EFFECTS OF STORAGE ON PHYSICOCHEMICAL PROPERTIES OF ORANGE-WATERMELON JUICE

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Abstract
Watermelon and orange were prepared in different blends 100:0 (Z4Y), 70:30 (APC), 50:50 (PVC), 30:70 (720) and 0:100 (PHC). The effects of storage on the physicochemical and quality characteristics of various refrigerated mixed orange and watermelon juices and their changes with storage time and temperature were investigated. The physicochemical characteristics of the juice were determined, Brix for orange juice was 12^{o} brix, acidity 0.18 g/ml, ascorbic acid 0.546 mg/100ml, pH 4.4, viscosity 0.1 DPa/s, specific gravity 1.0533, and the Brix values of watermelon 8.0^{o}brix, acidity 0.12 g/ml, and ascorbic acid 2.70±0.05 mg/100ml, pH 5.2, viscosity 0.1 DPa/s and specific gravity 1.0331. The results of the free radical scavenging ability of the juice against DPPH (1, 1- diphenyl-2-picryhydrazyl) in percentage were: PHC (40.22±0.06), Z4Y (10.24±0.08), PVC, (39.76±0.08), 720 (43.97±0.08) and APC (37.46±0.05); Total Phenolic Contents (TPC) in mg/g: PHC (0.67±0), Z4Y (0.42±0.01), PVC (0.56±0.02), 720 (0.68±0.01) and APC (0.48±01) and lycopene content in mg/100g: PHC (0.46±0), Z4Y (0.42±0.01), PVC (0.37±0.01), 720 (0.64±0) and APC (1.18±0.07). The acceptability of the product by sensory evaluation indicated that the overall acceptability of juice improved with increase in percentage of watermelon juice in the blend (sample 720). Some of the parameters could be used as indicators of quality loss or spoilage of the juices. The shelf life of the juices was established at 4 °C. The watermelon: orange juice 70:30 (APC) was accepted in all parameters and can be introduced on shelf.

Keywords: Watermelon, Orange, Juice, Blends, Physicochemical characteristics

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1.INTRODUCTION

Juices are often consumed for their perceived health benefit. 100% juices are naturally nutritious, while the calorie content can vary slightly from juice to juice; most 100% fruit juices have only 60-80 calories per 4-ounce (112 grams) portion. It contains naturally-occurring phytonutrients - compounds found in fruits, vegetables and other plants that researchers believe have disease-preventative and disease fighting properties. Natural fruit juices are a source of key nutrients like folate, vitamin C and potassium. In addition, research shows that drinking 100% fruit juice are associated with a more nutritious diet overall. Studies suggest that appropriate consumption of 100% juice is linked to an overall healthier eating pattern, including reduced intake of total dietary fat, saturated fat and added sugars (Baghurt, 2003).

Oranges, like other citrus fruits, is an excellent source of vitamin C (provides 53.2 mg per 100 g, about 90% of Daily Recommended Intake - DRI); Vitamin C is a powerful natural antioxidant. However, in the recent years, mixed juices, such as orange/carrot, orange/peach, peach/grape, have been commercialized with a very good success. Orange juice provide human with vitamin C as its major nutrient.The ascorbic acid content represents a stimulating factor for citrus fruit consumption (Lee and Coates, 1987). Fish *et al.* (2002) stated that watermelon is a gastronomically pleasing food and is rich in lycopene which makes it a highly desirable source of this phytochemical. Production of refrigerated fruit and vegetable juice mixtures with inherent health benefits has recently begun in the most developed countries. These juices are not derived from concentrates and in some cases are subjected to mild pasteurization, which increases their shelf life. Quality of these juices is very similar to that of freshly extracted juices. Combination of watermelon with orange juice will provide a nutrient-dense juice suitable for both the young and the adult. Much work has been done on the development, influence of storage conditions and nutritional advantages on orange or watermelon juice, on their own or mixed with other fruits or as enriched drinks (Charoensiri *et al*., 2009; Katherine *et al*., 2008; Oms-Oliu *et al*., 2009; Perkins-Veaize *et al*., 2006;Shofian *et al*., 2011), but nothing has been reported on the effects of storage conditions (refrigeration and ambient storage) on orange-watermelon juice. The objectives of the study therfore were to:

1 evaluate the effects of storage conditions on the physico-chemical characteristics of orange-watermelon juice
2 determine the quality acceptability of the orange-watermelon juice by sensory evaluation.
3 determine antioxidant characteristics of orange-watermelon juice

2. MATERIALS AND METHODS

2.1 Sample Collection

Orange and watermelon fruits were obtained from Shasha market, Akure Ondo State. Orange was extracted with an automatic orange extractor (Zomoval citrus extractor model 391) while watermelon was juiced whole (with the back and seed) with champion juice extractor at Esabol Juice Bar, Coca cola plaza, FUTA, Akure.

2.2 Production Process

The general production process for orange juice was as follows: after proper washing of the fruits, they were subjected to an extraction process (using Zumoval extractor). The juice was passed through a sieve to remove the pulp/fiber. The orange juice was collected into a bowl where it was taken in proportion for mixing with watermelon. The Brix and pH of the orange were determined.

For watermelon, the fruit was washed and subjected to cutting and the juice extracted using Champion fruit juicer and sieved to obtain a clear juice, The Brix and pH of the watermelon were determined. The juices were then pasteurized at 70^{o}C for 15min in a thermostatically controlled water bath. The juices were then mixed in proportions of 50-50, 30–70 and 100 percent in PET bottles of 200 ml each. Each sample was prepared in six bottles for refrigeration temperature (4-8 °C) and also for room temperature (30 °C). The samples were stored under refrigerated conditions for two weeks. The production flow chart is as shown in figure 1 below.

3. RESULTS AND DISCUSSION

3.1 Results

The titratable acidity pattern for orange, watermelon, and orange-watermelon juice is presented in Table 1, the titratable acidity ranged from 0.12-0.24 g/ml with the acidity increasing by the days.

Table 2 shows the pH range of all the samples i.e orange, watermelon and their blends with respect to storage time, the pH value ranged from 4.2-5.1 with the value reducing as storage increases. The resistance of the juice to flow is presented on Table 3.

The brix content of Orange-Watermelon juice is shown on Table 4, the values remaining constant with storage time.

Specific gravity of Orange-Watermelon juice is presented in Table 5

The sensory quality of the juices is presented on Table 6, mean scores ranged between 4.3864-7.7692.

The antioxidant properties of Orange-Watermelon juice is presented in Table 7 which was high in DPPH and low in lycopene.

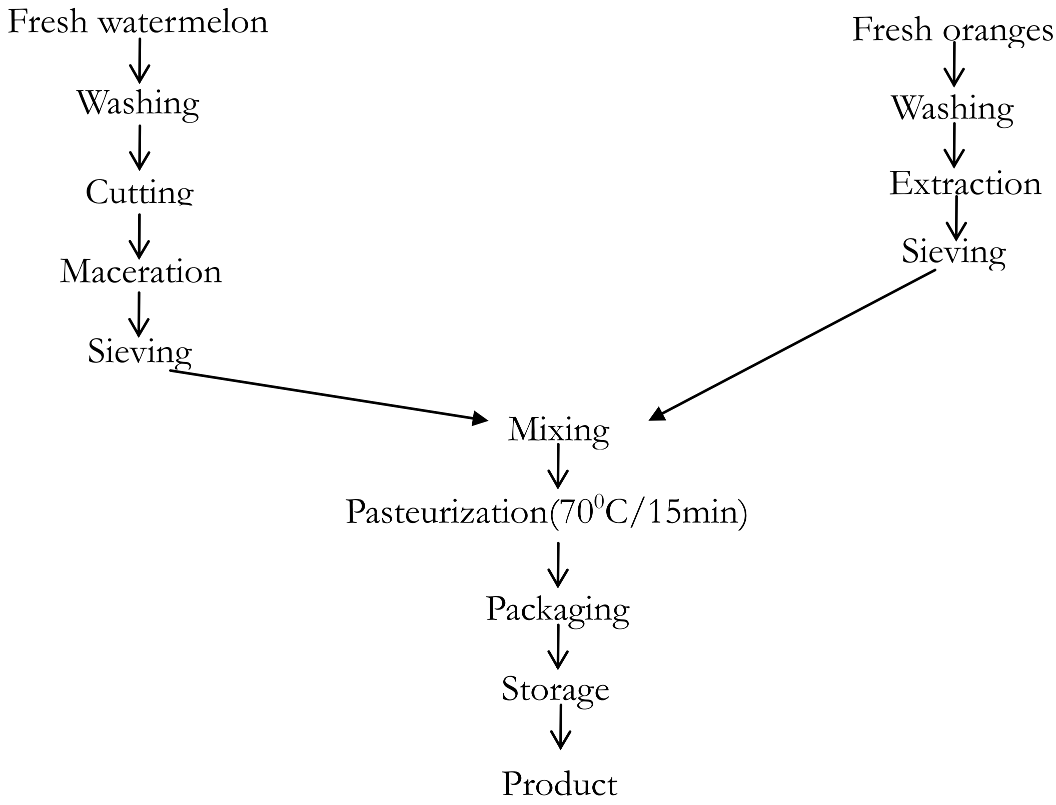

Figure 1: Flow chart for production of orange-watermelon juice

Table 1: Titratable acidity pattern with days (g/ml)

Titratable acidity	day1	day2	day5	day8	day12
Z4Y	$0.12^{b}\pm0.02$	$0.12^{b}\pm0.02$	$0.12^{b}\pm0.02$	$0.12^{c}\pm0.02$	$0.18^{b}\pm0.02$
PHC	$0.18^{a}\pm0.01$	$0.18^{a}\pm0.00$	$0.18^{a}\pm0.01$	$0.24^{a}\pm0.02$	$0.24^{a}\pm0.02$
PVC	$0.18^{a}\pm0$	$0.18^{a}\pm0.02$	$0.18^{a}\pm0.02$	$0.18^{b}\pm0.00$	$0.22^{a}\pm0.03$
720	$0.18^{a}\pm0.02$	$0.18^{a}\pm0.01$	$0.18^{a}\pm0$	$0.24^{a}\pm0.04$	$0.24^{a}\pm0$
APC	$0.12^{b}\pm0.01$	$0.12^{b}\pm0$	$0.12^{b}\pm0.02$	$0.24^{a}\pm0.02$	$0.24^{a}\pm0.02$

Values with different superscript on the same column are significantly different ($p \leq 0.05$)

- PHC =100 percent orange juice
- Z4Y = 100 percent watermelon
- PVC = 50%orange and 50% watermelon
- APC = 70% watermelon and 30% orange
- 720 = 30% watermelon and 70% orange

Table 2: pH range of orange-watermelon juice

pH	day1	day2	day5	day8	day12
Z4Y	$5.1^{a}\pm0.06$	$5.2^{a}\pm0.1$	$5^{a}\pm0$	$5.0^{a}\pm0$	$5.0^{a}\pm0.1$
PHC	$4.4^{d}\pm0.1$	$4.4^{d}\pm0.1$	$4.4^{c}\pm0.1$	$4.4^{c}\pm0$	$4.2^{d}\pm0$
PVC	$4.8^{bc}\pm0.1$	$4.7^{c}\pm0.1$	$4.7^{b}\pm0.1$	$4.7^{bc}\pm0.1$	$4.6^{c}\pm0$
720	$4.7^{c}\pm0.1$	$4.6^{c}\pm0.1$	$4.6^{b}\pm0.1$	$4.6^{c}\pm0$	$4.6^{c}\pm0.1$
APC	$4.9^{b}\pm0.1$	$4.9^{b}\pm0.1$	$4.9^{a}\pm0.1$	$4.8^{b}\pm0.1$	$4.8^{b}\pm0$

Values with different superscript on the same column are significantly different ($p \leq 0.05$)

Table 3: Viscosity trend with increasing days (DPa/s)

Viscosity	day1	day2	day5	day8	day12
Z4Y	0.1^{b}±0.02	0.1^{b}±0	0.1^{b}±0.03	0.2^{a}±0	0.2^{a}±0.02
PHC	0.2^{a}±0.02	0.2^{a}±0	0.2^{a}±0.02	0.1^{b}±0.02	0.1^{b}±0
PVC	0.2^{a}±0	0.2^{a}±0.02	0.2^{a}±0	0.1^{b}±0	0.2^{a}±0.03
720	0.2^{a}±0.02	0.2^{a}±0	0.2^{a}±0.03	0.2^{a}±0.03	0.1^{a}±0.03
APC	0.1^{b}±0	0.1^{b}±0.02	0.1^{b}±0	0.2^{a}±0	0.2^{b}±0

Values with different superscript on the same column are significantly different ($p \leq 0.05$)

Table 4: Brix content of orange-watermelon juice (^{O}Brix)

Brix	day1	day2	day5	day8	day12
Z4Y	8^{d}±0.2	8^{d}±0.2	8^{d}±0.2	8^{d}±0.2	8^{d}±0.2
PHC	12^{a}±0.1	12^{a}±0.1	12^{a}±0.1	12^{a}±0.1	12^{a}±0.1
PVC	10^{c}±0.2	10^{c}±0.2	10^{c}±0.2	10^{c}±0.2	10^{c}±0.2
720	10.8^{b}±0.1	10.8^{b}±0.1	10.8^{b}±0.1	10.8^{b}±0.1	10.8^{b}±0.1
APC	10^{c}±0	10^{c}±0	10^{c}±0	10^{c}±0	10^{c}±0

Values with different superscript on the same column are significantly different ($p \leq 0.05$)

Table 5: Specific gravity of orange-watermelon juice

day1	day2	day5	day8	day12
1.03^{d}±0.0001	1.04^{e}±0.001	1.04^{e}±0.001	1.04^{e}±0.0001	1.04^{e}±0.001
1.05^{a}±0.0001	1.05^{a}±0.0001	1.05^{a}±0.0001	1.05^{a}±0.0001	1.05^{a}±0.0001
1.04^{c}±0.001	1.04^{d}±0.0001	1.04^{d}±0.0001	1.04^{c}±0.0001	1.04^{d}±0.0001
1.04^{b}±0.0001	1.04^{c}±0.0001	1.04^{c}±0.0001	1.04^{d}±0.0001	1.04^{b}±0.0001
1.04^{c}±0.001	1.05^{b}±0.001	1.05^{b}±0.0001	1.05^{b}±0.0001	1.05^{c}±0.0001

Values with different superscript on the same column are significantly different ($p\leq 0.05$)

Table 6: Antioxidant properties of orange-watermelon juice

Anti-oxidant	DPPH	Lycopene	Phenol
PVC	39.76^{c}±0.08	0.37^{d}±0.01	0.56^{b}±0.02
APC	37.46^{d}±0.05	1.18^{a}±0.07	0.48^{c}±0.01
720	43.97^{a}±0.08	0.64^{b}±0	0.68^{a}±0.01
Z4Y	10.24^{e}±0.08	0.22^{e}±0	0.42^{d}±0.01
PHC	40.22^{b}±0.06	0.46^{c}±0	0.67^{a}±0

Values with different superscript on the same column are significantly ($p \leq 0.05$)

Table 7: Sensory quality of orange – watermelon juice

Samples	Taste	Aroma	Appearance	Overall acceptability
PHC	4.3846^{b}	5.1538^{b}	6.3077^{b}	5.2308^{b}
Z4Y	7.6923^{a}	6.9231^{a}	7.7692^{a}	7.3846^{a}
PVC	5.5385^{b}	5.4615^{b}	5.8462^{b}	5.5383^{b}
APC	5.3846^{b}	5.6923^{ab}	6.3077^{b}	6.3077^{ab}
720	5.3846^{b}	5.6154^{ab}	6.1538^{b}	6.2308^{ab}

Values with different superscript on the same column are significantly different ($p \leq 0.05$)

3.2 Discussion

3.2.1 Titratable acidity of orange-watermelon juice

Organic acids contribute to the particular flavour and palatability of orange juice and are found as a result of biochemical processes, or, in the case of fermentations, through the development of certain spoilage microorganisms. To a large extent, acidity protects against the development of pathogens. In orange juice, citric acid is the most abundant, followed by malic, both being present mostly as free acids, although in limited quantities they are also combined as citrates or malates, which gives orange juice its buffer effect. There is no significant difference between sample Z4Y and APC also between samples PHC, PVC, and 720 throughout the period of storage but there is significant difference in Z4Y, APC and PHC, PVC and 720. There was no change in acidity level of PVC, APC and Z4Y throughout the period of storage, but PHC and 720 showed some level of increase towards the end of second week (Table 1). This increase in acidity indicates the start of spoilage or fermentation of the sample and it's in line with Rodrigo *et al.,* (2003).

3.2.2 pH range of orange-watermelon juice

There was no significant difference in the pH of the juice samples as one would expect, the pH values are lower in the juices with more acidity (i.e the juice containing more orange juice compared to watermelon). Owing to the presence of a natural buffer medium in orange juices (mainly potassium citrates and malates), the variations in pH with storage were less pronounced than the variations in acidity. During the 12 days of storage at 4^{o}C the variations in pH observed in the juices studied are as follows; sample Z4Y was not significantly different throughout the period of storage, the same conclusion was reached by other authors (Esteve *et al*., 2005; kaanane *et al*., 1988; Martı´n *et al*., 1995) who studied the effect of storage time and temperature on the pH of juices. Sample PHC was significantly different on the 5th and the 8th day, sample PVC was significantly different on the 5th day of storage, sample 720 and APC were significantly different on the 5th day of storage.

3.2.3 Viscosity of orange-watermelon juice

Juices consist of a dispersing phase or serum, in which sugars, acids, soluble pectins, proteins, salts, etc., are dissolved, and a dispersed phase made up of particles of different sizes and volumes which come from the tissues of the fruit (Esteve *et al*., 2005). Irrespective of their pulp content, juices are considered Newtonian fluids. The viscosity of the juices is an important physical characteristic because it affects the manufacturing process, the conditions applied in the operation of stabilization, and acceptance by the consumer. During storage there were significant differences on the 8th day and 12th day of storage in all the samples. Sample Z4Y and APC are significantly different from samples PHC, PVC and 720 (Table 3). Significant changes in the viscosities of the juices observed after one week of storage may be connected with the onset of spoilage or the enzymatic reaction described earlier (Table 3).

3.2.4 Percentage brix of orange-watermelon juice

°Brix values were not significantly affected by thermal pasteurization. There was no significant difference between each sample throughout the period of storage. But there was significant difference between the samples Z4Y, PHC, PVC, 720, and APC. The brix value ranges from (8-12.8) for all the samples. (Table 4)

3.2.5 Specific gravity of orange-watermelon juice

The values obtained in the juices analyzed are within the recommended range (1.045–1.055 g/L) (Esteve *et al.,* 2005). There was no significant difference at ($p \leq 0.05$) level of significance in juice PHC throughout the period of storage but there was significant difference between sample PHC and other samples also there was significant difference between sample PVC, 720 and APC during the period of storage. Sample Z4Y on the first day was significantly different from all other period of storage. Sample PHC has the highest specific gravity throughout the period of storage (Table 5).

3.2.6 Antioxidant properties of orange-watermelon juice

Phenolic compounds are major plant secondary metabolites. They are found in rather large quantities in plant based foods and beverages and considered beneficial for human health. The key role of phenolic compounds as scavengers of free radicals is emphasized in several reports (Dueñas *et al.*, 2006). It has been reported that there is a direct relationship between the phenolic content and antioxidant capacity of plants (Al-Mamary *et al.*, 2002). The present results for total phenolic contents are in accordance with the outcomes of Shofian *et al*. (2011). They stated total phenolic contents 29.32 mg/100g for fresh watermelon that was comparatively higher than muskmelon. Findings of Fu *et al*., (2011) reported similar trend for TPC comparable with that of present research. They delineated total phenolic contents of three different watermelon varieties (i.e Jintong, red pulp and yellow pulp by 23.15±1.47, 24.66±1.04 and 18.62±1.32 mg/100g GAE, respectively). Tlili *et al*. (2011) observed total phenolic contents of watermelon cultivars at various ripening stages and stated that Giza, Dumara, P403 and P405 had 26.02±0.6, 24.64±0.5, 20.08±0.6 and 18.34±0.5 mg/100g GAE of TPC, respectively.

The present results are further supported by the research work of Egydio *et al*. (2010) for DPPH radical scavenging ability (18.90±0.7 to 49.7±1.5%). The findings about the lycopene of orange-watermelon juice are not in agreement with Barba *et al*. (2006) who computed lycopene through HPLC in various fruits and vegetables i.e., watermelon, tomato, meddler, persimmon, pepper and carrot. They expounded that watermelon and tomato had higher lycopene contents. The low lycopene content of the sample tested may be due to the fact that the watermelon used for the analysis was not fully ripe on the field before harvest. According to UK CES (Cooperative Extension Service) the more matured a red watermelon is the more its lycopene content.

3.2.7. Sensory quality of orange – watermelon juice

There was significant difference between sample PHC and all other samples at ($P \leq 0.05$) level of significance with a very low level of acceptability. There was no significant difference between all the sensory parameters for sample Z4Y, PVC, APC and 720. (Table 7)

4. CONCLUSION

Except for the brix content of the juice, all the samples are significantly different throughout the period of storage. This is due to the variations in the mixing of the juice. The low lycopene content of the watermelon was due to low level of ripeness of the watermelon used for the production. Variations in the characteristics measured with storage were more marked towards the end of the storage.

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