Sensory Evaluation Lab Report

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Abstract

The purpose of this study was to utilize and evaluate the importance of sensory analysis tests for determining food acceptability, preference, and characteristics. In a food laboratory at San Diego State University, a total of 89 untrained panelists between the ages of 19 and 35 years (79 females, 10 males) were subjects in seven different sensory evaluation tests including: descriptive analysis, beverage association, paired comparison, triangle testing, duo trio, scoring/rating testing, and a ranking test. Tests were conducted to illustrate the importance of the five senses (sight, smell, taste, touch, and hearing) in determining food acceptability and preference. Data and results were compiled and analyzed within this study to explain the different methods of sensory analysis and their relevance to food producers and consumers. Sensory evaluations have been proven useful in many food and beverage studies and aid in predicting the successfulness of products within the market. This study demonstrates the significance of chemical compositions of a food in relation to consumer liking, wanting, and behavioral attitude/perceptions toward it. Results of the scoring/rating test, paired comparison test, triangle test and ranking test demonstrated that panelist were able to differentiate sour intensity between apple juice samples containing different amounts of citric acid concentration. The beverage association test results explained and inverse relationship between perceived beverage artificiality and naturalness as color changes from light yellow to emerald green. The analysis of goldfish, raisins, marshmallows, and almonds using descriptive terms yielded results depicting flavor and aroma as being two of the most agreed upon categories to label within the panel. Some of the tests obtained results that correlated well together, while others proved to be limiting. Certain errors could have come into play for each of the tests which are explained within the study.

Introduction

Appearance, flavor, texture, aroma, consistency and mouthfeel are just a few of the factors influencing food selection and preference. In order to get a better understanding of why consumers select the foods that they do, sensory analysis is employed. Sensory analysis is an experimental approach to measuring consumer feedback of foods through the senses of sight, smell, taste, touch, and hearing. This type of evaluation is known as subjective because it relies largely upon the opinions of selected individuals, not on measurable, quantifiable data. Sensory Analysis can further be broken down into analytical (effective) tests and affective tests. For the purpose of this study analytical tests were used through a panel of untrained students in a food science class at San Diego State University. These analytical tests were used to detect differences among various samples of beverages and foods. Certain analytical tests differentiate between samples, these tests fall under the category of difference tests. Among these tests include triangle, duo-trio, paired comparisons, ranking, and scoring/rating. Others are descriptive tests that quantify differences and are "used to detail the specific flavors (garlic, vanilla, caramel, boiled milk) or textures (smoothness, springiness, moistness) of a food or beverage" (Brown 2011).

The Beverage Color and Association Test was the first to be conducted and was utilized to look into the influence of color on our perception of the flavor of food and drink. Five different beverages were placed on the front table of the laboratory and given color identities (light yellow, dark yellow, chartreuse, dark chartreuse, and emerald). Panelists were not told what was inside of the samples but were asked to rate them on a one to five scale in the categories of sweetness, sourness, artificiality, naturalness, prefer, and dislike. Panelists were also asked to record at what temperature they would drink the beverage sample (hot, warm, tepid, or cold) and if they would drink it (yes or no). According to a study by Shankar et al. "color conveys critical information about the flavor of food and drink by providing clues as to edibility, flavor identity, and flavor intensity". Color seems to constitute a key role in our perception of both food identity and flavor. In addition, color maintains symbolic and associative information as a result of lifetime experience. The study by Shankar et al. assessed the spontaneous color-flavor associations held by particular groups of individuals in order to examine how associations of color vary in different cultures. It was hypothesized that human flavor perception may not only be influenced by multisensory integration but also by higher level cognitive information such as expectations. These expectations are created through past experience and repeated co-occurrence of specific colors with specific tastes, flavors, and aromas. Twenty British Participants and 15 Taiwanese participants took part in the experiment. Seven drinks were presented to the participants, of which contained 125mL of water with varying amounts of food coloring to create brown, blue, orange, yellow, red, green, and clear samples. Participants were instructed to look at each drink that was presented and "based solely on its color, write down the first flavor or drink that came to mind upon viewing this color in the data table" provided (Shankar et al. 2010). The goal of the experiment was to see if color has a symbolic effect on the way individuals or groups perceive something to taste which would subsequently lead to an approach or avoidance behavior toward that food or beverage.

Descriptive analysis in sensory evaluations is used to describe sensory attributes or qualities of a certain food. For the study done in the nutrition lab, descriptive analysis was performed on marshmallows, almonds, goldfish, and raisins. Panelists analyzed their samples of each using descriptive terms for appearance, flavor,

texture, aroma, consistency, and mouthfeel. Typically this kind of test is done to help producers determine what consumers like or dislike about a particular product and the discernible attributes that it possesses. In a study by Varela et al., descriptive analysis was used to uncover the drive behind coffee liking. A total of ninety-six consumers of coffee took part in the study (31 men and 65 women, from 20 to 67 years of age). They received six samples of coffee including varying amounts of added sugar and milk. Participants were asked to rank the samples in order of preference and then leave "open comments" as to what they liked or disliked about the individual samples. Similar descriptive terms were stated by the participants in both the like and dislike categories, thus alluding there are strong traits of coffee that are seen amongst numerous people. Having this information and feedback demonstrates how descriptive analysis is useful in determining the prevailing sensory qualities a food or beverage may have. (Varela et al. 2013).

The triangle test was utilized to differentiate between three samples, two of which were the same and one was different. The triangle test simply asks of the evaluator, which sample is different from the other two? This type of test is beneficial to producers because it provides consumer feedback on whether or not two products contain recognizable differences. For this study, three coded beverage samples were given to the panelists, two containing apple juice with 0% citric acid added to them and one containing apple juice with 1% citric acid added to it. Panelists were unaware of the contents of the beverage and were asked to state which sample was different from the other two. At the University of California Davis, a triangle test was used in a study by Rousseau, et al. for commercially available Dijon style mustards. Each of the twenty participants participated in 8 triangle test sessions where they were presented with sample mustards given in different sequences, BAA, ABB, AAB, BAB, ABA, and BBA where A and B are indicative of different Dijon mustard brands. The results demonstrated that samples provided in certain sequences were more easily detected as being "same" or different". This would allude that the sample Dijon mustards provided possibly did not have a great variance of flavor between them (Rousseau et al 1999).

The duo-trio test is similar to the triangle test in that it involves three samples, two of which are the

same and one is different. Participants in the duo-trio test are asked to determine which sample is different and what attribute the odd sample has that makes it different. For this study, three cookies of similar appearance were presented to the panelists. Two cookies were the same and one was different. Panelists were asked to determine which cookie was odd and what made it stand out from the other two in relation to dryness, crunchiness, or having less vanilla. The duo-trio test in this regard might be useful for producers creating an imitation product to a name brand or creating a product fortified or enriched with additives for health purposes. One example of using the duo-trio test for fortified foods occurred in a study by Beinner et al. The study conducted was used to examine the perceived differences between conventional rice and rice fortified with iron among Brazilian people. The duo-trio test was applied under controlled conditions for thirty-seven untrained panelists. Each panelist received a standard rice sample and two unknown samples of rice. One was the same as the standard and one was different. Upon determining which rice was different, panelists described that difference using sensory analysis. These descriptions for the variance in product taste, texture and color help to determine consumer acceptability. This is one benefit of using duo-trio testing (Beinner et al.).

One difference test employed by this study was the ranking test, in which various samples are ranked by the intensity of a certain characteristic that they possess. The study used five different samples of apple juice, each with assorted amounts of citric acid added to them. Panelists were given the samples and allowed to try them in any order so long as they ranked them from least sour to most sour. This method is used by producers to understand and determine consumer acceptability for a certain sensory characteristic. Numerous other studies have been conducted using ranking tests, including one by Kildegaard et al. on the preference, liking, and wanting for beverages in children and the role of sourness perception in beverage selection. It was hypothesized that sourness perception is a strong factor in the rejection of a food. Research shows that "generally preferences increase with decreasing levels of citric acid". One hundred ninety-five children completed the study by tasting two types of beverages, apple juice and a Danish fruit drink made of 11 different kinds of fruits and berries. Acid content was held constant for both drinks but the amount of dry matter content was altered, there were no

visible color changes within samples. Children were told to rank 8 different samples (4 of each juice type) from most sour to least sour. Results demonstrated that dry matter content added to juices did in fact affect perceived sourness of the juice. The ranking test helped to determine a correlation between preference and perceived sourness (Kildegaard et al.)

The paired comparison test was used in this study to determine which of two samples has more of a certain characteristic. Two coded sample beverage were given to panelists for tasting to evaluate which sample had a greater sour intensity. One of the beverages was apple juice with 0% citric acid and the other was apple juice with the addition of 1% citric acid. This difference test is a beneficial source of food analysis because it is easily performed due to the requirement of a small sample size and is basic enough to be performed on an array of food products. Food and beverage producers would find the paired comparison test to be advantageous because it allows them to measure the intensity of a certain characteristic that their product may contain through the eyes of the consumer.

Scoring tests allow different samples to be arranged on a numeric scale relative to each other when being tested for a certain characteristic. For instance, in this study a reference sample was given and told that it was rated with the number 4 for its sour intensity. Two more samples were given after and panelists were asked to rate or score these two samples relative to the reference sample. The reference sample was apple juice with 2.5% citric acid and the other two samples were apple juice with 5% and 1% citric acid. Producers can use the results of a scoring test to measure the intensity of products and determine which will be accepted by consumers or possess the attributes that they are looking for.

Methods

Panelists

Experiments were conducted in a nutrition lab at San Diego State University amongst students enrolled in Introduction to the Science of Food (Nutrition 205). The experiments consisted of various sensory evaluation tests performed using an array of foods and beverages. Panelists were each given a paper labeled “Demographic

Questionnaire" and asked to answer all questions independently and without any discussion with other panelists. The questionnaire asked panelists to provide information regarding age, gender, major, student status, marital status, living arrangements, smoking, and food allergies. Once all questionnaires were completed, panelists' information was input into a single computer and compiled by the instructor of the course. In order to do this, panelists closed their eyes and the instructor asked each question separately. Answers to each question were given by students raising their hands when their answer was called out. A total of eighty-nine panelists from four different lab sections participated in the demographic questionnaire and subsequent sensory evaluation tests. Ages ranged from 19-35 years old with the average age being 23.4 years old. Of the eighty-nine panelists, 78.65% were between the ages of 19 and 23 and the remaining 21.35% were above the age of 23. Gender was split unevenly with females accounting for 88.76% of panelists and males accounting for 11.24%. When asked their marital status, 93.26% of panelists reported themselves as single, 5.618% married and 1.124% divorced. The panel was comprised of 95.51% undergraduate students and 4.494% graduate students. All panelists were foods and nutrition majors. Living status ranged from 12.36% of panelists living alone, 26.97% living with one roommate and 60.67%sharing a home with two or more roommates. The percentage of non-smokers among panelists was 98.88%. When asked if any food allergies were present only 10.11% of panelists said that they did have allergies from foods including: shellfish, salmon, cinnamon, eggs, mayonnaise, dairy, gluten, soy, and preservatives.

Environment

All sensory evaluation tests were conducted in a nutrition laboratory at San Diego State University. Panelists sat at individual desks that were arranged in five lines facing the front of the room. They were instructed to answer all questions and conduct all evaluations individually. The instructor sat at the front of the class and input data into the computer. All samples were placed on an island in the front of the class from which the first individual in each row collected them. The laboratory was well lit and had normal room temperature.

Color Association/Perception of Beverages

The Beverage Color and Association test was the first to be conducted. The lab instructor brought out five glass beakers from the refrigerator and lined them up evenly spaced on the island in the front of the room. Each beaker contained different colored beverages ranging from light to dark (light yellow, dark yellow, chartreuse, dark chartreuse, and emerald green). Panelists received a questionnaire form to record their individual perception. The first question asked was "Do you drink Apple Juice?" to which the panelists answered either yes or no. After answering this, each panelist was asked to rank the beverages at the front table based on a scale of 1 (lowest) to 5 (highest) for the following parameters: sweetness, sourness, artificiality, naturalness, prefer, and dislike. Participants then were asked at what temperature they would drink each beverage. They chose from the temperatures of hot, warm, tepid, or cold. The final question panelists answered was "would you drink it?", for this the answers were either yes or no.

Panelists filled out their questionnaires individually. Once each person was done, panelists were prompted to close their eyes for the instructor to perform a blind tally of raised hand votes for each question and category. When all results were collected and input into the computer, the beverage names were revealed. The light yellow was Mountain Dairy Lemonade, dark yellow was Xtremo Citrico Vibrante Gatorade, chartreuse was 350 mls. Lemon Lime Gatorade plus 150 mls., dark chartreuse was Green Squall Powerade, and emerald green was Watermelon Gatorade.

Evaluation of Food Products Using Descriptive Terms

This descriptive test was used to detail specific properties of almonds, marshmallows, gold fish and raisins. The first individual of each row of panelists approached the front of the classroom and obtained all sample cups for the rest of the panelists in their row. Each panelist received one sample cup for each food product being evaluated containing two of each item (ie. two raisins per person). Participants were prompted to evaluate each food product based on the categories: appearance, flavor, texture, aroma, consistency, and mouth feel. They performed the evaluation by assigning a term from a predetermined list of descriptive words to each

product. In the test for goldfish, two panelists did not participate and in the test for marshmallows one individual did not participate in some of the categories due to dietary restrictions. Results were first recorded in panelist's individual notebooks and then compiled by the lab technician into the computer. This required all panelists to close their eyes and raise their hands for the different categories and descriptive terms that they chose.

Difference Tests

Paired Comparison

This difference test was conducted to determine which of two samples given to the sensory panelist was identified as having a greater intensity than the other. For this comparison, the trait being tested for was sourness. The instructor allowed an individual from the beginning of each row of participants to collect samples and pass one of each to the rest of the individuals in their row. Panelists were presented with two samples in plain white paper cups labeled with arbitrary codes of 635T1 and 573T2. They were instructed to taste each one and record their perception of having a "greater" or "lesser" intensity based on the sourness characteristic. Panelists recorded their individual perceptions and then closed their eyes. The lab technician prompted for all participants to keep their eyes closed as they raised their hands to report which sample had a greater and lesser intensity. The lab technician counted hands and input the results into the computer. At the end panelists were informed that sample 635T1 was 0% citric acid solution and sample 573T2 was 1% citric acid solution.

Duo-Trio Test

This difference test was given to panelists in the form of three sample cookies. The lab technician passed out one cookie (Sample 8175) and told panelists that it was the standard. Two more cookies (Samples 6104 and 1108) were presented to the panelists and they were informed that one of the two cookies was the same as the standard and one was different. Participants were not told what this difference was but were asked to first taste the standard cookie and consider the characteristics they notice about its taste and mouth feel. Panelists were then able to eat the next two samples and drink water in between each sampling to cleanse their pallet. When

finished tasting the samples, panelists were told to record which sample they thought was the same as the standard. They then answered in their opinion what the major factor was that differed between samples: dryness, crunchiness, or vanilla content. All answers were given to the lab instructor by students raising their hands and recorded in the computer like previous tests. At the end, panelists were informed that the standard 8175 cookie was a Nabisco Nilla Wafer as well as sample 1108. Sample 6104 was First Street (Smart and Final) Vanilla Wafers brand cookie.

Scoring Test

Three beverage samples were introduced to the panelists: Sample 420M, Sample S723, and Sample 0110 (reference sample). An individual from the front of each row approached the front of the class and poured one of each sample for themselves and the others in their row. Samples were passed out by the individual and the seated panelists were informed which sample was which. Samples were ranked on a scale of 1 (more sour) to 7 (less sour). The reference sample was assigned an arbitrary score of 4. Panelists were instructed to rate the sour intensity of the other two samples relative to the reference. Panelists raised their hands as the instructor called out the various scores and samples so their answers could be recorded in the computer. When all responses were recorded, panelists were told what the samples consisted of. Sample S723 contained 5% citric acid solution, 420M contained 1% citric acid solution and the reference sample 0110 contained 2.5% citric acid solution.

Ranking Test

The ranking test was conducted using 5 similar beverage samples of varying intensity of sourness and assigned sample codes (695F8, 495P2, 192L3, 543K8, and 555D7). One person from the front of each row of panelists approached the front of the room and poured enough of each sample for all others in their row and distributed the samples. Panelists were instructed to taste each sample and rank them in descending order of sourness from #1 (most sour) to #5 (least sour). They then were to rank the samples in order of preference. No ties were allowed; however, panelists were allowed to retaste any sample. Panelists were encouraged to drink water in between tasting each sample. Results were recorded by the lab technician by having panelists close

their eyes and raise their hands when each ranking number for intensity and preference for each sample was called out. It was revealed that each sample contained varying amount of citric acid: 695F8 (2.5%), 495P2 (0%), 192L3 (5%), 543K8 (1%), and 555D7 (10%).

Triangle Test

The triangle test was utilized to have panelists differentiate between three beverage samples and determine which sample was not identical to the other two. All samples appeared similar and were given to panelists simultaneously by the first panelist in each row. Each sample had a code on it (777C1, 542E2, and 112H9) that the panelists were told to record and state which two samples were the same and which one was different. Results were given to the lab technician through a show of hands as the sample numbers were called out as being the same or different. Samples 777C1 and 542E2 were revealed to be the same with 0% citric acid in them and Sample 112H9 was the odd sample with 1% citric acid.

Statistical Analysis

A statistical analysis of results from four different laboratory groups of panelists was conducted by the head laboratory technician. Data and results from all participants were compiled into an excel sheet and reported as percentages. Percentages were calculated for the following sensory evaluation tests: duo-trio, triangle, paired comparison, ranking, scoring, descriptive evaluation, and color association/perception of beverages. Data regarding the demographics of panelists was depicted as well.

Results

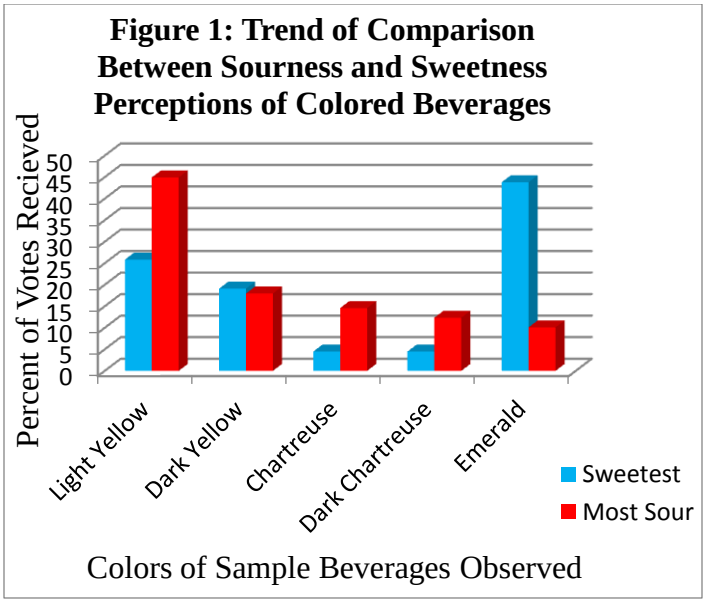
Color Association/Perception of Beverages

Among the panelists that participated in the beverage analysis test (N=89), popular trends were found when comparing associations of sourness vs. sweetness (Figure 1), most natural vs. most artificial (Figure 2), and prefer the most vs. dislike the most (Figure 3).

In Figure 1, it can be seen that there was an inverse relationship formed between color intensity and perceived sourness of the sample beverages as color changed from light to dark. Light yellow was perceived as

being the most sour (44.94% of votes), followed by dark yellow (17.98%), chartreuse (14.61%), dark chartreuse (12.36%) and emerald (10.11%). Color did not greatly affect perceived sweetness; however, as emerald received the most votes for perceived sweetness (43.82%), followed by light yellow (25.84%), dark yellow (19.1%), chartreuse (4.49%), and dark chartreuse (4.49%). There was no difference in perceived sweetness between chartreuse and dark chartreuse.

Figure 2 demonstrates a relationship between natural and artificial perception of the colored beverage samples. As color intensity increase from light yellow to emerald, voting for perceived naturalness increased. Light yellow received an overwhelming majority of panelist votes at 96.63% for seeming to be the most natural. The degree of perceived naturalness decreased as color ranged from dark yellow (2.25%), chartreuse (1.12%), dark chartreuse (0%), to emerald (0%). The most artificial colored beverages received votes in almost reverse order: emerald (79.78%), dark yellow (8.99%), dark chartreuse (5.62%), chartreuse (4.49%), light yellow (1.12%). Dark yellow was the only sample that caused questioning of an inverse relationship between perceived artificiality and perceived naturalness, as it was ranked second to emerald for being most artificial.



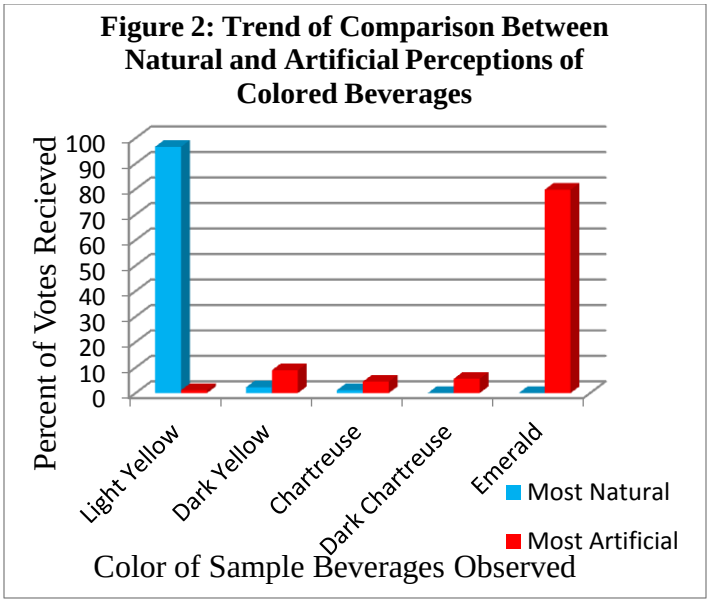
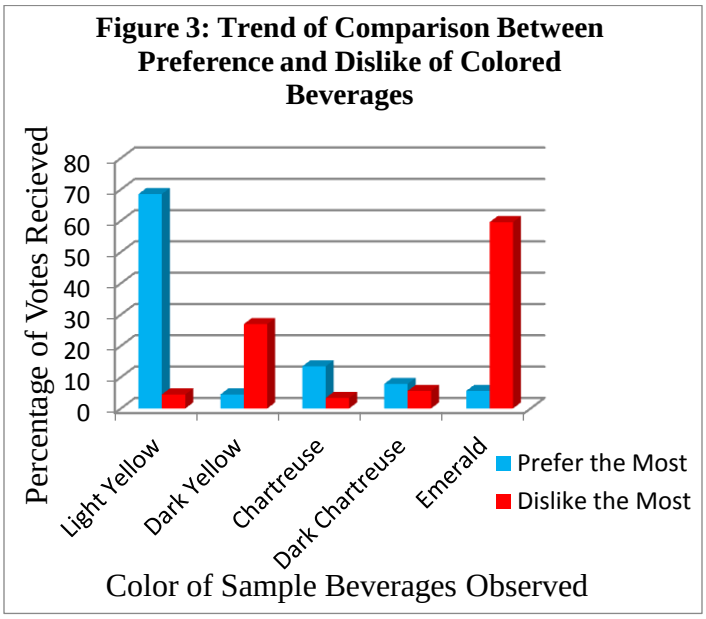


Figure 3 demonstrates the percentage of panelist votes in regards to preference and dislikes of the various beverage samples. Preference increased from light yellow (68.54%) to chartreuse (13.48%), to dark chartreuse (7.87%). The two least preferred samples were emerald (5.62%) and dark yellow (4.50%), which

coincidentally were also viewed as being the two most artificial samples. Dislike of beverages was greatest among these two samples with emerald receiving the most votes (59.55%) and dark yellow receiving the second most votes (26.97%). dark yellow (5.62%), light yellow (4.50%) and chartreuse (3.37%) followed next, demonstrating no significant pattern between color intensity and dislike.

When asked if they would drink the five beverages, panelists responded with either a yes or no. Yes votes are demonstrated in Figure 4. The greatest amount of "yes" votes was allotted to light yellow (35.10%), followed by chartreuse (22.86%), dark yellow (18.37%), dark chartreuse (14.29%) and emerald (9.39%).



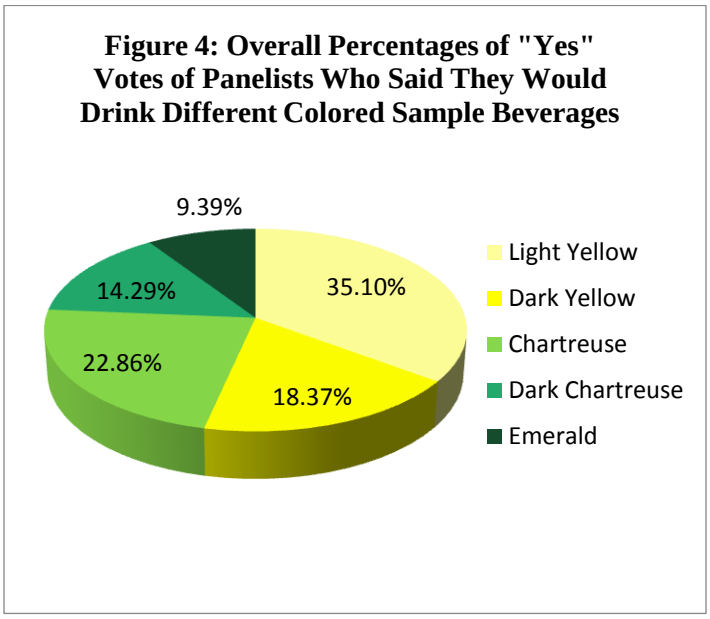


Table 1 depicts the temperatures at which panelists preferred to drink the varying beverages. All beverages were seen as being best served cold obtaining 94.38% of votes for light yellow, dark yellow, chartreuse, emerald and 95.51% of votes for dark chartreuse. The second most accepted temperature was tepid, receiving 5.62% of votes for emerald, 4.49% of votes for light yellow and dark yellow, and 3.37% of votes for chartreuse and dark chartreuse. Hot and warm temperatures acquired the least amount of votes for all colored beverages.

Table 1: Percentage of Panelist Votes for Preferential Beverage Temperatures

	Light Yellow	Dark Yellow	Chartreuse	Dark Chartreuse	Emerald
Cold	94.38%	94.38%	94.38%	95.51%	94.38%
Hot	2.25%	0.00%	1.12%	1.12%	3.37%
Warm	0.00%	2.25%	2.25%	1.12%	0.00%
Tepid	4.49%	4.49%	3.37%	3.37%	5.62%

Evaluation of Food Products Using Descriptive Terms

Panelists defined the qualities of goldfish that stood out most to them in the categories of appearance, flavor, texture, aroma, consistency and mouthfeel. Table 2 illustrates the top three descriptive terms for each sensory attribute evaluated. According to the panelists, the appearance of goldfish is best described as being golden brown (38.2%), dry (26.97%) and symmetrical (6.74%). The some of the other appearance descriptions included rough, asymmetrical, puffy, and light brown (26.97%). The flavor goldfish was found to be salty (77.52%), stale (6.74%), and sharp (5.62%). Texture evaluation determined that goldfish are perceived as being crunchy (50.56%), crisp (37.08%), gritty (3.37%) and other (5.62%). The aroma of goldfish is was not distinct, causing 53.9% of panelists to vote it as being "nothing". The other top two descriptive terms for goldfish aroma were burnt (29.2%) and spicy (8.99%). The consistency of goldfish is brittle (48.32%), cheesy (23.60%), and thin (13.48%). Crisp (44.94%), crunchy (37.08%), and gritty (11.24%) were the three most used terms to describe the mouthfeel of goldfish.

Table 2: Top Three Descriptive Terms Associated with Goldfish for Each Sensory Category

Appearance	Flavor	Texture	Aroma	Consistency	Mouthfeel
Golden Brown- 38.2%	Salty-77.52%	Crunchy- 50.56%	Nothing- 53.9%	Brittle- 48.32%	Crisp- 44.94%
Dry- 26.97%	Stale- 6.74%	Crisp- 37.08%	Burnt- 29.2%	Cheezy- 23.60%	Crunchy- 37.08%
Symmetrical- 6.74%	Sharp- 5.62%	Gritty-3.37%	Spicy- 8.99%	Thin- 13.48%	Gritty-11.24%
Other- 26.97%	Other- 5.62%	Other-5.62%	Other- 6.74%	Other- 11.24%	Other- 2.25%

Table 3 depicts the top three terms used to express the sensory qualities identified by panelists as being most prevalent for raisins. Raisins were believed to have an appearance that was best defined as sunken (23.60%), glossy (17.98%), or dark (16.85%). The flavor of raisins was best described as sweet (51.69%), fruity

(34.83%), and flowery (6.74%). The texture of raisins was characterized as chewy (42.70%), gummy (23.60%), and rubbery (13.48%). Fruity (42.70%), sweet (39.30%), and flowery (7.87%) were the most prevalent terms reported as the aroma. Consistency was represented by the terms chewy (47.19%), gummy (24.72%), and rubbery (22.47%). Mouthfeel was designated as sticky (61.80%), slimy (12.36%), and smooth (11.24%).

Table 3: Top Three Descriptive Terms Associated with Raisins for Each Sensory Category

Appearance	Flavor	Texture	Aroma	Consistency	Mouthfeel
Sunken-23.60%	Sweet- 51.69%	Chewy- 42.70%	Fruity- 42.70%	Chewy-47.19%	Sticky- 61.80%
Glossy-17.98%	Fruity-34.83%	Gummy- 23.60%	Sweet- 39.30%	Gummy-24.72%	Slimy- 12.36%
Dark- 16.85%	Flowery-6.74%	Rubbery-13.48%	Flowery- 7.87%	Rubbery-22.47%	Smooth- 11.24%
Other- 41.6%	Other-6.74%	Other- 20.22%	Other- 10.1%	Other- 6.07%	Other-14.6%

Table 4 demonstrates the top three terms used to describe almonds through sensory evaluation. The appearance of almonds was designated as dry (26.97%), golden brown (26.97%), and light brown (25.84%). Flavor attributes of almonds were majorly nutty (80.90%), flat (12.36%) and stale (3.37%). Texture was indicated as hard (25.84%), crunchy (24.72%), and firm (22.47%). 91% of votes for the aroma of almonds were allotted to the term “nothing”. The following top two terms were burnt (5.62%) and flowery (2.25%). The consistency of almonds from the panels perspective was mostly thick (56.18%), chewy (34.83%), and rubbery (3.37%). Crunchy (61.80%), gritty (21.25%), and crisp (7.87%) best express the mouthfeel of almonds.

Table 4: Top Three Descriptive Terms Associated with Almonds for Each Sensory Category

Appearance	Flavor	Texture	Aroma	Consistency	Mouthfeel
Dry- 26.97%	Nutty- 80.90%	Hard- 25.84%	Nothing-91%	Thick- 56.18%	Crunchy- 61.80%
Golden-Brown- 26.97%	Flat- 12.36%	Crunchy- 24.72%	Burnt- 5.62%	Chewy- 34.83%	Gritty- 21.35%
Light-Brown- 25.84%	Stale- 3.37%	Firm- 22.47%	Flowery- 2.25%	Rubbery- 3.37%	Crisp- 7.87%
Other- 20.20%	Other- 3.37%	Other- 26.97%	Other- 1.12%	Other-5.62%	Other- 8.99%

Marshmallows were judged using descriptive analysis for all the sensory qualities listed in Table 5. The appearance of marshmallows was identified most as puffy (83.15%), rounded (6.74%), and smooth (2.25%). Flavor was denounced by three similar terms: sweet (68.54%), floury (14.61%), and sweet (68.54%). Marshmallow texture was perceived as springy (22.47%), gummy (22.47%), and velvety (16.85%). A sweet

aroma was found most strongly in marshmallows with 86.50% of votes for the category. The following terms used to describe aroma of marshmallows were nothing (6.74%) and flowery (3.37%). Consistency was found to be gummy (32.58%), chewy (26.97%), and thin (12.36%). Mouthfeel resulted in descriptive terms including smooth (43.82%), sticky (29.21%), and slimy (19.10%).

Table 5: Top Three Descriptive Terms Associated with Marshmallows for Each Sensory Category

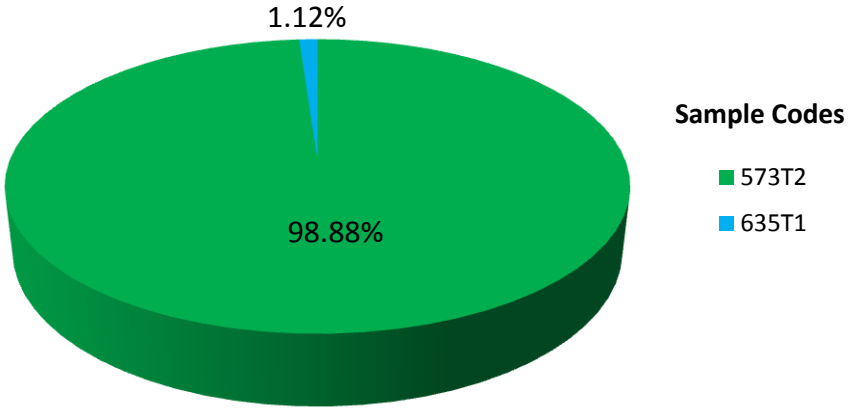
Appearance	Flavor	Texture	Aroma	Consistency	Mouthfeel
Puffy- 83.15%	Sweet- 68.54%	Springy- 22.47%	Sweet- 86.50%	Gummy- 32.58%	Smooth- 43.82%
Rounded- 6.74%	Floury- 14.61%	Gummy-22.47%	Nothing- 6.74%	Chewy- 26.97%	Sticky-29.21%
Smooth- 2.25%	Pasty-12.36%	Velvety- 16.85%	Flowery- 3.37%	Thin- 12.36%	Slimy- 19.10%
Other- 4.49%	Other- 0%	Other- 34.83%	Other- 0%	Other-24.72%	Other-3.37%

Difference Tests

Paired Comparison

The paired-comparison test resulted in 98.88% of panelists voting that sample 573T2 containing apple juice with 1% citric acid was the sample of greater sourness. Only 1.12% of panelist votes lead to the perception that sample 635T1 containing apple juice with 0% citric acid was of greater intensity for sourness. Those who voted for the sample apple juice with 1% added citric acid as being of greater sour intensity were correct in this paired comparison test as depicted in Figure 5. The chance of selecting the correct sample was one out of two.

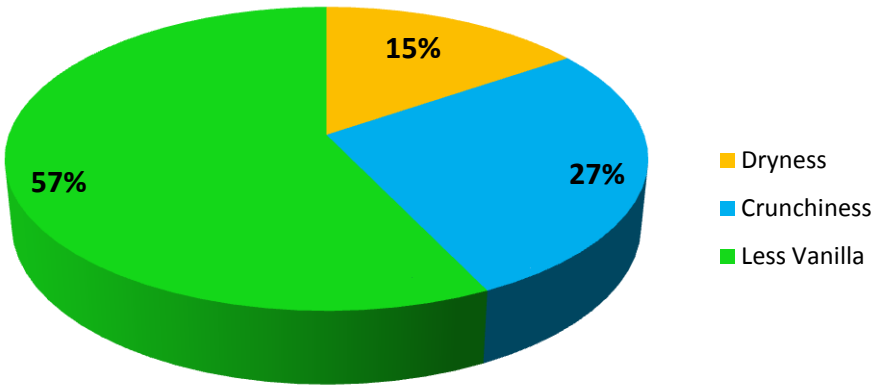
Figure 5: Paired Comparison Results Depicting Percentage of Panelists Votes for Greatness of Sour Intensity Between Two Unknown Samples



Duo-Trio Test

In the duo-trio test, both samples 8175 (standard) and 1108 were Nabisco Nilla Wafers brand cookies. 96% of panelists were able to determine that these two samples were the same while 4% of panelists thought sample 6104 was equal to the standard. This cookie was actually an off brand, First Street (Smart and Final) Vanilla Wafers. Figure 6 illustrates the reasoning of panelists as to why the off sample differed from the standard. 57% of panelists attributed the difference as the odd sample having less vanilla, while 27% thought it had a greater crunchiness. Dryness was explained by 15% of votes as being the source for differentiation among sample cookies.

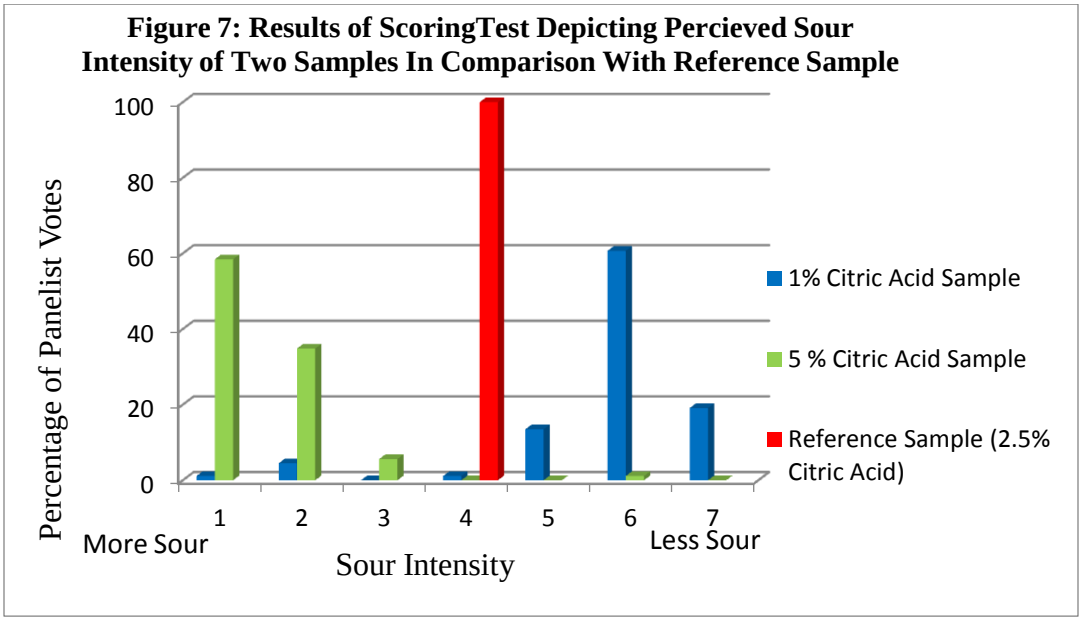
Figure 6: Duo Trio Test Results Depicting Subjective Evaluation of Panelist Votes for Most Distinct Difference Between Cookie Samples



Scoring/Rating Test

The reference sample (2.5% citric acid) for this scoring test was given an arbitrary number of 4 on the 1(more sour) to 7 (less sour) scale. As depicted in Figure 7, the majority of panelists voted 420M (1% citric acid sample as having a score above the reference sample, and therefore perceived it as being less sour. 60.6% of panelists rated the 1% citric acid sample as a 6 and 19.1% of panelists rated the sample as a 7. Approximately 5.61% of panelists thought the 1% citric acid sample was more sour than the reference and 1.12% thought it was of equivalent sourness. In regards to sample S723 (5% citric acid) only 1.12% of panelists votes perceived

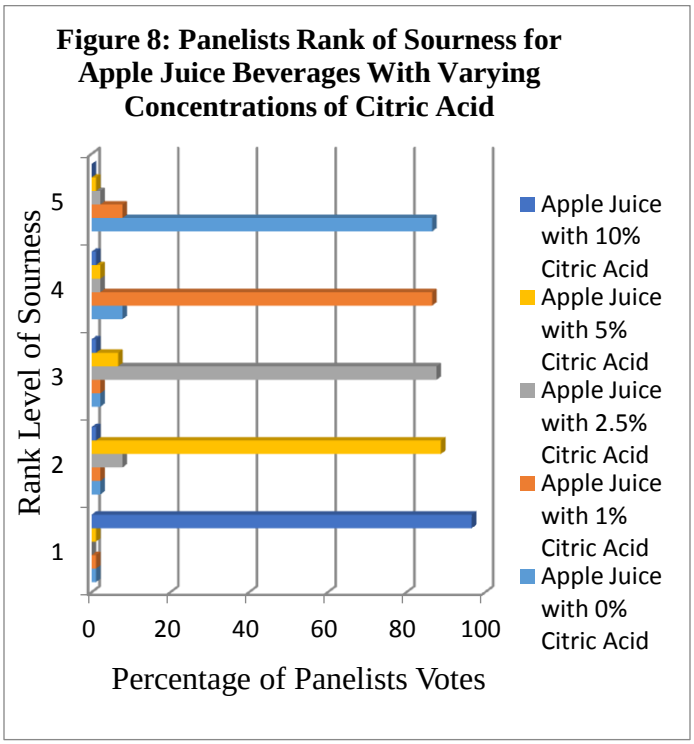
it as being less sour than the reference. A majority of voters (58.43%) gave the 5% citric acid sample a rating of 1 for being more sour, followed by 34.83% of votes rating the sample as 2.

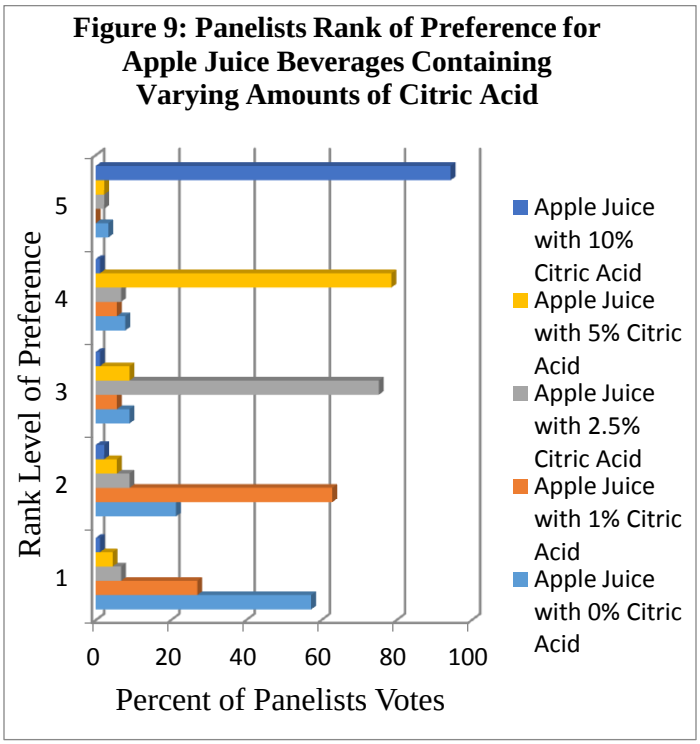


Ranking Test

The ranking test results for sourness and preference of apple juice beverages with varying amounts of citric acid are portrayed in Figure 8 and Figure 9. Figure 8 demonstrates a clear relationship between rank level of sourness and levels of citric acid in apple juice. As the amount of citric acid in the apple juice increases, so does the level of sourness. Panelists ranked apple juice with 0% citric acid as a 5 on average (86.52%). Apple juice with 1% citric acid was mostly associated with a rank of 4 (86.52%) and apple juice with 2.5% citric acid was associated with a rank of 3 (87.64%). Apple juice with 10% citric acid was ranked number one for being the most sour by the majority of voters (96.6%), followed by apple juice with 5% citric acid ranked as number 2 by 88.76% of votes.

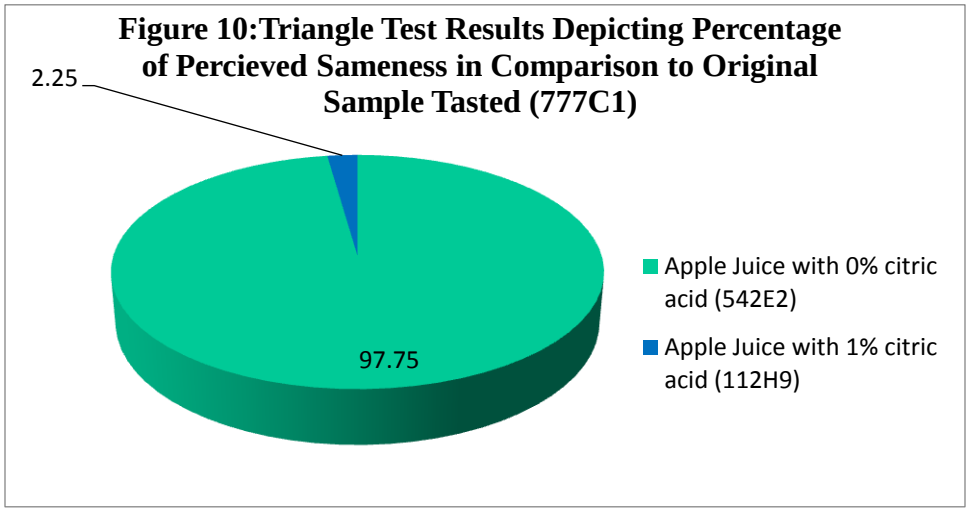
Figure 9 demonstrates that as the percent concentration of citric acid in apple juice increases, the rank of preference decreases. 94.38% of votes ranked 10% citric acid apple juice as a 5 on the preference scale, and 78.65% of votes for apple juice with 5% citric acid were allotted to a ranking of 4. Apple juice with 2.5% citric acid was found to be the second most preferential, receiving a rank of 2 from 62.92% of its votes. Apple Juice with 0% citric acid was ranked 1 by 57.3% of panelists votes.





Triangle Test

In the triangle test, 97.75% of panelists voted sample 542E2 as being the same as sample 777C1. Both of these samples contained apple juice with 0% citric acid. Only 2.25% of panelists found apple juice sample 112H9 as being the same as sample 777C1. In actuality, these two samples varied as 112H9 was apple juice with a 1% citric acid concentration and 777C1 had 0% citric acid concentration. The results are depicted in Figure 10 to visually demonstrate the percentage of correct matches and incorrect matched in the triangle test. The probability of determining the same sample was one out of two.



Discussion

In reference to the beverage color and association tests, the results demonstrated that color has an effect on perceived sweetness, sourness, naturalness, and artificiality of a beverage, which in turn influences a person's willingness to drink that beverage. The temperature of such beverages is affected as well by the color and individuals wanting to drink it. The results of this study demonstrated that, for the most part, as the color of the beverage became darker, perceived sourness of a beverage decreased. This perception is likely due to already existing beverage drink associations that panelists maintained. For example, light yellow is indicative of a beverage such as lemonade (very tart/sour) whereas dark chartreuse could be related to green Nyquil, which is not perceived as being sour to the average individual. Results for perceived sweetness of a beverage did not strongly correlate with color changes. Emerald and light yellow were one either extreme ends of the color spectrum and were both thought to be the sweetest among the five beverage samples. This may be due to external stimuli within the panelists as well. In the study by Shankar et al, it was found that the most common food associations made for green beverages were mint, lime, apple, and kiwi. Lemon beverages were associated most with lemon, pineapple, yellow soda, and white wine. Any of these plus more food affiliations could provide reasoning as to why panelists voted as they did in each of the categories. This reasoning is likely accountable for perceived artificiality and naturalness of colored beverages as well. This study found that as beverage color transitions from light yellow to emerald, perceived artificiality increases (with the exception of dark yellow) and perceived naturalness decreases. Overall, beverages were preferred most on the lighter side of the spectrum (light yellow to chartreuse) and disliked the most on the darker side of the spectrum (dark chartreuse to emerald). Shankar et al. determined in their experiment that flavor perception is "best conceptualized as the interplay between multisensory integration and expectancy effects". Panelists prefer the light yellow beverage because they possibly expect it to taste like lemonade whereas they dislike emerald the most because they expect it to taste artificial do to its unpopularity among natural drink sources (Shankar et al. 2010).

The results indicated that none of the colored drinks would on average be enjoyed as a temperature that was above cold. For each colored samples, at least 94% of panelists said they would prefer the beverage to be cold. The greatest percentage of panelists said that they would drink the light yellow beverage, likely due to the expected flavors that it possessed. Emerald was the least likely to be drunk by individuals. It could be inferred that this is due to its seemingly artificial nature based on color (ie. there are not many beverages associated with that color; therefore it does not seem natural).

The results of the descriptive analysis test performed in the lab demonstrated that different qualities of foods stand out to different individuals. Flavor and aroma proved to be the most easily examined because for these two categories, the greatest percentage of panelists used the same term to describe the attributes of the various samples. For example, when choosing a term to describe the flavor of almonds, 80.90% of panelists deemed the food to be nutty and 91% agreed that they had no aroma. The most inconsistent results were found when evaluating appearance of the different foods. This is exemplified by only 23.60% of panelists naming the appearance of raisins to be sunken. Though this was the term that the greatest number of panelists voted for, it is still a small percentage in relation to the total population. In the study by Varela et al. on what factors stimulate the liking of coffee it was found that most individual's preference was influenced by the flavor and aroma of coffee. Some examples of descriptive terms used to explain a liking for certain samples of coffee were right sweetness (26.9%), coffee flavor (9.6%), milky flavor (8.8%), soft flavor (8.5%), and good flavor (8.0%). Coffee aroma and good aroma were other comments used to describe a liking for the beverages. These findings allowed the authors of the study to conclude the qualities of coffee that were consistently found among consumers. Both the study on coffee and the study in the nutrition laboratory proved that descriptive analysis is relevant to finding the strong qualities that a product may possess, especially relating to flavor and aroma. (Varela et al. 2013)

There were also certain drawbacks to using the descriptive analysis test in the laboratory. Having a predetermined list of terms to use for the analysis could have created bias or swayed panel members opinions

within the various sensory categories. Also, all evaluation was performed in an open room where panelists could see and possibly interpret others reactions to the various samples. This would alter results for all categories of sensory evaluation in descriptive analysis. In addition, these sample evaluations did not ask of panelists to give feedback as to whether they liked or disliked the qualities evaluated within the samples. Therefore, it is not known whether or not the qualities mentioned are good or bad for product acceptability ratings.

The triangle test data revealed that 97.75% of panelists could accurately detect that sample 777C1 and 112H9 were different from each other and that sample 777C1 and 542E2 were the same. The likelihood of selecting the odd sample by change was one in two. For this reason, it should not have been difficult to detect which sample was different from the other two. In this test however, bias could have been created as panelists could see the reactions of each other tasting the apple juices with 1% and 0% citric acid concentration. If a sour face was made when one panelist was trying a sample, which could have led the other panelists to believe that was the odd sample when it may not have been. In the triangle test used by Rousseau et al in determining a difference in taste between commercial Dijon mustards, it was found that sequencing samples in different orders led to different outcomes of correct and incorrect assumptions. Participants in the Dijon mustard study were given six tests within numerous sessions of mustard triangle test tastings. One sequence of order proved to be accurate far more times than the other five. This example explains how triangle tests might not be the most beneficial for sensory analysis. Though they are easily performed, results can be altered based on sequencing of samples as well as bias if other individuals are present during the testing.

The duo-trio test results suggested that 96% of panelists could tell that the Smart and Final Vanilla Wafers sample was different from the standard Nabisco Nilla Wafers and 4% could not accurately determine which of the two samples provided was the same as the standard. Panelists evaluated the difference they found between the two wafer brands and determined that the greatest difference was in vanilla content, followed by crunchiness and dryness. In the case of the study performed by Beinner et al. it was conceived that the

differences observed between the iron fortified rice and conventional rice included alteration in texture, color difference, and a noticeable taste in one of the samples. Overall however, the iron fortified rice was well accepted. The duo trio test in this case was used to help a producer find out if improving a products nutritional content for health related reasons would affect consumer acceptance of that product. Duo trio tests can also be beneficial for store brands to compare their product to name brand foods and beverages for competitive reasons. One impediment to the duo trio test is that it merely compares products through differentiation; it does not measure to what extent the products differ as a ranking or rating test would (Beinner et al.)

The ranking test results provided insight into the inverse relationship between sourness of a beverage and preference for that beverage. The results indicated that with the addition of citric acid concentration to apple juice, ranking levels increase (from 5 to 1) for sourness and levels decrease (from 1 to 5) for preference. Not all panelists ranked their beverages in this way, but this assumption is based off of the average trends seen within the data. The study by Kildegaard et al. had similar findings when testing children's sourness perceptions and preferences for different apples juices and fruit drinks. The findings of the study showed that "in a citrus flavored model beverage system, the addition of sugars resulted in a suppression of sourness perception". They also found that preference increased as sourness decreased in both fruit drinks and apple juices. (Kildegaard et al 2010).

Multiple factors could have affected panelist's ranking choices, including sensory and memory fatigue. Sensory fatigue is likely to occur within ranking tests because panelists are asked to try numerous foods or beverages back to back and they are no longer sensitive to the stimuli that they are testing for. Drinking water in between samples is used to combat this problem but is not always effective. Memory fatigue also occurs when panelists are attempting to compare various items. If those items are not allowed to be retested, than a panelist may forget all together what something tasted like or how strong it tasted. For this reason samples should be allowed to be retested and should also be kept separately from each other to avoid confusion or swapping of samples.

The paired comparison test resulted in 98.88% of panelists detecting that sample 573T2 (apple juice 1% citric acid) contained more citric acid, and was therefore had a greater sour intensity than sample 635T1 (apple juice with 0% citric acid) . This test was incredibly simple too produce due to its use of only two samples and ease of data analysis. It is advantageous to food producers for that reason. Things that might interfere with the results of a paired comparison test might include mixing up of samples, taste fatigue, or using two samples that only have slight variations between them. Paired comparison also only allows for two samples to be used so it can be limiting. This test merely asks which sample contains more of a distinct characteristic, if more information is needed as to why the two samples are different, other tests would need to be conducted.

Results of the scoring/rating test were somewhat consistent among panelists. The reference sample (2.5% citric acid) was placed at a rating of 4 in the middle of the rating scale. In the case of the 5% citric acid sample, panelists could generally tell that I was had a greater sour intensity than the reference sample as all but 1.12% rated it on the less sour side of the scale. For the 1% citric acid solution however, ratings ranged all over the scale, indicating that panelists could not tell a prevalent difference between the reference and the sample at hand. For this reason, the scoring/rating test does not appear to be the most effective difference test. Misjudgment may have been caused by taste fatigue or confusion of instructions as to how to rate each sample. In the future, it might be better to allow panelists to rate the reference samples for themselves, so they are not basing their conclusions off of predetermined ratings.

Sensory analysis is affected by many external factors, which can be beneficial or harmful to a study. Because there are many different tests that can be manipulated in sensory analysis, it is important to choose the right one. Certain tests such as paired comparison, duo trio and triangle tests are good to used when comparing two items because the small sample sizes are easy to obtain feedback and results for in a short amount of time. Other tests such as ranking, scoring, and descriptive analysis are good to use when taking into consideration larger samples, but can also have their limitations. Many factors influence each of these tests and can alter the results easily so analysis should be conducted in a controlled environment to yield the most accurate results.

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Lab Report		Nov 27, 2013 10:54 AM GRADED	108.00 /120
Lab Pre/Post Questions		Dec 11, 2013 11:09 AM GRADED	200.00 /200
Math Units		Dec 2, 2013 3:05 PM GRADED	100.00 /100
Healthy Recipe		Dec 8, 2013 1:59 PM GRADED	30.00 /30