Author: **Lashore, Oluwabukola A.**

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STUDENT:

NAME: Oluwabukola Lashore **DATE: 03/12/18**

ADVISOR: (Committee Chair if MS Plan A or EdS Thesis or Field Project/Problem):

NAME: Dr. John Dzissah **DATE: 4/19/2018**

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Committee members (other than your advisor who is listed in the section above)

1. **CMTE MEMBER'S NAME:** **DATE:**
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Lashore, Oluwabukola A. ***Reformulation of Hamburger Buns using Select Vegetables***

Abstract

A majority of Americans have vitamin deficiency and do not ingest enough vitamins. There are many vegetables rich in vitamins and minerals, but most people do not gravitate toward vegetables. Hamburger is a staple food for Americans, but foods like this leads to obesity if not consumed in moderation.. The aim of this project was to use vegetable juice extract and puree in hamburger buns to create a healthy and more nutritive version of hamburger buns, which offer high levels of vitamins and minerals. Vegetables studied in this research project included purple sweet potatoes, beets, kale, spinach, and sweet potatoes. Various tests were conducted to illustrate the nutritive value, sensory perception and shelf life study. The findings from this study show that there was higher preference for the sweet potato bun compared to the plain (control bun) and the other samples. The beets sample and the kale and spinach sample were the least preferred.

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Table of Contents

List of Figures

Chapter I: Introduction

The short name for hamburger is burger. Hamburger was derived from the Hamburg steaks developed and introduced by German immigrants. Since then, Americans have always enjoyed consuming burgers. According to statistics, Americans enjoy consuming 50 billion burgers per year. In 2014, the "glamburger," was created in Honky Tonk, a restaurant in London, England. This burger was created using expensive ingredients such as black truffle, Kobe beef, venison, and a duck egg. This burger is priced at $1,768. ("25 Amazing Facts About Burgers," 2016).

Burgers were made popular in the U.S. after they were introduced at the St. Louis, Missouri World's fair in 1904. McDonald's sells approximately 75 hamburgers per second. They currently hold the record of selling 300 billion burgers at the time of this paper ("25 Amazing Facts About Burgers," 2016).

The burger business accrues a total of 73 billion dollars in the U.S. Across the country, there are over 50,000 places to purchase burgers (Harry, 2016). Burgers are common and a meal of convenience that people have gravitated toward. Although there are different types of burgers, including healthier choice burgers, there has been limited development of healthy burger buns.

Background

A majority of Americans have vitamin deficiency and do not ingest enough vitamins. There are many vegetables rich in vitamins and minerals, but most people do not gravitate toward vegetables as much as other foods. A burger is a staple food for Americans, but foods like this leads to obesity if not consumed in moderation.

In Japan, they have tried to be creative with burgers by creating the Kuro burger (black hamburger), which is offered at Burger King's in Japan (Penn, 2014). McDonald's has also tried

a creative approach for burgers by creating the gray burger (Cliff, 2015). Although this approach seems to be more on the creative side than the nutritive/healthy direction, it is possible that hamburger could be made into a healthy fast food menu.

Selected Vegetables

The goal of this project was to use vegetable juice extract and puree in hamburger buns to create a healthy and more nutritive version of hamburger buns, which offer high levels of vitamins and minerals. Vegetables are an important aspect of a healthy diet. People who incorporate vegetables into their diet have reduced risk of some chronic illnesses.

Vegetables have low fat and less calories, they are also known to offer many nutritional benefits such as potassium, dietary fiber, folic acid, and vitamin A, C etc. Vegetables such as sweet potatoes, beets, spinach, and kale are rich in potassium. Potassium is important to human health as it helps maintain healthy blood pressure. Vitamin A aids vision and helps radiate healthy skin. Vitamin C helps with speedy recovery of cuts and wounds and it also helps maintain healthy gum and teeth.

Kale has been known to provide the body with comprehensive support by aiding the body's detoxification system. It also has high levels of vitamins A, K, C, and manganese. Spinach is high in protein, fiber, vitamins A, C, E and K. Spinach is known to act as an antioxidant to prevent cholesterol from oxidizing. Beets contain vitamin B, C, fiber, potassium, etc., they also contain health benefits such as lowering blood pressure, boost of stamina, fight inflammation etc. Purple sweet potatoes are rich in antioxidants, vitamin A, B, C, calcium, and potassium. Orange sweet potatoes contain vitamin A and are rich in antioxidants, contain anti-inflammatory properties, and rich in vitamin C.

Statement of the Problem

Reformulating hamburger buns with select vegetables such as kale, spinach, beets, orange sweet potatoes, and purple sweet potatoes adds vitamins and minerals such as potassium, Vitamin A, Vitamin C, and Vitamin K to the bun.

Purpose of the Study

The purpose of this project was to illustrate the health benefits of the various vegetables used in this research. It attempted to assess the nutritive benefits of vegetable puree versus vegetable juice extracts in hamburger buns for a healthy alternative to the plain hamburger buns sold at fast food restaurants. This product development was geared toward increasing vitamin intake in unhealthy foods such as hamburger buns.

Definition of Terms

The following is a list of terms that were used throughout this project.

Reformulated. Reformulated is the process of remaking a product by changing the contents of the items and/or using additional ingredients or materials.

Reformulated hamburger buns. Reformulated hamburger buns embedded with selected vegetables (purple fleshed sweet potatoes, beets, yellow fleshed sweet potatoes, kale, and spinach) measures the appearance acceptability, taste, shelf life, and nutritional benefits of a vitamin rich hamburger bun.

Selected vegetables. The vegetables selected in this project were kale, spinach, beets, orange sweet potatoes, and purple sweet potatoes.

Limitations of the Study

There has not been much research done in the area of attempting to make healthier choice hamburger buns. This project was limited to the use of only kale, spinach, beets, orange sweet potatoes, and purple sweet potatoes to improve the nutritional value of hamburger buns.

Methodology

This project was conducted on campus in the food-processing lab. Four samples of hamburger buns were created and sent to an external lab for analysis on nutritional content. A sensory analysis was done on campus using participants from the University of Wisconsin-Stout in the sensory lab. Participants made choices regarding the hamburger buns based on a 7-point likeness scale. Preferences on all 4 samples used during the sensory process were assessed. Data from the sensory analysis and external lab are explained in the results and discussion section of this project. Equipment used by the external lab is discussed later in this paper.

Chapter II: Literature Review

As previously mentioned, burger is the short name for Hamburger, which was derived from the Germans that migrated to the U.S. Burgers have been made with various creative attempts both in the expensive direction and color variations. No major research or study has been conducted in reformulating hamburger buns with vegetables to help increase their nutritional value.

American Diet

Americans live a very busy life, especially with some working two jobs or college students too busy to make themselves a decent meal, so instead they opt for a fast food menu. By doing so, they are depriving themselves of beneficial nutrients. Unhealthy diets have led to the creation of dietary supplements such as vitamins and minerals made available over the counter. These vitamin supplements are said to contain carcinogenic compounds, which could pose risk to human health (Axe, nd.). Absorbing vitamins through plant sources such as fruits and vegetables is the best way for our system to easily absorb nutrients ("Is it Better to Get Vitamins From Foods or Supplements," 2012).

Reformulating hamburger buns with select vegetables provides beneficial nutrients that will not be otherwise easily obtained from consuming a poor fast food menu, which contains empty calories with little to no nutritional benefits. Nutritional and flavor benefits of kale, spinach, orange sweet potatoes, and purple sweet potatoes in hamburger buns were evaluated in this project. Variables such as texture, color, taste, shelf life, and nutritional facts were also included.

The following review of literature discusses the nutritional benefits of the selected vegetables. This information was taken into consideration being aware of their nutritional benefits and how much of it is made available after the baking process takes place.

Selected Vegetables

Sweet potatoes are considered an excellent novel source of natural health-promoting compounds such as β-carotene and anthocyaninthe (Bovell-Benjamin, 2007). Total amino acids, which are the building blocks for protein, were estimated at 5676.57mg% in purple sweet potatoes and 4550.86mg% in yellow sweet potatoes. The presence of fatty acids such as palmitic and linoleic acid were analyzed using gas chromatography. The presence of thiamin, riboflavin, niacin, and ascorbic acid contents were estimated in purple-fleshed sweet potato as 63.4 mg% and in yellow sweet potato and 48.7 mg% respectively (Kim & Chung, 1995).

Based on the analysis conducted on kale, the most abundant amino acids are glutamic acid, which was present at 33.2 mg g^{-1} dry weight. Aspartic acid, which was stated as the second most abundant amino acid, was estimated at 27.6 mg g^{-1} dry weight and accounted for 10.2% of the total amount of kale leaf. Based on this analysis, it was compared with the World Health Organization (WHO) standard and it compared well (Faik et al., 2006). There are various estimations for the vitamin content of kale, namely: vitamin C (23.43 mg/100g), vitamin E (4.06 mg/100g), and vitamin A (11.25 mg/100g) (Emebu & Anyika, 2011).

Research studies show that spinach is a good source of Ca, K and Fe and vitamins such as ascorbic acid and β- carotene (Kuti & Kuti, 1999). Betalains is responsible for color pigment observed in beets, which enables coloring using this compound as a “coloring fruit-and plant extracts” on the ingredient list. This provides a clean and stable color, which makes it more acceptable to health-conscious individuals who do not appreciate artificial colors in their meals.

(Stintzing & Carle, 2004).

Insufficient Vegetable Consumption

Based all the stated nutritional benefits and functions provided from different vegetables, it is obvious that people have a lot to gain from nutritional benefits of selected vegetables. Many people find it difficult to incorporate vegetables into their diets, especially busy people. This project was an opportunity to create a product that could be a staple on the American diet menu: enriched vitamins in reformulating hamburger buns.

Previous Studies on Vegetables

Incorporating vegetables into baked goods such as hamburger buns is a research area that was needed. The closest study to this was using sweet potato flour in bread not juice extract or puree (Green & Bovell-Benjamin, 2004). Many people consume hamburger buns because they are a part of a convenience meal. Studies on vegetables are mostly done on cooked or frozen vegetables or in puree for children. No research has looked into the possibility of incorporating vegetables into hamburger buns.

The study conducted by Green and Bovell-Benjamin (2004) showed the use of sweet potato flour in bread. In the study, sweet potato flour was averaged at 3.0-6.0% fat. Breads used were made using 50%, 55%, 60%, and 65% sweet potato flour in combination with whole wheat. SPB (sweet potato bread) 50% has an average of 8.2% protein, 21.2% CHO (carbohydrate), 35% moisture, 3386.2g/100g β- carotene, 1.3% vitamin C, and 3.8% fat. SPB 55% had an average of 7.8% protein, 19.9% CHO, 35.1% moisture, 4709g/100g β-Carotene, 1.3 mg/100g vitamin C, and 4.6% fat. SPB 60 had an average of 7.4% protein, 20.1% CHO, and 1.2% vitamin C. SPB 65% had an average of 7.1% protein, 21.4% CHO, 35.7% moisture, 6054g/100g, and 1.3g/100g

vitamin C. Compared to sweet potato flour, wheat flour has more protein, which explains why SPB 50 has more protein content than higher supplementation of sweet potato flour.

The SPB 65% in the Green & Bovell-Benjamin (2004) study showed a higher level of β-carotene compared to other SPB ratios. Overtime, it was also observed that the β-carotene content decreased throughout the storage period. According to the authors, other studies showed that β- carotene content decreases over time during storage period. Sweet potatoes have high levels of β-carotene, but probably using sweet potato flour could be the reason for losing the β-carotene, since the flour has been processed. Although the vitamin C levels were hardly lost compared to the β- carotene, shelf life of this product showed that mold growth was substantially minimal at the storage period of 5 days.

Additionally, weight loss of the bread was examined, and it indicated that SPB 65% had a lower weight loss compared to SPB 50%. The weight loss ranged from 6.5-7.7%, apparently from foods specifically red, orange, and yellow color. Overall, the inclusion of sweet potato flour had some nutritional affect, mainly high levels of β- carotene, but low levels of protein (Green & Bovell-Benjamin, 2004).

Sensory attributes of this product was somewhat a concern regarding whole-wheat bread in terms of smell, cell size, grittiness, and the denseness of the sweet potato bread. Future direction for the Green & Bovell-Benjamin (2004) study suggested that due to differences in the sensory analysis, it might make it unacceptable for consumers. To bridge the gap regarding hamburger bun research, a study direction to use sweet potato juice and puree extract to compare nutritional value was used in this project.

Nutritional Benefits From Vegetables

Yellow sweet potatoes like most other vegetables are rich in phytonutrients, beta-

carotene, vitamin A, vitamin C, manganese, copper, pantothenic acid and vitamin B6. Like spinach, it possesses vitamin B2, vitamin B1, potassium, dietary fiber, and niacin (The George Mateljan Foundation, n.d.-b).

The purple sweet potato is similar to the yellow sweet potato; it contains proteins, beta-carotene, dietary fiber, vitamin C, vitamin B6, potassium, iron, calcium, and manganese. The major difference between both colored sweet potatoes is that the purple sweet potato is packed with the antioxidant anthocyanin. Aside from nutritional benefit, there are also health benefits. It helps reduce blood pressure, fights against cancer, could aid in weight loss because it's filling, aids in immune system and aids digestion. It could also cure bronchitis, arthritis, diabetes, and stomach ulcers (Anonymous, 2013).

Sweet potatoes are packed with flavones, β-carotene, and anthocyanins. The purple sweet potato is sought after for its color attribute as a natural colorant giving a rich deep purple color. In Japan, purple sweet potatoes are being used in food products such as alcoholic beverages, chips, bread, jams, noodles, confectionery, and juices. The purple sweet potato has higher levels of radical scavenging compared to its yellow counterpart.

Sweet potato juice extract was used in this project. Research indicates that it has the capability to reduce CCl4 induced liver injury due to the presence of high anthocyanins contained in purple-fleshed sweet potatoes. Health benefits associated with purple sweet potato juice extract highlight its physiological properties, which include, ACE-inhibition, antihyperglycemic, hepato-protective, antihypertensive and α-glucosidase. This evidence points to the fact that purple sweet potato juice has health benefits. The future direction of this project shows that the purple-fleshed sweet potato should be used in more areas of the food industry to create healthy products with the hope of decreasing the possibility of chronic diseases.

Beets are one of the few vegetables consumed but have many nutritional benefits of which most people are not aware. Although beets are a very colorful vegetable, they are used to make sugar because it has the most sugar content compared to other vegetables. Sugar is mostly white and beets are either orange or purple, but they produce sugar.

Aside from playing a major role in the production of sugar, beets are nutritionally beneficial. They are packed with many positive health-related functions. Beets help to reduce blood pressure, which can be achieved by consuming an 8 oz. glass of beet juice. This benefit comes from the nitrates commonly found in them. Beets also help to boost stamina, which is especially beneficial during working out. They help to extend performance by decreasing the onset of fatigue. Beets also helps to fight inflammation because of being packed with betaine. This nutrient preserves proteins, cells, and enzymes from stress related to the environment. It helps to improve vascular risk, reduce the possibility of an inflammation, preserve internal organs, and aid in the prevention of chronic disease based on findings from the World's Healthiest Foods (Mercola, 2014). Moreover, studies conducted in various animal models show that beetroot extract decreased the presence of organ tumor when added to water. (Lechner et al., 2010).

Based on these findings, other research areas are being explored pertaining to the effect of beets on prostate cancers and breast and pancreatic cancers as well. Beets are also packed with vitamin C, fiber, and essential minerals such as manganese and potassium. Manganese is important to health, as it helps supports the development of the kidneys, pancreas, kidneys, bones, and liver. Potassium is key in the development of muscles and nerves. It also decreases birth related defects sue to the presence of B vitamin folate, which it possesses. It also helps to

purify blood vessels and liver, which is a form of detoxification helpful for the overall function of the body (Mercola, 2014).

The presence of betalains, which is a subfamily of amaranthaceae, in beets could aid the nutritional value of food products, especially during a time when processed foods are highly sought after. Processed foods have little to no nutritional value (Stintzing & Carle, 2004). Beets are packed with antioxidants and can serve as a source for natural colorants as well. (Yizhong, Sun, & Corke, 2003). Beet tends to give an earth-like overall flavor, which is perceived as unacceptable to consumers; however, using the right technique it could be reduced.

Spinach is quite rich in vitamins and minerals as well as phytonutrients such as carotenoids, namely: beta-carotene, lutein, and zeaxanthin, and flavonoids, which are a source of antioxidant protection. It is also an outstanding source of other antioxidant nutrients such as vitamin A, C, E, manganese, and selenium. These nutrients when consumed could help reduce the risk of oxidative stress. They could also help alleviate atherosclerosis as well as high blood pressure.

Zeaxanthin and lutein, found in abundance in spinach, act as antioxidants, which are present in the areas around the eyes, although no major research as shown the influence of spinach on prevention of diseases related to the eyes. Spinach contains an abundance of vitamin K, vitamin K1, which aids in the prevention of excessive activation of osteoclasts, which are the cells that break down the bone. It also possesses nutrients such as calcium and magnesium, which help support bone function. Other nutrients found in spinach include iron, copper, vitamin B6, vitamin B2, vitamin E, potassium, and vitamin C. It also serves as a beneficial source of pantothenic acid, selenium, niacin, omega-3 fatty acids, dietary fiber, choline, protein, zinc, phosphorus, and vitamin B1 (The George Mateljan Foundation, n.d.a).

Kale is one of the healthiest leafy greens currently gravitated toward but the most difficult to eat due to its bitter taste. Although there are various ways of preparing kale, which could involve steaming, boiling, or baking, most people incorporate it into their smoothies while adding various fruits to help sweeten the drink. Kale, although tricky to eat, is also known to prevent cancer, aid heart support, and help with detoxification.

Kale consists of nutrients such as vitamin A, C and K along with other minerals such as calcium, manganese, and potassium. It serves as an anti-inflammatory by promoting the presence of omega-5 and omega-3. Kale helps cleanse the body of toxin through the presence of sulfur and glucosinolates. It is rich in antioxidants such as vitamin C and beta-carotene. Kale helps support a healthy heart. It also aids in providing healthy vision. According to a study conducted in males, calcium is better absorbed from kale and spinach (Heaney & Weaver, 1990).

Amylase

In the food industry, amylase is an enzyme commonly used in brewing, baking, and in the production of digestive substances. A form of amylase used in baking is known as α-amylase. This enzyme, when added to bread, aids the degradation of starch by breaking it into smaller dextrins, which makes fermentation easier with yeast. Incorporating α-amylase into baking bread functions in various ways: it enhances the rate of fermentation, and helps increase volume and overall texture of bread. It produces sugar during this process, which affects the crust color, taste, and overall quality of bread. Shelf life of bread is associated with the quality of bread; anti-staling agents in bread making is crucial. Amylase possesses the qualities needed to function as an anti-staling agent and increases the texture; basically softness of bread (Souza & Magalhaes, 2010).

Amylase is mostly used in the food industry for its ability to extend the fermentation process while creating even crumb structure and a high loaf volume. Usage level of alpha-amylase at 45ppm gives an elastic crumb and soft bread, and 20µl of amylase dosage is used to help reduce staling in bread. (Caballero, Gomez, & Rosell, 2007).

Sensory Attributes

Taste, color, and texture was analyzed by the participants in this project, but the color was evaluated scientifically using the Hunter color device to obtain L* a* b* values. Nutritional benefits were explored using an external lab.

Food Analysis

For shelf life studies, data for moisture, water activity, and pH values were taking into consideration. Hamburger buns are generally made using water in the liquid phase of its formulation, but this project replaced the liquid phase with a puree and juice extract versions of the vegetables.

Summary

Overall, most information highlights the benefits of vegetables in relation to health and nutrition. Although most studies focus on various ways in preparation of vegetables, none focus on the incorporation of nutrient packed vegetables in baked goods such as hamburger bun, which is consumed by millions of people daily. This project focused on incorporating vegetable puree and juice extract into hamburger buns.

Increasing Nutritional Value

In optimizing the nutritional benefits for people in the U.S., efforts have been made to increase the supply of smoothie shops and outlets; however, in as much as that effort is channeled toward more good than harm, there is more added sugar, which is unnecessary.

Although some smoothie shops use fresh vegetables, they manage to include sweetness using sugar, which takes away from the nutritional benefits. The purpose of this was to use fresh vegetables in hamburger buns without compromising its nutritional benefits. From the review of literature, there are various functions and nutritional benefits of the vegetables selected for this project.

Findings Measured

With the creation of hamburger buns reformulated using selected vegetables, various test were conducted to illustrate the nutritive value, sensory perception, shelf life, and packaging conditions of the buns. Past research has only focused on the nutritional benefits, and have not shown any in-depth application of using vegetables in hamburger buns. A majority of Americans have vitamin deficiency and do not ingest enough vitamins. There are many vegetables rich in vitamins and minerals, but most people do not gravitate toward eating more vegetables.

The hamburger is a staple food for Americans, but foods like this leads to obesity if not consumed in moderation. In Japan, they have tried to be creative with hamburgers by creating the Kuro burger (black hamburger), which is offered at Burger King's in Japan. McDonald's has also tried a creative approach for hamburgers by creating the grey hamburgers. Although this approach seems to be more on the creative side than the nutritive/healthy direction, hamburger could be made into a healthy fast food menu.

This project used vegetable juice extract and puree in hamburger buns to create a healthy and more nutritive version of hamburger buns, which offer high levels of vitamins and minerals. The vegetables used in this project included purple sweet potatoes, orange sweet potatoes, beets, kale, and spinach. These vegetables are rich in vitamin A, vitamin C, vitamin K, beta-carotene, and much more.

Hamburger buns lack in nutritional benefits. By using the aforementioned selected vegetables, this project focused on how this product will be perceived by people in terms of texture, color, and taste. Texture, color, and taste were analyzed by participants, but the color was evaluated scientifically using the Hunter color device to obtain L* a* b* values. Shelf life and nutritional benefits were explored using an external lab. Shelf life data for moisture, water activity, and pH values were also gathered. Hamburger buns are generally made using water in the liquid phase of its formulation, but this project replaced the water with a puree and juice extract versions of the vegetables.

Chapter III: Methodology

The initial step of this process was preparing the vegetable extract and puree from select vegetables. Five to ten percent of either version of vegetables was incorporated into the dough. By dividing the dough into 10g before baking, mini hamburger buns were created. A sour dough starter was used to help the dough rise, which made it airy and light. Afterwards, samples were sent to an external lab for analysis while sensory analysis will be conducted on campus. Table 1 shows the coding used for the sensory analysis of the hamburger buns.

Table 1

Sensory Codes Used During Sensory Analysis

Sensory Data Phase 1 (Vegetable Juice)	Sensory Data Phase 2 (Vegetable Puree)
445- Control/ Plain Hamburger bun	363- Control/Plain Hamburger bun
662- Kale & Spinach juice	165- Kale & Spinach puree
595- Beets Juice	799-Orange Sweet Potato puree
891-Purple Sweet Potato Juice	216- Beets Puree
743- Orange Sweet Potato Juice	572- Purple Sweet Potato Puree

Participant Selection and Description

The sample size for this project came from an estimated pool of 100 persons from the University of Wisconsin-Stout, which included students and faculty members. The participants engaged in the sensory aspect of this project. A consent form was signed before commencing the sensory analysis. Afterwards, a short survey question will be administered asking about the

demographics of the participants. Participants used a 7-point likeness scale to analyze four samples of the mini hamburger buns.

Instrumentation

This project was conducted on campus at the food processing lab/ pilot lab/ pilot plant. The sensory analysis for this project took place in the sensory lab. Equipment used in this project involved an oven, a proofer, a colorimeter, dough mixer, compusense (for sensory analysis), and cooking utensils from the food science department. During this project, data was gathered using a food analysis system known as proximate analysis (carbohydrate, fat and protein content). The sensory analysis data was collected using the compusense, which complied data from participants. The shelf life studies data was collected to monitor mold growth.

Hamburger buns are estimated to last 5-7 days. The preservatives used in this project were monitored for mold growth and staleness at ambient temperatures. Shelf life studies were affected through data collected for moisture content, pH, and Aw (water activity). The control (plain) bun was made with white flour without the inclusion of vegetable juice extract or vegetable puree.

Vegetables Selected

Selected vegetables for this project included spinach, kale, beets, orange sweet potatoes, and purple sweet potatoes. These vegetables are used in two forms: a puree version and a juice extract form. These forms were incorporated into the reformulated hamburger buns and baked.

Materials and Methods

Vegetable juice extract for this project was made using the Hamilton beach juice extractor. A puree version of the vegetables was made using the blender. Vegetable juice extract and puree were stored in plastic containers at a refrigerated temperature of 32 F.

The dough was mixed using a kitchen aid mixer at a low to medium speed. Dough was allowed to rise for 1hour in a proof box. It was then divided into hamburger bun sizes of approximately 30g and allowed to rise for 20 minutes in a proof box. The dough was baked in the oven at 375 F for 15 minutes.

Afterwards, hamburger buns were cooled for 20 minutes on a cooling rack. The buns were then packaged using a transparent LDPE plastic bag designed for buns to prevent moisture loss. The buns were stored for shelf life analysis.

Sensory Analysis

A two-phase sensory analysis was conducted to evaluate the two phases of this project. The first phase was the vegetable juice extract incorporation, and the second phase was vegetable puree incorporation. The hamburger buns were made in house the day before the sensory analysis to maintain the freshness of the buns. Advertisement for this sensory evaluation was posted over campus, and a request was made to various professors to encourage participation of students in this project.

For the first phase of the sensory analysis, the samples were placed in the sensory lab 2 hours before the sensory evaluation commenced. Sample plates were coded, and compusense was used to randomize and balance sample placement for sensory participants.

The sensory evaluation prep room was held in Heritage Hall room 251 while the sensory evaluation was done in Heritage Hall room 252. Seven cubicles were used with seven computers where participants began and finished the evaluation process. Students were instructed to use the light switches to indicate when they were ready for samples. The green switch was used to indicate if the participants wanted any more samples or needed any help, while the red light indicated that participants were busy with evaluations and should not be disturbed.

In the first phase, participants were given a series of survey questions for this researcher's better understanding of them and how their evaluations would affect the outcome of the project. They were then given five samples that used vegetable juice extract on coded sample plates and a series of sample related questions were asked. The sensory evaluation took approximately 10 minutes. Sixty to sixty-two participants were involved in the first phase of the sensory evaluation.

In the second phase of the sensory evaluation, six cubicles were used, and red light filters were used to better understand the data. Instructions were the same as the first phase of the sensory evaluation except the samples. The samples used in this phase of the sensory evaluation were made using the vegetable puree. As with the first phase, 60-62 participants participated in this phase of the sensory evaluation. Sensory evaluation was based on appearance, texture, aftertaste, aroma, overall acceptability, and purchase intent.

Water Activity

The Aqua Lab Dew Point Moisture Analyzer was used to examine the water activity of the hamburger bun samples. The purpose of this test was to gather data for the shelf life study to evaluate the amount of water present to aid in the activity of microorganisms. The water activity was calibrated using the calibration kit at 0.984 using the calibration fluid. Two hamburger bun samples were blended in the Kitchen Aid food processor, and the samples were filled in the water activity container filled at the ¼ level. This was done to evaluate how the water activity varies throughout the shelf life study of these nine hamburger buns.

Texture Analysis

An Instron Texture Analyzer was calibrated at the start of the evaluation. The purpose of this test was to evaluate the texture of the hamburger buns over the course of 14 days while they

were stored in an LDPE bag at room temperature throughout the shelf life analysis. Hamburger buns were cut in half and placed in between the texture analyzer. Texture analysis was completed at the end of 14 days.

Moisture Content Analysis

The mechanical oven by Lindberg/Blue was used to measure the moisture content of the hamburger bun samples. Two of each of hamburger bun was processed in the Kitchen Aid food processors. The moisture oven foil pan was used to contain the processed hamburger bun samples. Then, 5g of each sample was placed in the aluminum foil sample pans in duplicates and labeled. The samples were all placed in a baking sheet pan and placed in the mechanical oven at 140F for 2 hours. At the end of the 2-hour cycle, the samples were in a desiccator for 20 minutes, and afterwards the weight of each sample was taken.

Color Hunter

The color hunter Color Flex EZ was used to analysis the color of all nine hamburger bun samples. The equipment was calibrated using a calibration kit provided, which consisted of a round white and black disk. Two samples of each hamburger bun were used for the color hunter analysis.

Mold Growth

Mold growth was noticed after 2 weeks of shelf life due to the absence of preservatives in the buns, which were stored at ambient temperature.

Data Collection Procedures

The data collection process involved both a sensory analysis and external testing of the hamburger buns.

Sensory analysis. Before the testing began, the hamburger buns were screened down to four samples. Participants were provided with water and four hamburger samples. At the start of the analysis, participants were asked to provide information about their demographics. A 7-point likeness scale was then presented to the participants, via computer, which was then used in the analysis.

External testing. Samples were sent to RL Food Testing laboratory for testing on nutritional facts and shelf life analysis. Duplicate samples of 10 hamburger buns were sent to the lab for testing.

Data Analysis

Nutritional value of the reformulated hamburgers was analyzed and compared among treatments. Vitamins and minerals retained from each bun were highlighted, including mineral levels of calcium, potassium, vitamin A, vitamin C, and vitamin K. Also, the demographics of the participants in the survey were analyzed. Results from sensory analysis were assessed based on the 7-point likeness scale. At the end of the sensory evaluation, participants were asked about their preference on the purchase of the tested hamburger buns.

Limitations

The lack of a calorimeter on campus made it challenging to get a result in house without the use of an external lab, which made it difficult to experiment with different levels of vegetable juice extract and puree. Additionally, the steam in the microbiological lab was shut off due to technical issues from the power, which explained the lack of results for microbiological analysis.

Summary

The methods explained in this chapter were used in this project to analyze if the nutritional value of a hamburger bun can be optimized with the introduction of vegetables in juice extract and/or puree into the bun.

Chapter IV: Results

This chapter provides the results of this project regarding the color, water activity, moisture content, nutritional facts, sensory data, and texture analysis of hamburger buns that were made with either vegetable juice extract or vegetable puree. The plain hamburger bun is also compared in the results.

Sensory Data

Phase 1 of the sensory analysis of the vegetable juice extract results is shown in Figures 1 through 6. Figure 1 shows the results of the appearance evaluation of vegetable juice extract hamburger buns.

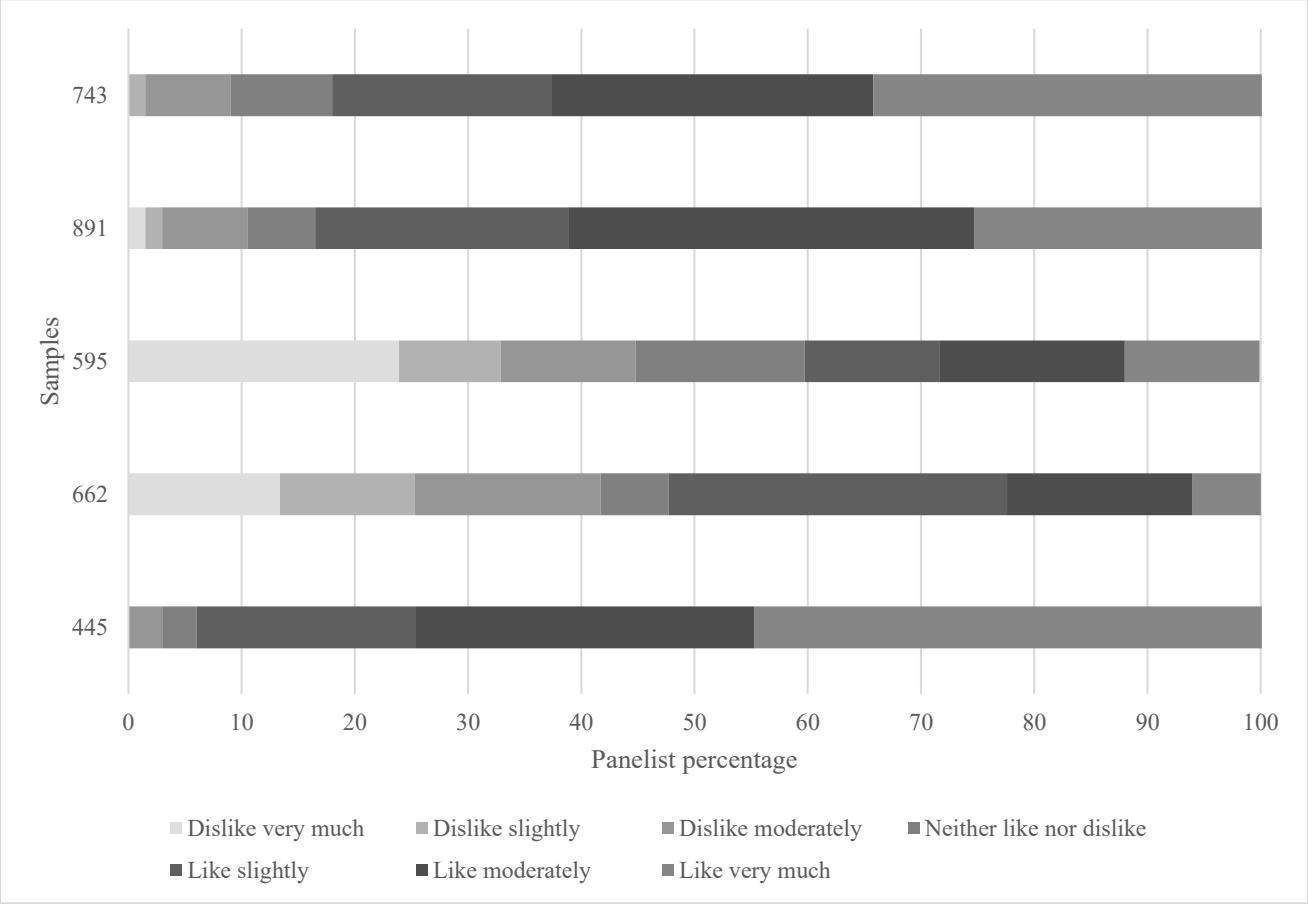

Figure 1. Appearance evaluation of the vegetable juice extract hamburger buns.

The appearance of the plain hamburger bun (control bun) was liked by 93.4% of the participants, 3% neither liked nor disliked like bun, and 3% disliked the appearance of the bun. For the kale and spinach bun, 52.3% of the participants liked the appearance, 6% neither liked nor disliked the appearance, and 41.7% disliked the appearance. For the beet bun, 44.8% of the participants liked the appearance, 14.9% neither liked nor disliked the appearance, and 40.2% disliked the appearance. For the purple sweet potato bun, 83.6% of the participants liked the appearance, 6% neither liked nor disliked the appearance, and 10.5% disliked the appearance. For the orange sweet potato bun, 82.1% of the participants liked the appearance, 9% neither liked nor disliked the appearance, and 9% disliked the appearance.

Figure 2 indicates the results of the aroma evaluation of the vegetable juice extract hamburger buns.

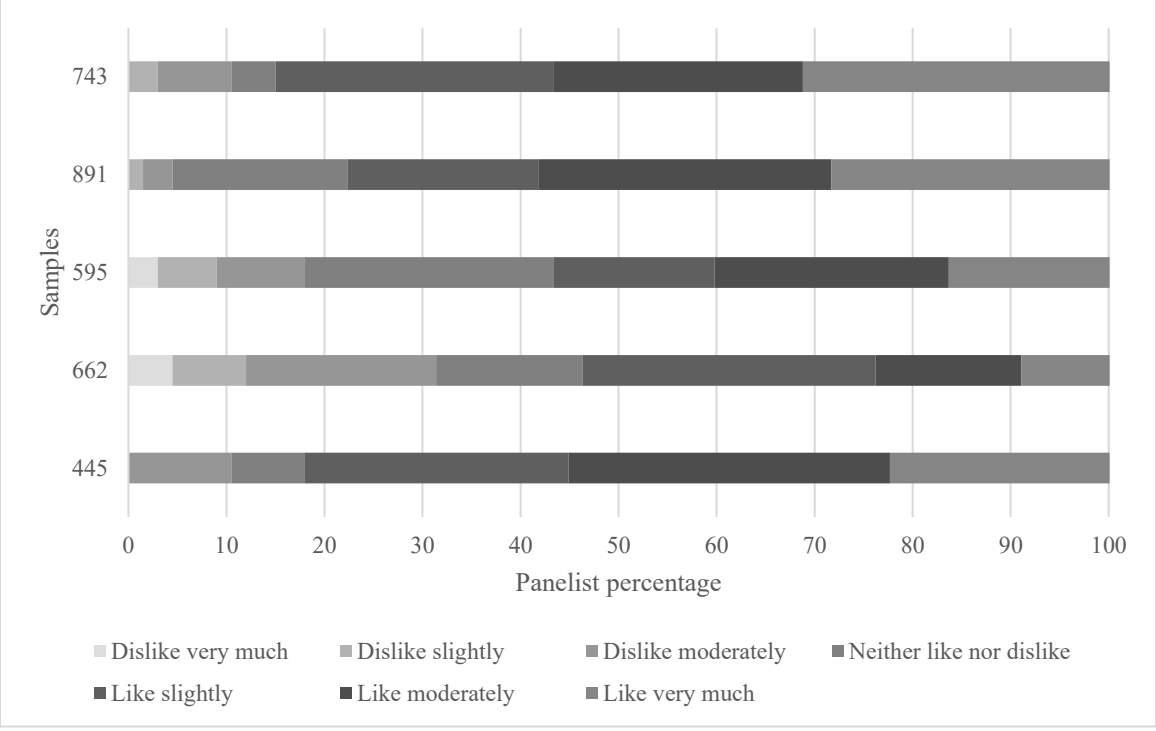

Figure 2. Aroma evaluation of the vegetable juice extract hamburger buns.

The aroma of the plain bun was liked by 82.1% of the participants, 7.5% neither liked nor disliked the aroma, and 10.5% disliked the aroma. For the kale and spinach bun, 53.8% of the participants liked the aroma, 14.9% neither liked nor disliked the aroma, and 31.4% disliked the aroma of the bun. For the beet bun, 56.7% of the participants liked the aroma, 25.4% neither liked nor disliked the aroma, and 18% disliked the aroma. The aroma of the purple sweet potato bun was liked by 77% of the participants, 17.9% neither liked nor disliked the aroma, and 1.8% disliked the aroma. For the orange sweet potato bun, 85.1% of the participants liked the aroma, 4.5% neither liked nor disliked the aroma, and 10.5% disliked the aroma.

Figure 3 shows the results of the texture of the vegetable juice extract hamburger buns.

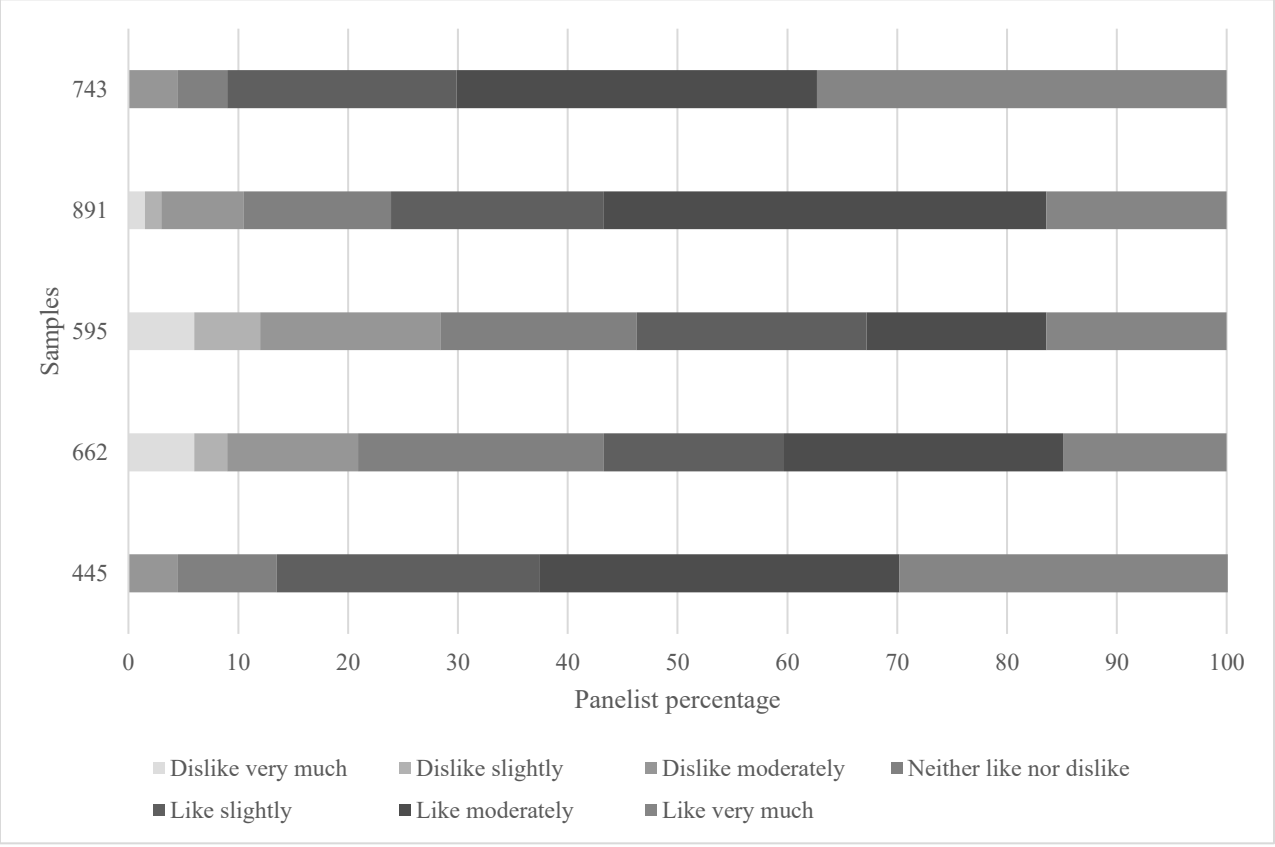

Figure 3. Texture evaluation of the vegetable juice extract hamburger buns.

The texture of the plain bun was liked by 86.6% of the participants, 9% neither liked nor disliked the texture, and 4.5% disliked the texture. For the kale and spinach bun, 56.7% of the participants liked the texture, 22.4% neither liked nor disliked the texture, and 20.9% disliked the texture. For the beet bun, 53.7% of the participants liked the texture, 17.9% neither liked nor disliked the texture, and 28.4% disliked the texture. For the purple sweet potato bun, 76.1% of the participants liked the texture, 13.4% neither liked nor disliked the texture, and 10.5% disliked the texture. For the orange sweet potato bun, 91% of the participants liked the texture of the orange sweet potato bun.

Figure 4 indicates the results of the flavor of the vegetable juice extract hamburger buns.

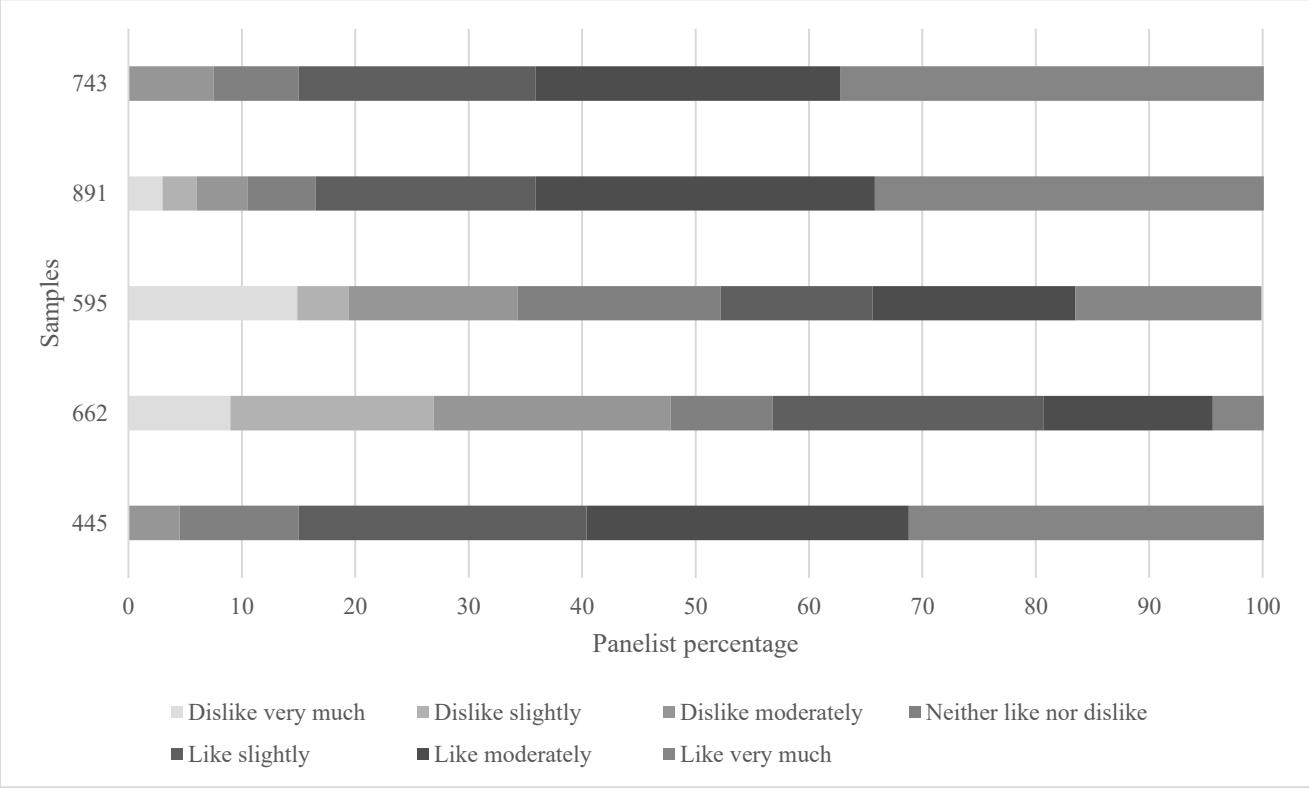

Figure 4. Flavor evaluation of the vegetable juice extract hamburger buns.

The flavor of the plain bun was liked by 85% of the participants, 10.5% neither liked nor disliked the flavor of the plain bun and 4.5% disliked the flavor of the plain bun. For the kale and

spinach bun, 43.3% of the participants liked the flavor, 9% neither liked nor disliked the flavor, and 47.8% disliked the flavor of the bun. For the beet bun, 47.7% liked the flavor, 17.9% neither liked nor disliked the flavor, and 34.3% disliked the flavor of the bun. For the purple sweet potato bun, 83.6% of the participants liked the flavor of the purple sweet potato bun, 6% neither liked nor disliked the flavor, and 10.5% disliked the flavor. For the orange sweet potato bun, 85.1% of the participants liked the flavor, 7.5% neither liked nor disliked the flavor, and 7.5% disliked the flavor.

Figure 5 shows the results of the aftertaste of the vegetable juice extract hamburger buns.

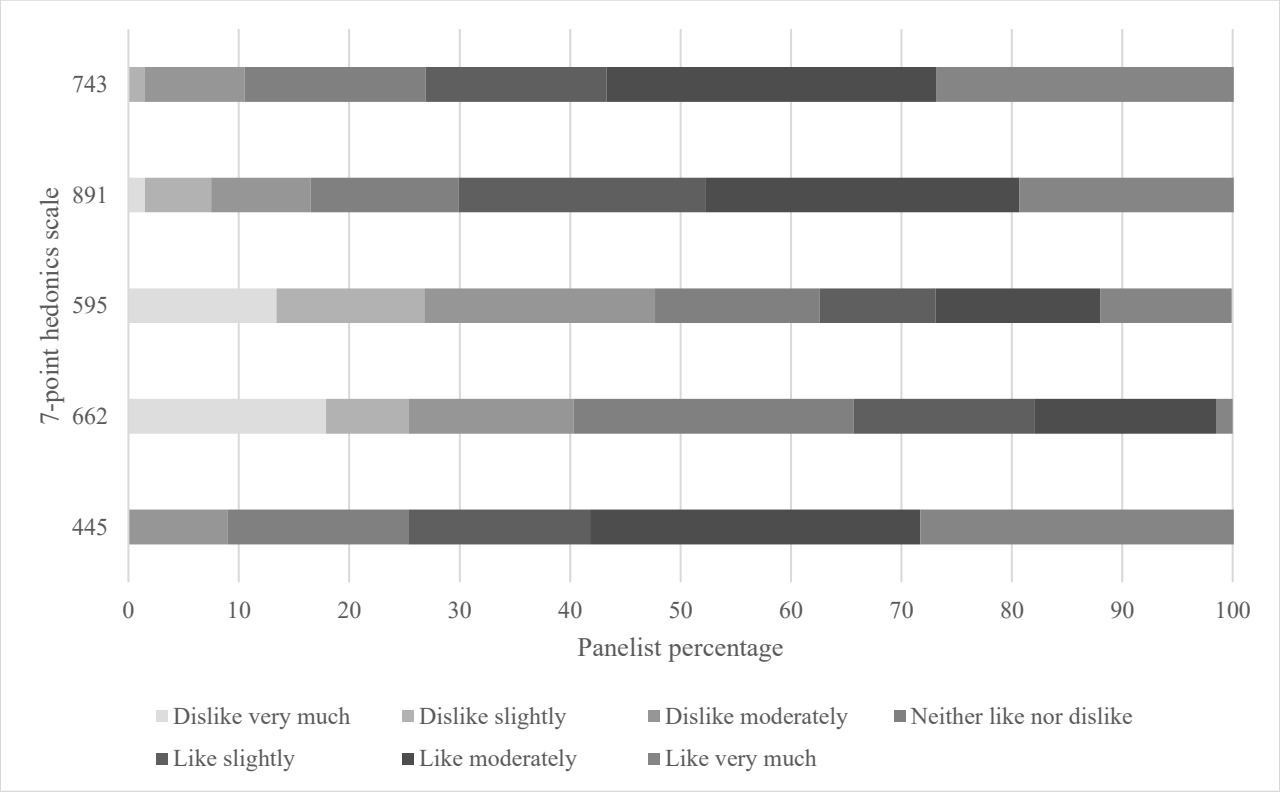

Figure 5. Aftertaste evaluation of the vegetable juice extract hamburger buns.

The aftertaste of the plain bun was liked by 74.7% of the participants, 16.4% neither liked nor disliked the aftertaste, and 9% of the participants disliked the aftertaste. The aftertaste of the kale and spinach bun was liked by 34.3% of the participants, 25.4% neither liked nor disliked the

aftertaste, and 40.3% disliked the aftertaste of the bun. The aftertaste of the beet bun was liked by 37.3% of the participants, 14.9% neither liked nor disliked the aftertaste, and 47.7% disliked the aftertaste. For the purple sweet potato bun, 70.2% of the participants liked the aftertaste, 13.4% neither liked nor disliked the aftertaste, and 16.5% disliked the aftertaste of the bun. For the orange sweet potato bun, 73.2% liked the aftertaste, 16.4% neither liked nor disliked the aftertaste, and 10.5% disliked the aftertaste of the bun.

Figure 6 indicates the overall acceptability of the vegetable juice extract hamburger buns.

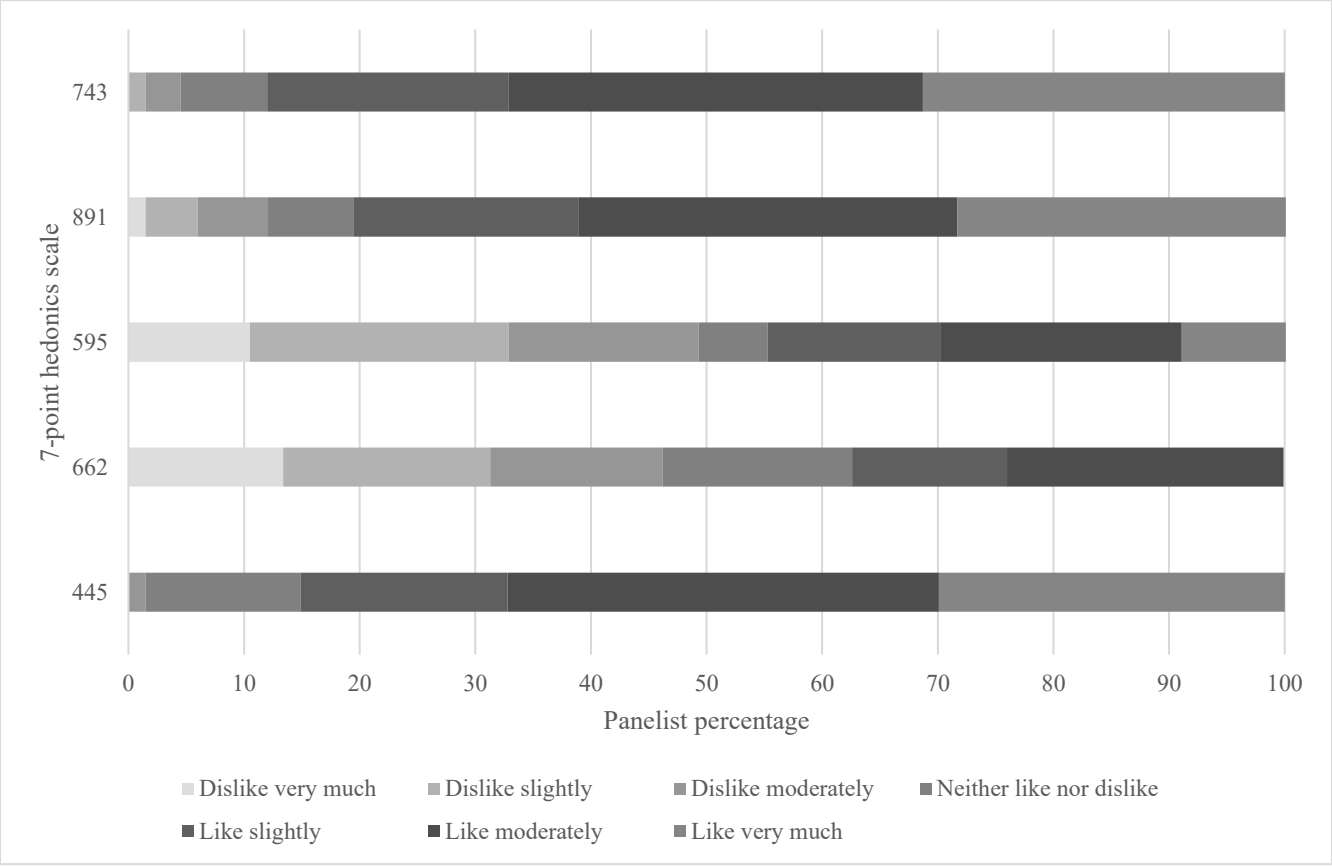

Figure 6. The overall acceptability of the vegetable juice extract hamburger buns.

The overall acceptability of the plain bun was liked by 85.1% of the participants, 13.4% neither liked nor disliked the bun, and 1.5% disliked the bun. For the kale and spinach bun, 37.3% of the participants liked it, 16.4% neither liked nor disliked it, and 46.2% disliked the bun.

For the beet bun, 44.8% of the participants liked it, 6% neither liked nor disliked it, and 49.3% disliked the bun. The purple sweet potato bun was liked by 80.6% of the participants, 7.5% neither liked nor disliked it, and 12% disliked the bun. For the orange sweet potato bun, 88% liked it, 7.5% neither liked nor disliked it, and 4.5% disliked the bun.

Phase 2 of the sensory data involved the results of the buns made with vegetable puree results are shown in Figures 7 through 11.

Figure 7 shows the results of the vegetable puree hamburger bun.

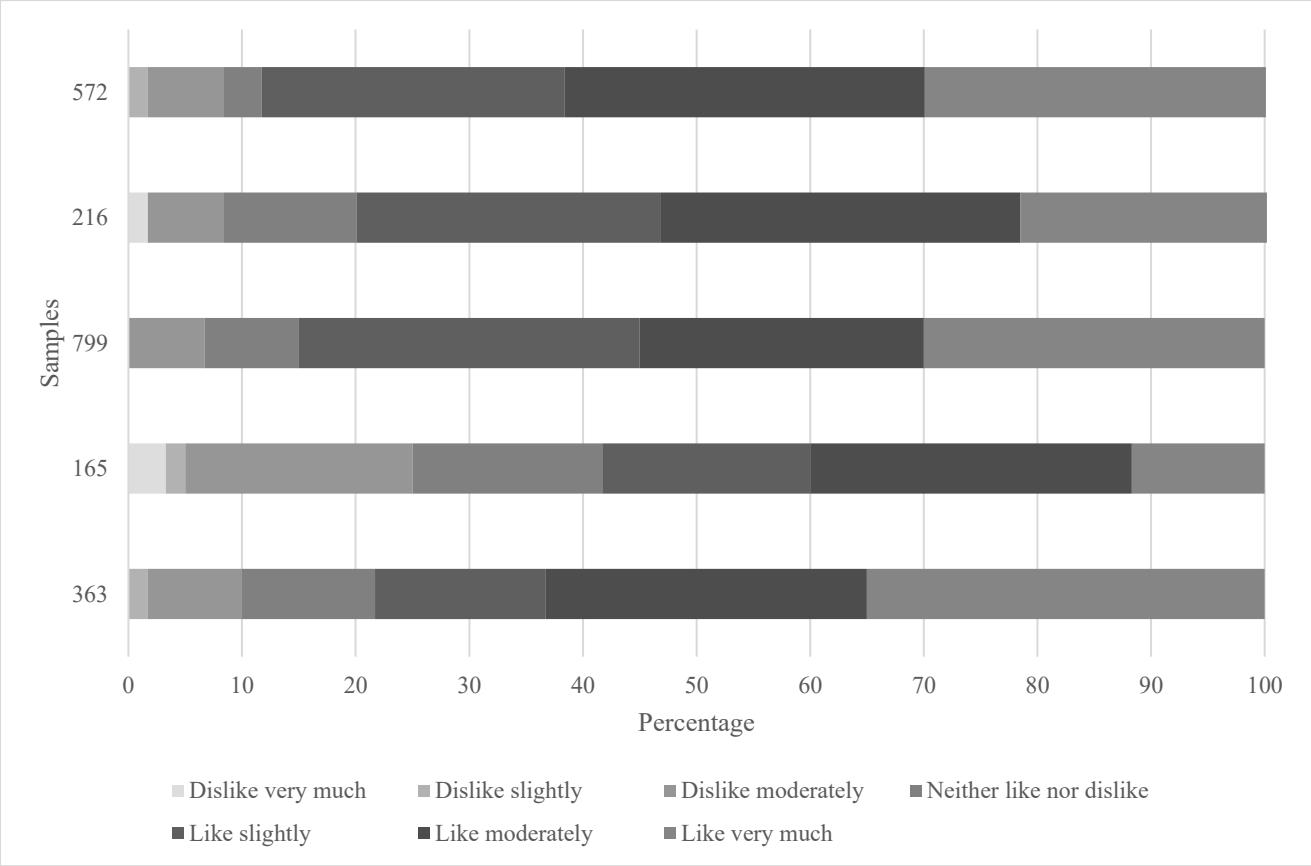

Figure 7. Aroma evaluation of the vegetable puree hamburger buns.

The plain bun was coded as sample 363. The aroma was liked by 78.3% of the participants, 11.7% neither liked nor disliked the aroma, and 10% disliked the aroma. For the kale and spinach bun, 58.3% of the participants liked the aroma, 16.7% neither liked nor disliked

the aroma, and 25% disliked the aroma. For the beets bun, 80.1% liked the aroma, 11.7% neither liked nor disliked the aroma, and 8.4% disliked the aroma. For the purple sweet potato bun, 88.4% of the participants liked the aroma, 3.3% neither liked nor disliked the aroma, and 8.4% disliked the aroma. For the orange sweet potato bun, 85% of the participants liked the aroma, 8.3% neither liked nor disliked the aroma, and 6.7% disliked the aroma.

Figure 8 indicates the results of the texture evaluation of the vegetable puree hamburger bun.

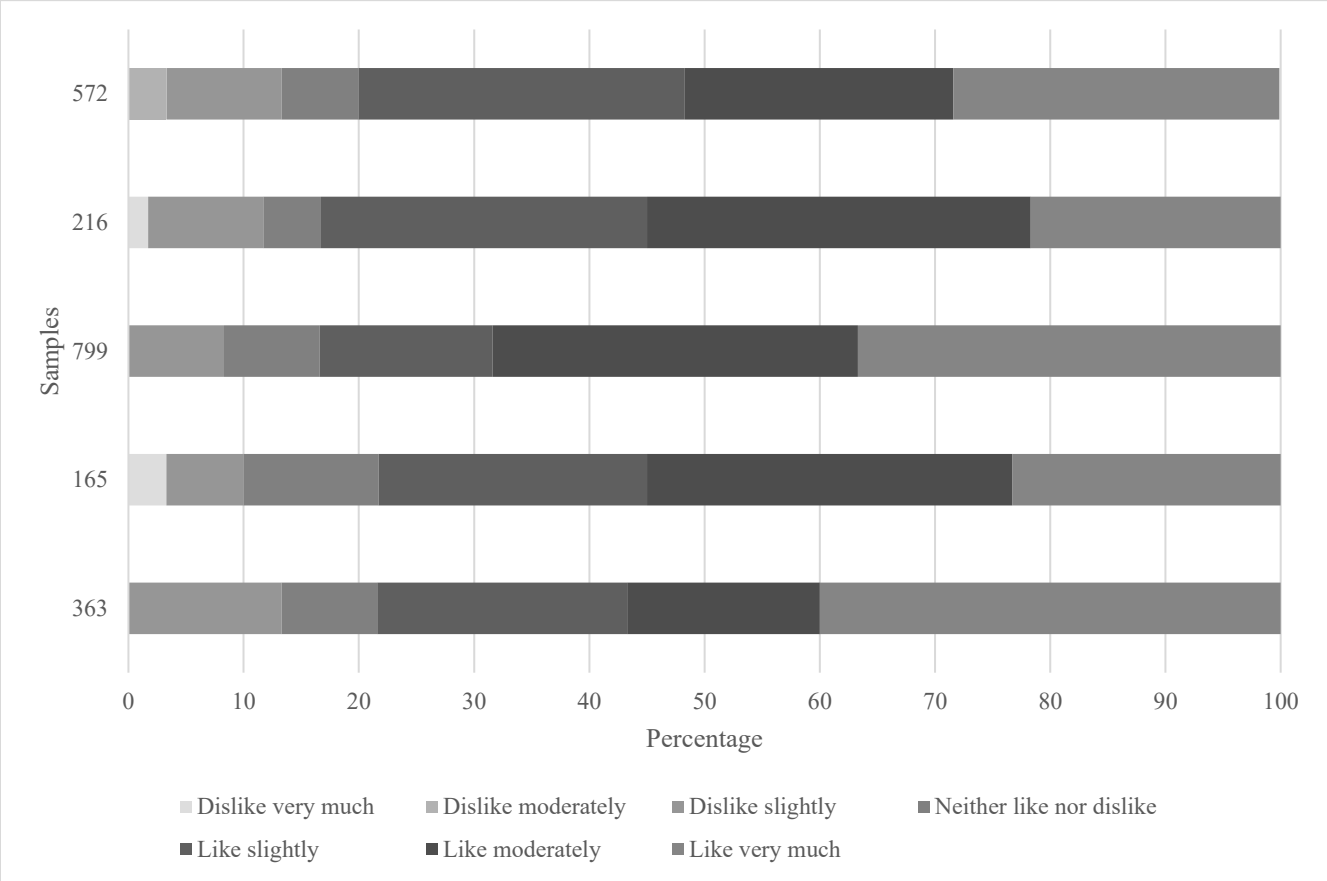

Figure 8. Texture evaluation of the vegetable puree hamburger buns.

For the plain bun, 78.4% of the participants liked the texture, 8.3% neither liked nor disliked the texture, and 13.3% dislike the texture. For the kale and spinach bun, 78.3% participants liked the texture, 11.7% neither liked nor disliked the texture, and 10% disliked the

texture. For the beets bun, 83.3% of the participants liked the texture, 5% neither liked nor disliked the texture, and 11.7% disliked the texture. For the purple sweet potato bun, 79.9% of the participants liked the texture, 6.7% neither liked nor disliked the texture, and 13.3% disliked the texture. For the orange sweet potato bun, 83.4% of the participants liked the texture, 8.3% neither liked nor disliked the texture, and 8.3% disliked the texture.

Figure 9 shows the results of the flavor evaluation of the vegetable puree hamburger bun.

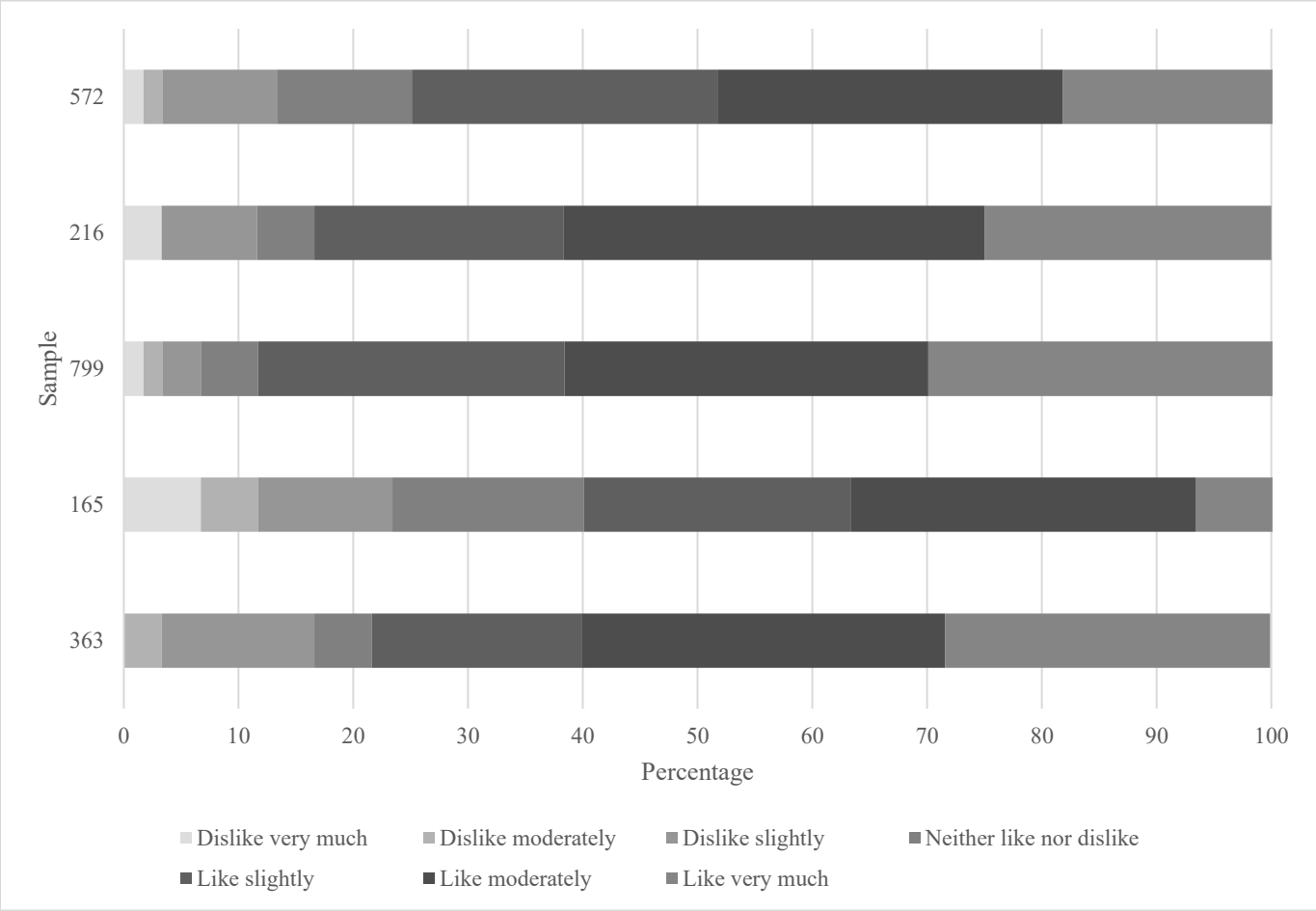

Figure 9. Flavor evaluation of the vegetable puree hamburger buns.

The flavor of the plain bun was liked by 78.3% of the participants, 5% neither liked nor disliked the flavor of the bun and 16.3% disliked the flavor of the bun. For the kale and spinach bun, 60% of the participants liked the flavor, 16.7% neither liked nor disliked the flavor, and

23.4% disliked the flavor. For the beets bun, 83.4% of the participants liked the flavor, 5% neither liked nor disliked the flavor, and 11.6% disliked the flavor. For the purple sweet potato bun, 75% of the participants liked the flavor, 11.7% neither liked nor disliked the flavor, and 3.4% disliked the flavor. For the orange sweet potato bun, 88.4% of the participants liked the flavor, 5% neither liked nor disliked the flavor, and 6.7% disliked the flavor.

Figure 10 indicates the results of the aftertaste test of the vegetable puree hamburger bun.

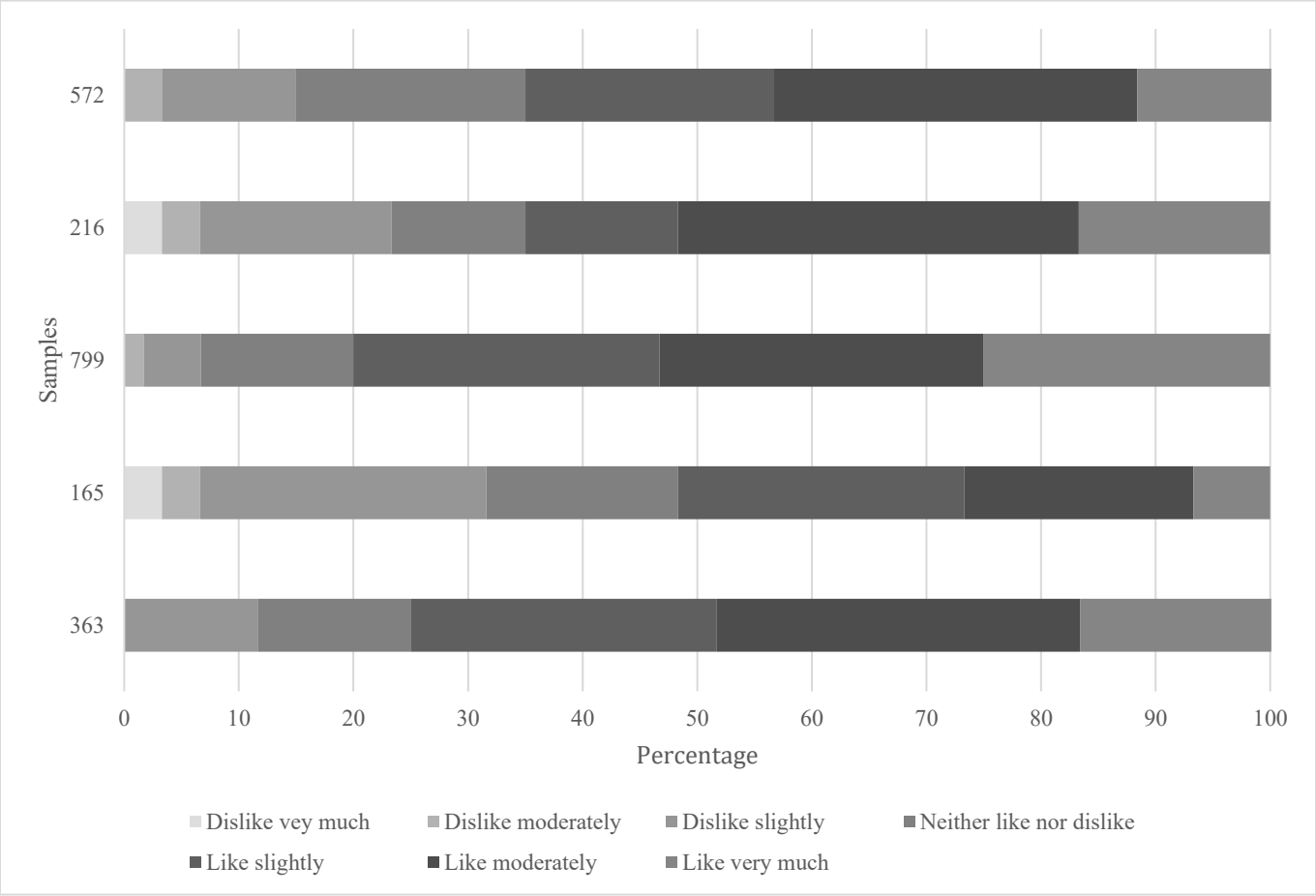

Figure 10. Aftertaste evaluation of the vegetable puree hamburger buns.

The aftertaste of the plain bun was liked by 75.1% of the participants, 13.3% neither liked nor disliked the aftertaste, and 11.7% disliked the aftertaste. For the kale and spinach bun, 51.7% of the participants liked the aftertaste, 16.7% neither liked nor disliked the aftertaste, and 31.6%

disliked the aftertaste. For the beets bun, 65% liked the aftertaste, 11.7 neither liked nor disliked the after taste, and 23.3% disliked the aftertaste. For the purple sweet potato bun 65.1% of the participants liked the aftertaste, 20% neither liked nor disliked the aftertaste, and 15% disliked the aftertaste. For the orange sweet potato bun, 80% of the participants liked the aftertaste, 13.3% neither liked nor disliked the aftertaste, and 6.7% disliked the aftertaste.

Figure 11 shows the results of the overall acceptability of the vegetable puree hamburger bun.

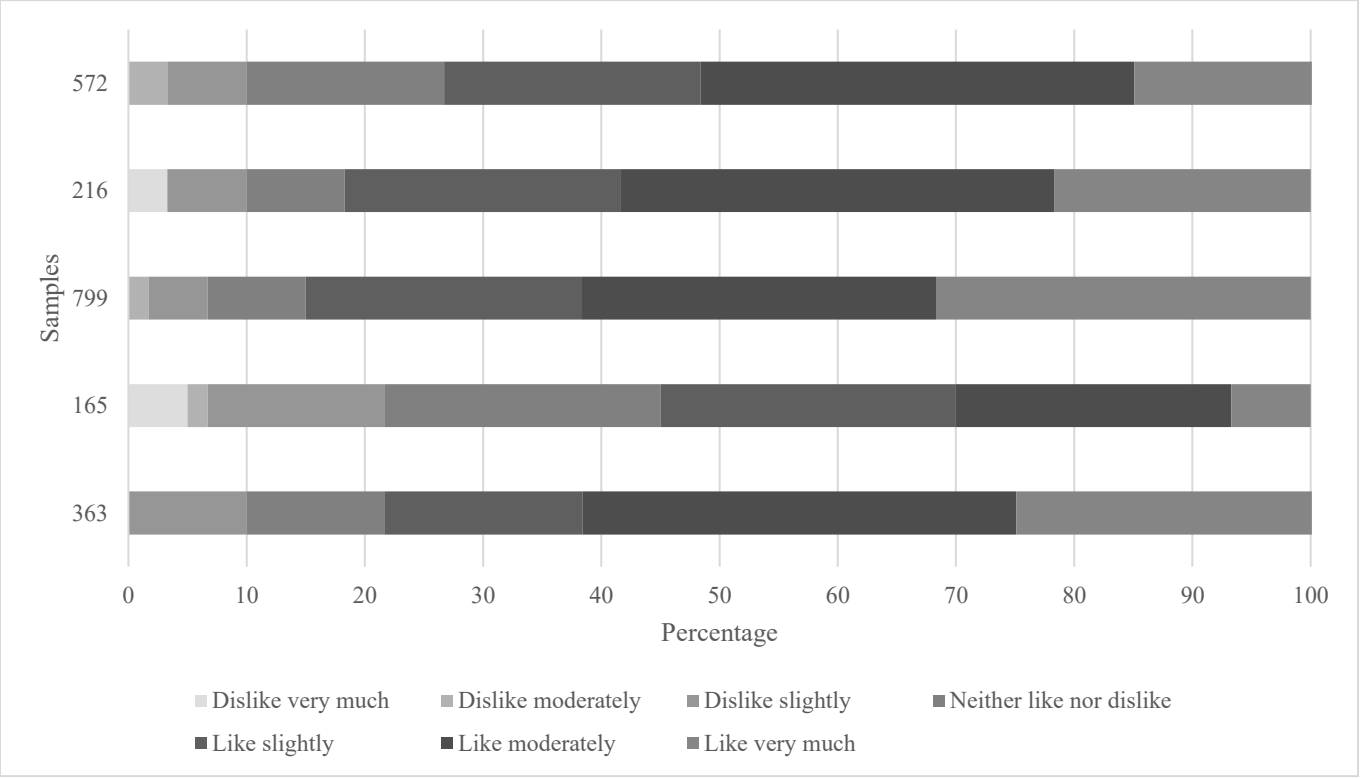

Figure 11. Overall acceptability of the vegetable puree hamburger buns.

For the acceptability of the plain bun, 78.4% of the participants liked it, 11.7% neither liked nor disliked it, and 10% disliked the bun. For the kale and spinach bun, 55% of the participants liked it, 23.3% neither liked nor disliked it, and 21.7% disliked the bun. For the beets bun, 81.7% of the participants liked it, 8.3% neither liked nor disliked it, and 10% disliked the

bun. For the purple sweet potato bun, 73.4% of the participants liked it, 16.7% neither liked nor disliked it, and 10% disliked the bun. For the orange sweet potato bun, 85% of the participants liked it, 8.3% neither liked nor disliked it, and 6.7% disliked the bun.

Water Activity Data

Figure 12 indicates the results of the water activity of vegetable juice extract and puree hamburger buns.

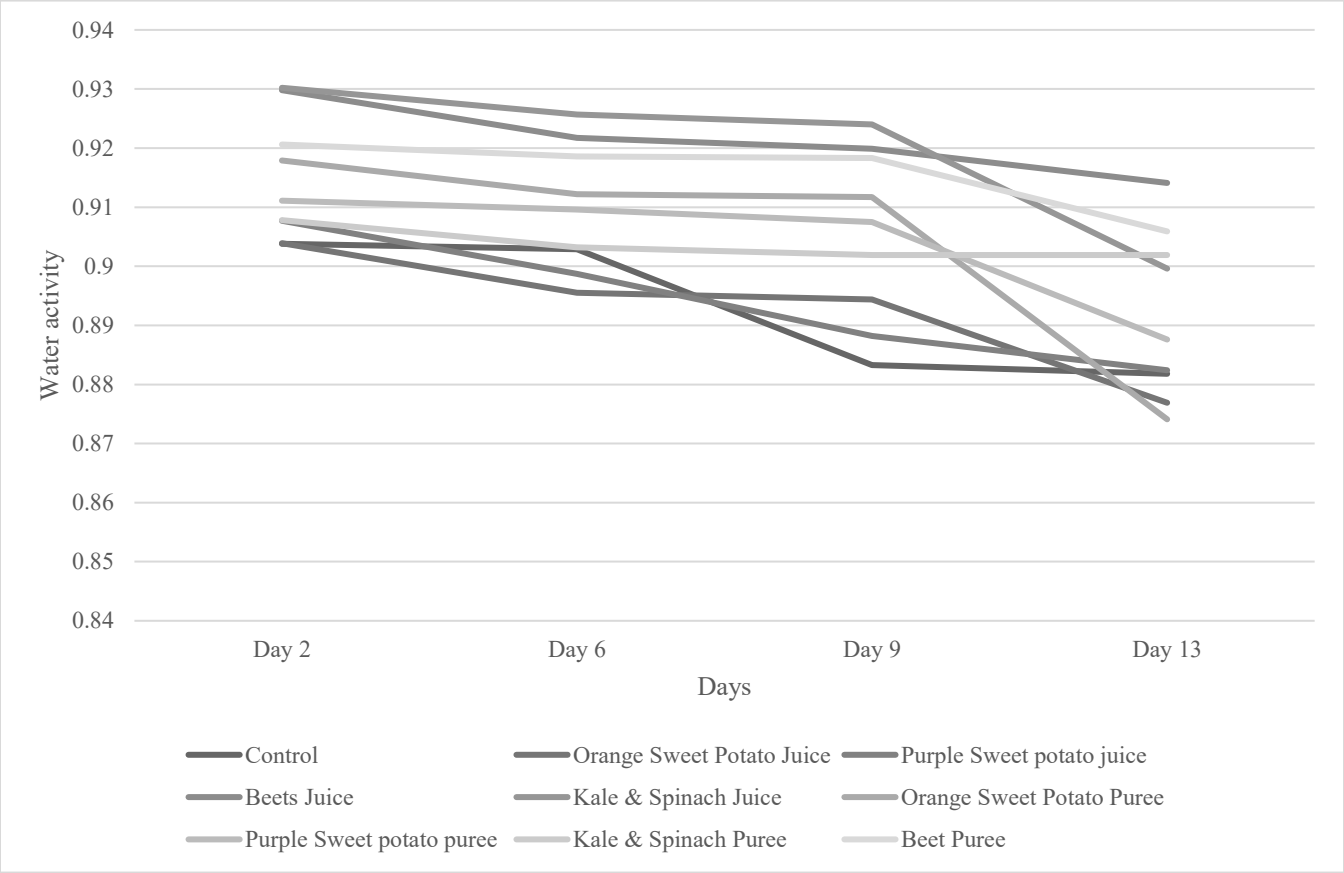

Figure 12. Water activity of vegetable juice extract and puree hamburger buns.

Water activity is the ratio of water vapor pressure of the food to the water vapor pressure of pure water under the same conditions. The plain bun had a water activity of 0.9038 on day 2, which reduced to 0.8818 on day 13. The kale and spinach juice bun had a water activity of 0.9302 on day 2 and 0.8996 on day 13. The beet juice had a water activity of 0.9298 on day 2

and 0.9141 on day 13. The purple sweet potato juice had a water activity of 0.9077 on day 2 and 0.8824 on day 13. The water activity for orange sweet potato juice was 0.9039 on day 2 and 0.8769 on day 13.

For the vegetable puree buns, the water activity of kale and spinach puree bun was 0.9078 on day 2 and 0.9019 on day 13. The water activity of the beet puree bun was 0.9206 on day 2 and 0.9059 on day 13. The water activity of the purple sweet potato puree bun was 0.9111 on day 2 and 0.8876 on day 13. The water activity of the orange sweet potato puree bun was 0.9179 on day 2 and 0.8741 on day 13.

Texture Analysis Data

Figure 13 shows the results of the hardness of vegetable juice extract and puree hamburger buns.

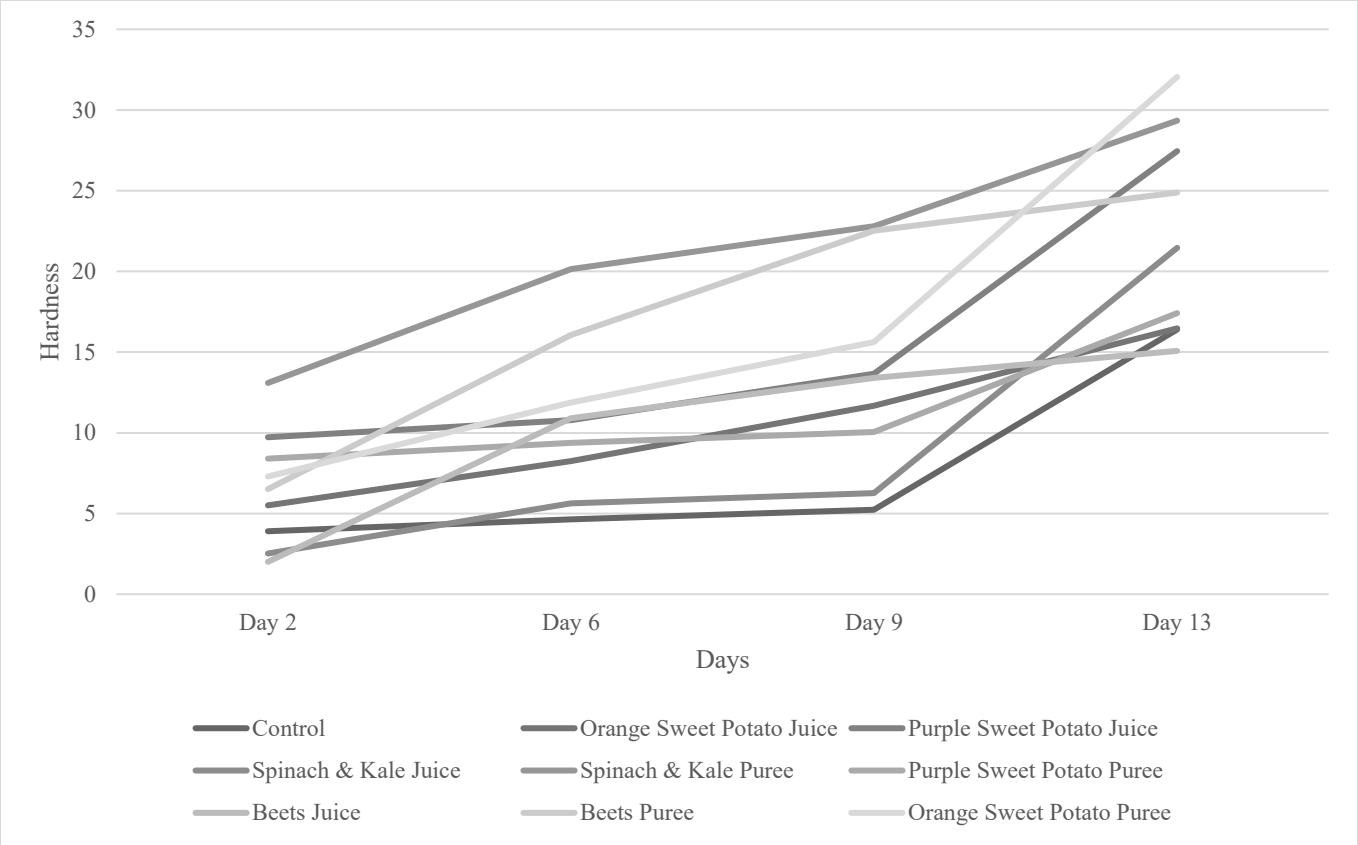

Figure 13. Hardness of vegetable juice extract and puree hamburger buns.

The Instron Texture Analyzer was used to gather a TPA (Texture profile analysis) on the hamburger buns for shelf life studies. Hardness, chewiness, springiness, and resilience were the four main attributes that were considered for overall quality over time. For the plain bun, the hardness was at 3.09023 on day 2 and 16.402 on day 13. The kale and spinach juice bun had a hardness value of 2.5252 on day 2 and 21.4600 on day 13. The beet juice bun had a hardness value of 6.5122 on day 2 and 24.889 on day 13. The purple sweet potato juice bun had a harness value of 9.7261 on day 2 and 27.455 on day 13. The value for hardness for orange sweet potato juice bun was 5.5072 on day 2 and 16.471 on day 13.

For the vegetable puree buns, the spinach and kale puree bun had a hardness value of 13.091 on day 2 and 29.342 on day 13. The beet juice puree bun had a hardness value of 2.0073

on day 2 and 15.078 on day 13. The purple sweet potato puree bun had a hardness value of 8.4025 on day 2 and 17.417 on day 13. The orange sweet potato puree bun had a hardness value of 7.2927 on day 2 and 32.046 on day 13.

Figure 14 indicates the chewiness of vegetable juice extract and puree hamburger buns.

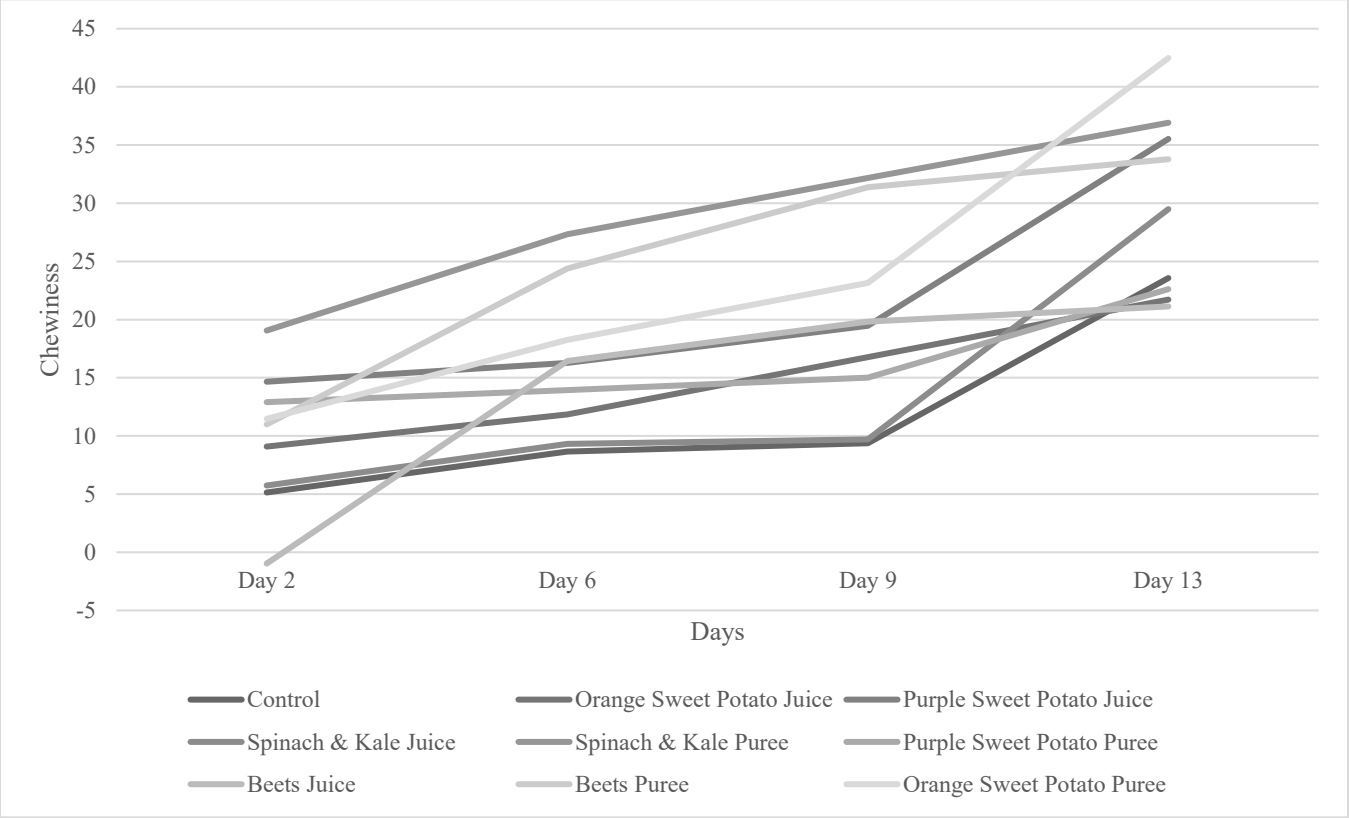

Figure 14. Chewiness of vegetable juice extract and puree hamburger buns.

The chewiness value of the plain bun was 5.1375 on day 2 and 23.569 on day 13. The chewiness value of the kale and spinach juice bun was 5.7393 on day 2 and 29.492 on day 13. The chewiness value of the beet juice bun had a -0.9719 on day 2 and 21.129 on day 13. The chewiness value of the purple sweet potato juice bun was 14.66 on day 2 and 35.525 on day 13. The chewiness value of the orange sweet potato juice bun was 9.0859 on day 2 and 21.716 on day 13.

For the vegetable puree buns, the chewiness value of the kale and spinach puree bun was 19.057 on day 2 and 36.915 on day 13. The chewiness value of the beet puree bun was 10.991 on day 2 and 33.781 on day 13. The chewiness value of the purple sweet potato puree bun was 12.903 on day 2 and 22.617 on day 13. The chewiness value of the orange sweet potato puree was 11.465 on day 2 and 42.476 on day 13.

Figure 15 shows the springiness of the vegetable juice extract and puree hamburger bun.

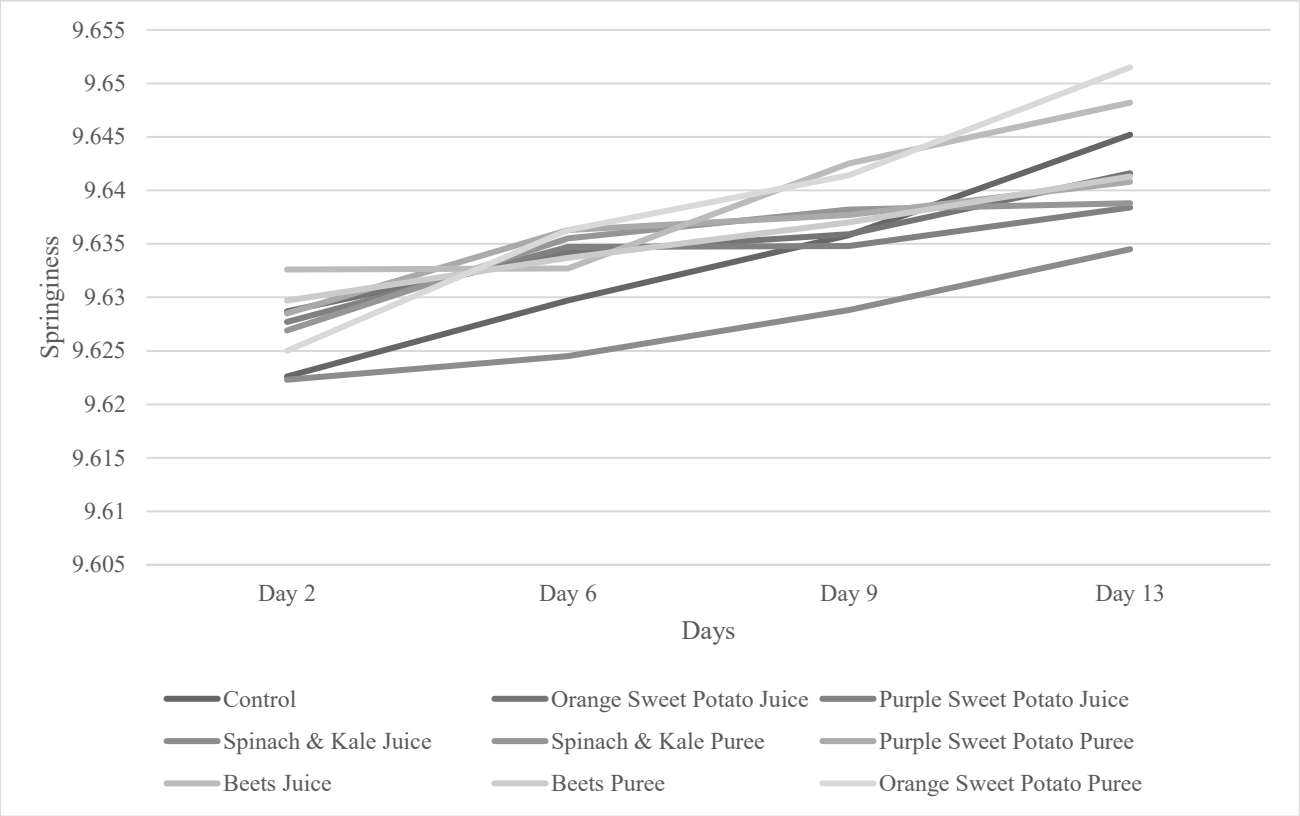

Figure 15. Springiness of vegetable juice extract and puree hamburger buns.

The springiness value of the plain bun was 9.6226 on day 2 and 9.6452 on day 13. The springiness value of the kale and spinach juice bun was 9.6223 on day 2 and 9.6345 on day 13. The springiness of the beet juice bun was 9.6326 on day 2 and 9.6482 on day 13.The springiness value of the purple sweet potato juice was 9.6277 on day 2 and 9.6384 on day 13. The springiness value of the orange sweet potato juice was 9.6287 on day 2 and 9.6416 on day 13.

For the vegetable puree buns, the springiness value of the kale and spinach puree bun had a springiness value of 9.6269 on day 2 and 9.6388 on day 13. The springiness of the beet puree bun was 9.6297 on day 2 and 9.6413 on day 13. The springiness of the purple sweet potato puree bun was 9.6285 on day 2 and 9.6408 on day 13. The springiness of the orange sweet potato puree bun was 9.6250 on day 2 and 9.6515 on day 13.

Figure 16 indicates the resilience of the vegetable juice extract and puree hamburger bun.

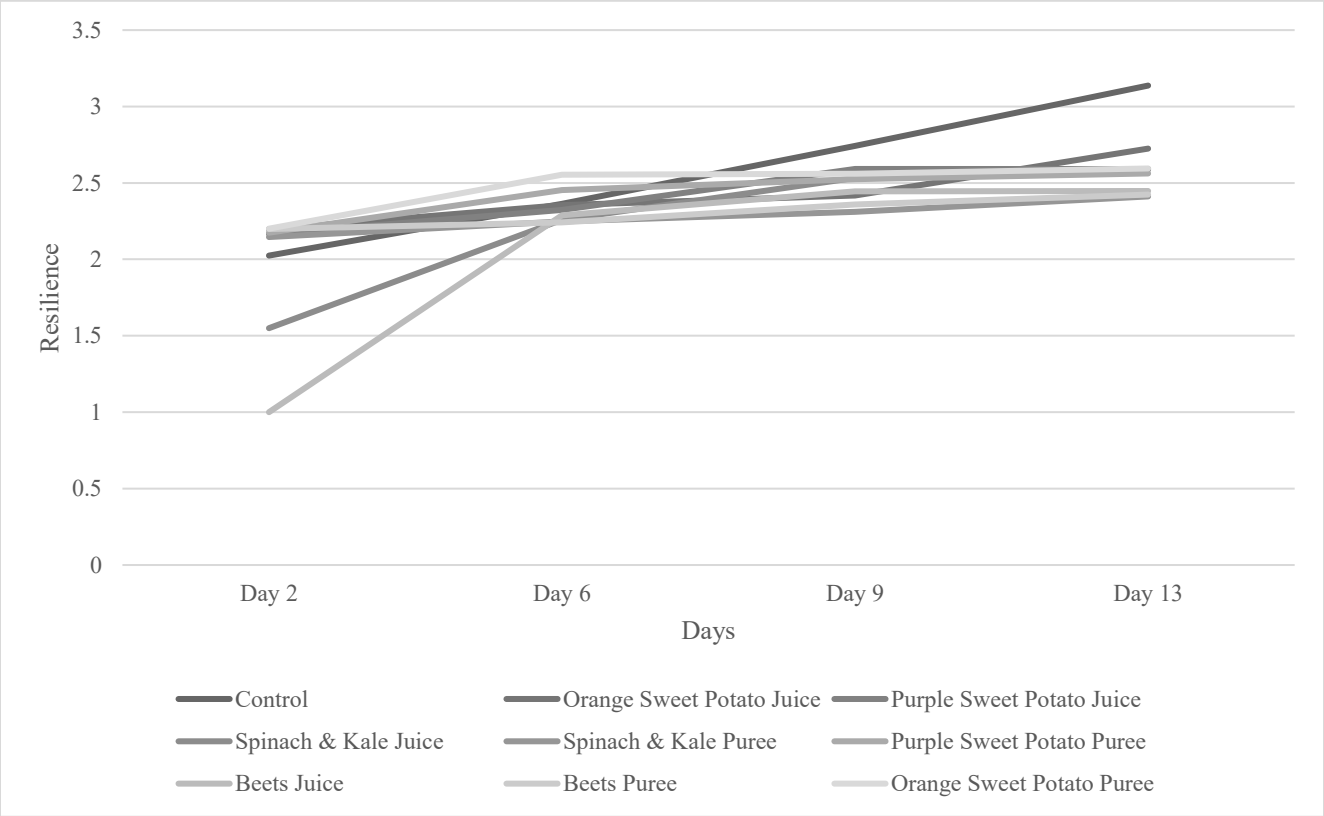

Figure 16. Resilience of vegetable juice extract and puree hamburger buns.

The resilience value of the plain bun was 2.0246 on day 2 and 3.1371 on day 13. The resilience value of the kale and spinach juice bun was 1.5496 on day 2 and 2.5874 on day 13. The resilience value of beet juice bun was 1 on day 2 and 2.4472 on day 13. The resilience value of the purple sweet potato juice bun was 2.1665 on day 2 and 2.591 on day 13. The resilience value of the orange sweet potato juice bun was 2.1965 on day 2 and 2.7246 on day 13.

For the vegetable puree buns, the resilience value of the kale and spinach puree bun was 2.1459 on day 2 and 2.4118 on day 13. The resilience value of the beet puree bun was 2.1984 on day 2 and 2.4237 on day 13. The resilience value of the purple sweet potato puree bun was 2.1745 on day 2 and 2.5619 on day 13. Orange sweet potato puree bun had a resilience value of 2.2007 on day 2 and 2.5945 on day 13.

L*a*b* Values

Figure 17 shows the results of the L*a*b* values of vegetable juice extract and puree hamburger buns on day 2.

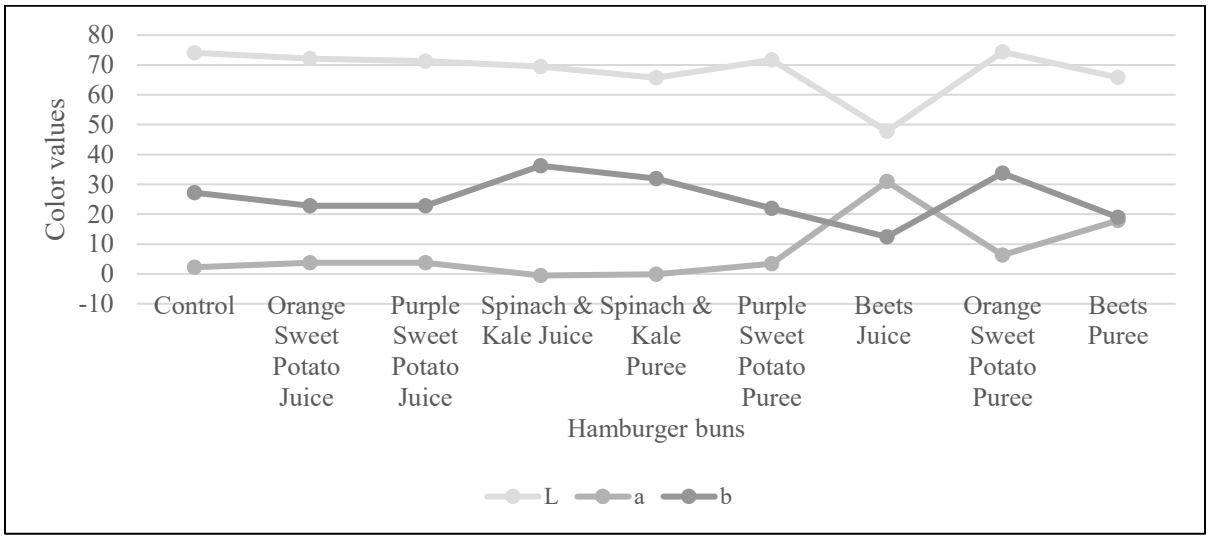

Figure 17. Day 2 lab values of vegetable juice extract and puree hamburger buns.

Figure 18 indicates the results of the L*a*b* values of vegetable juice extract and puree hamburger buns on day 13.

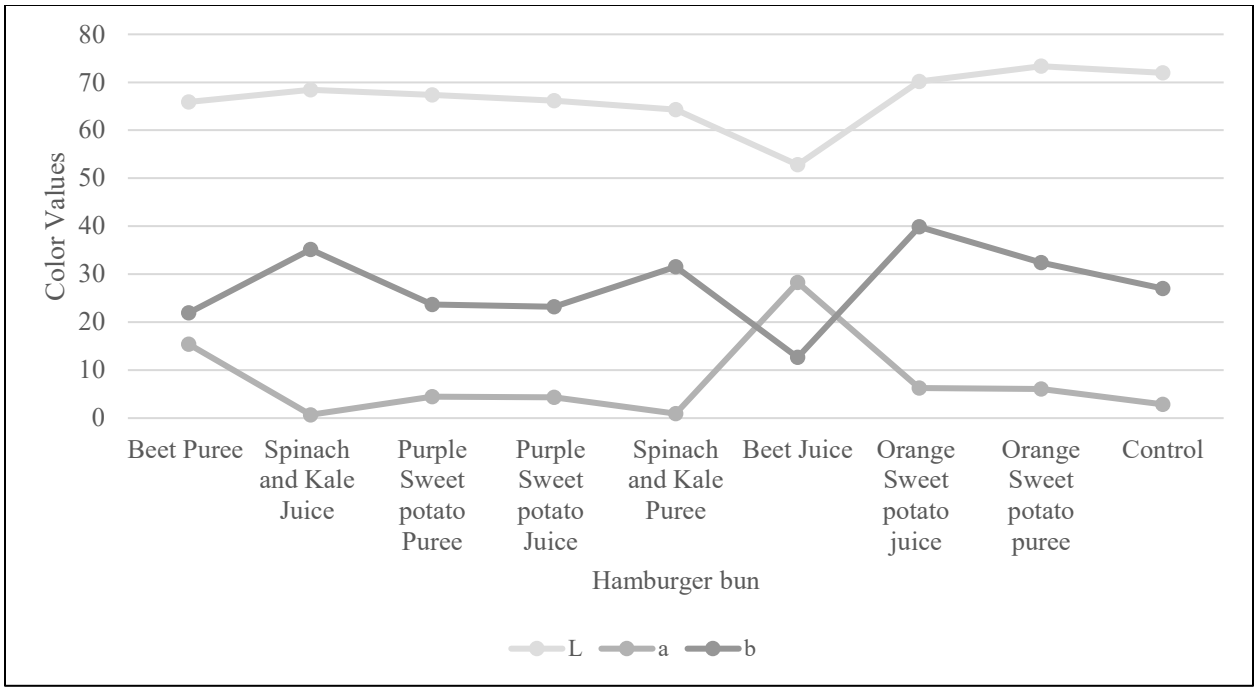

Figure 18. Day 13 lab values of vegetable juice extract and puree hamburger buns.

Nutritional Facts

Figure 19 shows the nutritional facts for the control/plain hamburger bun.

Nutrients	Per Serving	Per 100g	Nutrients	Per Serving	Per 100g
Basic Components			Total Sugars (g)	2.17	7.76
Calories (kcal)	77.02	275.06	Protein (g)	2.70	9.65
Calories from Fat (kcal)	12.62	45.08	Vitamins		
Fat (g)	1.48	5.29	Vitamin A - IU (IU)	54.39	194.26
Saturated Fat (g)	0.78	2.78	Vitamin C (mg)	6.98	24.92
Trans Fatty Acid (g)	0.00	0.01	Minerals		
Cholesterol (mg)	15.51	55.41	Sodium (mg)	121.18	432.80
Carbohydrates (g)	12.77	45.62	Calcium (mg)	25.42	90.80
Total Dietary Fiber (g)	0.45	1.62	Iron (mg)	0.58	2.09

Figure 19. Nutritional facts of control/plain bun.

Figure 20 indicates the nutritional facts for the kale and spinach juice hamburger bun.

Nutrients	Per Serving	Per 100g	Nutrients	Per Serving	Per 100g
Basic Components			Total Sugars (g)	2.19	7.83
Calories (kcal)	74.70	266.80	Protein (g)	2.66	9.50
Calories from Fat (kcal)	12.30	43.92	Vitamins		
Fat (g)	1.44	5.15	Vitamin A - IU (IU)	55.76	199.15
Saturated Fat (g)	0.75	2.69	Vitamin C (mg)	8.79	31.40
Trans Fatty Acid (g)	0.00	0.01	Minerals		
Cholesterol (mg)	15.85	56.62	Sodium (mg)	64.00	228.57
Carbohydrates (g)	12.35	44.10	Calcium (mg)	25.23	90.12
Total Dietary Fiber (g)	0.45	1.61	Iron (mg)	0.57	2.03

Figure 20. Nutritional facts of the kale and spinach juice bun.

Figure 21 shows the nutritional information for the beet juice extract hamburger buns.

Nutrients	Per Serving	Per 100g	Nutrients	Per Serving	Per 100g
Basic Components			Total Sugars (g)	2.29	8.17
Calories (kcal)	75.05	268.03	Protein (g)	2.64	9.41
Calories from Fat (kcal)	12.34	44.07	Vitamins		
Fat (g)	1.45	5.16	Vitamin A - IU (IU)	53.50	191.07
Saturated Fat (g)	0.76	2.71	Vitamin C (mg)	6.67	23.84
Trans Fatty Acid (g)	0.00	0.01	Minerals		
Cholesterol (mg)	15.87	56.67	Sodium (mg)	63.25	225.90
Carbohydrates (g)	12.44	44.41	Calcium (mg)	22.06	78.79
Total Dietary Fiber (g)	0.43	1.55	Iron (mg)	0.56	2.01

Figure 21. Nutritional facts of beet juice extract bun.

Figure 22 indicates the nutritional facts for the purple sweet potato Juice bun.

Nutrients	Per Serving	Per 100g	Nutrients	Per Serving	Per 100g
Basic Components			Total Sugars (g)	2.17	7.74
Calories (kcal)	77.40	276.43	Protein (g)	2.69	9.62
Calories from Fat (kcal)	12.46	44.51	Vitamins		
Fat (g)	1.46	5.22	Vitamin A - IU (IU)	53.70	191.79
Saturated Fat (g)	0.77	2.75	Vitamin C (mg)	6.90	24.64
Trans Fatty Acid (g)	0.00	0.01	Minerals		
Cholesterol (mg)	15.32	54.72	Sodium (mg)	119.50	426.79
Carbohydrates (g)	12.93	46.19	Calcium (mg)	25.08	89.57
Total Dietary Fiber (g)	0.45	1.60	Iron (mg)	0.58	2.07

Figure 22. Nutritional facts of purple sweet potato Juice bun.

Figure 23 shows the nutritional facts for the orange sweet potato juice bun.

Nutrients	Per Serving	Per 100g	Nutrients	Per Serving	Per 100g
Basic Components			Total Sugars (g)	2.11	7.55
Calories (kcal)	75.68	270.30	Protein (g)	2.63	9.38
Calories from Fat (kcal)	12.11	43.24	Vitamins		
Fat (g)	1.42	5.07	Vitamin A - IU (IU)	52.17	186.32
Saturated Fat (g)	0.75	2.67	Vitamin C (mg)	6.70	23.93
Trans Fatty Acid (g)	0.00	0.01	Minerals		
Cholesterol (mg)	14.89	53.16	Sodium (mg)	116.09	414.61
Carbohydrates (g)	12.68	45.30	Calcium (mg)	24.36	87.02
Total Dietary Fiber (g)	0.44	1.56	Iron (mg)	0.56	2.01

Figure 23. Nutritional facts of orange sweet potato juice bun.

Figure 24 indicates the nutritional facts of the kale and spinach puree hamburger bun.

Nutrients	Per Serving	Per 100g	Nutrients	Per Serving	Per 100g
Basic Components			Total Sugars (g)	2.22	7.93
Calories (kcal)	78.61	280.75	Protein (g)	2.80	10.01
Calories from Fat (kcal)	12.86	45.94	Vitamins		
Fat (g)	1.51	5.39	Vitamin A - IU (IU)	406.01	1450.04
Saturated Fat (g)	0.79	2.82	Vitamin C (mg)	7.76	27.71
Trans Fatty Acid (g)	0.00	0.01	Minerals		
Cholesterol (mg)	15.68	56.01	Sodium (mg)	123.80	442.16
Carbohydrates (g)	13.05	46.60	Calcium (mg)	28.60	102.14
Total Dietary Fiber (g)	0.52	1.87	Iron (mg)	0.66	2.35

Figure 24. Nutritional facts of kale and spinach puree bun.

Figure 25 shows the nutritional facts of beet puree bun.

Nutrients	Per Serving	Per 100g	Nutrients	Per Serving	Per 100g
Basic Components			Total Sugars (g)	2.43	8.67
Calories (kcal)	79.12	282.56	Protein (g)	2.78	9.93
Calories from Fat (kcal)	12.82	45.78	Vitamins		
Fat (g)	1.50	5.37	Vitamin A - IU (IU)	55.98	199.92
Saturated Fat (g)	0.79	2.81	Vitamin C (mg)	7.12	25.43
Trans Fatty Acid (g)	0.00	0.01	Minerals		
Cholesterol (mg)	15.68	55.98	Sodium (mg)	124.65	445.17
Carbohydrates (g)	13.20	47.13	Calcium (mg)	26.03	92.95
Total Dietary Fiber (g)	0.52	1.85	Iron (mg)	0.61	2.19

Figure 25. Nutritional facts of beet puree bun.

Figure 26 indicates the nutritional facts for orange sweet potato puree hamburger bun.

Nutrients	Per Serving	Per 100g	Nutrients	Per Serving	Per 100g
Basic Components			Total Sugars (g)	2.29	8.16
Calories (kcal)	76.61	273.59	Protein (g)	2.64	9.44
Calories from Fat (kcal)	12.17	43.47	Vitamins		
Fat (g)	1.43	5.10	Vitamin A - IU (IU)	598.95	2139.11
Saturated Fat (g)	0.75	2.68	Vitamin C (mg)	7.14	25.50
Trans Fatty Acid (g)	0.00	0.01	Minerals		
Cholesterol (mg)	14.90	53.21	Sodium (mg)	117.22	418.65
Carbohydrates (g)	12.88	46.00	Calcium (mg)	25.43	90.83
Total Dietary Fiber (g)	0.52	1.87	Iron (mg)	0.59	2.10

Figure 26. Nutritional facts of orange sweet potato puree bun.

Purchase Intent

Figure 27 indicates the percentage of the purchase intent of the control/plain hamburger bun in sample 445.

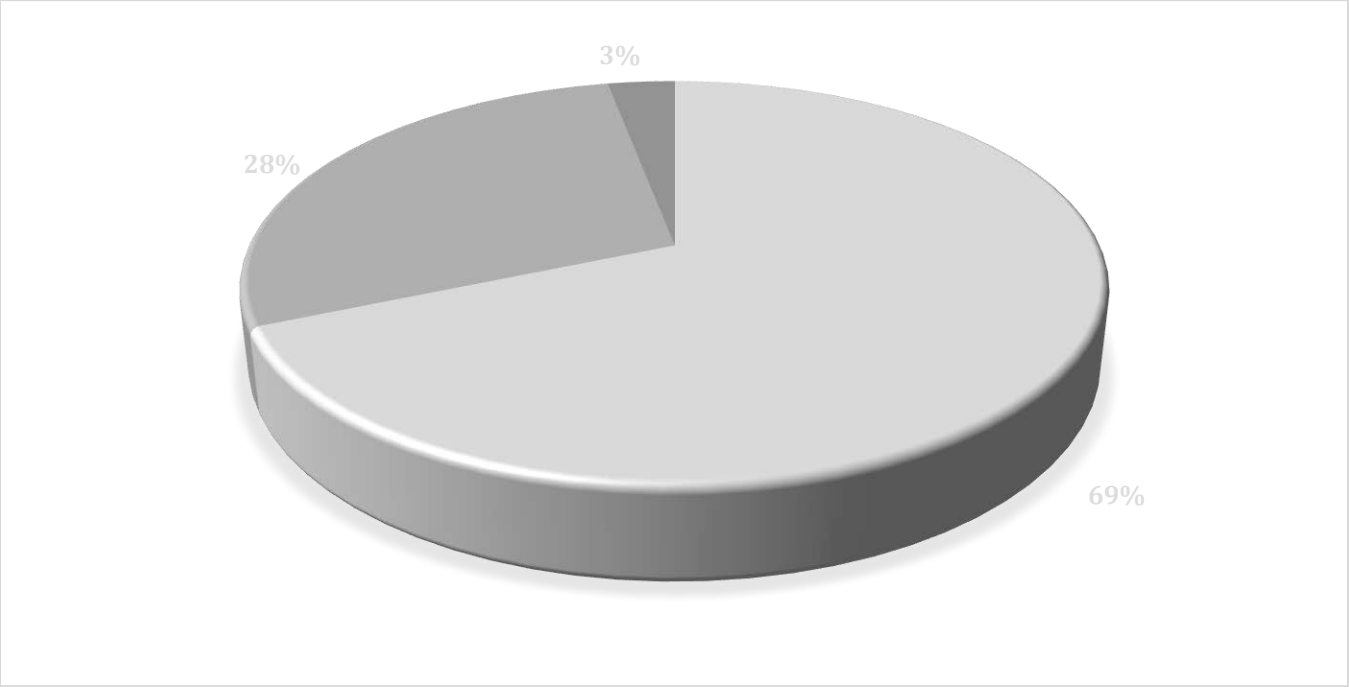

Figure 27. Purchase intent of control/plain hamburger bun.

Sample 445 is the control or plain bun. Results showed that 69% of the participants would purchase this bun, 28% would or would not purchase it, while 3% would not purchase this bun. Although this bun was quite similar to the regular bun sold at a store, the purchase intent of this bun was 19% above average.

Figure 28 shows the percentage of the purchase intent of the kale and spinach juice hamburger bun in sample 662.

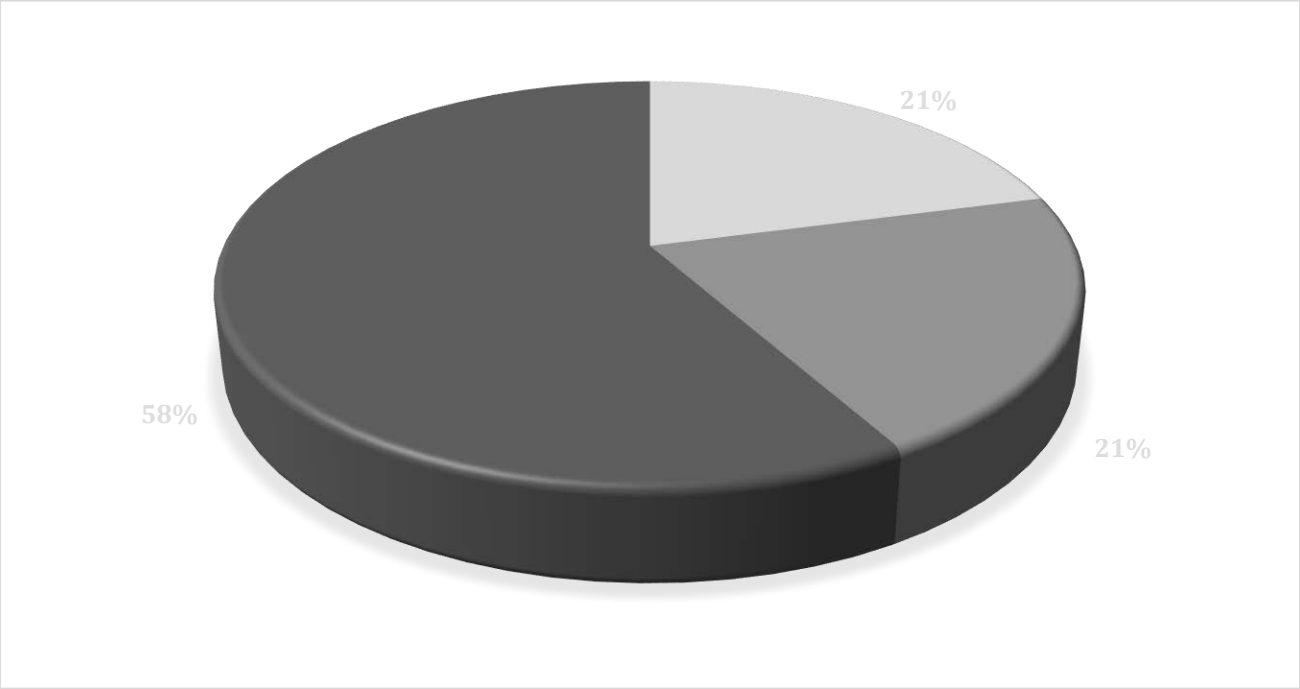

Figure 28. Purchase intent of kale and spinach juice hamburger bun.

The kale and spinach sample bun was coded as 662. It had a green hue due to the presence of the green juice, which affected the final quality of the bun. The results indicated that 21% of the participants would purchase this bun, 21% would or would not purchase it, while 58% would not purchase the bun. The green hue of the bun could have been a factor in reducing purchase intent of the participants, as this is an unusual color for a hamburger bun.

Figure 29 shows the percentage of the purchase intent for the beet juice hamburger bun in sample 595.

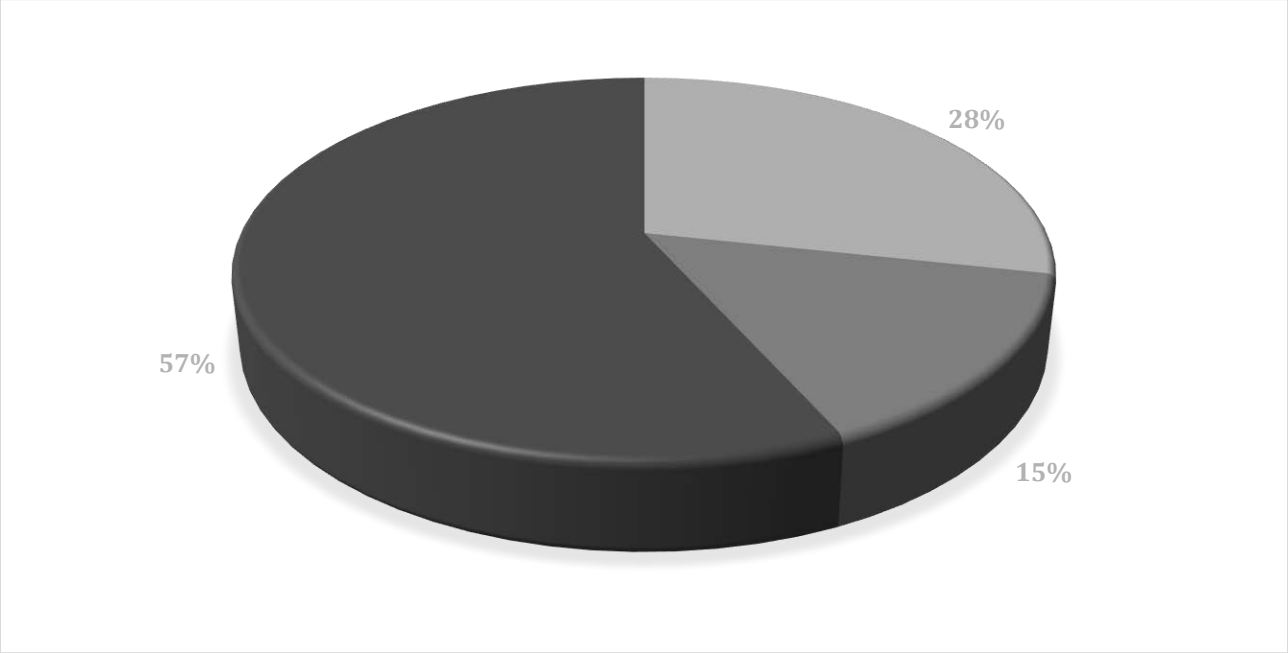

Figure 29. Purchase intent of beet juice hamburger bun.

Sample 595 was the code for the beet juice hamburger bun. The results showed that 28% of the participants would purchase this bun, 15% would or would not purchase it, while 57% would not purchase this bun. This could be due to the presence of beet and the deep pinkish hue of the bun. This is an unusual color for a bun, and beets have a strong earthy note, which could have swayed the purchase intent of the participants.

Figure 30 indicates the percentage of the purchase intent for purple sweet potato juice hamburger bun in sample 891.

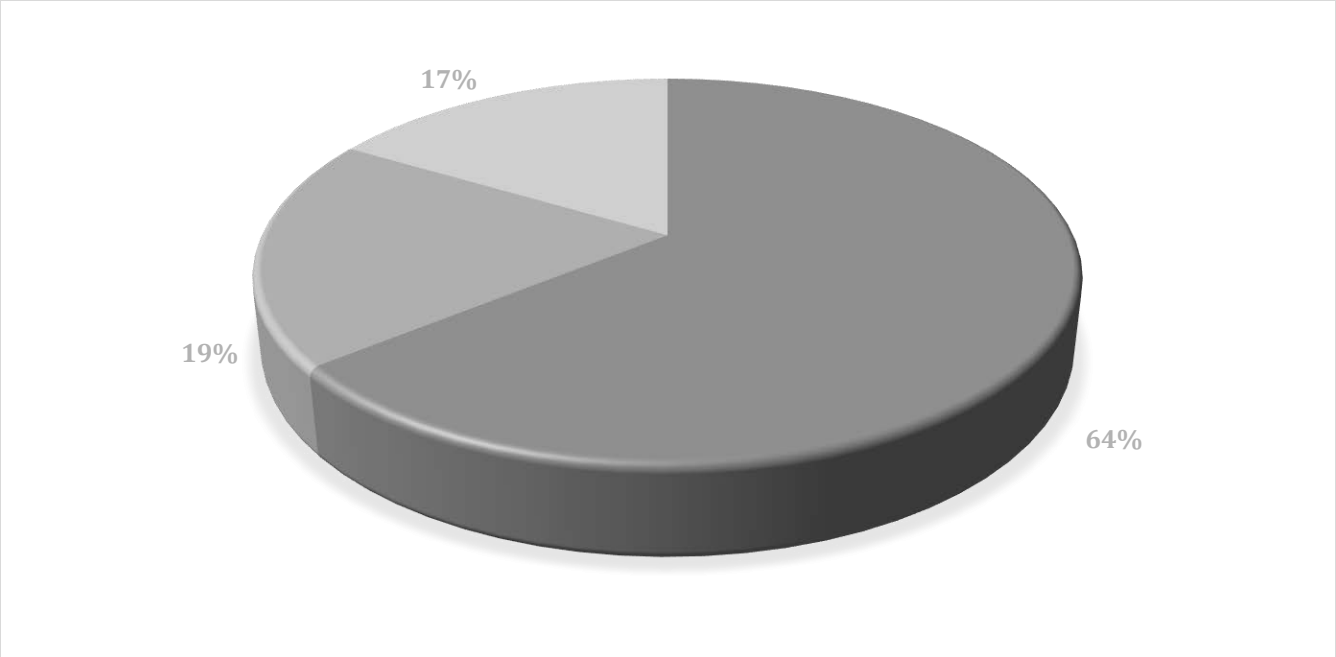

Figure 30. Purchase intent of purple sweet potato juice hamburger bun.

The purple sweet potato was coded as sample 891. The results showed that 64% of the participants would purchase this bun, 19% would or would not purchase it, and 17% would not purchase this bun. This could be due to the unfamiliarity with the taste of the purple sweet potato. This potato is quite different in taste from the regular potato and the orange sweet potato.

Figure 31 shows the percentage of the purchase intent for the orange sweet potato juice bun in sample 743.

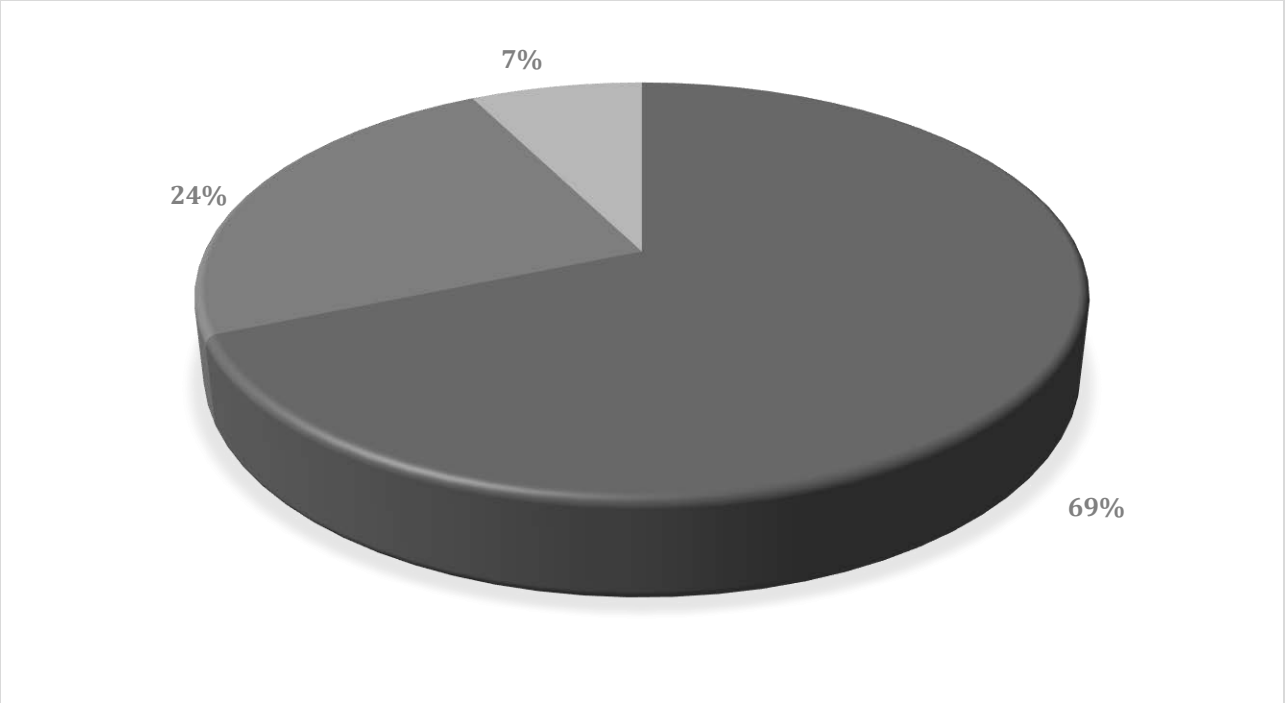

Figure 31. Purchase intent of orange sweet potato juice hamburger bun.

The orange sweet potato bun was the closest in preference to the plain bun regarding all the attributes tested. Purchase intent was the last question the participants answered after rating the various hamburger bun samples on the 7-point hedonics scale. The results indicated that 69% of the participants would purchase this bun, 24% indicated they would or would not purchase this bun, while 7% would not purchase this bun.

Figure 32 indicates the percentage of the purchase intent for the control/plain hamburger bun.

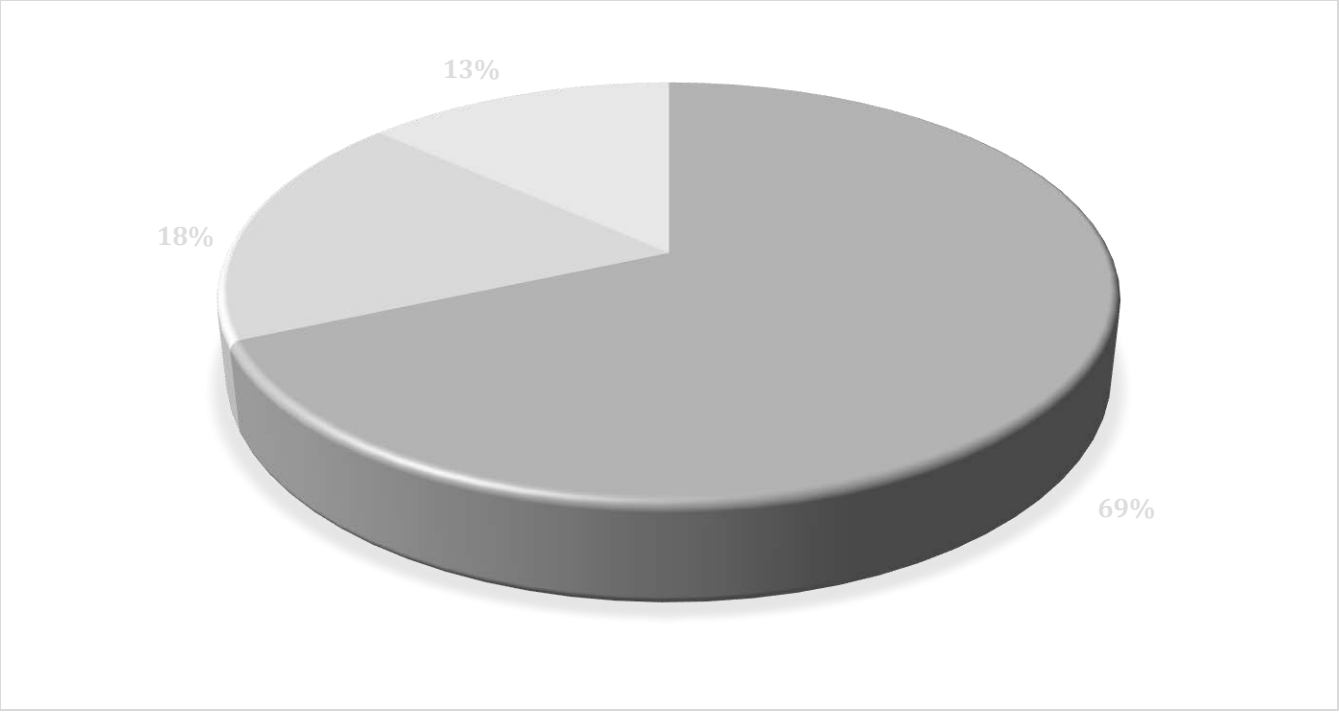

Figure 32. Purchase intent of control/plain hamburger bun.

Purchase on the data collected from the participants regarding the plain bun indicated that 68% would purchase the bun, 18% would or would not purchase it, and 13% would not purchase the bun. The plain bun was the control bun, which was like the regular buns.

Figure 33 shows the percentage of the purchase intent of the kale and spinach puree hamburger bun in sample 165.

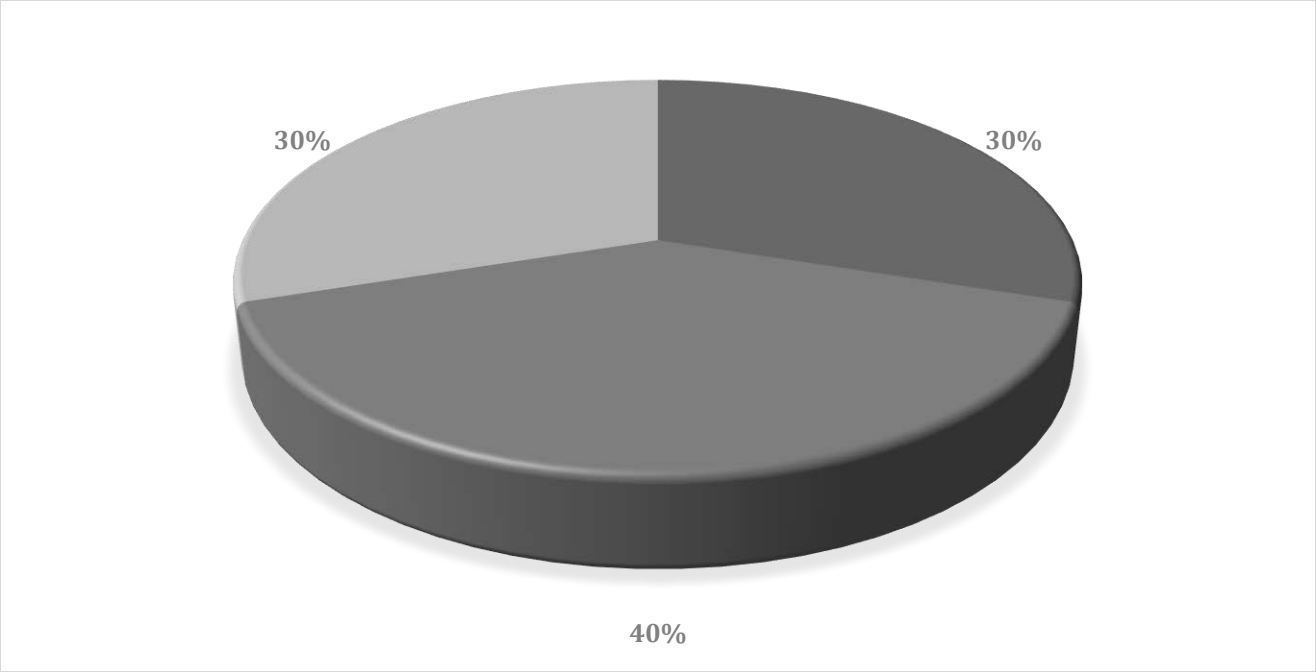

Figure 33. Purchase intent of kale and spinach puree hamburger bun.

The kale and spinach bun had a light green hue. The results indicated that 68% of the participants would purchase this bun, 18% would or would not purchase it, and 13% would not purchase this bun.

Figure 34 shows the percentage of the purchase intent for the beet puree hamburger bun for sample 216.

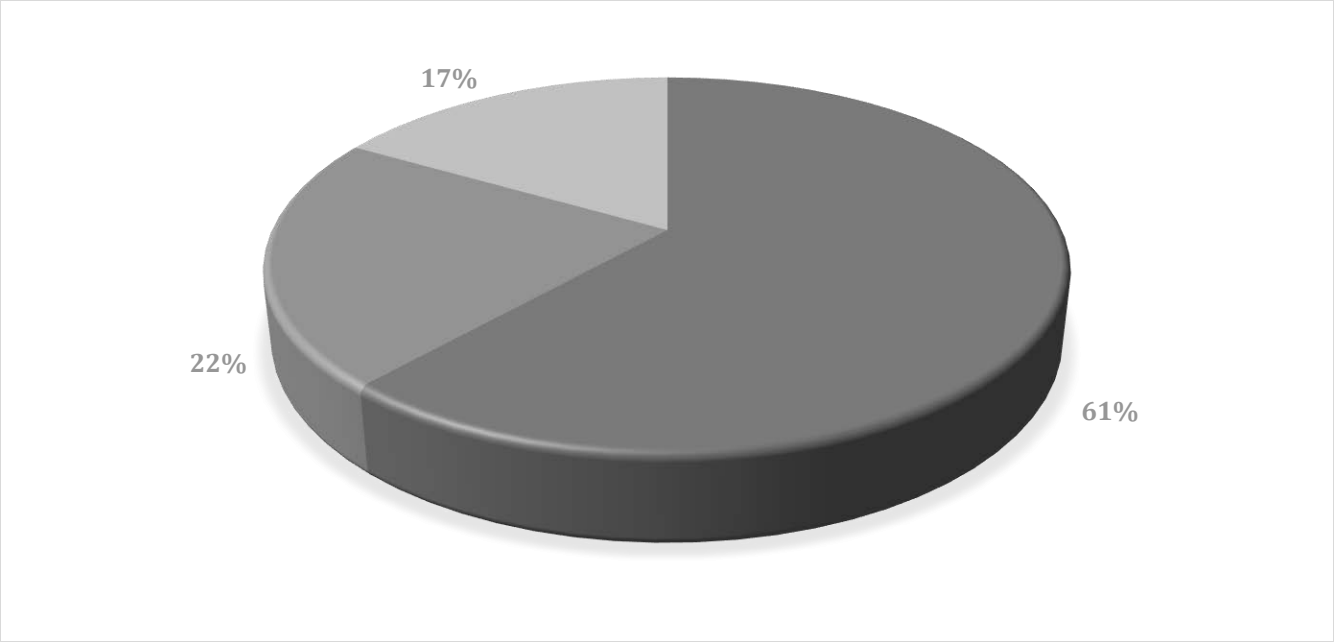

Figure 34. Purchase intent of beet puree hamburger bun.

The beet sample coded 216. The results showed that 62% of the participants would purchase the bun, 20% would or would not purchase it, and 17% would not purchase the bun.

Figure 35 indicates the percentage of the purchase intent for the purple sweet potato puree hamburger bun.

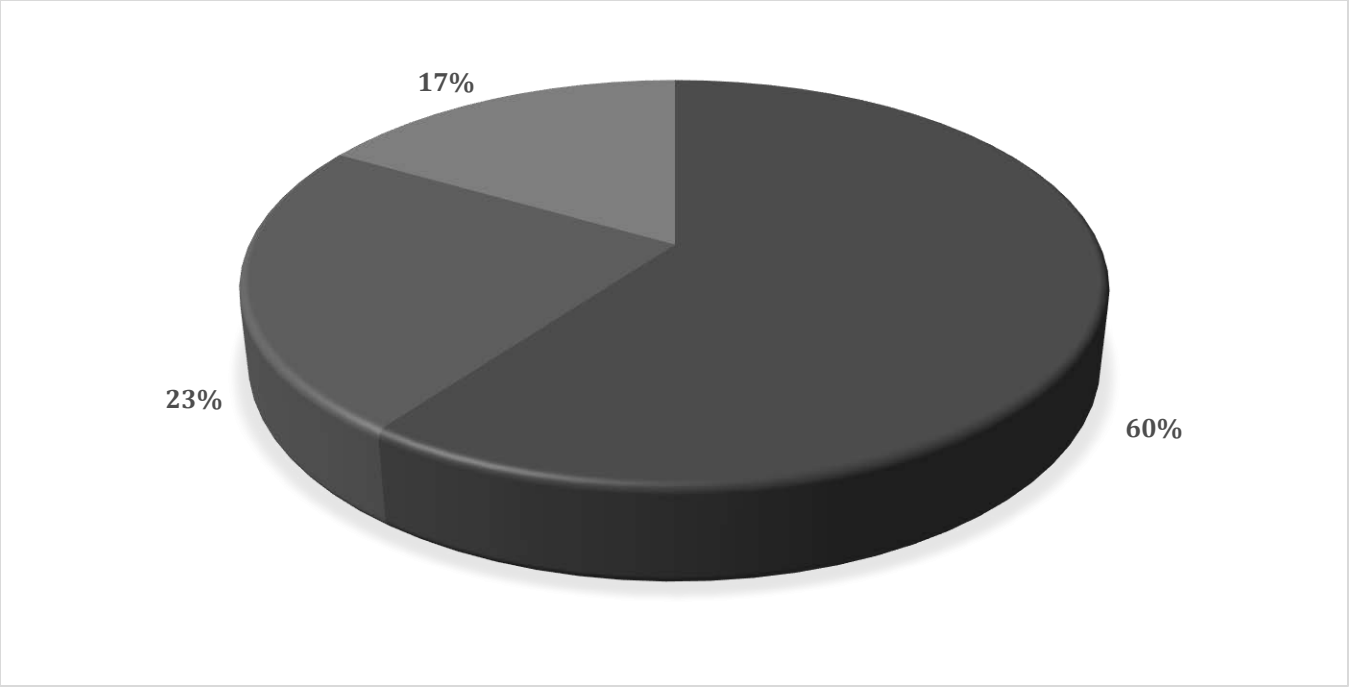

Figure 35. Purchase intent of purple sweet potato puree hamburger bun.

Purple sweet potato bun was coded as sample 572. The results indicated that 60% of the participants would purchase this bun, 23% would or would not purchase it, while 16% would not buy this bun.

Figure 36 indicates the percentage of the purchase intent of the orange sweet potato hamburger bun in sample 799.

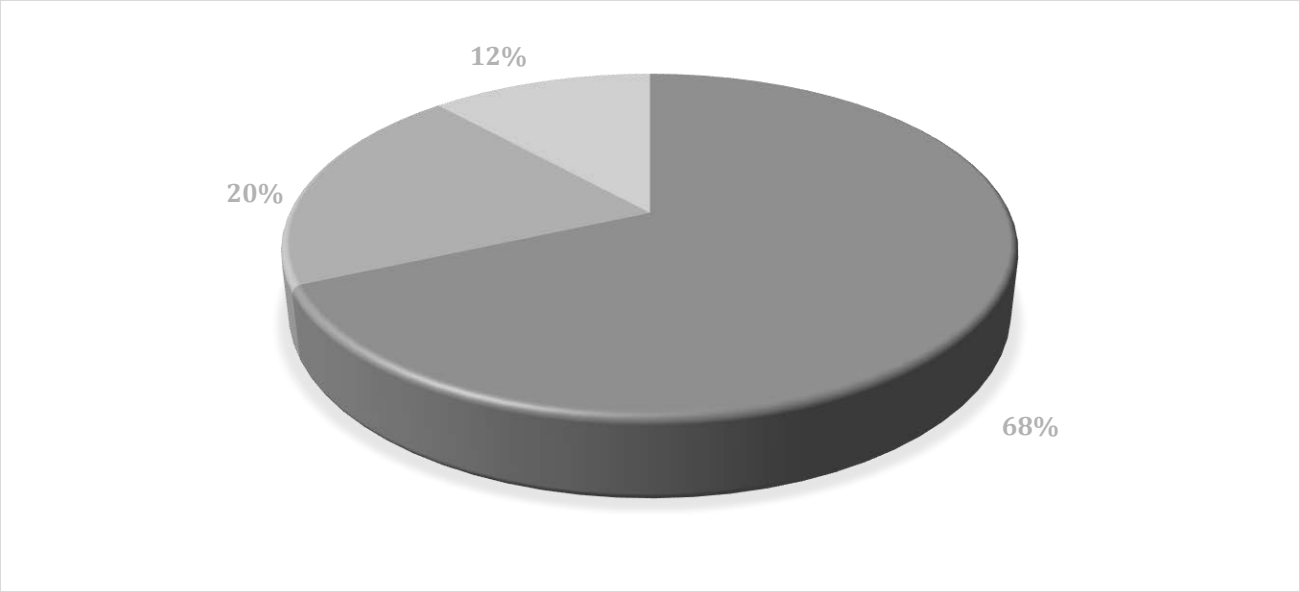

Figure 36. Purchase intent of orange sweet potato hamburger bun.

The orange sweet potato bun was coded as sample 799. The results indicated that 68% of the participants would purchase the bun, 20% would or would not purchase it, and 12% would not purchase the bun.

Moisture Level

Figure 37 indicates the moisture level of the shelf life for the hamburger buns used in this project.

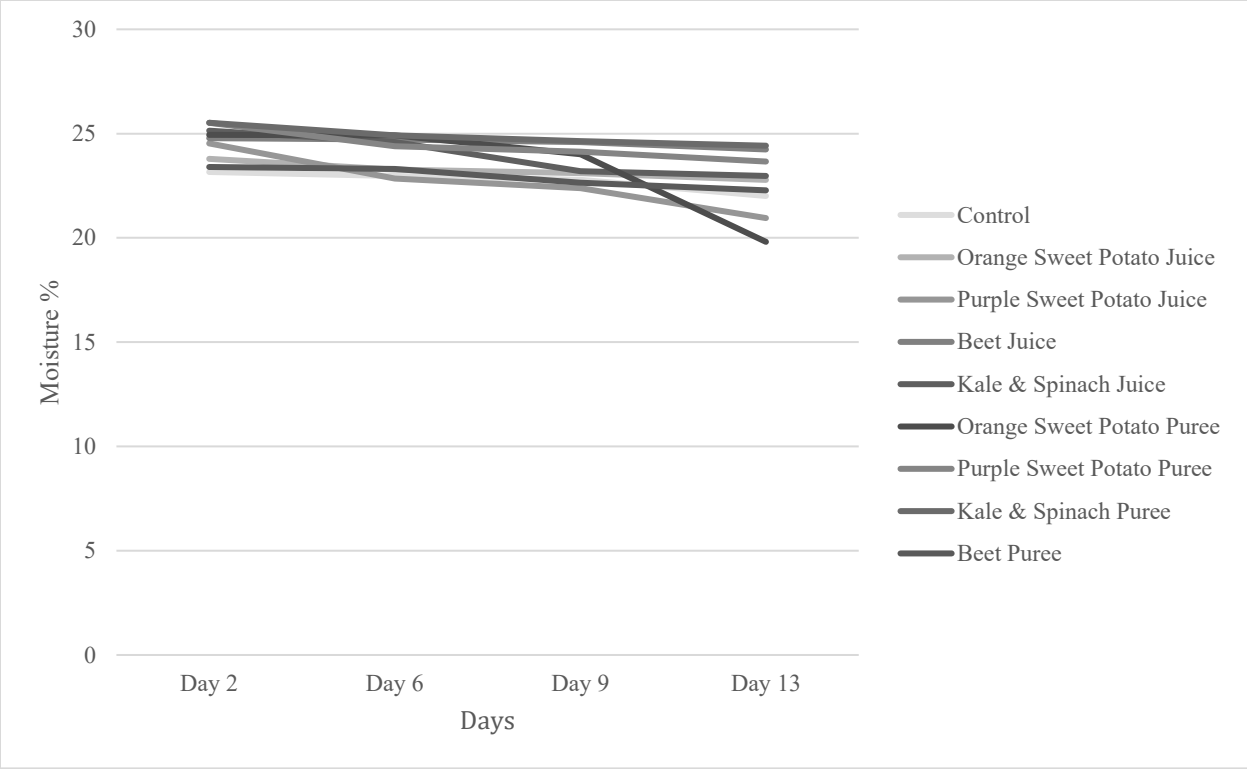

Figure 37. Moisture level of hamburger buns during shelf life.

The moisture level of the buns reduced shelf life from day 2 through day 13. The plain bun had a moisture value of 23.16% on day 2 and was reduced to 22.01% by day 13. The moisture value of kale and spinach juice was 25.14% on day 2 and was reduced to 22.97% on day 13. The moisture value for the beet juice bun was 24.78% on day 2 and was reduced to 24.24% by day 13. The moisture value for the purple sweet potato juice bun was 24.53% day 2 and was reduced to 20.95% by day 13. The moisture level of the orange sweet potato juice bun was 23.79% on day 2 and was reduced to 22.78% by day 13.

For the puree buns, the kale and spinach puree bun decreased in moisture value of 25.53% on day 2 and was reduced to 24.42% on day 13. The beet puree bun decreased in moisture value from 23.40% on day 2 to 22.28% on day 13. The purple sweet potato puree bun

decreased in moisture value from 25.52% to 23.66% by day 13. The orange sweet potato puree bun decreased significantly in moisture value from 24.94% on day 2 to o 19.81%. on day 13.

Chapter V: Discussion, Conclusion and Recommendation

The hamburger buns for this project were made and analyzed on various attributes from a sensory and instrumental basis.

Discussion

In the juice phase of the hamburger buns, for all the attributes tested, namely appearance, aroma, texture, flavor, aftertaste, and overall acceptability, the plain (control) bun, orange sweet potato bun and purple sweet potato bun were liked the most by the participants, and the beets and spinach buns were liked the least. In the vegetable puree phase, the aroma of the plain, beets, orange sweet potato, and purple sweet potato buns were liked more than the kale and spinach bun. The texture of orange sweet potato bun was liked the most, and the others were equally liked except the kale and spinach buns, which were liked the least. The flavor of the beets, orange sweet potato, and the plain buns were preferred to the purple sweet potato bun and the kale and spinach bun. The aftertaste of the buns were equally accepted except for the kale and spinach bun that was least accepted. Overall, all other buns were more preferred than the kale and spinach bun.

Conclusion

This was the first attempt at creating hamburger buns using different processes of vegetable juice extraction and puree. The results from the shelf life studies in moisture, water activity, and color did not change rapidly over the course of 13 days. Although the texture of the buns changed rapidly over time, they become harder and dry. The overall quality of the buns after 24 hours in the juice phase was quite acceptable with the exception of the kale and spinach bun and beets bun. In the puree phase, the kale and spinach bun was the least accepted.

Recommendations

Based on the results gathered from various test conducted, there is more work needed on the development of vegetable extract and vegetable puree hamburger buns to increase their overall acceptability. The kale and spinach bun was not highly received by the participants. Both the green color and flavor influenced the perceptions of the participants.

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