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Production and Storage Stability of Composite Juice from Watermelon, Grape, Soursop, and Cashew Apple

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Abstract

Storage stability and keeping quality of fruit juice blends made from watermelon, grape, soursop, and cashew apple (WGSC) was investigated. The juice was divided into three portions and stored for 10 days in the room (WGSC1), refrigeration (WGSC2), and freezing temperatures (WGSC3). The sensory properties of the juice blend were determined on the first day of production prior to storage. Physiochemical properties, total viable, and coliform counts were determined for stored juice. The pH of the juice ranged from 4.0 to 5.1 and decreased with increasing days of storage. However, WGSC3 was not significantly different. Total soluble solids ranged from 3.2 to 5.2%, and vitamin C content ranged from 20.41 to 59.29 mg/mL. The sugar content of WGSC3 (5.2 ^{o}Brix) was found to be the highest. The vitamin C content decreased with an increase in storage days under varying storage temperatures. Furthermore, the total titratable acidity ranged from 0.024-0.103%, with an increase in storage days and varying storage temperatures studied. The specific gravity varied between 1.01% and 1.03%, and the total solids ranged from 5.01 to 6.23% and increased with increasing storage days. The total viable bacteria count of juice samples ranged from 1×10^3 to 9×10^3. Although no coliform was detected, the total fungi spore count increased at the 5th and 10th days of storage. However, the microbial counts of the samples were within the acceptable limits (1×10^5 CFU/mL). An acceptable and quality watermelon-grape-Soursop-Cashew apple juice can be preserved without a chemical preservative at room, refrigeration or freezing storage temperatures for 10 days.

Keywords: *Juice, blends, proximate composition, acidity, total viable count, sensory qualities*

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Introduction

Fruit juice is an unfermented but fermentable liquid obtained from the edible portion of mature and fresh fruit intended for direct consumption (Akinola et al., 2018; Woodroof and Luh, 2000; FAO/WHO, 2005). Fruit juice is often regarded as either an appetizer or a desert after major meals, hence the need for its preservation. Most fruits are prone to spoilage, especially in tropical regions of the world where the weather conditions encourage microbial and enzymatic degradation of agricultural commodities. In addition, postharvest losses of fruits and vegetables are also associated with poor storage, processing, and distribution facilities (Siddiqui et al., 2015). Hence, there is a need to process them into juice, which is usually preserved by the use of chemical and biological preservatives to arrest the chemical and enzymatic action that causes degradation in fruit juices. There has been concern for public health over the use of chemical preservatives, which have been alleged to be associated with the spread of degenerative diseases (Akinola et al., 2017; Walker and Phillip, 2008). Juice is a liquid extract from nectars or fleshy parts of fruits and vegetables that possess qualities that correspond to the type of fruits they emanate from, and several fruits and vegetables have been exploited in the production of fruit juices with an inexhaustible list.

Watermelon (*Citrullus lanatus*) is a rich source of beta-carotene, lycopene, and carotenoids, which have the potential to act as antioxidants. Beyond the presence of lycopene, it is a source of B vitamins, mainly B_1 and B_6, as well as health-promoting minerals such as potassium and magnesium (Huh et al., 2008). Grape *(Genus vitis)* is a non-climacteric fruit grown mostly in the orient and is known to be a good source of vitamins C, A, K, carotenes, and B-complexes. Soursop (*Annona muricata* L.) is a juicy fruit with reported juice claimed to be rich in amino acids, vitamins, especially ascorbic acid, fibre, proteins, unsaturated fats, and essential minerals (Amusa et al., 2005; Aluko, 1989). While cashew apple (*Anacardium occidentale*) is good and enriched with sugars, minerals, and vitamins, it is acknowledged as one of the richest sources of ascorbic acid, B complex, and other vitamins (Attri, 2009).

Therefore, the combination of two or more fruit juices to form a blend has been widely accepted by consumers, who believe it will deliver better utilization and promotion of better health as well as a reduction of fruit waste, which in turn reduces postharvest losses and improves nutritional value, food security, and the health of consumers (Akande and Ojekemi, 2013). Several popular techniques include heat treatment (boiling, pasteurization) and the use of chemical preservatives to improve the shelf life of processed fruits (Quek et al., 2012; Umme et al., 2001). In spite of these benefits, the use of chemical preservatives has been associated with negative effects on health via food toxicity, immune depression, and cancer in consumers. This has led to the ban or restriction of permissible uses of artificial preservatives (Vwioko et al., 2013). Therefore, this study is aimed at determining the storage stability of naturally blended watermelon, grape-soursop-cashew apple juice and their quality under three storage temperature and time conditions.

Materials and Methods

Materials

Freshly harvested and fully ripe watermelon (*Citrus lanatus*), grape (*Genus vitis*), cashew (*Anacardium occidentale),* and soursop (*Annona muricata*) used for this work were sourced from a known retailer at Erekesan Market, Akure, Ondo State, Nigeria. All chemical reagents used were of analytical grade and were purchased from Pascal Chemicals, Akure, Ondo State.

Methodology

A juice blend was produced as shown in Figure 1. Fruits (watermelon, grape, soursop, and cashew apple) were sorted and cleaned by washing with sodium hypochlorite and then rinsed in portable water. Fruits were peeled using a sterile stainless-steel knife to reveal their pulp and for seed removal. The pulps were blended and filtered using a clean muslin cloth to obtain juice filtrate. The different fruit juices were mixed in the proportions 70:10:10:10 (watermelon, grape, soursop, and cashew apple), respectively, and packaged into opaque glass bottles. Juice samples were pasteurized at 70 ºC for fifteen minutes.

The juice produced was divided into three portions and stored for a duration of 10 days at different storage temperatures. The first portion (WGSC1) was stored at room temperature (25±2 ºC), the second portion was stored at refrigeration temperature (WGSC2) of 4±2 ºC, and the third portion was stored at freezing temperature (WGSC3) of -4±2 ºC throughout the experiment. The samples were then analysed for physicochemical properties and microbial quality with increasing storage days. Juice samples analysed at day zero served as the control in the study.

Chemical analysis

The chemical properties (pH, titratable acidity, sugar content, total solids, and ascorbic acid) of juice samples were all determined using standard methods as described by AOAC (2014) and specific gravity (Crawford and Gould, 1957). All analyses were made in triplicate.

Microbiological analysis

The effect of storage temperature and time on the microbial quality of the juice blend was determined using standard pour plating techniques (Adeola and Aworh, 2014; Harrigan and McCane, 1976). One mL of juice blend was serially diluted and plated on nutrient agar.

(Merck, South Africa) for total viable bacteria count (TVBC), while the total mould and yeast viable spores were determined by plating on Sabouraud Dextrose agar (SDA, Biomark Laboratories, India). The total coliform count (TCC) was assayed by plating on MacConkey agar (MCA, Merck). Inoculated bacteria plates (TVBC and TCC) were incubated aerobically at 37 ºC for 24 h, while the fungi plates were incubated at 28 ºC for 72 h. The counts were expressed in colony-forming units per millilitre (CFU/mL).

Sensory evaluation

Sensory evaluation was conducted on the juice blend using a panel of 20 untrained panellists comprising both staff and students of the Department of Food Science and Technology, Federal University of Technology, Akure, Nigeria. The panel was comprised of members who are regular consumers of fruit juices. The panellists evaluated samples based on colour/appearance, taste, aroma, and overall acceptability on a nine-point hedonic scale, ranging from like extremely (9 points) to dislike extremely (1 point).

Statistical analysis

Statistical Package for Social Sciences version 16.0 was employed in the statistical analysis of the data obtained from the study. Data were collected in triplicate, and the means were determined using analysis of variance (ANOVA). The means were separated using the Duncan New Multiple Range Test (DNMRT) at a confidence interval of $P \geq 0.05$.

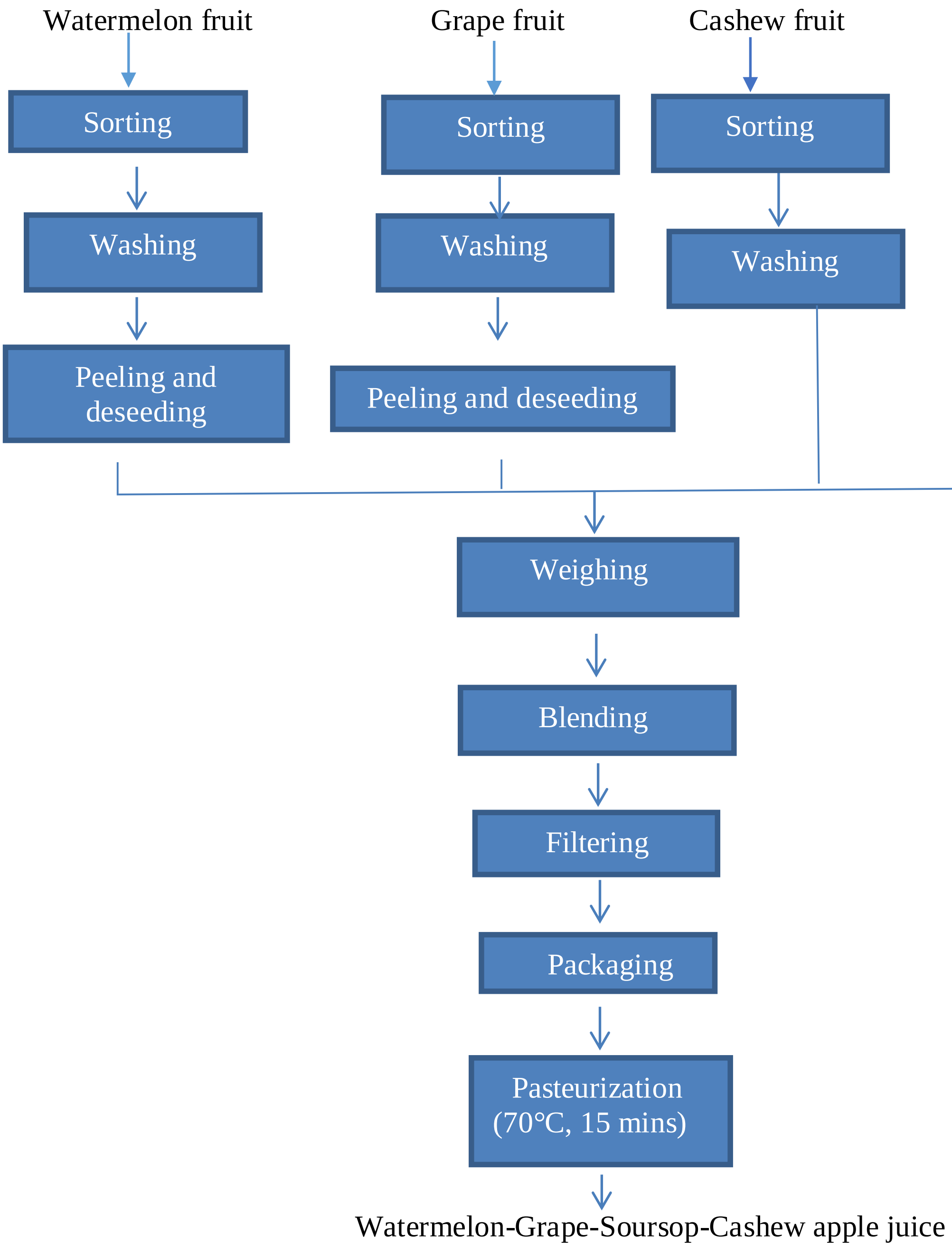

Figure 1: Production of Watermelon-Grape-Soursop-Cashew apple juice

Results and Discussion

Chemical analysis

The effect of storage temperature and time on the chemical properties of watermelon-grape-soursop-cashew juice is presented in Table 1. The total soluble solids of the juice blend ranged from 3.17 to 5.40 °brix and decreased with increasing storage days. The soluble solids of WGSC3 were not significantly different from samples stored at room temperature (WGSC1) and WGSC2 (refrigeration temperature). The duration of storage influenced the soluble solid content of the juice blend; however, the storage did not. The total solid content of WGSC2 and WGSC1 followed the same trend as reported for WGSC3. However, a sharp decrease was observed in the juice blends as the days of storage increased as compared to the control (Day 0). This observation aligned with the findings of Akande and Ojekemi (2013), who observed and reported a decrease in total sugar with the storage period in the watermelon pineapple juice stored for 6 weeks. The reduction in total soluble solids showed that the chemical reactions that could degrade sugars or reduce their concentration are at their minimum.

The total solids of the juice samples ranged from 5.01 to 6.67 mg/mL for the storage period of ten days. The total solids of juice samples increased with increased storage days, while no significant difference ($p \geq 0.05$) exists between the juice samples stored for 0–5 days and the samples stored for 10 days. The total solid content of the studied juice samples was highest in WGSC2, which was stored for 10 days. The duration of storage influenced the quality of stored watermelon-grape-soursop-cashew apple juice, while the temperature of storage influenced the total solid content of the developed juice blend after ten days of storage. This is in conformity with the findings of Kaur and Aggarwal (2014) and Akinola et al. (2018), who evaluated the effect of preservatives on the total solid content of bitter gourd juice and orange juice, respectively.

Table1: Chemical properties of watermelon-grape-soursop-cashew apple juice stored at different storage temperature and time

Storage days	Samples	Brix (degree)	Total solids (mg/mL)	TTA (%)	Vitamin C (mg/100g)
Day 0	**WGSC 1**	5.40^{a}±0.00	5.01 ^{c} ±0.01	0.024^{a}±0.01	52.22^{c}±0.15
	WGSC 2	5.40^{a}±0.00	5.11 ^{b}±0.01	0.023^{a}±0.01	57.85 ^{b} ±0.06
	WGSC 3	5.40^{a}±0.00	5.21 ^{a} ±0.01	0.024^{a}±0.06	59.29 ^{a} ±0.06
Day 5	**WGSC 1**	5.03^{b} ±0.58	5.72 ^{c} ±0.01	0.063^{b}±0.01	21.43^{c}±0.06
	WGSC 2	5.37 ^{a} ±0.58	5.75 ^{b} ±0.01	0.024^{a}±0.06	35.71^{b}±0.06
	WGSC 3	5.40 ^{a} ±0.00	5.74 ^{a} ±0.01	0.024^{a}±0.01	47.85 ^{a} ±0.01
Day 10	**WGSC 1**	3.17 ^{c} ±0.06	6.17 ^{b} ±0.01	0.103 ^{a} ±0.01	20.41 ^{c} ±0.01
	WGSC 2	5.17 ^{b} ±0.06	6.67 ^{a} ±0.01	0.062 ^{b} ±0.00	35.71 ^{b} ±0.01
	WGSC 3	5.37 ^{a} ±0.06	6.23 ^{a} ±0.01	0.024 ^{c} ±0.01	46.39 ^{a} ±0.30

Values represent means ± standard deviation of triplicate determination. The superscripts represent a significant difference in samples along the column at a 95% confidence interval ($P \geq 0.05$).
Keys: WGSC1 = Watermelon + Grape + Soursop + Cashew Apple juice stored at room temperature; WGSC2 = Watermelon + Grape + Soursop + Cashew Apple juice stored at refrigeration temperature; WGSC3 = Watermelon + Grape + Soursop + Cashew Apple juice is stored at freezing temperature; TTA = total titratable acid.

The total titratable acidity (TTA) of the juice blend stored at varied temperatures and times ranged from 0.023 to 0.103%. The TTA increased with an increased number of days of storage in all juice samples except in WGSC3. Both the time of storage and the temperature of storage influence the total titratable acid content of stored juice samples. The TTA was highest in the samples stored at room temperature, irrespective of the time of storage, except day zero, which served as the control. There is no significant difference ($p \geq 0.05$) between WGSC2 and WGSC3 from day zero to day five of storage; however, on day 10, there was a significant increase in TTA values. The increase observed in the samples stored at room and refrigeration temperatures could be due to the deteriorative activities of fermenting bacteria by converting organic sugars to acids, thus increasing the acidity of the samples. This supports the previous submissions of authors on the increase of TTA on storage (Akinola et al., 2017; Nwachukwu and Ezejiaku, 2014).

The ascorbic acid (vitamin C) content of the juice samples decreased with an increase in storage duration and was significantly different along the storage temperatures ($p \geq 0.05$), as shown in Table 1. The vitamin C content of stored juice ranged from 20.41 to 59.29 mg/100g. The vitamin C level decreased with an increase in storage temperature and was highest in the frozen juice samples (WGSC 3). The vitamin C was lowest in the samples kept at room temperature for 10 days (WGSC 3). There is a significant difference in juice samples based on storage temperature and time. The observed decrease in the vitamin C content of the juice blend could be due to the degradative nature of ascorbic acid when exposed to light and oxygen. Similar findings have been reported on the influence of storage time on the quality of vitamin C in juice (Akinola et al., 2018; Akinola et al., 2017; Bhattacherjee et al., 2014).

Figure 2 presents the effect of storage temperature and time on the pH of the juice blend. The pH of samples ranged from 4 to 5.1 and was highest in the WGSC3 and was not significantly different with the effect of days of storage. The pH of the juice sample (WGSC3) was influenced by both the temperature and the time of storage, while samples WGSC1 and WGSC2 were influenced by temperature and not time of storage. The observed high effect of temperature on the pH value in the WGSC1 could be due to a more conducive temperature for microbial activity, which could increase the pH of fruit juices by the production of acids as metabolites. Also, the decrease in pH might be due to the possible biochemical reactions that may lead to a decrease in pH (Akande and Ojekemi, 2013). Fruit juices have a low pH because they are comparatively rich in organic acids (Tasnnim et al., 2010). The findings in this study support the findings of Bhardwaj and Mukherjee (2011), who evaluated the effect of juice blends on juice stored at ambient temperatures, and Makanjuola et al. (2013), who investigated the effect of different preservation methods on the quality attributes of selected tropical fruit juices.

The effect of storage temperature and time on the specific gravity of the stored juice blend is presented in Figure 3. The specific gravity of the samples ranged from 1.0 to 1.03 g/cm3. The effect of storage temperature and time was not significant ($P \geq 0.05$) on the stored juice samples. This finding supports the previous report of Akande and Ojekemi (2013), who worked on the biochemical changes in watermelon-pineapple juice during storage, specifying that specific gravity is not influenced by storage temperature and time.

Microbial analysis

The total viable count of food samples is regarded as an index of the safety of food commodities. The effect of storage temperature and time on the microbial counts of stored juice blends is presented in Table 2. The total viable bacteria count of the juice samples ranged from 2 x 10^3 to 1 x 10^4 CFU/mL and TFSC (4 x 10^3 to 2.0 x 10^4 CFU/mL). No coliform count was detected in the samples with increasing days of storage and temperature. The TVBC and TFSC increased with increasing storage temperature and time in all samples studied. However, the TVBC and TFSC values were within the acceptable limits (10^6 CFU/mL) in foods (Kornacki, 2017). The TVBC and TFSC were highest in the sample stored for 10 days at room temperature (WGSC1). TVBC and TFSC were the lowest in the frozen sample stored for 5 days as compared to the control. Hence, storage conditions such as storage temperature and time could influence the shelf life of watermelon-grape-soursop-cashew apple juice. Low microbial count observed on day zero and at freezing storage might be attributed to the high acidity and high level of hygiene employed during sample preparation. This result conforms to the findings of Adeola and Aworh (2014) on a tamarind beverage and Nwachukwu and Ezeigbo (2013), who worked on the effect of preservatives and lime on the microbial quality of pasteurized soursop juice.

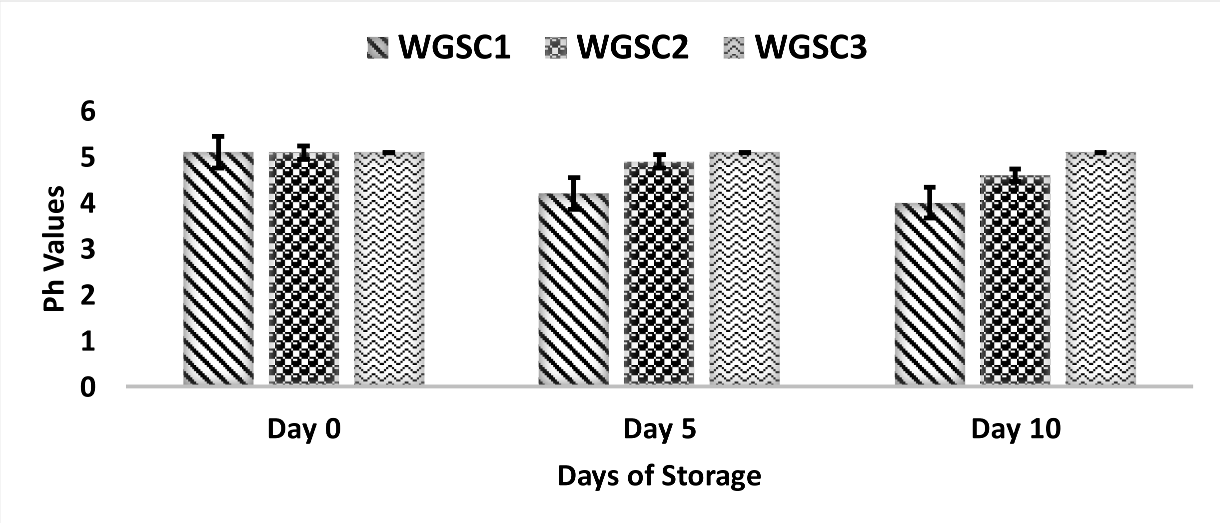

Figure 2: Effect of storage temperature and time on the pH of Watermelon-Grape-Soursop-Cashew Apple Juice.
Keys: WGSC1 = Watermelon + Grape + Soursop + Cashew Apple juice stored at room temperature; WGSC2 = Watermelon + Grape + Soursop + Cashew Apple juice stored at refrigeration temperature; WGSC3 = Watermelon + Grape + Soursop + Cashew Apple juice is stored at freezing temperature; TTA = total titratable acid.

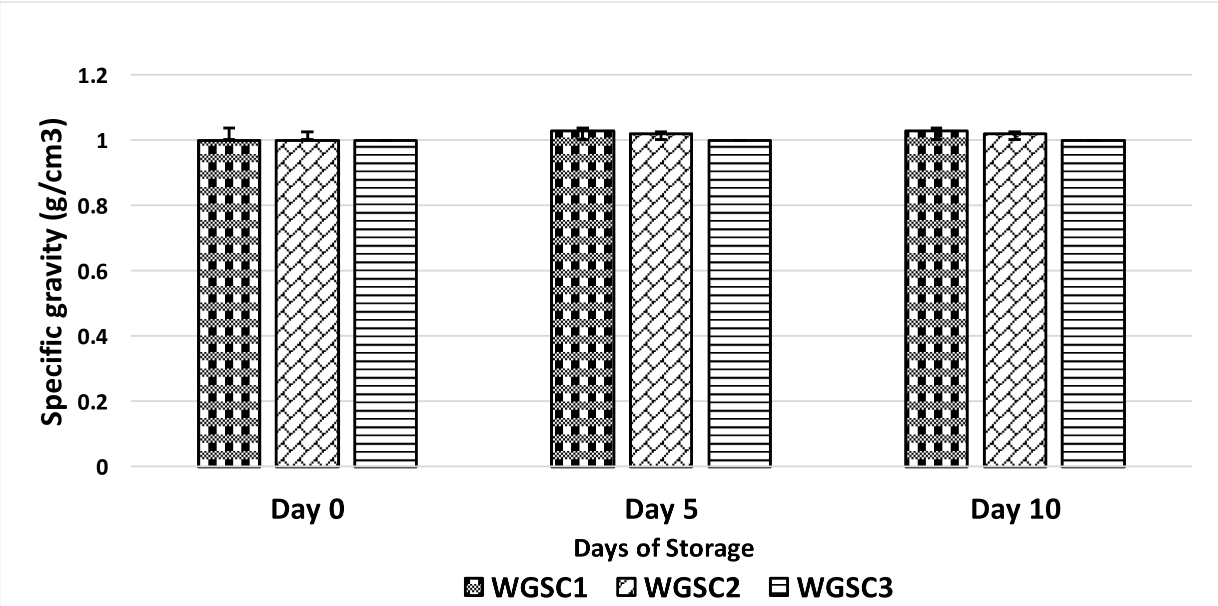

Figure 3: Effect of storage temperature and time on the Specific Gravity of Watermelon-Grape-Soursop-Cashew Apple Juice.
Keys: WGSC1 = Watermelon + Grape + Soursop + Cashew Apple juice stored at room temperature; WGSC2 = Watermelon + Grape + Soursop + Cashew Apple juice stored at refrigeration temperature; WGSC3 = Watermelon + Grape + Soursop + Cashew Apple juice is stored at freezing temperature; TTA = total titratable acid.

Table 2: Effect of storage temperature and time on the microbial quality of Watermelon-Grape-Soursop-Cashew apple juice.

Storage days	Samples	TVBC (CFU/mL)	TFSC (CFU/mL)	TCC (CFU/mL)
Day 0	**WGSC1**	3×10^3	ND	ND
	WGSC2	2×10^3	ND	ND
	WGSC3	2×10^3	ND	ND
Day 5	**WGSC1**	6×10^3	1.4×10^4	ND
	WGSC2	4×10^3	1.1×10^4	ND
	WGSC3	3×10^3	4×10^3	ND
Day 10	**WGSC1**	1.0×10^4	2.0×10^4	ND
	WGSC2	9×10^3	2.0×10^4	ND
	WGSC3	7×10^3	8.0×10^3	ND

Values are a means of triplicate determination. Keys: WGSC1 = Watermelon-Grape-Soursop-cashew Juice Blend stored at room temperature; WGSC2 = watermelon-grape-soursop-cashew juice Bend stored at refrigeration temperature; WGSC3 = watermelon-grape-soursop-cashew juice Blend stored at freezing temperature; TVBC = Total Viable Bacteria Count; TFSC = Total Fungi Spore Count; TCC = Total Coliform Count.

Sensory evaluation of the juice samples

Table 3 presents the sensory evaluation of juice blends. The panellists score for the taste of samples ranged from dislike moderately to dislike slightly. The better-rated sample in terms of taste was the WGSC2; however, it's comparable to the WGSC3. The colour of the samples was rated like slightly while the flavour was neither liked nor dislike. The viscosity of juice samples was scored as dislike slightly, while the overall acceptability of samples ranged from dislike slightly (4) to like slightly (6). Based on temperature, the taste and overall acceptability of sample WGSC2 were preferred to those of sample WGSC1. There was no significant difference ($p\geq0.05$) in the colour, taste, flavour, and thickness of the samples stored at room temperature, refrigeration temperature, and freezing temperature. There was a significant difference in the overall acceptability of the samples. The observed low score for taste, flavour, and viscosity of the WGSC3 juice sample could be due to the cold storage applied to the juice that formed ice crystals within the juice. This was believed to have had a negative effect on the assayed qualities of the juice. Also, the WGSC1 scored lowest in overall acceptability of the juice samples; this might be due to the expected chilling property of the juice and the tart taste emanating from the soursop, which was believed to have been masked by the cold temperature in other samples.

Table 3: Sensory evaluation of the watermelon-grape-soursop-cashew juice blend

Samples	Taste	Colour	flavour	Viscosity	Overall acceptability
WGSC1	$3.86^b\pm1.88$	$6.56^b\pm1.28$	$5.64^a\pm2.06$	$4.21^c\pm1.63$	$4.71^{b}\pm1.64$
WGSC2	$4.29^a\pm1.77$	$6.64^a\pm1.35$	$5.43^b\pm2.21$	$4.57^a\pm1.56$	$5.71^{ab}\pm1.33$
WGSC3	$4.21^a\pm2.67$	$6.64^a\pm1.74$	$5.07^c\pm2.46$	$4.50^b\pm1.99$	$6.29^{a}\pm1.86$

Values represent the means ± standard deviation of triplicate determinations. Values with different superscripts are significantly different along the column at $p<0.05$.
Keys: WGSC1=watermelon-grape-soursop-cashew juice blend stored at room temperature; WGSC2 = watermelon-grape-soursop-cashew juice blend stored at refrigeration temperature; WGSC3 = watermelon-grape-soursop-cashew juice blend stored at freezing temperature.

Conclusion

The time of storage influences the total soluble solid content of the juice blend, not the storage temperature. The total solids content of the juice blend increased with increased storage time, while the total titratable acidity, ascorbic acid, and pH of watermelon-grape-soursop-cashew apple juice are a function of its storage time and temperature. On the other hand, the temperature and time of storage of the studied juice have no relationship with its specific gravity. The microbial quality of stored juice increases with increasing temperature and time of storage. From a food safety perspective, WGSC1, WGSC2, and WGSC3 are of good quality; however, WGSC3 is mostly preferred by panellists. Further studies could be done on the sensory assessment of this product using electronic tongue systems.

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Declaration of Competing Interest

The authors declare no conflict of interest.

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