightly closed container. Store in a cool, dry, well-ventilated area away from incompatible substances.

Section 8 - Exposure Controls / Personal Protection

Engineering Controls:
Ventilation: Provide general or local exhaust ventilation systems to maintain airborne concentrations below OSHA PELs (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.
Administrative Controls:
Respiratory Protection: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. Select respirator based on its suitability to provide adequate worker protection for given working conditions, level of airborne contamination, and presence of sufficient oxygen. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a written respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas.
Protective Clothing/Equipment: Wear chemically protective gloves, boots, aprons, and gauntlets to prevent prolonged or repeated skin contact. Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Contact lenses are not eye protective devices. Appropriate eye protection must be worn instead of, or in conjunction with contact lenses.
Safety Stations: Make emergency eyewash stations, safety/quick-drench showers, and washing facilities available in work area.
Contaminated Equipment: Separate contaminated work clothes from street clothes. Launder before reuse. Remove this material from your shoes and clean personal protective equipment.
Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9 - Physical and Chemical Properties

Physical State: solid
Appearance and Odor: white crystals/odorless
Odor Threshold:
Vapor Pressure: Not applicable.
Vapor Density (Air=1): Not applicable.
Formula Weight: 201.24
Bulk Density:
Specific Gravity (H_2O=1, at 4 °C):
pH (0.1 N solution):

Water Solubility: Very soluble
Other Solubilities:
Boiling Point:
Freezing/Melting Point:
Viscosity (50% aqueous soln.):
Refractive Index: 1

Section 10 - Stability and Reactivity

Stability: Acesulfame K is stable at normal room temperature in closed containers under normal storage and handling conditions. Anhydrous citric acid readily absorbs moisture from air.
Polymerization: Hazardous polymerization cannot occur.
Chemical Incompatibilities:
Conditions to Avoid: Dispersing powder in the air, contact with incompatibles, and exposure to heat and ignition sources.
Hazardous Decomposition Products: Thermal oxidative decomposition of citric acid can produce oxides of carbon, nitrogen and sulfur.

Section 11- Toxicological Information

Toxicity Data:*

Acute Inhalation Effects:
Human, inhalation, TC_{Lo}: ?? ppm
Acute Oral Effects:
Rat, oral, LD_{50}: 7430 mg/kg

Chronic Effects:
Carcinogenicity:
Mutagenicity: No data available.
Teratogenicity: No data available.

* See NIOSH, *RTECS* (GE7350000), for additional toxicity data.

Section 12 - Ecological Information

Ecotoxicity:
Environmental Fate: This chemical is expected to be readily biodegradable and is not likely to bioconcentrate.
Environmental Degradation:
Soil Absorption/Mobility:

Section 13 - Disposal Considerations

Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

Section 14 - Transport Information

DOT Transportation Data (49 CFR 172.101): NOT REGULATED

Shipping Name:
Shipping Symbols:
Hazard Class:
ID No.:
Packing Group:
Label:
Special Provisions (172.102):

Packaging Authorizations
a) Exceptions:
b) Non-bulk Packaging:
c) Bulk Packaging:

Quantity Limitations
a) Passenger, Aircraft, or Railcar:
b) Cargo Aircraft Only:

Vessel Stowage Requirements
a) Vessel Stowage:
b) Other:

Section 15 - Regulatory Information

TSCA
CAS# 55589-62-3 is listed on the TSCA inventory.
Health & Safety Reporting List
None of the chemicals are on the Health & Safety Reporting List.
Chemical Test Rules
None of the chemicals in this product are under a Chemical Test Rule.
Section 12b
None of the chemicals are listed under TSCA Section 12b.
TSCA Significant New Use Rule
None of the chemicals in this material have a SNUR under TSCA.
SARA

Section 302 (RQ)
None of the chemicals in this material have an RQ.
Section 302 (TPQ)
None of the chemicals in this product have a TPQ.
SARA Codes
CAS # 55589-62-3: acute.
Section 313
No chemicals are reportable under Section 313.
Clean Air Act:
This material does not contain any hazardous air pollutants. This material does not contain any Class 1 Ozone depletors.
This material does not contain any Class 2 Ozone depletors.
Clean Water Act:
None of the chemicals in this product are listed as Hazardous Substances under the CWA. None of the chemicals in this product are listed as Priority Pollutants under the CWA. None of the chemicals in this product are listed as Toxic Pollutants under the CWA.
OSHA: None of the chemicals in this product are considered highly hazardous by OSHA.
STATE
CAS# 55589-62-3 is not present on state lists from CA, PA, MN, MA, FL, or NJ.
California No Significant Risk Level: None of the chemicals in this product are listed.
European/International Regulations
European Labeling in Accordance with EC Directives
Hazard Symbols:
Not available.
Risk Phrases: Phrases:

Section 16 - Other Information

Disclaimer: All information, recommendations and suggestions appearing herein are based upon sources believed to be reliable: However, it is the users responsibility to determine the safety, toxicity and suitability for its own use of this product. WEGO CHEMICAL & MINERAL CORP. DOES NOT ASSUME ANY LIABILITY ARISING OUT OF THE USE BY OTHERS OF THIS PRODUCT.

Figure E-2. Aspartame certificate of analysis & MSDS

Wego Chemical Mineral Corp.
239 Great Neck Road
Great Neck, NY 11021
UNITED STATES
Phone: (516) 487-3510
Fax: (516) 487-3794

TECHNICAL DATA

CERTIFICATE OF ANALYSIS

Certificate Date

Product Name: ASPARTAME FCC POWDER - 25 KG CRTN PAGE 1

Wego Tracking Number 00019521

File Number 55359

CAS # 22839-47-0

Synonyms eligible for SPI K

ITEMS	Specifications	TEST RESULTS
Batch No 11102006		*Quantity* *1,000.0000 KGS*
Assay	98 -102%	100.23
Specific Rotation	+14.5° to +16.5°	+15.5
Other Related Substances	2.0% max.	1.71
Transmittance	95% min.	99.5
Heavy Metals	10 mg/kg max.	<10
pH	4.5 -6.0	4.68
Residue on Ignition	0.2% max.	0.12
Arsenic	3 ppm max.	<3
Loss on Drying	4.5% max.	3.69
5-benzyl-3,6-dioxo-2-piperazineacetic	1.5% max.	0.48
Appearance	White Crystalline Powder	Complies
Particle Size	80% through 100 mesh	Complies
Identification Value	Pass Test	Complies
Lead	1 ppm max	<1
Mfg Date	-	10/20/2011
Expiry Date	-	10/19/2016

The information set forth herein is offered as a service to our customers and is not intended to relieve a customer from its responsibility to determine the suitability of the information or of the materials described herein for purchaser's purposes, to investigate other sources of information, to comply with all laws and procedures regarding safe use of these materials and to use these materials in a safe manner. No warranty is made of the merchantability or fitness of any product, and nothing herein waives any of the Seller's conditions of sale.

Material Safety Data Sheet

WEGO CHEMICAL & MINERAL CORP

239 Great Neck Road

Great Neck, NY 11021

Phone: (516) 487 3510; email: sales@wegochem.com

Date of Revision: 7/2011 **Aspartame**

Section 1 - Chemical Product and Company Identification

Product/Chemical Name: Aspartame
Chemical Formula: $C_{14}H_{18}N_2O_5$
CAS Number: 22839-47-0
Other Designations: L-Aspartyl-L-Phenylalanine Methyl Ester, Methyl Aspartylphenylalate
General Use:
Emergency Telephone: **(ChemTel)** Contract MIS0000335; 800 255-3924; INTL - 813 248-0585

Section 2 - Composition / Information on Ingredients

Ingredient Name	CAS Number	EINECS/ELINCS	% wt *or* % vol
Aspartame	22839-47-0	245-261-3	100

Trace Impurities:

	OSHA PEL		ACGIH TLV		NIOSH REL		NIOSH
Ingredient	**TWA**	**STEL**	**TWA**	**STEL**	**TWA**	**STEL**	**IDLH**
Aspartame	none estab.	none estab.	none estab.	none estab.	none estab.	none estab.	none estab.

Section 3 - Hazards Identification

☆☆☆☆☆ **Emergency Overview** ☆☆☆☆☆

Appearance: white. Caution! This is expected to be a low hazard for usual industrial handling. May cause reproductive effects based upon animal studies. May cause eye and skin irritation. May cause respiratory and digestive tract irritation.

HMIS	
H	0
F	1
R	0
PPE†	
†Sec. 8	

Potential Health Effects

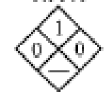
Primary Entry Routes: Inhalation, ingestion, eye and skin contact.
Target Organs: None
Acute Effects
Eye: May cause eye irritation.
Skin: May cause skin irritation.
Ingestion: May cause irritation of the digestive tract. Low hazard for usual industrial handling. Ingestion of large amounts may cause gastrointestinal disturbances, headache, fever, dizziness, urticaria, folliculitis and conjunctivitis.
Inhalation: Low hazard for usual industrial handling. May cause respiratory tract irritation.
Carcinogenicity: IARC, NTP, and OSHA do not list Aspartame as a carcinogen.
Medical Conditions Aggravated by Long-Term Exposure:
Chronic Effects: Reproductive effects have been reported in animals.

Section 4 - First Aid Measures

Eyes: Flush eyes with plenty of water for at least 15 minutes, occasionally lifting the upper and lower eyelids. If irritation develops, get medical aid.
Skin: Flush skin with plenty of soap and water for at least 15 minutes while removing contaminated clothing and shoes. Get medical aid if irritation develops or persists. Wash clothing before reuse.
Ingestion: Wash mouth out with water. Get medical aid if irritation or symptoms occur.
Inhalation: Remove from exposure to fresh air immediately. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical aid if cough or other symptoms appear.
After first aid, get appropriate in-plant, paramedic, or community medical support.
Note to Physicians: Treat symptomatically and supportively.
Special Precautions/Procedures:

Section 5 - Fire-Fighting Measures

NFPA



Flash Point: Not applicable
Autoignition Temperature: Not applicable
LEL: 3.00 vol %
UEL: 17.50 vol %
Flammability Classification: Non-flammable
Extinguishing Media: Use agent most appropriate to extinguish fire. For small fires, use dry chemical, carbon dioxide, water spray or regular foam.
Unusual Fire or Explosion Hazards: Dusts at sufficient concentrations can form explosive mixtures with air.
Hazardous Combustion Products: During a fire, irritating and highly toxic gases may be generated by thermal decomposition or combustion. Vapors may be heavier than air. They can spread along the ground and collect in low or confined areas.
Fire-Fighting Instructions: Do not release runoff from fire control methods to sewers or waterways.
Fire-Fighting Equipment: Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode.

Section 6 - Accidental Release Measures

Spill /Leak Procedures:
Small Spills: Sweep up, then place into a suitable container for disposal. Avoid generating dusty conditions.
Large Spills
Containment: For large spills, dike far ahead of spill for later disposal. Do not release into sewers or waterways.
Cleanup: Sweep up or absorb material, then place into a suitable clean, dry, closed container for disposal. Provide ventilation.
Regulatory Requirements: Follow applicable OSHA regulations (29 CFR 1910.120).

Section 7 - Handling and Storage

Handling Precautions: Wash thoroughly after handling. Remove contaminated clothing and wash before reuse. Use with adequate ventilation. Minimize dust generation and accumulation. Avoid contact with skin and eyes. Keep container tightly closed. Avoid ingestion and inhalation.
Storage Requirements: Store in a cool, dry place. Keep container closed when not in use. No special precautions indicated.

Section 8 - Exposure Controls / Personal Protection

Engineering Controls: Use adequate ventilation to keep airborne concentrations low.
Ventilation: Provide general or local exhaust ventilation systems to maintain airborne concentrations below OSHA PELs (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.
Administrative Controls:
Respiratory Protection: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. Select respirator based on its suitability to provide adequate worker protection for given working conditions, level of airborne contamination, and presence of sufficient oxygen. For emergency or non-routine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a written respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas.
Protective Clothing/Equipment: Wear chemically protective gloves, boots, aprons, and gauntlets to prevent prolonged or repeated skin contact. Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Contact lenses are not eye protective devices. Appropriate eye protection must be worn instead of, or in conjunction with contact lenses.
Safety Stations: Make emergency eyewash stations, safety/quick-drench showers, and washing facilities available in work area.
Contaminated Equipment: Separate contaminated work clothes from street clothes. Launder before reuse. Remove this material from your shoes and clean personal protective equipment.
Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9 - Physical and Chemical Properties

Physical State: Crystalline powder
Appearance: white
Odor: odorless
Vapor Pressure: Not available.
Vapor Density (Air=1): 10.1
Formula Weight: 294.3
Density/Specific Gravity (H_2O=1, at 4 °C): .15 -.35 @ 77°F
PH(8% soln.): 5.3

Water Solubility: slightly soluble
Other Solubilities:
Boiling Point: Not available.
Freezing/Melting Point: 248 - 250 °C
Viscosity:
Refractive Index:
Surface Tension:
% Volatile:
Evaporation Rate: Not available.

Section 10 - Stability and Reactivity

Stability: Aspartame is stable at room temperature in closed containers under normal storage and handling conditions.
Polymerization: Hazardous polymerization cannot occur.
Chemical Incompatibilities: Strong oxidizing agents.
Conditions to Avoid: Incompatible materials, dust generation, excess heat, strong oxidants.
Hazardous Decomposition Products: Thermal oxidative decomposition of Aspartame can generates toxic fumes of carbon monoxide and carbon dioxide.

Section 11- Toxicological Information

Toxicity Data:*

Eye Effects:

Skin Effects:

Acute Oral Effects:
Rat, oral, LD_{50}: mg/kg

Epidemiology: Experimental reproductive effects have been reported.
Carcinogenicity: No information available.
Mutagenicity: No information available.
Teratogenicity: No information available.

* See NIOSH, *RTECS* (WM3407000), for additional toxicity data.

Section 12 - Ecological Information

Ecotoxicity: No information available.
Environmental Fate: Will not bioconcentrate but rapidly biodegrades. Half life in soil or water is 3.6 hours.

Section 13 - Disposal Considerations

Disposal: Chemical waste generators must determine whether a discarded chemical is classified as a hazardous waste. US EPA guidelines for the classification determination are listed in 40 CFR Parts 261.3. Additionally, waste generators must consult state and local hazardous waste regulations to ensure complete and accurate classification. Contact your supplier or a licensed contractor for detailed recommendations.
Disposal Regulatory Requirements: Follow applicable Federal, state, and local regulations.
Container Cleaning and Disposal:

Section 14 - Transport Information

DOT Transportation Data (49 CFR 172.101): NOT REGULATED

Shipping Name:	**Packaging Authorizations**	**Quantity Limitations**
Shipping Symbols:	**a) Exceptions:**	**a) Passenger, Aircraft, or Railcar:**
Hazard Class:	**b) Non-bulk Packaging:**	**b) Cargo Aircraft Only:**
ID No.:	**c) Bulk Packaging:**	
Packing Group:		**Vessel Stowage Requirements**
Label:		**a) Vessel Stowage:**
Special Provisions (172.102):		**b) Other:**

Section 15 - Regulatory Information

US FEDERAL

TSCA

CAS# 22839-47-0 is listed on the TSCA inventory.
Health & Safety Reporting List
None of the chemicals are on the Health & Safety Reporting List.
Chemical Test Rules
None of the chemicals in this product are under a Chemical Test Rule.
Section 12b
None of the chemicals are listed under TSCA Section 12b.
TSCA Significant New Use Rule
None of the chemicals in this material have a SNUR under TSCA.
SARA

Section 302 (RQ)
None of the chemicals in this material have an RQ.
Section 302 (TPQ)
None of the chemicals in this product have a TPQ.
Section 313
No chemicals are reportable under Section 313.
Clean Air Act:
This material does not contain any hazardous air pollutants. This material does not contain any Class 1 Ozone depletors. This material does not contain any Class 2 Ozone depletors.
Clean Water Act:
None of the chemicals in this product are listed as Hazardous Substances under the CWA. None of the chemicals in this product are listed as Priority Pollutants under the CWA. None of the chemicals in this product are listed as Toxic Pollutants under the CWA.
OSHA: None of the chemicals in this product are considered highly hazardous by OSHA.
STATE
CAS# 22839-47-0 is not present on state lists from CA, PA, MN, MA, FL, or NJ.
California No Significant Risk Level: None of the chemicals in this product are listed.

Section 16 - Other Information

Disclaimer: All information, recommendations and suggestions appearing herein are based upon sources believed to be reliable: However, it is the users responsibility to determine the safety, toxicity and suitability for its own use of this product. WEGO CHEMICAL & MINERAL CORP. DOES NOT ASSUME ANY LIABILITY ARISING OUT OF THE USE BY OTHERS OF THIS PRODUCT.

Figure E-3. Coconut palm sugar certificate of analysis

BIG TREE

CERTIFICATE OF ANALYSIS

Product Description : SweetTree Coconut Palm Sugar – Blonde Organic - 12.5Kg
Ingredient : Certified Organic Coconut Palm Sugar
Country of Origin : Indonesia
Lot # : 195-21-056-14
Production Date : July 8th, 2011
Expired Date : July 8th, 2013

Characteristic	Analyze	Standard	Unit	Result	Methods
A. Chemical	Moisture Content	2 - 3	% v/w	1.05	Gravimetric
	Ash Content	2 - 3	% v/w	2 - 3	SNI 01-3743-1995
	Sucrose	≥ 75	% v/w	≥ 75	SNI-01-3743-1995
	Reduction Sugar	≤ 10	% v/w	≤ 10	SNI-01-3743-1995
	Total Sugar as Invert	< 90	% v/w	< 90	SNI-01-3743-1995
B. Physical	Mesh Size	15 - 20 Mesh	-	15 - 20 Mesh	N/A
	Color	Light Brown	-	Light Brown	N/A
	Appearance	Powder	-	Powder	N/A
	Aroma	Unique	-	Unique	N/A
	Flavor	Sweet	-	Sweet	N/A
C. Microbiological	Total Plate Count	$< 1 \times 10^4$	cfu/gr	0.8×10^3	SNI 19-2897-1992
	Total Yeast	$< 1 \times 10^4$	cfu/gr	Negative	SNI 19-2897-1992
	Total Mold	$< 1 \times 10^4$	cfu/gr	Negative	SNI 19-2897-1992
	Salmonella sp	Negative	In 25 gr	Negative	SNI 19-2897-1992
	Escherichia Coli	Negative	In 11 gr	Negative	SNI 19-2897-1992

Shelf Life : 2 years under proper conditions
Proper Storage : store in airtight container in dry place, away from sunlight and heat

Approved by

Tassa Agustriana
QA Manager

PT. BENING BIG TREE FARMS
Br. [illegible], Sibang Kaja, Abian Semal, Badung 80352, Bali – Indonesia
Telp.+62-361-8463327 – Fax.+62-361-8463328
www.bigtreefarms.com

Figure E-4. 42% High fructose corn syrup specification sheet

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Specification Sheet

ISOSWEET® 100 High Fructose Corn Syrup

(Product Specifications)

Dry Substance	70.5 - 71.5%
pH (as is, undiluted)	3.3 - 4.3
Fructose	42% minimum dsb
Total Monosaccharides	93% minimum dsb
Color (after heat)	2.5 maximum
Odor	Good
Flavor	Good
Sulfur Dioxide	3 ppm maximum
Ash	0.05% maximum
Acetaldehyde	80 ppb maximum
Microbiological:	
Total Bacteria	200 maximum/10 gm d.s.
Yeast	10 maximum/10 gm d.s.
Mold	10 maximum/10 gm d.s.

FDA Status:
Complies with FDA Regulation 21CFR184.1866 as High Fructose Corn Syrup - Generally recognized as safe.

Recommended Storage Conditions:

Storage Temperature 90 - 105°F, Tank Truck Shipping temperature range from 90 - 105° F based on weather conditions, Tank Car recommended unloading temperature is 100 - 105°F.

Shelf Life:

Estimated 6 to 9 months in tank car and storage tanks.

(Revised 6/27/2012)

Tate & Lyle 2200 E. Eldorado Street Decatur, IL 62525 Phone: 217/423-4411 Fax: 217/421-2216 www.tateandlyle.com

Figure E-5. Monk fruit extract certificate of analysis, specification sheets, nutritional sheet & MSDS

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CERTIFICATE OF ANALYSIS

SEND TO:

PRODUCT: PUREFRUIT 20KG DRM

REPORT DATE: 10/17/2012
CARRIER ID: -

PO #:
ORDER #:
DELIVERY #:
DATE SHIPPED:

ANALYTICAL DATA
INSPECTION LOT 10000033912
LOT NUMBER 45GF120303
MFG DATE 05/10/2012

			SPECIFICATIONS MIN	MAX
Mogroside V	%DSB	50.5	48.0	52.0
Identification		PASS		
Particle Size	%	97.2	95.0	
Moisture	%	5.31		6.00
Ash	%	0.68		5.00
Arsenic	PPM	< 0.01		0.50
Lead	PPM	0		1
Cadmium	PPM	< 0		1
pH		4.4	4.0	5.0
Total Bacteria Count	CFG	90		5000
Yeast and Mold	CFU/G	< 10		100
Coliforms		< 0		10
E coli		None Detected		
Salmonella		Negative		

Shelf life of this product is 24 months from the date of manufacture, when stored in a sealed container in a cool, dry area.

REPORTED BY:

Catherine P.F. McClurkin
Corporate QA Manager
2200 East Eldorado Street
Decatur, IL 62521

Tate & Lyle Ingredients Americas LLC
2200 E. Eldorado Street, Decatur, IL 62521
Telephone (217)423-4411 Facsimile (217)421-2216

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Specification Sheet

PURETRUIT™, Monk Fruit Extract

Previously supplied by Biovittoria as Fruit Sweetness™ M50

Description

PUREFRUIT™ is an off-white to light yellow powder

Routine Tests	Specifications	Test Numbers
Mogroside V	48 – 52%	45980
Identification	The infra-red spectrum corresponds to that of a similarly prepared reference	47701
Particle size	≥ 95% pass mesh 80	70046
Moisture	≤ 6.0%	46040
Ash	≤ 5.0%	09560
Arsenic	≤ 2 ppm	44292
Lead	≤ 1 ppm	44290
Total bacteria count	5,000 max /gram	10560
Yeasts & Mold	100 max /gram	10528
Coliforms	10 max /gram	10510
E Coli	Negative (MPN < 3 / gram)	10512
Salmonella	Negative in 25 gram	10547

Labeling

Monk fruit extract

GRAS Status

This product meets the requirements of the GRAS notice GRN 000301

Allergens

PUREFRUIT™ does not contain any allergens that would require labeling under the FDA Food Allergen Labeling and Consumer Protection Act of 2004.

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TATE & LYLE

Specification Sheet

PUREFRUIT^{TM}, Monk Fruit Extract

Previously supplied by Biovittoria as Fruit Sweetness^{TM} M50

Genetically Modified Organisms

PUREFRUIT^{TM} is not produced from ingredients or processing aids derived by genetic modification.

BSE

No animal derived ingredients are used in the production of PUREFRUIT^{TM}. There are no animal derived ingredients used in the facility where PUREFRUIT^{TM} is produced

Kosher

PUREFRUIT^{TM} is certified as Kosher Parve

Halal

PUREFRUIT^{TM} is certified as Halal

Recommended Storage Conditions

Store at ambient temperature. Recommended storage is in a sealed container in a cool, dry area

Shelf Life

24 Months if stored under recommended conditions

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Nutritional

PUREFRUIT™

Monk Fruit Extract

Nutritional Information

Nutrients Per 100 Grams

WATER	≤ 6g
CALORIES (calculated)	380
PROTEIN	8 g
ASH	≤ 5g
TOTAL FAT	0 g
AVAILABLE CARBOHYDRATE	87 g
CALCIUM	90 mg
PHOSPHORUS	< 1 mg
IRON	< 1 mg
SODIUM	40 mg
POTASSIUM	15 mg
MAGNESIUM	130 mg

Note: At typical usage levels (<0.2%) this product is not a significant source of calories, protein, fat, vitamins, dietary fiber or sugars

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TATE & LYLE

MATERIAL SAFETY DATA SHEET

SECTION 1 CHEMICAL PRODUCTS & COMPANY IDENTIFICATION

Tate & Lyle
2200 E. Eldorado Street
Decatur, IL 62525

FOR EMERGENCY SOURCE INFORMATION
CHEMTREC: 800-424-9300

For Non-Emergency Product & MSDS Information: 217-421-4411
8 AM – 5 PM Central Day-light Savings Time

TRADE NAME: PUREFRUIT™
SYNONYMS: Luo Han Guo, Monk Fruit Extract
SUBSTANCE: Monk fruit extract, monk fruit concentrate, Luo Han Guo extract, Luo Han Guo concentrate, Luo Han fruit extract, Luo Han Fruit concentrate
CAS NUMBER: Mogroside V (CAS# 88901-36-4), Mogroside IV (CAS# 89590-95-4), and Mogroside VI (CAS# 89590-98-7)

CREATED BY: Tate & Lyle
CREATION DATE: October 10, 2010 REVISION DATE: 14th April 2011

SECTION 2 COMPOSITION/INFORMATION ON INGREDIENTS

Product is an organic material that may form explosive dust concentrations in air.

COMPONENT	CASRN	EXPOSURE LIMITS
Nuisance Dust	Not applicable	OSHA PEL (Total 15 mg/M^3) (Respirable 5 mg/M^3)
PNOR (Particulate Not Otherwise Regulated)		ACGIH TLV (Inhalable 10 mg/M^3) NIOSH REL (Total 15 mg/M^3) (Respirable 5 mg/M^3)

SECTION 3 HAZARDS IDENTIFICATION

Emergency Overview
Dry or powdered ingredients are combustible. Dispersal of finely divided dust from products into air may form mixtures that are ignitable or explosive. Minimize airborne dust generation and eliminate sources of ignition.

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POTENTIAL ACUTE HEALTH EFFECTS FROM:
Not known to produce acute health effects from occupational exposure.
INHALATION: Exposure to high airborne concentrations may cause mild respiratory irritation due to drying effects of dust.
SKIN CONTACT: Sustained exposure in a dusty manufacturing enviroment may result in mechanical irritation in the creases of the skin, particularly at the fingers. No health effects known or anticepated.
EYE CONTACT: May cause slight mechanical irritation from acute exposure.
INGESTION: No effects known or anticipated.

CARCINOGEN STATUS:
OSHA: Not listed.
NTP: Not listed.
IARC: Not listed.

SECTION 4 FIRST AID MEASURES

INHALATION: Remove to fresh air.
SKIN CONTACT: Clean with soap and water.
EYE CONTACT: Rinse well with eye wash solution or clean water. If symptoms develop, obtain medical attention.
INGESTION: Not applicable.

SECTION 5 FIREFIGHTING MEASURES

FIRE AND EXPLOSION HAZARD: Possibility of dust explosion. It is recommended that all dust control equipment and material transport systems involved are engineered to prevent conditions contributing to dust explosions. Do not allow dust to accumulate on flat surfaces, in rafters or building structural components. See NFPA 61, Standard for the Prevention of Fire and Dust Explosions in Agricultural and Food Processing Facilities, 2008 Edition, and other related-standards.
EXTINGUISHING MEDIA: Water spray, dry powder, carbon dioxide or media appropriate for surrounding fire. Use of water jet may cause explosive dust conditions.
FIREFIGHTING: Wear self-contained breathing apparatus and full protective gear. Use water spray to cool fire exposed containers.
FLAMMABLE LIMITS: LEL: Not determined; UEL: Not determined.
FLAMMABILITY CLASS (OSHA): Not applicable.
HAZARDOUS COMBUSTION PRODUCTS: Carbon dioxide and carbon monoxide

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SECTION 6 ACCIDENTAL RELEASE MEASURES

OCCUPATIONAL SPILL: Vacuum or sweep up spills. Minimize dust generation. If washing down spilled area is necessary, use copious amounts of water and control runoff. Follow local, state and Federal regulations for product disposal.

SECTION 7 HANDLING AND STORAGE

STORAGE: Store in a cool dry place. Store in a tightly closed container.
HANDLING: See NFPA 61, Standard for the Prevention of Fire and Dust Explosions in Agricultural and Food Processing Facilities, 2008 Edition, and other related standards. Use with adequate ventilation. Minimize dust generation and accumulation. It is recommended that all dust control equipment and material transport systems involved are engineered to prevent conditions contributing to dust explosions. Do not allow dust to accumulate on flat surfaces, in rafters or building structural components.
PACKAGING MATERIALS: The packaging material should have reasonable moisture and air barriers and comply with food regulations.

SECTION 8 EXPOSURE CONTROLS/PERSONAL PROTECTION

EXPOSURE LIMITS: See section 2.

VENTILATION: See NFPA 61, Standard for the Prevention of Fire and Dust Explosions in Agricultural and Food Processing Facilities, 2008 Edition, and National Fire Protection Association 650, Standard for Pneumatic Conveying Systems for Handling Combustible Materials, 1997 Edition and other related standards. Normal industrial hygiene measures should be sufficient for protection of employees from exposure to dusts. Local and mechanical exhaust is desirable when dumping bags.
EYE PROTECTION: Safety glasses are recommended. Safety goggles are desirable when dumping bags.
EMERGENCY WASH FACILITIES: Eye wash is recommended for conditions where dust generation is likely.
SPECIAL PROTECTIVE CLOTHING: None.
GLOVES: None.
RESPIRATOR: NIOSH approved N-95 dust respirator if working in situations that could generate large amounts of airborne dust.

FOR FIREFIGHTING AND OTHER IMMEDIATELY DANGEROUS TO LIFE OR HEALTH CONDITIONS: See section 5.

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SECTION 9 PHYSICAL AND CHEMICAL PROPERTIES

DESCRIPTION: Off-White
ODOR: Characteristic
MOLECULAR WEIGHT: N/A
MOLECULAR FORMULA: N/A
BOILING POINT: No N/A
MELTING POINT: N/A
SPECIFIC GRAVITY: ($H_20 = 1$): N/A
WATER SOLUBILITY: ~ 100%
PERCENT, VOLATILE BY WEIGHT (%) N/A

SECTION 10 STABILITY AND REACTIVITY

REACTIVITY: Stable.
CONDITIONS TO AVOID: Practices which produce dust or disperse finely divided dust in air. See NFPA 61, Standard for the Prevention of Fire and Dust Explosions in Agricultural and Food Processing Facilities, 2008 Edition, and other related standards.
INCOMPATIBILITIES: Oxidizing agents
HAZARDOUS DECOMPOSITION PRODUCTS: Nothing unusual.
POLYMERIZATION: Will not occur

SECTION 11 TOXICOLOGY INFORMATION

ACUTE HEALTH EFFECTS:
INHALATION: Exposure to high airborne concentrations may cause mild respiratory irritation due to drying effects of dust. Classified as a Particulate Not Otherwise Regulated (PNOR) because the ingredients are not known to cause adverse health effects from occupational exposure.
SKIN CONTACT: Sustained exposure in a dusty manufacturing enviroment may result in mechanical irritation in the creases of the skin, particularly at the fingers, or other drying effects. No health effects known or anticipated.
EYE CONTACT: May cause slight mechanical irritation from acute exposure.
INGESTION: No effects known or anticipated.
CHRONIC HEALTH EFFECTS: None known or anticipated.

SECTION 12 ECOLOGICAL INFORMATION

ACUTE AQUATIC TOXICITY: No data
DEGRADABILITY: No data

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BIOCONCENTRATION FACTOR (BCF): No data
OCTANOL/WATER PARTITION COEFFICIENT: No data

SECTION 13 DISPOSAL INFORMATION

Follow local, state and Federal regulations for product disposal. Not a hazardous waste unless contaminated with hazardous products.

SECTION 14 TRANSPORTATION INFORMATION

D.O.T. CLASSIFICATION: Not regulated
UN NUMBER: Not applicable

SECTION 15 REGULATORY INFORMATION

US FEDERAL REGULATIONS:
Clean Air Act: ODS: Not applicable
TSCA STATUS: Not applicable
SARA (EPCRA) SECTION 313 (40 C.F.R. § 372.65): Not applicable

STATE REPORTING REQUIREMENTS:
California Proposition 65: Not applicable

SECTION 16 OTHER

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Figure E-6. Sucralose specification sheets

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Customer Specification

Subject:	SPLENDA® Sucralose Granular (DFF-1)	**Document No:**	*770401.4*
Product(s):	Sucralose – Granular (DFF-1)	**Master Category #:** **Record Series #:** **Review Frequency:**	N/A 1840 3 Years

This specification is the property of Tate & Lyle and contains CONFIDENTIAL information that must not be photocopied or distributed outside Tate & Lyle without permission.

1. DESCRIPTION:

SPLENDA® Sucralose Granular (DFF-1) solid is a sweet, white to off-white, practically odorless, crystalline powder and is fit for human consumption.

2. PROPERTIES, REQUIREMENTS AND TEST METHODS:

2.1	Appearance	White to off-white, crystalline powder	TM 1012
2.2	Assay	98.0% to 102.0%, anhydrous basis	TM1129
2.3	Water content (KF)	NMT 2.0%	TM 1123
2.4	pH	Decrease of one pH unit maximum	TM 1090
2.5	(A) Identity (IR) *and* (B) Identity (HPLC) *and* (C) Identity (TLC)	The infrared spectrum corresponds to that of a similarly prepared reference *and* The relative retention time corresponds to that of the sucralose standard in the assay procedure *and* R_f value of principal spot in chromatogram of test solution corresponds to that of standard solution as obtained for the test for related substances	TM1130 *and* TM 1129 *and* TM1138
2.6	Related Substances (Other Chlorinated Disaccharides)	Passes test (NMT 0.5%)	TM 1138
2.7	Hydrolysis Products (Chlorinated Monosaccharides)	Passes test (NMT 0.1%)	TM 1120
2.8	Specific Rotation	+84.0 to +87.5 $[\alpha]_D^{20}$ anhydrous basis	TM 1137
2.9	Organoleptic Evaluation	Passes test	TM1126

SPLENDA® is a trademark of McNeil Nutritionals, LLC

Document Issue Date: 30-Nov-11 Released By: Kareen Sim

Customer Specification

Subject:	SPLENDA® Sucralose Granular (DFF-1)	**Document No:**	*770401.4*
Product(s):	Sucralose – Granular (DFF-1)	**Master Category #:** **Record Series #:** **Review Frequency:**	N/A 1840 3 Years

This specification is the property of Tate & Lyle and contains CONFIDENTIAL information that must not be photocopied or distributed outside Tate & Lyle without permission.

2.10	Particle Size	X10 >80 um X50 140 – 300 um	TM 1324
2.11	Residue on Ignition (Sulfated Ash)	NMT 0.7%	TM1134
2.12	Lead	NMT 1 ppm	TM 1515
2.13	Arsenic (as As)	NMT 3 ppm	TM 1474
2.14	Methanol	NMT 0.1%	TM 1484
2.15	Triphenylphosphine oxide	NMT 1 ppm	TM 1139
2.16	Heavy Metals (as Pb)	NMT 10 ppm	TM 1136
2.17	Clarity	Must Comply	TM 1084

3. MICROBIOLOGICAL REQUIREMENTS:

3.1	Total Aerobic Count	250/g maximum	TM 1498
3.2	Yeasts/Molds	50/g maximum	TM 1499
3.3	Coliforms	Negative to test (< 10/g)	TM 1504
3.4	*E. coli*	Negative to test (< 10/g)	TM 1504
3.5	*S. aureus*	Negative to test (< 10/g)	TM 1501
3.6	*Salmonella*	Negative to test (Absent in 25g)	TM 1502

Customer Specification

Subject:	SPLENDA® Sucralose Granular (DFF-1)	**Document No:**	*770401.4*
Product(s):	Sucralose – Granular (DFF-1)	**Master Category #:**	N/A
		Record Series #:	1840
		Review Frequency:	3 Years

4. CERTIFICATIONS:

4.1 SPLENDA® Sucralose Granular (DFF-1) solid meets FCC and JECFA specifications and EU specification (Directive 2008/60/EC).

4.2 Kosher for Passover
SPLENDA® Sucralose Granular (DFF-1) solid is certified as Kosher Pareve and Kosher for Passover by the Orthodox Jewish Community of Singapore and bears this organization's symbol.

4.3 Halal
SPLENDA® Sucralose Granular (DFF-1) solid is certified as Halal by Majlis Ugama Islam Singapura and bears this organization's symbol.

4.4 Genetically Modified Organisms:
SPLENDA® Sucralose is not produced from ingredients or processing aids derived by genetic modification. SPLENDA® Sucralose does not contain genetically modified organisms and labeling is not required under EC regulations 1829/2003 and 1830/2003.

4.5 BSE:
No animal derived ingredients are used in the production of SPLENDA® Sucralose. There are no animal derived ingredients used in the facility where sucralose is produced.

4.6 Allergens:
SPLENDA® Sucralose does not contain any commonly known sources of allergenic responses. Labeling is not required under FDA Food Allergen Labeling and Consumer Protection Act of 2004 (FALCPA) or under the EU Directive 2007/68/EC.

4.7 Bioterrorism Regulation Facility Registration:
SPLENDA® Sucralose production facilities are registered with the U.S. FDA in accordance with the requirements of the "Security and Bioterrorism Preparedness and Response Act of 2002".

Subject:	SPLENDA® Sucralose Granular (DFF-1)	**Document No:**	*770401.4*
Product(s):	Sucralose – Granular (DFF-1)	**Master Category #:** **Record Series #:** **Review Frequency:**	N/A 1840 3 Years

5. PACKAGING, HANDLING, STORAGE, AND MARKING:

5.1 Supplier Packaging:
SPLENDA® Sucralose Granular (DFF-1) solid is packaged in an appropriate container.

5.2 Handling and Storage Conditions:
SPLENDA® Sucralose Granular (DFF-1) solid must be maintained at a Controlled Room temperature as defined by USP/NF - 77°F (25°C) or b elow, with a maximum temperature never to exceed 95°F (35°C). SPLENDA ® Sucralose Granular (DFF-1) must be stored away from odoriferous material. Reseal container before storing unused product.

5.3 Shipping Requirements:
SPLENDA® Sucralose Granular (DFF-1) solid may be shipped under standard shipping conditions if total shipping time will not exceed 48 hours. If shipments of longer than 48 hours are necessary, every effort should be made to ship the product under Controlled Room Temperature as defined by USP/NF - 77°F (25°C) or below, with a maximum temperature not to exceed 95°F (35°C) or by next day courier. If a standard shipment is unavoidably delayed, adherence to Controlled Room Temperature conditions should be confirmed and documented.

5.4 Markings:
Markings will include product name, lot number, date of manufacture, best used by date, material number, ingredients, net weight, Kosher and Halal Certification, manufacturer information, and will specify usage information.

6. TESTING REQUIREMENTS:

6.1 A Certificate of Analysis (COA) will be provided with each shipment.

6.2 Properties and requirements in sections 2.1 – 2.10 and 3.1 – 3.6 will be analyzed for each lot produced.

6.3 Properties in sections 2.11 to 2.17 will be analyzed minimally on a quarterly basis.

6.4 If in-house customer testing is required upon receipt, it is recommended that this product be tested for compliance of assay, pH, and Organoleptics. These tests will provide the most information about the product without performing the entire battery of tests listed in section 2.

Subject:	SPLENDA® Sucralose Granular (DFF-1)	**Document No:**	*770401.4*
Product(s):	Sucralose – Granular (DFF-1)	**Master Category #:**	N/A
		Record Series #:	1840
		Review Frequency:	3 Years

7. SHELF LIFE:

It is recommended that this product be used within 24 months of manufacture, while stored under conditions stated in section 5.2.

8. RECOMMENDED USAGE CONDITIONS:

Buyer shall not use the Product in any application in which the pH of any product of manufactured good containing the Product is greater than 7.0, excluding applications of baked goods, in which Buyer shall not use the Product in any application in which the pH of any product or manufactured good containing the Product is greater than 8.0.

9. SAFETY PRECAUTIONS:

Consult appropriate MSDS and other relevant resources for personal protective equipment and other precautions.

Appendix F. IRB#13-244 Approval Letter

VirginiaTech

Office of Research Compliance
Institutional Review Board
North End Center, Suite 4120, Virginia Tech
300 Turner Street NW
Blacksburg, Virginia 24061
540/231-4606 Fax 540/231-0959
email irb@vt.edu
website http://www.irb.vt.edu

MEMORANDUM

DATE:	April 8, 2014
TO:	Susan E Duncan, Kristen Leitch, Virginia C Fernandez-Plotka
FROM:	Virginia Tech Institutional Review Board (FWA00000572, expires April 25, 2018)
PROTOCOL TITLE:	Acceptability and Emotional Response to Alternative Sweeteners
IRB NUMBER:	**13-244**

Effective April 8, 2014, the Virginia Tech Institution Review Board (IRB) Chair, David M Moore, approved the Continuing Review request for the above-mentioned research protocol.

This approval provides permission to begin the human subject activities outlined in the IRB-approved protocol and supporting documents.

Plans to deviate from the approved protocol and/or supporting documents must be submitted to the IRB as an amendment request and approved by the IRB prior to the implementation of any changes, regardless of how minor, except where necessary to eliminate apparent immediate hazards to the subjects. Report within 5 business days to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.

All investigators (listed above) are required to comply with the researcher requirements outlined at:

http://www.irb.vt.edu/pages/responsibilities.htm

(Please review responsibilities before the commencement of your research.)

PROTOCOL INFORMATION:

Approved As:	**Expedited, under 45 CFR 46.110 category(ies) 6,7**
Protocol Approval Date:	**April 24, 2014**
Protocol Expiration Date:	**April 23, 2015**
Continuing Review Due Date*:	**April 9, 2015**

*Date a Continuing Review application is due to the IRB office if human subject activities covered under this protocol, including data analysis, are to continue beyond the Protocol Expiration Date.

FEDERALLY FUNDED RESEARCH REQUIREMENTS:

Per federal regulations, 45 CFR 46.103(f), the IRB is required to compare all federally funded grant proposals/work statements to the IRB protocol(s) which cover the human research activities included in the proposal / work statement before funds are released. Note that this requirement does not apply to Exempt and Interim IRB protocols, or grants for which VT is not the primary awardee.

The table on the following page indicates whether grant proposals are related to this IRB protocol, and which of the listed proposals, if any, have been compared to this IRB protocol, if required.

Invent the Future

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY
An equal opportunity, affirmative action institution

Appendix G. IRB#13-244 Consent Form for Blinded Study

Virginia Polytechnic Institute and State University
Informed Consent for Participation in Sensory Evaluation

Title of Project: Acceptability and Emotional Response to Alternative Sweeteners

Investigators: Dr. Susan E. Duncan, Kristen Leitch and Tina Plotka

I. PURPOSE OF PROJECT

You are invited to participate in a study examining consumer perception and overall acceptance of various artificial and all natural sweeteners in tea. This study will help us determine whether there is a correlation between traditional sensory methods of understanding consumer-product interactions and a new technique using facial recognition software. The outcomes of this project will be analyzed and used in Kristen Leitch's graduate thesis project and related publications and presentations.

II. PROCEDURES

After you sign the consent form there will be **two sessions** of sensory testing today: each session will last approximately 15-20 minutes. There will be **two additional sessions** of sensory testing to follow at a later date.

In the first session, you will be presented with one plain water sample followed by 3 samples of sweetened tea products sequentially. You will be asked to rate your overall liking of each sweetened tea sample on a 9-point scale where 1=extremely dislike and 9=extremely like. Your responses to each sample will be videotaped for further analysis using a facial expression software program. Instructions will be given on your position within the laboratory and how you interact with the sample and the computer screen. It is important that you maintain eye contact with the computer screen/video camera in order to capture the best video data. As such, please keep your face positioned towards the touch screen monitor, as you taste the sample. Please try to refrain from looking to the sides or the floor. Please do not touch your face after consuming each sample.

Guidance for each sample will be provided on the touch screen monitor. Please hold the colored index card associated with each sample cup to the webcam prior to tasting the sample. Take the full sample in your mouth and immediately remove the cup from your mouth. After swallowing, please fill out the hedonic questionnaire provided on the monitor for the associated sample. Follow this same procedure for all samples. Upon completed the evaluation for all 3 samples you will be directed to another room for the second session.

In the second session you will first be asked to fill out several questionnaires that will only be given once (demographic survey, beverage questionnaire). You will then be asked to complete a self-assessment questionnaire pertaining to your overall health and well being, stress levels and general attitude and mood for the day in question. Immediately following the 3 questionnaires, you will be presented with 3 coded samples of sweetened tea products and asked to evaluate them using a 9-point hedonic rating test and a ballot list of emotional terms that you associate with your response to the product.

For each sample, please take a generous sip and fill out the associated hedonic worksheet and ballot.

Participants will also be asked to return for the messaging study upon completion of these four sessions in order for the researchers to be able to compare results within the two studies.

III. BENEFITS/RISKS OF THE PROJECT

There are no more than minimal risks for participants in this study. The following sweeteners will be used: Sucrose, Acesulfame potassium (Ace-K, aka: Sunett, Sweet One), Sucralose (Splenda), Honey and High Fructose Corn Syrup. If you are aware of any allergies associated with artificial sweeteners or all-natural sweeteners, please do not participate. Your participation will provide valuable information related to consumer perception of and their related emotional response to various alternative sweeteners in beverages. If you would like a summary of the research results, please contact the researcher at a later time.

IV. EXTENT OF ANONIMITY AND CONFIDENTIALITY

The results of your performance as a panelist will be kept strictly confidential. Individual panelists will be referred to by code for analyses and in any publication of the results.

V. COMPENSATION

Snacks will be provided at the conclusion of each session as an expression of our gratitude for your participation. A $2 gift card is provided for completion of the study. If all 8 sessions are attended, an additional $2 gift card will be provided for a total of $10. In addition, for you participation you may accept two cans of food or we will donate shelf-stable food to the local food bank in Christiansburg, VA as a part of the food science sensory lab “Serving Science and Society” marketing campaign. You must provide your signature on the form indicating receipt of the gift card and your decision (accept or donate) for the canned food items.

VI. FREEDOM TO WITHDRAW

It is essential to sensory evaluation projects that you complete this session in so far as possible. However, there may be conditions preventing your completion of the session. Examples of conditions might include short-term health impairment such as a cold, chronic or acute taste disorders, allergies, or sensitivities to the listed sweeteners, concerns about interactions of sweeteners with medications or fear of being videotaped. If after reading and becoming familiar with the sensory project, you decide not to participate as a panelist, you may withdraw at any time without penalty. The snacks are available even if you withdraw but the gift card will not be offered.

VII.APPROVAL OF RESEARCH

This research project has been approved by the Institutional Review Board for projects involving human subjects at Virginia Polytechnic Institute and State University and by the human subjects review of the Department of Food Science and Technology.

VIII. SUBJECT'S RESPONSIBILITIES

I know of no reason I cannot participate in this study, which will require approximately 20 minutes of data collection in each session (two sessions; about 40-45 minutes total). It is my responsibility to

- Taste each sample and rate the sample on a 9-point hedonic scale in both sessions
- To follow the protocols as directed while being videotaped
- Complete all questionnaires in session 2
- To not discuss my observations with other study participants
- Return for the second testing day
- Return for the "messaging" study unless circumstances prevent this
- Excuse myself from participation if I have any health conditions or taste disorders that are affecting my sensory perception of the taste/flavor (e.g. head cold or sinus infection) on the day of evaluation.

IX. SUBJECT'S PERMISSION

I have read the information about the conditions of this sensory evaluation project and give my voluntary consent for participation in this project. I also give my consent to be videotaped throughout the sensory evaluation. I know of no reason I cannot participate in this study.

______________________________ ______________________

Subject signature Date

____

Subject printed name

----------------------------------For human subjects to keep---------------------------------------

Should I have any questions about this research or its conduct, I should contact:

Kristen Leitch, Master's Student kaleitch@vt.edu
Investigator/E-Mail

Tina Plotka, Research Associate 540-231-9843 tplotka@vt.edu
Co-Investigator/Phone/E-Mail

Dr. Susan E. Duncan 540-231-8675 duncans@vt.edu
Faculty/Investigator/Phone/E-Mail

Dr. David Moore (540)231-4991
Chair, IRB/Phone for Research Division

Appendix H. IRB#13-244 Ballots

Figure H-1. SIMS Scorecard for Blinded Study

Facial Expression Analysis No Messaging Instructions Hedonic Scorecard

Instructions [Instructions and Evaluation will be on the touch screen monitor]: You will be provided a total of 4 samples to evaluate. For each sample, you are to evaluate how well you like each sample. For each product, take the full sample into your mouth and then swallow.

It is important that you follow specific protocols while evaluating the sample in order for the response to be collected.

- **Focus your attention on the monitor in front of you. Refrain from looking to your left/right or looking up/down.**
- **Do not lean your head; keep your posture comfortable but alert.**
- **Immediately after taking in the sample from the cup, drop your hand/cup below your chin as quickly as possible.**
- **Refrain from touching your face after sample consumption.**
- **Face the monitor while you are evaluating the sample.**

Samples 1-4:

Please consume the sample in front of you. Sample ____[color]_____

[20-30 second timer will display]

Indicate how much you like this sample by checking the term that best describes your response to the product.

Like extremely	______
Like very much	______
Like moderately	______
Like slightly	______
Neither like nor dislike	______
Dislike slightly	______
Dislike moderately	______
Dislike very much	______
Dislike extremely	______

When you are finished, hit “Next”. Pass your tray through the slot to receive your next sample. Rinse your mouth with water, take a bite of cracker, and rinse your mouth again.

You are done tasting all the samples.

Thank you for your participation. Please exit the lab and go to the incentives table to sign for and collect your gift card and other incentives as compensation for your participation.

Figure H-2. Modified EsSence™ Profile ballot with additional terms (angry, content, fearful, sad and safe)

Panelist #_______________
Product #_______________

Please taste the product in front of you now.

Select how much you LIKE or DISLIKE the product?

- ☐ 9- like extremely
- ☐ 8- like very much
- ☐ 7- like moderately
- ☐ 6- like slightly
- ☐ 5- neither like nor dislike
- ☐ 4- dislike slightly
- ☐ 3- dislike moderately
- ☐ 2- dislike very much
- ☐ 1- dislike extremely

Please select the word(s) which describe how you **FEEL RIGHT NOW**. *Select all that apply.*

☐ Active	☐ Friendly	☐ Quiet
☐ Adventurous	☐ Good	☐ Sad
☐ Affectionate	☐ Good-natured	☐ Safe
☐ Aggressive	☐ Guilty	☐ Satisfied
☐ Angry	☐ Happy	☐ Secure
☐ Bored	☐ Interested	☐ Steady
☐ Calm	☐ Joyful	☐ Tame
☐ Content	☐ Loving	☐ Tender
☐ Daring	☐ Merry	☐ Understanding
☐ Disgusted	☐ Mild	☐ Warm
☐ Eager	☐ Nostalgic	☐ Whole
☐ Energetic	☐ Peaceful	☐ Wild
☐ Enthusiastic	☐ Pleased	☐ Worried
☐ Fearful	☐ Pleasant	
☐ Free	☐ Polite	

Figure H-3. Modified Beverage Questionnaire (Hedrick, et al 2010) with additional beverages

Beverage Questionnaire (BEVQ-15)

Instructions:

Panelist #

Date

In the past month, please indicate your response for each beverage type by marking an "X" in the bubble for "how often" and "how much each time."

1. Indicate how often you drank the following beverages, for example, if you drank 5 glasses of water per week, mark 4-6 times per week.

2. Indicate the approximate amount of beverage you drank each time, for example, if you drank 1 cup of water each time, mark 1 cup under "how much each time."

3. Do not count beverages used in cooking or other preparations, such as milk in cereal.

4. Count milk added to tea and coffee in the *tea/coffee with cream beverage category* **NOT** in the milk categories.

	How Often (Mark One)							How Much Each Time (Mark One)				
Type of Beverage	**Never or less than 1 time per week (go to next bev)**	**1 time per week**	**2-3 times per week**	**4-6 times per week**	**1 time per day**	**2+ times per day**	**3+ times per day**	**Less than 6 fl oz (3/4 cup)**	**8 fl oz (1 cup)**	**12 fl oz (1 ½ cups)**	**16 fl oz (2 cups)**	**More than 20 fl oz (2 ½ cups)**
Water	o	o	o	o	o	o	o	o	o	o	o	o
100% Fruit Juice	o	o	o	o	o	o	o	o	o	o	o	o
Sweetened Juice Beverage/Drink (fruit, lemonade, punch,)	o	o	o	o	o	o	o	o	o	o	o	o
Whole Milk	o	o	o	o	o	o	o	o	o	o	o	o
Reduced Fat Milk (2%)	o	o	o	o	o	o	o	o	o	o	o	o
Low Fat/Fat Free Milk (Skim, 1%, Buttermilk, Soymilk)	o	o	o	o	o	o	o	o	o	o	o	o
Soft Drinks, Regular	o	o	o	o	o	o	o	o	o	o	o	o
Diet Soft Drinks/Artificially Sweetened Drinks	o	o	o	o	o	o	o	o	o	o	o	o
Sweetened Tea (**iced**)	o	o	o	o	o	o	o	o	o	o	o	o
Hot/Cold Tea or Coffee, with cream and/or sugar (includes non-dairy creamer)	o	o	o	o	o	o	o	o	o	o	o	o
Hot/Cold Tea or Coffee, black, with/without artificial sweetener (no cream or sugar)	o	o	o	o	o	o	o	o	o	o	o	o
Beer, Ales, Wine Coolers, Non-alcoholic or Light Beer	o	o	o	o	o	o	o	o	o	o	o	o
Hard Liquor (shots, rum, tequila, etc.)	o	o	o	o	o	o	o	o	o	o	o	o
Wine (red or white)	o	o	o	o	o	o	o	o	o	o	o	o
Energy/Sports Drinks	o	o	o	o	o	o	o	o	o	o	o	o

Figure H-4. Demographic Questionnaire

Demographic Questionnaire

Please answer the following questions

Thank you for sharing your personal information. It will help us better understand your experiences.

1. What is your gender?
- Male
- Female

2. What is your age range? *Please note, if you are under 18 we cannot accept your participation due to IRB protocol.
- 18-20
- 20-25
- 25-30
- 30-35
- 35-40
- 40-45
- 45-50
- 50-55
- 55-60
- 60-65
- 65+

3. What is the highest level of education you have completed?
- Less than high school
- High school/ GED
- Some college
- 2-year college degree (Associates)
- 4-year college degree (BS, BA)
- Master’s degree
- Doctoral degree/Post doc/Professional degree (DVM, JD, MD, etc.)

4. Please select the one that best describes you:
- Undergraduate student
- Graduate student (Masters/PhD)
- Faculty/Staff
- Community member

5. Which category of sweeteners do you tend to use in your beverages more frequently?
- Natural sweeteners
- Artificial sweeteners
- None

Figure H-4. Demographic Questionnaire (continued)

6. Of the following list which one(s) do you routinely use in your beverages? Check all that apply.
- Coconut palm sugar
- Equal
- Granulated (white) sugar
- High fructose corn syrup
- Honey
- Monk fruit extract
- Sweet 'N Low
- Sweet One
- Splenda
- None
- Other (please list below)

Figure H-5. Self-Assessment (Well-Being) Questionnaire

Self-Assessment (Well-being) Questionnaire

1. On a scale of 1 to 5 (1=excellent, 5=poor), how would you describe your overall *physical* health today? Circle one.

1=excellent (healthy)
2=good
3=average
4=below average
5=poor (sick)

2. On a scale of 1 to 5 (1=excellent, 5=poor), how would you describe your overall *mental* health today? Circle one.

1=excellent
2=good
3=average
4=below average
5=poor

3. On a scale of 1 to 5 (1=no stress, 5=extremely stressed), how would you describe your stress level today? Circle one.

1=no stress
2=slightly stressed
3=moderately stressed
4=very stressed
5=extremely stressed

> 3a. If you are more stressed today than normal, can you attribute it to something specific? Describe below (optional):

4. On a scale of 1 to 5 (1=very tired, 5=very awake), how tired/awake are you today? Circle one.

1=very alert/awake
2=moderately awake
3=borderline awake/tired
4=moderately tired
5=very tired

Appendix I. IRB#13-244 Consent Form for Study with Varying Product Information

Virginia Polytechnic Institute and State University
Informed Consent for Participation in Sensory Evaluation

Title of Project: Acceptability and Emotional Response to Alternative Sweeteners

Investigators: Dr. Susan E. Duncan, Kristen Leitch and Tina Plotka

I. PURPOSE OF PROJECT

You are invited to participate in a study examining how messaging plays a role in consumer perception and overall acceptance of various artificial and all natural sweeteners in tea. This study will help us determine whether consumers are affected by messaging (information labels) about products. The outcomes of this project will be analyzed and used in Kristen Leitch's graduate thesis project and related publications and presentations.

II. PROCEDURES

After you sign the consent form there will be **two sessions** of sensory testing today; each session will last approximately 15-20 minutes. There will be **two additional sessions** of sensory testing to follow at a later date.

In the first session, you will be presented with one plain water sample followed by 3 samples of sweetened tea products sequentially. You will be asked to rate your overall liking of each sweetened tea sample on a 9-point scale where 1=extremely dislike and 9=extremely like. Your responses to each sample will be videotaped for further analysis using a facial expression software program. Instructions will be given on your position within the laboratory and how you interact with the sample and the computer screen. It is important that you maintain eye contact with the computer screen/video camera in order to capture the best video data. As such, please keep your face positioned towards the touch screen monitor, as you taste the sample. Please try to refrain from looking to the sides or the floor. Please do not touch your face after consuming each sample.

Guidance for each sample will be provided on the touch screen monitor. Please hold the colored index card associated with each sample cup facing the webcam prior to tasting the sample. Make sure to read the product information on the monitor before taking the full sample in your mouth. Upon swallowing, immediately remove the cup from your mouth and please fill out the hedonic questionnaire on the monitor for the associated sample. Follow this procedure for all samples. Upon completed the evaluation for all 3 samples you will be directed to another room for the second session.

In the second session you will first be asked to complete a self-assessment questionnaire pertaining to your overall health and well being, stress levels and general attitude and mood for the day in question. Immediately following this questionnaire, you will be presented with 3 samples of sweetened tea products with varying information about each and asked to evaluate them using a 9-point hedonic rating test and a ballot list of emotional terms that you associate with your response to the product. For each sample, please take a generous sip and fill out the associated hedonic worksheet and ballot.

III. BENEFITS/RISKS OF THE PROJECT

There are no more than minimal risks for participants in this study. The following sweeteners will be used: Sucrose, Acesulfame potassium (Ace-K, aka: Sunett, Sweet One) and High Fructose Corn Syrup (HFCS). If you are aware of any allergies associated with artificial sweeteners or all-natural sweeteners, please do not participate. Your participation will provide valuable information related to consumer perception of and their related emotional response to various alternative sweeteners in beverages as well as messaging. If you would like a summary of the research results, please contact the researcher at a later time.

IV. EXTENT OF ANONIMITY AND CONFIDENTIALITY

The results of your performance as a panelist will be kept strictly confidential. Individual panelists will be referred to by code for analyses and in any publication of the results.

V. COMPENSATION

Snacks will be provided at the conclusion of each session as an expression of our gratitude for your participation. A $2 gift card is provided for completion of the study. If all 8 sessions are attended, an additional $2 gift card will be provided for a total of $10. In addition, for you participation you may accept two cans of food or we will donate shelf-stable food to the local food bank in Christiansburg, VA as a part of the food science sensory lab “Serving Science and Society” marketing campaign. You must provide your signature on the form indicating receipt of the gift card and your decision (accept or donate) for the canned food items.

VI. FREEDOM TO WITHDRAW

It is essential to sensory evaluation projects that you complete this session in so far as possible. However, there may be conditions preventing your completion of the session. Examples of conditions might include short-term health impairment such as a cold, chronic or acute taste disorders, allergies, or sensitivities to the listed sweeteners, concerns about interactions of sweeteners with medications or fear of being videotaped. If after reading and becoming familiar with the sensory project, you decide not to participate as a panelist, you may withdraw at any time without penalty.

VII.APPROVAL OF RESEARCH

This research project has been approved by the Institutional Review Board for projects involving human subjects at Virginia Polytechnic Institute and State University and by the human subjects review of the Department of Food Science and Technology.

VIII. SUBJECT'S RESPONSIBILITIES

I know of no reason I cannot participate in this study, which will require approximately 20 minutes of data collection in one session (about 40-45 minutes total). It is my responsibility to

- Taste each sample and rate the sample on a 9-point hedonic scale in both sessions
- To follow the protocols as directed while being videotaped
- Complete all questionnaires in session 2

- To not discuss my observations with other study participants
- Return for the second testing day
- Excuse myself from participation if I have any health conditions or taste disorders that are affecting my sensory perception of the taste/flavor (e.g. head cold or sinus infection) on the day of evaluation.

IX. SUBJECT'S PERMISSION

I have read the information about the conditions of this sensory evaluation project and give my voluntary consent for participation in this project. I also give my consent to be videotaped throughout the sensory evaluation. I know of no reason I cannot participate in this study.

_____________________________ _______________________

Subject signature Date

____

Subject printed name

----------------------------------For human subjects to keep--

Should I have any questions about this research or its conduct, I should contact:

Kristen Leitch, Master's Student kaleitch@vt.edu

Investigator/E-Mail

Tina Plotka, Research Associate 540-231-9843 tplotka@vt.edu

Co-Investigator/Phone/E-Mail

Dr. Susan E. Duncan 540-231-8675 duncans@vt.edu

Faculty/Investigator/Phone/E-Mail

Dr. David Moore (540)231-4991

Chair, IRB/Phone for Research Division

Appendix J. SIMS Ballots Provided with Varying Product Information

Figure J-1. SIMS Ballot with True Information

Facial Expression Analysis No Messaging Instructions Hedonic Scorecard

Instructions [Instructions and Evaluation will be on the touch screen monitor]: You will be provided a total of 4 samples to evaluate. For each sample, you are to evaluate how well you like each sample. For each product, view the message associated with each sample and then take the full sample into your mouth and swallow.

It is important that you follow specific protocols while evaluating the sample in order for the response to be collected.

- **Focus your attention on the monitor in front of you. Refrain from looking to your left/right or looking up/down.**
- **Do not lean your head; keep your posture comfortable but alert.**
- **Immediately after taking in the sample from the cup, drop your hand/cup below your chin as quickly as possible.**
- **Refrain from touching your face after sample consumption.**
- **Face the monitor while you are evaluating the sample.**

Sample 1:

Please consume the sample in front of you. Sample _water_

[20-30 second timer will display]

When you are finished, hit “Next”. Pass your tray through the slot to receive your next sample. Rinse your mouth with water, take a bite of cracker, and rinse your mouth again.

Sample 2:

Please consume the sample in front of you. Product description: Natural sweetener; provides 4 kcal/g (~144 kcal for a 12 oz beverage)

Sample ____sugar____

[20-30 second timer will display]

Indicate how much you like this sample by checking the term that best describes your response to the product.

Like extremely ______

Like very much ______
Like moderately ______
Like slightly ______
Neither like nor dislike ______
Dislike slightly ______
Dislike moderately ______
Dislike very much ______
Dislike extremely ______

When you are finished, hit “Next”. Pass your tray through the slot to receive your next sample. Rinse your mouth with water, take a bite of cracker, and rinse your mouth again.

Sample 3:

Please consume the sample in front of you. Product description: Naturally sweetened; provides 3 kcal/g (~126 kcal for a 12 oz beverage)

Sample _high fructose corn syrup_

[20-30 second timer will display]

Indicate how much you like this sample by checking the term that best describes your response to the product.

Like extremely ______
Like very much ______
Like moderately ______
Like slightly ______
Neither like nor dislike ______
Dislike slightly ______
Dislike moderately ______
Dislike very much ______
Dislike extremely ______

When you are finished, hit “Next”. Pass your tray through the slot to receive your next sample. Rinse your mouth with water, take a bite of cracker, and rinse your mouth again.

Sample 4:

Please consume the sample in front of you. Product description: Artificially sweetened; provides 0 kcal/g (~0 kcal for a 12 oz beverage)

Sample ____Sweet One____

[20-30 second timer will display]

Indicate how much you like this sample by checking the term that best describes your response to the product.

Like extremely	______
Like very much	______
Like moderately	______
Like slightly	______
Neither like nor dislike	______
Dislike slightly	______
Dislike moderately	______
Dislike very much	______
Dislike extremely	______

You are done tasting all the samples.

Thank you for your participation. Please exit the lab and go to the incentives table to sign for and collect your gift card and other incentives as compensation for your participation.

Figure J-2. SIMS Ballot with False Information

Facial Expression Analysis No Messaging Instructions Hedonic Scorecard

Instructions [Instructions and Evaluation will be on the touch screen monitor]: You will be provided a total of 4 samples to evaluate. For each sample, you are to evaluate how well you like each sample. For each product, view the message associated with each sample and then take the full sample into your mouth and swallow.

It is important that you follow specific protocols while evaluating the sample in order for the response to be collected.

- **Focus your attention on the monitor in front of you. Refrain from looking to your left/right or looking up/down.**
- **Do not lean your head; keep your posture comfortable but alert.**
- **Immediately after taking in the sample from the cup, drop your hand/cup below your chin as quickly as possible.**
- **Refrain from touching your face after sample consumption.**
- **Face the monitor while you are evaluating the sample.**

Sample 1:

Please consume the sample in front of you. Sample _water_

[20-30 second timer will display]

When you are finished, hit “Next”. Pass your tray through the slot to receive your next sample. Rinse your mouth with water, take a bite of cracker, and rinse your mouth again.

Sample 2:

Please consume the sample in front of you. Product description: Natural sweetener; provides 4 kcal/g (~144 kcal for a 12 oz tea beverage)

Sample ____sugar____

[20-30 second timer will display]

Indicate how much you like this sample by checking the term that best describes your response to the product.

Like extremely ______
Like very much ______

Like moderately ______
Like slightly ______
Neither like nor dislike ______
Dislike slightly ______
Dislike moderately ______
Dislike very much ______
Dislike extremely ______

When you are finished, hit "Next". Pass your tray through the slot to receive your next sample. Rinse your mouth with water, take a bite of cracker, and rinse your mouth again.

Sample 3:

Please consume the sample in front of you. Product description: Artificially sweetened; provides 0 kcal/g (~0 kcal for a 12 oz tea beverage)

Sample _high fructose corn syrup_

[20-30 second timer will display]

Indicate how much you like this sample by checking the term that best describes your response to the product.

Like extremely ______
Like very much ______
Like moderately ______
Like slightly ______
Neither like nor dislike ______
Dislike slightly ______
Dislike moderately ______
Dislike very much ______
Dislike extremely ______

When you are finished, hit "Next". Pass your tray through the slot to receive your next sample. Rinse your mouth with water, take a bite of cracker, and rinse your mouth again.

Sample 4:

Please consume the sample in front of you. Product description: Naturally sweetened; provides 3 kcal/g (~126 kcal for a 12 oz tea beverage)

Sample ____Sweet One____

[20-30 second timer will display]

Indicate how much you like this sample by checking the term that best describes your response to the product.

Like extremely	______
Like very much	______
Like moderately	______
Like slightly	______
Neither like nor dislike	______
Dislike slightly	______
Dislike moderately	______
Dislike very much	______
Dislike extremely	______

You are done tasting all the samples

Thank you for your participation. Please exit the lab and go to the incentives table to sign for and collect your gift card and other incentives as compensation for your participation.

Appendix K. Additional Hedonic Information for Sweeteners Provided with Varying Product Information

Table K-1. Mean hedonic scores[1], standard deviation, 95% C.I., & Median for sweeteners presented with varying information[2] in cold tea

No Information

Natural Session

	FER[3]				ETS[3]			
Sweetener	Mean	SD	95% CI	Median	Mean	SD	95% CI	Median
Sucrose	6.7	1.2	6.3-7.2	7.0	6.4	1.4	5.9-6.9	7.0
HFCS	6.5	1.1	6.1-6.9	6.0	6.1	1.4	5.6-6.6	6.0

Artificial Session

	FER[3]				ETS[3]			
Sweetener	Mean	SD	95% CI	Median	Mean	SD	95% CI	Median
Sucrose	6.8	1.3	6.3-7.3	7.0	6.6	1.4	6.1-7.1	7.0
Ace-K	5.9	1.3	5.4-6.4	6.0	5.3	1.9	4.6-6.0	6.0

True Information

	FER[3]				ETS[3]			
Sweetener	Mean	SD	95% CI	Median	Mean	SD	95% CI	Median
Sucrose	6.8	1.2	6.3-7.3	7.0	6.8	1.4	6.3-7.3	7.0
Ace-K	5.0	1.5	4.4-5.6	5.0	5.4	1.5	4.9-6.0	6.0
HFCS	6.3	1.3	5.8-6.8	7.0	6.3	1.2	5.8-6.7	6.0

False Information

	FER[3]				ETS[3]			
Sweetener	Mean	SD	95% CI	Median	Mean	SD	95% CI	Median
Sucrose	6.7	1.1	6.3-7.1	7.0	6.9	1.5	6.3-7.5	7.0
Ace-K	5.6	1.7	4.9-6.2	6.0	5.1	1.6	4.5-5.7	5.0
HFCS	6.1	1.3	5.6-6.6	6.0	5.9	1.5	5.3-6.5	6.0