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Research Article

Quality And Shelf Life Of Pumpkin Juice Fortified With Beetroot And Watermelon As Influenced By Blending Ratios And Storage Duration.

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Abstract

This study investigated the impact of blending ratios and storage duration on the quality and shelf life of pumpkin juice fortified with beetroot and watermelon. Different blending ratios were evaluated, and the juice was subjected to various storage conditions. The pumpkin, watermelon and beetroot juice were formulated and blended in different proportion (in v/v/v) as control treatment T0 (P 100:00:00), T1(50:40:10), T2(50:30:20), T3(50:20:30) and T4(50:10:40) respectively. Pumpkin blended juice physicochemical characteristics, microbial, and sensory analyses were examined over time. Results revealed optimal blending ratios for maximizing nutritional value and sensory acceptability. Storage duration significantly influenced nutrient degradation and microbial growth. Having this in the mind T4 (50:10:40) scored best result in overall acceptability of pumpkin blended juice. Heat pasteurization (80ºC for 3 min.) was used in all treatment combination during the first day of storage and prior to testing the juice to inactivating the microbial flora. However, the shelf life of juice was established within 90 days. The present study showed that blending of fruit juices could enhance their nutritional quality and development of new products. The findings provide valuable insights for developing a stable and nutritious fortified juice, promoting the consumption of these underutilized fruits and vegetables.

Keywords: Pumpkin, Beetroot, Watermelon, Blended juice, Shelf-life, Formulation, Storage duration.

INTRODUCTION

Background of the Study

Pumpkin is the fruit of (*Cucurbitacea*) family which is cultivated worldwide. It is produced for pulp and seeds for human nutrition, either direct consumption or for preparation of other foods such as syrups, jellies, jams, and purees. China, India, Russia, Ukraine, the United States, and Mexico are the top pumpkin-producing nations, with over 23 million tons produced worldwide in 2019, according to the Food and Agriculture Organization of the United Nations (FAO).

Due to its tropical location, Ethiopia offers an ideal climate for pumpkin cultivation. Pumpkins and grains are grown in the gardens of farms close to fences so that the plants can quickly spread to houses, fences, waste or marginal land, decomposing hay, and piles of cow dung. Ethiopia produces 15 to 25 tons of pumpkin per hectare on average (Meseret, 2018).

Pumpkin has a rich nutritional makeup, but because of its bland flavor, it is not typically eaten by the general public (Venkattapuram and Sellimuthu, 2012). In Ethiopian rural areas, people use the pumpkin seed and discard the pulp or use it as animal feed because of its flat taste. It appears to be an underappreciated fruit. The ordinary populace is not fully benefiting from the advantages of this incredibly nutritious diet because of its terrible flavor and bland taste, which prevents it from becoming a favorite food.

Beetroot is an alkaline food with pH in the range of 7.5 to 8.0. It is the taproot (bulb) portion of the beet plant. The world average production status is 20-25 t/ha (Hinkova *et al.,* 2000). In Ethiopia an average of 13 to 25 tons from beetroot can be produce per hector from un-irrigated farmland and irrigation increases yield by 15 to 30 percent (Hinkova *et al.,* 2000).

Now a day there is an increased growing interest among people for using it as a natural food color, because synthetic dyes are becoming more critically assessed by the consumer.

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To improve the red color of tomato pastes, sauces, jams, jellies, ice creams, sweets and breakfast cereals, fresh beetroot or beet powder or extracted pigments are used (Roy *et al*.2004). Native to tropical Africa, watermelon (Citrulluslanatus) is a member of the Cucurbitaceae family. It has significant demand throughout Africa, particularly among foreigners and some members of the population, and is utilized as pulp and juice. It's unclear exactly when watermelon fruit was brought to Ethiopia, but according to farmers in east Showa, which is close to Koka Lake, the crop was brought by Italians in the 1950s. Particularly among foreigners and some members of the central Ethiopian population, watermelon pulp and juice are in high demand these days. It's a great way to quench your thirst on hot summer days. In order to meet customer demands, watermelon juice is particularly important for hydration, high in nutrients, and low in calories, which aids in weight loss.

Blending pumpkin juice with beetroot and watermelon juice is expected to mask flat taste and unacceptable flavor and make the blended product readily acceptable by the consumer. Such a blended product will be highly nutritious and will have advantage of having functional and therapeutic ingredients.

Therefore, the rational for combining blending pumpkin, watermelon and beetroot in juice blend is that they are complementary nutrients because each ingredient contributes unique nutrients. Watermelon has a lot of lycopene, vitamin A, vitamin C, and hydration, whereas pumpkin has a lot of vitamins A, C, and E, fiber, and antioxidants. Vitamins, antioxidants, and nitrates are abundant in beetroot. A more nutritionally complete and balanced beverage is produced when they are combined (De Carvalho et al. 2007). Adding watermelon, beetroot, and pumpkin also improves the product's antioxidant capacity, hydration, and flavor balance while also making it look better. It can encourage the use of seasonal vegetables and help local farmers by combining locally farmed beetroot, watermelon, and pumpkin, which can improve sustainability and value addition.

Nutritional deficiency in Ethiopia is a well-documented fact and there is an urgent need to address this issue. The selection of fruit and vegetable-based beverages is focused on the development of consumer-acceptable goods from highly nutritious, sustainable, and reasonably priced locally available sources. The results of this study should help producers by providing useful data for creating a product that can be sold commercially, which could open up new revenue opportunities for farmers and business owners. By laying the groundwork for future studies on the creation and improvement of beverages made from fruits and vegetables, it is anticipated to encourage future research. Therefore, the objective of this study was to develop a functional and therapeutic juice of pumpkin from the blends of beetroot & watermelon and study various storage changes including consumer acceptance of fresh and stored juice.

MATERIALS AND METHODS

Description of Study Area

Arba Minch University's Chemistry and Advanced Biotechnology Laboratories served as the site of the experiment. The primary area for making and evaluating the fortified pumpkin juice is the laboratory. It has all the facilities needed to process, combine, and experiment with food. In order to guarantee the precision and dependability of the research findings, the laboratory offers the sterile and regulated atmosphere required. There are instruments in the laboratory for testing pH, color, proximate composition, sensory test, and other pertinent qualities.

Procurement of Raw Materials

In Ethiopia's southern nation nationality and people region (SNNPR), local farmers provided pumpkin and beetroot of a consistent maturity variation on October 19, 2023. As shown in **Figure 1**, Ria watermelon of consistent ripeness was purchased from the Arba Minch University farm. The correct protocol was adhered to in order to guarantee consistency in raw material maturity. Moreover, sugar was procured from nearby markets. We bought glass bottles, knives, heating stoves, juice mixers, and other items from the neighborhood market.

Figure 1. Raw material procured



Juice Extraction and Bottling

The following process was used to create a blended juice made from watermelon and beetroot that is based on pumpkin. A computerized electronic balance was used to weigh sixteen kilograms (16 kg) of pumpkin, nine kilograms (9.2 kg) of beetroot tubers, and fifteen kilograms (15 kg) of watermelon for the extraction juice. In the preparation of the juice blends, various fruit pulps were utilized to enhance flavor and nutritional content. **Figure 2** illustrates the different pulp sources used for juice extraction, including pumpkin, beetroot, and watermelon.

Figure 2. Pumpkin, beetroot and watermelon pulp for juice extraction.



(a) Peeled pumpkin



(a) Peeled pumpkin



(a) Peeled pumpkin



A, Peeled beetroot



B, Watermelon juice

To guarantee quality and safety, a number of crucial procedures were followed when making the blended juice from watermelon, beetroot, and pumpkin. The fruits and vegetables were first carefully sorted, with any that were broken or faulty being eliminated. Each kind of produce was cleaned separately after sorting in order to get rid of any surface impurities. Following fruit peeling, each variety was positioned in a specific location to preserve order and avoid cross-contamination, as seen in figure 4. To determine the waste production, each peel was weighed separately. To make processing easier, the cleaned fruits and vegetables were then chopped into little pieces.

In order to extract the juice, the pumpkin and beetroot slices were blanched separately in hot water at 83 degrees Celsius for three minutes and then immediately cooled to room temperature. Each fruit and vegetable was then chopped separately, and water was added to the pumpkin and beetroot slices in a 1:1 ratio (one part pulp to one part water) while no water was added to the watermelon pulp. The mashed pulp from each fruit and vegetable was then placed in sanitized muslin cloths and pressed to extract the juice, which was then collected in stainless steel containers. The juices were then blended in accordance with the ratio listed in Table 3 and a preliminary sensory evaluation was carried out to determine their acceptability by consumers.

Each blended batch received 4.7% sugar, which was added and carefully mixed based on the sensory evaluation data. After being heated to 85 degrees Celsius, each lot of juice was hotly poured into 300ml bottles that had been previously sanitized, allowing roughly 3/8 inch of headspace. As shown in figure 3, the bottles were then corked and pasteurized in boiling water for around 20 minutes to get rid of any potentially dangerous germs. Following pasteurization, the bottles were cooled under running water before being dried and branded once they had reached room temperature. After that, the labeled bottles were kept at room temperature for additional research. Samples were examined every 30 days for 90 days of storage. The goal of this methodical and meticulous approach to juice preparation was to guarantee customer satisfaction and product safety.

Figure 3. Filled, corked, pasteurized, cooled and stored blended juice.



a) pasteurized pumpkin juice b) stored blended juice

Experimental Design and Treatments

The studies were carried out using a 5*4 factorial design setup with three replications using a complete randomized design (CRD). **Table 1** shows that the experimental treatment had five different levels of blending ratio: 100% pumpkin juice as control, 50% pumpkin + 10% beetroot + 40% watermelon, 50% pumpkin + 20% beetroot + 30% watermelon, 50% pumpkin + 30% beetroot + 20% watermelon, and 50% pumpkin + 40% beetroot + 10% watermelon. It also had four different levels of storage periods: 0, 30, 60, and 90 days. The stored blended juice was assessed every 30 days for a total of 90 days. Treatments were randomly assigned using the lottery method.

Table 1. CRD Factorial Design with three replications (5*4*3)

Treatments		Treatment Combinations
Blending ratio (%)	**Storage duration (Days)**	
100% P (control,T_0)	1st day	100 % P *1st day
	30th day	100% P *30th day
	60th day	100% P *60th day
	90th day	100% P *90th day
P 50%, B 40%, W 10% (T_1)	1st day	P 50%, B 40%, W 10%*1st day
	30th day	P 50%, B 40%, W 10%*30th day
	60th day	P 50%, B 40%, W 10% *60th day
	90th day	P 50%, B 40%, W 10%*90th day
P 50%, B 30%, W 20% (T_2)	1st day	P 50%, B 30%, W 20%*1st day
	30th day	P 50%, B 30%, W 20%*30th day
	60th day	P 50%, B 30%, W 20%*60th day
	90th day	P 50%, B 30%, W 20%*90th day
P 50%, B 20%, W 30% (T_3)	1st day	P 50%, B 20%, W 30%*1st day
	30th day	P 50%, B 20%, W 30%*30th day
	60th day	P 50%, B 20%, W 30%*60th day
	90th day	P 50%, B 20%, W 30%*90th day
P 50%, B 10%, W 40% (T_4)	1st day	P 50%, B 10%, W 40%*1st day
	30th day	P 50%, B 10%, W 40%*30th day
	60th day	P 50%, B 10%, W 40%*60th day
	90th day	P 50%, B 10%, W 40%*90th day

Where: - P-Pumpkin, B-Beetroot, W-Watermelon

Proximate Analysis

Moisture content

Pumpkin juice that was combined with watermelon and beetroot was tested for moisture content in line with the Association of Official Analytical Collaboration (AOAC) (2000). Crucibles were cleaned, dried for two hours at 105°C in an oven, and then allowed to cool for 30 minutes in a desiccator to ascertain the moisture content. The weight (W1) of the empty crucible was

measured. Ten milliliters of each sample were transferred to the dried crucible and weighed (W2) after the prepared samples had been well mixed. The sample-containing dried crucible was dried with a drier until its weight (W2) stayed constant. After drying, the crucible was weighed again (W3) and left in a desiccator to cool to room temperature. The moisture content was calculated using the following formula.

$$\%\text{Moisture} = (m_w/m_{sample}) \times 100$$

Where m_w is the mass of the water and m_{sample} is the mass of the sample.

Ash content

The ash contents of pumpkin blended juice with beetroot and watermelon were determined according to Association of Official Analytical Collaboration (A.O.A.C) method (1990). Porcelain dishes were used for the analysis and placed in an oven for 30 minutes at 105 °C. Before being weighed, the dishes were removed and left to cool in desiccators for 30 minutes.

Each plate received ten milliliters of the juice sample, which had been weighed. The plates holding the sample were placed on a hotplate beneath a fume hood, and the temperature was progressively increased until the smoke ceased and the samples were fully charred. The dishes were then maintained at 550 °C for three hours in the muffle furnace. Following its removal from the muffle furnace, it was cooled in a desiccator before being weighed. The amount of total ash was calculated using the formula below.

$$\text{Ash Content}\,(\%) = \frac{\text{M3} - \text{M1}}{\text{M2} - \text{M1}} \times 100$$

Where: M3 is final mass of sample (ash + crucible) with crucible (g), M2 is sampling mass with crucible (g) and M1 is mass of crucible (g).

Crude fat content

Pumpkin juice that was combined with watermelon and beetroot had its crude fat level measured in accordance with (Association of Official Analytical Collaboration, 2000). After being cleaned with hot water, the extraction cylinder was dried for an hour at 70 degrees in a drying oven, chilled for 30 minutes in a desiccator, and weighed. A thin layer of cotton free of fat was placed across the bottom of the extraction thimble. After weighing and transferring two grams of the material into an extraction thimble, cotton was placed over the thimble. The soxhlet extraction chamber was filled with the thimbles containing the samples. Fifty ml of petrolatum ether was added to the extraction flask through condenser. The extraction was conducted for four hours, after that the extraction flask with their content were removed from the extraction chamber.

$$\text{Fat Content}\,(\%) = \frac{\text{w2} - \text{w1}}{\text{w3}} \times 100$$

Where: W1 represents the weight of the flask when it is empty (g); W2 represents the weight of the flask plus fat (g); and W3 represents the weight of the sample that was collected (g).

Crude Protein Content

ACC (2000) Method № 46–11 states that the micro-Kjaldahl method will be used to determine the sample's total nitrogen concentration. Three grams of dried injera will be broken down in a flask with three milliliters of a solution of H2SO4+ Se (100 milliliters) and salicylic acid (7.2 grams), as well as three pieces of boiling chips. Using a digestion device, the flask's contents will be broken down at 350°C until the process is transparent. At room temperature, the digest will be permitted to cool. The digested sample will be moved to the distillation unit, where it will undergo distillation by adding 30 milliliters of distilled water, 25 milliliters of 40% NaOH, and connecting it to a distillation apparatus whose outlet tube will be submerged in 25 milliliters of a solution of 4% boric acid. About 150 mL of the distillate will be gathered and titrated using 0.1N HCl, a standard acid.

$$\text{Nitrogen}\,(\%) = \frac{\text{V}_{\text{HCL}}\text{in L} \times \text{N}_{\text{HCL}}\,(\text{ca.0.1}) \times 14}{\text{sample weight on drymatter basis}} \times 100$$

Proten (%) = 6.25 × *Nitrogen* (%) Where N is the amount of HCL used (often 0.1N), V is the volume of HCL consumed in liters to the titration's end point, and 14.00 is the molecular weight of nitrogen. By applying the proper conversion factor, the percentage of nitrogen is changed to the percentage of protein (% Protein = % N x 6.25).

Crude Fiber Contents

Pumpkin juice that was combined with watermelon and beetroot had its fiber content measured in accordance with the Association of Official Analytical Collaboration (2000). The cleaned crucible was put in a desiccator to cool after being dried for an hour at 105 °C in the oven. Three grams of the sample were put in a crucible that had dried. Each beaker was filled with two hundred milliliters of 1.25% H2SO4, which were then left to boil for 37 minutes. Following 37 minutes, a vacuum pump was used to drain the acid, and the samples were chilled for five minutes before being cleaned three times with distilled water.

The second stage involved adding 1.25% NaOH solution to each column and then repeating the first procedure. Remaining crucibles were dried in a drying oven at 130 °C for two hours, cooled in a desiccator, and weighed (W2). Before being taken out of the muffle furnace (W3), crucibles were moved there and heated to 550 °C for three hours. They were then cooled to 250 °C. Crucibles were then weighed after cooling in the desiccators. The crude fiber was then computed using the formula that follows:

$$\text{Crude Fiber}\,(\%) = \frac{\text{W2} - \text{W3}}{\text{W1}} \times 100$$

Where: -

W1 = sample weight (3g)

W2 = crucible weight with fiber and ashes, after drying in an oven at 130 °C for 120 minutes
W3 = crucible weight with ashes, after muffle at 550 °C for three hours

Carbohydrate

The % of carbohydrate was calculated by the difference as 100 - (moisture + protein + fat + ash + crude fiber) (Merrill and Watt, 1973).

Chemical Analysis

pH

The pH meter was used to determine the pH of the juice. Buffer of pH 7 and 4 were used to adjust pH meter. The juice was putted in a clean beaker and then the electrode of pH meter dipped in to the juice and the pH value of the juice recorded from the display of pH meter. This was done in triplicates and the average value was taken.

Total Soluble Solids (TSS 0Brix)

TSS was measured with a hand refractometer. First, distilled water was used to clean and zero the refractometer. A drop of juice was placed on the refractometer's clean prism once it had dried, and the prism cover was shut. An eyepiece was used to monitor the TSS reading (Association of Official Analytical Collaboration, 1995).

Determination of Vitamin C

Sigma (Madrid, Spain) provides analytical-grade ascorbic acid, 2,6-Dichloroindophenol (DCIP), metaphosphoric acid, and acetic acid. A 100cm3 volumetric flask was pipetted with 50cm3 of unconcentrated juice. As a stabilizing agent, 25 cm3 of 20% acetic acid was added, and the volume was diluted to 100 cm3. 2.5 cm3 of acetone was pipetted into a conical flask containing 10 cm3. The 2, 6-Dichloroindophenol (DCIP) Standard solution was used to titrate it. There was a slight pink tint that lasted for roughly 15 seconds. The amount of dye used in the titration was calculated volumetrically and utilized to calculate the fruit samples' vitamin C content (milligrams per 100 milliliters). (The Official Analytical Collaboration Association, 2006)

Titratable acidity

Acidity was determined according to the method of Association of Official Analytical Chemists (Association of Official Analytical Collaboration, 2000). A sample of the juice measuring 10 ml was diluted with distilled water (25ml) and titrated with 0.1 N NaOH solution using titration kits, where phenolphthalein (1-2 drops) was used an indicator. The emergence of the pink color was ending titration (AOAC, 2000). The acidity was expressed as gram of acid per 100milliliters (g/100ml).

$$\text{Total acidity (mg/100g)} = \frac{[\text{mls NaOH used}] \times [0.1\text{N NaOH}] \times [\text{mil liequivale nt factor}] \times [100]}{(\text{Sample weight})}$$

Sensory Acceptability Evaluation

A partially-trained panel of 20 judges, consisting of 8 females and 13 males, ages 20 to 35, participated in a training session on sensory evaluation procedures, individual practice, and group discussions prior to the process commencing. Pre- and post-tests were utilized to evaluate the panelists' knowledge and abilities before and throughout training, and performance evaluations about the execution of training exercises were also carried out. At Arba Minch University, postgraduate food engineering students and teaching staff evaluated the sensory qualities of the juices created through mixing. Visual color, flavor, taste, appearance, and overall acceptance were among the sensory qualities that were covered. A hedonic scale with nine points, ranging from 1 to 9, was used to assess this (Schiffman, 1996). The recommended guidelines for sensory evaluation were adhered to, as indicated in **Table 2**. Initially, the juice was transferred into sterile glasses or cups, which were then randomly assigned three-digit codes. Each chosen product's code samples were served to the panelists in a randomly chosen order on the lab tables.

Table 2. Sensory evaluation scale

R/ no	Hedonic scale	Scores
1	Like Extremely	9
2	Like very much	8
3	Like moderately	7
4	like slightly	6
5	neither like nor dislike	5
6	dislike slightly	4
7	dislike moderately	3
8	dislike very much	2
9	dislike extremely	1

In between tastings, the panelists were given questionnaires and clean tap water to rinse their mouths. Prior to sensory evaluation, the microbial flora was eliminated by heat pasteurization (80ºC for 3 min). The panelists were given an explanation of each attribute's meanings at a pre-assessment session prior to evaluation in order to prevent misunderstandings (Hinkova, Andrea, and Zdenek Bubnk, 2000). Data from sensory evaluations were displayed as panelists' average scores.

Microbiological analysis

Microbial study (mold and bacteria) was carried out by a series of dilution and spread plate method (Rangarajan, 2000).
Media preparation: Standard plate count was done using different growth media e.g. nutrient agar media was used for bacteria and Martin's Rose Bengal Agar for mould count. All the components of individual media were dissolved in 1liter of water in a conical flask and heated for few minutes to get homogenized mixture. 100 ml medium was dispensed in 250

ml conical flasks. All the flasks were then tightly plugged with cotton and sterilized in autoclave at 121°C for 15 minutes.

Plating: Serial dilution of the heat processed juice blends were made using sterilized distilled water. Dilution was increased with the advancement of storage for counting. The 1ml of sample from each dilution was transferred into sterilized petri-plates and over to this 30 ml of medium was poured and mixed thoroughly by gentle stirring. Then petri-plates were allowed for solidification.

Incubation and counting: after solidifying the media, the petri plates were kept in biochemical oxygen demand at 28°C for incubation. After 24 hours of incubation, the population of the bacteria and molds were counted. It was expressed as colony forming units per ml of juice.

Statistical Analysis

Software (SAS) version 9.1 was used to appropriately arrange and statistically analyse all of the data collected for each parameter. For statistical changes, a mean of three replications was obtained. The degree of significance was evaluated by using the Analysis of Variance (ANOVA). The Duncan Multiple Range test was used to further examine the means with the least significant differences at ($p<0.05\%$) (Peterson, 1985).

RESULTS AND DISCUSSION

Juice Yields and Compositions

In the present study the following juice yield was obtained from the fruits and vegetable under study.

According to previous studies by Norfezah et al. (2011), the fractional makeup of pumpkins was as follows: peel section 10-12%, pulp portion 3-4%, edible meat portion 79-82%, and seed portion 4-6%. Watermelon fruit is made up of 42% juice, 33.6% rind, and 23.6% pomace (including seeds), according to Sogi et al. (2020). The fractional makeup of beetroot tubers was reported by Sawicki et al. (2016) as pulp portion 91%, pomace 4%, and peel portion 5%.

Table 3. Juice yield and components of selected fruit and vegetable.

Fruit/vegetable	% of Rind	% of Pulp	% of Pile	% of Juice	% of Pomace with seed
Pumpkin	-	76.5	14	-	9.5
Beetroot	-	83	7	-	10
Watermelon	34.5	-	-	39	26.5

The juice extraction procedure of small juicer with manual pressing of chopped mash and as such the yield was relatively low. The following parameters were measured in the juice extracted from watermelon, beetroot, and pumpkin: moisture, total soluble solids, total sugar, pH, acidity, and vitamin C. **Table 4** displays the findings.

Table 4. Proximate Composition of fresh fruit and vegetable used for preparation of blended product

Sample	Moisture	Ash	TSS	pH	Acidity%
Pumpkin	89.75	0.73	5.3	5.5	0.35
Beetroot	88.6	0.75	6.5	6.8	0.32
Watermelon	91.8	0.46	7.5	5.2	0.5

Composition and consumer Acceptability of Blended juice

To increase consumer acceptance, sugar (4.7%) was added to each lot after the extracted juices were blended in the proportions shown in Table 4. The freshly blended juice's chemical calculation and sensory assessment are shown in **Table 5** and **Table 6**, respectively.

Table 5. Computation the freshly blended Juice

Blended juice	Mean value				
	TSS(°Brix)	pH	Acidity (TA)	Moisture	Ash
T0 (100% P)	9.5	5.1	0.3	86.2	0.3
T1 (50%P+40%BR+10%WM)	9.7	5.2	0.3	87.2	0.2
T2 (50%P+30%BR+20%WM)	9.8	5.2	0.3	88.3	0.2
T3 (50%P+20%BR+30%WM)	9.7	5.2	0.3	88.5	0.23
T4 (50%P+10%BR+40%WM)	9.6	5.2	0.4	88.9	0.4

Table 6. Sensory Evaluation of Freshly blended juice.

Blended juice	Mean value				
	Color	Taste	Aroma	Texture	Overall
T0(100% P)	8.89	6.50	7.16	8.66	6.2
T1 (50%P+40%BR+10%WM)	5.35	7.25	7.23	7.25	5.4
T2 (50%P+30%BR+20%WM)	6.72	7.50	7.66	7.5	5.8
T3 (50%P+20%BR+30%WM)	5.72	7.91	7.56	7.75	5.8
T4 (50%P+10%BR+40%WM)	5.56	8.33	8.33	8.33	6.9

The Effects on Proximate composition

Moisture content

On the 90-day storage period, the mean moisture value reached a maximum of 90.01%, whereas on the first day of storage, the mean moisture value was 87.5%. The nature of the various blended fruit and vegetable products and the loss of the same nutritional components from the blended product could be the cause of the samples' altered moisture content as a result of varying storage times. The experiment's results were similar to the 88.23 to 92.24% moisture percentage of fresh pumpkin juice reported by See et al. (2007). On the other hand, the moisture contents found in this experiment were somewhat greater than the 84.10 to 88.21% moisture content of pumpkin juice and puree and certain other fruit mixes reported by Atef et al. (2012).

Crude fiber

Method of extracting crude fiber was illustrated in figure 5.Pumpkin enriched juice's crude fiber content significantly decreased as a result of the blending ratio and storage time. On the first day of storage, the T2 treatment (P 50 + B 30 + W 20) recorded the mean maximum of 5.90%, while the control treatment recorded the mean minimum of 1.5% on the 90th day of storage. When the blending ratio and storage duration were taken into account, the crude fiber content of pumpkin-enriched juice dropped considerably. The reason for this could be because the fiber content could turn to ash as the storage time increased (Desmedt, 2001).

Carbohydrate Content

The blending ratio and storage period had an impact. On the first day of storage, the control treatment recorded a mean maximum value of 11.88% carbohydrates, whereas on the 90th day of storage, the T4 treatment recorded a mean minimum of 4.60% (P50%: B10%: W40%) (Table 7). When products are stored, their carbohydrate content may decrease because of enzymatic destruction of the sugars and pigments, oxidative breakdown, or isomerization. Although just 5.57 percent of carbohydrates were reported in pumpkin juice by Abdel (2002), the current research may differ due to variance and nutritional management.

Crude Protein

Crude protein extraction from blended juice is depicted in Figure 7. T4 (P50 + B10 + W40) had the mean maximum value of crude protein (3.73%) on the first day of storage, whereas T0 (Pumpkin 100) had the mean minimum of 1.24% on the 90th day of storage, according to Table 7, which combined the impacts of blending ratio and storage period. There may be a direct correlation between the moisture content and nutritional value of the stored juice, which results in a decrease in protein. This could be because the juice experiences a number of biochemical and structural changes that cause sediment from the pumpkin juice and slow denaturation of protein during storage (Liu et al., 2013). These findings were similar to El Awad's (2001) estimate of 1.13% for pumpkin juice.

Ash Content

Table 7 displays the amount of ash in pumpkin juice as influenced by the ratio of blending and storage time. On the first day of storage, T1 (P 50%, B 40%, W 10%) recorded the mean lowest value of 0.2%, while T2 (P50 + B30 + W20) recorded the mean maximum value of 0.7% on the 90th day. This can be the result of a slow decrease in vital nutrients, which raises the blended pumpkin juice's ash level gradually. The experiment's results were less than the ash content of pumpkin-pineapple juice blends reported by Joseph et al. (2016), which ranged from 0.66 to 0.83% for treatments and from 0.37 to 0.6% for storage. The row material utilized to formulate the juice may be the cause of this discrepancy.

Table 7. The effect of blending ratio and storage duration on proximate composition of blended juice

Treatment		Protein	Fat	Moisture	Ash	Fiber	CHO
Blending	ST						
T0	0	1.27±0.3^{i}	0.23±0.3^{c}	86.1±0.1^{i}	0.36±0.0^{j}	1.94±0.0^{m}	11.8±0.2^{a}
	30	1.22±0.0^{k}	0.25±0.2^{b}	86.2±0.0^{i}	0.33±0.0^{l}	1.81±0.0^{n}	11.4±0.3^{b}
	60	1.24±0.0^{j}	0.27±0.0^{a}	87.0±0.7^{h}	0.34±0.0^{k}	1.8±0.0^{n}	11.3±0.7^{c}
	90	1.24±0.0^{j}	0.27±0.0^{a}	88.9±0.2^{g}	0.34±0.0^{k}	1.5±0.0^{o}	9.2±0.2^{g}
T1	0	1.47±0.0^{g}	0.25±0.0^{b}	87.3±0.4^{f}	0.20±0.0^{n}	4.79±0.8^{e}	10.79±0.3^{d}
	30	1.47±0.0^{g}	0.27±0.0^{a}	87.3±0.4^{f}	0.56±0.1^{d}	3.9±0.0^{k}	10.38±0.5^{e}
	60	1.42±0.0^{h}	0.27±0.0^{a}	89.6±0.6^{c}	0.52±0.0^{c}	3.92±0.0^{j}	8.18±0.5^{i}
	90	1.42±0.0^{h}	0.27±0.0^{a}	89.6±0.6^{c}	0.52±0.0^{f}	3.90±0.0^{k}	8.18±0.5^{i}
T2	0	1.58±0.0^{f}	0.27±0.0^{a}	88.3±0.1^{e}	0.22±0.0^{m}	5.90±0.3^{a}	9.59±0.2^{f}
	30	1.58±0.0^{f}	0.27±0.0^{a}	88.4±0.1^{e}	0.58±0.1^{c}	4.31±0.0^{g}	9.06±0.1^{h}
	60	1.57±0.0^{f}	0.27±0.0^{a}	90.5±0.9^{a}	0.68±0.1^{a}	4.22±0.1^{i}	6.93±0.8^{k}
	90	1.57±0.0^{f}	0.27±0.0^{a}	90.5±0.9^{a}	0.70±0.1^{a}	3.77±0.1^{l}	6.93±0.8^{k}
T3	0	2.29±0.0^{c}	0.27±0.0^{a}	88.3±0.2^{e}	0.22±0.0^{c}	5.06±0.2^{b}	8.90±0.3^{i}
	30	2.29±0.1^{c}	0.27±0.0^{a}	88.4±0.1^{e}	0.64±0.0^{b}	4.90±0.0^{d}	8.35±0.2^{j}
	60	2.26±0.1^{d}	0.27±0.0^{a}	90.4±0.8^{b}	0.64±0.0^{b}	4.39±0.2^{f}	6.43±0.8^{n}
	90	2.21±0.2^{e}	0.27±0.0^{a}	90.4±0.8^{b}	0.64±0.0^{b}	4.04±0.1^{c}	6.48±0.7^{c}
T4	0	3.73±0.0^{a}	0.27±0.0^{a}	88.7±0.0^{d}	0.37±0.0^{i}	4.94±0.2^{c}	6.85±0.1^{l}
	30	3.73±0.0^{a}	0.27±0.0^{a}	88.7±0.0^{d}	0.51±0.0^{g}	4.28±0.0^{h}	6.65±0.0^{m}
	60	3.69±0.0^{b}	0.27±0.0^{a}	90.1±1.4^{b}	0.53±0.0^{e}	3.96±0.0^{j}	5.38±1.4^{o}
	90	3.72±0.0^{a}	0.27±0.0^{a}	90.9±0.5^{a}	0.50±0.07^{h}	3.87±0.0^{k}	4.60±0.4^{p}
CV		2.96	5.41	0.64	11.8	6.3	6.79

The Effects on pH, TA and TSS Content of Pumpkin Juice

pH Content

The pH value of the blended juice varied substantially ($P<0.05$) depending on the blending ratio and storage time (Table 8). The pH trended downward in all treatments over the storage period, according to a comparison of treatment means. The current study's findings also demonstrated that storage time and treatment had significant effects on the pH of all juice samples, increasing their acidity and lowering their pH. On the first day of storage, T4 recorded the highest pH value (5.24), while on the ninetieth day of storage, the same treatment recorded the lowest pH value (4.00). This could result from excessive fermentation and the presence of lactic acid-reducing microorganisms, or it could be caused by the breakdown of reducing carbohydrates, which produces acidic chemicals. This outcome was comparable to the research conducted by Awsi Jan and Masih (2012), who found that the pineapple juice mixed with carrot and orange juice gradually lost pH and gained acidity (0.97–1.83%) over the course of storage. In comparison to these trials, the result was lower. Majumdar et al. (2008) also noted that throughout the course of six months of storage, the pH values in the juice of ash gourd and mint leaves dropped from 4.0 to 3.93%.

TA Content

The TA of pumpkin juice was considerably ($P < 0.05$) affected differently by the blending ratio and storage time (Table 8). All storage procedures resulted in an increase in TA. During the 90th day of storage, T4 recorded the highest titratable acidity (0.53 g/100 ml), while the control fruit recorded the lowest TA (0.28 g/100 ml) on the first day of storage. The breakdown of carbohydrates by microbes, which results in the generation of acids in juice, may be the reason of the pH drop and acidity increase after storage. This outcome is consistent with that of Majumdar et al. (2008), who found that the acidity of cucumber-basil juice increased from 0.25 to 0.36 grams per 100 milliliters while it was being stored. Krishna et al., 2012 also reported marginal changes in acidity in jack fruit RTS beverage (0.25-0.27 g/100ml).

TSS (° Brix) Content

On the 90th day of storage, T4 (50%P+10%BR+40%WM) recorded the highest TSS 9.85°Brix, while T0 recorded the lowest TSS 9.41°Brix on the first day of storage. It is possible that the hydrolysis of polysaccharides into monosaccharides and oligosaccharides is the cause of the TSS's progressive increase with storage time. To maintain high-quality juice, the TSS concentration of the juice should either remain constant or grow as little as possible while being stored. Tiwari (2000) reported similar results with papaya and guava juice, which exhibited a small increase in TSS. TSS rose while cucumber-melon juice was being stored, according to Humaira et al. (2012).

Vitamin C contents

The blending ratio and storage time had distinct and significant (P < 0.05) effects on the VC of pumpkin juice (**Table 8**). On the 90th day of storage, the control treatment (Pumpkin 100) had the lowest value, 7.22%, whereas on the first day of storage, the greatest value, 63.03%, was observed in (T4). (T4) showed a higher ascorbic content than fresh pumpkin juice, even after three months of storage. Ascorbic acid loss during storage may be caused by the irreversible conversion of ascorbic acid into dehydroascorbic acid oxidase as a result of trapped or residual oxygen in the glass bottles (Jaiswal et al., 2008). The results of Anju et al. (2018), who discovered that ascorbic acid in pumpkin pulp drastically decreased after a six-month storage period, are in line with this outcome. Similarly, Ankush et al. (2015) found that ascorbic acid decreased from 118.86 to 86.92 in watermelon mixtures with beetroot juice.

Table 8. The effect of blending ratio and storage duration on chemical property of blended juice.

Treatment		PH	TA	TSS	Vitamin C
Blending. R	SD				
T0	0	5.00±0.2^{d}	0.28±0.0^{o}	9.41±0.0^{i}	15.8±2.4^{p}
	30	4.80±0.0^{f}	0.33±0.0^{m}	9.46±0.0^{h}	15.0±2.7^{q}
	60	4.81±0.0^{f}	0.33±0.0^{m}	9.46±0.0^{h}	9.28±0.2^{s}
	90	4.81±0.0^{f}	0.38±0.0^{j}	9.50±0.1^{g}	7.22±1.5^{t}
T1	0	5.21±0.0^{b}	0.29±0.0^{n}	9.73±0.0^{e}	34.5±1.7^{f}
	30	5.13±0.0^{c}	0.35±0.0^{c}	9.80±0.1^{c}	27.4±1.7^{i}
	60	5.13±0.0^{c}	0.35±0.0^{c}	9.76±0.0^{d}	19.0±0.5^{n}
	90	5.13±0.0^{c}	0.43±0.0^{f}	9.76±0.0^{d}	13.3±0.6^{r}
T2	0	5.23±0.0^{a}	0.35±0.0^{c}	9.80±0.1^{c}	40.1±0.4^{e}
	30	5.19±0.0^{b}	0.40±0.0^{i}	9.80±0.0^{c}	31.0±0.7^{h}
	60	5.19±0.0^{b}	0.45±0.0^{e}	9.83±0.0^{b}	20.5±0.6^{m}
	90	5.19±0.0^{b}	0.50±0.0^{c}	9.83±0.0^{b}	16.0±0.3^{o}
T3	0	5.20±0.0^{b}	0.35±0.0^{l}	9.70±0.1^{f}	54.1±0.3^{c}
	30	4.94±0.0^{e}	0.43±0.0^{f}	9.76±0.0^{d}	44.1±1.8^{d}
	60	4.94±0.0^{e}	0.47±0.0^{d}	9.76±0.0^{d}	25.5±0.8^{j}
	90	4.90±0.0^{h}	0.51±0.0^{b}	9.83±0.1^{b}	21.0±0.0^{l}
T4	0	5.24±0.0^{a}	0.36±0.0^{k}	9.83±0.0^{b}	63.3±1.0^{a}
	30	4.30±0.0^{g}	0.42±0.0^{h}	9.76±0.0^{d}	56.9±0.7^{b}
	60	4.20±0.0^{g}	0.45±0.0^{e}	9.84±0.1^{ab}	33.5±1.8^{g}
	90	4.00±0.0^{h}	0.53±0.0^{a}	9.85±0.0^{a}	25.1±0.4^{k}
CV		1.6	9.0	0.8	4.6

The Effects of Blending ratio and Storage Duration on Sensory Characteristics of Pumpkin Juice

Color

The sensory colour of pumpkin juice was significantly (P<0.05) influenced by the blending ratio and storage duration, according to statistics, as table 9 shows.

In the case of the control treatment, the judges acquired the greatest color score (8.89%) on the first day of storage, while T4 received the lowest color score (4.90%) on the 90th day. Figure 6 shows that the variations in the coloring pigments of the fruit and vegetable used to make the blended juice could be the cause of the color shift. Nonetheless, every treatment received a respectable color score. In their storage research of sour grape beverages, Balaswamy et al. (2011) showed similar color loss results. Likewise, Main et al. (2001) observe color deterioration in blueberry juice mixes with grape and cranberry juices after three months of storage. These findings were consistent with those of Bhardwaj and Mukheerjee (2011), who examined the impact of blending kinnow juice preservation and storage and discovered a decline in color score with storage progression.

Taste

Table 9 illustrates that T4 had the highest flavor acceptance score (8.4%) on the first day of storage and T0 had the lowest taste acceptability score (6.3) on the ninetieth day of storage.

This could be because the acidity increased with storage time, leading to a decreased preference at the end of the day. In a similar vein, Atef et al. (2012) noted that pumpkin and certain other fruit mixes lost flavor with time. Furthermore, Iglesias

and Echeverría (2009) explained that organic acids have a significant part in creating the flavor and taste of peaches and influence the fruit's overall acceptability for consumption when combined with volatiles that give them their aroma.

Aroma

As shown in table 9, the results of the statistical analysis indicated that the sensory smell of pumpkin juice was significantly (P<0.05) impacted by the blending ratio and storage period.

During the first and sixty days of storage, T2 had the highest scent acceptance score (8.55%), followed by T3 (7.33%). T0 had the lowest aroma acceptability score (6.1%) during the ninetieth day of storage. The findings showed that the blended juice's scent gradually diminished after storage. Increased acidity in juices may be the cause of a decline in scent after storage. According to Atef et al. (2012), the aroma of pumpkin and some other fruit mixes increases with storage duration.

Texture

As indicated in table 9, the results of the statistical analysis demonstrated that the blending ratio and storage duration significantly (P<0.05) impacted the sensory texture of pumpkin juice.

According to the findings, treatments during the storage days of observation had a substantial impact on the texture score of juice blends. Throughout the storage period, the texture scores steadily declined for every treatment. The final assessment of a product is greatly impacted by its texture. A product's poor texture could render it intolerably distasteful to the user, even if it tastes well. This metric is affected by the gelling agent, sweetener, and fruit freshness level. Over the course of all storage times, the control treatment had the best texture (8.66%), followed by T1 (8.318%), while T4 had the lowest texture value (7.250%). The texture of the blended juice decreased somewhat during storage, from 8.02% to 7.07%, according to the data from the storage tests in chart 4. The product's textural acceptability is increased by the higher beetroot juice mixing percentage.

Overall acceptability

The statistical analysis's findings showed that the blending ratio and storage time had a significant (P<0.05) impact on the sensory acceptability of pumpkin juice. Figure 6 illustrates that the evaluation of overall acceptability was based on the texture, taste, aroma, and visual appearance of the juice during the storage period.The present study revealed the interaction effect of juice blend in **Table 9**. The maximum overall acceptability was scored in T4 (7.91) followed by the control fruit (7.44) during the first day of storage while, the minimum overall acceptability was scored in the control fruit (6.3) during 90th days of storage. There was decrease in overall acceptability during storage which might be due to the loss in color, aroma, taste, texture and mouth feel of the blended fruit drinks. However, all treatments remained acceptable during storage and obtained acceptable score for overall acceptability. The similar changes of slight decrease in overall acceptability due to loss of color and flavor were reported by Balaswamy et al. (2011) during storage study of sour grape beverages. These results are in agreement with the Bhardwaj and Mukheerjee (2011) who found decrease in overall acceptability score with storage advancement while studying effect of blending on kinnow juice preservation and storage.

Table 9. The effect blending ratio and storage duration on sensory evaluation of blended juice.

Treatment		Color	Taste	Aroma	Texture	Overall
Blending	ST					
T0	0	8.89±0.2^{a}	6.50±0.2^{g}	7.3±0.2 ^{h}	8.66±0.2^{a}	7.44±0.0^{b}
	30	8.82±0.2^{a}	6.4±0.2^{g}	7.1±0.2^{g}	8.66±0.2 ^{a}	7.2±0.1^{d}
	60	8.59±0.1^{b}	6.4±0.2^{g}	6.9±0.5^{g}	8.66±0.2 ^{a}	7.1±0.1^{c}
	90	8.10±0.1^{c}	6.39±0.2^{h}	6.1±0.2^{h}	8.66±0.2 ^{a}	6.39±0.0^{i}
Mean		8.6	6.475	7.11	8.66	6.12
T1	0	5.35±0.2^{g}	7.25±0.4^{f}	8.16±0.28^{c}	7.25±0.2^{d}	6.41±0.0^{j}
	30	5.31±0.2^{h}	7.25±0.4^{f}	7.23±0.25^{f}	7.25±0.2^{d}	6.41±0.0^{j}
	60	5.31±0.2^{h}	7.25±0.4^{f}	7.23±0.25^{f}	7.25±0.2^{d}	6.59±0.0^{i}
	90	5.31±0.2^{h}	7.25±0.4^{f}	7.2±0.25^{h}	7.25±0.2^{d}	6.41±0.0^{j}
Mean		5.32	7.25	7.4625	7.25	5.45
T2	0	6.72±0.1^{d}	7.50±0.2^{d}	8.55±0.05^{a}	7.5±0.0^{c}	6.87±0.0^{g}
	30	6.66±0.0^{e}	7.50±0.2^{d}	7.66±0.28^{d}	7.5±0.0^{c}	6.86±0.0^{g}
	60	6.66±0.0^{e}	7.50±0.2^{d}	7.66±0.28 ^{d}	7.5±0.0^{c}	7.04±0.0^{d}
	90	6.66±0.0^{e}	7.50±0.2^{d}	7.63±0.28^{d}	7.5±0.0^{c}	6.86±0.0^{g}
Mean		6.675	7.5	7.8825	7.75	5.90

T3	0	5.72±0.2^{f}	7.91±0.1^{c}	7.56±0.40^{e}	7.75±0.2^{c}	6.79±0.1^{h}
	30	5.72±0.2^{f}	7.89±0.1^{c}	7.56±0.40^{e}	7.75±0.2^{c}	6.79±0.1^{h}
	60	5.72±0.2^{f}	7.86±0.1^{c}	8.33±0.28^{b}	7.75±0.2^{c}	6.94±0.0^{e}
	90	5.72±0.2^{f}	7.8±0.1^{c}	7.56±0.40^{e}	7.75±0.2^{c}	6.790±0.1^{g}
Mean		5.72	7.91	7.7525	7.75	5.82
T4	0	5.56±0.1^{j}	8.4±0.2^{a}	8.33±0.2^{b}	8.33±0.2^{b}	7.91±0.1^{a}
	30	4.56±0.1^{j}	8.33±0.2^{ab}	8.33±0.2^{b}	8.33±0.2^{b}	6.91±0.1^{f}
	60	4.61±0.1^{i}	8.33±0.2^{ab}	8.33±0.1^{b}	8.33±0.2^{b}	7.32±0.1^{a}
	90	4.90±0.2^{i}	8.25±0.3^{b}	8.33±0.3^{b}	8.25±0.3^{c}	6.87±0.1^{g}
Mean		4.90	8.31	8.33	8.31	6.25
CV		2.61	3.88	3.93	2.53	1.68

Microbial Quality of Pumpkin Juice

Bacterial and Mold Quality

Typically, microbial analyses serve as tracking indicators of food deterioration. Mold and bacteria were subjected to microbiological investigation; **Table 10** shows the variations in microbial counts over storage. Five samples were collected, and they were designated as T0, T1, T2, T3, and T4. T0 stands for the control glass bottle treatment.

According to the results, no substantial coliform was detected for 30 days, although the total number of plates increased over the course of storage. Additionally, the blending ratio and storage duration had a minor impact on the number of microorganisms that increased with time; T4 had a lower rate of microbial load rise than the control treatment. The blending ratio and storage time affect the growth of the microbial load during storage. A higher watermelon juice treatment results in a lower coliform count. This might be because watermelon juice has more sugar. This number climbed consistently to 13 x 102 after 90 days of storage. Since these values did not surpass the standard values of 1.0 x 1010 as documented in Ihekoronye (1985), they were within the safe level for juices. The interaction was not significant, however the main effect showed a significant result at $p<0.05$. The findings were nearly identical to those of a previous study on watermelon blends with beetroot juice during storage conducted by Ankush et al. (2015).

Table 10. The effect of blending ratio and storage duration on microbial load of juice.

Treatment		**MOLD**	**BACTERIA**
Blending Ratio	**ST**		
100% p	0	0.025±0.0^{c}	0.09±0.0^{c}
	30	0.025±0.0^{c}	0.04±0.0^{c}
	60	0.086±0.0^{c}	0.04±0.0^{c}
	90	0.086±0.0^{c}	0.56±0.4^{c}
P50%+B 40%+W 10%	0	0.00±0.0^{c}	0.00±0.0^{c}
	30	0.03±0.0^{c}	0.013±0.0^{c}
	60	0.05±0.0^{c}	0.03±0.0^{c}
	90	0.07±0.0^{c}	0.024±0.3^{c}
P50%+B 30%+W 20%	0	0.0±0.0^{c}	0.00±0.0^{c}
	30	0.02±0.0^{c}	0.013±0.0^{c}
	60	0.05±0.0^{c}	0.03±0.0^{c}
	90	0.06±0.0^{c}	0.046±0.0^{c}
P50%+B 40%+W 10%	0	0.0±0.0^{c}	0.00±0.0^{c}
	30	0.01±0.0^{c}	0.013±0.0^{c}
	60	0.04±0.0^{c}	0.03±0.0^{c}
	90	0.06±0.0^{c}	0.056±0.0^{c}
P50%+B 40%+W 10%	0	0.0±0.0^{c}	0.00±0.0^{c}
	30	0.04±0.0^{c}	0.015±0.0^{c}
	60	0.03±0.0^{c}	0.023±0.0^{c}
	90	0.05±0.0^{c}	0.045±0.0^{c}
CV		33.8	197

CONCULSIONS

The findings of this study demonstrate that blending ratios significantly influence the sensory attributes and nutritional composition of pumpkin juice fortified with beetroot and watermelon.

Optimal blending ratios were identified that maximized consumer acceptability while maintaining desirable levels of key nutrients.

Storage duration significantly impacted the quality of the fortified juice, with notable decreases in vitamin content, increases in microbial counts, and changes in sensory properties observed over time.

Pasteurization was found to be crucial in mitigating quality deterioration during storage.

Further research is recommended to investigate the impact of different processing techniques (e.g., pasteurization, high-pressure processing) on the stability and shelf life of the fortified juice and to

optimize packaging materials to minimize light exposure, oxygen ingress, and maintain product integrity.

Consumer acceptability trials to further refine the optimal blending ratios to be conducted and to assess the market potential of the fortified juice.

Exploration of the potential to incorporating natural preservatives or antioxidants to enhance the shelf life and maintain the nutritional quality of the juice needs to conducted

Investigation of the potential for scaling up production to commercial levels while ensuring consistent quality and maintaining the nutritional integrity of the product is further needed.

Declarations

Ethics Approval Committee: Not applicable(Project not funded)

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Author Contribution declaration

Shimelis Adimasu: Project conceptualization, investigation, project execution, Manuscript writing.

John Barnabas: Manuscript construction, analysis, editing, compilation, technical support, Communications.

Competing Interest declaration

Authors declare that there are no competing interests

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Figure 4. Material preparation (Appendix)



Figure 5. Determination of Crude Fiber Content (Appendix).



Figure 6. Sensory Acceptability Evaluation.



Figure 7. Protein analysis



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