ABSTRACT

OLTMAN, AMY. Qualitative and Quantitative Research Methods to Measure Consumer Valuation and Consumer Acceptability. (Under the direction of Dr. MaryAnne Drake).

Sensory analysis is a field that aims to discover which parameters of products drive consumer liking and ultimately purchase. To investigate what consumers are willing to buy, quantitative and qualitative methods are used. The objective of this thesis was to apply quantitative and qualitative research techniques to identify key consumer attributes for tomatoes and protein beverages. Three different studies were conducted. The first study used an adaptive choice based conjoint with Kano analysis (n=1037) and focus groups (n=28) to understand consumer preferences for fresh tomatoes. Results were analyzed by multivariate analyses. The study revealed that external attributes were the main drivers of liking for fresh tomatoes and segmented groups of consumers were differentiated by preference for color, firmness, flavor and health benefits. The second study conducted descriptive analysis on 7 tomato cultivars and a consumer test (n=177) with the same cultivars. Overall liking was evaluated across three stages: appearance, slicing and consumption of tomatoes. Preference mapping was applied to descriptive analysis and consumer liking scores, and clusters were characterized based on liking during the 3 stages of consumption. Clusters were differentiated by preference for color, flavor, ripeness and firmness. Drivers of liking during appearance evaluation were color related, drivers of liking during slicing were juiciness/wetness and aroma and drivers of liking during consumption were wetness/juiciness, seed presence, ripe flavor, sweet taste and umami taste. The third study identified key attributes for protein beverages and subsequently tested the effect of priming on liking of protein beverages. An adaptive choice based conjoint with Kano analysis

(n=432) was conducted and analyzed using multivariate analyses. The most important protein beverage attributes were protein amount, protein type, great flavor and satiety. A consumer test (n=151) was consequently conducted, investigating the effect of priming great taste or amount of protein on consumer liking of protein beverages. Two pairs of clear acidic whey protein beverages were manufactured that differed by age of protein (prime = great flavor) and amount of whey protein per serving (prime = 20 g protein per serving). Consumers tasted beverages either primed or unprimed on two separate occasions. A 2-way analysis of variance was applied to determine the effect of each priming statement. Priming statements positively impacted concept liking ($p<0.05$) but had no effect on overall liking after tasting ($p>0.05$). Conclusions from these studies can help developers and marketers determine discerning methods to implement in order to understand consumer preferences.

Qualitative and Quantitative Research Methods to Measure Consumer Valuation and Consumer Acceptability

by
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DEDICATION

This thesis is dedicated to my parents.

BIOGRAPHY

Amy Oltman was born in Atlanta, Georgia. She developed a love for food on the open dishwasher. She received Bachelor's degrees in Food Science and German from the University of Georgia in 2012. She moved to Raleigh, North Carolina to earn her Master's degree in Food Science. Along the way, she happened upon a very special bean that she grows and grows with every day. She hopes to continue her career doing what she loves and growing a magnificent garden in the future.

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Thank you to my fellow lab members for working with me through this undertaking.

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CHAPTER 1

Literature Review

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Quantitative and Qualitative Research Methods

When a new product is introduced to the market, millions of dollars and the time and efforts of many are at stake. To ensure new products have the best chance of becoming profitable in an often times saturated market, research techniques involving consumers are implemented to gauge consumer valuation and willingness to pay for these goods. Such techniques allow us to determine how much to charge for a good, the part-worth of attributes that make up the good and how consumers value different goods (with varying attributes) against each other. These research techniques can be conducted with actual prototypes or product concepts.

To characterize consumer willingness to pay (WTP) for an item, methods that are widely recognized include stated preferences, consisting of contingent valuation and choice experiments, and auctions (Tempesta and Vecchiato, 2012). Observing what an individual has purchased in the past does not reveal how much more they would have been willing to pay- it only establishes that the consumer's price limit is equal to or greater than the market price (Noussair et al., 2004a). In addition to characterizing willingness to pay, other methods such as conjoint analysis and the multi attribute attitude model (MAAM) allow the researcher to break down a product to see how consumers value or like individual attributes that make up a whole product.

While these previously described methods explore consumer perception of value quantitatively, qualitative methods may provide further insight to understand *why* consumers value the things they do. Qualitative research uncovers the motivations that dictate behavior, which includes purchase behavior (Berkwits and Inui, 1998). This information is useful

because it investigates how valuation can be predicted in a larger market. Focus groups, means end chains, laddering and ethnography are all common qualitative research techniques that may be used to gain understanding of consumer valuation. This review will examine quantitative and qualitative research methods and how they may be used to understand how consumers make decisions.

Stated Preferences

The term 'stated preferences' generally refers to both contingent valuation and choice experiments. Stated preference surveys address consumer preferences (Carson and Louviere 2011). Contingent valuation is a technique used to determine the value of a non-market commodity or a good that is public (Carson and Louviere, 2011). The approach is often used in environmental policy making (Carson et al., 2001; Bateman 1996; Willis et al., 1996; Garrod 1996) including willingness to accept compensation for converting land to different uses. Contingent valuation method, where consumers are asked their hypothetical willingness to pay, has been shown to be inaccurate in determining what consumers are actually willing to pay (Blumenschein et al., 1998; Hanley et al., 1998). Consumers have been shown to overestimate their hypothetical willingness to pay versus their actual willingness to pay (Blumenschein et al., 1998). No hypothetical choice method has been established to overcome the bias inherent in hypothetical evaluations (Combris, et al., 2009). Choice experiments are experiments designed to have individuals choose between alternative "bundles" of attributes of products (Adamowicz et al., 1998). In choice experiments, consumers make their choice not by evaluating a good directly, but evaluating the

decomposed attributes of a good (Tempesta and Vecchiato, 2012). This allows the researcher to vary which attributes are present, making a choice set of comparable goods. Value can then be assigned to attributes to see which ones affect overall liking or purchase intent of the whole good the most (Adamowicz et al., 1998). For example, in a study that gauged willingness to pay for local milk, the choice experiment contained the attributes price, production area, product origin and type of rearing to differentiate the milks (Tempesta and Vecchiato, 2012). Choice evaluation has also been used with caribou management (Adamowicz et al., 1998), health care evaluation (Norman et al., 2013), women's preferences for miscarriage management (Petrou and McIntosh, 2009) and livestock purchase (Vestal et al., 2013).

A popular experimental practice within stated preference methods to elicit WTP is to have subjects or bidders evaluate a product and record their WTP for that product; THEN have them state WTP for the same product after having been given information about the product. This has been conducted with fiber content in french bread (Ginon et al., 2009), grass fed versus conventional beef (Xue et al., 2010) and a nutraceutical rich juice (Lawless et al., 2012). Providing additional information to consumers impacts their WTP (Saulais and Ruffieux, 2012). In a study on WTP of organic versus conventional beef, providing information on the benefits of organic production led to higher WTP of organic beef (Napolitano et al., 2010). The change in WTP before and after information is provided measures the extent of how much participants value the characteristic (Jaeger et al., 2004). Lange et al. (1999) reported that external information was equally as important to consumers as sensory characteristics when regarding orange juices. Lange et al. (2002) also reported that

auctions were more relevant to obtain valid information on value of the product (or brand) when external information was presented.

Auctions

Unlike stated preferences, the use of experimental auctions has been used extensively to determine willingness to pay for food products (Lusk and Shogren, 2007). Often, the process is used to value a certain attribute of a product such as pesticide treatment of apples (Roosen et al., 1998), sensory attributes of tangerines (Bi et al., 2011) and modified kiwi fruits (Jaeger and Harker, 2005). The goal of an auction is to provide a situation that is as close to a real market setting as possible. In a hypothetical situation, the participant will not experience an adverse effect when they state their willingness to pay- in an auction, they will.

Experimental auctions are distinguished because they are NOT hypothetical (Lusk et al., 2010). Consumers tend to state higher WTP in hypothetical situations that they would not actually be willing to spend in a real situation (Van Loo et al., 2011). Much evidence exists proving that hypothetical methods are prone to bias: (Chang et al., 2009; Cummings et al., 1995; List and Gallet, 2001; Loomis et al., 1997; Lusk, 2003; Murphy et al., 2005; Neill et al., 1994; Silva et al., 2007). A reason experimental auctions are not very widespread is because of the higher cost; often it is easier and cheaper to ask consumers hypothetically how much they would be willing to pay for a certain product. An auction is an example of an incentive compatible method, which aims to provide incentive for the participant to tell the truth and reveal true WTP. The commonality among incentive compatible methods is that the participant becomes a buyer- actually given the chance to buy or obtain an item for gain and

choosing them against others (Combris et al. 2009). By holding participants accountable for their actions (using real money), it creates higher reliability and validity of stated WTP data (Jaeger et al., 2004).

Auctions reveal an individual's price limit directly. Noussair et al. (2004b) characterized demand revealing mechanisms as follows: "Economists usually advocate auctions that are demand revealing, that is, where the particular rules in effect imply that the individual bidders maximize expected payoffs in the auction setting if they accurately reveal preferences." Three auction demand revealing mechanisms are the Vickrey auction (Vickrey, 1961), random nth price auction (Shogren et al., 2001) and the Becker-DeGroot-Marschak (BDM) mechanism (Becker et al., 1964).

In the Vickrey (or second price) auction, subjects simultaneously submit a sealed bid for an item. The subject who submits the highest bid receives the item but pays the same amount as the second-highest bid. In a similar method, random nth price auction, each bidder submits their bid with the knowledge that there is a uniform chance that the auction could be a 3rd, 4th 5th etc price auction where multiple winners are possible. For example, in the 4th price auction, the top 3 bidders win the good at the 4th price. Although the Vickrey and random nth price auction are very similar, the nth price auction is designed to keep off margin (low) bidders involved, by increasing their chance of winning (Shogren et al., 2001). It could be assumed that by keeping bidders interested and engaged, they would be more likely to show true WTP. In the second or 'nth' priced auction, 8-10 consumers are used for each auction group (Shogren et al., 2001).

In a Becker-DeGroot-Marschak (BDM) auction, subjects submit sealed bids for an item. After bids are submitted, a sale price is randomly drawn from a distribution of prices ranging from zero to a price greater than the expected maximum bid. Any subject who bids higher than the randomly drawn sale price receives the item and pays the sale price, not their actual bid. In this case as well, off margin (low) bidders stay involved because the sale price is randomly drawn. The BDM auction is unique in that it is the only mechanism that does not require a group of participants- individuals can be recruited and submit their own bids (Jaeger et al., 2004). Lusk et al. (2001) reported this fact makes the BDM mechanism applicable for eliciting values in field settings. Because a group present is not required, a BDM auction can have a greater number of participants than the Vickrey or nth price auction (Shogren et al., 2001).

In the Vickrey, nth price and BDM auctions, strategic bidding is eliminated because subjects do not pay their submitted bid (Coursey et al., 1987). Whether their price is low or high, all bidders are given the same incentive and comparison between bidders is avoided. Bid strategy is independent of other bidders. Bidding less than one's true value reduces the opportunity to win the auction. Bidding more than one's true value leads to winning, but at a price that is higher than one's true value (Shogren et al., 1994). Literature is inconclusive as to which auction is more accurate. Rozan et al. (2004) reported that the BDM method can lead to significantly higher bids than the Vickrey auction; Noussair et al. (2004a) and Rutström (1998) concluded the opposite and Völckner (2006) stated that that there was no significant difference between the two.

In the case of a series of auctions, both Vickrey and BDM models have an initial bias to underbid in order to test the market (Noussair et al., 2004a). However, as subsequent auctions are run, the "wealth effect" is seen too- the tendency of buyers to place lower bids on the next good being sold because they have become satiated. Previous auction studies show that market price lowers with each successive auction (Umberger and Feuz, 2004). However, it was noted by Knez et al. (1985) that "Most (but not all) experimental markets show some learning effects over time with equilibrium behavior quite different from startup behavior." Other studies have agreed that multiple trials are better to allow a participant's true value to be revealed (Coppinger et al.,1980; Cox et al.,1982). In some auction series, such as Lawless et al. (2012), only one is binding. This technique could help to ensure that satiation does not occur and that participants do not become concerned about rationing their money and thus changing bidding behavior throughout the series of auctions. It has been proposed by Roosen et al. (1998) that participants psychologically treat each auction in a series as binding even though they are aware that one is binding. This theory supports the validity of WTP values in each trial; not just the one with real monetary involvement. It has also been reported that WTP estimated in auctions for new goods can be higher than what consumers would be willing to pay realistically (Shogren et al., 2000). Furthermore, consumers are more concerned about the price of a new product as compared to what is currently available than they are with the value of the new product itself (Umberger and Feuz, 2004).

Umberger and Feuz (2004) reported that the novelty of the auction setting induced bias. The auction procedure does not resemble the way a consumer would normally shop and

choose a preferred good. Although the market setting could never be experimentally recreated, the auction mechanism's goal is to be as close to a real market setting as possible while manipulating what consumers (bidders) are presented with. Alfnes and Rickertsen (2003) argued that bidding on all alternatives simultaneously was efficient in determining WTP differences- simultaneous multiple good presentation was the most realistic reflection of a market setting. Zero bidding is another bias exhibited in auction settings where participants bid low or zero to items being sold or where they see that they have a low probability of winning. Three theories for zero bidding are as follows: the product was of no value to the bidder; the bidder has already purchased their preferred product and subsequent purchases were of no value and the bidder concentrated their bid on the item worth most to them at the expense of other items (Noussair et al., 2004b).

Auctions have been used in food research for willingness to pay for brand name candy bars, irradiated pork (Shogren et al., 2000), country of origin labelling (Chern et al., 2013; Dickinson and Baily 2005), food safety claims (Hayes et al., 1995), bread with a functional ingredient (Hellyer et al., 2012), fish from sustainable fisheries (Uchida et al., 2014), U.S. beef (Alfnes and Rickertsen, 2003) and improved animal welfare products (Heid and Hamm, 2013; Napolitano et al., 2008).

Conjoint analysis

Conjoint analysis is a method that decomposes a product into different attributes in order to determine which of those attributes drives a consumer to purchase the product. It is a technique that estimates consumer preference by evaluating all possible products based on all

combinations of levels of attributes (Green and Srinivasan, 1978). There are four main conjoint types: full profile conjoint analysis, adaptive conjoint analysis (ACA), choice based conjoint (CBC) and compositional method, which is also referred to as adaptive choice based conjoint (ACBC) (Rao 2010). Conjoint analyses require a large number of respondents- n>500 (Orme 2010). In a full profile analysis, all possible combinations of attributes are presented, which carries the disadvantage of taking longer to complete than other methods. In a study that used full profile analysis to evaluate consumer response for healthy soup, there were 36 attributes that consumers were presented with 2-4 at a time; evaluating a total of 60 combinations (Krieger et al., 2003). ACA was developed to more time effectively handle a large number of attributes by having the respondent rank levels within each attribute based on preference and then give an importance value to each attribute (Orme 2010; Rao 2010). In an adaptive choice survey soliciting patients' preference for vaccination options, the format was used to gather 4-step price information once participants indicated an original selection (Norman et al., 2014). ACA cannot measure attribute interactions (Orme, 2010). Unlike ACA, CBC can measure interactions between attributes (Orme, 2010).CBC analysis is more representative of a real market situation by presenting respondents with questions that reflect how they would make a choice in a real setting (Orme, 2010; Rao, 2010). It has been suggested that in CBC analysis, no more than 6 attributes and no more than 9 levels for each attribute be included in the study (Green and Srinicasan, 1978; Orme, 2010), for the reason that too many attributes and levels can be overwhelming (Cunningham, 2010). In a CBC analysis study with latte-style coffee beverages, 5 attributes and corresponding levels (most = 5) made up the survey, with respondents evaluating 3 potential products at a time, with

randomly generated levels within attributes (Jervis et al., 2012b). In another CBC study estimating consumer perception of irradiated fruit, consumers evaluated random product generation of 3 attributes with 2 levels each (Deliza et al., 2010). CBC is the most popular conjoint method used today (Jervis et al., 2012a). Other CBC studies involving sensory analysis include consumer evaluation sour cream (Jervis et al., 2012a), chocolate milk (Melo et al., 2010) and wine quality (Tempesta et al., 2010).

In addition to these three conjoint methods, a new hybrid of CBC and ACA takes the best aspects of each and combines them to produce the adaptive choice based conjoint (ACBC). Given the format of this approach, respondents are more engaged and may give responses closer to actual market-setting behavior (Jervis et al., 2012). In an ACBC survey, respondents first consider different product concepts and then choose products based on their responses of the first section. Each respondent's survey is tailored to the preferences they indicated in their responses. In a third part of the survey that more closely resembles CBC, respondents choose a preferred product in a series of product concepts (Jervis et al., 2012). The advantages of using an ACBC survey are that the individual level responses are more accurate than CBC (Toubia et al., 2004; Houser et al., 2009; Yu et al.; 2011), provide better estimates of real market setting decisions (Cunningham et al., 2010) and are more accurate than CBC at measuring consumer responses when price is an attribute (Chapman et al., 2009; Gensler et al., 2012). Additionally, ACBC may require fewer responses than CBC to obtain similar results (Orme, 2010; Jervis et al., 2012).

Additional conjoint studies involving food include: beef (Cheng et al., 1990; Mennecke et al., 2007; Mesias et al., 2005), produce including apples (Wang et al., 2010),

irradiated fruit (Deliza et al., 2010), tomatoes (Oltman et al., 2014), asparagus (Behe, 2006) and vegetable products (MacKenzie and Spiller, 1996); wine (Gil and Sánchez 1997) and beer (Cerjak et al., 2010).

Multi Attribute Attitude Model

The multi attribute attitude model (MAAM) is a model to predict consumer preference that centers around two components: beliefs about attributes (that make up a product) and how the belief is evaluated in terms of importance of that belief (Fishbein, 1976; Bass and Talarzyk, 1972). Consumers are asked to rate the importance of an attribute and rate how well a product/brand fulfills that attribute. The method is usually used in marketing to evaluate brands (Bass and Talarzyk, 1972). Quantitatively, the model is represented as thus: Ab = $\sum_{i=1}^{N} W_i \, B_{ib}$, where Ab is the attitude towards a brand, Wi is a measure of how important a single attribute is, Bib is the belief about how the brand fulfills the attribute and N is the number of attributes used to evaluate the given brand. The multi attribute attitude model has been used to understand store image (James et al., 1976), decisions to illegally download music (Sirkeci and Magnúsdóttir, 2011), social identity (Kleine et al., 2009) and as a measurement in the multi attribute preference response for health-related quality of life (Krabbe, 2013). MAAM studies have included consumer sample sizes of 125 (Fishbein, 1963), 199 (James et al., 1976), 275 (Kleine et al., 2009) and 140 (Sirkeci and Magnúsdóttir, 2011). Due to the nature of the study, as little as one attribute can be the focus of study, however the greatest number of attributes from aforementioned studies is 10 (Fishbein, 1963).

Focus groups

A focus group is defined by Morgan (1998) as a research technique that collects data through group interaction. The purpose of a focus group is to provide qualitative information about a preconceived topic and to gain insight into consumer behavior regarding that topic (Bellenger et al., 1979). Focus groups are distinguished from other group interactions because the group moderator directs discussion. To analyze, focus groups are usually recorded, transcribed and content is evaluated (Gross et al., 2014; Hendricks et al., 2009; Pope et al., 2000). A focus group is often used when developing new products; specifically, to gauge consumers' reaction and acceptance of new product concepts, new advertising messages and packaging (David, 2007). Using the focus group technique allows the product to be positioned and marketed in a way that is attractive to the target audience. A focus group can also be used to learn about consumer habits, expectations and product usage (David 2007). According to Morgan (1998), focus groups have three strengths: (i) **exploration and discovery-** to find out as much as possible about people, groups or a specific topic, (ii) **context and depth-** the process through which thoughts and experiences are brought to consciousness and (iii) **interpretation-** offering an explanation for as to why current thoughts, experiences, and trends are exhibited. By "sharing and comparing", participants in a focus group will generate their own interpretation of topics discussed in the group (Morgan, 1998). Participants'/consumers' interpretation of why attitudes and usage are the way they are will provide marketers valuable information about how to cater to the group they are trying to reach.

Morgan (1998) also describes four major areas where focus groups are best suited for: academic research, product marketing, evaluation research and quality improvement. In conjunction with the four stages of unfolding a focus group (problem identification, planning, implementation and assessment), product marketing may be sequentially presented as such: generation of a new product idea, developing the new product, monitoring customer response and refining the product or marketing stance. For quality improvement, the four stages would follow: identifying opportunity for change, planning intervention, implementing intervention and assessment redesign (Morgan 1998). In conjunction, these two paths provide a "map" to creating a new product or undiscovered niche within the market.

The number of focus groups to be held on the given topic is variable. By using multiple groups, different discussions may take place and different attitudes may be generated. However, when data generated becomes redundant, a condition of qualitative data gathering is reached, termed 'saturation'. When this happens, additional focus groups are unnecessary (Morrison et al., 2011). For qualitative data collection, 2-4 focus groups are utilized most of the time and 2 groups are recommended. The number of participants in a focus group varies among researchers, between 8-10 individuals (David, 2007), 3-8 individuals (Stewart et al., 1994), 8-12 (Chalofsky 1999) and 6-8 (Casey and Krueger, 2000). Krueger and Casey (2009) have reported that smaller focus groups (3-6 participants) are gaining popularity because participants may feel more comfortable sharing views in a smaller group.

Focus groups have been applied in food sciences to explore consumer perception of sustainable foods (Ulvila et al., 2009), food choices of children (Ishak et al., 2013),

consumption of protein-rich foods in older adults (Best et al., 2013), consumer awareness of organic foods (Zepeda et al., 2006) and in conjunction with conjoint analysis to explore consumer attitudes of ginseng food products (Chung et al., 2011). By using focus groups to first explore consumer views on a product, meaningful conjoint attributes and levels can be generated based on the findings of focus groups.

Nominal and Delphi groups are alternatives to a traditional focus group where participants generate ideas on their own (Van de Ven and Delbecq, 1974). In the nominal group technique, group members work independently and individually to generate their own estimate of the topic. Then, the group enters an open discussion to deliberate, followed by a final, individual estimate of the topic (Graefe and Armstrong, 2011). In the Delphi method, multiple-round surveys are conducted. Each participant generates and records their estimate of a topic and all estimates of the group are summarized and reported back to the whole group as feedback. After receiving feedback, participants record their new estimate in a following round (Graefe and Armstrong 2011). This method avoids interactions between group members completely and participants can be geographically dispersed. The benefits of using such groups are that group members must clarify and justify their own position and that structured communication can help generation of ideas (Graefe and Armstrong 2011). It is inconclusive as to whether one of these structured group methods is better than the other (Boje and Murnighan, 1982; Fischer, 1981). Nominal and Delphi groups have been used to evaluate strategies in Brazil to prevent violence against children (Deslandes et al., 2010), challenges for global tourism (von Bergner et al., 2014) and developing concepts for knowledge management (KM) capabilities (Ekionea and Fillion, 2011).

Means end chain and Laddering

Means-end chain (MEC) method is another qualitative research technique meant to uncover consumer emotions and values that drive choice. Three concepts define MEC: product attributes (A), consequences (C) and value (V) (Lin, 2011). The hypothesis of the MEC is that product attributes are means for consumers to obtain their desired values through the consequences that those attributes bring (Gutman, 1982). Laddering is an in-depth one-on-one interview used to understand how consumers translate product attributes into meaningful values, following the MEC concepts A, C and V. The laddering interview consists of a series of probes with the general question "why is that important to you?" asked until the value to the consumer is reached and the goal of identifying linkages between consequences is identified (Gutman, 1982). For example, the product attribute of 'car' could be its design as an SUV (as opposed to a minivan). The consequence of having an SUV is that the consumer feels trendier than they would in the van. The consequence of feeling trendier is acceptance from their social group. The end value is increased self-esteem. There are two types of laddering: soft and hard. Soft laddering refers to an oral interview while hard laddering refers to creating linkages using pen and paper (Leppard et al., 2004). To analyze laddering data, summarization of responses across respondents is conducted while keeping in mind the level of abstraction according to the MEC. Then, a summary table is generated showing the connections between elements which gives way to a tree diagram called a hierarchical value map (HVM) (Reynolds and Gutman, 1988).A hierarchical value map is constructed through laddering (Lin, 2011).

The HVM is favored from other methods because it represents linkages across levels of abstraction (Lin, 2011). Linkages between elements on the HVM provide understanding of the drivers of product choice and help marketers determine how to promote the product (Audenaert and Steenkamp, 1997). A cutoff level must be predetermined in order to separate important data from non-important on the HVM. This level is defined as the threshold number of times a link (attributes, consequences and values) is present before it can be included as a connection on the HVM (Leppard et al., 2004). If the frequency of A-C-V linkages is greater than the cutoff level, the linkage will be considered important enough to include on the HVM. The frequency at which a connection is termed "important" is of high importance to generating the HVM (Lin, 2011). Previous research has proposed multiple ways for determining the cutoff value (Pieters et al., 1995) which may depend on sample size and the depth of the ladder linkages (Leppard et al., 2004). A cutoff value too high will show few linkages to interpret but if the cutoff is too low, the map will become complicated and confusing, making linkages difficult to elucidate (Leppard et al., 2004). Means end chain analysis and laddering has been used extensively regarding the food industry with studies including fish consumption (Valette-Florence et al., 2000), meal choice (Costa et al., 2007), steak preference (Grunert, 1997) and yogurt (Boecker et al., 2008).

Ethnography

Ethnography is a qualitative research method that aims to describe and characterize phenomena that occur in a specific environment or segment of the population (Tsuji, 2012). Data is collected through observation (Jervis et al., 2012). The practice has roots in

anthropology and sociology, and studies small groups or individuals in their own cultural environment, where the researcher becomes immersed in the subject's surroundings (Singer, 2009). By studying individuals carefully instead of trying to gain information from a much larger group, ethnography allows the researcher to probe each person's behavior to understand the meaning and drive behind their actions (Singer, 2009). The approach gathers data that other research methods cannot: accessing what people actually do, rather than what they report they do (Elliot and Jankel-Elliot, 2003). The goal in ethnography is to minimize the effect/influence the researcher has on the subject and maximize the depth of information collected (Elliot and Jankel-Elliot, 2003). To collect data, field notes are taken, interviews conducted or a self-observation report is recorded (Tsuji, 2012). To analyze field notes, patterns from the collected data are explored and recorded. Interviews are used to "confirm the validity of discovered phenomena patterns while taking field notes" (Tsuji, 2012). Self-observation reports are recorded by the subject- they are asked to write down happenings that reflect their everyday life (Tsuji, 2012). Visual data such as photographs, drawings or video may also be employed to stimulate subjects or as a reference to interpret behavior (Elliot and Jankel-Elliot, 2003). Ethnography is often employed in marketing to focus on consumption behavior of users (Arnould and Wallendorf, 1994). Ethnography has been used to observe and characterize consumers at an athletic store (Peñaloza, 1998) coffee consumers (Jervis et al., 2012), children and clothing choice (Pole, 2007), food consumption movements (Cherry et al., 2010) and international backpackers (Sørensen, 2003).

Protein Beverages

Research techniques involving consumers, as previously described, are helpful to understand how and why consumers make purchase decisions. In many methods, the product is broken down into attributes, allowing the researcher to determine the importance of individual features. However, when consumers are faced with a new product, or one that cannot be evaluated before purchase, they must use extrinsic cues to infer quality (Speed, 1998). Protein beverages are one such product. Taste is an important factor that is not readily determined at the time of purchase. In functional beverages (protein beverages), consumers will not like even a highly functional beverage if it does not deliver great flavor (Gruenwald and Paquin, 2009). The beverage industry is heavily influenced by both marketing and taste (Fuhrman, 2011). Since consumers cannot directly evaluate "great taste" intrinsically in a market setting, they must rely on extrinsic cues (ex. marketing claim) to determine whether the claim of great taste will cause them to purchase the product.

Previous research has aimed to discern the value of extrinsic product characteristics such as the presence of GMOs (Lusk and Rozan, 2005), organic production (Napolitano et al., 2010) and food safety processes such as irradiation (Fox et al., 2002). Lusk and Rozan (2005) showed that American consumers were willing to pay more for a genetically modified, higher nutrition type of rice when given information about it. Similarly, Napolitano et al., (2010) showed that when consumers were given information about beef production, perceived liking and willingness to pay for organic beef was higher than conventional beef. The effect of positive information given before consumption on willingness to pay also affected willingness to pay for an irradiated pork sandwich- consumers were willing to pay

more when given information about how irradiation would make a safer sandwich (Fox et al., 2002).

Providing information about a protein beverage having great flavor or a desired amount of protein may indicate a tradeoff to some consumers. For example, altering the nutritional quality of a food product may imply for some consumers that the processing mode has changed. If these qualities are conflicting to the consumer, they will be forced to make a tradeoff between processing and nutrition (Saulais and Ruffieux, 2012). In the case of protein beverages, functional ingredients often have a negative effect on flavor. Off flavors are associated with protein beverages (Childs et al., 2007; Wright et al., 2009; Evans et al., 2010). Indicating to consumers that a protein beverage tastes great or has a high amount of protein might spur some consumers to decide whether they would like a high protein beverage or one that tastes better with less protein if they believe the two characteristics cannot co-exist in their preferred drink.

The amount of protein required to be considered a protein beverage has not been defined and there is a wide range of protein amounts. Commercial protein beverages contain 5-40 g protein per serving. Functional foods have been loosely defined as providing necessary nutrients to prevent nutrition-related diseases (Menrad 2003; Henry 2010); however, a clear definition for functional food also remains undefined (Menrad 2003). The term ‘functional food’ exists as a marketing tool and is not legally recognized (Henry 2010). Protein beverages, which are considered a functional food, are also legally undefined at the time of this literature review.

Although desired characteristics of protein beverages are scantly reported in literature, high protein foods are growing in popularity (Gerdes 2012). Current and past research has focused on protein sources, flavors, properties of ingredients and processing. Whey proteins have widespread use in protein beverages because of high-quality, readily available proteins and solubility over a wide range of pH (Pelegrine and Gasparetto 2005, Fachin and Viotto, 2005). The two most common forms of whey protein as a functional ingredient are whey protein concentrate and whey protein isolate, which contain 34-80% and 85-90% protein respectively (Smithers 2008). Solubility of whey protein increases as pH decreases (Pelegrine and Gasparetto 2005). Whey proteins are soluble over a wide pH range but they have improved clarity and heat stability at low pH because their isoelectric point is at pH 4.5 (Pelegrine and Gasparetto 2005). For beverages that are clear and low pH, fruit flavors can be used (Beecher et al., 2008). Whey proteins are typically spray dried to concentrate protein and extend shelf life. However, whey source, processing and addition of instantizing agents affect solubility and sensory characteristics (Wright et al., 2009). Although milk and soy proteins can be used in mid to higher pH beverages, only whey proteins can be used in protein beverage formulations at low pH (Childs and Drake, 2010).

There is extensive literature concerning the flavor of whey proteins (Wright et al., 2009; Childs et al., 2007; Carunchia et al., 2005; Russell et al., 2006); common sensory terms include cooked, sweet aromatic, grassy, brothy, cardboard and milk fat (Drake et al., 2003). There is also research that has addressed the impact of whey source, starter culture and processing on whey ingredient flavor: whey source (Liaw et al., 2010; Liaw et al., 2011; Whitson et al., 2011), starter culture (Campbell et al., 2011a; Campbell et al., 2011b),

processing (Fox et al., 2013; Kang et al., 2012; Campbell et al., 2012; Croissant et al., 2009; Park et al., 2014; Whitson et al., 2011).

Fewer studies have focused on protein beverages. Childs et al. (2007) characterized several protein beverages and reported vitamin/mineral, grainy, metallic, astringent, sour and bitter as the sensory descriptors. In a consumer study comparing protein beverages with milk serum protein concentrates or whey protein concentrates, beverages containing serum protein concentrates scored higher in liking than whey protein concentrates (Evans et al., 2010). Serum proteins are whey proteins removed from milk directly and have not been subject to cheese and whey manufacture steps. As such, serum proteins have a milder flavor profile and lower concentrations of lipid oxidation products compared to whey proteins. The peach flavored protein beverages in this previous study made with whey protein had cardboard flavor. Another study used consumer testing of peach flavored protein beverages to test acceptability of agglomerated and nonagglomerated whey protein concentrate and whey protein isolate (Wright et al., 2009). In this study, consumer acceptance was lower for beverages made with agglomerated products, which had higher intensities of lipid oxidation flavors (cardboard, brothy, cucumber and fatty). In addition, this study investigated shelf life of agglomerated and nonagglomerated product protein beverages. Protein beverages made with fresh whey proteins had higher acceptance than products made with stored products, and stored agglomerated products developed lipid oxidation flavors more rapidly than stored nonagglomerated products (Wright et al., 2009). Childs et al. (2008) applied a conjoint survey to show that consumers had low preference for specific protein type but valued protein content as a general feature of protein beverages. In addition to protein content,

consumers in this study also valued meal replacement products (including protein drinks) that were low fat/fat free, contained calcium, were all natural and had heart health and muscle building claims (Childs et al., 2008). Recent work has not addressed consumer attitudes towards protein beverages. This thesis will explore consumer test methods to evaluate consumer perception of protein beverages and fresh tomatoes.

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CHAPTER 2

Consumer Attitudes and Preferences for Fresh Market Tomato Attributes

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ABSTRACT

This study established attractive attributes and consumer desires for fresh tomatoes. Three focus groups (n=28 participants) were conducted to explore how consumers perceived tomatoes, including how they purchased and consumed them. Subsequently, an Adaptive Choice Based Conjoint (ACBC) survey was conducted to understand consumer preferences towards traditional tomatoes. The ACBC survey with Kano questions (n=1037 consumers) explored the importance of color, firmness, size, skin, texture, interior, seed presence, flavor and health benefits. The most important tomato attribute was color, then juice when sliced, followed by size, followed by seed presence, which was at parity with firmness. An attractive tomato was red, firm, medium/small sized, crisp, meaty, juicy, flavorful and with few seeds. Deviations from these features resulted in a tomato that was rejected by consumers. Segmentations of consumers were determined by patterns in utility scores. Cluster 1 and cluster 3 were similar in attractive tomato attributes but were differentiated by preference for juiciness and lycopene, which were more attractive to cluster 1. Cluster 2 was driven by a firm texture. Cluster 4 was color driven and indifferent to health claims. External attributes were the main drivers of tomato liking, but different groups of tomato consumers exist with distinct preferences for juiciness, firmness, flavor and health benefits.

INTRODUCTION

In 2011, tomatoes grown in the US had a gross production value of 11.74 billion USD (FAOSTAT 2011). As a widely produced and consumed crop, sensory attributes of fresh tomatoes are important and lack of characteristic taste and flavor is a frequent complaint of fresh tomato consumers (Bruhn and others 1991). Tomatoes (*Solanum lycoperiscum*) have been characterized as having a sweet-sour taste with a complex mix of aromatics such as fruity/floral and green notes (Baldwin and others 2008). Hongsoonern and Chambers (2008) identified a descriptive language for fresh tomatoes and reported fruity, ripeness, sweetness, sourness and bitterness as well as green/viney, musty/earthy and fermented as attributes applicable to fresh tomatoes. In another study with trained panelists, sweet taste and fruity flavor of tomatoes were correlated (Baldwin and others 2008). Additionally, a tomato perceived as having good overall flavor was rated high in sweet taste, "tomato-like flavor" and fruity flavor with low intensities of sourness, bite and "green tomato flavor" by a trained panel (Tandon 2006). Sweet taste was correlated with overall tomato flavor liking (Malundo and others 1995; Baldwin and others 1998). Room ripened tomatoes had lower flavor quality than vine ripened tomatoes (Bisogni and others 1976; Stevens and others 1977), which could be due to the lower sugar content (Davies 1966; Kader and others 1977; Jones and Scott 1983). In a previous consumer study with cherry tomatoes, internal preference mapping revealed two consumer clusters: one that preferred red color and sweet taste and one that preferred acidity and firm texture (Pagliarini and others 2001).

Texture is also an important aspect of consumer perception of fresh tomatoes (Causse and others 2003; Serrano-Megias and Lopez-Nicolas 2006). Texture traits previously

established include flesh firmness, mealiness, meltiness, crispness and juiciness (Harker and others 1997; Redgwell and Fischer 2002; Szczesniak 2002). Previous research has focused on creating tomatoes with greater firmness in order to have greater disease resistance and longer shelf life (Hongsoongnern and Chambers 2008). The amount of gel and seeds within locules are unique aspects of tomato perceptions (Chaïb and others 2007). Finally, visual appearance of tomatoes is of utmost importance to consumer purchase decision, as other factors such as flavor and texture are not evident during purchase. Wolters and Gemert (1990) indicated that color and size were the most important visual attributes of tomatoes. Other extrinsic attributes such as health/nutrition and growing conditions may also influence consumer purchase.

Consumer decisions for food purchase are influenced by various factors, including familiarity with ingredients and manufacturers, taste, price and the perceived product health benefits (Cardello and Schutz 2003). With many elements to weigh upon, choosing a fresh tomato becomes a complex task. Tomato varieties and consumer preferences may vary vastly and by characterizing both tomato attributes and consumer drivers for purchase, ideals can be pinpointed and optimized. The qualitative information gained in a focus group allows the researcher to study consumer behavior and product usage (Bellenger and others 1976). Focus groups have been used on a number of foods including mungbean noodles (Galvez and Resurreccion 1992), steak (Grunert 1997), butter (Krausse and others 2007), protein beverages (Childs and others 2008) and chocolate milk (Thompson and others 2007). Conjoint analysis is a technique that decomposes a product into different attributes to determine which of those attributes contribute to liking. Consumer preference is estimated by

evaluating all possible combinations of pre-selected, evaluated product attributes (van Kleef and others 2005). Conjoint analysis has also been widely applied to determine consumer preferences for extrinsic and intrinsic product attributes (Jervis and others 2012; Kim and others 2013; Childs and others 2009; Chung and others 2011). To our knowledge, studies have not addressed the role that both extrinsic and intrinsic properties contribute to consumer perception of tomatoes. The objective of this study was to determine the attributes of fresh market tomatoes that influence consumer purchase decisions. Focus groups and a conjoint analysis survey were utilized.

MATERIALS AND METHODS

Focus Groups

Three focus groups were conducted to determine how consumers used tomatoes and to identify attractive tomato qualities. Panelists (n=28) (females, 19–45 y) that consumed tomatoes at least once a week and were the primary shoppers of the household participated. All subjects were recruited through email listservs to an online database of more than 5,000 consumers in the Raleigh/Durham, NC area maintained by the Sensory Service Center at North Carolina State University. A moderator facilitated the discussion using a planned discussion guide (Table 1). Each focus group was approximately 1.5 h and panelists were compensated for their participation with $40 gift cards.

Diverse types of fresh tomatoes were purchased for use in focus groups. Some tomatoes were cut into slices and presented in 473 mL styrofoam bowls with plastic wrap (for tasting and visualization) and others remained whole to visualize extrinsic factors. Focus

groups were videotaped and tape-recorded for subsequent reference, and two observers took notes of key points mentioned by participants. Key points (those issues mentioned by two-thirds or more of the participants) from focus groups were recorded.

Conjoint Survey and Kano Questions

An online survey was created using SSI Web (Sawtooth Software version 7.0.22, Sequim, WA). Prior to starting the survey, a series of knowledge and awareness questions about fresh tomatoes were asked. These questions were aimed at understanding how aware consumers were of terminology used in describing tomatoes. A short demographic section was included to eliminate participants who did not consume tomatoes monthly. The attributes and levels for the conjoint analysis were developed based on information collected in the focus groups (Table 2). These attributes and levels were developed with qualitative level definitions rather than quantitative definitions since the goal was to present levels that would be understood by consumers. Adaptive Choice Based Conjoint (ACBC) is a type of conjoint analysis that is a hybrid design of Choice Based Conjoint (CBC) and Adaptive Choice Analysis (ACA) (Orme 2010; Rao 2010). The ACBC, which incorporates the benefits of both ACA and CBC, has been shown to engage respondents more; allowing them to respond in a way that is closer to how they would actually behave in a real market setting (Jervis and others 2012). The ACBC survey was designed with one build-your-own (BYO) task followed by 10 choice tasks, with 3 product concepts per task with the possible responses of “a possibility” or “won’t work for me” for each product concept. A minimum of two and a maximum of three attributes varied from the BYO selections for each product concept. Each product concept was a random generation of levels within each attribute, with each attribute

represented in all 10 choice tasks. Five unacceptable questions and four must-have questions were built in through the survey. The screening task was followed by a 10-question choice task tournament section. A maximum of 20 product concepts were brought into the tournament section, with three concepts per choice task.

Kano questions were subsequently asked regarding the same attributes evaluated in the ACBC survey with the addition of places where tomatoes were purchased (ex. Farmers' market). Kano analysis is a technique where attributes are classified into quality based categories (Kano and others 1984; Erto and others 2011; Kim and others 2013). These categories include: **Attractive-** unexpected by the consumer; consumers are satisfied if this attribute is present. **Indifferent-** attributes that the consumer does not care about. **Must have-** expected by the consumer; if unavailable, consumers are dissatisfied. **One dimensional-** as the attribute increases, so does consumer liking. **Reverse-** leads to dissatisfaction. Attributes were presented to participants in the form of a paired question. Each question was posed to the consumer as the attribute (functional) and not fulfilled (dysfunctional). For example: tomatoes that are RED in color and tomatoes that are NOT RED in color. The response options for each question included 'I will like it', 'I must have it', I do not care', 'I can live with it' and 'I will dislike it'.

The complete survey (awareness questions, demographics, conjoint, and Kano) was constructed and uploaded to an internet server. Participants (n=1037) were recruited through email listservs to an online database of more than 5,000 consumers in the Raleigh/Durham, NC area maintained by North Carolina State University. Participants were entered into a drawing for one of twenty $25 Target® gift cards drawings.

Statistical Analysis

Individual utility scores were extracted by hierarchical Bayesian (HB) estimation and rescaled using a zero-centered difference method (Childs and Drake 2009). The zero-centered difference method was used to standardize utility scores for easy interpretation. A one-way analysis of variance with Fisher's least significant difference was applied to utility scores. Cluster analysis of utility scores was performed with XLSTAT version 2012.6.06 (Addinsoft, Paris, France) using Euclidean distances and Wards linkage to categorize similar respondents into groups, and chi-square analysis was applied to determine any demographic differences among clusters. Principal component analysis (PCA) (XLSTAT) was also conducted to see how attributes and clusters were characterized. Kano questions were evaluated according to the model proposed by Kano and others (1984).

RESULTS

Focus groups

Participants indicated their various usages of fresh tomatoes, among which, salads, sandwiches, home-made salsa, chili and soups were the most frequently mentioned. The majority of participants used fresh tomatoes for salads and sandwiches. Many participants (>50%) used both fresh and processed tomatoes. Almost all (90%) participants indicated that they liked the concept of freshness and healthiness with fresh tomatoes and considered purchasing a fresh tomato as an enjoyable feeling that would give them a higher quality of life. More than half of participants used canned tomatoes more often than fresh in preparing warm tomato recipes such as soups or sauces. When probed as to why this was the case,

freshness and flavor of the produce would not be easily detected in the dish were the most frequent responses. In all groups, at least one participant stated that they did not like tomatoes that were pre-packaged on foam trays- it was important that they were able to handle the tomato and evaluate it for themselves before purchasing. After this point was brought up, most participants (>80%) agreed that they preferred to touch the tomato before purchasing**.** Tomatoes on the vine were an indicator of freshness to some (30%) consumers. Many participants (>50%) were generally not willing to pay more for organic tomatoes. When asked why, some participants said that the organic tomato selection was not more visually appealing than conventional tomatoes.

The preference of buying a tomato in the grocery store versus a farmers' market was also discussed in the groups. Participants expected to buy different kinds of tomatoes in different shopping environments. For example, because consumers can talk to the farmers and try samples in a farmers market, more than half of participants said it made them feel more comfortable buying specialty types of tomatoes with unique colors and shapes in the farmers market. A few participants (<30%) said it would improve tomato shopping in the grocery store if they were able to sample tomatoes like at the farmers' market. When participants were introduced to a dark green and brown tomato variety "Kumato", many (>50%) indicated they would never buy one of those in a grocery store without knowing any details about its flavor. Participants were only willing to buy unconventional tomato varieties such as "Costoluto Genovese" which is large and has "ugly" ridges, when given positive information about the produce, such as nutrient content or good flavor. Even so, very few participants (<20%) indicated they would be willing to purchase unconventional tomato

varieties. In the grocery store, the majority of participants (>80%) expected to buy traditional types of tomatoes, such as round and roma types. Buying tomatoes of local origin was an attractive feature to the majority of participants (>80%). When asked why, people agreed that it made them feel good to support the local economy by purchasing locally grown tomatoes.

Firmness to touch was considered an important attribute by the majority of participants (>80%). Most participants (70%) would only buy tomatoes that were firm, though some said it would also depend on how soon they plan to use the tomato. Another highly cited attribute that determined tomato purchase was color. Most people (80%) liked dark-red colored tomatoes, with only a few people (<20%) mentioning they would not mind a lighter red, or yellow, or orange color.

Other attributes of interests, such as flavor, shape, size, juiciness, crispness, and skin types were mentioned by a small number of participants (25%). Some participants (20%) commented that flavorless tomatoes were unacceptable; some participants (30%) described a good tomato flavor as "fresh." However, for many consumers (50%), good tomato flavor was not considered a key attribute for purchase decision, especially when tasting a tomato was impossible in the grocery store. The majority of participants (>50%) generally preferred perfectly round shaped tomatoes, but when compared with other factors such as firmness, color and price, shape was not as important.

Some unfavorable attributes were also identified by the focus groups. The top three of these were mealy texture, seedy and full of gel (too juicy). When it came to mealy tomatoes, almost every participant in every group considered it unacceptable- crisp was a preferred tomato texture. For tomatoes that were seedy or full of gel, a great number of participants

(75%) indicated they would not use those parts, and considered them an unfavorable attribute.

Conjoint analysis

Seventy seven percent of those surveyed were female and 23% were male. Participants were mostly Caucasian (70%) followed by African American (15%). Most consumers had at least some college education (>95%). There was an even spread of age (18-65) and income (<$20,000 to over $95,000 per year). Sixty five percent of participants consumed tomatoes weekly and 28% consumed tomatoes at least 2-3 times a month. Nearly half of participants (48%) purchased tomatoes at least once a week. Most of those surveyed (93%) purchased tomatoes at a local grocery store and 48% purchased tomatoes at a local farmer's market. Color was most important ($p<0.05$), followed by juice when sliced ($p<0.05$), followed by size (Table 3). Skin thickness and interior (juicy versus meaty) were the least important attributes. The importance of color was consistent with an internal preference mapping study with cherry tomatoes by Pagliarini and others (2001). Wolters and Gemert (1990) also cited color as an important tomato attribute as well as size. Color was also an important attribute cited in the focus groups in the current study.

An importance score differentiates the importance of attributes. A utility score explains the attractiveness of levels within attributes, higher utilities indicate more attractive attributes. Negative utility values do not necessarily indicate that an attribute is unattractive, rather it is less attractive compared to positive utility values within the same attribute. For utility scores: red tomatoes were favored over other colors ($p<0.05$) (Table 4). Among exterior attributes, firm tomatoes were preferred over soft ($p<0.05$), thin skinned tomatoes

were preferred over thick skinned ($p<0.05$) and medium size was preferred over small and large ($p<0.05$). For interior attributes, crisp texture was preferred over soft ($p<0.05$), a juicy interior was preferred over meaty ($p<0.05$), few seeds were preferred to many or none ($p<0.05$), bold flavor was preferred over mild ($p<0.05$) and a small amount of juice was preferred over a large amount or none ($p<0.05$).

Four consumer clusters were identified from utility scores (Figure 1). Cluster 1 (n=223) was characterized by consumers who liked tomatoes that were juicy, red, soft, had bold flavor and a large amount of juice. Cluster 2 (n=279) contained consumers who preferred firm, crisp tomatoes with no seeds. Cluster 3 consumers (n=219) were attracted to color, health benefits, bold flavor and a small amount of juice and few seeds. Cluster 4 consumers (n=316) had the highest importance score for color and preferred tomatoes red in color, also rejecting soft tomatoes.

Kano questions

All attributes were labelled ‘attractive’ except for the colors yellow, orange, light red and green, areas of different color, soft (exterior and texture), large size, thick skin, organic and the presence of many seeds. Though attributes were classified as either “attractive” or “reverse”, across all consumers, clusters were distinct (Table 5). Green color across the general survey population was a negative attribute but for two clusters, green color had no effect. Cluster 1 (n=223) was the only cluster to assign juicy interior as a one dimensional performer, meaning the juicier the interior, the higher consumer satisfaction would be. This result is consistent with utility scores for juiciness (Figure 1). This cluster assigned ‘attractive’ to features relating to health benefits, small/medium size and juiciness. This

cluster was most dissatisfied with no juice, no seeds and thick skin. This cluster was also most accepting of ‘non-red’ color.

Cluster 2 (n=279) was the only cluster to classify firm tomatoes as attractive, this attribute was indifferent to other consumers. Soft interior texture and softness of the whole tomato were dissatisfying attributes to these consumers. High satisfaction scores within cluster 3 (n=219) were assigned to dark red and juicy. Cluster 4 (n=316) was the only cluster to assign ‘one dimensional’ to red, and ‘reverse’ to yellow, orange and multiple areas of a different color. This cluster was also the only one to assign ‘indifferent’ to antioxidants, vitamins A, C and D and bold flavor. This cluster had the highest number of indifferent attributes (n=31) as well as the lowest number of attractive attributes (n=3, dark red color, flavor, health benefits), suggesting that cluster 4 consumers are less likely to purchase fresh tomatoes for specific tomato attributes but perhaps purchase them solely as condiments (eg on a sandwich) or for color in an application (salad), or have been disappointed with previous purchases and have key expectations for color, flavor and health benefits.

DISCUSSION

Focus group results were generally consistent with survey results. Focus groups revealed that external appearance (such as color) was an indicator of the quality of a tomato to consumers. This was consistent with the conjoint survey: color was the attribute with the highest importance score. From the Kano questions, it was also apparent that appearance was important: colors other than red or dark red were negative attributes to the total population. However, just as a small proportion (20%) of people in focus groups indicated that they

would be willing to try “unconventional appearing” tomatoes, some consumer clusters in the survey (clusters 1, 2 and 3) were indifferent to “deviant” tomato colors and conjoint and Kano questions allowed greater clarification of these attributes compared to focus groups alone. According to the focus groups, traditional red color was desired because of familiarity and consumers do not want to “risk” buying an unconventional tomato.

Juice when sliced received the second highest ($p<0.05$) importance score by conjoint analysis. Firmness, which relates to the juice content, was important to focus group participants as well as to some in the conjoint survey- firmness was classified as an attractive attribute in Kano analysis for the total population as well as by cluster 2. Degree of firmness may also indicate the presence of gel and being soft and mealy; soft was undesirable in Kano questions to all clusters. Tomatoes that are not firm are susceptible to chilling injury (Jackman and others 1990). Chilling injury (physical damage that occurs in plants because of exposure to low but not freezing, temperature) can be characterized by non-uniform color, uneven surfaces and patches of green and yellow (Jackman and others 1990). These terms Jackman and others (1990) used to describe the tomato skin are similar to attributes used in this survey: yellow, green, small area of a different color and multiple areas of a different color. All of these attributes were reverse in Kano analysis meaning they were undesirable to consumers. Firmness may be used to evaluate a tomato for the extent of its chilling injury, which consumers may able to visualize.

Among health benefits, lycopene received the highest utility score in the conjoint survey ($p<0.05$), greater than vitamins A and C, and fiber. When asked about familiarity with lycopene in the demographic section, only approximately 25% of participants were not

familiar with lycopene. While discussing health benefits in focus groups, most participants (>80%) were aware that tomatoes contained lycopene but very few (20%) mentioned other specific health benefits that they thought tomatoes possessed. Cluster 4, which was color driven, was indifferent to individual health benefits although they classified the general term 'health benefits' as attractive. The importance score for health benefits was low compared to the importance of other attributes. In another study concerning dairy products, health benefits were attractive, but were not as important as the flavor of the product (Bower and others 2003). Health benefits of tomatoes may be important to the consumer, but when faced with other attributes to choose from, health takes a back seat to other attributes such as color, firmness or flavor.

Size, a top three attribute for the total population, was also defined as important by focus group participants. Half of focus group participants stated size was important in selecting a tomato. Medium tomato size (baseball sized) was the ideal size for the total population in the conjoint survey. This was consistent with those in focus groups- 65% of people said that medium tomatoes were the ideal size. Those who preferred smaller tomatoes said they would use smaller tomatoes for a salad. Some participants (20%) stated in the focus groups that large tomatoes were undesirable because they were more likely to be mealy. In Kano analysis, tomato sizes (small, medium and large) were all indifferent attributes. Literature is sparse on consumer preference for tomato size.

In a previous consumer study with cherry tomatoes, 2 consumer clusters were revealed; preferring either red color or firm texture (Pagliarini and others 2001). Clusters 1, 3 and 4 in this study were driven by color and cluster 2 was driven by firmness. In the current

study with regular-sized tomatoes, the three clusters driven by color were further differentiated by preference for juice when sliced (cluster 1), health benefits (cluster 2) and rejection of soft tomatoes (cluster 4). Both color and firmness can be used to judge the ripeness of a tomato. Ripe tomatoes are higher in sugar than unripe tomatoes, and sweet taste in tomatoes was previously correlated with overall tomato flavor liking (Malundo and others 1995, Baldwin and others 1998). Color is not a surprising purchase decision and has been established as a driver of liking (Pagliarini and others 2001). Firmness was also a driver of purchase decisions but consumers differed in their preferred level of firmness. Although consumers varied in their preferred level of firmness, this attribute is one that can be perceived externally and is used to help consumers select a tomato in a situation where it cannot directly be sampled. Although flavor was an attractive attribute in Kano analysis, it was not a top attribute by conjoint. The majority of focus group participants (80%) indicated that flavor was important, and they expect tomatoes to have good flavor. Good flavor is an attribute consumers expect. Other attributes may be indirectly used to judge the flavor of a tomato, since flavor cannot be evaluated before purchase. While previous research has evaluated some of the attributes consumers like when consuming tomatoes, this study establishes how consumers select a desirable tomato.

CONCLUSION

The use of focus groups and a conjoint survey helped to identify and characterize tomato attributes that consumers were familiar with. Consumers were driven by attributes that helped them judge ripeness which included color, firmness and juiciness. The most

important tomato attribute of the total population surveyed, as well as focus group participants, was color. Color was indicative of tomato quality. A traditional red color was most familiar and preferred. Juice when sliced was also an important attribute and was indicative of ripeness. Consumer clusters were identified and differentiated by their preferences for juiciness (cluster 1), health benefits and firmness (cluster 2), color combined with juiciness (cluster 3) and red/dark red color and the rejection of “deviant” colored and soft tomatoes (cluster 4).

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Table 1. Moderator's guide for fresh Tomatoes

Moderator Introduction- purpose of focus group
Respondent introductions: introduce yourself and share one dish you like to cook.
Focus area 1- Tomatoes you and your family eat:

- How do you use fresh tomatoes?
- Is ease of cutting a tomato important to you? (probe frequency, seasonal)
- How important is shelf life?
- Do you process tomatoes yourself? (blending, juicing, peeling) Would you be more likely to buy a tomato product (such as sauce or paste) than process yourself?
- What makes you want a fresh tomato over canned?
- How does buying fresh make you **feel**? (probe emotions)

Focus area 2- visual/extrinsic factors (Allow participants to touch/feel whole tomatoes)

- What are the most important factors when you select a tomato from the store?
- What is the ideal tomato color? **show shades of tomato color**
- Good skin: Is it thin? Thick? Smooth?
- Size? How important?
- Firmness: what do you want?
- Can you predict what is inside? How?
- Types. How do you pick? Do you only use one type primarily?
- Other than appearance, are there other things that you look for when you purchase? (looking for price, local, organic as well as smell/touch feel)
- What would steer you away?

Focus area 3- texture (prompt participants to touch and reference the tomatoes on the table as well as sliced tomatoes in their individual cups)

- Are there any descriptors that come to mind when describing your ideal tomato texture?
- Do you like tomatoes that are firm or soft? (Probe why)
- Juiciness: more or less?
- Flavors associated with juicy/nonjuicy
- Texture of the inside: what's good and bad?

Focus area 4- flavor (prompt participants to taste their tomatoes)

- What are some descriptors that come to mind when you think 'tomato flavor'?
- Which contributes more to a "good" tomato: flavor or texture? Why?

Focus area 5- nutrition and miscellaneous

- Nutrients in tomatoes
- What is attractive about nutrition?
- What nutritional factors are important for a tomato? Low calorie? Fiber? Antioxidants?
- Is organic important to you? Is locally grown important to you?
- How important are organic and locally grown compared to price?

Table 2. Attributes and levels used for conjoint analysis.

Attribute	Levels
Color	Red Dark red Light red Orange Yellow Green
Firmness	Firm Soft
Size	Small (lemon sized) Medium (baseball sized) Large (grapefruit sized)
Skin	Thin skinned Thick skinned
Texture	Crisp Soft
Interior	Juicy Meaty
Seed presence	No seeds Few seeds Many seeds
Flavor	Bold tomato flavor Mild tomato flavor
Health benefits	Lycopene Vitamin C Fiber Vitamin A None
Juice	Small amount of juice Large amount of juice No juice

Table 3. Importance scores for attributes evaluated in conjoint survey (n=1037).

Attribute	Average importance
Color	22.9a
Juice when sliced	14.0b
Size	10.3c
Seed presence	9.6d
Firmness to touch	9.4de
Health benefits	9.0e
Texture	7.2f
Flavor	6.7f
Interior	5.6g
Skin	5.3g

Attribute importance scores for the total population. Letters (a-g) indicate significant differences ($p<0.05$).

Table 4. Average utility scores for attributes evaluated in the conjoint survey (n=1037).

Attribute	Level	Average utility
Color	Red	85.4a
	Dark red	69.3b
	Light red	35.0c
	Orange	-25.6d
	Yellow	-62.3e
	Green	-101.9f
Firmness	Firm	38.9a
	Soft	-38.9b
Size	Medium (baseball sized)	41.2a
	Small (lemon sized)	-4.1b
	Large (grapefruit sized)	-37.2c
Skin	Thin skinned	20.2a
	Thick skinned	-20.2b
Texture	Crisp	16.0a
	Soft	-16.0b
Interior	Juicy	5.2a
	Meaty	-5.2b
Seed presence	Few seeds	38.1a
	No seeds	1.3b
	Many seeds	-39.5c
Flavor	Bold tomato flavor	21.3a
	Mild tomato Flavor	-21.3b
Health benefits	Lycopene	26.0a
	Vitamin C	6.5b
	Fiber	5.2b
	Vitamin A	1.4c
	None	-39.1d
Juice	Small amount of juice	53.0a
	Large amount of juice	-6.1b
	No juice	-47.0c

Zero centered utility values for levels within attributes. Letters (a-f) indicate significant differences ($p>0.05$) within each attribute for the total population (n=1037).

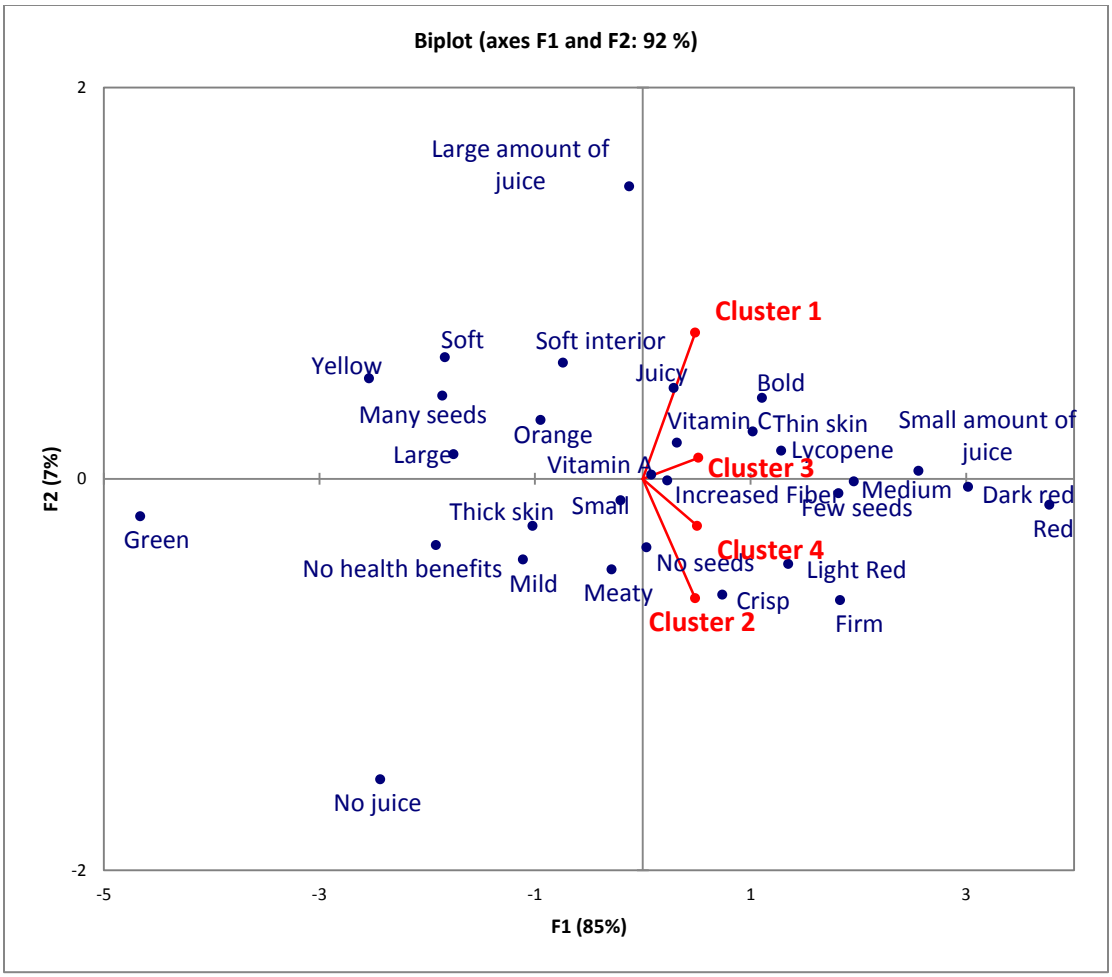

Figure 1. Principal component biplot of consumer clusters with respect to utility score

Table 5. Total Population and Clustered Kano Results

Feature	Total pop. (n=1037)	Cluster 1 (n=223)	Cluster 2 (n=279)	Cluster 3 (n=219)	Cluster 4 (n=316)
Yellow	Reverse	Indifferent	Indifferent	Indifferent	Reverse
Orange	Reverse	Indifferent	Indifferent	Indifferent	Reverse
Light red	Reverse	Indifferent	Indifferent	Indifferent	Indifferent
Red	Attractive	Attractive	Attractive	Attractive	One dimensional
Dark red	Attractive	Attractive	Attractive	Attractive	Attractive
Green	Reverse	Indifferent	Indifferent	Reverse	Reverse
Even color	Attractive	Indifferent	Indifferent	Indifferent	Indifferent
Small area of different color	Reverse	Indifferent	Indifferent	Indifferent	Indifferent
Multiple areas of a different color	Reverse	Indifferent	Indifferent	Indifferent	Reverse
Firm (firmness)	Attractive	Indifferent	Attractive	Indifferent	Indifferent
Soft (firmness)	Reverse	Reverse	Reverse	Reverse	Reverse
Small (lemon sized)	Attractive	Indifferent	Indifferent	Indifferent	Indifferent
Medium (baseball sized)	Attractive	Indifferent	Indifferent	Indifferent	Indifferent
Large (grapefruit sized)	Reverse	Indifferent	Indifferent	Indifferent	Indifferent
Thick skin	Reverse	Indifferent	Indifferent	Indifferent	Indifferent
Thin skin	Attractive	Indifferent	Indifferent	Indifferent	Indifferent
Crisp (texture)	Attractive	Indifferent	Indifferent	Indifferent	Indifferent
Soft (texture)	Reverse	Indifferent	Reverse	Indifferent	Indifferent
Meaty	Attractive	Attractive	Attractive	Indifferent	Indifferent
Juicy	Attractive	One dimensional	Indifferent	Attractive	Indifferent
No seeds	Attractive	Indifferent	Indifferent	Indifferent	Indifferent
Few seeds	Attractive	Indifferent	Indifferent	Indifferent	Indifferent
Many seeds	Reverse	Indifferent	Indifferent	Indifferent	Indifferent
Mild	Attractive	Indifferent	Indifferent	Indifferent	Indifferent
Bold	Attractive	Attractive	Attractive	Attractive	Indifferent
Health benefits	Attractive	Attractive	Attractive	Attractive	Attractive
Antioxidants	Attractive	Attractive	Attractive	Attractive	Indifferent
Lycopene	Attractive	Attractive	Attractive	Indifferent	Indifferent
Vitamin A	Attractive	Attractive	Attractive	Attractive	Indifferent
Vitamin C	Attractive	Attractive	Attractive	Attractive	Indifferent
Vitamin D	Attractive	Attractive	Attractive	Attractive	Indifferent
Fiber	Attractive	Attractive	Indifferent	Attractive	Indifferent
No juice	Reverse	Reverse	Indifferent	Reverse	Indifferent
Small amount of juice	Attractive	Indifferent	Indifferent	Indifferent	Indifferent
Large amount of juice	Reverse	Indifferent	Indifferent	Indifferent	Indifferent
Flavor	Attractive	Attractive	Attractive	Attractive	Attractive
Organic	Indifferent	Indifferent	Indifferent	Indifferent	Indifferent
Farmers market	Attractive	Attractive	Indifferent	Attractive	Indifferent
Heirloom	Attractive	Attractive	Indifferent	Indifferent	Indifferent
Vine	Attractive	Attractive	Attractive	Indifferent	Indifferent

Kano classification was calculated by previously described methods (Kano and others 1984). The satisfaction and dissatisfaction questions were asked to consumers and the contingency table of satisfaction and dissatisfaction answers was created for each feature.

CHAPTER 3

Preference Mapping of Fresh Tomatoes Across Three Stages of Consumption

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ABSTRACT

The objective of this study was to determine drivers of liking for fresh tomatoes across three stages of consumption. Seven tomato cultivars were ripened to a 6 on the USDA color chart. Trained panelists documented appearance, flavor and texture attributes of tomatoes in triplicate. Tomato consumers (n=177) were provided with knives and cutting boards and evaluated tomatoes across three stages: appearance (stage 1), slicing (stage 2), and consumption (stage 3). Consumers evaluated overall liking and purchase intent at each stage. A 2-way analysis of variance and external and internal preference mapping were conducted. Overall liking was highest during the appearance portion of the test and lowest during the consumption portion ($p<0.05$). Drivers of liking at stage 1 were color intensity, even outside color and overall aroma. Drivers of liking at stage 2 were wetness/juiciness and overall aroma. Wetness/juiciness, seed presence, ripe flavor and sweet and umami tastes were drivers of liking for tomatoes at consumption (stage 3). Four separate clusters of tomato consumers were identified. Cluster 1 preferred tomatoes with even color, higher color intensity and flavor intensity. Cluster 2 preferred firm tomatoes. Cluster 3 preferred tomatoes that were soft and at peak ripeness; this cluster also had the highest liking scores for all tomatoes. Cluster 4 consumers generally consumed tomatoes in sandwiches rather than as-is and preferred tomatoes with even and high color. Tomato growers can utilize these results to target cultivars that are well liked by consumers.

INTRODUCTION

Tomatoes (*Solanum lycoperiscum*) are a popular produce choice worldwide, providing both diverse, delicious applications in the diet as well as being nutritionally dense and able to support numerous health needs. The production of tomatoes in the U.S. in 2012 was 13,206,950 tons (FAOSTAT 2012). Tomatoes provide lycopene and other carotenoids, play a role in cardiovascular health and have been linked in population studies to lower incidences of cancer (Freeman and Reimers 2010). In addition to flavor and health benefits, tomatoes are able to meet consumer demands of price and convenience, making them a staple in many populations' diets (Freeman and Reimers 2010).

External factors of tomatoes (size, color, appearance) have been shown to be important in consumer liking (Hetherington and MacDougall 1992, Pagliarini and others 2001). Texture has also been shown to play a large role in consumer perception as it can indicate quality (Causse and others 2003, Aurand and others 2012). Flavor is the greatest indicator of quality to consumers (Aurand and others 2012), but for fresh fruits and vegetables that are purchased based on external attributes, flavor cannot be directly assessed. Oltman and others (2014) recently demonstrated using focus groups and a conjoint survey that the primary drivers of purchase for fresh tomatoes were appearance and firmness attributes evaluated by hand.

Worldwide, there are numerous tomato varieties with a wide range of genomic variability which influences acid content and flavor compounds, among other parameters (Kavitha and others 2014). Characteristic tomato flavor is influenced by the action of volatile aroma compounds and non-volatile compounds. Sweet and sour tastes are characteristic of

tomatoes and are due to sugar and organic acid content (Kimyas 2001). There are hundreds of volatiles present in tomatoes, but only about 30 are considered to be important and contribute to fresh tomato flavor (Buttery and others 1989, Buttery 1993, Buttery and Ling 1993). Baldwin and others (2004) reported that consumer perception of tomato flavor can be improved by enhancing sweetness. In several studies, a correlation between sweet taste and overall tomato flavor liking was confirmed (Malundo and others 1995, Baldwin and others 1998, Tandon and others 2006).

Preference mapping has been used in previous studies of fresh fruits including raspberries (Villamor and others 2013), apples (Jaeger and others 1998), strawberries (Lado and others 2010) and tomatoes (Sinesio and others 2010) to confirm product attributes that drive consumer liking. In these studies, flavor intensity, texture and appearance/color were cited as important with respect to consumer acceptability (Villamor and others 2013). A preference mapping study regarding French and Dutch tomatoes demonstrated that sweet taste, fruity flavor, juiciness and seeds correlated with Italian consumer liking (Sinesio and others 2010). Despite previous instrumental and consumer studies on tomatoes, no previous studies have compared liking of tomatoes across stages of consumer consumption- visual (when purchasing the tomato), after slicing the tomato (to visualize texture and juice) and eating (flavor and texture). It is important to study consumer acceptance of tomato varietals at each stage of the usage occasion as the totality of the experience will affect consumer overall acceptance of the tomato varietal, and possible re-purchase. The process of choosing and consuming a tomato involves these multiple stages and an understanding of consumer

perception at each stage is crucial to optimize consumer liking. The objective of this study was to identify tomato drivers of liking across multiple stages of consumption.

MATERIALS AND METHODS

Tomatoes

Seven tomato cultivars (Red Bounty, Scarlet Red, Tasti-Lee, HM 1823, HM 8849, HMX 8845 and Tygress) shipped from FL (Harris Moran Seed Company, Modesto, CA) were the subject of this study. Fruits arrived in boxes lined with foam sheets. Upon arrival, the tomatoes were removed from their packaging boxes and examined for bruising and other damage. Satisfactory fruits were placed (unrinsed) in single layers without touching on absorbent paper towels on metal trays. Damaged fruit was discarded. The tomatoes were stored below room temperature (16C) out of direct sunlight. All tomatoes were between stages 4 and 6 of the Florida Tomato Guide (www.floridatomatoes.org) color chart. Samples were subjected to consumer testing at stage 6, defined as being even and red in color (>90% of the surface) and having firmness that yields slightly to pressure. Prior to evaluation, tomatoes were rinsed with deionized water, dried with towels and placed on trays such that no tomato was touching another.

Descriptive analysis

Descriptive analysis was conducted on stage 6 ripe tomatoes using a trained panel and the Spectrum ™ method with a universal 0 to 15 point intensity scale. Each of the eight trained descriptive panelists (n=7, ages 44-54 y) had logged >500 h of previous experience with the Spectrum ™ method. Descriptive analysis involved color, aromatics and basic

tastes. The lexicon used (Table 1) was adapted from a previous lexicon established for tomatoes (Hongsoongnern and Chambers 2008). Ten 1h training sessions were conducted with fresh tomatoes, other produce, processed tomato products and basic taste solutions to calibrate the panel and refine lexicon terms. Analysis of variance from data collected in preliminary evaluation sessions confirmed that panelists could consistently differentiate tomatoes ($p<0.05$) using the established lexicon. Each panelist evaluated each cultivar in triplicate. Appearance attributes were evaluated with a whole tomato on a 15 cm Styrofoam plate and aroma, flavor and aftertaste attributes were evaluated with tomatoes cut into 1/3 wedges plated on 15 cm Styrofoam plates. Data were collected using Compusense five v5.6 (Guelph, Canada).

Consumer Evaluation

Tomato consumers were recruited through email listservs to an online database of more than 7,000 consumers maintained by the Sensory Service Center of North Carolina State University. Participants (n=177) consumed tomatoes at least once per month and were required to consent to using a serrated knife in the taste test. Whole tomatoes, level 6 ripeness, were plated on 15 cm Styrofoam plates (Dart Container Corp., Mason MI) with three digit codes. Tomatoes were served at room temperature. The serving order was randomized and balanced and a 3 minute rest between each sample was enforced. Data were collected using Compusense five v5.6 (Guelph, Canada).

Tomatoes were evaluated by consumers in three stages: **Appearance**: Consumers were instructed to evaluate the whole tomato visually and answer the following questions regarding external qualities: Overall liking, appearance liking, color JAR (just about right),

firmness JAR, size JAR and purchase intent. **Slicing**: Consumers were provided with a white plastic cutting board (Winco Cutting Board 15x25cm, Amazon.com) and serrated tomato knife (WMF 23.5cm Tomato Knife, Amazon.com) and asked to cut through the middle of each tomato and answer the following questions: Overall liking (ease of cutting), ease of cutting JAR, Juiciness JAR, seeds JAR and purchase intent. **Tasting**: Consumers were instructed to consume several bites of each sliced tomato where they must consume skin and meat, and answer the following questions: Overall liking, flavor liking, flavor JAR, texture (liking and JAR), juiciness (liking and JAR), skin texture (liking and JAR) and purchase intent. All liking questions were scored on a 9 pt scale, where 1= dislike extremely and 9= like extremely. All JAR questions were scored on a 5 pt scale where 1-2= too little, 3= just about right and 4-5= too much. Purchase intent was scored on a 5 pt scale where 1-2= would not buy, 3= maybe buy and 4-5= would buy. Consumers were compensated with a gift card to a local store following evaluation.

Statistical analysis

Descriptive analysis and consumer acceptance scores were first analyzed by analysis of variance (ANOVA) with means separation using Fisher's least significant difference. Principal component analysis (PCA) (XLSTAT) was applied to evaluate how descriptive attributes characterized cultivars. Correlation analysis was also conducted to determine individual relationships between descriptive attributes. Cluster analysis was performed on all consumer data across all stages, using k-means with Euclidean distances and Wards linkage to separate consumers into groups. Internal preference mapping was conducted on tomato cultivars with cluster liking scores plotted on principal component eigenvectors. External

preference mapping was conducted on descriptive attributes and consumer liking scores for each cluster using partial least squares regression. All analyses were performed using XLSTAT version 2012.6.06 (Addinsoft, Paris, France).

RESULTS

Descriptive analysis

Tomatoes were differentiated by color, flavor and texture attributes ($p<0.05$, Fig 1). Principal components 1 and 2 explained 55% of the variance. Principal component 1(33% variability) was comprised of metallic, hardness, fibrous and skin aware loading positively and color intensity, even outside, overall flavor impression, earthy, ripeness and mealy loading negatively. Principal component 2 (22% variability) was comprised of vegetative, wetness, juicy and seed aware loading positively and astringent mouthfeel loading negatively. Principal component 3 (16% variability) was comprised of even outside, sour aromatic and sour taste loading positively and umami loading negatively. Principal component 4 (9% variability) was comprised of sweet taste loading positively and overall aromatic intensity and vegetative aroma loading negatively. Tomato cultivars Red Bounty and HM 1823 were characterized by vegetative flavor, umami taste, metallic, fibrous, skin aware and seed aware. HMX 8845 was characterized by sour aromatic, sour and sweet tastes, astringent mouthfeel and hardness. Scarlet Red and HM 8849 were characterized by vegetative aroma, sweet taste, earthy flavor, even outside color, astringent mouthfeel and mealy texture. Tygress tomatoes had high color intensity, even inside and outside color, ripe

flavor and mealy texture. Tasti-Lee was characterized by overall flavor and aroma intensity, vegetative aroma, juicy, wetness, ripeness and seed aware.

Correlations among the descriptive attributes were noted. Color intensity and juiciness were correlated with overall flavor impact (r^2 =0.732, r^2=0.792 respectively, $p<0.05$). Ripeness and wetness were correlated with juicy (r^2 =0.689, r^2=0.581 respectively, $p<0.05$). Seed aware was correlated with wetness (r^2=0.650, $p<0.05$) and fibrous was correlated with metallic (r^2 = 0.889, $p<0.05$).Skin aware and fibrous were correlated with hardness (r^2 =0.766, r^2=0.608 respectively, $p<0.05$).

Consumer Evaluation

Full demographic information of participants can be found in Table 2. Differences in liking for the tomato cultivars were observed across the stages of consumption. For the appearance evaluation of the test, Tygress scored the highest for overall liking and was at parity with Tasti-Lee ($p<0.05$) (Table 3). In appearance liking, Tygress scored the highest and was at parity with Scarlet Red, Tasti-Lee and HM 8849 ($p<0.05$), which were also at parity with Red Bounty, HM 1823 and HMX 8845 ($p<0.05$). Following slicing, Tasti-Lee scored the highest for overall liking (Table 4) and was at parity with Red Bounty, Tygress and HM 8849 ($p<0.05$) which were also at parity with Scarlet Red ($p<0.05$) (Table 4). After tasting, Tasti-Lee received the highest score for overall liking and was at parity with Red Bounty ($p<0.05$) (Table 5). Across the 3 stages, Tasti-Lee was liked best and HMX 8845 was liked least.

Four clusters of consumers were identified (Table 2). Each cluster had unique attributes ($p<0.05$) relative to the total population and/or other clusters. Cluster 1 had fewer

females than compared to other clusters and thought the attribute ‘firmness’ was less important than other clusters based on ranking of most important attributes . There were more people who consumed tomatoes at least once per week, people who purchased tomatoes at the farmers market and greater importance for the attribute flavor in other clusters compared to cluster 2. In cluster 3, fewer people were 25-34 y and the attribute skin color was less important. There were more females, people who consumed tomatoes two or more times per week, people who grew tomatoes themselves and people who purchased beefsteak tomatoes in other clusters compared to cluster 4.

Internal preference mapping was used to differentiate tomato liking scores by clusters (Figure 2-4). During appearance evaluation (Figure 2), Cluster 1 preferred tomatoes Scarlet Red, HM 8849 and Tygress; cluster 2 preferred tomatoes Red Bounty and HM 8849; Cluster 3 preferred tomatoes Scarlet Red and HM 8849; cluster 4 preferred tomatoes HM 1823 and Tasti-Lee. After slicing (Figure 3), clusters 1, 3 and 4 preferred tomatoes Red Bounty and Tasti-Lee. Cluster 2 preferred tomatoes Tygress and HM 8849. After tasting (Figure 4), cluster 1 preferred Scarlet Red, cluster 2 preferred HM 8849, cluster 3 preferred Red Bounty and Tasti –Lee and cluster 4 preferred Red Bounty.

Across all consumers and with few exceptions within clusters, overall liking decreased as consumers moved through the 3 stages of tasting, liking scores were highest at the appearance evaluation, lower after slicing and lowest after tasting (Figures 5-9). Tomatoes that were most liked during appearance evaluation were characterized by color intensity and even outside color. Drivers after stage 2 (slicing) were wetness/juiciness and overall aroma. Drivers after tasting evaluation were wetness/juiciness, seed presence, ripe

flavor and umami taste. Cluster 3 had the highest liking scores across all stages ($p<0.05$) (Figure 8), followed by clusters 1 and 2 which were at parity ($p<0.05$) (Figures 6 and 7). Cluster 4 had the lowest liking scores across all stages ($p<0.05$) (Figure 9).

External preference mapping predicted cluster acceptance of each tomato characterized by descriptive analysis attributes. In cluster 1 (Figure 10), consumers preferred tomatoes Tygress, Tasti-Lee, HM 8849 and Scarlet Red. These tomatoes were characterized by juicy, overall flavor intensity, ripeness, color intensity, even color, vegetative aroma, mealy and earthy. Cluster 2 consumers (Figure 11) preferred tomatoes Tasti-Lee, Red Bounty and HM 1823. These tomatoes were characterized by wetness, seed aware, vegetative, umami, metallic, fibrous, skin aware and hardness. Consumers in cluster 3 (Figure 12) liked all tomatoes; every tomato was liked by at least 80-90% of consumers in that cluster. Cluster 4 consumers (Figure 13) had the lowest liking for tomatoes; only Tygress was liked by 80-90% of consumers and one other, Tasti-Lee was liked by 70-80% of consumers. These tomatoes were characterized by even inside and outside, overall flavor and aroma intensity, ripeness and color intensity.

DISCUSSION

Consumer clusters in this study were differentiated by their liking of tomatoes that correlated with color, flavor/aroma and firmness attributes. Cluster 1 was driven by color and ripeness, cluster 2 was driven by firmness, cluster 3 was driven by soft/ripe tomatoes and color, cluster 4 was driven by mild flavor/aroma and juiciness. Consistent with previous research regarding the importance of color and appearance to tomato liking (Hetherington

and MacDougall 1992, Pagliarini and others 2001, Oltman and others 2014), cluster 1 and 3 consumers identified in this study relied on even color and color intensity to evaluate liking. Color is an indicator of ripeness to consumers (Oltman and others 2014; Baldwin and Scott 2002; Bruhn and others 1991). Another previously identified driver of liking for tomatoes is texture (Causse and others 2003, Aurand and others 2012, Schouten and others 2010). The current study also identified a group of tomato consumers where firmness was a key driver of liking (cluster 2); firmness also characterized the most liked varieties in a tomato study that focused on physicochemical, volatile and sensory parameters and their role on tomato liking (Piombino and others 2012) .

Unique to this study was the liking evaluation of tomatoes across three stages (appearance, slicing and tasting). Appearance (Pagliarini and others 2001), slicing-particularly texture (Causse and others 2003) and flavor (Aurand and others 2012) have all separately been cited as important to consumer liking. However, by having consumers evaluate each cultivar across the three stages, consumer perception across all three stages and for all attributes can be directly compared. Liking was highest at appearance evaluation, decreased at slicing and was lowest at tasting. This may indicate that appearance is the highest indicator of quality to consumers or may also indicate lack of decreased satisfaction with slicing and flavor attributes. It is important to note that all tomatoes overall were somewhat to well liked in appearance and hand texture with a mean liking score >6.7. One possibility not accounted for in this study was a decrease in liking during tasting because tomatoes are not generally eaten without being a part of a meal or snack as opposed to just the fruit itself. The tomato was consumed without other accompaniments so consumers

could evaluate the in-mouth texture and flavor without interference from a more complex food matrix.

Another consumer study with tomatoes found that tomatoes scored higher in appearance liking than overall liking after tasting (Sinesio and others 2010). In a previous conjoint study comparing the importance of external and internal tomato attributes, the attribute color was most important, followed by juiciness (visualized after slicing) with flavor much lower in importance (Oltman and others 2014). Oltman and others (2014) attributed the low importance of flavor on purchase to the inability of consumers to directly assess flavor before purchase. As such, consumers relied on external attributes even though flavor was valued by consumers in focus groups. The current results also confirm the importance of tomato flavor and that flavor is a key attribute for improvement. Drivers of liking during appearance evaluation were color, color intensity and appearance; consistent with previous studies on tomato purchase (Oltman and others 2014). The drivers of liking after slicing evaluation were juiciness related. Sinesio and others (2010) and Pagliarini and others (2001) cite juiciness as a driver of tomato liking. Drivers of liking after consumption were flavor, taste, juiciness and seed presence. Piombino and others (2013) and Sinesio and others (2010) reported that consumers liked tomatoes with higher perceived content of seeds. Pagliarini and others (2001) reported that tomato flavor was also a driver of liking. The higher liking consumers exhibit for appearance and post-slicing evaluation indicate that attributes perceived during that evaluation (ex. appearance- color, uniformity; slicing- juiciness, texture) should be the focus for tomato promotion. Alternatively, flavor or mouthfeel, which is evaluated during tasting, could be improved.

CONCLUSION

The greatest driver for tomato liking is appearance. Consumers generally preferred tomatoes that had intense color, were ripe, juicy/wet, had firm texture (hardness, fibrous, skin aware), were sweet and had high overall flavor intensity. Consistent with previous tomato studies with consumers, appearance and texture were important attributes to consumers but flavor remains an opportunity for improvement. Considering the purchase environment allows for the exploration of appearance and hand-texture evaluated attributes as the primary attributes evaluated prior to purchase, these attributes still remain key for cultivators in selecting tomato cultivars for appealing to consumers. Because flavor is an important driver for specific clusters, flavor development in tomato cultivars should be an area of focus. Possible ways to appeal to these consumers in the purchase environment could be tastings in grocery store. The clusters of consumers were identified by different preferences for tomatoes: cluster 1 was driven by color and flavor, cluster 2 was driven by firmness, cluster 3 was driven by softness and ripeness and cluster 4 was driven by mild flavor and juiciness. This research will aid the tomato industry in growing varietals that enhance tomato attributes that are responsible for the drivers of liking of the specific consumer segments identified in this research.

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Table 1. Lexicon for Fresh Tomatoes

Attribute	Definition	Reference or Example
Appearance - evaluate the representative whole sample presented on plates to entire panel		
Color intensity outside	strength of color from light (pink) to dark (dark red), view the blossom end	Campbell's Tomato Juice (diluted 3:1 = 5, full strength = 9); Kumato is dark / intense = 11; Holland House Red Cooking wine = 15
Evenness outside	degree to which the color of the outside of the whole tomato is even and not blotchy (view from blossom end)	blotchy = low # and even = high #
Evenness inside	degree to which the color of the inside meaty portion of the tomato is even and not blotchy, view center slice	blotchy = low # and even = high #
Aroma, Flavor, Aftertaste- evaluate samples cut into 1/3 wedges		
Aroma overall impression	a balanced, overall impression of the aromatics typically associated with fresh cut tomatoes: rate from very low to high	ripe Kumato or Zebrino = H
Aroma vegetative	aromatics of rotting green plant material; includes any fermented notes	cut green stems (flower stems) in water ≥ 1 week; chopped curly parsley in water 5 days @ room temp = 12.0
Flavor overall impression	the aromatics commonly associated with tomato, which may be described as sweet, fruity, earthy, viney, ripe and sour	Campbell's Tomato Juice = 10
Cardboard	aromatics associated with wet cardboard and wet paper packaging	cardboard backing from writing tablet, 8.5x2-inch pc cut in strips and soaked in 500ml DI water 24hrs @ room temp = 4.0 (aroma) and 8.0 (flavor)
Aroma vegetative	aromatics of rotting green plant material; includes any fermented notes	cut green stems (flower stems) in water > 1 week; chopped curly parsley in water 5 days @ room temp = 12.0
Vegetative	aromatics of plant material, freshly cut green stems and vines, freshly cut grass	1/2-inch wedge fresh Kumato tomato or Zebrino = 7+; 1 g crushed tomato leaves = 10.0
Fermented	aromatics of overripe fruit, wine-like	Holland House Red Cooking Wine aroma = 6.5
Earthy / musty	aromatics that are humus-like and reminiscent of damp soil, damp basement	raw white potato 1/2-inch sliced in jar = 8.5
Ripeness	degree of ripe flavor from underripe (low #) to optimal ripe flavor (12) to very overripe (15).	Campbell's Tomato Juice = 12; fresh Kumato or Zebrino = 12
Sour	basic taste sensation elicited by acids	0.08% citric acid solution = 5
Sweet	basic taste sensation elicited by sugars and high potency sweeteners	5 % sucrose solution = 5
Bitter	basic taste sensation elicited by alkaloids	0.08% caffeine solution = 5
Umami	basic taste of savoriness	0.5 % monosodium glutamate solution = 3
Metallic mouthfeel/ sensation	a mouthfeel sensation (not aromatic) described as coppery, serum-like	Dole canned pineapple tidbits; copper wire soaked in water; Campbell's Tomato Juice (plastic jug) = 2-2.5
Texture - center one-third of a wedge		
Wetness to lips	amount of wetness from cut surface lightly rubbed across lips	fresh unbagged carrot slice = 2.5; fresh bagged 'baby' carrot slice = 6.0; water = 15.0
Hardness first bite	force required to bite completely through sample to the skin with molar teeth, holding wedge upright with skin side down	red seedless grapes = 9.0; grape tomatoes = 12.0
Juiciness first and second bite	amount of liquid that exudes from the product during the first and second chews	red seedless grapes = 9; Dole canned Pineapple Tidbits = 10.0
Fiber awareness	degree to which fibers are present throughout mastication	Dole canned Pineapple Tidbits = 10.0
Mealiness	perception of fine, soft, somewhat rounded and smooth particles during mastication	Red Delicious apple out of season = 9; stored fresh peaches
Skin awareness	degree to which the skin is perceptible during mastication	seedless red grapes = 12.0; grape tomatoes
Seed awareness	amount of perceived seeds throughout mastication	1/2 c Hunt's Tomato Sauce + 1 tsp sesame seeds = 8.5; Synergy Cherry Chia bevg. = 12.0

Adapted from Hongsoongnern and Chambers, 2008

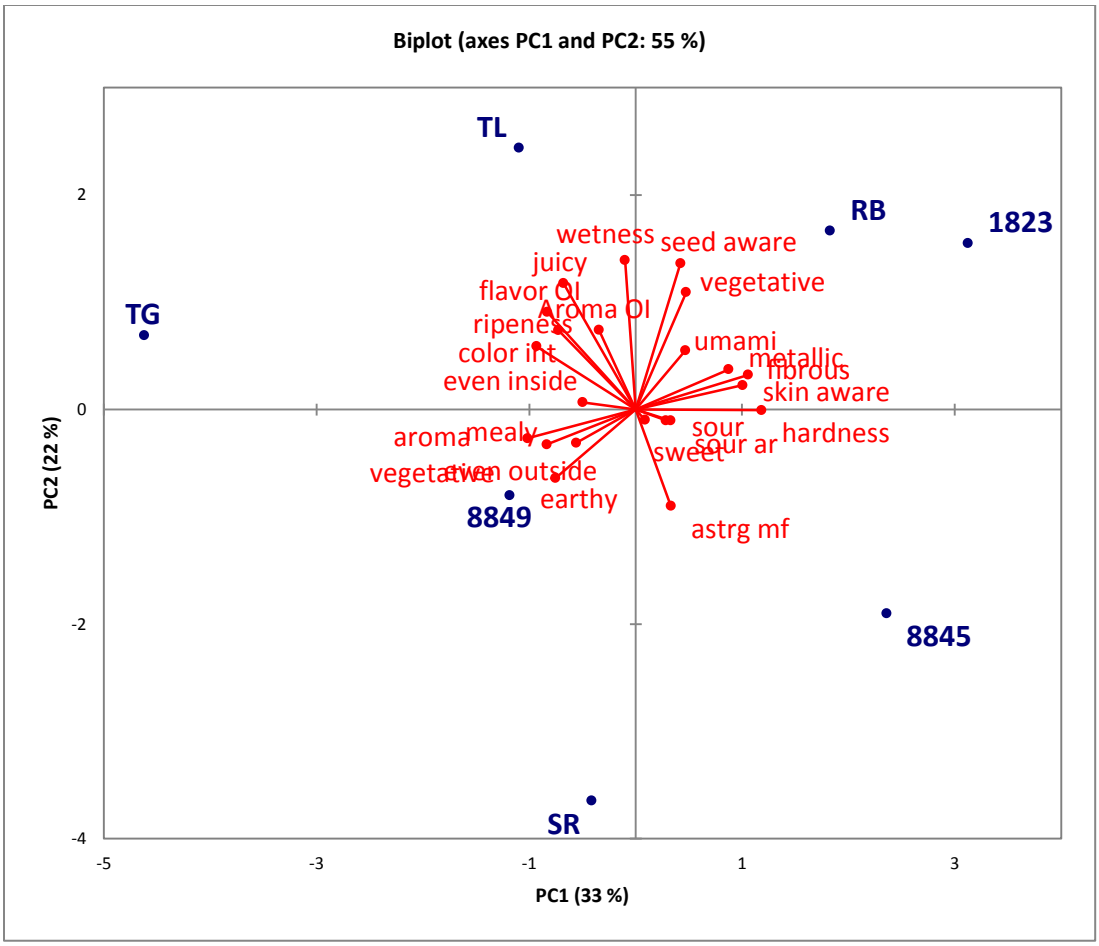

Figure 1. Principal component biplot of trained panel profiles of tomato cultivars. TL- Tasti-Lee, RB- Red Bounty, 1823- HM 1823, 8845- HMX 8845, 8849- HM 8849, TG- Tygress

Table 2. Demographic information of tomato consumers and specific consumer clusters

		Cluster 1 (n=54)	Cluster 2 (n=23)	Cluster 3 (n=65)	Cluster 4 (n=35)	Total Population (n=177)
Gender	Male	48.1a	17.4b	30.8ab	45.7a	37.3
	Female	51.9c	82.6a	69.2ab	54.3bc	62.7
Age	Younger than 18 years old	0.0	0.0	0.0	0.0	0.0
	18-24 years old	7.4a	13.0a	13.8a	14.3a	11.9
	25-34 years old	38.9a	34.8ab	16.9b	42.9a	31.1
	35- 44 years old	25.9a	17.4a	23.1a	17.1a	22.0
	45-54 years old	9.3a	21.7a	18.5a	11.4a	14.7
	55-64 years old	16.7a	13.0a	26.2a	11.4a	18.6
	65 years old and older	1.9a	0.0	1.5a	2.9a	1.7
Ethnicity	American Indian or Alaska Native	0.0	0.0	1.5	0.0	0.6
	Asian	7.4a	4.3a	4.6a	17.1a	7.9
	Black or African American	13.0a	30.4a	16.9a	20.0a	18.1
	Hispanic	5.6a	8.7a	1.5a	0.0	3.4
	Latino	1.9a	0.0	0.0	0.0	0.6
	Native Hawaiian or other Pacific Islander	0.0	0.0	0.0	0.0	0.0
	White	70.4a	52.2a	72.3a	54.3a	65.5
	Other	1.9a	4.3a	3.1a	5.7a	3.4
	Prefer not to answer	0.0	0.0	0.0	2.9a	0.6
Household shopping responsibility	Primary	88.9a	91.3a	90.8a	88.6a	89.8
	Secondary	11.1a	4.3a	4.6a	11.4a	7.9
	I do not do the shopping	0.0	4.3a	1.5a	0.0	1.1
How often do you eat fresh tomatoes?	Never	0.0	0.0	1.5a	0.0	0.6
	A few times per year	0.0	4.3a	1.5a	8.6a	2.8
	At least once per month	3.7a	8.7a	1.5a	8.6a	4.5
	At least 2-3 times per month	18.5a	30.4a	23.1a	20.0a	22.0
	At least once per week	25.9ab	17.4b	32.3ab	42.9a	30.5
	Two or more times per week	51.9a	39.1a	40.0a	20.0b	39.5
How do you prepare fresh tomatoes?	In a salad	94.4a	95.7a	93.8a	80.0a	91.5
	On a sandwich	90.7a	95.7a	93.8a	80.0a	90.4
	In a cooked dish	57.4a	69.6a	67.7a	77.1a	66.7
	Plain	50.0a	39.1a	61.5a	40.0a	50.8
	Other	5.6a	8.7a	10.8a	2.9a	7.8
Where do you purchase fresh tomatoes?	Grocery store	96.3a	100.0a	98.5a	97.1a	97.7
	Farmers market	68.5a	43.5b	73.8a	60.0ab	65.6
	I grow them myself	24.1ab	34.8a	29.2a	11.4b	24.9
	Other	7.4a	4.3a	7.7a	5.7a	6.8
What kind of fresh tomatoes do you purchase?	Cherry	87.0a	87.0a	75.4a	77.1a	80.8
	Roma	87.0a	78.3a	86.2a	80.0a	84.2
	Plum	37.0a	52.2a	46.2a	57.1a	46.3
	Hothouse	33.3a	47.8a	40.0a	37.1a	38.4
	Beefsteak	33.3ab	43.5ab	49.2a	28.6b	39.5
	Heirloom	51.9a	34.8a	49.2a	40.0a	46.3
	Green	9.3ab	21.7a	20.0a	2.9b	13.6
	Other	13.0a	4.3a	9.2a	2.9a	8.5
Percentage of consumers indicating each factor as 'most important'	Skin color	24.1ab	13.0ab	12.3b	31.4a	19.8
	Juiciness	7.4a	4.3a	1.5a	8.6a	5.1
	Firmness	9.3b	39.1a	27.7a	25.7a	23.2
	Texture	3.7a	13.0a	6.2a	2.9a	5.6
	Health claim	0.0	0.0	0.0	0.0	0.0
	Size	0.0	4.3a	1.5a	2.9a	1.7
	Price	1.9a	4.3a	9.2a	2.9a	5.1
	Amount of seeds	1.9a	0.0	0.0	0.0	0.6
	Flavor	46.3a	21.7b	40.0a	25.7ab	36.7
	Organic	5.6a	0.0	1.5a	0.0	2.3

Different letters in rows following means signify significant differences ($p<0.05$)

Table 3. Overall Appearance Results (n=177)

		Red Bounty	Scarlet Red	Tasti-Lee	HM 8849	HM 1823	HMX 8845	Tygress
Overall liking		6.9b	7.0b	7.1ab	7.0b	6.9b	6.8b	7.3a
Appearance		6.9b	7.1ab	7.1ab	7.1ab	6.9b	7.0b	7.3a
Color	Too light	21.1%a	12.5%b	1.7%c	22.9%a	25%a	27.2%a	6.8%bc
	JAR	71.4%c	85.2%a	78%abc	73.7%c	71%c	71.7%c	83%ab
	Too dark	7.4%bc	2.3%d	20.3%a	3.4%cd	4%cd	1.2%d	10.2%b
Firmness	Too soft	14.9%a	9.7%a	13.6%a	8.6%a	10.2%a	1.2%b	8.5%a
	JAR	57.1%c	67.6%ab	68.9%ab	68%ab	59.7%bc	42.2%d	75.6%a
	Too firm	28%b	22.7%bc	17.5%c	23.4%b	30.1%b	56.6%a	15.9%c
Size	Too small	1.1%c	0.6%c	11.3%a	3.4%bc	1.1%c	1.2%c	7.4%ab
	JAR	67.4%bc	59.7%c	82.5%a	61.7%c	67%bc	62.4%c	73.3%b
	Too large	31.4%a	39.8%a	6.2%c	34.9%a	31.8%a	36.4%a	19.3%b
Purchase intent after looking		3.7ab	3.7ab	3.8a	3.7ab	3.7ab	3.5b	3.9a

Different letters in rows following means signify significant differences ($p<0.05$)

Liking attributes were scored on a 9-point hedonic scale where dislike extremely =1 and like extremely =9

JAR scales were scored on a 5-point scale too little =1 or 2, just about right =3 and too much=4 or 5. Percentage of consumers that selected these options is presented.

Purchase intent question was scored on a 5-point scale where would not buy = 1 or 2, may nor may not buy = 3, would buy = 4 or 5

Table 4. Impression After Slicing Results (n=177)

		Red Bounty	Scarlet Red	Tasti-Lee	HM 8849	HM 1823	HMX 8845	Tygress
Overall liking		6.8ab	6.6bc	6.9a	6.7abc	6.4c	6.4c	6.8ab
Ease of cutting	Too delicate	2.3%b	0%c	6.8%a	2.9%ab	4%ab	0.6%c	1.1%bc
	JAR	76%bc	78.4%abc	82.5%ab	81.7%abc	73.9%c	59%d	84.7%a
	Too tough	21.7%b	21.6%b	10.7%c	15.4%bc	22.2%b	40.5%a	14.2%b
Juiciness	Too dry	22.3%bc	25%ab	15.8%cd	16.6%cd	27.3%a	33.5%a	10.2%d
	JAR	68%ab	68.2%ab	70.1%ab	74.9%a	62.5%b	64.2%b	76.7%a
	Too juicy	9.7%ab	6.8%b	14.1%a	8.6%ab	10.2%ab	2.3%c	13.1%ab
Seeds	Too few	20%a	19.9%a	16.4%a	13.7%a	13.1%a	17.3%a	13.6%a
	JAR	74.9%a	67%a	74.6%a	73.1%a	69.9%a	72.3%a	72.2%a
	Too many	5.1%b	13.1%a	9%b	13.1%a	17%a	10.4%ab	14.2%a
Purchase intent after cutting		3.7a	3.6a	3.7a	3.6a	3.5a	3.5a	3.7a

Different letters in rows following means signify significant differences ($p<0.05$)

Liking attributes were scored on a 9-point hedonic scale where dislike extremely =1 and like extremely =9

JAR scales were scored on a 5-point scale too little =1 or 2, just about right =3 and too much=4 or 5. Percentage of consumers that selected these options is presented.

Purchase intent question was scored on a 5-point scale where would not buy = 1 or 2, may nor may not buy = 3, would buy = 4 or 5

Table 5. Overall Tasting Results (n=177)

		Red Bounty	Scarlet Red	Tasti-Lee	HM 8849	HM 1823	HMX 8845	Tygress
Overall liking		6.8ab	6.6bc	6.9a	6.5bc	6.3cd	6.1d	6.5bcd
Flavor		6.8a	6.5ab	6.9a	6.5ab	6.4b	6.2b	6.4b
Flavor	Too mild	27.4%c	31.3%bc	24.3%c	36%ab	41.5%a	38.2%ab	35.8%ab
	JAR	65.1%a	59.1%ab	65%a	54.9%b	51.7%b	50.9%b	52.3%b
	Too strong	7.4%a	9.7%a	10.7%a	9.1%a	6.8%a	11%a	11.9%a
Texture		6.5ab	6.4ab	6.6a	6.3ab	6.2b	5.8c	6.2ab
Texture	Too soft	11.4%bc	6.8%c	19.2%a	9.7%b	14.2%ab	2.3%d	11.9%abc
	JAR	62.3%a	64.2%a	66.7%a	61.7%a	61.4%a	46.2%b	66.5%a
	Too firm	26.3%b	29%b	14.1%c	28.6%b	24.4%b	51.4%a	21.6%bc
Juiciness		6.6a	6.4ab	6.7a	6.5a	6.4ab	6.1b	6.5a
Juiciness	Too dry	22.9%bc	28.4%b	15.8%c	20.6%bc	26.1%b	39.3%a	15.3%c
	JAR	66.9%a	64.2%ab	69.5%a	68.6%a	63.6%ab	54.9%b	68.8%a
	Too juicy	10.3%ab	7.4%b	14.7%a	10.9%ab	10.2%ab	5.8%b	15.9%a
Skin texture		6.5a	6.4a	6.6a	6.4a	6.4a	6.0b	6.2ab
Skin texture	Too delicate	4%ab	4.5%ab	7.9%a	4.6%ab	5.1%ab	2.3%b	4.5%ab
	JAR	67.4%a	64.2%ab	67.2%a	64.6%ab	65.9%a	56.1%b	61.9%ab
	Too tough	28.6%b	31.3%ab	24.9%b	30.9%b	29%b	41.6%a	33.5%ab
Purchase intent after tasting		3.6a	3.5ab	3.7a	3.5ab	3.4ab	3.2b	3.4ab

Different letters in rows following means signify significant differences ($p<0.05$)

Liking attributes were scored on a 9-point hedonic scale where dislike extremely =1 and like extremely =9

JAR scales were scored on a 5-point scale too little =1 or 2, just about right =3 and too much=4 or 5. Percentage of consumers that selected these options is presented.

Purchase intent question was scored on a 5-point scale where would not buy = 1 or 2, may nor may not buy = 3, would buy = 4 or 5

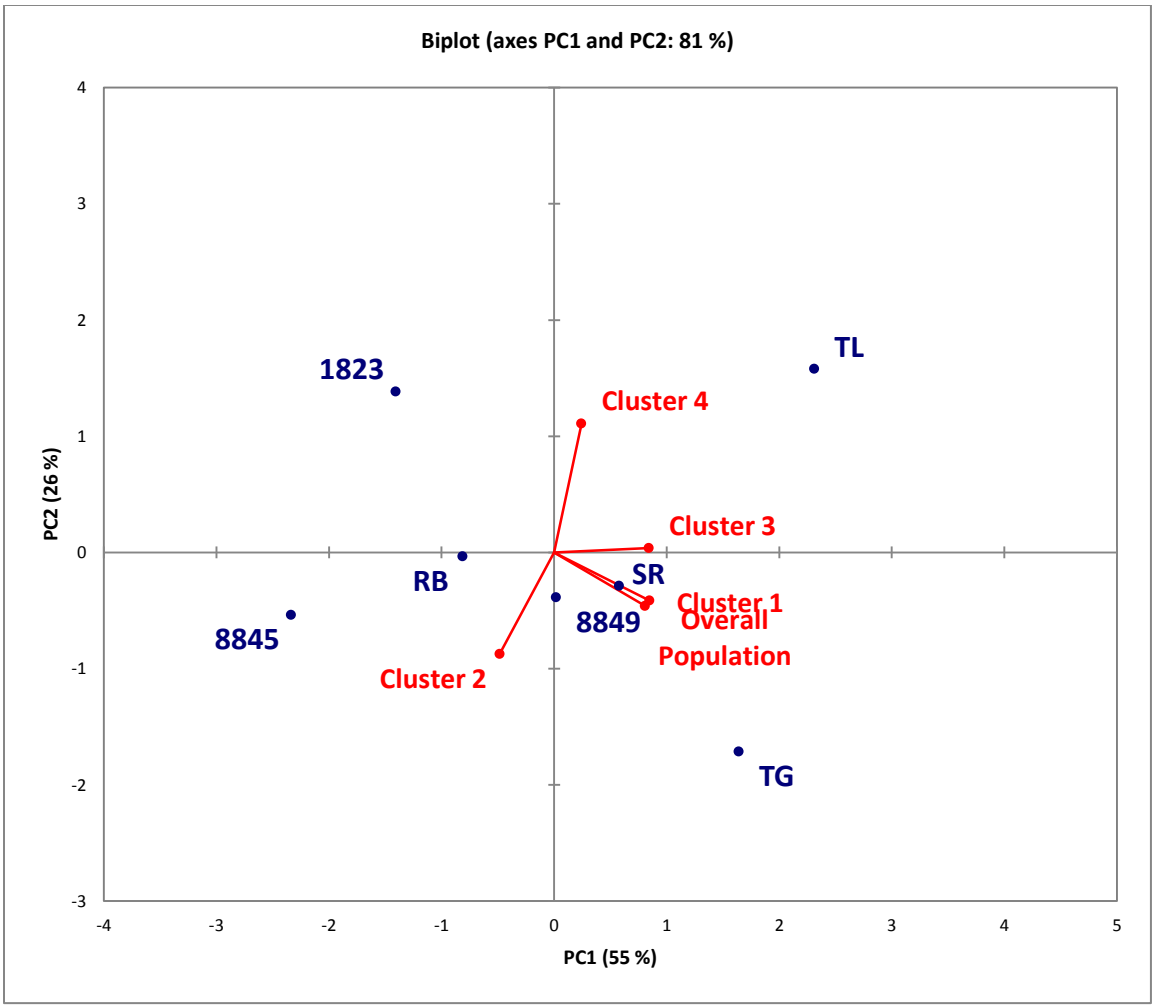

Figure 2. Internal preference map of consumer liking during appearance evaluation. TL- Tasti-Lee, RB- Red Bounty, 1823- HM 1823, 8845- HMX 8845, 8849- HM 8849, TG- Tygress

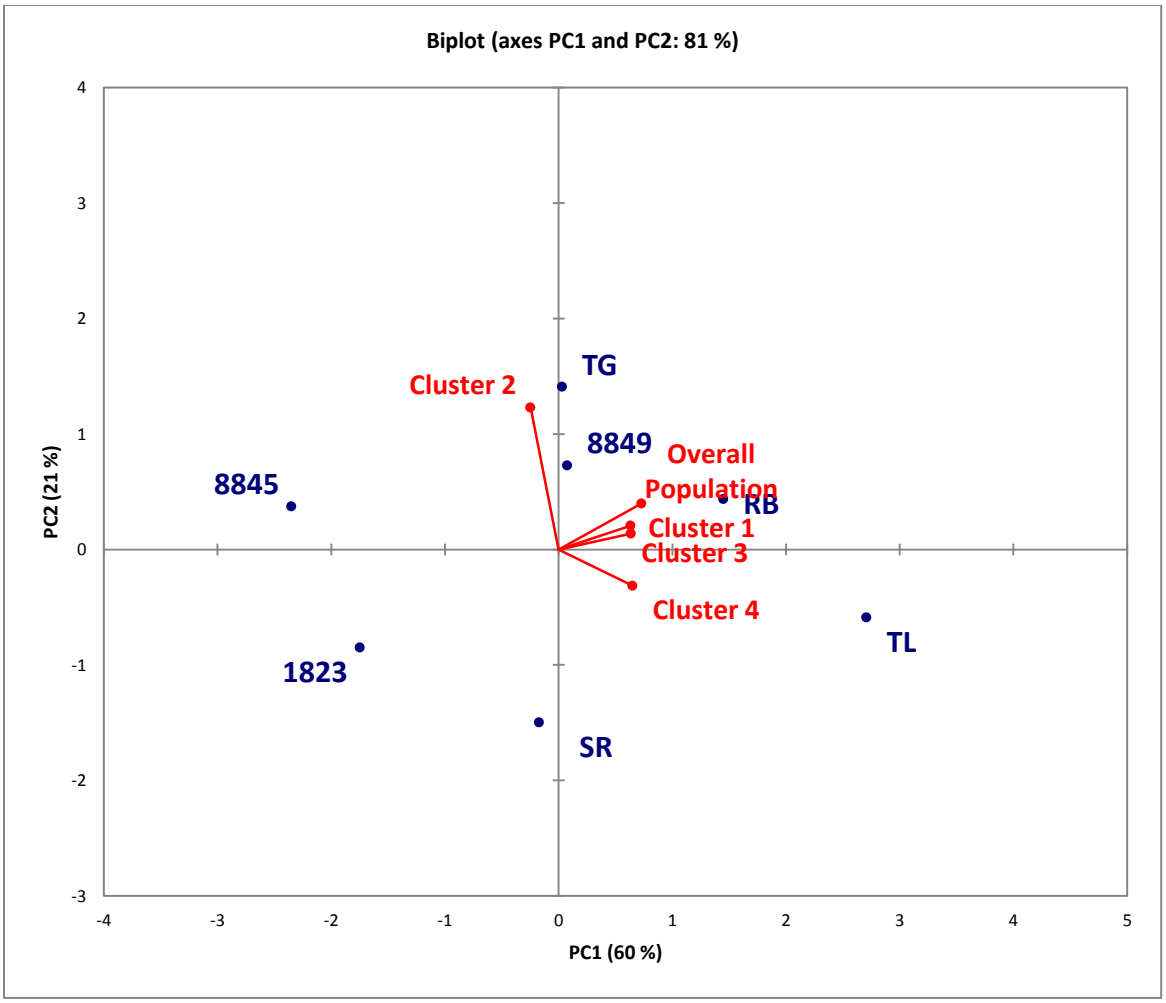

Figure 3. Internal preference map of consumer liking after slicing evaluation. TL- Tasti-Lee, RB- Red Bounty, 1823- HM 1823, 8845- HMX 8845, 8849- HM 8849, TG- Tygress

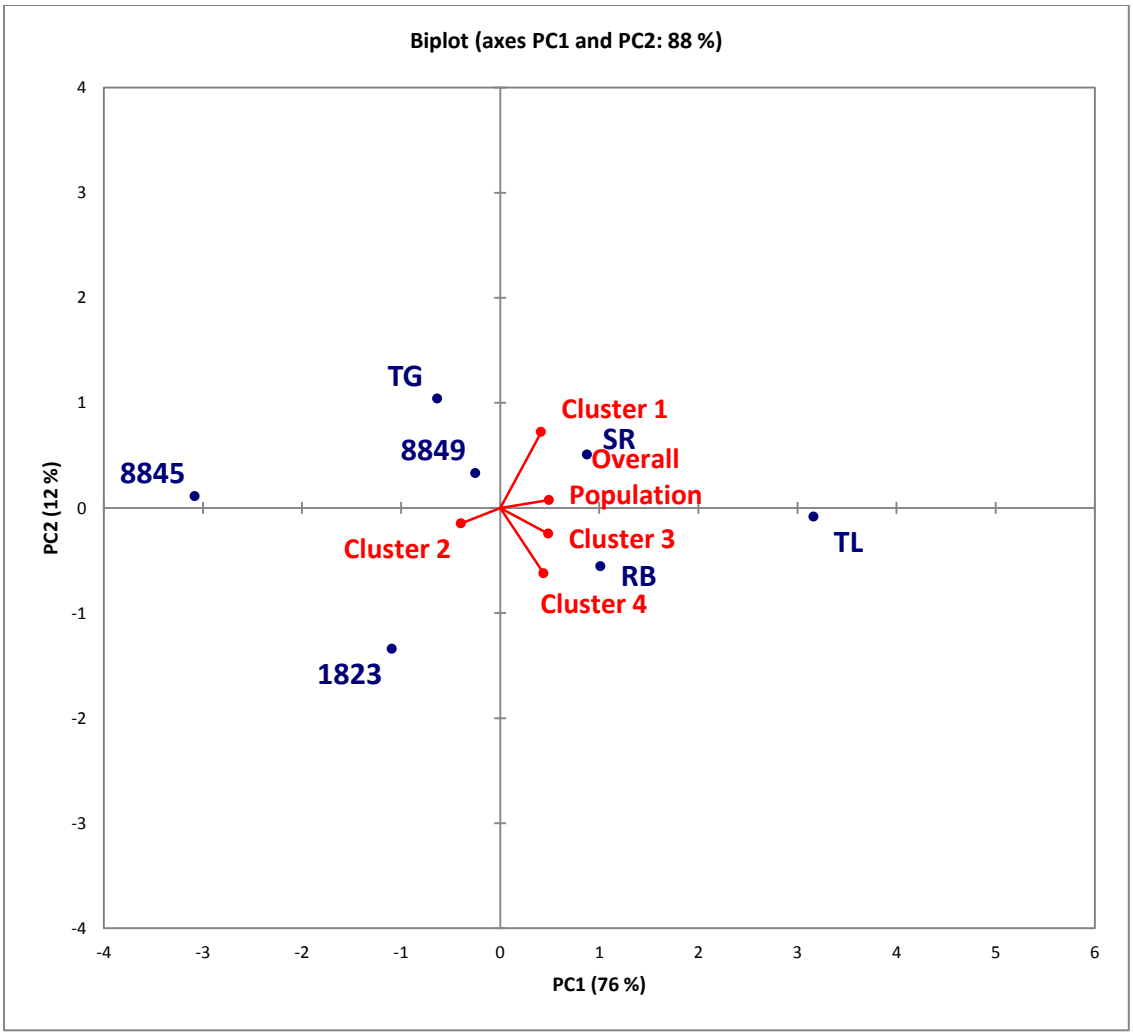

Figure 4. Internal preference map of consumer liking after tasting evaluation. TL- Tasti-Lee, RB- Red Bounty, 1823- HM 1823, 8845- HMX 8845, 8849- HM 8849, TG- Tygress

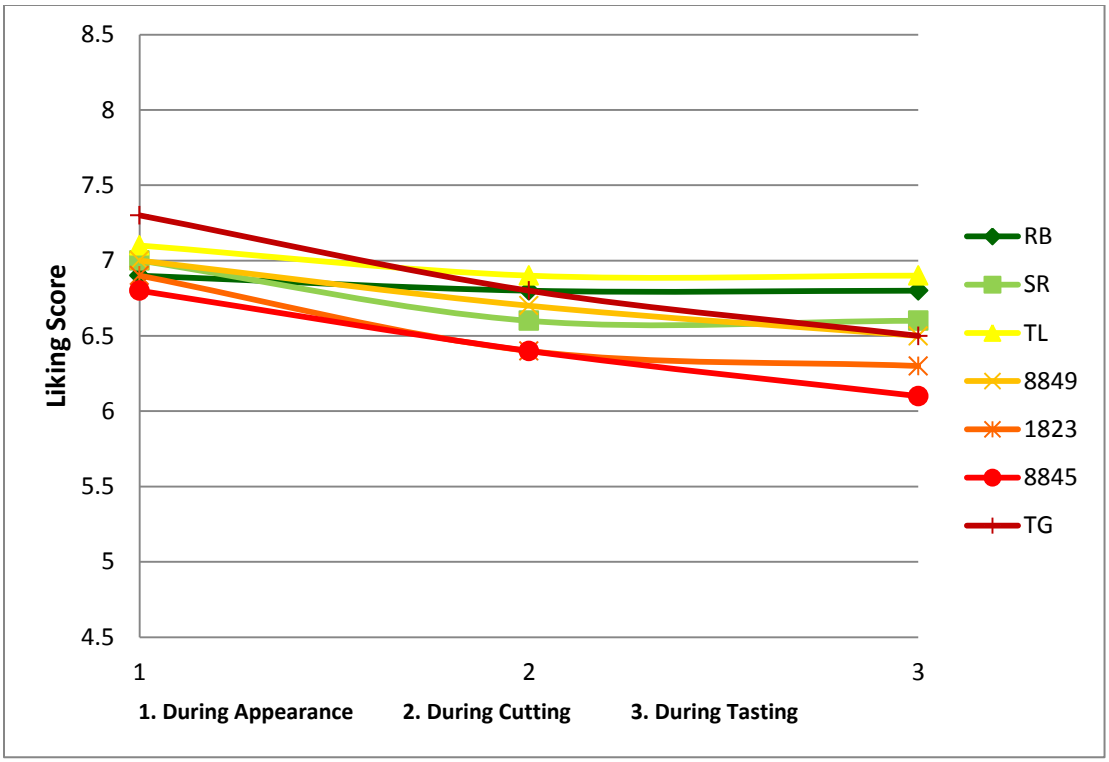

Figure 5. Overall liking across 3 stages- Total population (n=177)

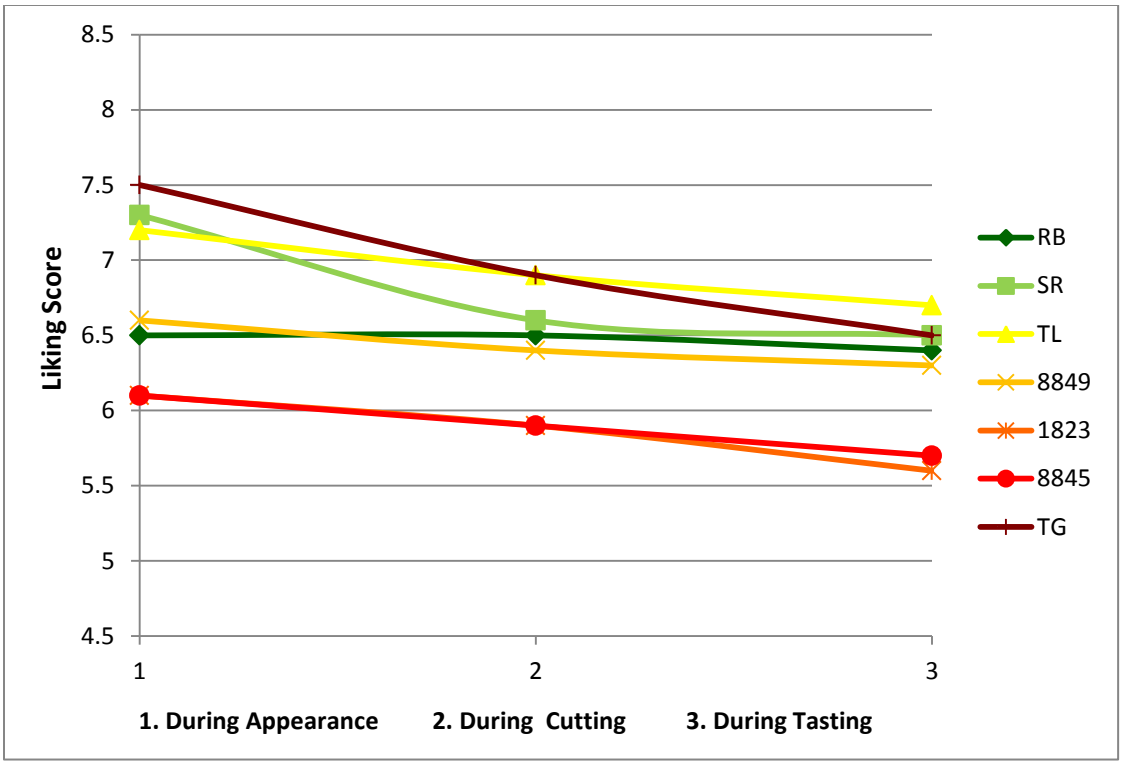

Figure 6. Overall liking across 3 stages- Cluster 1 (n=54)

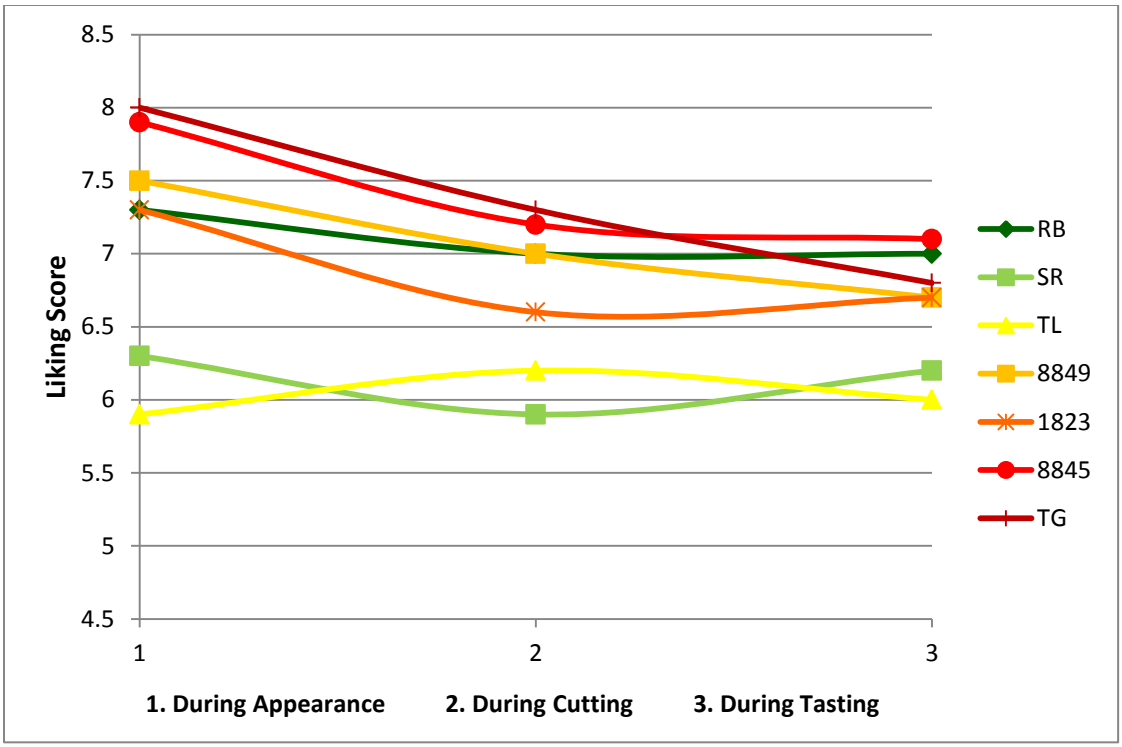

Figure 7. Overall liking across 3 stages- Cluster 2 (n=23)

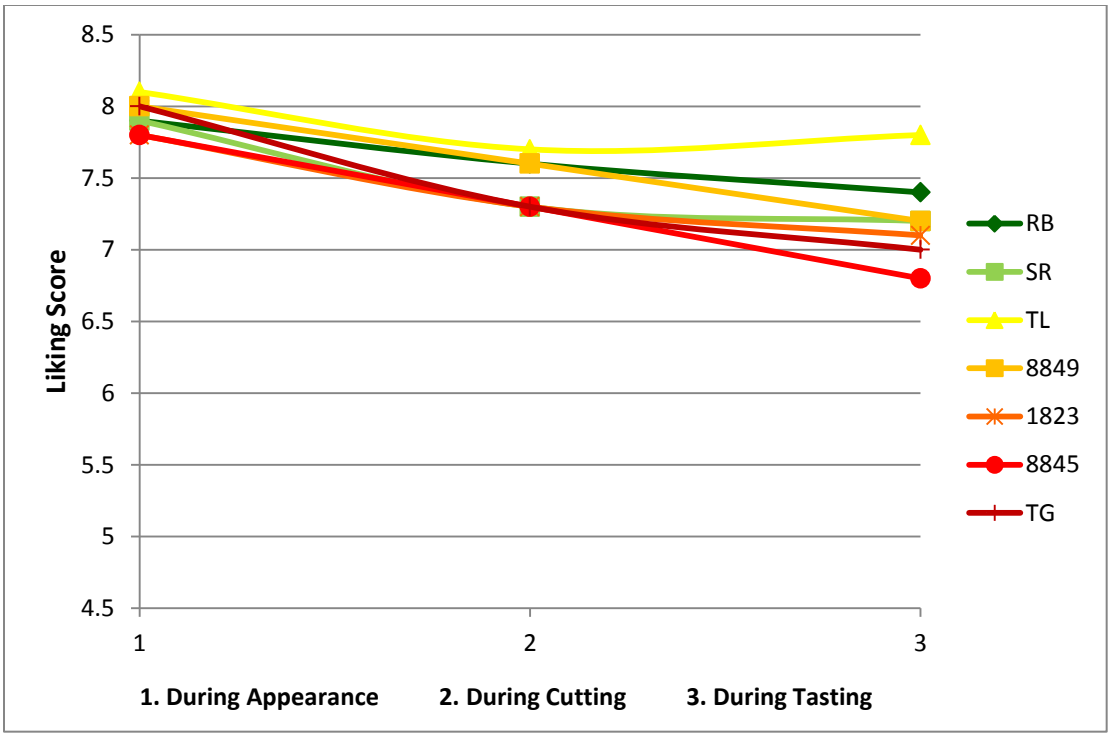

Figure 8. Overall liking across 3 stages- Cluster 3 (n=65)

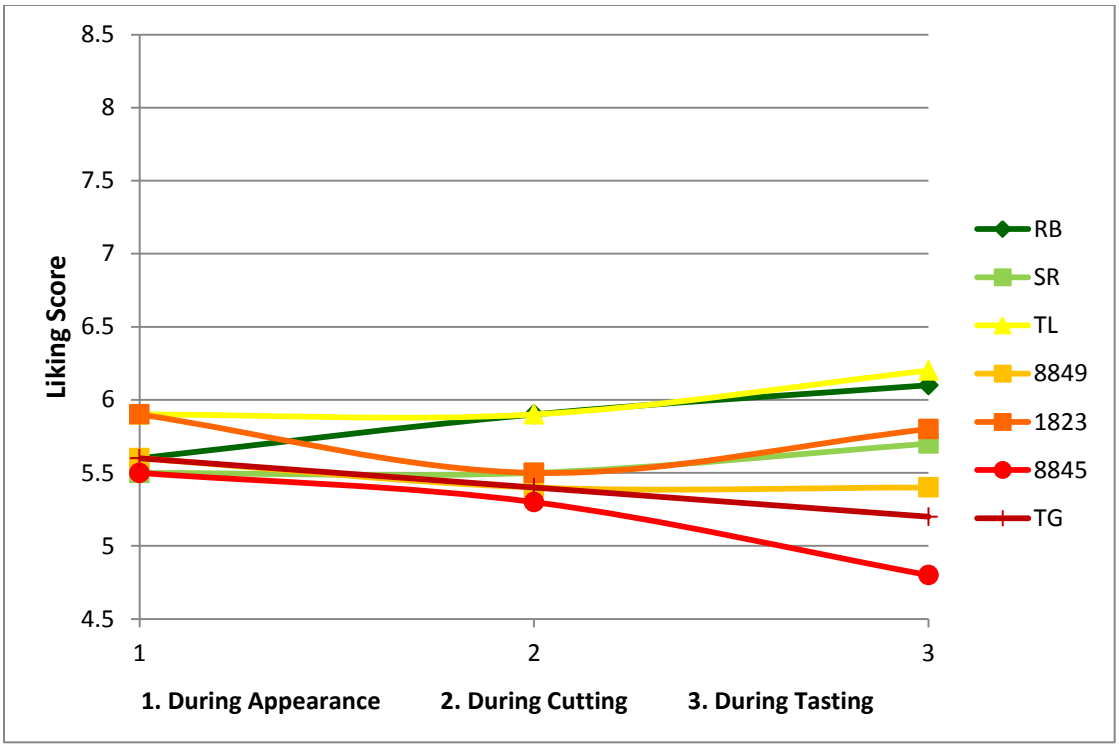

Figure 9. Overall liking across 3 stages- Cluster 4 (n=35)

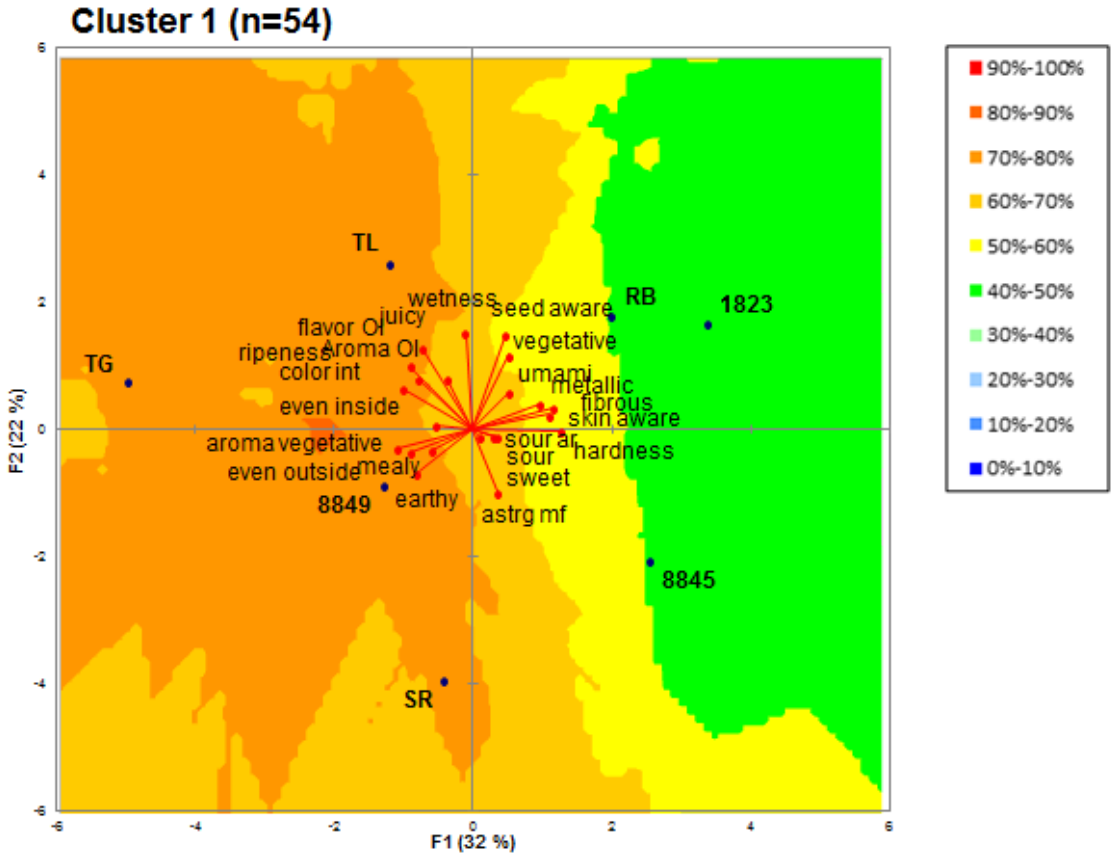

Figure 10. External Preference Map of tomato descriptive terms with percentage of cluster 1 consumers predicted to like tomatoes in that area of the map. Bold terms represent tomato cultivars (Table 3). Colors indicate the percentage of consumers in cluster 1 predicted to like each cultivar.

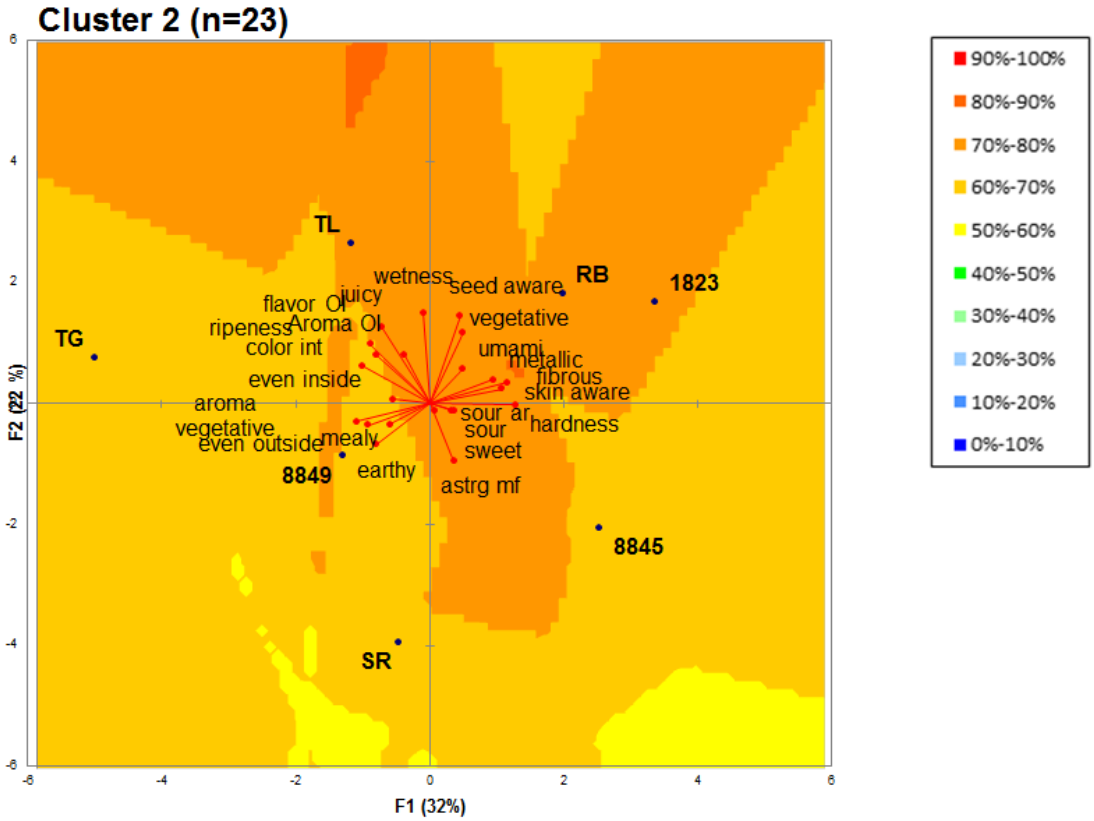

Figure 11. External Preference Map of tomato descriptive terms with percentage of cluster 2 consumers predicted to like tomatoes in that area of the map. Bold terms represent tomato cultivars (Table 3). Colors indicate the percentage of consumers in cluster 2 predicted to like each cultivar.

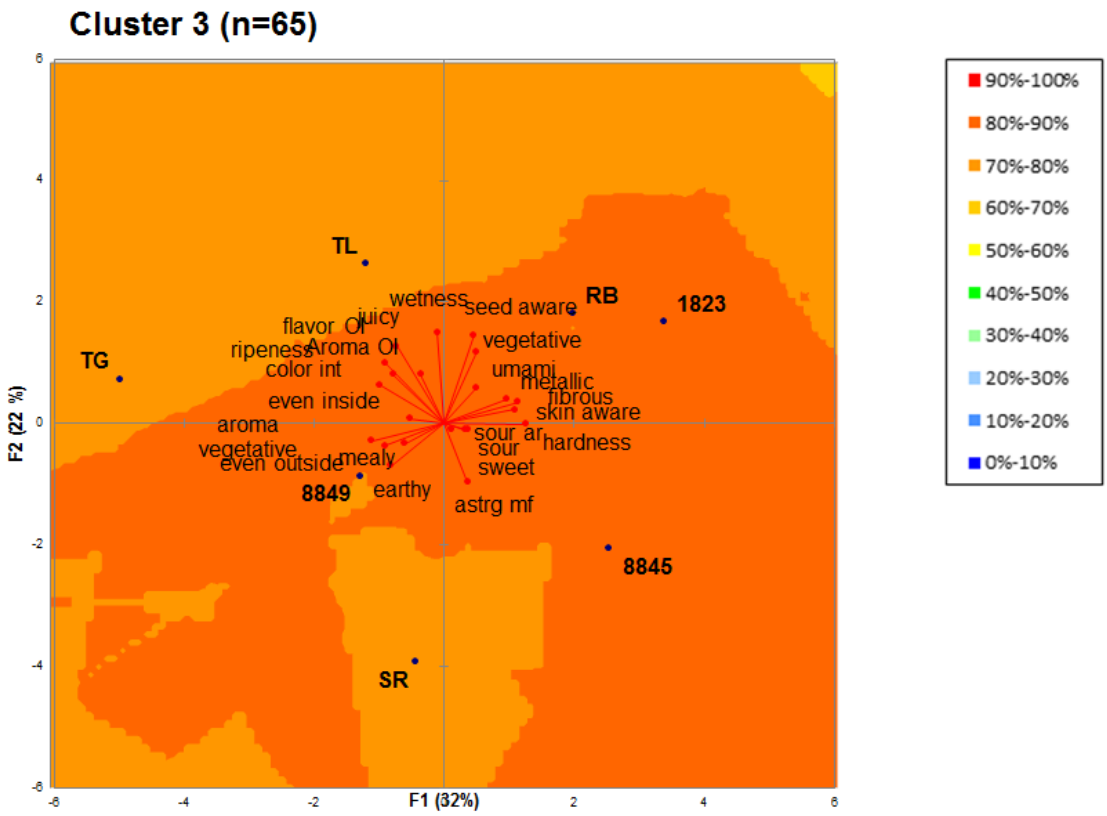

Figure 12. External Preference Map of tomato descriptive terms with percentage of cluster 3 consumers predicted to like tomatoes in that area of the map. Bold terms represent tomato cultivars (Table 3). Colors indicate the percentage of consumers in cluster 3 predicted to like each cultivar.

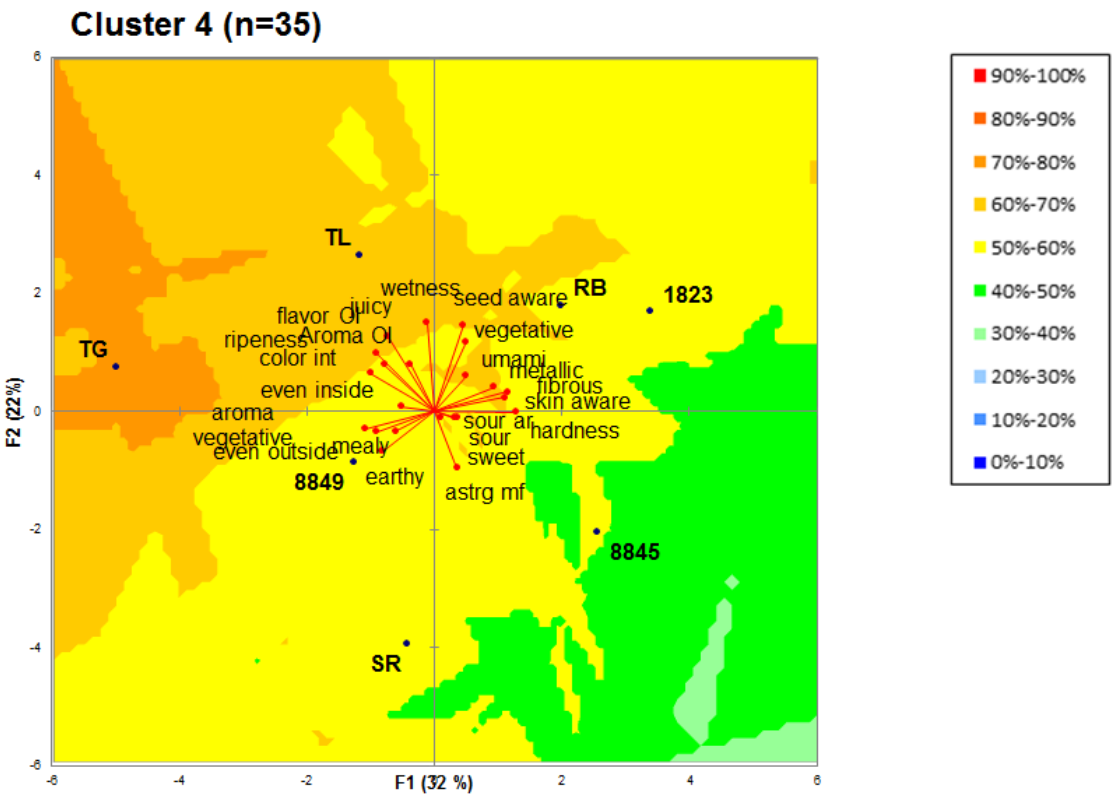

Figure 13. External Preference Map of tomato descriptive terms with percentage of cluster 4 consumers predicted to like tomatoes in that area of the map. Bold terms represent tomato cultivars (Table 3). Colors indicate the percentage of consumers in cluster 4 predicted to like each cultivar.

CHAPTER 4

Identifying Key Consumer Attributes for Protein Beverages

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ABSTRACT

This study identified key consumer attributes of protein beverages and evaluated effects of priming on liking of protein beverages. An adaptive choice-based conjoint study was conducted along with Kano analysis to gain insight on protein beverage consumers (n=432). Attributes evaluated included label claim, protein type, amount of protein, carbohydrates, sweeteners and metabolic benefits. Utility scores for levels and importance scores for attributes were determined. Subsequently, two pairs of clear acidic whey protein beverages were manufactured that differed by age of protein source or the amount of whey protein per serving. Beverages were evaluated by 151 consumers on two occasions with or without priming statements. One priming statement declared "great flavor", the other priming statement declared 20 g protein per serving. A two way analysis of variance was applied to discern the role of each priming statement. The most important attribute for protein beverages was sweetener type, followed by amount of protein, followed by type of protein followed by label claim. Beverages with whey protein, naturally sweetened, reduced sugar and $\geq$15 g protein per serving were most desired. Three consumer clusters were identified, differentiated by their preferences for protein type, sweetener and amount of protein. Priming statements positively impacted concept liking ($p<0.05$) but had no effect on overall liking ($p>0.05$). Consistent with trained panel profiles of increased cardboard flavor with higher protein content, consumers liked beverages with 10 g protein more than beverages with 20 g protein (6.8 vs 5.7, $p<0.05$). Protein beverages must have desirable flavor for wide consumer appeal.

INTRODUCTION

Protein beverages are consumed in the US for various health benefits. They are used by consumers to manage weight, for sports nutrition and those looking for a satiating snack. The functional beverage market is a growing area because there is a developing interest by consumers to take a more proactive role in health without relying on pharmaceuticals (Corbo and others 2014). In addition, as medical costs rise, consumers are looking for a more cost-effective way to ensure proper nutrition and health (Özer and Kirmaci 2010). Typically, commercial protein beverages contain 5-40 g protein per serving, and a required protein content for protein beverages has not yet been established. Similarly, functional foods are only loosely defined as providing necessary nutrients (like protein) to prevent nutrition related diseases (Henry, 2010; Spano, 2010). High protein foods are a growing commodity with 54% of U.S. consumers trying to incorporate more protein into their diets (Gerdes 2012). Whey proteins are desirable for protein beverage formulation because of their high quality proteins and solubility over a wide pH range (Pelegrine and Gasparetto 2005, Fachin and Viotto 2005). In addition to whey proteins, other sources of protein are commonly used in beverages including casein, milk protein and plant proteins.

Functional beverages must be able to deliver good flavor in addition to the functional ingredient in order to gain consumer acceptance (Gruenwald, 2009). Previous studies with protein beverages have addressed specific flavors associated with whey and soy proteins (Wright and others 2009, Childs and others 2007, Carunchia and others 2005, Russell and others 2006). Other studies have addressed astringency and consumer perception of astringency in whey protein beverages (Withers and others 2014, Childs and Drake 2010).

The impact of different processing parameters on whey protein flavor and comparisons with milk serum proteins have also been evaluated for impact on consumer acceptance of protein beverages (Evans and others 2010; Wright and others 2009). Childs and others (2007) compared sensory properties and consumer acceptance of beverages made with soy or whey protein. In this study, whey protein beverages were preferred over beverages made with whey/soy blends, and these were preferred over beverages made with soy protein. All of these studies demonstrated that protein-specific flavors (e.g. cardboard, brothy, cereal) were not liked by consumers in protein beverages.

Conjoint analysis is a research survey technique that separates a product into different attributes in order to determine the weight of importance of each attribute to consumers. Conjoint analysis has been widely applied to determine consumer preference of both intrinsic and extrinsic attributes of food products (Jervis and others 2012; Kim and others 2013; Childs and others 2009; Chung and others 2011). Childs and others (2008) conducted a conjoint analysis with protein bars and beverages and found that consumers had a low preference for specific protein type, but were aware of and desired protein content in protein bars and beverages. If manufacturers are aware of attributes consumers desire in a protein beverage, an opportunity exists to prime them with such facts in order to increase liking of that product.

Priming is a technique that uses an exposure to engage specific mental feelings (She and MacDonald, 2014). Using priming statements before a consumer has a chance to taste the product means the consumer has already formed an opinion on that product without ever having seen it. Priming can be used to activate positive implicit attitudes and measuring these

implicit attitudes in comparison to conscious liking evaluation may provide important information for understanding consumer behavior (Veldhuizen and others 2010). Although the application of proteins in beverages and the popularity of protein beverages are known, there is limited information detailing which attributes consumers find desirable in protein beverages. Childs and others (2008) used focus groups and a conjoint study and reported that protein content, vitamin/mineral content and heart health claim were among the top attributes when evaluating both protein beverages and protein bars. However, the protein beverage market has expanded considerably since 2008 and more information about the benefits of protein and specific protein types are now more widely known. Further, no studies to our knowledge have evaluated consumer perception of protein beverages and subsequently, the effects of priming on beverage liking. Because of the knowledge gap in the area of desirable protein beverage attributes and effectiveness of priming protein beverages, the objective of this study was to identify key attributes for protein beverages and to investigate whether priming consumers with these drivers would increase liking of protein beverages.

MATERIALS AND METHODS

Experimental Overview

An online survey with conjoint and Kano analysis was conducted. Subsequently, protein beverages were manufactured and a consumer acceptance test was conducted with the manufactured beverages. Consumers evaluated beverages on two different occasions with or without different priming statements. The use of priming statements was investigated to determine if priming statements increased liking of the beverages.

Survey

An online survey was created using SSI Web (Sawtooth Software version 8.2.2, Orem, UT). Participants (n=432) were 18-70 y, with an even spread of age, gender and income, and consumed protein beverages at least twice per month. The survey was launched to an online database maintained by North Carolina State University with over 5,000 participants at the time of the survey. Participants were selected based on their responses from a short demographic section before the survey. Participants who did not meet the usage requirements described above were eliminated.

An adaptive choice based conjoint (ACBC) was used, which incorporates the benefits of both choice based conjoint (CBC) and adaptive choice analysis (ACA) (Orme 2010). ACBC has been shown to engage respondents more, allowing them to respond in a way that is more indicative of how they would actually behave in a market setting (Jervis and others 2012). The attributes and levels (Table 1) were designed to be easily understood by consumers. There were 6 attributes with 3-5 levels per attribute. The survey was designed with one build-your-own (BYO) task followed by 10 choice tasks, with 3 product concepts per task with the possible responses of “a possibility” or “won’t work for me” for each product concept. A minimum of 2 and a maximum of 3 attributes varied from the BYO selections for each product concept. Each product concept was a random generation of levels within each attribute, with each attribute represented in all 10 choice tasks. Three unacceptable questions and 2 must-have questions were built in through the survey. The screening task was followed by a 10-question choice task tournament section. A maximum of

20 product concepts were brought into the tournament section, with three concepts per choice task.

Kano questions were asked after the conjoint tournament; questions contained the same elements of the conjoint survey, with questions about calcium, all-natural, organic, vitamins and minerals and free amino acids added. Kano analysis is a technique where attributes are classified based on how consumers assess them (Kano and others 1984; Erto and others 2011; Kim and others 2013). The assessment shows how consumers react when certain elements are present/missing. The classification includes the labels: **Attractive-** unexpected by the consumer; consumers are satisfied if this attribute is present. **Indifferent-** attributes that the consumer does not care about. **Must have-** expected by the consumer; if unavailable, consumers are dissatisfied. **One dimensional-** as the attribute increases, so does consumer liking. **Reverse-** leads to dissatisfaction. Attributes were presented to participants in the form of a paired question. Each question was posed to the consumer as the attribute fulfilled (functional) and not fulfilled (dysfunctional). For example: protein beverage WITH 10 grams of protein per serving and protein beverage WITHOUT 10 grams of protein per serving. The response options for each question included 'I will like it', 'I must have it', I do not care', 'I can live with it' and 'I will dislike it'. The complete survey (demographics, conjoint and Kano questions) was uploaded to an internet server. Participants (n=432) were recruited through email listservs to the online database described previously. Upon completion of the survey, participants were entered into a drawing for one of twenty $25 Target ® gift card drawings.

Beverage Formulation

Following the consumer survey, whey protein isolates (WPI) were selected for beverages by sensory screening of >15 WPI of various ages and sources (described in descriptive analysis section). Liquid whey protein (90% protein, 30% solids) was selected for its mild flavor profile and a 24 mo dried WPI with cardboard and brothy flavors was selected for its distinct storage-associated off flavors (Wright and others 2009). Both whey proteins were from Cheddar whey. Beverages were formulated to contain either 10 or 20 grams protein in a 237 mL serving. Two pairs of protein beverages were manufactured: one differed on the amount of protein (10 versus 20 g per serving) and the other differed on the type of protein used (fresh liquid whey protein versus 24mo WPI). The acidified whey protein beverage was adapted from that reported by Childs and Drake (2010) and White and others (2013) (Table 2). A 3:1 2M blend of phosphoric:malic acid was used to acidify beverages to pH 3.2 (White and others 2013). Beverages were pasteurized at 85C for 15 sec (Cole and Jones 1990) and stored at 3C until serving.

Descriptive analysis

WPI were rehydrated to 10% solids w/v and tempered to room temperature (21 C) before tasting. Descriptive analysis was also conducted to document sensory attributes of the beverages (Table 3). Liquid or rehydrated WPI or beverages were poured into 118 mL lidded soufflé cups (Dart Container Corp., Mason MI) and tempered to 15C prior to evaluation. Trained panelists (6 panelists: females ages 23-50 y) used an established lexicon (Wright and others 2009, Evans and others 2010) to evaluate whey proteins or beverages. Attributes were scaled using a 0-15 point Spectrum ™ universal intensity scale (Meilgaard and others 1999).

Each panelist evaluated each whey protein or beverage in triplicate. Panelists were instructed to expectorate products. A 3 minute rest with a water and cracker rinse were enforced to minimize carryover effects. Paper ballots or Compusense five v5.6 (Guelph, Canada) were used for data collection.

Consumer Testing

Consumer acceptance testing was conducted to determine the effect of priming statement on liking of protein beverages. Consumers (n=151) evaluated 2 beverage pairs on 2 separate occasions, 6 weeks apart. Pair 1 differed on the type of protein used (fresh liquid whey protein versus stale WPI powder) with beverages both formulated to contain 10 grams of protein in a 237 mL serving. Pair 2 differed on the amount of protein (made with fresh liquid whey protein) present in a 237 mL serving: 10 grams per serving versus 20 grams per serving. Beverages were processed the day before the consumer test to ensure freshness. Consumer testing was approved by the University Institutional Review Board for Human Subjects. Participants (50% male, 50% female, ages 19-64 y) purchased and consumed protein beverages within the past month, were not lactose intolerant and willing to try a clear fruit flavored protein beverage. Participants were recruited through email listservs to an online database of more than 7,000 consumers in the Raleigh/Durham, NC area maintained by North Carolina State University Sensory Service Center and compensated with a $40 Target ® gift card after the second day of testing.

Approximately 75 mL of beverage was poured into black 118 mL soufflé cups (Dart Container Corp., Mason MI) with three-digit codes; black cups were used to minimize visual differences between beverages. The beverages were served at 4C. Both beverage pairs were

evaluated each day, repeating the same two pairs for the second day of testing. On the first day, consumers evaluated 2 pairs of beverages with or without a priming statement. At the subsequent evaluation 6 weeks later, the same beverages with or without priming statements were presented. A balanced, randomized presentation was used both days. The priming statement for the first pair was "Sample XXX is a **great tasting** fruit flavored protein beverage with 10 grams of protein per serving (20% of what your body needs daily)" and the unprimed statement to accompany pair 1 was "Sample XXX is a fruit flavored protein beverage with 10 grams of protein per serving (20% of what your body needs daily)." The priming statement for the second pair was "Sample XXX is a fruit flavored protein beverage with **20 grams of protein** per serving (>35% of what your body needs daily)." The unprimed statement for pair 2 was "Sample XXX is a fruit flavored protein beverage that provides protein and nutrients for you." The order of pair presentation, within pair presentation and priming statement presence was balanced and randomized. Consumers were provided with de-ionized water for palate cleansing between samples and a 5 minute rest between beverages was enforced. Crackers and deionized water were provided for palate cleansing.

Consumers evaluated all products for concept liking followed by beverage appearance liking, overall liking and apple flavor liking on a 9-point hedonic scale where 9= like extremely and 1= dislike extremely. Consumers were asked to evaluate purchase intent after concept liking using a 5-point scale where 1= definitely would not purchase and 5= definitely would purchase. Consumers were also asked to evaluate apple flavor, protein flavor and aftertaste on a 5 point JAR scale where 1= too little, 3= just about right and 5= too

strong. Compusense® version 5.2 Plus (Compusense, Guelph, Canada) was used for data collection.

Statistical Analysis

For the conjoint survey, individual utility scores were extracted by hierarchical Bayesian (HB) estimation and rescaled using a zero-centered difference method (Childs and Drake 2009). The zero-centered difference method was used to standardize utility scores for easy interpretation. A one-way analysis of variance with Fisher's least significant difference was applied to utility scores. Cluster analysis of utility scores was performed with XLSTAT version 2012.6.06 (Addinsoft, Paris, France) using Euclidean distances and Wards linkage to categorize similar respondents into groups, Principal component analysis (PCA) (XLSTAT) was also conducted to see how attributes and clusters were characterized. Kano questions were evaluated according to the model proposed by Kano and others (1984).

Repeated measures two way analysis of variance (ANOVA) (priming statement x beverage type) was performed on the consumer acceptance data using XLSTAT (Addinsoft, New York, NY) with means separation using Fisher's least significant difference test. JAR scores were evaluated using penalty analysis and chi-square and 5 point non JAR questions were evaluated using Kruskal-Wallis with the Dunn post hoc procedure also using XLSTAT. All analyses were performed at 95% confidence ($p<0.05$).

RESULTS

Conjoint Survey

The most important protein beverage attribute for the population surveyed (n=432) was sweetener type (figure 1). Sweetener type was followed by amount of protein ($p<0.05$), followed by protein type ($p<0.05$), followed by label claim ($p<0.05$), followed by carbohydrates which was at parity with metabolic benefits ($p>0.05$). Within the attribute sweetener type, naturally sweetened had the highest utility score, followed by reduced sugar ($p<0.05$) (Figure 2). For the attribute amount of protein, 20 grams per serving had the highest utility, followed by 15 grams per serving ($p<0.05$). Whey had the highest utility for protein type, followed by milk protein ($p<0.05$), followed by soy protein ($p<0.05$). For the attribute label claim, great taste had the highest utility, followed by all natural ($p<0.05$), followed by no claim ($p<0.05$), followed by gluten free ($p<0.05$), followed by lactose free ($p<0.05$). Low carb had the highest utility, followed by carb free for carbohydrates ($p<0.05$), and keeps you full (satiety) had the highest utility, followed by helps stimulate your metabolism ($p<0.05$), followed by easy to absorb by your body ($p<0.05$), followed by easy to digest ($p<0.05$).

Three distinct consumer clusters were identified from utility scores (figure 3). Important attributes to consumers in cluster 1 (n=86) were protein type, followed by amount of protein which was at parity with sweetener ($p>0.05$). Of these attributes, milk protein had the highest utility score within protein type, 10 grams of protein per serving was the preferred level for amount of protein and naturally sweetened had the highest utility of attribute sweetener. In cluster 2 (n=184), sweetener was the most important attribute, followed by protein type ($p<0.05$), followed by amount of protein ($p<0.05$). For these consumers,

naturally sweetened, whey protein and 20 grams per serving had the highest utilities. In cluster 3 (n=162), amount of protein had the highest utility, followed by protein type ($p<0.05$), followed by label claim and sweetener, which were at parity ($p<0.05$). Twenty grams protein per serving, whey protein, great taste and naturally sweetened had the highest utilities within attributes for these consumers.

Kano questions

Clusters observed in utility scores were also present for Kano analysis (Table 3). Cluster 1 (n=86) consumers reported great taste and keeps me full as one dimensional items and all natural and vitamins and minerals as attractive attributes. For cluster 2 consumers (n=184), vitamins and minerals (plus calcium), keeps me full and all natural were attractive. Artificial sweetener was a reverse attribute. In cluster 3 (n=162), great taste was one dimensional, keeps me full was a must have and sugar free, reduced sugar, all natural nonnutritive sweetener, vitamins and minerals (plus calcium), 15 grams of protein per serving and 20 grams of protein per serving were all attractive attributes. Other attributes for clusters were indifferent.

Descriptive analysis

Beverages made with fresh liquid WPI at 10 g protein per serving had high intensities of fruity flavor and sweet and sour tastes and had low levels of cardboard flavor; beverages formulated with 20 g protein per serving had higher viscosity, astringency and sweet and sour tastes (Table 4). Beverages with 24 mo WPI had higher cardboard, sulfur/brothy and soapy flavors than those made with fresh liquid WPI ($p<0.05$).

Consumer testing

No interactions were observed between sample and priming statement for both beverage pairs tested ($p>0.05$). Main effects were observed ($p<0.05$) for both beverage pairs and for both priming statements: protein source (pair 1) and protein amount (pair 2) influenced overall liking ($p<0.05$); priming statements influenced concept liking but had no effect on overall liking after tasting ($p>0.05$).

In pair 1, primed concept liking was scored higher than unprimed concept liking (Figure 4). Also in pair 1, source of whey protein (fresh versus 24 mo) impacted liking with beverages made with fresh whey protein preferred to those made with 24 mo WPI (Figure 5). For pair 2, primed concept liking scored higher than unprimed concept liking (Figure 6). There was a significant difference in liking for appearance of pair 2 beverages. Beverages with 10 g per serving protein scored higher in appearance liking than beverages containing 20 g per serving protein (Figure 7), this may be due to the increased visual viscosity of the higher protein beverage. For the overall liking of pair 2 beverages, beverages with 10 g per serving protein scored higher in overall liking than beverages containing 20 g per serving protein (Figure 8).

DISCUSSION

Sweetener type was the most important attribute, with natural sweetener having the highest utility. In Kano analysis, for cluster 2, artificial sweeteners were a reverse attribute. Bearth and others (2014) reported that consumers preferred natural to artificial sweeteners and hypothesized that consumers were apprehensive of consuming artificial sweeteners

because of perceived risk of food additives and lack of awareness of health risks. Additionally, consumers have been shown to have more positive attitudes towards natural or organic products than those without such qualities (Apaolaza and others 2014, Abrams and others 2010, Rozin and others 2004). Kano analysis supported the findings of the conjoint, with all natural being attractive for the entire population.

Amount of protein was important to all consumers, which is consistent with the findings of Childs and others (2008).However, an awareness of specific protein type was apparent in the current study and cluster 1 consumers identified protein type as the most important beverage attribute. This result was not observed by Childs and others (2008) where whey and soy proteins were the only protein sources evaluated. Childs and others (2008) reported that consumers had a low preference for specific protein type. From the present study, milk and whey proteins were more desirable in protein beverages than casein or soy protein or other plant based protein sources. This may be due to greater familiarity with milk and whey proteins and their specific health benefits. Studies have proved the positive effect of familiarity (with a product or concept) on liking (Hong and others 2014, Hansen and Wänke 2009). Milk and whey proteins have been shown to have health benefits beyond basic nutrition such as bioactive compounds with antimicrobial or antiviral activity, immune promoting compounds, anticarcinogenic properties and cardiovascular health-promoting features (Solak and Akin 2012).

Among label claims, consumers preferred satiation and stimulated metabolism. With carbohydrate content, consumers preferred low-carb. These combined results suggest that consumers want a protein beverage that will not contribute many calories to their daily

intake, added energy to engage in sustained activity and a functional beverage that keeps them from overeating (by not feeling satiated). These findings were identical to Kano analysis where keeps me full was an attractive feature for the entire population. Preventing hunger and smaller calorie intake leads to weight loss. Popular diets such as the South Beach Diet and the Atkins diet promote high protein and low-carbohydrate foods, which can include dairy foods (Powers 2005). In several studies, participants reported higher satiety when consuming high protein diets rather than normal protein diets (Westerterp-Plantenga and others 2006, Westerterp-Plantenga and others 2009a, Westerterp-Plantenga and others 2009b, Lejeune and others 2006). Consumers may look to protein beverages to fulfill requirements for weight loss.

From the survey with conjoint and Kano sections, 3 clusters of protein beverage consumers were characterized. Great taste was important to all consumers. Gruenwald (2009) reviewed functional beverages and stated that functional beverages must taste good in addition to providing advanced nutrition in order to be deemed acceptable by consumers. In cluster 1, consumers were driven by the type of protein (milk protein preferred), amount of protein and sweetener (all natural attractive). These consumers want a beverage that fulfils multiple functions but did not consider any attribute to be especially more important than others. Cluster 2 consumers also thought sweetener type was most important and wanted a functional, healthy beverage: naturally sweetened and low sugar were important, artificial sweeteners were disliked and calcium and vitamins were attractive. Cluster 3 consumers placed the highest importance on amount of protein per serving and wanted a protein beverage with low sugar that promised satiety. These results suggest that these consumers

consume protein beverages for the functionality of protein content. Childs and others (2008) reported that consumers were aware of protein content in functional products. Additionally, some consumers desire low carbohydrate products to reduce body weight (Crowe 2005). Childs and others (2008) also identified a cluster of consumers who, like cluster 3 in the present study, valued whey protein in a beverage, preferred low carbohydrates and needed the beverage to be a good source of protein. As stated earlier, consumers may look at protein content as an indicator of satiety.

Since protein amount and great taste were key attributes for protein beverages in the conjoint portion in this study, these parameters were used to gauge the effectiveness of priming attributes in actual beverages. From consumer testing results, priming with a statement declaring protein content increased concept liking of that protein beverage, consistent with conjoint results. Declaring great taste increased concept liking of protein beverages; consumers value great taste of functional beverages in addition to health benefits (Gruenwald 2009). Consumers are also aware of protein content in a protein beverage. Declaring protein content may indicate to consumers that this beverage will be satiating, which was also an important feature to consumers from the conjoint study. Weigle and others (2005) and Leidy and others (2007) reported that test subjects reported greater satiety when consuming an increased-protein diet than a control diet. Bilman and others (2010) reported that consumers perceived snacks containing high amounts of protein to be more satiating compared to sweet products and multiple small items. The satiating effects of protein may be known to consumers.

Overall liking was scored after tasting, and consumers preferred beverages made with fresh versus 24 mo whey protein and beverages with 10 g per serving protein versus 20 g per serving protein regardless of whether a priming statement was present. Trained panel results confirmed the presence of higher protein-related flavor attributes in the 24 mo and 20 g per serving protein beverages (Table 3). Previous studies have demonstrated that consumers dislike protein beverages that have protein-associated off flavors such as cardboard and brothy flavors and that these flavors increase with increased protein content (Wright and others 2008, Evans and others 2010, Childs and Drake 2010). Frankowski and others (2013) noted that consumers also preferred lower viscosity in clear acidic protein beverages. These previous studies did not have priming statements of any type presented to consumers. Lawless and others (2012) reported that consumers exhibited higher willingness to pay for nutraceutical juices when given positive priming statements after tasting the beverages. Additionally, when given information about great brands of champagne versus middle or low-priced brands, consumers had a distinct preference for great brand champagnes whereas when the champagnes were tasted blind, there was no distinct preference (Lange and others 2002). Additional information given and primes may positively influence subsequent liking or willingness to pay for certain products, but don't necessarily influence overall liking when the product has an undesirable flavor. The current study further emphasizes consumer desire for a functional beverage to deliver great taste. In addition to differentiating flavors of beverages, consumers were able to differentiate beverages with different protein content based on appearance. A significant difference in appearance liking was observed for 10 g protein per serving and 20 g protein per serving beverages. Appearance is an important factor

for protein beverages in a buying situation because the product cannot readily be sampled at the time of purchase. Visual viscosity may be a positive or negative factor in protein beverages based on what the consumer expects (eg higher viscosity is desirable for a chocolate “shake” but may not be desirable for clear fruit flavored beverages). A protein beverage, regardless of functional ingredient, nutrition content or health claim will not be liked unless it can deliver great taste in addition to functionality or nutrition.

CONCLUSION

Key attributes for protein beverages were sweetener type, amount and type of protein, great taste and satiation. Clusters of protein beverage consumers have different preferences for their ideal beverage: cluster 1 was interested in a functional beverage as a whole, cluster 2 was health conscious and sweetener aware and cluster 3 was interested in a high protein beverage with few calories from sugar. All 3 clusters believed taste and satiation were important. In the consumer study with protein beverages, it was found that priming with positive statements can increase concept liking of protein beverages, which is applicable to a successful package design. The use of priming statements did not impact overall liking of beverages; flavor influences liking more than a positive prime. Liking scores were highest for beverages with 10 g fresh WPI per serving, which displayed the lowest intensities of protein-related flavors. Positive priming statements about great taste or protein content do not affect overall liking of a protein beverage. However, great taste and declaration of protein content in concepts are more favorable than beverages without such claims. Great taste is the main parameter for overall liking of protein beverages.

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Table 1- Attributes and levels used in conjoint survey

Attribute	Label Claim	Protein Type	Amount of protein	Carb content	Sweetener	Metabolic benefits
Levels	Great taste	Whey protein	20 grams per serving	Low carb	Naturally sweetened	None
	All natural	Milk protein	15 grams per serving	Carb-free	Reduced sugar	Keeps you full (satisfying)
	No claim	Soy protein	10 grams per serving	Contains carbs	Sugar-free	Helps stimulate metabolism
	Gluten free	Casein	5 grams per serving		Non-caloric sweetener	Easy to absorb by your body
	Lactose free	Other protein source				Easy to digest

Table 2- Whey protein beverage formulations

Protein per serving	Liquid whey protein isolate (%)	fructose (%)	3:1 2M phosphoric: malic acid (%)	Apple flavor (%)	Red food coloring (%)	Deionized water (%)
10 grams	13.66	13.05	2.61	0.03	0.03	70.65
20 grams	25.73	13.93	4.10	0.02	0.03	56.22

*24 mo. whey protein isolate, 10 g serving beverage contained 5.2% whey protein isolate and 79.1% deionized water

Whey protein isolate (Glanbia Nutritionals, Twin Falls ID), Fructose (Tate & Lyle, London UK), phosphoric and malic acids (Mallinckrodt Chemicals, Phillipsburg NJ), apple flavor (FONA, Chicago IL), red food coloring (Food Lion, Salisbury NC)

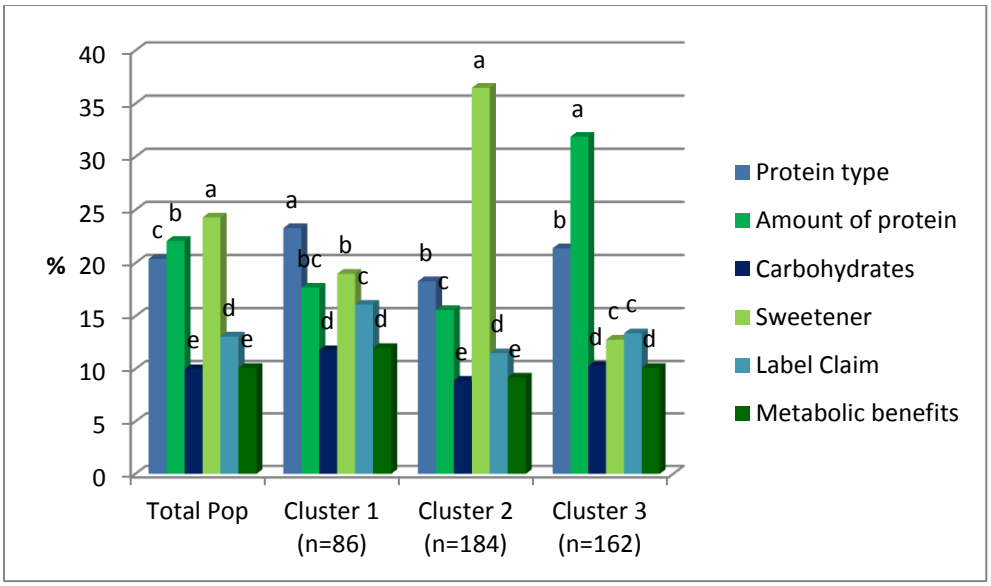

Figure 1- Importance scores of attributes for total population (n=432) and clusters

Attribute importance scores for the total population. Letters (a-e) indicate significant differences ($p<0.05$).

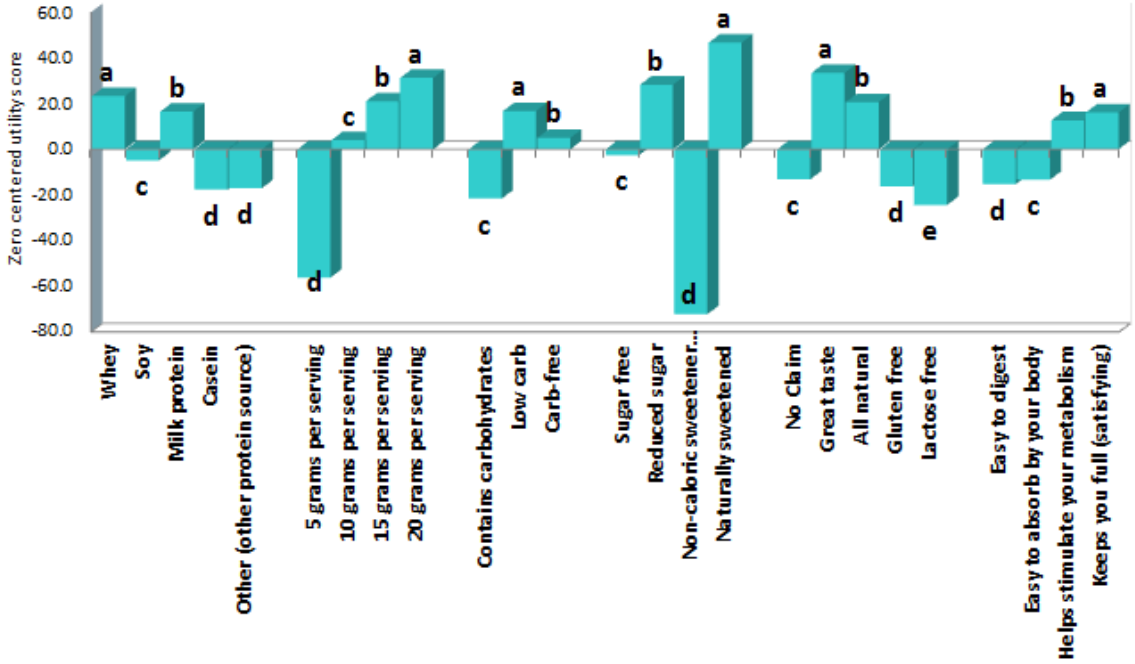

Figure 2- Overall utilities of attributes and levels for total population (n=432)

Zero centered utility values for levels within attributes. Letters (a-e) indicate significant differences ($p<0.05$) within each attribute for the total population (n=432).

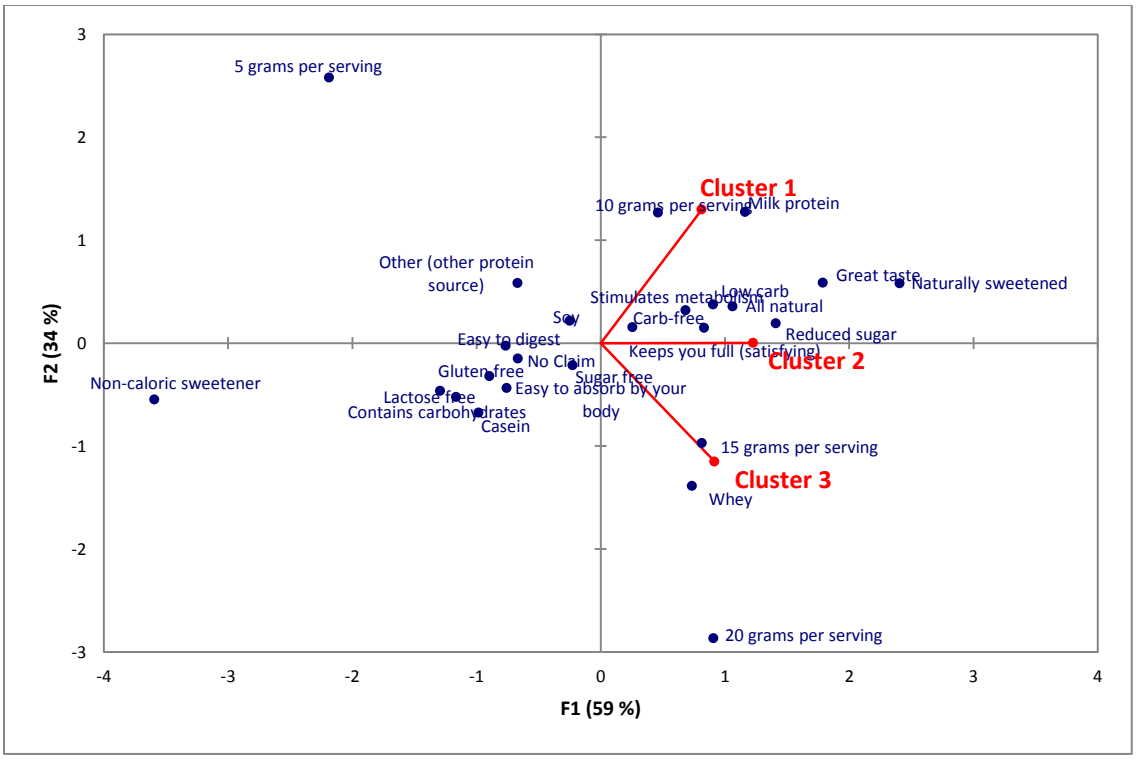

Figure 3- Principal component biplot of clusters from conjoint survey

Principal component biplot of comsumer clusters with respect to utility scores.

Table 3- Kano questionnaire results

Feature: Protein beverages with:	Kano classification			
	Total (n=432)	Cluster 1 (n=86)	Cluster 2 (n=184)	Cluster 3 (n=162)
Calcium	Attractive	Indifferent	Attractive	Attractive
Great taste	One dimensional	One-dimensional	One dimensional	One-dimensional
Whey Protein	Indifferent	Indifferent	Indifferent	Indifferent
Soy Protein	Indifferent	Indifferent	Indifferent	Indifferent
Milk Protein	Indifferent	Indifferent	Indifferent	Indifferent
Casein Protein	Indifferent	Indifferent	Indifferent	Indifferent
Hydrolyzed Protein	Indifferent	Indifferent	Indifferent	Indifferent
5 grams of protein	Indifferent	Indifferent	Indifferent	Indifferent
10 grams of protein	Indifferent	Indifferent	Indifferent	Indifferent
15 grams of protein	Must Have	Indifferent	Indifferent	Attractive
20 grams of protein	Indifferent	Indifferent	Indifferent	Attractive
Keeps me full	One dimensional	One-dimensional	Attractive	Must have
Sugar Free	Indifferent	Indifferent	Indifferent	Attractive
Reduced Sugar	Indifferent	Indifferent	Indifferent	Attractive
All Natural Nonnutritive	Indifferent	Indifferent	Indifferent	Attractive
Artificial Sweetener	Indifferent	Indifferent	Reverse	Indifferent
All natural	Indifferent	Attractive	Attractive	Indifferent
Organic	Indifferent	Indifferent	Indifferent	Indifferent
Vitamins and Minerals	Attractive	Attractive	Attractive	Attractive
Free Amino Acids	Indifferent	Indifferent	Indifferent	Indifferent

Kano classification was calculated by previously described methods (Kano and others 1984). The satisfaction and dissatisfaction questions were asked to consumers and the contingency table of satisfaction and dissatisfaction answers was created for each feature.

Table 4- Descriptive analysis sensory properties of beverages

Beverage	10g/serving fresh	10g/serving stale	20g/serving fresh
Fruity	4.0a	4.0a	3.5b
Cardboard	0.5b	3.5a	1.5b
Sulfur/Brothy	ND	4	ND
Soapy	ND	ND	0.5
Sweet taste	7.0b	7.0b	9.0a
Sour taste	4.0b	4.0b	5.0a
Astringency	3.5b	3.5b	4.0a
Viscosity	1.4b	1.4b	1.7a

Attributes were scored on a 0-15 universal intensity scale. Means in a column followed by a different letter are different ($p<0.05$). ND- Not detected.

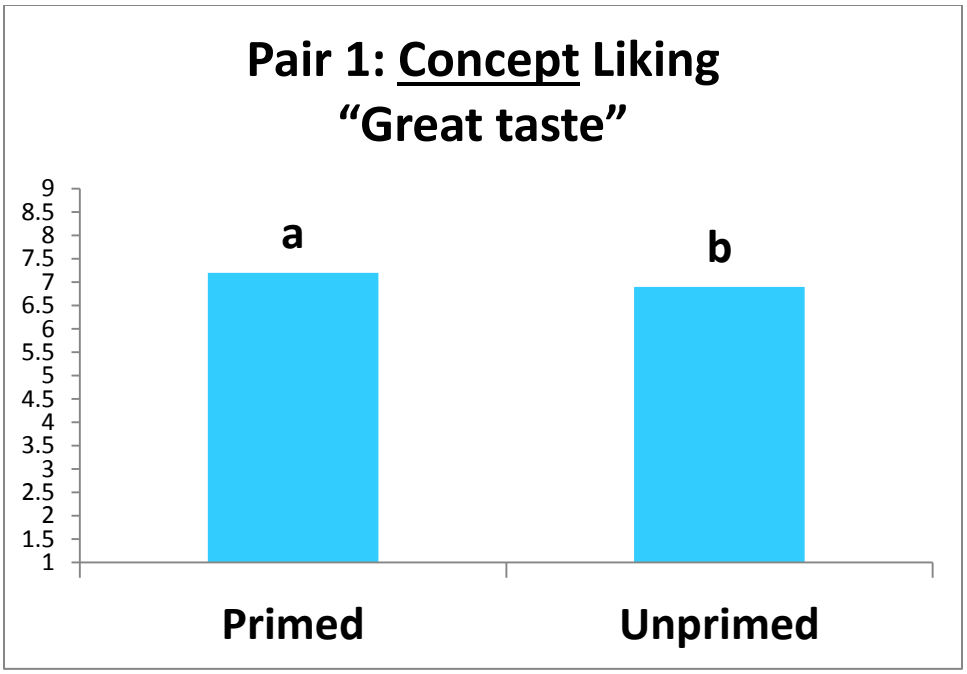

Figure 4- Main effects observed for pair 1 concept liking

Primed and unprimed concept liking hedonic score. Letters (a-b) indicate significant differences ($p<0.05$).

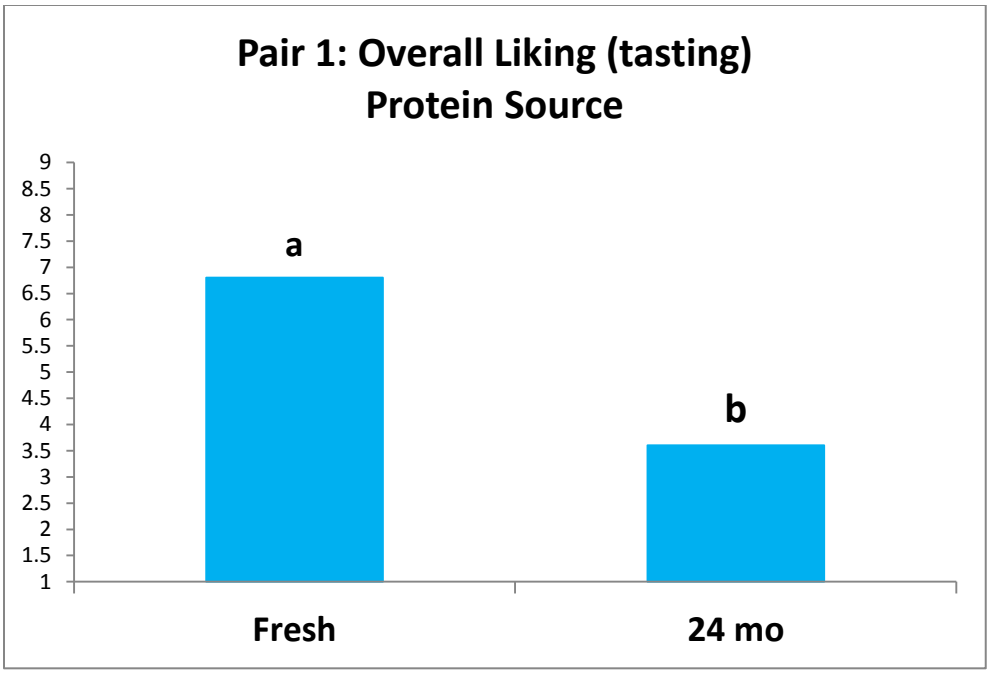

Figure 5- Main effects observed for pair 1 overall liking

Beverages made with fresh or 24 mo whey protein isolate overall liking hedonic score.

Letters (a-b) indicate significant differences ($p<0.05$).

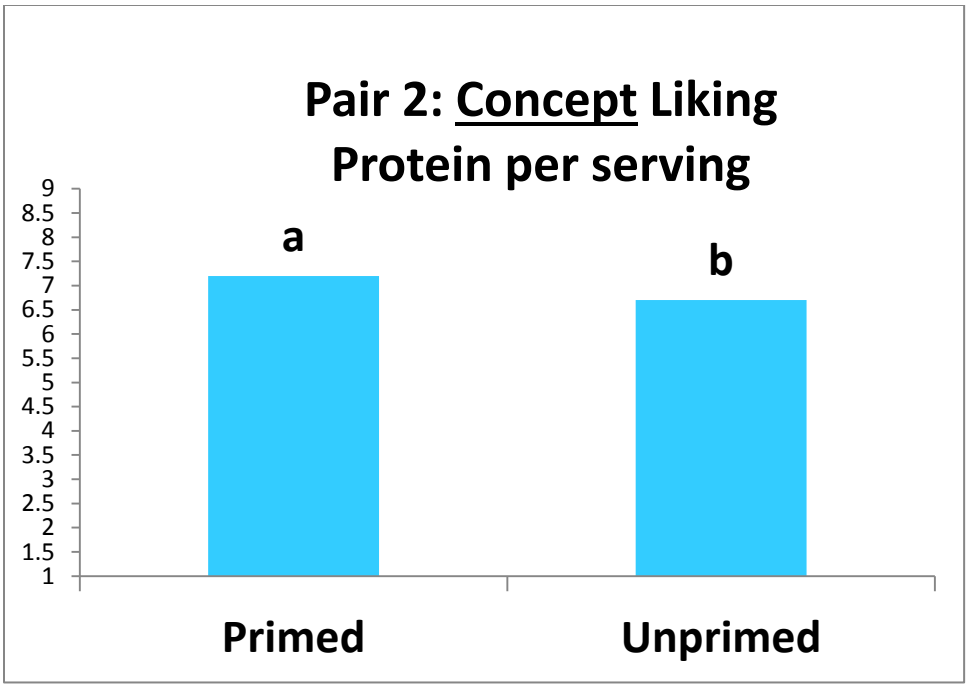

Figure 6- Main effects observed for pair 2 concept liking

Primed and unprimed concept liking hedonic score. Letters (a-b) indicate significant differences ($p<0.05$).

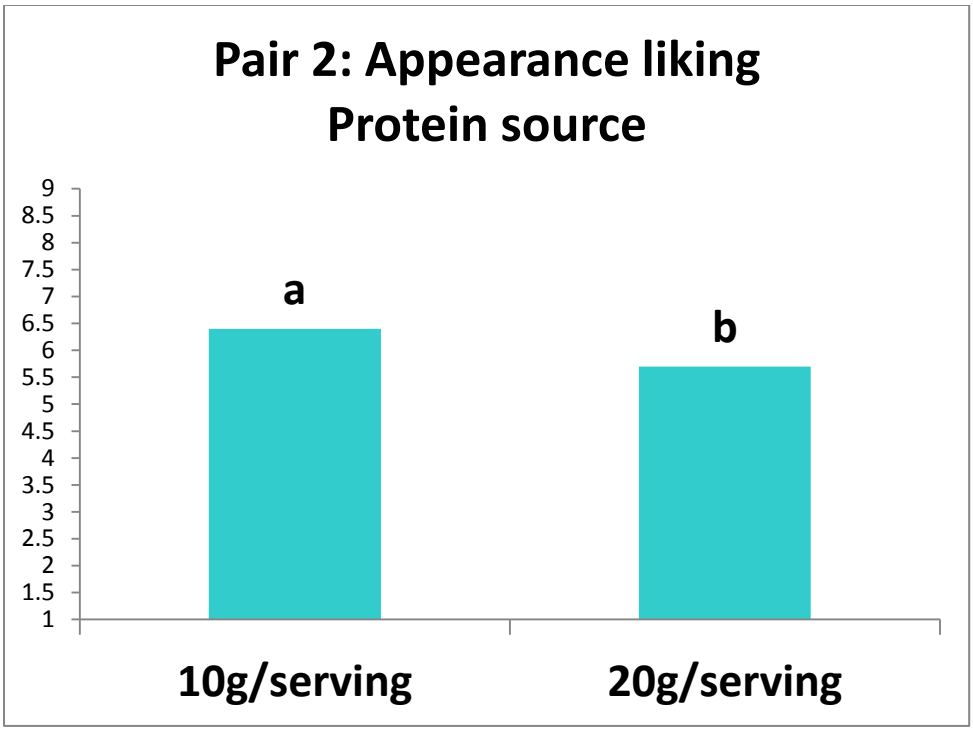

Figure 7- Main effects observed for pair 2 appearance liking

Beverages made with 10 g or 20 g per serving whey protein isolate appearance liking hedonic score. Letters (a-b) indicate significant differences ($p<0.05$).

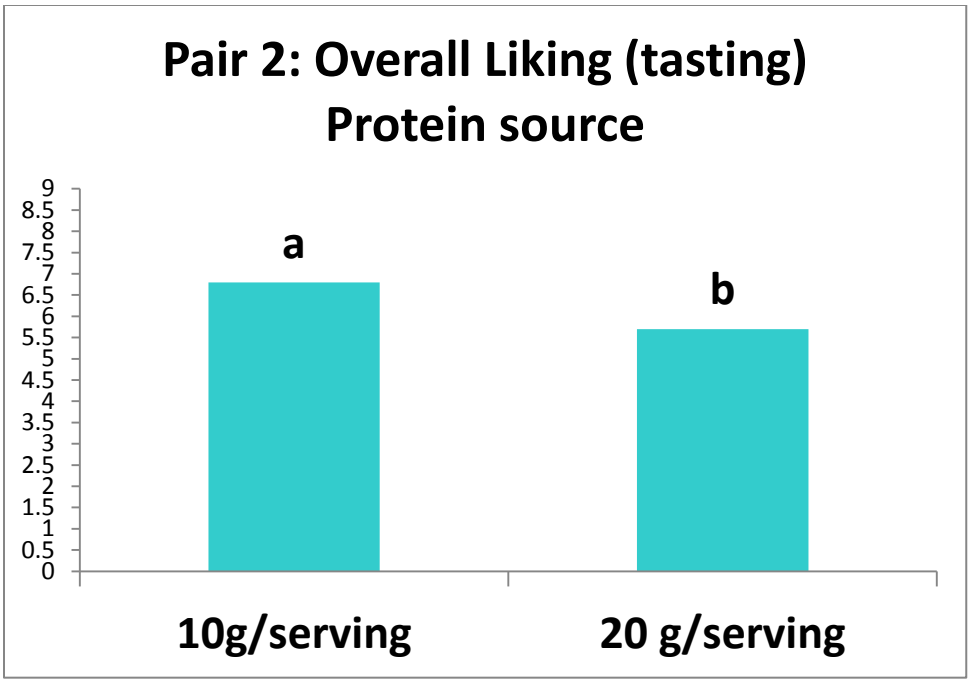

Figure 8- Main effects observed for pair 2 overall liking

Beverages made with 10 g or 20 g per serving whey protein isolate overall liking hedonic score. Letters (a-b) indicate significant differences ($p<0.05$).

Table 5- Hedonic scores for Consumer test

	Primed	Unprimed	Fresh	24 mo	10g/ serving	20g/ serving
Pair 1 Concept	7.2	6.9	-	-	-	-
Pair 2 Concept	7.2	6.7	-	-	-	-
Pair 1 Overall Liking	-	-	6.8	3.6	-	-
Pair 2 Overall Liking	-	-	-	-	6.8	5.7
Pair 2 Appearance Liking	-	-	-	-	6.4	5.7

1-9 scale hedonic scores for concept liking, overall liking and appearance liking for different beverage treatments