FREEZING, PASTEURIZING, AND DRYING EFFECTS ON POMEGRANATE JUICE FLAVOR AND ACCEPTANCE

by

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Abstract

Pomegranate fruits are seasonally produced and require processing to provide year round availability. Effects of processing on phenolic compounds, color, and other physical properties have been examined but few studies have examined the sensory effects. Juice prepared from fresh Wonderful pomegranates was used to prepare fresh frozen juice, batch pasteurized juice, and reconstituted juice from dried arils. These juices were evaluated using analytical and affective sensory methods to increase the understanding of processing effects on pomegranate juice properties. A modified consensus flavor profile showed that a large number of small differences existed. The accumulation of these changes demonstrates the distinction among processing methods. Time intensity multi-evaluation (TIME) profiling, a new method, was used to further understand how multiple attributes, including aromatics, feeling factors, and basic tastes, changed over the course of one sip. Fruity flavor was consistently the first to appear in the profile while bitterness and astringency lasted the longest. The attribute woody displayed longer peak times in the pasteurized and reconstituted samples than seen in fresh frozen juice. Semi-Continuous Consumption (SCC) profiling, another new method, explained product differences over 25 sips that mimicked consumption. Overall, astringent and bitter components increased while fruity and overall sweet attributes declined. These profile changes differed by sample with reconstituted juice showing the least increase in astringency over consumption. The juice samples were subjected to an acceptance test that showed four liking clusters, one that accepted all three juices and three clusters that disliked one of each juice type. The results from these studies are an initial step in describing how processing of pomegranate juice can effect flavor. Understanding the flavor differences is beneficial to processors for marketing products

and for purchasers of these products for ingredient usage. Furthermore, the process of TIME and SCC profiling are described which are beneficial for understanding how multiple flavors change over single and multiple consumption events of a product respectively. These new methodologies are useful in explaining the experience of complex products such as teas and coffees or products exhibiting build-up such as nutrition aides.

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Chapter 1 - Literature Review

Pomegranate Popularity and Consumer Choice

Originating from Iran and the surrounding area, pomegranates have been cultivated for thousands of years yet are still considered emerging crops although well noted for ancient uses and cultural importance (Hummer *et al.* 2012). Pomegranate products have been increasing in popularity as a result of recent studies documenting their health benefits (Faria and Calhau. 2011). Aside from health benefits, Mintel reports that liking the taste is the top reason (at 77%) for juice purchase (Mintel. 2013). Focusing on flavor Koppel *et al*. (2014) have shown that differences in pomegranate juice acceptance exist across countries. Moreover, pomegranate cultivars in various areas of the world show differentiating characteristics. For example, some Spanish and Turkish varieties exhibit sweeter characteristics than the American variety 'Wonderful' which is typically more sour. Pomegranates are being used in foods, beverages, cosmetics, and in medicines. In the United States, POM Wonderful, a major pomegranate processor, has been recently strengthening its brand (Rymon. 2011). POM Wonderful has announced that it has launched a program to further the development of pomegranate based products. Beverage World magazine noted that this includes the use of juices, powders, extracts and arils in a variety of food and beverages (Anonymous. 2013).

Health

Pomegranates contain a number of functional compounds that are responsible for beneficial health properties. Polyphenolic compounds are primarily responsible for these benefits and include phenolic acids, flavonoids (e.g. anthocyanins), and tannins (Tzulker *et al.*

2007). These compounds have shown effects in many studies including those related to cardiovascular, anti-inflammatory, anticancer, and antidiabetic conditions. However, many of the documented benefits have not been investigated through clinical trials and further research in this area has been indicated to be beneficial for further understanding (Faria and Calhau. 2011; Johanningsmeier and Harris. 2011; Viuda-Martos *et al.* 2010).

Recently, an initial clinical trial has exposed patients undergoing hemodialysis treatment to pomegranate juice to measure the resulting effects on cardiovascular risk factors and events. Shema-Didi *et al.* (2014) administered 100 ml of pomegranate or placebo juice to hemodialysis patients three times a week during dialysis treatment for one year in a double-blind study. Hemodialysis patients have been shown to have an increased risk for factors contributing to cardiovascular disease compared to the general population. Markers of cardiovascular disease risk, including blood pressure, pulse pressure, and blood lipid profiles, were measured in this study. The results demonstrated improved systolic blood pressure, pulse pressure, and improved lipid profiles (specifically related to high density lipoproteins and triglycerides).

Type 2 diabetes can cause types of inflammation that play a key role in cardiovascular disease development. Due to this risk, insulin levels and inflammatory markers have been examined pre and post consumption of pomegranate or placebo juice in a recent initial clinical trial (Sohrab *et al.* 2014). Each patient in this double blind procedure was provided enough product to consume 250 ml of pomegranate or placebo juice on a daily basis for 12 weeks. Post consumption significant differences were exhibited in two inflammatory markers (interlukin-6 and C-reactive protein) when compared to baseline within the pomegranate juice group and in comparison to the placebo group.

Understanding Consumer Choice

Many reasons consumers decide to purchase juice are related to health (Mintel. 2013). There are several ways to understand if consumers are interested in healthy eating. These methods typically include dietary assessment to understand current eating habits. Tests such as Food Diaries, Food Recall, and Food Frequency Questionnaires are not only lengthy but expensive processes. However, a model by Soontrunnarudrungsri (2011) using three questions related to the stages of change is suggested to be the best way to segment consumers interested in healthier eating. The stages of change, as described by Prochaska and Norcross (2001), are listed in Table 1-1.

Table 1-1 Stages of Change Descriptions

Stage of Change	Description
Precontemplation	Individual is unaware of problems and there is no intention to change behavior
Contemplation	Individual is aware problem(s) exists is thinking of taking action but has not yet committed to the action
Preparation	Individual plans to take action in the next month and has had unsuccessful action in the past year
Action	Individual is modifying behavior and environment to overcome problem
Maintenance	Individual continues to modify behavior to prevent relapse of the problem for at least 6 months

The first question asks the consumer if they regularly consume a healthy diet. Upon answering "no" the consumer is then asked if they plan to change their diet to be healthier. If not planning to change their diet they were considered to be in the Precontemplation stage. If planning to change in the next month to 6 months they were considered to be in the Preparation and Contemplation stages respectively. If answering "yes" to the first question and making serious changes in the last 6 months they were considered in the Action stage. If indicating a healthy diet for longer than 6 months they were considered in the Maintenance stage (Soontrunnarudrungsri. 2011).

The USDA recommends eating a variety of fruits as they contain varying nutritional content (United States Department of Agriculture. 2014). However, health benefits may not be the only reason for selecting a variety of fruits. Western markets, such as the United States, provide a high level of product choices. It has been suggested that alternating between choices may increase the quality of consumption. This action is classified as variety-seeking behavior (Van Trijp. 1995). A series of 8 statements (VARSEEK), has been developed to quantify this intrinsic variety seeking behavior of foods by using a rating system for each statement from 1 = completely disagree to 5 = completely agree (Table 1-2). Calculating an individual's score is accomplished by reversing the scale for statement number 7 then adding the values of all statements together (Van Trijp and Steenkamp. 1992).

Table 1-2 Variety Seeking Scale (VARSEEK) (Van Trijp and Steenkamp. 1992)

Variety Seeking Scale (Each Statement rated on scale from 1-5; 1= completely disagree, 5= completely agree)
1. When I eat out, I like to try the most unusual items, even if I am not sure I would like them.
2. While preparing foods or snacks, I like to try out new recipes.
3. I think it is fun to try out food items one is not familiar with.
4. I am eager to know what kind of foods people from other countries eat.
5. I like to eat exotic foods.
6. Items on the menu that I am unfamiliar with make me curious.
7. I prefer to eat food products I am used to.
8. I am curious about food products I am not familiar with.

The VARSEEK scale has been successfully used to measure consumers' desire to seek variety in food consumption. Examples of this can be seen in studies evaluating sandwich types as well as spreads (butter or margarine) and cheese. Eight sandwich types were evaluated for liking and users variety seeking tendencies. Although sandwich liking did not reflect variety seeking scores as expected, those with higher variety seeking scores had a higher tendency to try out what was classified as "less appropriate" sandwich fillings (Lähteenmäki and Van Trijp. 1995). Spreads and cheese were investigated in respect to variety seeking tendencies due to their common purchase frequency, wide variety of alternatives available, and product familiarity. Study participants indicated cheeses and spreads bought in the previous six-month period and completed ratings on the VARSEEK scale. Consumers who were considered to have higher variety seeking tendencies also showed more variation in purchase behavior. This was displayed more clearly in cheeses than in spreads, suggesting that product characteristics (and those with greater sensory variation) may drive intrinsic variety seeking behavior (Van Trijp *et al.* 1992).

Pomegranate Processing

Pomegranates are typically transformed into juice by pressing the fruit. During this process the rind of the fruit is typically left on (Vázquez-Araújo *et al.* 2011a; Alper *et al.* 2005). Fischer *et al.* (2011) compared several impacts of processing on pomegranates including pressing with and without rinds. Some samples were steamed prior to pressing. Steamed samples produced the highest levels of phenolics. However, fruits pressed with the rind without steaming contained more phenolic compounds than those which had the rind removed prior to pressing. Steamed samples, due to their high levels of phenolic compounds resulted in strong bitterness and were deemed too bitter for use in sensory evaluation.

Pasteurization, clarification, and concentration of pomegranate juice and its effects on color and phenolic compounds in the resultant products have been examined in multiple studies. Pasteurization of fruit juice may be performed at 63°C for 30 minutes to destroy common pathogenic bacteria, however higher temperatures for shorter periods of time may be utilized (Lozano. 2006). Alighourchi, Barzegar, and Abbasi (2008) investigated how pasteurization would affect anthocyanin content of four varieties of Iranian pomegranate fruit once juiced and stored. Juice was pasteurized in Pyrex tubes at 85°C for 5 minutes. Increase or decrease in anthocyanins due to pasteurization was variety dependent. After 10 weeks of storage a decrease in anthocyanin content occurred in all varieties examined.

Clarification is used during juice processing to improve color, flavor, and stability during storage. Betonite, gelatin, polyvinylypolypyrolidone (PVPP) and kieselsol are clarifying agents that may be used to remove particles that cause cloudiness. Betonite is used to remove protein, gelatin and PVPP work to remove polyphenols, and kieselsol is used to remove excess gelatin (Turfan *et al.* 2011; Vardin and Fenercioğlu. 2003). Juice from pressed arils and juice pressed from whole fruits were clarified using gelatin, pasteurized, then measured for anthocyanin content and color and compared to their counter parts that were (a) unclarified and unpasteurized, (b) unclarified and pasteurized, or (c) clarified and unpasteurized. Pomegranate juice samples that were clarified were found to have higher polymeric color and lower levels of anthocyanins. Depending on what specific anthocyanins were being examined some decreased and some increased due to pasteurization (Turfan *et al.* 2011). Further focusing on clarifying agents, fresh pomegranate juice samples were clarified via varying sedimentation times, the use of different levels of PVPP or gelatin. Total phenolic content was more highly reduced by gelatin while PVPP had the greater reducing effect on anthocyanin content and color density (Vardin and Fenercioğlu. 2003).

Filtration processes may be used individually or in combination with clarifying agents to clarify juices. Fischer *et al.* (2011) compared pomegranate juice in which the whole fruit received steam treatment prior to pressing to juice that was additionally clarified with bentonite, gelatin, and kieselsol or microfiltration. The juices clarified via microfiltration had a greater loss of anthocyanins than those treated with gelatin. Mirsaeedghazi *et al.* (2012) studied the use of ultrafiltration and microfiltration for pomegranate juice. Both of these processes showed similarities in turbidity reduction and removal of phenolic compounds. However microfiltration retained a greater level of anthocyanins than ultrafiltration, and this may be beneficial to the food industry when marketing health benefits.

Pomegranate seasonality requires processing to conserve the fruit for year round use through processes such as concentration and dehydration. Reducing the amount of available water decreases susceptibility to enzymatic and microbial deterioration increasing storage time and portability (Yousefi *et al.* 2012). Maskan (2006) evaluated the effect of concentration method on color using microwave heating, rotary vacuum evaporation, and electromagnetic heating. The concentration decreased all *L*, *a*, and *b* values bringing forth concern for anthocyanin content. All color levels decreased as the solid concentrations increased; microwave heating demonstrated the quickest rate. Yousefi *et al.* (2012) took this a step further by evaluating anthocyanin content when heating. Comparing microwave and rotary vacuum evaporation methods showed that microwave heating at higher pressures would better conserve antioxidant capacities.

Drying methods of preservation have been examined through spray drying of juice and aril dehydration. Robert *et al.* (2010) investigated the encapsulation of pomegranate juice using maltodextrin and soy protein isolates. The soy protein isolate demonstrated a higher recovery of polyphenols and antioxidants than maltodextrin. Pomegranate powders were further investigated by Huruz *et al.* (2012) to understand the effects of processing conditions on physical and chemical parameters. They found that anthocyanin and phenolic content was better preserved with both higher temperatures and levels of maltodextrin.

Pomegranates in India are known as anar; the arils are typically dried prior to use and are known as anardana. Anardana are used in medicines and culinary preparations such as chutneys and curries (Kingsly *et al.* 2006; Singh and Sethi. 2003). Singh and Sethi (2003) evaluated pysio-chemical characteristics of seven pomegranate types in the production of anardana. Compared to fresh pomegranate arils, anardana demonstrated an increase in anthocyanins by weight. The authors felt that the increased levels of ascorbic acid may play a role in anthocyanin retention. The levels of anthocyanins in anardana were further researched by Jaiswal *et al.* (2010). Noting that polyphenol oxidase (PPO) may oxidize anthocyanins, drying effects on anthocyanin and PPO were studied. Sun drying was found to cause a greater loss of anthocyanins and a lesser reduction of PPO than oven drying in comparison to amounts present in fresh arils. Other research regarding aril dehydration has primarily focused on physical properties. When investigating physical properties Kingsly *et al.* (2006) found that rehydration post drying demonstrated a decrease in hardness and toughness of dried arils due to moisture absorption.

A few processing studies have included sensory components as part of their experiment. These studies include Fischer *et al.* (2011) who used 30 untrained panelists to evaluate juice preference and relative level of bitterness among juices. Vardin and Fenercioğlu (2003) also examined preferences by measuring liking of three differently clarified juices. Huruz *et al.* (2012) used 10 semi-trained panelists to evaluate difference of reconstituted powders from original juice samples. The majority of sensory work with pomegranate juice has not focused on processing effects, but evaluation of fresh or fermented pomegranate juices and juice blends or commercial juices by descriptive methods using trained panels or affective methods using consumers.

Pomegranate Sensory Research

Initial Consumer Research

Pomegranate juice, used for its noted availability and not popularity, was examined combined with watermelon juice based on a recommendation to impart sour taste to watermelon juice. These juice blends were assessed for acceptability (Hayaloglu and Vardin. 2001). More recently, pomegranate juice was evaluated by consumers in juice blends with different berry types due to increased interest in products containing antioxidants (Endrizzi *et al.* 2009). The consumer sample did not demonstrate a high level of fruit consumption and found pomegranate juice blends to be least liked of each group of berry blends overall. Two consumer clusters were observed; the first cluster included consumers who were of a younger age (average 19.8 years), primarily without children, and of medium educational level. This cluster showed a dislike of pomegranate juice and preference for orange or blood orange blends. The second cluster, although slightly smaller, was composed of almost 75% women who had knowledge of polyphenols and antioxidants and over half drank juice on a regular basis. Cluster 2 did not reject juice blends that contained pomegranate and generally disliked orange and blood orange samples, thus demonstrating that some consumer groups may be more receptive to pomegranate juice than others (Endrizzi *et al.* 2009).

Pomegranate berry juice blends were further evaluated to improve consumer acceptability of the products while maintaining health benefits. Three berry types were blended in five pomegranates to berry ratios to create 15 sample variations for consumer testing. Mixtures with blueberry juice resonated the best with consumers, while consumer liking of blackberry and raspberry declined as the amount of berry juice increased. Blends with more than 10% blackberry or raspberry juice were considered too dark in color. The 10% blackberry juice blend contained the highest level of phenols and was not significantly different in liking from that of the blueberry blends (Vázquez-Araújo *et al.* 2010).

Volatile compounds and consumer liking of Spanish pomegranate cultivars were investigated due to the growing interest of pomegranates as a functional food. A group of 30 consumers who consumed fruit juice a minimum of two times per week evaluated the juices of nine Spanish pomegranate cultivars for overall liking and liking in different categories. A sweet variety, Mollar de Elche, was most liked and consequently contained the highest level of volatile compounds. This study also provided understanding that consumers have a lesser preference for samples with high levels of astringency more common in sour cultivars (Calín-Sánchez *et al.* 2011).

Lexicon Development

Health benefits and popularity increased interest in the study of pomegranate flavor and consumer understanding as demonstrated in "Initial Consumer Interest," however no studies had described the flavor of pomegranate juice. To resolve this issue, Koppel and Chambers (2010) developed a lexicon using 33 commercial pomegranate juices. A wide array of samples were used, inclusive of domestic (US) and international samples comprised of nine concentrated juices, nine containing natural flavors, 15 made from concentrate, one enriched with fructose, and two prepared from organic pomegranates. Five trained panelists developed over 30 attributes based upon these samples. These attributes included basic tastes, feeling factors, and a wide array of aromatics. From these attributes, the juices were described overall as sour, sweet, fruity, musty/earthy, and astringent. Yet distinct profiles were able to be determined and five cluster types were found. Cluster 1 was best described by berry, fruity dark, sweet, and overall sweet characteristics. Cluster 2 was associated with grape and cranberry attributes. Cluster 3 was described with fermented and toothetch characteristics. Samples prepared from concentrate made up Cluster 4 and demonstrated a musty/earthy attribute. Finally, Cluster 5 contained candy-like samples. It was hypothesized that processing parameters may drive these results. This comprehensive lexicon covers a wide array of pomegranate juices and has been used as a springboard for attribute references in several descriptive analysis studies. Studies referencing this lexicon include comparison of commercial and fresh juices in the United States (Vázquez-Araújo *et al.* 2011b), assessment of fresh juices containing albedo and carpellar membranes (Vázquez-Araújo *et al.* 2011a), evaluation of juice and wine (Andreu-Sevilla *et al.* 2013), as well as use to better understand consumer liking (Koppel *et al.* 2014).

Descriptive Analysis

Thirteen commercial juices from the United States were compared to fresh juice prepared from Wonderful pomegranates using the lexicon created by Koppel and Chambers (2010). Fresh juice was characterized as having a high fruity aroma containing berry, cranberry, fruity dark, and floral components. Commercial juices from direct extract had fruity, cranberry, grape, musty/earthy and wine-like characteristics. Juices from concentrate with natural flavorings added contained notes that were similar to the juices from direct extract and fresh juice, with some displaying apple and cherry notes. Juices from concentrate displayed differentiating characteristics including candy-like, molasses, vinegar, and woody notes not found in the other juices. Based on volatile analysis and descriptive analysis results it was concluded that processing method had an influence on flavors present in these products (Vázquez-Araújo *et al.* 2011b).

Processing methods, such as clarification used to reduce the content of phenolic substances, can influence juice properties such as improving clarity and reducing bitterness (Vardin and Fenercioğlu. 2003). The removal of these substances would additionally reduce health benefits. Vázquez-Araújo *et al.* (2011a) examined how adding albedo and carpellar membranes to increase health benefits would influence sensory properties. Characteristics of fresh pomegranates were found similar to those encountered by Vázquez-Araújo *et al.* (2011b) with the addition of some new characteristics such as carrot, beet, woody, and salty which may be related to fruit seasonal or regional variability. Although not demonstrating large differences it was recommended that consumer evaluation of these juice types would be beneficial to understand their acceptability.

Further attributes were found when assessing fresh pomegranate juice and wine prepared from two different cultivars. Andreu-Sevilla *et al.* (2013) used juice from the Wonderful and Mollar de Elche varieties, separately and in combination of the two juices in juice evaluation and in wine preparation and evaluation. Referencing the lexicon prepared by Koppel and Chambers

(2010) panelists adapted references to fit on a scale of 0 to 10 points. The Wonderful variety juice exhibited lower levels of fruity flavor along with the attributes of grape and green-viney not seen in previous evaluations. Fermentation brought out new characteristics from the prepared juices including anise, blackberry, cherry, fermented, vinegar, and wine-like. Wonderful juice and wine had higher sourness and astringency as compared to Mollar de Elche juice and wine. The juice and wine of the combined juices showed characteristics that were intermediate between the two cultivars.

Consumer and Descriptive Evaluation

Consumer and descriptive studies have been combined to increase knowledge in areas previously explored including that of Spanish pomegranate varieties, pomegranate juice blends, and understanding of a variety of commercial juices. Expanding the knowledge base of Spanish pomegranates, commercial juices prepared from the previously studied Mollar de Elche variety were compared to fresh juice from a potential cultivar (C25) for the juice industry. The fresh juices were prepared with and without sucrose. Intensities of eight different descriptive attributes were determined by a trained panel while 50 consumers evaluated their level of liking for each product. Caramel odor and flavor were significantly higher in the commercial samples, which was attributed to pasteurization. Although significantly less sweet, the fresh C25 juice without sugar had the highest liking score of the four juices (Carbonell-Barrachina *et al.* 2012).

Pomegranate juice blends containing black cherry and Concord grape juices were studied to understand the optimal blend for consumers as well as the impact of potential antioxidant content on consumer liking. The pomegranate juice lexicon developed by Koppel and Chambers (2010) was used in ballot development for the descriptive portion of this study. Consumers evaluated liking before and after information was provided on antioxidant potential. External preference mapping showed that much of the hedonic liking was associated with characteristics of sweet and caramelized most associated with Concord grape juice. Desirability functions were used to generate optimal juice blends based on liking. Liking scores changed significantly after the presentation of antioxidant potential information. The change in liking scores influenced the calculation of the optimal juice blend to contain a greater level of pomegranate juice while decreasing the amount of black cherry juice (Lawless *et al.* 2013).

Juices used to create the previously discussed pomegranate juice lexicon were used in consumer evaluation in the United States, Estonia, Spain, and Thailand by Koppel *et al.* (2014). Five juices were tested, each representing a descriptive cluster previously discussed during lexicon development (Koppel and Chambers IV. 2010). The juices were evaluated at room temperature and refrigerator temperature by descriptive analysis. The analysis determined that minimal intensity differences made it reasonable to serve the consumers refrigerated samples to represent most common juice consumption temperature. All countries surveyed displayed a dislike of Sample A, described as dark fruity, sour and astringent by descriptive analysis. An even greater dislike was demonstrated for Sample D that was found to be fermented, metallic, and had a high level of astringency. Additionally consumers in all countries indicated this juice was too sour and had too high of flavor intensity. Sample B was liked in Thailand and Estonia although not well received in the United States or Spain. Sample C, containing musty/earthy flavors and chalky mouthfeel did not show liking or disliking in Spain or Estonia but was disliked in Thailand and the United States. Across all countries tested, Sample E was not found to be liked or disliked although considered to be more candy-like and high in sweet aromatics through descriptive analysis. Liking scores within countries may be related to familiarity with the products or related to type of product (fresh or processed juice) typically drank within the vicinity.

Although differences across countries existed, consumer clusters were found across countries (Koppel *et al.* 2014). Cluster1 liked Sample C and E, but disliked Sample D. Cluster 2 best liked Sample B, but disliked A, C, and D. Cluster 3 did not particularly like any sample, while cluster 4 demonstrated liking for all of the samples, except Sample C. Finally, cluster 5 disliked samples A, D, and E. Considering drivers of liking, low liking scores in this situation may better contribute to drivers of disliking for each cluster. Clusters 1, 2, 3, and 5 sat further away from attributes such as metallic, toothetch, sour, astringent, bitter, floral, and fermented. Cluster 4 was centrally located among attributes and did not show strong liking for a particular juice, but only a disliking of Sample C. This information indicated that finding a product that worked well across several consumer clusters may also work well in multiple countries.

Time Intensity Sensory Methodology

Methodology Overview

Most descriptive profiling methods capture overall intensity aspects of a product. The element of time, typically used when evaluating food products, is factored into the analysis to further understand how food flavors change throughout the eating process. Time-intensity methodologies have the ability to provide information such as maximum intensity, time to reach maximum intensity, rate to maximum intensity, rate of decrease from maximum intensity, and total length of intensity of a variation of attributes relating to flavor, aroma, mouthfeel, or texture. In order to complete these types of evaluations, panelists must be able to track the intensities of attributes over time. There are several approaches that can be used to track these changes.

Lawless and Heymann (2010) divided these approaches into three main categories: discontinuous sampling, continuous tracking, and temporal dominance techniques. Discontinuous sampling evaluates the intensity of attributes at different phases of sampling. The amount of attributes that can be evaluated in one phase is not specifically defined. The phases may consist of time points while consuming food (common in textural studies), such as first bite and first chew or ratings at defined time intervals. Progressive profiling is an example of a discontinuous sampling method and demonstrates the change in textural attributes at different time points while consuming cheese. Nine different cheeses were rated at chew stroke intervals from onset of chewing to swallowing. Each cheese was rated on nine attributes using an intensity scale from zero to five; one piece of cheese was used to evaluate each attribute. The amount of time to chew each sample was additionally tracked. The data from this study was analyzed using Principal Components Analysis (PCA) at different time points (Jack *et al.* 1994).

A discontinuous sampling evaluation using time intervals was performed by Ayya and Lawless (1992) in the evaluation of high-intensity sweeteners and sweetener mixtures. The attributes of sweetness and bitterness were evaluated on a 15-point scale for each solution. These were measured at 15 second intervals for the first minute, then at 30 second intervals for the remaining four minutes for a total of five minutes. Panelist means for each attribute interval were used to create time-intensity curves for each sample.

Continuous tracking is typically performed using a computer. The intensity of attributes is continually recorded by the panelists. The panelist records the attribute intensity changes as they occur while the computer samples this information at pre-set intervals. Using this method changes can be recorded in one attribute (using one axis) or two attributes (using two axes) (Lawless and Heymann. 2010). The evaluation of sea salts was performed using continuous tracking (Drake and Drake. 2011). Compusense Five (Compusense, Inc. Guelph, Ontario, Canada) was used to track intensity over a 90 second interval. Panelists placed the sample in their mouth when the first signal was given and provided their initial intensity of the salty taste. On the second signal the panelist expectorated. The intensity was tracked until the end of the test, indicated by a third signal. From the data collected maximum intensity, time of maximum intensity, area under the curve, and total duration of stimulus were determined (Drake and Drake. 2011).

The third technique, Temporal Dominance of Sensations (TDS), utilizes continuous tracking via computer programing to measure multiple attributes. All attributes being tracked are programmed into the computer and after swallowing the sample the panelists begin recording the intensity on the dominant attribute. When a new dominant attribute appears, this attribute is selected; this process continues until all sensations are scored in the order perceived. Using the curves from each panelist, a curve can be constructed for each attribute. TDS score may also be calculated by calculating average of the scores given to an attribute multiplied by its duration then dividing by the total duration (Lawless and Heymann. 2010). TDS was employed to evaluate flavor intensities in peach and mint cooling gels using FIZZ software. Five attributes were evaluated including: overall flavor, coldness, sourness, sweetness, and bitterness. All attributes were present on the screen, when the panelist had swallowed the sample they selected start and selected the attribute intensity of the dominant attribute, switching attributes as dominance fluctuated for a time period of five minutes. From this data TDS scores were calculated and compared using analysis of variance and PCA in addition to curves created for each attribute (Labbe *et al.* 2009).

Time intensity can be used to track aromatic components of flavor, basic tastes, and feeling factors. Although this type of methodology is versatile, it is most commonly used to describe basic tastes and feeling factors. Recent studies have captured information regarding salty (Drake and Drake. 2011; Souza *et al.* 2013a), sweet (Souza *et al.* 2013b; Palazzo *et al.* 2011; Palazzo and Bolini. 2009), sour/acidic (Palazzo and Bolini. 2009), and bitter tastes (Kobue-Lekalake *et al.* 2012; Calvino *et al.* 2004). Feeling factors have also recently been observed, including astringency (Kobue-Lekalake *et al.* 2012) and cooling (Labbe *et al.* 2009)

Multi-Attribute Methodologies

It is possible to describe multiple attributes using all of the basic time intensity methodologies. As previously described, Jack *et al.* (1994) captured textural attributes using discontinuous methodology by evaluating each attribute on a separate cube of cheese. Up to two attributes can be described at once using typical continuous profiling, as performed with bitterness and astringency in sorghum (Kobue-Lekalake *et al.* 2012). Continuous methodology requires more than one sample to complete evaluation of more than two attributes, as seen the evaluation of three attributes with raspberry gelatin (Palazzo and Bolini. 2009). TDS has the goal of examining multiple attributes efficiently as discussed in the example of peach and mint gels (Labbe *et al.* 2009) and more recently in butter (Souza *et al.* 2013a). However this method is limiting in that each attribute is not being scored at regular time intervals or continuously.

Two additional methods have been presented that evaluate multiple attributes; these include the Dynamic Flavor Profile (DFP) Method (DeRovira. 1996) and Multi Attribute Time-

Intensity (MATI) method (Kuesten *et al.* 2013). DeRovira (1996) argued that attributes (traditional profiling), intensity (traditional profiling and time profiling), and time (time profiling) need to be viewed together to truly measure the flavor experience. The DFP method used an approach that creates a web result graphic; instead of a point representing intensity on each spoke, a curve displays the sample's intensity over time. A multitude of flavors may be detected in one product. To simplify the possible amount of spokes on the plot, 14 different taste and odor compounds were classified. These were based on theory that similar flavors can be mixed as a standard. These standards included: salt, sour, sulfury, lactonic, brown, spicy, terpenoid, green, sweet, bitter, floral aldehyde, woody, ester, and acid. Panelists created curves individually and then combined the individual curves amongst themselves to create curves for each of the 14 attributes. At any given time point a cross section of this three dimensional plot could be taken to display a spider plot at that specific interval.

Kuesten *et al.* (2013) contended that traditional methods are not efficient enough for rapid timelines, as one attribute per sample is typically measured. Although TDS measures multiple attributes at one time, these authors felt that this method only displays the relative effect of attributes rather than the intensity over time. The MATI method collects data on multiple attributes by rotating between attributes at timed intervals. This method was demonstrated for both descriptive attributes and consumer liking. When descriptive attributes trials were performed, attribute intensities were measured on a scale of 0 to 15 using flavor attributes alone, textural attributes alone, and flavor and textural attributes combined. Consumers were asked about flavor and texture liking on a scale of 1 to 9 both during and after consumption. The intensities are measured through specialized computer software that allows the panelist to control when they start. Once the evaluation procedure is started, the panelists cycled through the provided attributes at defined time intervals until completion. During this process the panelists selected when the product dissolved or if it stuck to their teeth. Graphs of time-intensity curves were created based on compilation of descriptive or consumer data. The authors recognized that this method is beneficial not only for evaluating multiple attributes, but relating texture and flavor data as well as descriptive and consumer data. Drawbacks to the MATI method include discontinuous methodology that could result in "missed moments". In addition constant change in attributes may cause fatigue, and less attributes may be accounted for than using TDS.

Time-Intensity during Consumption

Most time intensity methods typically track one portion of the eating experience. Some contemporary methods have been suggested recently that explore tracking throughout the eating experience. These newer approaches have been used to evaluate nutritional supplements, beer, and chewing gum. Chewing gum, which Delarue and Loescher (2004) mention, is a good candidate for time intensity as its flavor lasts for an extended period of time. These authors investigated the dynamics of chewing gum liking. Consumers evaluated one gum sample per session, liking was evaluated using an incremented approach indicating liking level after one minute, five minutes, and 30 minutes. These scores were analyzed using Analysis of Variance (ANOVA). It was found that average liking varies with test duration, but is product dependent. However, concern was presented that assessing one's hedonic response during consumption has the potential to bias the consumer as it is not part of the typical eating/drinking situation.

Sequential profiling was used by Methven *et al.* (2010) to better understand hedonic liking of an oral nutritional supplement for subjects at risk of malnutrition. Five sensory attributes consisting of sweet, metallic, soya milk flavor, mouth coating, and mouth drying were evaluated by a trained panel. Each attribute was scored upon ingestion of a 5mL sip, 30 seconds, and 60 seconds afterwards, with a total of a two minute wait period before the subsequent sip, for a total of eight sips. Consumers also tasted these samples and rated initial liking, liking after they finished eight 5mL sips, and liking after trying another sample. Data was analyzed using ANOVA and PCA. The sequential consumption of the product showed that a build-up of metallic, mouth coating, and mouth drying attributes occurred. This phenomenon may have contributed to decline in liking scores after repeated consumption. The authors recommended using this methodology for products that have aftertastes.

A similar concept was evaluated in the drinking profile used by Vázquez-Araújo *et al.* (2013). Each panelist rated the attributes of alcohol/solvent, bitterness, estery, and hoppy of beer after each of five sips, waiting 45 seconds in between sips. To imitate consumer behavior water consumption between sips was not allowed but cracker consumption was. Differences between beers were similar to what was exhibited in traditional profiling to characterize these samples but changes in the samples over the sipping period used in the drinking profile were not shown. Preliminary studies showed that changes may be more apparent as further sips are taken. The method developers indicated that although strong results were not presented in this case, this profile method provided data similar to the real drinking experience and should be further investigated.

Research Objectives

Pomegranates and its related products have been increasing in popularity due to numerous reported health benefits. Not until recently have pomegranate sensory properties been researched. Most of the current research has focused on flavor properties of different pomegranate cultivars, pomegranate juice blends, and commercial pomegranate juices. Clear documentation is available showing that the processing method chosen for pomegranates has an effect on various physical and chemical aspects of the product. Certain processes have an effect on beneficial health compounds which result in flavor changes, for example the relationship between phenolic compound level and bitterness and astringency. Pomegranate juice has not yet been evaluated through time intensity methods to understand how the flavors change upon initial trial or throughout the drinking process. The hypothesis of this study is that processing methodology has an effect on consumer acceptability of pomegranate juice flavor; the flavor differences of the differently processed juices can be shown through new time intensity methodologies. This thesis is directed to understand the following objectives: 1) a) differences in consumer acceptability of pomegranate juices that have been frozen fresh, batch pasteurized, and rehydrated from dried arils and b) if associations occur between consumer acceptability of these juices and variety seeking tendencies and healthy eating; 2) differences in these processed juices through new time intensity methodology which better explains product trial; and 3) differences in these processed juices through a new time intensity procedure which better explains the consumption experience.

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Chapter 2 - Descriptive Analysis and Consumer Evaluation of Processing Variants of Pomegranate Juice

Abstract

Increasing evidence of pomegranate health benefits has boosted their popularity. Several studies have evaluated processing methods (e.g. pasteurization, drying), effects of processing (e.g. color, phenolic content), and the sensory attributes of pomegranate juices. The objective of this study was to understand if processing, such as pasteurization or drying, has an effect on pomegranate juice acceptance and if acceptance is related to healthy eating habits or variety seeking tendencies. Arils were removed from fresh Wonderful pomegranates for juicing or drying. Four samples were prepared: fresh, fresh frozen, pasteurized, and reconstituted juice from dried arils. Samples were evaluated by a trained panel using a consensus modified flavor profile. Fresh and fresh frozen juices were found to be similar in flavor; subsequently fresh frozen, pasteurized, and reconstituted juices were evaluated by consumers for acceptance. Four clusters were found from evaluation of these juice samples. Each juice was individually disliked by one of three clusters, demonstrating the effect of processing on acceptance. The fourth and largest cluster liked all three samples. Liking scores were not found to be highly associated with healthy eating habits or variety seeking tendencies. This information is beneficial for the fruit processing industry, showing that processing can influence consumer acceptance.

Introduction

Pomegranates, originally from Iran and the surrounding area, have spread to China, the United States, and Mediterranean countries such as Spain and Morocco. Popularity growth within the United States is largely due to health benefits (Hummer *et al.* 2012). Cardiovascular, anti-inflammatory, anticancer, and antidiabetic effects encompass the areas of successful in vitro and in vivo investigation. Although many positive results have been encountered, these studies would benefit from further clinical investigation (Faria and Calhau. 2011; Johanningsmeier and Harris. 2011,Viuda-Martos *et al.* 2010). Recent clinical trials of pomegranate juice for hemodialysis patients have shown improvements in systolic blood pressure, pulse pressure, and lipid profiles (Shema-Didi *et al.* 2014). Type 2 diabetes patients have also benefited from pomegranate juice consumption by decreasing levels of inflammatory markers that play a role in cardiovascular disease (Sohrab *et al.* 2014). Polyphenolic compounds including phenolic acids, flavonoids (e.g. anthocyanins), and tannins are largely responsible for these types of health benefits (Tzulker *et al.* 2007).

Many studies have reported the effects of processing on health beneficial phenolic compounds. Processing methods that have been explored include pasteurization, clarification, concentration, and dehydration. The effect of pasteurization has been shown to increase or decrease anthocyanin content based on pomegranate cultivar and anthocyanin type (Turfan *et al.* 2011; Alighourchi *et al.* 2008). Clarification, using chemical agents and filtration processes, is used to remove cloud from juices to improve color, flavor, and storage stability. Clarifying methods have displayed differences in levels of phenolic removal, for example gelatin has shown a greater level of total phenolic reduction while polyvinylypolypyrrolidone (PVPP) had a greater effect on anthocyanin reduction (Vardin and Fenercioğlu. 2003). However, filtration processes, such as microfiltration, have shown a greater reduction in anthocyanin content than the use of chemical agents (Fischer *et al.* 2011).

Reduction of available water through concentration or drying methods not only helps preserve this seasonal fruit, but also increases storage time and provides a more convenient form for shipping. Concentration methods, although resulting in anthocyanin loss, show better retention if microwave heating at high pressures is available (Yousefi *et al.* 2012). Pomegranate powder production parameters, such as drying agent type and level as well as temperature, can also influence phenolic content. Huruz *et al.* (2012) found anthocyanin and phenolic content to be best preserved using higher levels of both maltodextrin and temperatures during drying. However, Robert *et al.* (2010) found that soy protein isolates prevent reduction of these compounds better than maltodextrin. Pomegranate arils are commonly dried in India for use in medicines and culinary preparations (Kingsly *et al.* 2006; Singh and Sethi. 2003). Singh and Sethi (2003) found when drying pomegranate that the anthocyanin level concentrated resulting in a product with a higher level of anthocyanins by weight compared to fresh arils. Jaiswal *et al.* (2010) further studied drying of arils and found that drying reduced the level of anthocyanins compared to the levels found in fresh arils. Anthocyanin reductions were greater during sun drying than oven drying.

The understanding of the effects of processing on bioactive compounds is fairly comprehensive; little investigation has taken place to understand the effects these methods have on flavor. Sensory studies have previously investigated descriptive flavor profiles of different pomegranate cultivars (Andreu-Sevilla *et al.* 2013; Carbonell-Barrachina *et al.* 2012), pomegranate juice blends (Lawless *et al.* 2013), and commercial products (Koppel and

Chambers IV. 2010; Vázquez-Araújo *et al.* 2011). Consumer studies have been used to further understand the liking of differing profiles (Koppel *et al.* 2014; Lawless *et al.* 2013; Carbonell-Barrachina *et al.* 2012).

Questioning beyond liking can be used to gain further understanding of consumers' behaviors and attitudes (Lawless and Heymann. 2010). Many reasons consumers decided to purchase juice have been related to health (Mintel. 2013). Understanding their interest in health related products could be assessed through methods such as Food Diaries, Food Recall, and Food Frequency Questionnaires which can be lengthy and expensive approaches. However, three questions suggested by Soontrunnarudrungsri (2011) can be used to segment consumers interested in healthy eating. The variety seeking scale (VARSEEK) may be used to assess a consumer's intrinsic desire to try different food products (Van Trijp and Steenkamp. 1992).

Understanding the effects processing imparts on flavor will provide information that is useful in ingredient selection. Additionally, gaining understanding of consumer liking will provide information to processors on the impact of processing methods on acceptability. If dissimilarities are apparent across processing methods, flavor profiles and consumer acceptance should be taken into consideration when selecting products for use. The objectives of this study were to (1) understand the effect of processing including freezing, batch pasteurization, and rehydration of ground, dried arils on consumer acceptability of pomegranate juices, and (2) understand if associations exist between consumer acceptability of these juices and interest in healthy eating and variety seeking tendencies.

Materials and Methods

Samples

Fresh pomegranates of the Wonderful cultivar grown in the United States were acquired from Youngstown Grape Distributors (Reedley, CA, USA). The fruits were randomly divided into four groups; washed, and damaged fruits were discarded. Each fruit was cut in half and arils were removed manually by placing each half on top of a Seed-Out (Pahrump, NV, USA), a round raised platform with spokes to support pomegranate halves. Each half was gently tapped and arils falling below Seed-Out were removed for further processing. Any remaining arils connected to the rind were separated manually. Arils were rinsed to further remove any remaining carpellar membranes.

The arils were divided into four parts. Three of the four parts of the resultant pomegranate arils were used for juicing while the fourth was used for drying. Arils used to prepare juice were placed into a Hamilton Beach Health Smart Juice Extractor 67800 (Hamilton Beach/Proctor Silex Inc., South Pines, NC, USA). Approximately four liters of fresh juice was produced in total over a period of 3 days for immediate analysis. Approximately 17 liters was frozen fresh in 946 mL Ziploc freezer bags (SC Johnson, Racine, WI, USA) in a Standex BCF93558-0DX6 blast freezer (Standex, Salem, NH, USA) at (-26±1°C), for a minimum of 30 minutes. Once frozen the samples were transferred to a freezer for storage at -18±1°C. Of the remaining juice, approximately 15 liters was batch pasteurized using a Pastomaster 60 RTX (Carpigiani, Bologna, Italy) at 63°C for 30 minutes prior to freezing using the process described for the fresh frozen samples. The remaining arils in the amount of 29 kg, were dried in batches. Each batch was placed in single layers onto trays of an Excalibur 3926T Food Dehydrator

(Excalibur Products, Sacramento, CA, USA). Each batch of arils was dried at 57°C for 10 hours resulting in approximately 6 kg of dried arils. Dried arils were stored frozen in Ziploc freezer bags at -18±1°C until sample preparation.

Descriptive Analysis

Sample Preparation

The morning of evaluation, fresh juice was prepared using the procedure described above. Frozen juice samples were placed in a refrigerator at 4ºC to thaw overnight. Frozen, dried arils were ground using a Black and Decker Smart Grind CBG5 (Applica Consumer Products, Inc, Miami Lakes, FL, USA). The ground arils were rehydrated with purified water using a ratio of 22.2 parts arils to 78.2 parts water. The slurry of ground arils was allowed to rest for 10 minutes to reach a level of 14-15 degrees brix. After resting, the solids were separated from the resulting juice by passing through a sieve two times and the brix measurement was confirmed using a MT-032 Hand Refractometer (QA Supplies Perishable and Environmental Management, Norfolk, VA, USA). Thirty mL of sample was served in an odor-free, disposable 96mL cup at ambient room temperature (21±1°C). Additional samples were available upon request.

Panelists

Six highly trained panelists with over 1000 hours testing experience from the Sensory Analysis Center, Kansas State University (Manhattan, KS, USA) evaluated these samples. The panelists had prior experience evaluating a variety of products including pomegranates and pomegranate juices. All panelists participated in orientation of the juices they were testing.

Orientation and Evaluation

The four juice samples were evaluated using a consensus modified flavor profile previously used by Cherdchu *et al*. (2013), Di Donfrancesco *et al.* (2012), and Koppel and Chambers (2010). Samples were evaluated using descriptive attributes, definitions, and references modified from Koppel and Chambers (2010) found in Table 2-1 (Appendix A). During orientation samples were tasted to determine attributes to make up the ballot (Appendix B). A total of 27 attributes were evaluated on the ballot. Each panelist evaluated all attributes for each sample individually on an intensity scale from 0 (none) to 15 (extremely strong). Following individual evaluation the group discussed each attribute and assigned it an intensity based on reference intensities provided. Samples were evaluated during 1.5 hour sessions, 2 samples per session. Samples were labeled using three-digit codes and served in a random order. Purified water, unsalted crackers, and low-moisture part-skim mozzarella were used as palate cleansers.

Table 2-1 Pomegranate Juice Definitions and References

Attribute	Definition	Reference
Apple	A sweet, light, fruity, somewhat floral aromatic commonly associated with apple juice and apples	Gerber Applesauce = 6.0 (flavor)
Berry	The sweet, sour, sometimes dark aromatics associated with a variety of berries such as blackberries, cherries, currants, raspberries etc, excluding cranberries.	Blackwell Red Currant Jelly = 8.5 (flavor)
Cranberry	The sweet, fruity, slightly sour and sharp aromatics commonly associated with cranberries.	Old Orchard's Frozen Cranberry diluted (1:1) = 3.5 (flavor) Reconstitute Cranberry Concentrate according to instructions on the can. Dilute the reconstituted cranberry juice 1(juice):1(water) Ocean Spray Dried cranberries = 9.0 (flavor)
Cherry	The sour, fruity, slightly bitter aromatics commonly associated with cherries.	RW Knudsen Cherry Juice diluted (1:2) = 4.0 (flavor)
Grape	The sweet, brown, fruity, musty aromatics commonly associated with grapes.	Welch's Concord Grape Juice diluted (1:1) = 5.0 (flavor) Welch’s White Grape Juice diluted (1:1) = 5.0 (flavor)
Floral	Sweet, light, slightly perfumey impression associated with flowers.	Welch's White Grape Juice diluted (1:1) = 5.0 (flavor)
Fruity	An aromatic blend of a variety of fruits, excluding citrus, cranberry and concord grape. May include apples, pears, white grapes etc.	Welch’s white grape juice diluted (1:1) = 5.0 (flavor)
Carrot	The aromatics commonly associated with canned, cooked carrots.	Del Monte Sliced Canned Carrots= 7.0 (flavor)

Attribute	Definition	Reference
Beet	The damp, musty/earthy, slightly sweet aromatics commonly associated with beets	Diluted Kroger Canned Beet juice (1:2) = 4.0 (flavor)
Brown Spice	Aromatics associated with a range of brown spices such as cinnamon, nutmeg, cloves and allspice.	McCormick Spices, mixed=7.5 (aroma) Combine ¼ tsp of cinnamon, ¼ of ground cloves, ¼ of ground nutmeg and ¼ of allspice in a vile, shake well to combine. Steep ¼ tsp of spice mixture in ½ cup boiling water for 5 minutes, strain and dilute with water 1(spice water):1(water), pour ¼ cup dilution into medium snifter, cover.
Fermented	The aromatics associated with ripe/ overripe fruit; can be somewhat sweet, sour, browned, musty, and fruity.	Regina Cooking Wine = 10.0 (aroma)
Fruity-Dark	The sweet, brown honey/caramel-like aromatics commonly associated with dark fruits such as raisins and prunes that have been cooked.	Mixture of Sun Maid Raisins, Prunes, Ocean Spray Cranberries and water; juice = 5.0 (flavor) Mix of ¼ cup raisins, 1/3 cup dried cranberries and 1/4 cup of prunes (chopped), add ¾ cup of water and cook on high for 2 minutes. Strain, serve juice.
Green-Viney	A green aromatic associated with green vegetables and newly cut vines and stems; characterized by increased bitter and musty/earthy character.	Campbell's Tomato Juice = 2.0 (flavor)
Musty/Earthy	Humus-like aromatics that may or may not include damp soil, decaying vegetation, or cellar-like characteristics.	Raw potatoes = 3.0 (aroma) Cut potato into slices, place one slice in medium snifter, cover. Diluted Kroger Canned Beet juice (1:2) = 7.0 (aroma) Drain juice from beets, dilute beet juice 1(juice):2(water) Pour half cup in medium snifter, cover

Attribute	Definition	Reference
Brown Sweet	A rich full-bodied brown sweet aromatics.	C&H Golden Brown Sugar dilution = 5.0 (flavor) Mix 2 tsp of C&H Golden Brown Sugar in 1 cup of water
Honey	Sweet, light brown, slightly spicy aromatics associated with honey.	Busy Bee Honey dilution = 6.5 (flavor) Mix 2 teaspoons busy bee honey in 250 mL water
Molasses	Dark, caramelized top notes that are slightly sharp and characteristic of molasses.	Grandmas Molasses dilution = 6.5 (flavor) Mix 2 teaspoons of molasses in 250ml water
Sweet, Overall	The perception of the combination of sweet taste, sweet aromatics, caramelized, brown sugar, honey, and maple	3% C&H Golden Brown Sugar solution = 4.0
Sweet	The fundamental taste factor associated with a sucrose solution.	2% Sucrose Solution = 2.0 4% Sucrose Solution = 4.0
Woody	The aromatics associated with dry freshly cut wood.	Forster Craft Stick = 7.5 (aroma) Break stick into four pieces and put in snifter, cover
Salt	Fundamental taste factor of which sodium chloride is typical.	0.20% NaCl Solution = 2.5 0.25% NaCl Solution = 3.5
Sour	A fundamental taste factor of which citric acid in water is typical.	0.025% Citric Acid Solution = 2.5 0.050% Citric Acid Solution = 3.5 0.080% Citric Acid Solution = 5.0
Bitter	The fundamental taste factor of which caffeine or quinine is typical.	0.010% Caffeine Solution = 2.0 0.020% Caffeine Solution = 3.5 0.035% Caffeine Solution = 5.0
Metallic	The impression of slightly oxidized metal, such as iron, copper and silver	0.10% Potassium Chloride Solution = 1.5 0.2% Potassium Chloride solution = 4.0

Attribute	Definition	Reference
Astringent	The dry puckering mouthfeel associated with an alum solution.	0.05 % Alum Solution = 2.5 0.1 % Alum Solution = 5.0
Toothetch	A sensation of abrasion and drying of the surface of the teeth.	Welch's Concord Grape Juice diluted (1:1) = 5.0
Chalky Mouthfeel	A dry, powdery sensation. Can be on mouth and /or teeth.	Cornstarch solution = 3.0 Mix 1g of corn starch in 100 ml water

Consumer Evaluation

Sample Preparation

Frozen juice samples were placed in the refrigerator at 4°C two days prior to the study to facilitate thawing. Reconstituted samples were prepared the same day of the study as described in Descriptive Analysis Sample Preparation. A total of 30 mL of juice were poured into odor-free, disposable 96mL cups and stored in the refrigerator at 4°C prior to evaluation. Samples were served at 5±1°C.

Consumers

Consumers were recruited from the Manhattan, Kansas area to participate in pomegranate juice evaluation. Initial screening was performed using Compusense at-hand® (Compusense, Inc. Guelph, Ontario, Canada). The 100 consumers that participated met all eligibility requirements including: had no food allergies, drank juice a minimum of 2 to 3 times a week and were willing to try pomegranate juice (Appendix C). All consumers were scheduled by telephone (Appendix D) and received a confirmation email of the scheduled participation time. In total, 45% males and 55% females participated in the consumer study (Table 2-2).

Table 2-2 Consumer Demographics

Gender	Consumer %	Age Range	Consumer %	Ethnicity	Consumer %
Female	55	18-24	14	Hispanic/Latino	6*
Male	45	25-34	19	American Indian or Alaska Native	1
		35-44	15	Asian	3
		45-54	21	Black or African American	2
		55-64	29	Native Hawaiian or Pacific Islander	0
		over 65	2	White	86*
				Indian Subcontinent	1
				Prefer not to answer	2

N=100, *One consumer identified as hispanic/latino and white

Test Design and Sample Evaluation

Compusense at-hand® (Compusense, Inc. Guelph, Ontario, Canada) was used to generate the test design that was balanced for carryover effects. All positions and orders were blocked by groups of six for a possible 120 consumers (Appendix E).

Evaluation of samples was completed in a total of six sessions over a two-day period; each consumer participated in one of the six sessions. Before beginning the session, consumers were provided with information regarding the study and the procedures that would be used during the testing session (Appendix F). The consumers then electronically signed consent forms stating that they agreed to participate in the study and could withdraw at any time without penalty (Appendix G). Each session lasted for approximately 30 minutes. Consumers were provided with purified water and unsalted crackers for use in between samples, and optional cups for expectoration.

Compusense at-hand® (Compusense, Inc. Guelph, Ontario, Canada) was used on iPads to collect data. Panelists first confirmed their demographic information. Then samples were presented monadically according to each panelists serving order. The consumers rated each sample using five categories of liking including: overall, fruit flavor, sweetness, sourness, and aftertaste (Appendix H). A nine-point hedonic scale ranging from dislike extremely to like extremely was used to indicate level of liking. After completing sample evaluation, consumers rated their association with the statements on the VARSEEK scale using a five point scale; ranging from completely disagree to completely agree (Van Trijp and Steenkamp. 1992) (Appendix H). Additionally, each answered questions described by Soontrunnarudrungsri (2011) regarding their habits towards a healthy diet (Appendix H). After the session was completed, consumers were monetarily compensated for their time to participate in the study.

Statistical Analysis

Analysis of Variance (ANOVA) was used to test if significant differences existed at a 5% significance level between juice sample liking scores. Ward's minimum variance procedure was performed to determine if distinct groups existed among consumers. ANOVA with post-hoc means separation using Fisher's protected LSD was used to evaluate significant differences at the 5% significance level across all juice liking scores by variety seeking level, across all juice liking scores by healthy eating interest, and across all juice liking scores and variety seeking scores for all clusters. All analyses were performed using SAS® statistical software (version 9.3, SAS Institute Inc, Cary, NC, USA). Appendix I contains all codes.

Results

Descriptive Evaluation

The descriptive analysis results were described by Koppel *et al.* (Accepted for Publication June 18, 2014). They found the pomegranate juice samples did not differ as much in their magnitude of each attribute as they did in the sum of the amount of attributes (Table 2-3). The fresh juice did not display many fluctuations in comparison to the fresh frozen juice. The most noticeable difference in fresh juice was the lack of carrot flavor, apparent in the other samples. Although musty/earthy and molasses flavors did not occur in the fresh frozen sample, these flavors were present in the pasteurized and reconstituted sample. The pasteurized juice, in comparison to the fresh frozen, lacked apple flavor, was lower in cherry flavor and astringency, and higher in grape, dark fruity, and brown sweet flavors intensities. The reconstituted sample was the most differentiated showing slight characteristics of brown spice and fermented with lack of beet, green-viney, and honey flavors.

Table 2-3 Modified Consensus Flavor Profile Results

	Samples			
Attribute	F	FF	P	R
Apple	1.5	2	0	1.5
Berry	3	2.5	3	3
Cranberry	3	3.5	3.5	3
Cherry	2	3	1.5	2
Grape	2	2	3	2
Floral	3	2.5	3	3
Fruity	4	4	4	3.5
Carrot	0	1.5	2	2
Beet	2	2	2.5	0
Brown Spice	0	0	0	1.5
Fermented	0	0	0	1.5
Fruity-Dark	2.5	2	3	3.5
Green-Viney	1.5	2	1.5	0
Musty/Earthy	1.5	0	2	1.5
Brown Sweet	2	2	3	3
Honey	1.5	2	1.5	0
Molasses	1.5	0	2	2
Sweet, Overall	4	4	4	4.5
Sweet	2.5	2.5	3	3
Woody	2	2.5	2	2.5
Salty	1.5	2.5	1.5	2.5
Sour	3	3.5	3.5	3.5
Bitter	3.5	3.5	3.5	3.5
Metallic	2	2	2.5	1.5
Astringent	4	5	4	4
Toothetch	2.5	2.5	2	2
Chalky Mouthfeel	2	2	2	2.5

F=Fresh, FF=Fresh Frozen, P=Pasteurized, R=Reconstituted

Consumer Evaluation

According to the average liking scores for each category assessed, no significant differences were present at a 5% significance level (Figure 2-1). Further assessment of liking scores was performed to determine if liking clusters existed. Total of four clusters were discovered (Figure 2-2). Consumer comments overall reflected their cluster preference and scores in the different liking categories. The consumers in Cluster 3 did not display a distinct preference for any of the samples. Cluster 1 particularly disliked the fresh frozen juice, Cluster 2 disliked the rehydrated juice, and Cluster 4 disliked the pasteurized juice.

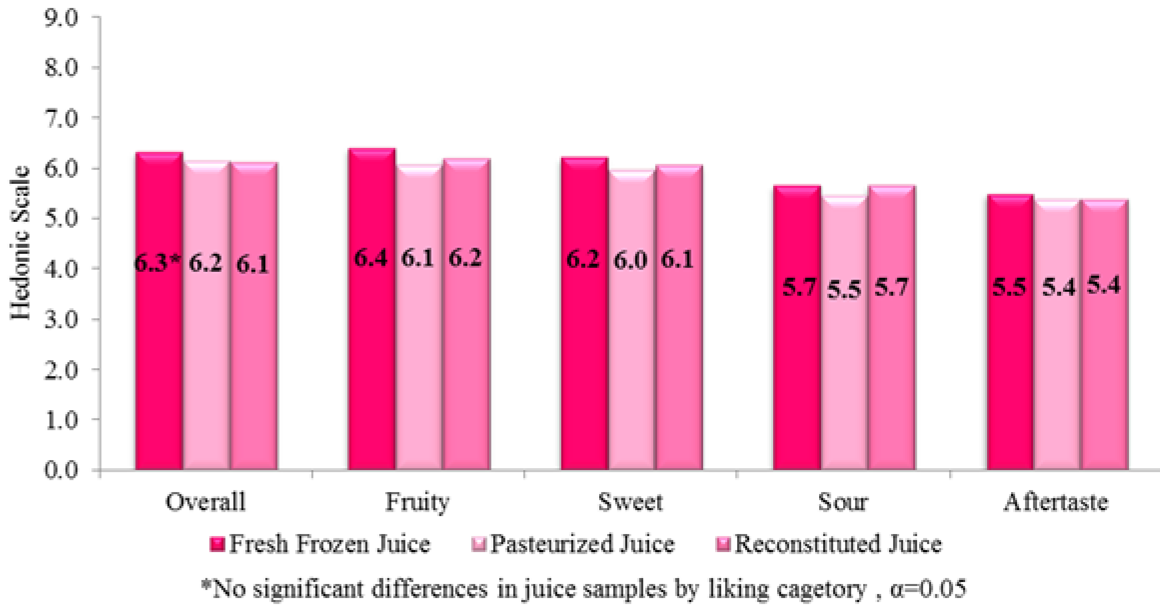


Figure 2-1 Average Consumer Scores by Liking

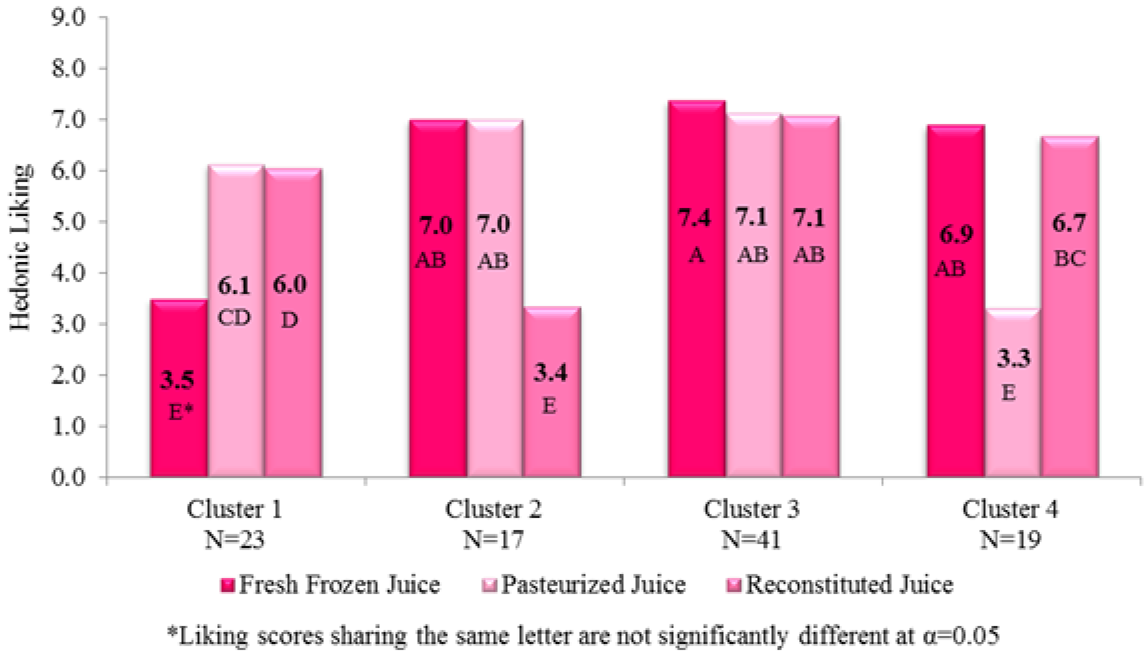


Figure 2-2 Average Overall Liking by Consumer Cluster

The majority of the consumers (80%) felt that they usually eat a healthy diet. The consumers' interest in healthy eating results can be explained by the Stages of Change model (Soontrunnarudrungsri. 2011). The distribution of consumers throughout the Stages of Change model reflected the results previously found by Soontrunnarudrungsri (2011) showing that most of the consumers fall in the Maintenance stage, decreasing in percentage to the Contemplation stage (Table 2-4). However, no participants in this study were found to be in the Precontemplation stage where they felt their diet was not usually healthy and were not considering changing to a more healthful diet. Overall liking scores showed that the consumers in the Action stage disliked the pasteurized and reconstituted juices significantly less than the consumers in the Contemplation stage liked the pasteurized juice (Figure 2-3).

Table 2-4 Consumer Interest in Healthy Eating Habits

Stage of Change	Description	% Consumers
Maintenance	Healthy diet for 6 months or more	61
Action	Made changes in last 6 months to be more healthful	19
Preparation	Considering to a more healthful diet in next month	13
Contemplation	Considering changing to a more healthful diet in the next 6 months	7

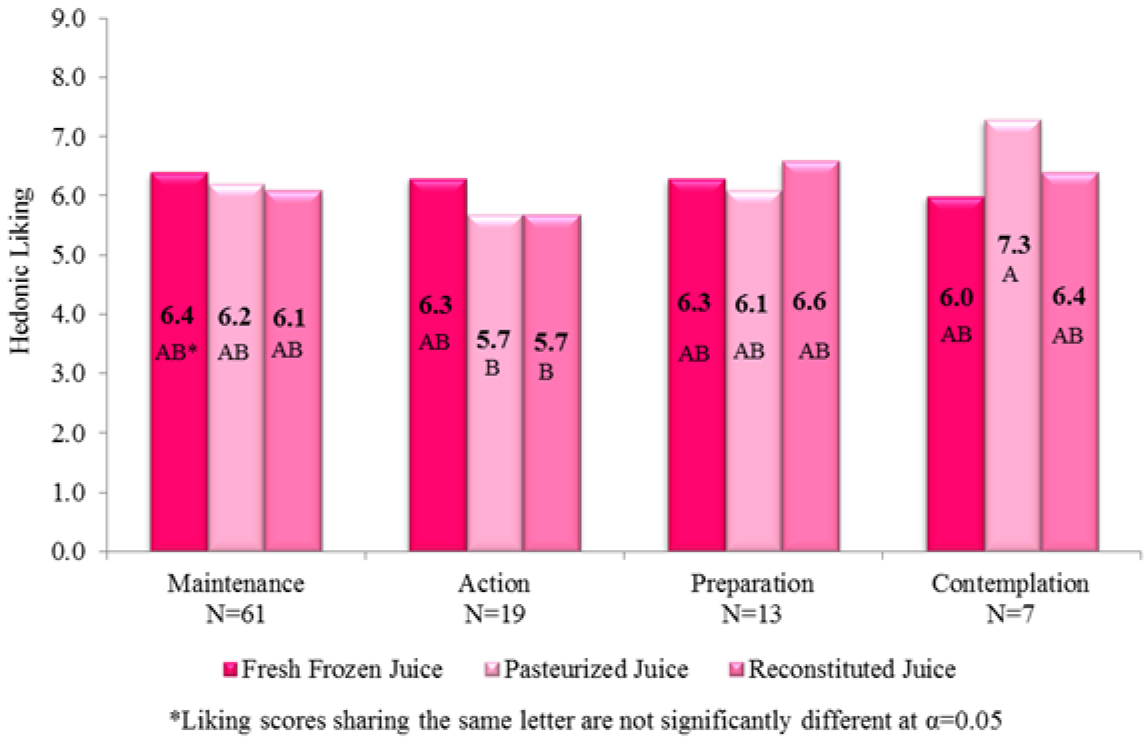
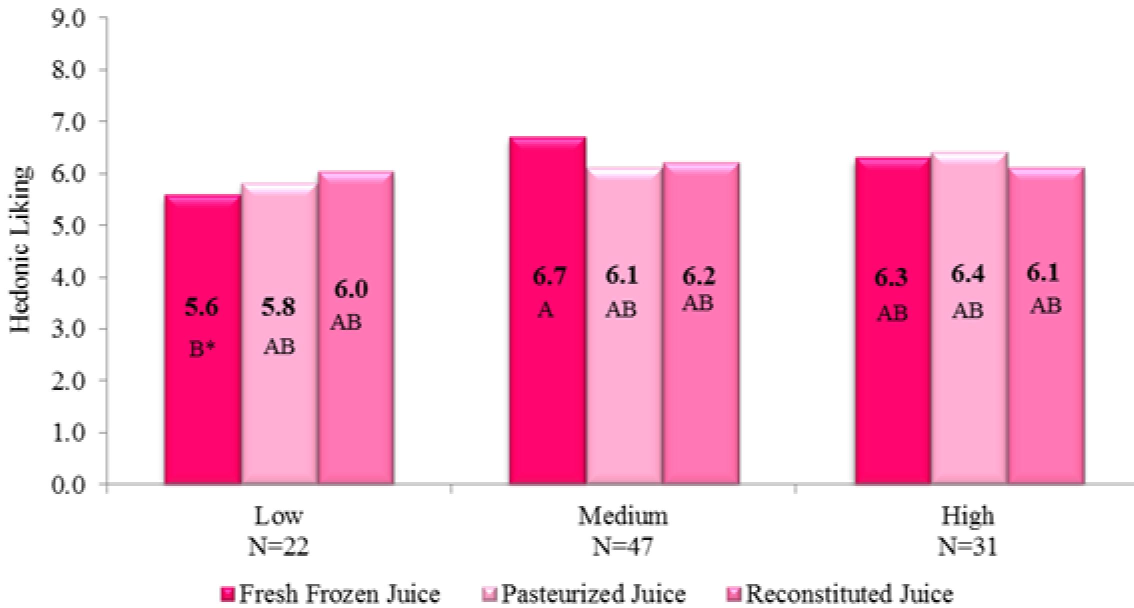


Figure 2-3 Average Overall Liking by Stages of Change

Van Trijp and Steenkamp (1992) have divided the possible variety seeking scores into the levels of low, medium, and high (Table 2-5). The average consumer in this study was considered to have a medium intrinsic variety seeking level with a score of 30.33. Based on these category divisions, liking scores were compared across low, medium, and high variety seeking groups. None of the variety seeking groups showed a strong level of liking for any of the juice types (Figure 2-4). However, compared to medium variety seekers, low variety seekers liked the fresh frozen juice significantly less.

Table 2-5 Consumer Variety Seeking Scores

Variety Seeking Level	Score Range	% Consumers
Low	25 and below	22
Medium	26 - 34	47
High	35 and above	31



*Liking scores sharing the same letter are not significantly different at α=0.05

Figure 2-4 Average Overall Liking by Variety Seeking Category

Discussion

The profiles of the fresh and fresh frozen juices were found to be quite similar which allows for comparison of pasteurized and reconstituted juice to the fresh frozen juice as similar to fresh during the consumer study. Although differences were not large in magnitude differences did exist among samples for each processing treatment. These differences probably had an influence on consumer acceptability.

Consumer clusters were expected as Koppel *et al.* (2014) previously found different liking clusters across countries. The juices in this study were surprisingly well liked, particularly by Cluster 3, as previous studies had not seen as high of liking scores in pomegranate juices or juice blends (Koppel *et al.* 2014; Vázquez-Araújo *et al.* 2010; Endrizzi *et al.* 2009), and a consumer cluster was expected that did not like any samples as found by Koppel *et al.* (2014). Our finding that groups individually each disliked a sample indicated that processing methods may play a role in consumer choice when pursuing pomegranate products. From the samples evaluated, the appearance of specific flavors such as brown spice and fermented and lack of beet, green-viney, and honey may have contributed to the significant dislike of the reconstituted product by Cluster 2. A summation of small changes may have influenced consumer significant dislike of the pasteurized sample by Cluster 4. These small changes include lack of apple flavor, lower cherry flavor and salty taste, increased grape and musty/earthy flavor.

Processing exhibited changes that may be associated with heating such as increase in level of grape, dark fruity, or brown sweet flavors. Flavors such as these were previously noted in commercial juices that had undergone processing (Vázquez-Araújo *et al.* 2011). The elevation of these flavors may have influenced the liking of Cluster 1, which significantly disliked the fresh frozen juice in comparison to those that had undergone processing. Lozano (2006) suggested that pasteurization at higher temperatures (such as that greater than 121°C for 0.1 seconds) may impart cooked flavor to juice. Further processing may have the capability of enhancing specific notes while decreasing others potentially impacting consumer acceptability. Future studies may address this potential by examining variables such as pasteurization temperature as it relates to product liking.

Stages of change related to interest in healthy eating showed significant differences in acceptance of pomegranate juices in the action and contemplation stages. Examining scores in the other liking categories these differences appear to relate to aftertaste. The pasteurized juice received the highest score in aftertaste liking from the Contemplation group at 6.7. While the pasteurized and reconstituted juices received the lowest aftertaste score from the Action group at 4.5 and 4.8 respectively. These groups showed a trend in aftertaste liking; the Action group was the least accepting of aftertaste, the Maintenance group was the second least accepting, and preparation and Contemplation groups were the most accepting. From this study, we observed that the majority of juice drinkers tend to be more interested in healthy eating and did not discriminate much among juices. Future studies may consider investigating if consumers who are more interested in healthful eating are more discriminatory among other foods and beverages.

VARSEEK scores were expected to be higher with higher liking of samples, as pomegranate juice popularity is relatively recent. We found that acceptability was not well distinguished by VARSEEK scores as there were no significant differences among clusters in this respect and few differences among liking of the samples at different variety seeking levels. Previously, Lähteenmäki and Van Trijp (1995) also were unable to relate variety seeking tendencies to liking in the evaluation of sandwiches, but did find that those with higher variety seeking tendencies tried more “less appropriate” sandwich fillings than those with lower scores. Based on the previous results with sandwiches, it may be useful to consider evaluation of liking scores in combination with juice purchasing habits for a variety of juices to better understand the variety seeking tendencies of pomegranate juice consumers. Moreover, consumer demographics did not demonstrate large differences across clusters, including interest in healthy eating. All clusters had consumers that typically ate a healthy diet overall and if they did not believe they had a healthy diet overall were planning to change their diet to be more healthful.

These findings present additional opportunities for further understanding of sensory effects of pomegranate processing on consumer acceptance. The samples used in this study were prepared on a small scale. As differences were present in both pasteurization and drying effects, comparison of products produced on a larger scale would be beneficial to understand processing influences in industry. Additionally, processes such as clarification and concentration should be considered for testing as noted changes are produced by polyphenol reduction and heating processes respectively. Both processes are used in industry to improve storage stability. Clarification reduces phenolic compounds decreasing the level of astringency (Fischer *et al.* 2011). Methods that involve heating increase the browning index, an indicator of browning reactions such as in Maillard browning or caramelization, forming new flavor compounds (Yousefi *et al.* 2012). Astringency level fluctuation and flavor changes due to browning may impact consumer acceptance. Lawless *et al.* (2013) found that presentation of antioxidant information influenced acceptance of black cherry, concord Grape, and pomegranate juice blends. Several studies have proven that processing has an influence on polyphenols; these influences could be presented to consumers as antioxidant levels to determine their impact on acceptance.

Conclusions

Flavor variations were found as a result of processing methods although small in magnitude. The amount of attributes presenting small changes is influential, presenting distinct differences in consumer liking. Most juice drinkers tend to be interested in healthy eating, however did not discriminate much among juices overall. Future investigations may consider examining if this is the case with other product types. Variety seeking tendencies did not show a defined relationship with product liking scores. However, the variation in processing methods exposed three consumer clusters that each individually disliked a particular sample within the study. The largest cluster surprisingly liked all three juices at a level not previously seen in other studies. Further exploration in the areas of pomegranate processing on consumer acceptance such as full scale processing changes, additional processing methods, and antioxidant information influence would be beneficial to explore.

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Chapter 3 - Measuring Single Consumption Using Time Intensity Multi-Evaluation (TIME) Profiling

Abstract

The objective of this study was to demonstrate a new method, Time-Intensity Multi-Evaluation (TIME) using pomegranate juice to understand the experience of one sip. Arils removed from fresh Wonderful pomegranates were used to prepare fresh frozen juice, pasteurized frozen juice, and reconstituted juice from dried arils. Samples were evaluated in duplicate by a trained descriptive panel using a consensus modified flavor profile method and new TIME methodology. In TIME methodology, panelists rated the intensity of each attribute at predetermined time intervals to express how the flavor of the pomegranate juice changed during and after sipping. Using consensus methodology (1) time and order of flavor onset, (2) length of flavor peak, and (3) how flavors dissipate post bite/sip consumption were described. TIME methodology can describe multiple attribute changes experienced during a bite or sip using better explaining complex products and the consumer experience of first product trial.

Introduction

Sensory profiling of consumer products can be performed using numerous methodologies. However, only one methodology category can provide information on a product over consumption. Time-intensity methodologies are useful in determining how products, specifically food, can change over a defined period of usage. Different approaches can be taken to understand these changes. Traditional time intensity methodology can be divided into three main categories. These include discontinuous sampling, continuous tracking, and temporal dominance techniques as defined by Lawless and Heymann (2010).

The first of these three methodologies is discontinuous or discrete sampling, which can be completed in two fashions, the first focuses on rating different phases of consuming food, which is specifically appropriate for texture (Lawless and Heymann. 2010). Segments of measurement may include, for example, first bite and first chew. Attributes are then divided into which categories they appear in (such as first bite), as previously demonstrated with cheese (Jack *et al.* 1994). The second fashion is to continually rate selected attributes at designated time intervals used previously with products such as artificial sweeteners (Ayya and Lawless. 1992).

Continuous tracking can easily be completed using audible cues or specifically designed sensory programming. Through this programming, panelists continually record the changes they observe in 1-2 attributes. The programming is usually set to sample the continual tracking at pre-determined time segments as previously performed using sea salt solutions (Drake and Drake. 2011).

Temporal dominance techniques utilize continual tracking but allow panelists to switch between attributes dependent upon their observation of which attribute is dominant. Peach and mint gels were previously used to demonstrate this technique; when a new dominant attribute appears it is selected and intensity is measured until a new dominant attribute arises (Labbe *et al.* 2009).

Time intensity tracking commonly focuses on basic tastes and feeling factors, but less frequently attempts to capture aromatic components of flavor. In recent studies examples of salty (Drake and Drake. 2011; Souza *et al.* 2013a), sweet (Palazzo and Bolini. 2009; Palazzo *et al.* 2011; Souza *et al.* 2013b), sour/acid (Palazzo and Bolini. 2009), and bitter (Calvino *et al.* 2004; Kobue-Lekalake *et al.* 2012) time intensity curves were captured. Feeling factor tracking such as astringency (Kobue-Lekalake *et al.* 2012) and cooling (Labbe *et al.* 2009) have recently been observed. In the last 20 years, minimal attempts have been made to capture the time intensity eating experience of a product. The Dynamic Flavor Profile Method divides a product into the four basic tastes and 10 odorant groups (DeRovira. 1996). In this method, time intensity is measured individually and by consensus for each taste/odorant. The result is a three-dimensional spider plot with each spoke representing an attribute's time intensity profile. In another study, nine textural attributes of cheddar cheese were examined using a Progressive Profile (Jack *et al.* 1994). Progressive profiling measured each specified attribute at each chew stroke of an individual panelist. The multi-attribute data was then analyzed by Principal Components Analysis. Kuesten *et al*. (2013) used a Multi Attribute Time-Intensity (MATI) method to evaluate taffy. This method cycles through attributes at timed intervals so that multiple attributes can be collected during one evaluation. Panelist attributes were combined using a weighted rating mean.

Profiling methods used to describe variations among products only depict a portion of what the consumer experiences, especially in complex products. Time intensity methods can be used to track changes throughout the length of an eating or drinking experience. Time Intensity Multi-Evaluation (TIME) profiling methodology is proposed to understand the consumer experience of food and beverages by evaluating one sip or bite of a product. This discontinuous method demonstrates the benefits of examining multiple taste and aroma attributes over time. The TIME methodology displays (1) time and order of flavor onset, (2) length of flavor peak, and (3) how flavors dissipate post bite/sip consumption using consensus methodology.

Many types of food products can benefit from this developing methodology to aid in describing the consumer experience of one bite or sip of a product. Pomegranate juice will be discussed to demonstrate this emerging methodology. Pomegranate juice is a complex product displaying multiple aromatic attributes as well as basic tastes (Koppel and Chambers IV. 2010). The objective of this study was to demonstrate the use of TIME methodology in understanding flavor dynamics through differently processed pomegranate juice.

Materials and Methods

Samples

Three pomegranate juice samples were prepared from fresh pomegranates of the Wonderful cultivar. Arils were separated from the pomegranate rind and albedo. Two-thirds of the arils were juiced using a Hamilton Beach Health Smart Juice Extractor 67800 (Hamilton Beach/Proctor Silex, Inc., South Pines, NC, USA). The resulting juice was frozen fresh or batch pasteurized before freezing. Batch pasteurization was performed using a Pastomaster 60 RTX (Carpigiani, Bologna, Italy) at 63°C for 30 minutes. The remaining third of the arils were dried using an Excalibur 3926T Food Dehydrator (Excalibur Products, Sacramento, CA, USA) at 57°C for 10 hours. The resulting dried arils were frozen until preparation for testing.

Sample Preparation

Frozen juice samples were thawed in the refrigerator prior to pouring into serving cups. Dried arils were measured and ground frozen using a Black and Decker Smart Grind CBG5 (Applica Consumer Products, Inc, Miami Lakes, FL, USA). Ground pomegranate aril powder was rehydrated with deionized water (0.29:0.71 respectively). This mixture was allowed to rest and rehydrate for 10 minutes to achieve a measurement of 14-15 degree brix. After 10 minutes, the solids were separated from the resulting juice and the brix measurement was confirmed using a MT-032 Hand Refractometer (QA Supplies Perishable and Environmental Management, Norfolk, VA, USA). Sample amount was determined by the method used for descriptive analysis measurement.

Panelists

Six highly trained panelists from the Sensory Analysis Center, Kansas State University (Manhattan, KS, USA) participated in this study. These panelists received over 120 hours of training and over 1000 hours testing experience with many types of food products. The panelists also received additional orientation on the products they were testing, in this case, fresh and processed pomegranate juices.

Pomegranate Juice Evaluation

The three samples were first evaluated individually with a consensus modified flavor profile method used by Cherdchu *et al.* (2013), Di Donfrancesco *et al.* (2012), and Koppel and

Chambers (2010). The procedure was performed in duplicate, for further use with TIME profile evaluation. In this method panelists received 30mL of sample in a 96 mL cup. Panelists agitated the samples to suspend any sediment before evaluation. The samples were individually evaluated for 27 attributes seen in Chapter 2, Table 2-1 on a scale from 0 (weak) to 15 (extremely strong) using 0.5 increments (Appendix B). Following individual evaluation, consensus intensity for each attribute was established; panelists reviewed the results in conjunction with the project leader to determine which attributes were best suited for the TIME method. Factors influencing this decision included representative product type attributes, product differentiating attributes, and attributes which maintained their presence after expectoration. With these considerations, eight product attributes (from the total 27) were selected for evaluation including cranberry, fruity, green-viney, fermented, woody, sweet overall, astringent, and bitter.

The proposed TIME method examined one sip/bite (product dependent) during and after its consumption. No references were used throughout the evaluation. The size of the sip/bite, time the product is in the mouth, amount and type of manipulation, time of swallowing, and evaluation time and frequency after swallowing were determined prior to evaluation. Panelists first evaluated each attribute intensity individually at each chosen time point (including when attribute flavor starts and peaks); these measurements were discussed and agreed upon by consensus.

Panelists were provided with their intensity scores from the consensus modified flavor profile method, as a reference of intensity. Pomegranate juice samples of 5mL (the determined size of one sip) were served in 30 mL cups at ambient room temperature (21±1°C) one cup was provided for each attribute to be evaluated. Samples were agitated by panelists to suspend any sediment before evaluation. Panelists were instructed when to sip, swallow, and record individual measurements. The sample sipped was swished across the tongue and remained in the mouth for 10 seconds, allowing enough time to determine the time each specific flavor started and its intensity (0 (weak) to 15 (extremely strong)). At the eleventh second, panelists were instructed to swallow the sip and rate the intensity as it moved through the oral cavity to the throat. The intensities of aftertaste were evaluated every 15 seconds, starting at the 25th second through the 100th second, with a final measurement made at the end of 2 minutes (Appendix J). Palate cleansers of water, unsalted crackers, and low-moisture part skim mozzarella cheese were used in between sip and sample evaluations. The initial time point and intensities at each time point were agreed upon by consensus.

Data Analysis

Data analysis was completed by interpreting consensus TIME profiles, consisting of all attributes evaluated, in figures created in Microsoft Excel.

Results

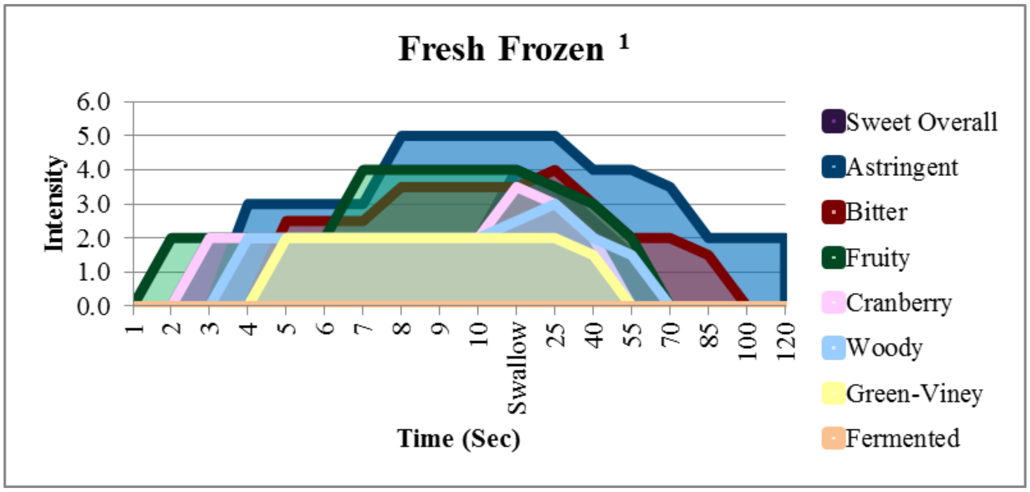
The results of the consensus modified flavor profile demonstrated that the pomegranate juices were defined by low intensities of several different attributes. Some products were lacking in specific attributes, for example the fresh frozen product did not display any fermented flavor whereas the reconstituted sample did (Table 3-1). The flavor contributors chosen for use in the TIME profile included 1 basic taste (bitter), 4 aromatics (cranberry, fruity, woody, and sweet overall), 1 feeling factor (astringent), and 2 flavor attributes (green-viney and fermented) not found in all samples. Fruity flavor always showed up at the beginning of the TIME profile, while bitter and astringent lasted longer than all other attributes (Figure 3-1).

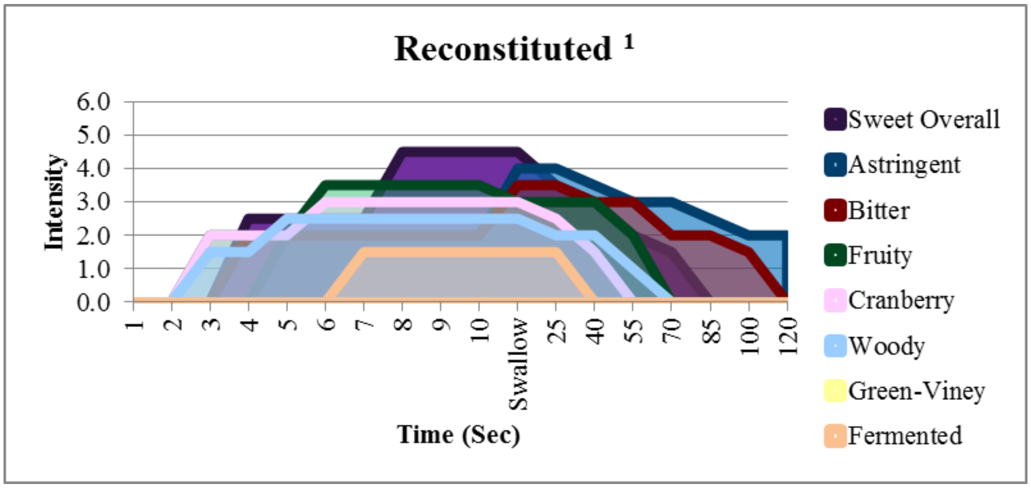
Table 3-1 Modified Consensus Flavor Profile Results for TIME Profiling

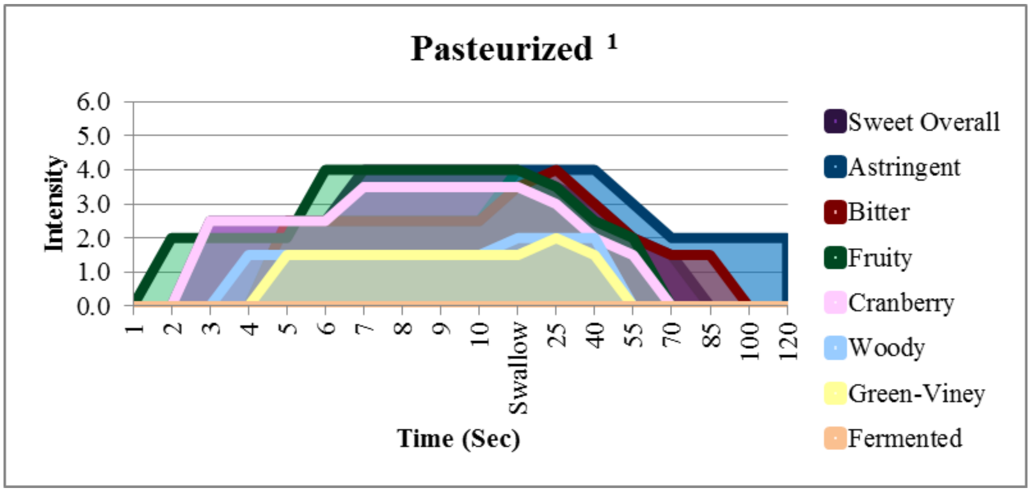
	Attribute Intensity							
Sample	Cranberry	Fruity	Fermented	Green-Viney	Sweet Overall	Woody	Bitter	Astringent
Fresh Frozen[1]	3.5	4.0	-	2.0	4.0	2.5	3.5	5.0
Fresh Frozen[2]	3.0	4.0	-	1.0	3.5	2.5	4.0	4.0
Pasteurized[1]	3.5	4.0	-	1.5	4.0	2.0	3.5	4.0
Pasteurized[2]	2.5	3.0	2.0	-	4.0	3.5	3.5	4.5
Reconstituted[1]	3.0	3.5	1.5	-	4.5	2.5	3.5	4.0
Reconstituted[2]	3.0	3.5	2.0	-	4.0	2.5	3.5	3.5

[1]Repetition 1 [2]Repetition 2

The fresh frozen samples showed that fruity and cranberry flavors were always perceived before the other attributes. Although the peak for the fruity attribute was relatively short (5-6 seconds) (Table 3-2), it was the third longest lasting attribute explored in this sample (Table 3-3). Cranberry and woody displayed short peak times of only one second. Green-viney was one of the first attributes to dissipate after swallowing followed by woody. Even though green-viney was one of the first flavors to dissipate, it demonstrated a longer peak holding time of 20 seconds at its low level peak. The two processed samples demonstrated longer peak times of the attribute woody than in the fresh frozen samples. When comparing to the fresh frozen sample, the pasteurized sample displayed a lengthier presence of sweet overall flavor. The reconstituted sample showed that sweet overall was the last attribute to peak before swallowing and sweet overall and cranberry attributes were the first to decline after swallowing. The woody flavor in the reconstituted juice consistently carried on longer than cranberry flavor. Additionally it was shown that astringent and bitter peaked for the same amount of time in the reconstituted sample, and the fermented characteristic held the longest peak intensity even at low levels. In all samples we can observe that bitter was the second last attribute to dissipate followed by astringency.


Fresh Frozen 1
Intensity
6.0
5.0
4.0
3.0
2.0
1.0
0.0
1
2
3
4
5
6
7
8
9
10
Swallow
25
40
55
70
85
100
120
Time (Sec)
Sweet Overall
Astringent
Bitter
Fruity
Cranberry
Woody
Green-Viney
Fermented


Reconstituted 1
Intensity
6.0
5.0
4.0
3.0
2.0
1.0
0.0
1
2
3
4
5
6
7
8
9
10
Swallow
25
40
55
70
85
100
120
Time (Sec)
Sweet Overall
Astringent
Bitter
Fruity
Cranberry
Woody
Green-Viney
Fermented


Pasteurized 1
Intensity
6.0
5.0
4.0
3.0
2.0
1.0
0.0
1
2
3
4
5
6
7
8
9
10
Swallow
25
40
55
70
85
100
120
Time (Sec)
Sweet Overall
Astringent
Bitter
Fruity
Cranberry
Woody
Green-Viney
Fermented

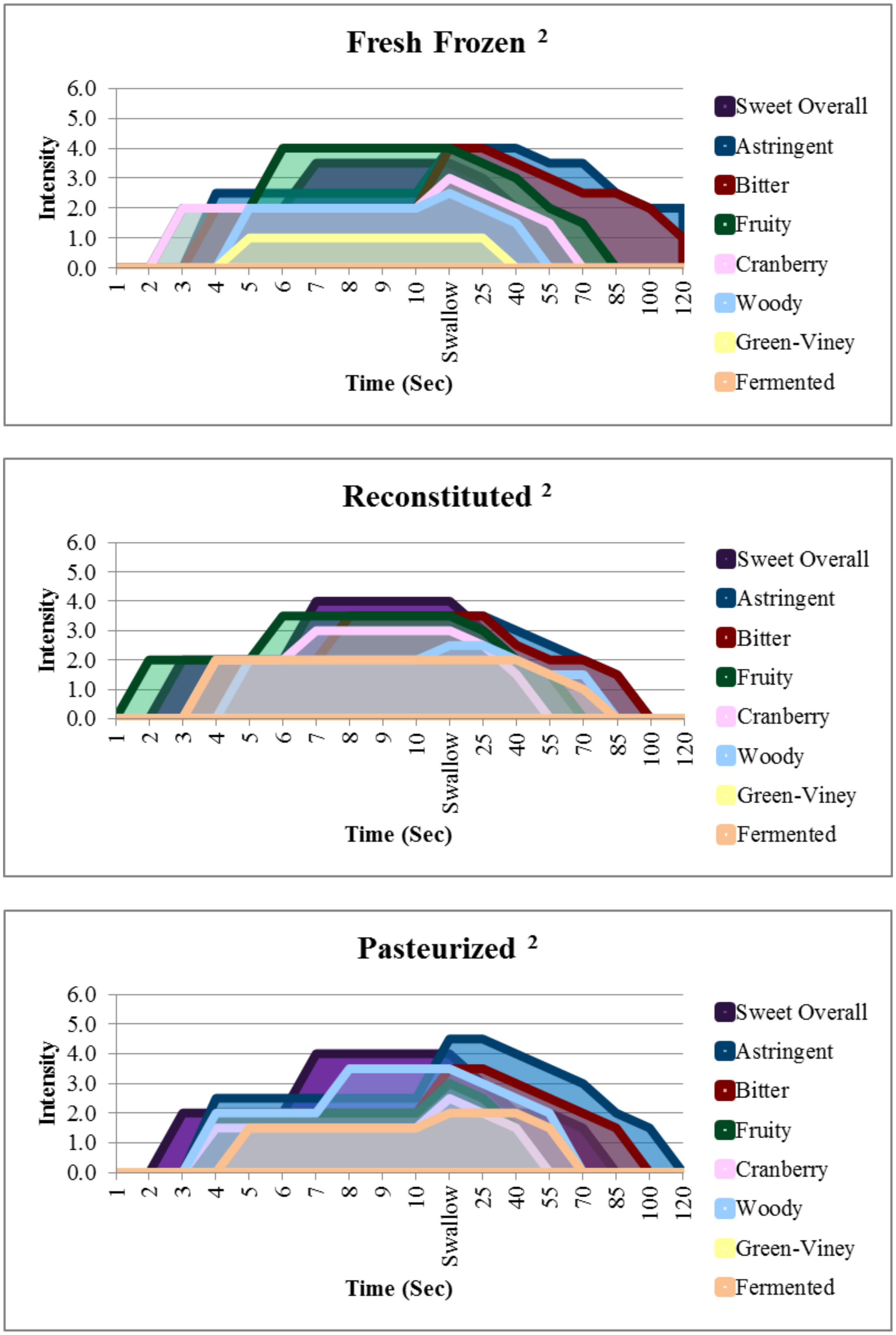


Figure 3-1 TIME Profiles

([1]Repetition 1 [2]Repetition 2)

Table 3-2 TIME Profile Attribute Time at Peak Intensity

	Attribute Time at Peak Intensity (seconds)							
Sample	Cranberry	Fruity	Fermented	Green-Viney	Sweet Overall	Woody	Bitter	Astringent
Fresh Frozen[1]	1	5	-	20	1	1	1	17
Fresh Frozen[2]	1	6	-	20	5	1	14	29
Pasteurized[1]	5	6	-	1	5	29	1	29
Pasteurized[2]	1	1	29	-	5	4	14	14
Reconstituted[1]	6	5	18	-	4	7	14	14
Reconstituted[2]	5	6	36	-	5	14	17	17

[1]Repetition 1 [2]Repetition 2

Table 3-3 TIME Profile Attribute Length of Appearance

	Attribute Length of Appearance (seconds)							
Sample	Cranberry	Fruity	Fermented	Green-Viney	Sweet Overall	Woody	Bitter	Astringent
Fresh Frozen[1]	52	68	-	50	67	66	95	116+
Fresh Frozen[2]	67	82	-	35	66	50	116+	116+
Pasteurized[1]	67	68	-	50	82	51	95	115+
Pasteurized[2]	51	51	65	-	82	66	96	116
Reconstituted[1]	52	67	33	-	81	67	116	115+
Reconstituted[2]	53	68	81	-	67	80	96	96

[1]Repetition 1 [2]Repetition 2

Discussion

The results presented from the proposed method exhibited information that can lead to greater product understanding from both descriptive analysis and consumer evaluation perspectives. The benefit of standard profiling methods (e.g. quantitative descriptive analysis methods) used in sequence with time intensity measurements (e.g. temporal dominance of sensations (TDS)) can be beneficial in a commercial setting as concluded by Ng *et al.* (2012).

Flavor profiles that show minimal magnitude differences, such as the case exhibited in this study, may be missing a dimension that better explains what is happening during the eating/drinking process. As seen in the presented case, further differentiation among products can be seen when looking at how multiple attributes change over time. Examining multiple attributes gives a broader picture of what is happening when a product is initially tasted. Initial product trial, such as a free sample, has been shown to have positive effects on immediate purchase (Lammers. 1991) as well as purchase over an extended period of time, such as a half a year (Bawa and Shoemaker. 2004). Understanding how the first bite/sip is experienced could be imperative to determining how to increase consumer product acceptance, thus having an impact on future sales. Bitter taste and astringency, found in pomegranate juice, may have a negative impact on the consumer experience. Past studies displaying bitter components such as those of green tea (Lee *et al.* 2010), sweet potatoes (Leksrisompong *et al.* 2012), and juice blends (Lawless *et al.* 2013) have shown negative consumer responses related to this attribute. At what time and for how long during tasting disliked attributes appear may have an effect on consumer approval (or disapproval) of the product. A consumer study performed in Estonia, Spain, Thailand, and the United States using pomegranate juices found that the sample displaying the highest level of bitter taste, metallic flavor, and astringency among samples was least liked overall by consumers in each country (Koppel *et al.* 2014). When exploring drivers of liking only one consumer cluster out of five, representing 15-32 % of the total consumers surveyed in each country, was found near these attributes. Understanding how these flavors interact with more desired characteristics, such as sweetness, within a bite or sip of a product could help identify what types of product flavor patterns are desired or should be avoided, thus creating a more favorable consumer product. This method would be particularly useful if a group of products displayed similar flavor profile information but differentiated consumer liking. The ability of TIME profiling to relate to both descriptive data as well as consumer liking demonstrates the benefits to performing this method.

Using modified consensus profiling data has benefits as well as drawbacks. Consensus information does not rely upon statistics as the different results per definition are statistically significant (Keane. 1992). When interpreting some of the information presented in this study, it can be seen that not all of the information is identical across sample types. Panelists discussed that they found the consensus modified flavor profile score important in determining initial intensities at low levels in the TIME profiling process. By allowing panelists to access the maximum intensity scores, differences found in these samples during the consensus modified flavor profile appear to have carried over to the beginning of TIME profile. This shows that using the modified flavor profile score can have a strong impact on results. The formation of a TIME profile without maximum intensity references may result in a more pure understanding of intensity changes. Examination of the TIME profile creation with and without consensus modified flavor profile scores as a reference would be beneficial to further understand any effect from this reference.

Although steps have been taken to facilitate uniformity, natural variation within the juices and variation among panelists' perception may have contributed to attribute differences across replications. Reviewing one sample of each product will provide the clearest understanding. However, this presents an issue when trying to account for products with inherent variation. To account for this situation, methodology related to the traditional Flavor Profile method as discussed by Keane (1992) may be used. Multiple replications of samples may be evaluated using the TIME method first creating a preliminary profile, followed by attribute intensities adjustments by panelists to best represent product variability.

The proposed TIME methodology has multiple testing parameters that must be determined prior to testing. These include bite/sip size, time the product remains in mouth before swallowing, amount and type of manipulation of the product in mouth, and time intervals used before and after swallowing. These measurements and techniques are dependent upon the product that is being evaluated. In the case presented, panelists helped determine the sip size of the products. Panelist opinion in this area is important to include so that reasonable expectations of the panelists are set. However, in order to best reflect the consumer experience focus groups or observational studies could be used to better understand how a product is consumed prior to TIME evaluation. These studies may help understand how new users test their boundaries with a product that is unfamiliar to them such as those with exotic flavors, new brands, or completely new product types. Attributes that are to be examined may be in part determined by the project objective, by panelist insights (as performed in the cases of pomegranate juice), or by better understanding of what the consumer experiences (as done through observational studies or focus groups).

The current American Society for Testing and Materials (ASTM) Standard Guide for Time Intensity Evaluation of Sensory Attributes (2013) contains guidelines specific to single attribute time intensity evaluations. Examining multiple attributes is not explained; however cued and real-time techniques for data collection are discussed. Neither of these collection methods presents a consensus methodology. TIME methodology is similar to the Dynamic Flavor Profile Method (DeRovira. 1996) in that consensus methodology is used and evaluates attributes individually, but product specific attributes are used as in the MATI method (Kuesten *et al.* 2013). This only allows comparison between samples evaluated with similar attributes, where the Dynamic Flavor Profile Method condensed flavor into four basic tastes and 10 odorant groups allowing for potential comparison across product types. The MATI method allows for multiple attribute examination in one period of evaluation, however timing of these evaluations can be complex when examining many attributes in one assessment, whereas the TIME method allows for an unlimited number of evaluations. Furthermore, textural attributes have the potential to be evaluated at various time points using the proposed method, in place of chew counts used in Progressive Profiling (Jack *et al.* 1994).

Conclusions

TIME methodology combines beneficial elements from previously proposed multi-attribute time intensity evaluations. These include consensus scoring, use of product specific attributes, and potential use of textural attributes in addition to flavor. Not only does TIME profiling have the potential to better explain how processing effects influence a product, it can also help explain the consumer experience of more complex systems. These complex products may include items such as teas, coffees, chocolates, spiced and flavored snacks, and numerous other products.

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Chapter 4 - Flavor Evaluation Using a Semi-Continuous Consumption Method

Abstract

Pomegranate juices exhibit characteristics, like astringency, that can build in strength over consumption. The objective of this study was to develop and demonstrate a new methodology to show how flavor changes during a semi-continuous consumption period. Arils were removed from fresh Wonderful pomegranates to prepare fresh frozen juice, pasteurized juice, and reconstituted juice from dried arils for evaluation. Samples were evaluated in duplicate using a modified flavor profile method and the proposed Semi-Continuous Consumption (SCC) method. In the SCC method, panelists scored the intensity of each attribute after a determined number of sips to show flavor intensity changes during consumption. It was found that different processing methods resulted in some profile similarities. However, samples were distinguished by level of increase in bitterness and astringency as well as decrease in other attributes such as fruity and sweet overall. The SCC method provides insight to the eating experience and information regarding possible reasons some foods may be rejected.

Introduction

Foods and beverages can be evaluated by an array of descriptive analysis tests measuring the magnitude of various flavor and textural components of a product. Many of these methods focus on making a static product profile. Dynamic processes were not explored until the early 1950's and 1960's by examination of temporal responses to bitterness in beer and other substances such as quinine (Cliff and Heymann. 1993). Currently, time-intensity tracking is completed using one of three categories of techniques. These are comprised of discontinuous sampling, continuous tracking, and temporal dominance discussed further by Lawless and Heymann (2010).

Continuous sampling commonly tracks one or two attributes, while discontinuous sampling and temporal dominance techniques may track multiple attributes at once. Some methods have evolved to capture multiple attributes since the 1990's. These methods include Progressive profiling (Jack *et al.* 1994), the Dynamic Flavor profile (DeRovira. 1996), and Multi-Attribute Time Intensity (MATI) method (Kuesten *et al.* 2013).

Traditional time profiling methods only capture a moment of what is happening during the eating experience. A few efforts have been made to capture the eating experience of multiple attributes of foods or beverages. Sequential profiling was used to better understand why oral nutrition supplements (beverage) may not be consumed as directed (Methven *et al.* 2010). Profiling using Quantitative Descriptive Analysis (QDA) and evaluation using multiple consumption events were both performed. During continual consumption evaluation, panelists used uniform sip sizes to evaluate five flavor components during ingestion, 30 seconds post tasting, and 60 seconds post tasting. This continued for eight sips, with a total of 2 minutes in between sips. Another method, the drinking/eating profile was introduced to better understand the consumer perception during a whole drinking event (Vázquez-Araújo *et al.* 2013). Beer was used as medium to demonstrate this method. Panelists scored multiple attributes individually for five separate sips with the allowance of crackers in between sips. Continuous profiling has also been used to evaluate consumer liking. Dynamic flavor profiling was used with hedonic evaluation of chewing gum (Delarue and Loescher. 2004). Consumers were asked to score their liking of 6 different chewing gums at 1 minute, 5 minutes, and 30 minutes. Oral nutritional supplements were also studied with consumers (Methven *et al.* 2010). Consumers were provided with 5mL sips and asked to indicate their level of liking of the product after their initial trial and then again after 8 sips.

Most food products are consumed in multiple bites or sips to finish the intended portion or serving size. Some foods and beverages can be noted to cause specific flavor heightening with continual ingestion. This change in flavor could have an influence beyond what happens during a product's initial trial. Methodology to understand how flavor changes throughout the eating and drinking process has been minimally explored. The proposed SCC method has similarities to the most recently explored methods in this area, where subsequent sips/bites are used to evaluate a product at regular time intervals. The SCC method differentiates in that the new method uses a determined sample amount for each sip/bite (where some have previously not) and is used over an extended period of time to mimic a consumer continually eating or drinking a product at length. Consensus agreement was performed in place of individual scores to demonstrate this procedure, as individual replications of time intensity profiles can have inherent natural variability among panelists, which can result in an inaccurate representation of taste perception over time (Bloom *et al.* 1995).

The SCC method may provide additional understanding of many food and beverage products, particularly products that leave a lingering aftertaste, prominent mouth feel component, and/or potential of flavor masking with continual use. Pomegranate juice samples were used to demonstrate the use of this emerging methodology as they contain a multitude of flavors, basic tastes, and feeling factors (Koppel and Chambers IV. 2010). The objective of this study was to demonstrate the preparation and use of the SCC profiles in understanding of multifaceted products, such as pomegranate juice.

Materials and Methods

Samples

Fresh pomegranates of the Wonderful cultivar were used to prepare three pomegranate juice samples. Arils were first separated from the pomegranate rind and albedo. Two-thirds of the separated arils were juiced using a Hamilton Beach Health Smart Juice Extractor 67800 (Hamilton Beach/Proctor Silex Inc., South Pines, NC, USA). The resulting juice was frozen fresh or batch pasteurized using a Pastomaster 60 RTX (Carpigiani, Bologna, Italy) at 63°C for 30 minutes before freezing. An Excalibur 3926T Food Dehydrator (Excalibur Products, Sacramento, CA, USA) was used to dry the remaining third of the arils at 57°C for 10 hours. Once dried, the arils were frozen until preparation for testing.

Sample Preparation

Frozen juice samples were transferred to refrigeration temperature to fully thaw prior to distribution among serving cups. Frozen dried arils were measured and ground using a Black and Decker Smart Grind CBG5 (Applica Consumer Products, Inc, Miami Lakes, FL, USA). The resulting pomegranate aril powder was rehydrated with deionized water (0.29:0.71 respectively). Rest and rehydration of this mixture occurred for 10 minutes to achieve a measurement of 14-15 degrees brix. After resting, the solids were separated from the resulting juice and the brix measurement was confirmed using a MT-032 Hand Refractometer (QA Supplies Perishable and Environmental Management, Norfolk, VA, USA).

Panelists

Six highly trained panelists, with over 120 hours of training and over 1000 hours of testing experience, from the Sensory Analysis Center, Kansas State University (Manhattan, KS, USA) participated in this study. The panelists received additional orientation on the pomegranate juice samples they were testing and new methodology. Additionally, all participating panelists had previous experience with methodology development.

Evaluation

Fresh frozen, pasteurized, and reconstituted juices were first individually evaluated with a consensus modified flavor profile used by Cherdchu *et al*. (2013), Di Donfrancesco *et al.* (2012), and Koppel and Chambers (2010). A 96mL cup containing 30mL of juice at ambient temperature (21±1°C) was provided to each panelist. Panelists agitated samples prior to evaluation to suspend sediment. The samples were evaluated for 5 attributes (fruity, sweet overall, and woody flavors, bitter taste, and astringent feeling factor), shown in Chapter 2, Table 2-1 using 0.5 increments on a scale of 0 (weak) to 15 (extremely strong). Individual evaluation was preceded by establishing a consensus score for each of the attributes described. Two replications were completed for each sample for use in the following evaluation.

The proposed SCC method explores how flavor perception changes during its consumption over a fixed time frame. References and palate cleansers (such as water and unsalted crackers) are not used during this method to prevent adulteration of the product flavor while simulating consumption. The panelists need to determine the size of the bite/sip, the number of bites or sips to be taken, time in between bites/sips, time the product is in the mouth, amount and type of in-mouth manipulation, time of swallowing or expectoration, and if swallowing or expectoration will occur after each sip/bite.

Intensity scores from the five attributes from the consensus modified flavor profile method were provided to the panelists as a reference for each sample. Panelist discussion and trial of different sip sizes determined that 5mL was an acceptable sip size. The number of sips taken was determined by trial of the evaluation procedure, described below, with different numbers of sips to examine if change in flavor was still occurring at a large sip number. A total volume of 125 mL, taken in 25 sips of 5mL was deemed acceptable to represent changes experienced in products over time. Pomegranate juice samples were served in 30 mL cups, each panelist received 25 cups (one for each 5mL sip) per sample at (21±1°C). Each cup was agitated by the panelists to suspend sediment before evaluation. During the SCC method panelists were instructed when to sip, swallow (only after the first sip), expectorate (sips 2-25), and record individual measurements. Samples were sipped, swished across the tongue, and remained in the mouth for 10 seconds before expectorating or swallowing on the 11th second. After a period of 19 seconds post swallow/expectoration, panelists were instructed to take their next sip. All four attribute intensities were recorded after the 1st, 5th, 10th, 15th, 20th, and 25th swallow/expectoration of the sample (Appendix K). Palate cleansers of water, unsalted crackers, and low-moisture part skim mozzarella cheese were provided after the 25th sample evaluation. The intensity of each attribute was agreed upon by consensus at the sip numbers determined for recording. Two replications of each sample were evaluated to examine repeatability of the methodology.

Data Analysis

Data analysis was completed by interpreting consensus SCC profiles which were created in Microsoft Excel, containing all attributes evaluated.

Results and Discussion

No more than a point difference in attribute intensity across replicates existed, with the exception of the fruity characteristic in the reconstituted samples (Table 4-1). There was little difference across samples in each replication; however the pasteurized sample was noted to be the most astringent.

Table 4-1 Modified Consensus Flavor Profile Results for SCC Profiling

	Time At Peak (seconds)				
Sample	Fruity	Sweet Overall	Woody	Bitter	Astringent
Fresh Frozen[1]	5	4	3	4	5
Fresh Frozen[2]	5	4.5	3	4.5	4
Pasteurized[1]	4	4	3	4.5	5.5
Pasteurized[2]	5	4	2.5	4	5
Reconstituted[1]	4	4	3	4	4.5
Reconstituted[2]	5.5	5	3	4	4

[1]Repetition 1 [2]Repetition 2

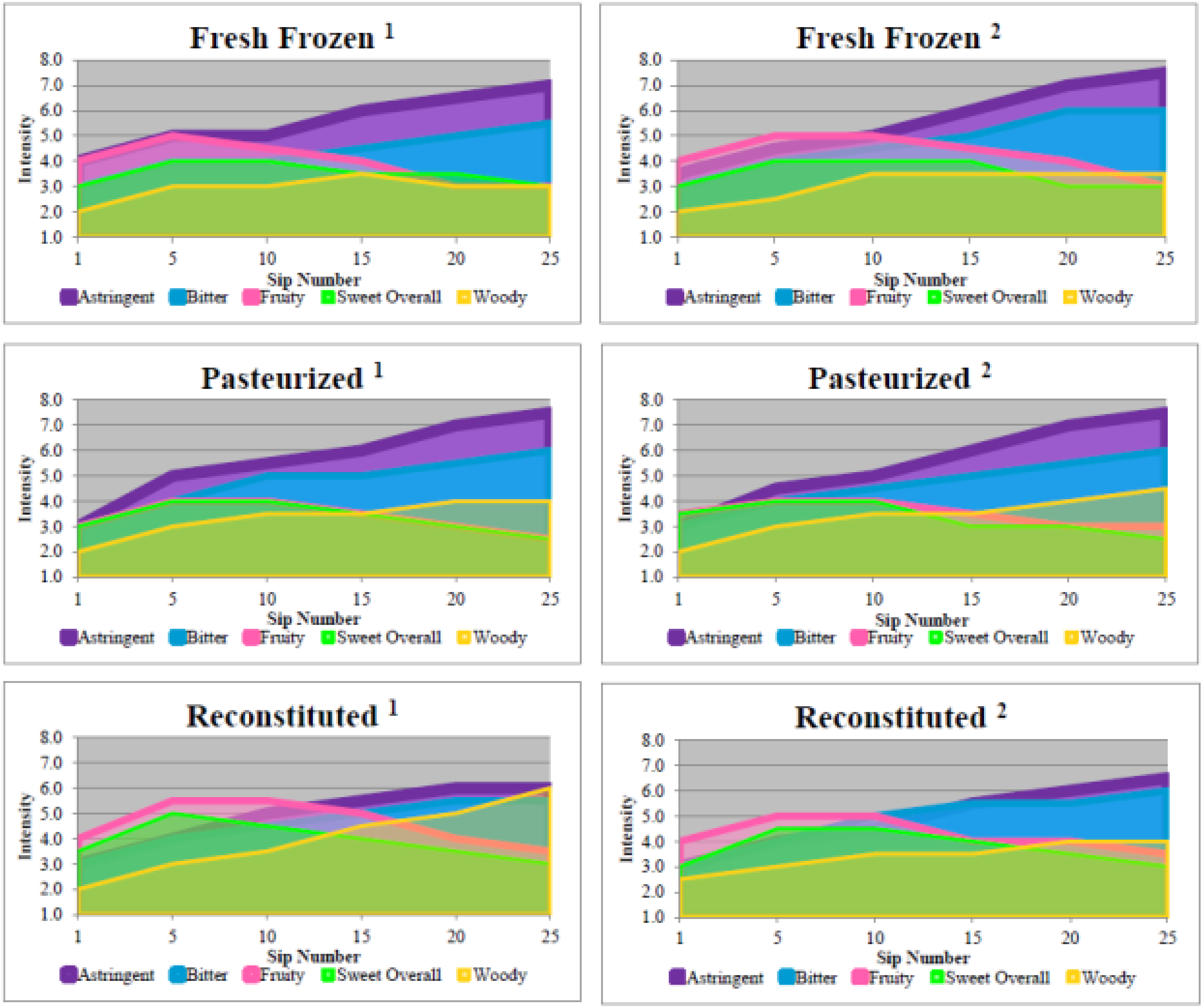

Figure 4-1 SCC Profiles

([1]Repetition 1 [2]Repetition 2)

A few trends were exhibited across samples, mainly that bitter and astringent components increased in intensity over consumption while fruity and overall sweet declined, although these interactions differed by sample type (Figure 4-1). Additionally, no sample reached a higher level of sweet overall or fruity flavor intensity than what was observed in the 5th sip. Bitterness followed a similar pattern across samples, ending at an intensity of 5.5 or 6.0 in each sample.

Woody flavor leveled out or approached decline by the 15th sip of the fresh frozen sample, while the pasteurized and reconstituted samples showed leveling off by the 20th sip or were in a continually increasing mode. By the 25th sip the woody characteristic was a minimum of 1.0 higher than fruity and sweet overall in both pasteurized and reconstituted samples. The level of difference observed between the replications of the reconstituted samples in woody flavor may be attributed to how reconstituted samples were prepared. Although the frozen arils from all pomegranates were combined together to reduce variability in preparation, rehydration of replicated samples were prepared on separate days. The separate rehydration of reconstituted samples may have also influenced the difference in magnitude of the fruity flavor of the flavor profile. Completing multiple replications and using consensus refinement to the initial profile would be beneficial to capture differences in products with natural variability as performed in the Flavor Profile method (Keane. 1992).

The fruity characteristic of these products was most closely followed by sweet overall in the pasteurized sample. The fresh frozen and reconstituted samples had higher intensity of fruity flavor than sweet overall by at least 0.5 for the first 10 sips. The fruity characteristic of the reconstituted sample was higher for a longer period of time throughout the sampling process when compared to the other samples.

Bitter and astringent attributes were observed in relation to one another differently in each sample. Fresh frozen samples showed bitter and astringent at different intensities from the 1st sip and continued at different levels through the 25th sip, although the gap between bitter and astringent intensity by the last sip was wider than when it started. Pasteurized juice began with bitter and astringent at the same level of intensity and the gap between the levels of these attributes widened as the total amount sipped increased. The bitter and astringent intensities in the reconstituted samples followed each other closely, with no more than 0.5 points between the two intensities. By the 25th sip the reconstituted sample was notably less astringent than the fresh frozen and pasteurized samples, although similarly bitter.

The lack of explanation in sample differences when viewing the results of the consensus modified flavor profile can be explained, as demonstrated, by investigating flavor changes through semi-continuous consumption. It should be noted that the intensities of the attributes on the first sip were different from the consensus modified flavor profile scores. This is likely due to the difference in amount of juice and objectives of the two methodologies. The consensus modified flavor profile gives an overall impression of each flavor intensity with an unspecified amount of juice used in evaluation. The goal of SCC profiling is to capture how the flavor increases over specified measurements of sip size. The overall flavor intensity may or may not appear in the SCC profile. Several factors could contribute to the appearance or lack thereof of each attribute degree including frequency of data collection, inability to use references, or focus on multiple attributes over a minimal time period. This inconsistency between methods may be remedied by increasing frequency of data points (i.e. record information every 3 sips in place of every 5 sips). "Missing" moments due to the use of discontinuous data collection methods for time profiling has been noted by Kuesten *et al.* (2013). Decreasing the number of attributes to be measured (i.e. 3 or 4 attributes in place of 5) during the SCC method may also help prevent "missing" moments, as panelist attention to detail is less divided. Although SCC methodology does not directly reflect the results of the consensus modified flavor profile, it still provides depth in understanding product differences.

The demonstration of this methodology used panel trial and discussion to determine sip size and amount of sips to be taken, however varying approaches may be taken to achieve these numbers based on the project objectives. Sip or bite size may also be determined by observational studies or focus groups of consumers with descriptive panelist input (to ensure reasonable expectations are set). The number of sips taken could be influenced by product serving size or observed consumer eating/drinking habits. The amount of consumption versus expectoration may also be altered based on the project objective. Expectoration deviates from normal consumption behavior of food and beverages. Although it has been found that bitter intensity was not influenced by expectoration during time intensity application, this was used in short term application (Calvino *et al.* 2004). In this study, panelists were instructed to only swallow on the first sip, to help development of aromatic compounds. No further consumption was allowed due to concern that satiation through ingestion of several samples may decrease the acuity of flavor recognition. However, swallowing product on the intervals being measured (dependent upon frequency and product type) may be beneficial to better relate the semi-continuous experience to what the consumer experiences, with lesser chance of decreasing acuity. Feeling factors and basic tastes, as demonstrated with pomegranate juice, can exhibit an intensity increase as more product is continually consumed. Aftertaste evaluation following the SCC evaluation could enhance the simulated product experience and consumer understanding.

Until recently, no methodology had been developed to examine the fluctuation of flavor intensity during extended product consumption. Although, Vázquez-Araújo *et al.* (2013) were unable to find differences in the drinking profile of beer after five sips, Methven *et al.* (2010) were able to find beneficial information on flavor build-up of an oral nutritional supplement after eight sips, thus indicating a larger amount of sips could be required for understanding. As demonstrated in SCC profiles, a lengthier understanding of product consumption can be displayed explaining the changes in multiple flavors. The Dynamic Flavor Profile Method

(DeRovira. 1996) is one of the only time-intensity methods that utilizes consensus methodology. The benefit of using consensus methodology in SCC profiling is that it allows for potential refinement of the profile to accommodate product variation and differentiation. This is accomplished by the agreement of highly trained panelists allowing for immediate interpretation upon profile completion (Keane. 1992). TDS and the MATI method (Kuesten *et al.* 2013) allow for viewing of multiple attributes within the specified time frame; however these attributes are not evaluated simultaneously which presents gaps when wanting to compare at defined time points in evaluation. Using discontinuous sampling while evaluating multiple attributes, SCC profiles allow for comparison of multiple attributes within one time point.

SCC profiles can add value to consumer information. Consumer testing of pomegranate juice blends has demonstrated, at best, moderate liking scores of these products (Endrizzi *et al.* 2009; Vázquez-Araújo *et al.* 2010). Vázquez-Araújo *et al*. (2010) found that combinations of blueberry and pomegranate juices were more receptive with consumers than when pomegranate was combined with raspberries and blackberries at the same level. Several factors are discussed that may play into this result including color, sourness, sweetness, and specific aroma compounds unique to each berry type. They note that the phenolic compounds, responsible for bitter taste, did not seem to play a role in liking but further research should be performed to confirm this finding. The understanding of liking related to phenolic compounds may be enhanced by SCC profiling. Although consumers in the study of Vázquez-Araújo *et al.* (2010) were only provided with 30mL of juice, we can see from the results of this study that differences in profiling can be distinct by the consumption of 25mL (5 sips) and bitterness may build in intensity throughout consumption.

Build-up of mouth drying, metallic, and mouth coating attributes were found over just eight sips of oral nutritional supplement (Methven *et al.* 2010). A hedonic evaluation was conducted after consumers finished the same number of sips completed by the descriptive panel, contributing to a better understanding of why patients do not always finish the recommended product amount. Similarly, the SCC method has potential to be used with hedonic questioning as well. Consumers may be provided with samples in the same fashion as trained panelists (same sip/bite sizes and amounts). Hedonic scoring could then take place at each interval (or selected intervals) used by trained panelists providing information on liking throughout the dynamic consumption process. These intervals may be short or extend over longer periods of time as demonstrated by Delarue and Loescher (2004) using chewing gum. Other products that may benefit from this type of analysis include products containing artificial sweeteners or salt substitutes, highly spiced products (especially those producing a sensation of "heat") and medical or nutritional supplements.

Conclusion

The SCC method was shown to be repeatable and provide insight to flavor changes during consumption where static profiling methods and many time-intensity methods do not. Not only can multiple attributes be examined at multiple time points but an understanding of how flavor changes during consumption is created. Although this is a time intensive method, it provides evidence beneficial to product flavor and consumer understanding. Furthermore, SCC profiling could be paired with hedonic consumer profiling over time that may be beneficial for products that exhibit flavor build up, such as nutrition aides.

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Appendix A - Modified Consensus Flavor Profile Definitions & References

Pomegranate Juice Study
Definitions & References

Apple:
A sweet, light, fruity, somewhat floral aromatic commonly associated with apple juice and apples
Reference: Gerber Applesauce = 6.0
Preparation: Serve in 1oz cup.

Berry:
The sweet, sour, sometimes dark aromatics associated with a variety of berries such as blackberries, cherries, currants, raspberries etc, excluding cranberries.
Reference: Blackwell Red Currant Jelly = 8.5
Preparation: Serve in 1oz cup.

Cranberry:
The sweet, fruity, slightly sour and sharp aromatics commonly associated with cranberries.
Reference: Old Orchard's Frozen Cranberry diluted (1:1) = 3.5
Ocean Spray Dried cranberries = 9.0
Preparation: Reconstitute Cranberry Concentrate according to instructions on the can.
Dilute the reconstituted cranberry juice 1(juice):1(water)
Serve in 1oz cup (all)

Cherry:
The sour, fruity, slightly bitter aromatics commonly associated with cherries.
Reference: RW Knudsen Cherry Juice diluted (1:2) = 4.0
Preparation: Dilute the cherry juice 1(juice):2(water), serve in 1oz cup.

Grape: The sweet, brown, fruity, musty aromatics commonly associated with grapes.

Reference: Welch's Concord Grape Juice diluted (1:1) = 5.0
Welch's White Grape Juice diluted (1:1) = 5.0

Preparation: Dilute concord grape juice 1(juice):1(water)
Dilute white grape juice 1(juice):1(water)
Serve in 1oz cup (all)

Floral: Sweet, light, slightly perfumey impression associated with flowers.

Reference: Welch's White Grape Juice diluted (1:1) = 5.0 (f)

Preparation: Serve in 1oz cup

Fruity: An aromatic blend of a variety of fruits, excluding citrus, cranberry and concord grape. May include apples, pears, white grapes etc.

Reference: Welch's white grape juice diluted (1:1) = 5.0 (f)

Preparation: Serve in 1oz cup (all)

Carrot: The aromatics commonly associated with canned, cooked carrots.

Reference: Del Monte Sliced Canned Carrots= 7.0

Preparation: Place sliced carrots (drained) in 3.5oz cup

Beet: The damp, musty/earthy, slightly sweet aromatics commonly associated with beets

Reference: Diluted Kroger Canned Beet juice (1:2) = 4.0

Preparation: Drain juice from beets, dilute beet juice 1(juice):2(water) serve in 1oz cup

Brown Spice: Aromatics associated with a range of brown spices such as cinnamon, nutmeg, cloves and allspice.

Reference: McCormick Spices, mixed=7.5 (a)

Preparation: Combine ¼ tsp of cinnamon, ¼ of ground cloves, ¼ of ground nutmeg and ¼ of allspice in a vile, shake well to combine. Steep ¼ tsp of spice mixture in ½ cup boiling water for 5 minutes, strain and dilute with water 1(spice water):1(water), pour ¼ cup dilution into medium snifter, cover.

Fermented: The aromatics associated with ripe/ overripe fruit; can be somewhat sweet, sour, browned, musty, and fruity.

Reference: Regina Cooking Wine = 10.0 (a)

Preparation: Pour ½ cup in medium snifters, cover with watch glass

Fruity-Dark: The sweet, brown honey/caramel-like aromatics commonly associated with dark fruits such as raisins and prunes that have been cooked.

Reference: Mixture of Sun Maid Raisins, Prunes, Ocean Spray Cranberries and water: juice = 5.0 (f)

Preparation: Mix of ¼ cup raisins, 1/3 cup dried cranberries and 1/4 cup of prunes (chopped), add ¾ cup of water and cook on high for 2 minutes. Strain, serve juice in 1oz cup.

Green-Viney: A green aromatic associated with green vegetables and newly cut vines and stems; characterized by increased bitter and musty/earthy character.

Reference: Campbell's Tomato Juice = 2.0 (f)

Preparation: Pour Campbell's Tomato Juice into 1oz cup

Musty/Earthy: Humus-like aromatics that may or may not include damp soil, decaying vegetation, or cellar-like characteristics.

Reference: Raw potatoes = 3.0 (aroma)
Diluted Kroger Canned Beet juice (1:2) = 7.0 (aroma)

Preparation: Cut potato into slices, place in medium snifter, cover.
Drain juice from beets, dilute beet juice 1(juice):2(water) Pour half cup in medium snifter, cover

Brown Sweet: A rich full-bodied brown sweet aromatics.

Reference: C&H Golden Brown Sugar dilution = 5.0

Preparation: Mix 2 tsp of C&H Golden Brown Sugar in 1 cup of water serve in 1oz cup.

Honey: Sweet, light brown, slightly spicy aromatics associated with honey.

Reference: Busy Bee Honey dilution = 6.5 (f)

Preparation: 2 teaspoons busy bee honey in 250 mL water, serve in 1oz cup.

Molasses: Dark, caramelized top notes that are slightly sharp and characteristic of molasses.

Reference: Grandmas Molasses = 6.5 (f)

Preparation: Mix 2 teaspoons of molasses in 250ml water, serve in 1oz cup

Sweet, Overall:	The perception of the combination of sweet taste, sweet aromatics, caramelized, brown sugar, honey, and maple	
	Reference:	3% C&H Golden Brown Sugar solution = 4.0
	Preparation:	Serve in 1oz cup (both)
Sweet:	The fundamental taste factor associated with a sucrose solution.	
	Reference:	2% Sucrose Solution = 2.0
		4% Sucrose Solution = 4.0
Woody:	The aromatics associated with dry freshly cut wood.	
	Reference:	Forster Craft Stick = 7.5 (a)
	Preparation:	Break stick into four pieces and put in snifter, cover
Salt:	Fundamental taste factor of which sodium chloride is typical.	
	Reference:	0.20% NaCl Solution = 2.5
		0.25% NaCl Solution = 3.5
Sour:	A fundamental taste factor of which citric acid in water is typical.	
	Reference:	0.025% Citric Acid Solution = 2.5
		0.050% Citric Acid Solution = 3.5
		0.080% Citric Acid Solution = 5.0
Bitter:	The fundamental taste factor of which caffeine or quinine is typical.	
	Reference:	0.010% Caffeine Solution = 2.0
		0.020% Caffeine Solution = 3.5
		0.035% Caffeine Solution = 5.0
Metallic:	The impression of slightly oxidized metal, such as iron, copper and silver spoons.	
	Reference:	0.10% Potassium Chloride Solution = 1.5
		0.2% Potassium Chloride solution = 4.0
Astringent:	The dry puckering mouthfeel associated with an alum solution.	
	Reference:	0.05 % Alum Solution = 2.5
		0.1 % Alum Solution = 5.0
Toothetch:	A sensation of abrasion and drying of the surface of the teeth.	
	Reference:	Welch's Concord Grape Juice diluted (1:1) = 5.0
	Preparation:	Dilute concord grape juice 1(juice):1(water) serve in 1oz cup

Chalky Mouthfeel: A dry, powdery sensation. Can be on mouth and /or teeth.
Reference: Cornstarch solution = 3.0
Preparation: Mix 1g of corn starch in 100 ml water, serve in 1oz cup.

15 point scale with 0.5 increments. Clean Out: Cubed Mozzarella
The Sensory Analysis Center

Appendix B - Modified Consensus Flavor Profile Ballot

Pomegranate Juice
Attribute Intensity

Panelist #

Sample #

Attributes	Attribute Intensity: Individual score		Attribute Intensity: Consensus score
Flavor	*0-15 with 0.5 increments*		
Apple			
Berry			
Cranberry			
Cherry			
Grape			
Floral			
Fruity			
Carrot			
Beet			
Brown Spice			
Fermented			
Fruity-Dark			
Green-Viney			
Musty Earthy			
Brown Sweet			
Honey			
Molasses			
Sweet Overall			
Sweet			
Woody			
Salty			
Sour			
Bitter			
Metallic			
Astringent			
Toothetch		-	
Chalky Mouthfeel			

Appendix C - Consumer Screener

Welcome![†]
Click the *next* button to begin

---

1. What is your gender?
   - ☐ Male
   - ☐ Female

---

2. What is your age?
   - ☐ Under 18***** ***Terminate**[††]
   - ☐ 18 – 24
   - ☐ 25 – 34
   - ☐ 35 – 44
   - ☐ 45 – 54
   - ☐ 55 – 64
   - ☐ Over 65

---

3. What is your race? (select all that apply)
   - ☐ Hispanic/Latino
   - ☐ American Indian or Alaskan Native
   - ☐ Asian
   - ☐ Black or African American
   - ☐ Native Hawaiian or Pacific Islander
   - ☐ White
   - ☐ Indian Subcontinent
   - ☐ Prefer not

---

4. Do you have any dietary restrictions or food allergies?
   - ☐ Yes***** ***Terminate**
   - ☐ No

---

5. Which of the following beverages would you consider purchasing when shopping for food? (select all that apply)
   - ☐ Milk?
   - ☐ Juice?***** ***Terminate if <u>not</u> selected**
   - ☐ Soda?
   - ☐ Tea?
   - ☐ Coffee?
   - ☐ Energy Drinks?

---

6. How often do you drink juice? (select one)
   - ☐ Once a day or more
   - ☐ 4 to 6 times a week
   - ☐ 2 to 3 times a week
   - ☐ Once a week***** ***Terminate**
   - ☐ Less than once a week***** ***Terminate**

---

7. Which of the following fruit juices would you consider trying? (select all that apply)
   - ☐ Mango?
   - ☐ Cranberry?
   - ☐ Orange?
   - ☐ Grape?
   - ☐ Pomegranate?***** ***Terminate if <u>not</u> selected**
   - ☐ Blueberry?
   - ☐ Cherry?
   - ☐ None of the Above

Qualifier Message

Thank you for completing our survey.

The study will consist of one 30 minute session. This study will be held on May 15-16 at the Kansas State University, Manhattan Campus.

If you qualify, you will be contacted by our sensory analysis staff.
The compensation for this study will be $15.

Are you willing to participate in this study?

☐ Yes** **** Fill out contact info**

☐ No* ***Send to Thank you message**

Please fill out the following contact information.

Please enter your First and Last Name in the box below

Please enter your daytime phone number (*with area code*) in the box below

Please enter your home address (*including state and zip code*) in the box below.

Please enter your email address in the box below.

Thank you for your information. We will contact you in the next few days *if you qualify for the study*.

You are not a panelist in this study until you have received a phone call from us and have a session time scheduled.

Thank You Message

Thank you for your time.

We look forward to your participation in future studies.

Termination Message

Thank you for your time.
Unfortunately, you did not qualify for this study.

We look forward to your participation in future studies.

Thank you!

---

† Each screen displayed in Compusense at-hand® is separated by a line.
†† Items displayed in bold are directions or screen titles not seen by consumer

Appendix D - Consumer Scheduling Script

Hi. This is __(YOUR NAME)__ from K-State Sensory Analysis Center.

You have qualified for our Beverage study next week. I'm calling to schedule you for a study session.

We will have sessions on **WEDNESDAY and THURSDAY**. - Will one of those days work better for your schedule?

(Then offer SPECIFIC SESSION TIMES – and mark the time they prefer on the EditGrid Call List.)

DAY, DATE	AFTERNOON	EVENING
Wednesday, 5/15	**1:30pm, 4pm**	**5:30pm**
Thursday, 5/16	**1:30pm, 4pm**	**5:30pm**

Have you ever done a study for us before?

YES

Okay, then I'll quickly go over reminders –

- We'll send you the reminder email 24 hrs before your session.

- It will have the test location and a phone number in case you need to contact us

NO, this is the first time.

Okay, I just need to go over a few things with you –

- We'll send you the reminder email 24 hrs before your session.

- It will have the test location and a phone number in case you need to contact us

- The study will be on the Kansas State, Manhattan Campus in 115 Justin Hall. Signs will be located inside the building to direct you to the room

- Arrive 10 MINUTES EARLY, bring a PHOTO ID to check in and be prepared to tell us your SSN in order to receive compensation. Bring glasses to read if you need them.

- Please don't EAT, DRINK anything other than H2O, SMOKE or CHEW GUM for 30 minutes before the session

- The day of the study, DON'T WEAR ANY COLOGNE (man) / PERFUME (woman) or any type of fragrance.

- Do you have any questions for me? (Answer any questions they have.) How long will it take? – About 30 minutes
How much does it pay? - $15

- Be sure to watch for our email AND we'll see you at (1:20, 3:50, 5:20) next (Wednesday, Thursday)

- Please call and let us if you are running late or if you have to cancel on the day of the study.

Thank you and have a nice day / evening!

Appendix E - Consumer Test Pomegranate Juice Rotation Order

Key	
Sample Name	Blinding Code
Pasteurized Pomegranate Juice	805
Fresh Frozen Pomegranate Juice	622
Reconstituted Pomegranate Juice	319

	Sample Set Code	Position 1	Position 2	Position 3
Block 1	1	805	622	319
	2	805	319	622
	3	622	805	319
	4	622	319	805
	5	319	805	622
	6	319	622	805
Block 2	7	805	622	319
	8	805	319	622
	9	622	805	319
	10	622	319	805
	11	319	805	622
	12	319	622	805
Block 3	13	805	622	319
	14	805	319	622
	15	622	805	319
	16	622	319	805
	17	319	805	622
	18	319	622	805

	Sample Set Code	Position 1	Position 2	Position 3
Block 4	19	805	622	319
	20	805	319	622
	21	622	805	319
	22	622	319	805
	23	319	805	622
	24	319	622	805
Block 5	25	805	622	319
	26	805	319	622
	27	622	805	319
	28	622	319	805
	29	319	805	622
	30	319	622	805
Block 6	31	805	622	319
	32	805	319	622
	33	622	805	319
	34	622	319	805
	35	319	805	622
	36	319	622	805
Block 7	37	805	622	319
	38	805	319	622
	39	622	805	319
	40	622	319	805
	41	319	805	622
	42	319	622	805
Block 8	43	805	622	319
	44	805	319	622
	45	622	805	319
	46	622	319	805
	47	319	805	622
	48	319	622	805

	Sample Set Code	Position 1	Position 2	Position 3
Block 9	49	805	622	319
	50	805	319	622
	51	622	805	319
	52	622	319	805
	53	319	805	622
	54	319	622	805
Block 10	55	805	622	319
	56	805	319	622
	57	622	805	319
	58	622	319	805
	59	319	805	622
	60	319	622	805
Block 11	61	805	622	319
	62	805	319	622
	63	622	805	319
	64	622	319	805
	65	319	805	622
	66	319	622	805
Block 12	67	805	622	319
	68	805	319	622
	69	622	805	319
	70	622	319	805
	71	319	805	622
	72	319	622	805
Block 13	73	805	622	319
	74	805	319	622
	75	622	805	319
	76	622	319	805
	77	319	805	622
	78	319	622	805

	Sample Set Code	Position 1	Position 2	Position 3
Block 14	79	805	622	319
	80	805	319	622
	81	622	805	319
	82	622	319	805
	83	319	805	622
	84	319	622	805
Block 15	85	805	622	319
	86	805	319	622
	87	622	805	319
	88	622	319	805
	89	319	805	622
	90	319	622	805
Block 16	91	805	622	319
	92	805	319	622
	93	622	805	319
	94	622	319	805
	95	319	805	622
	96	319	622	805
Block 17	97	805	622	319
	98	805	319	622
	99	622	805	319
	100	622	319	805
	101	319	805	622
	102	319	622	805
Block 18	103	805	622	319
	104	805	319	622
	105	622	805	319
	106	622	319	805
	107	319	805	622
	108	319	622	805

	Sample Set Code	Position 1	Position 2	Position 3
Block 19	109	805	622	319
	110	805	319	622
	111	622	805	319
	112	622	319	805
	113	319	805	622
	114	319	622	805
Block 20	115	805	622	319
	116	805	319	622
	117	622	805	319
	118	622	319	805
	119	319	805	622
	120	319	622	805

Appendix F - Moderator Guide

Debriefing Statement

Hello, my name is ______________. On behalf of the Sensory Analysis Center, I would like to thank you for your participation in this study. This session will last approximately ___ minutes. You will receive $___ for your time and opinions at the completion of the session.

You should have a consent form in front of you. Please read and sign this if you haven't already done so. Following the consent form will be some basic demographic questions.

Afterwards, you will be asked to answer questions pertaining to your liking of pomegranate juice. Each sample will be evaluated one at a time. When you receive a sample, please check to make sure that the code on the sample cup matches the one on the ballot. Taste each sample as many times as needed to evaluate each sample.

After your thrid sample you will be asked some questions regarding variety seeking and health opinions.

Ballots are printed front to back. Please make sure that you have answered each question before moving on to the next sample.

There are several things you need to remember as you participate today.

- Please silence your cell phones.
- Be honest in answering the questions. There is no right or wrong answers to any of the questions.
- Do not discuss your answers with your neighbors. We want to know your personal opinion.
- Take your time considering each sample - your input is very important to us.
- If you have any questions during the session, please raise your hand.
- There will be short periods of wait time in between serving of the samples. Please sit quietly during that time.
- The results of this study are confidential. Please do not discuss what you have tested with anyone outside this room.
- Make sure that you answer all of the questions. Please double check all responses when you are done to make sure all questions have been answered.
- Please take a bite of cracker and a sip of water between samples. Raise your hand if you need more crackers or water.

After you complete all pages and have double checked that all questions have been answered you may leave the room quietly to receive your payment.

Thank you again for your time and opinions.

Appendix G - Consumer Consent Form

INFORMED CONSENT STATEMENT
THE SENSORY ANALYSIS CENTER
Kansas State University
Justin Hall, 139
Manhattan, KS 66506

1. I (print) ______________________________, agree to participate as a panelist in research conducted by The Sensory Analysis Center at Kansas State University.

2. I understand that the purpose of this project is to participate in a taste test evaluating pomegranate juice. I understand that if I have allergies to any product similar to those in a study I should not participate in the study.

3. For this test, I will receive $15 when I complete this 30 minute study.

4. I understand my performance as an individual will be treated as research data and will in no way be associated with me for other than identification purposes, thereby assuring confidentiality of performance and responses.

5. I understand that I do not have to participate in this research, and may choose not to participate without penalty.

6. I understand that I may withdraw from the research at any time.

7. If I have any questions concerning this study, I understand that I that I may contact Dr. Kadri Koppel, Justin 139, at 532-0163 or Dr. Edgar Chambers IV, Justin 143D, at 785-532-0156.

8. If I have any questions about my rights as a consumer or about the manner in which this research was conducted, I may contact Dr Rick Scheidt, Chair, Committee on Research Involving Human Subjects, or Dr. Gerald Jaax, Associate Vice-provost for Research, 1 Fairchild Hall (532-2334)

I understand the above statements (Participant must sign):

_________________________ ____ Date: ______________
(Participant Signature)

Appendix H - Consumer Ballot

Instructions: Please mark an X in the box the best describes your answer.

8. What is your gender?
   - ☐ Male
   - ☐ Female

9. What is your age?

☐ 18 – 24 ☐ 25 – 34 ☐ 35 – 44 ☐ 45 – 54

☐ 55 - 64 ☐ Over 65

10. What is your race? (Select all that apply)

☐ Hispanic/Latino	☐ Native Hawaiian or Pacific Islander	☐ American Indian or Alaska Native
☐ White	☐ Asian	☐ Indian Subcontinent
☐ Black or African American	☐ Prefer not answer	

Date: ______________ **Panelist #** _____

Sample: ____

Mark an X in the box that best represents your answer.
Please taste the sample and answer the following questions. Re-taste as necessary.

How much do you **LIKE or DISLIKE** this sample **OVERALL**?

☐	☐	☐	☐	☐	☐	☐	☐	☐
Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely

How much do you **LIKE or DISLIKE** the **FRUITY FLAVOR** of this sample?

☐	☐	☐	☐	☐	☐	☐	☐	☐
Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely

How much do you **LIKE or DISLIKE** the **SWEETNESS** of this sample?

☐	☐	☐	☐	☐	☐	☐	☐	☐
Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely

How much do you **LIKE or DISLIKE** the **SOURNESS** of this sample?

☐	☐	☐	☐	☐	☐	☐	☐	☐
Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely

How much do you **LIKE or DISLIKE** the **AFTERTASTE** of this sample?

☐	☐	☐	☐	☐	☐	☐	☐	☐
Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely

Comments about this sample:

____

____

____

____

Please take a bite of cracker and a drink of water before tasting the next sample.

Date: _______________ **Panelist #** _____

Sample: ____

Mark an X in the box that best represents your answer.
Please taste the sample and answer the following questions. Re-taste as necessary.

How much do you **LIKE or DISLIKE** this sample **OVERALL**?

Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely

How much do you **LIKE or DISLIKE** the **FRUITY FLAVOR** of this sample?

Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely

How much do you **LIKE or DISLIKE** the **SWEETNESS** of this sample?

Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely

How much do you **LIKE or DISLIKE** the **SOURNESS** of this sample?

Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely

How much do you **LIKE or DISLIKE** the **AFTERTASTE** of this sample?

Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely

Comments about this sample:

____

____

____

____

Please take a bite of cracker and a drink of water before tasting the next sample.

Date: _______________ **Panelist #** _____

Sample: ____

Mark an X in the box that best represents your answer.
Please taste the sample and answer the following questions. Re-taste as necessary.

How much do you **LIKE or DISLIKE** this sample **OVERALL**?

☐	☐	☐	☐	☐	☐	☐	☐	☐
Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely

How much do you **LIKE or DISLIKE** the **FRUITY FLAVOR** of this sample?

☐	☐	☐	☐	☐	☐	☐	☐	☐
Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely

How much do you **LIKE or DISLIKE** the **SWEETNESS** of this sample?

☐	☐	☐	☐	☐	☐	☐	☐	☐
Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely

How much do you **LIKE or DISLIKE** the **SOURNESS** of this sample?

☐	☐	☐	☐	☐	☐	☐	☐	☐
Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely

How much do you **LIKE or DISLIKE** the **AFTERTASTE** of this sample?

☐	☐	☐	☐	☐	☐	☐	☐	☐
Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely

Comments about this sample:

____
____
____
____

Date: ____________ **Panelist # _____**

Please rate how much you **agree or disagree** with the following statements by marking an X in the box that best represents your answer.

1. When I eat out, I like to try the most unusual items, even if I am not sure I would like them.

Completely Disagree ☐ ☐ ☐ ☐ ☐ Completely Agree

2. While preparing foods or snacks, I like to try out new recipes.

Completely Disagree ☐ ☐ ☐ ☐ ☐ Completely Agree

3. I think it is fun to try out food items one is not familiar with.

Completely Disagree ☐ ☐ ☐ ☐ ☐ Completely Agree

4. I am eager to know what kinds of foods people from other countries eat.

Completely Disagree ☐ ☐ ☐ ☐ ☐ Completely Agree

5. I like to eat exotic foods.

Completely Disagree ☐ ☐ ☐ ☐ ☐ Completely Agree

6. Items on the menu that I am unfamiliar with make me curious.

Completely Disagree ☐ ☐ ☐ ☐ ☐ Completely Agree

7. I prefer to eat food products that I am used to.

Completely Disagree ☐ ☐ ☐ ☐ ☐ Completely Agree

8. I am curious about food products I am not familiar with.

Completely Disagree ☐ ☐ ☐ ☐ ☐ Completely Agree

Please read the questions and make an X in the box that is closest to your own opinion and behavior.

Do you think you usually eat a healthy diet overall?

☐ Yes, I do (please continue to question 3) ☐ No, I do not (please continue to question 2)

Do you plan to change your diet to be healthier?

☐ Yes, I am considering changing my overall diet in the **next month** to be more healthful (skip question 3)

☐ Yes, I am considering changing my overall diet in the **next 6 months** to be more healthful (skip question 3)

☐ No, I have no plans to change my overall diet to increase its healthfulness (skip question 3)

How long ago did you change and start eating a healthier diet overall?

☐ I made serious changes in my overall diet to be more healthful in the past 6 months

☐ I made changes to a more healthful diet and have eaten that way for 6 months or more

Appendix I - SAS ® Code for Analyzing Consumer Data

ANOVA

All Liking Scores

```
dm'log;clear;output;clear;';
options nodate nonumber
data (data name);
Input Cluster$ Cons$  Sample$         OverallFruity  Sweet  Sour    AT;
cards;
(insert raw data here)
;
ods rtf;

proc mixed data = (data name) covtest cl;
        class Sample Cons;
        model Overall = sample/outp= (data name);
        title 'Overall Liking';
        random Cons;
        lsmeans Sample/cl pdiff;
run;

proc mixed data = (data name) covtest cl;
        class Sample Cons;
        model Fruity = sample/outp= (data name);
        title 'Fruit Flavor Liking';
        random Cons;
        lsmeans Sample/cl pdiff;
run;

proc mixed data = (data name) covtest cl;
        class Sample Cons;
        model Sweet = sample/outp= (data name);
        title 'Sweetness Liking';
        random Cons;
        lsmeans Sample/cl pdiff;
run;
```

```
proc mixed data = (data name) covtest cl;
        class Sample Cons;
        model Sour = sample/outp= (data name);
        title 'Sourness Liking';
        random Cons;
        lsmeans Sample/cl pdiff;
run;

proc mixed data = (data name) covtest cl;
        class Sample Cons;
        model AT = sample/outp= (data name);
        title 'Aftertaste Liking';
        random Cons;
        lsmeans Sample/cl pdiff;
run;
ods rtf close;
quit;
```

Liking across Cluster/ Variety Seeking Level/ Healthy Eating Interest

```
dm'log;clear;output;clear;';
options nodate nonumber
data (data name);
Input (group name)$   Cons$  Sample$        OverallFruity  Sweet  Sour    AT;
cards;
(insert raw data here)
;
ods rtf;
        proc glm data = (data name);
        class (group name) Cons Sample;
        model Overall = Sample (group name) cons((group name)) sample*(group name)/ss3;
        means sample/lsd;
        lsmeans (group name)*sample/pdiff lines;
run;

proc glm data = (data name);
        class (group name) Cons Sample;
        model Fruity = Sample (group name) cons((group name)) sample*(group name)/ss3;
        means sample/lsd;
        lsmeans (group name)*sample/pdiff lines;
run;
```

```
proc glm data = (data name);
        class (group name) Cons Sample;
        model Sweet = Sample (group name) cons((group name)) sample*(group name)/ss3;
        means sample/lsd;
        lsmeans (group name)*sample/pdiff lines;
run;

proc glm data = (data name);
        class (group name) Cons Sample;
        model Sour = Sample (group name) cons((group name)) sample*(group name)/ss3;
        means sample/lsd;
        lsmeans (group name)*sample/pdiff lines;
run;

proc glm data = (data name);
        class (group name) Cons Sample;
        model AT = Sample (group name) cons((group name)) sample*(group name)/ss3;
        means sample/lsd;
        lsmeans (group name)*sample/pdiff lines;
run;
ods rtf close;
quit;
```

VARSEEK Scores across Clusters

```
dm'log;clear;output;clear;';
options nodate nonumber;
data (data name);
Input Cluster$ Cons$  VARSEEK;
datalines;
(insert raw data here)
;
ods rtf;
proc glm data = pomvc;
        class Cluster Cons;
        model VARSEEK = cluster/ss3;
        means Cluster/lsd;
        lsmeans Cluster/pdiff lines;
run;
ods rtf close;
quit;
```

Cluster Analysis – Consumer Overall Liking Scores

```
dm 'log;clear;output;clear;';
title 'Pom Frag Cluster';
data (data name);
input Consumer$      FPJ     PPJ     RPJ;
datalines;
(insert raw data here)
;
ods rtf;
ods graphics on;

proc cluster data=(data name) outtree=treew method=ward pseudo std  CCC ;
id consumer;
Var FPJ        PPJ     RPJ;
run;
legend1 frame cframe=ligr
position=center value=(justify=center);
axis1 label=(angle=90 rotate = 0) minor=none order=(0 to 70 by 2);
axis2 minor=none order=( 1 to 28 by 1);

proc gplot;
plot _CCC_*_ncl_ /
frame cframe=ligr legend=legend1 Vaxis= axis3 haxis= axis2;
PLOT _PSF_*_NCL_ _PST2_*_NCL_ /OVERLAY
frame cframe=ligr legend=legend1 Vaxis= axis1 haxis= axis2;
run;

proc tree data=treew nclusters=4 out= result1 sort;
id consumer;
run;

Proc sort data= result1;by cluster;
run;

proc print data= result1; by cluster;
run;

ods graphics off;
ods rtf close;
quit;
```

Appendix J - TIME Profile Ballot

Date:________________

Pomegrante Juice
One Sip Method

Panelist:________________

Sample:

Flavor	**Max. Intensity**	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11** Swallow							
Cranberry																			
Fruity																			
Sweet Overall																			
Woody																			
Bitter																			
Astringent																			
Green-Viney																			
Fermented																			
Flavor (Aftertaste)		*25**			*40**			*55**			*70**			*85**			*100**		*120**

Appendix K - SCC Profile Ballot

Date:________________ | **Pomegrante Juice**
Multiple Sip Method | Panelist:___________

Sample:

	Intensity from Consensus Profile	**Sip 1*	*Sip 2*	*Sip 3*	*Sip 4*	**Sip 5*	*Sip 6*	*Sip 7*	*Sip 8*	*Sip 9*	**Sip 10*	*Sip 11*	*Sip 12*	*Sip 13*
Fruity														
Overall Sweet														
Woody														
Bitter														
Astringent														
Continued		*Sip 14*	**Sip 15*	*Sip 16*	*Sip 17*	*Sip 18*	*Sip 19*	**Sip 20*	*Sip 21*	*Sip 22*	*Sip 23*	*Sip 24*	**Sip 25*	
Fruity														
Overall Sweet														
Woody														
Bitter														
Astringent														