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Microbiological and Some Sensory Attributes of Water Melon Juice and Watermelon-orange Juice Mix

¹U.J.J. Ijah, ¹H.S. Ayodele and ²S.A. Aransiola

¹Department of Microbiology, Federal University of Technology, P.M.B. 65, Minna, Nigeria

²Bioresources Development Center, National Biotechnology Development Agency, KM 5, Ogbomoso/Iresapa Road, Onipaanu, Ogbomoso, Oyo State, Nigeria

Corresponding Author: S.A. Aransiola, Bioresources Development Centre, National Biotechnology Development Agency, KM 5, Ogbomoso/Iresapa Road, Onipaanu, Ogbomoso, Oyo State, Nigeria Tel: +2348034300190

ABSTRACT

Juice was produced from watermelon and stored at room ($28\pm 2^{\circ}\text{C}$) and refrigeration (8°C) temperatures and was analyzed for its microbiological and nutritional qualities. The total aerobic bacterial, coliform, mold and yeast counts increased with time. Total aerobic bacterial counts ranged from 1.5×10^2 to 3.6×10^3 for water melon juice (WM), 1.3×10^3 to 2.3×10^2 for water melon/orange juice mix (WO) and 1.0×10^3 to 2.9×10^2 for commercially packaged juice (ST). Coliform counts were 1.0×10^3 to 2.9×10^2 for WM, 2.1×10^2 to 2.3×10^3 for WO and no counts were recorded for ST, while the yeast counts ranged from 2.4×10^2 to 2.6×10^3 for WM, 2.4×10^3 to 3.2×10^3 for WO and 0 to 1.2×10^2 for ST. Bacteria isolated were *Bacillus* sp. *Staphylococcus aureus*, *Klebsiella* sp. and *Pseudomonas* sp., while the mold isolates were *Aspergillus niger*, *Aspergillus flavus* and *Mucor* sp. The yeast isolate was *Saccharomyces cerevisiae*. Vitamin C and total solid contents decreased with time while total titratable acidity and ash content increased on storage in freshly made juice samples, commercially packaged juice which served as a control showed negligible changes. The general acceptability tests revealed that the commercially packaged juice (ST) was preferred on account of taste and flavor while water melon juice (WM) was preferred based on colour. The water melon/orange juice mix (WO) was however, not preferred because of colour, flavor and taste.

Key words: Water melon juice, microorganisms, nutrients, sensory evaluation

INTRODUCTION

Watermelon (*Citrullus lanatus*) is a popular staple summer fruit in the world which is consumed frequently as a dessert, fruit salad and used in garnishing drinks. It is a natural source of antioxidants (Alim-un-Nisa *et al.*, 2012). Water melon is an unusual fruit source of the carotenoid lycopene and a rich source of phenolic antioxidants. It contains cucurbitacin E, a triterpene anti-inflammatory phytonutrient and unusual amounts of the amino acid citrulline (Dimitrovski *et al.*, 2010). Water melon is an excellent source of immune-supportive vitamin C. It is also a very good source of vitamin A (Dimitrovski *et al.*, 2010; Sivudu *et al.*, 2014). In addition, water melon is a good source of potassium and magnesium. The nutritional profile of water melon is full array of nutrients, including carbohydrates, sugar, soluble and insoluble fiber, sodium, vitamins, minerals, fatty acids, amino acids etc (Adedeji and Oluwalana, 2013).

Water melon juice, as a beverage, is found almost exclusively as an over-the-counter drink made by hand from the pink flesh of the water melon fruit. While in some cultures such as those of

Mexico and India, such water melon drinks are popular in Nigeria and elsewhere, water melon juice drinks are rare, with commercially available packaged water melon juice drinks still in its developing state (Alam *et al.*, 2013). Due to its low acidity and growing conditions, water melon is regarded as a potentially hazardous food (FDA., 2001). According to the CDC (2006) water melon caused a *Salmonella* outbreak in 2002 and 2006, a Norovirus outbreak in 2005 and 2006 and a *Campylobacter* outbreak in 2006. Because of these pathogens, water melon juice must be pasteurized prior to consumption. In the fruit juice industry, juice is typically pasteurized by High Temperature Short Time (HTST) pasteurization. This process uses plate heat exchangers to heat the sample quickly at 78°C (Alam *et al.*, 2013).

Juices are the aqueous liquids expressed or otherwise extracted usually from one or more fruits (Bello *et al.*, 2014). Juices are prepared mechanically by squeezing or macerating the pulp of fresh fruits or vegetables without application of heat or solvent to give an unfermented clouded, unclarified and untreated juice ready for consumption. Diluting or blending is a common practice as many fresh juices are either too acidic or too strongly flavored to be pleasant for consumption (Asha *et al.*, 2014). Fresh fruit and vegetable juices are an important part of modern day diet in many parts of the world as they are rich source of nutrients such as vitamins, minerals and other naturally occurring phytochemicals which are of health and therapeutic benefits (Ukwo *et al.*, 2011).

The consumption of fruit juices could have both positive and negative effects on the part of consumers. Fruit juices processed under hygienic conditions could play important role in enhancing consumer's health through inhibition of breast cancer, Congestive Heart Failure (CHF) and urinary tract infection (Bello *et al.*, 2014). However, freshly extracted juices may not always be safe owing to the heavy load of microbes. Major ingredients of juices such as water, sugar, natural fruit pulp, etc may also carry some microbial contaminants which may cause spoilage of the drinks or gastrointestinal disorders to consumers (Asha *et al.*, 2014). The food market has stimulated the development of new products that present good sensory acceptance and of high nutritional value. Development of new products where two or more kinds of fruit juices are blended to obtain a product that combines the nutritional value of both fruits with the benefit of a pleasant taste has been encouraged by the food industry and has been well accepted by consumers (Ameh *et al.*, 2015).

Pathogenic organisms can enter fruits and vegetables through damaged surfaces, such as punctures, wounds, cuts and splits that occur during growing or harvesting. Contamination from raw materials and equipment, additional processing conditions, improper handling, prevalence of unhygienic conditions contributes substantially to the entry of microbial pathogens in juices prepared from these fruits or vegetables. Processing the fruits to juice could therefore be the solution to the problem of spoilage of fruits. The aim of this research work was to produce juice from water melon and orange and determine the microbiological and nutritional qualities of the juice samples produced.

MATERIALS AND METHODS

Collection and processing of fruits: Mature, ripe healthy water melon and orange fruits were bought from different sales point in Bosso and Minna Central Markets, Minna, Niger State, Nigeria. The water melon and orange fruits were washed with distilled water to remove adhering soils, dirt and extraneous materials and then washed with 5% hypochloride solution and immediately rinsed again with distilled water. The fruits were peeled and cut into small pieces and the seeds were removed.

Production of watermelon and orange juice: The pieces of water melon were introduced into sterile juice extractor and the juice extracted. The juice extractor was thoroughly washed with distilled water and extraction of orange juice was also carried out with the same juice extractor. The juice was filtered separately using clean muslin cloth into sterile conical flasks. The fresh water melon juice was diluted 50:100 (that is, juice/water, respectively) and preservatives were added to the juice as follows:

- Flask 1: It contained 0.01 g sodium benzoic acid, 25 orange juice, 25 water melon juice and 100 distilled water
- Flask 2: It had 0.01 g sodium metabisulphite, 100 distilled water and 50 water melon juice

The flasks were corked for pasteurization. The juice samples were pasteurized at 80°C for 15 min in a hot water bath (Grant SUB 28). On cooling, the juice was dispensed into clean polythene and sealed with the aid of a sealing machine and stored at refrigeration temperature (8°C) for a period of 14 days. Commercially packaged juice served as the control.

Physicochemical analysis of fruit juice

Determination of pH: Ten milliliters of the juice was dispensed into a beaker and the pH was determined with a previously standardized pH meter (Labtech Digital). The pH meter was calibrated using phosphate buffer of pH 4.0 and 7.0 (AOAC., 2005).

Determination Total Titratable Acidity (TTA): Standard method of Antony and Chandra (1997) and Ferrati *et al.* (2005), was used to measure the titratable acidity. Five of the sample of fruit juice was homogenized in distilled water (20) and filtered through whatman No. 1 filter paper. Phenolphthalein was added to 20 of the filtrate as indicator and titrated against 0.05 M NaOH. Titratable acidity was calculated using the equation:

$$TA = \frac{M_{NaOH} \times NaOH \times 0.09 \times 100}{\text{Juice sample}}$$

Where:

TA = Titratable acidity

M_{NaOH} = Molarity of NaOH used

NaOH = Amount (in) of NaOH used

0.09 = Equivalent weight of lactic acid

Determination of brix and ascorbic acid (vitamin C) contents: The Brix content in the juice was determined using the hand refractometer (Bellingham and Stanly, Model A85171). Few drops of the juice were mounted on tip of the refractometer and readings were taken. Ascorbic acid and Vitamin B1 content of the juice were determined by the method of AOAC (2005).

Determination of total solids: Total solids content was determined by evaporating a known weight of juice in an oven (Fisher Isotemp 175) at 105°C for 2-3 h. The solid left after evaporation was then weighed and used to calculate the total solids (AOAC., 2005).

Determination of total ash: The ash content was determined from the loss in weight that occurred during incineration of the evaporated sample at a temperature high enough to allow all organic matter to be burnt off without allowing appreciable decomposition of the ash constituents. Ashing was carried out in a muffle furnace subjected to heat at 550°C for 6 h (AOAC., 2005).

Determination of fat: This was carried out using the method of AOAC (2005). Clean and dried thimble was weighed (W1) and 5 g oven dried sample was added and re-weighed (W2). Round bottom flask was filled with petroleum ether (40-60°C) up to ¾ of the flask. Soxhlet extractor was fixed with a reflux condenser to adjust the heat source so that the solvent boiled gently, the sample was put in the thimble and inserted into the soxhlet apparatus and extraction under reflux was carried out with petroleum ether for 6 h. After the barrel of the extractor was empty, the condenser was removed and the thimble was removed, taken into the oven at 100°C for 1 h and later cooled in the desiccator and weighed again (W3):

$$\text{Fat (\%)} = \frac{W_2 - W_3}{W_2 - W_1} \times 100$$

Determination of crude protein: One gram of the sample was introduced into micro Kjeldahl digestion flask and one tablet of Selenium catalyst was added. The mixture was digested on an electro thermal heater until a clear solution was obtained. The flask was allowed to cool after which the solution was diluted with distilled water to 50 and 5 of this was transferred into the distillation apparatus, 5 of 2% boric acid was added into a 100 capacity conical flask (the receiver flask) and four drops of methyl red indicator were added. A 50% of NaOH was continually added to the digested sample until the solution turned cloudy which indicated that the solution had become alkaline. Distillation was carried out in the boric acid solution in the receiver flask with the delivery tube below the acid level. As the distillation was going on, the pink colour solution of the receiver flask turned blue indicating the presence of ammonia. Distillation was continued until the content of the flask was about 50 after which the delivery of the condenser was rinsed with distilled water. The resulting solution in the conical flask was then titrated with 0.1 M HCl and the protein content calculated (Pearson, 1970; AOAC., 2005).

Vitamin A determination: Reversed phase High Performance Liquid Chromatography (HPLC) was used for the estimation of provitamin A content in the juice samples. Homogenized juice of 120 µL was extracted with 500 µL of hexane. The mixture was vigorously shaken on an electronic shaker for 4 min, centrifuged for 2 min at 10,000 rpm and the supernatant pooled. The extraction process was repeated. The pooled supernatant was evaporated to dryness under Nitrogen gas and redissolved in 120 µL mobile phase (1% tetrahydrofuran in methanol). The resulting aliquot (120 µL) was then injected into the HPLC (C-R6A Chromatopaa, Shimadzu Cooperation, Japan) column with ultraviolet detection (UV-VIS) spectrophotometric detector, Shimadzu, Japan at 450 nm. A standard was prepared and chromatographed. Areas corresponding to the standard retention time were identified and used in the estimation of vitamin A content in the beverages samples.

Sensory evaluation of fruit juice: The method of Larmond (1979) and Ihekoronye and Ngoddy (1985) were used. The freshly made water melon juice and water melon/orange juice mix

was compared with the commercial packaged juice and evaluated for the following parameters: taste, flavor, color and general acceptability by a panel of ten judges (using a questionnaire) of regular fruit juice consumers using the Hedonic Scale. The sensory scores were analyzed statistically (Duncan, 1955).

Microbiological analysis of fruit juice

Isolation and enumeration of microorganisms in juice: The fruit juice was serially diluted and one of the sample was aseptically introduced into sterile petri dishes after which molten agar (about 45°C) was poured into them, mixed and allowed to set. The different agar plates were incubated under appropriate conditions. Nutrient Agar (NA) was used for the enumeration of total aerobic bacteria in the samples and was incubated at 37°C for 24-48 h, while Sabouraud Dextrose Agar (SDA) was used for the enumeration of moulds and yeasts in the sample. The SDA plates were incubated at room temperature (28±2°C) for 3-5 days. MacConkey Agar (MCA) was used for the enumeration of total coliforms in the samples. The MCA plates were incubated at 37°C for 24-48 h. Colonies which developed on the plates were counted and expressed as colony forming units per milliliter (CFU mL⁻¹) of the sample.

Characterization and identification of microbial isolates: Following repeated sub-culturing, pure cultures of the different isolates were obtained, characterized and identified using biochemical tests (Cheesbrough, 2000). The bacterial isolates were identified by comparing their characteristics with those of known taxa as outlined in Bergey's Manual of Systematic Bacteriology (Holt, 1994). Minute quantity of the fungal culture was placed on the surface of a clean slide containing a drop of lacto-phenol blue. It was covered with a coverslip and viewed under the microscope using ×40 objective lens of the microscope. The moulds and yeasts were identified using the scheme of Alexopoulos and Mims (1979) and Pitt and Hocking (1997).

RESULTS

pH, total solids and titratable acidity of fruit juice samples: The results of the pH, total solids and titratable acidity of the juice are presented in Table 1. The pH of water melon juice (WM) was higher than that of the water melon/orange juice mix (WO) while the commercially packaged juice (ST) had the least pH (3.70-3.75). Generally, the pH which was acidic decreased as the time of storage of the fruit juice increased. The total solid contents were higher in freshly made juice samples (WM and WO) than in commercially packaged juice (ST). The total solids ranged from 7.55-10.12% for WM, 9.55-11.0% for WO and 5.89-6.30% for ST. It was observed that the total solid contents of the three juice samples decreased as the time of storage increased. The total titratable acidity in the commercially packaged juice (ST) was higher than that of the water melon juice (WM) while the water melon/orange juice mix (WO) had the least titratable acidity. The titratable acidity increased gradually as the time of storage of the fruit juice samples increased and ranged from 0.07-0.09 mg per WM, 0.28-0.37 mg per WO and 0.56-0.57 mg per ST (Table 1).

Ash, vitamin C and fat contents of fruit juice samples: The results (Table 2) revealed that ash content of WO was the highest (0.98-1.10%) followed by WM (0.75-0.80%) while ST had the least ash content (0.30-0.32%). The ash contents of the fruit juice samples increased with increase in time, this may be due to changes chemical composition of the juice in the store. The vitamin C content was higher in ST than the WO and WM. It was observed that the vitamin C contents

ranged from 18 mg/100 to 23 mg/100 for WM, 30-40 mg/100 for WO. No change in value was observed for ST and remained 65 mg/100 (Table 2). The fat content of WO was the highest, followed by WM while ST had the lowest fat content. The fat contents ranged from 0.45-0.50% for WM, 0.89-1.0% for WO and 0.38-0.45% for ST (Table 2).

Crude protein, vitamin A, taste, aroma and colour

Crude protein and vitamin A contents of fruit juice samples: The crude protein content of the fruit juice samples increased gradually with time and ranged from 1.67-1.75% for WM, 1.10-1.39% for WO and 0.82-0.98% for ST. The vitamin content of the fruit juice samples decreased as the time of storage of the samples increased. The values ranged from 240-300 mg/100 for WM, 60-80 mg/100 for WO and 70-75 mg/100 for ST within 14 days (Table 3).

Major mineral contents: The potassium and calcium contents in the freshly made juice samples WM and WO were lower than that in commercially packaged juice (ST) but the reverse was the case in the phosphorus content (Fig. 1). The potassium and calcium contents in WM were 220 and 15 ppm while that of WO was 328 and 22 ppm, respectively. The phosphorus contents were 48 and 20 ppm for WM and WO, respectively.

Microbial counts and identification: The total aerobic bacterial counts, coliform counts and yeast/mold counts of the juice samples are presented in Table 4. The total aerobic bacterial counts for all the juice samples increased with time. However, the commercially packaged juice had the

Table 1: Changes in pH, total solids and titratable acidity of juice samples

Sample	pH			Total solids (%)			Total titratable acidity (mg L ⁻¹)		
	Time (days)			Time (days)			Time (days)		
	0	7	14	0	7	14	0	7	14
WM	5.34	5.29	5.12	10.12	9.85	7.55	0.07	0.08	0.09
WO	4.47	4.39	4.34	11.00	10.86	9.55	0.28	0.29	0.37
ST	3.75	3.73	3.70	6.30	5.98	5.89	0.56	0.56	0.57

WM: Water melon juice, WO: Water melon/orange juice mix, ST: Commercially packaged juice

Table 2: Changes in ash, vitamin C and fat contents of fruit juice samples

Sample	Ash (%)			Vitamin C (mg/100)			Fat (%)		
	Time (days)			Time (days)			Time (days)		
	0	7	14	0	7	14	0	7	14
WM	0.75	0.79	0.80	23.0	20.0	18.0	0.50	0.48	0.45
WO	0.98	1.00	1.10	40.0	35.0	30.0	1.00	0.94	0.89
ST	0.30	0.32	0.32	65.0	65.0	65.0	0.45	0.42	0.38

WM: Water melon juice, WO: Mixture of water melon and orange juice, ST: Packaged juice used as standard (orange juice)

Table 3: Crude protein and vitamin A contents of fruit juice samples

Sample	Crude protein (%)			Vitamin A (mg/100)		
	Time (days)			Time (days)		
	0	7	14	0	7	14
WM	1.67	1.69	1.75	300.0	270.0	240.0
WO	1.10	1.30	1.39	80.0	73.0	60.0
ST	0.82	0.94	0.98	75.0	73.0	70.0

WM: Water melon juice, WO: Water melon/orange juice mix, ST: Commercially packaged juice

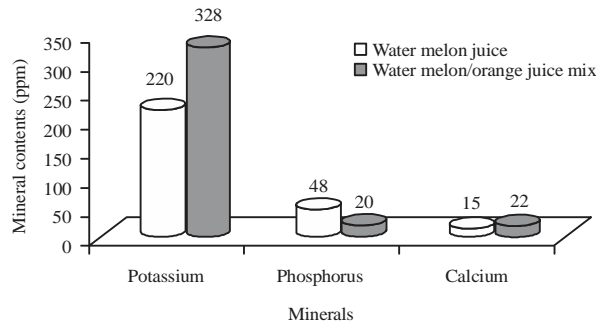


Fig. 1: Major mineral content in fruit juice samples analyzed

Table 4: Total aerobic bacterial, coliform, yeast and mold counts of juice samples analyzed

Microbial counts (CFU)									
Time (days)	Total aerobic bacterial counts			Coliform counts			Yeast and mold counts		
	WM	WO	ST	WM	WO	ST	WM	WO	ST
0	1.5×10^2	1.3×10^3	NG	1.0×10^3	NG	NG	NG	NG	NG
7	2.8×10^3	2.3×10^2	1.0×10^2	2.5×10^2	2.1×10^2	NG	2.4×10^2	3.2×10^3	NG
14	3.6×10^3	2.2×10^4	2.2×10^2	2.9×10^2	2.3×10^3	NG	2.6×10^3	2.4×10^3	NG

Data are mean values of duplicate determinations, WM: Water melon juice, WO: Water melon/orange juice mix, ST: Commercially packaged juice, NG: No growth detected

Table 5: Sensory evaluation of juice samples

Parameters	ST	WM	WO
Taste	8.80±0.42	8.00±0.82	6.20±0.92
Colour	8.10±0.57	8.60±0.69	6.40±1.08
Flavor	8.5±0.53	7.80±0.92	6.20±1.03
General acceptability	8.80±0.42	8.30±0.68	6.20±1.35

ST: Commercially packaged juice (orange juice), WM: Water melon juice, WO: Water melon/orange juice mix

lowest microbial counts (1.0×10^2 CFU mL⁻¹). It was observed that the commercially packaged fruit juice (ST) had no coliforms as compared to the water melon juice (WM) and water melon/orange juice mix (WO) which had high counts of coliforms (Table 4). The coliform counts increased with increase in storage time. While molds and yeasts were detected in ST after 14 days, the organisms were detected in WM and WO after 7 days. The mold and yeast counts in WM increased gradually with time while the counts in WO decreased after 14 days.

The bacterial contaminants of the fruit juice samples were identified as species of *Bacillus*, *Staphylococcus*, *Klebsiella* and *Pseudomonas*, while the mold isolates were *Aspergillus niger*, *Aspergillus flavus* and *Mucor* sp. *Saccharomyces cerevisiae* was the only yeast identified in the fruit juice samples. *Bacillus* species were more consistently isolated among the bacterial isolates while *Aspergillus niger* predominated among the mold isolates.

Sensory qualities of fruit juice samples: The results of the sensory evaluation of the fruit juice samples using the Hedonic scale is presented in Table 5. The results showed that the commercially packaged juice scored highest in terms of taste (8.80±0.42) and overall acceptability (8.80±0.42) closely followed by water melon juice which had the highest score for colour (8.60±0.69) and (7.80±0.92) for flavor while its acceptability was 8.30±0.68 (Table 5). The results revealed that the commercially packaged juice was preferred based on taste and flavor while water melon juice was preferred based on colour. The water melon/orange juice mix (WO) was however not preferred because of the colour, flavor and taste.

DISCUSSION

The study revealed that the pH of the freshly made water melon juice and water melon/orange juice mix ranged from 5.1-5.3 and 4.3-4.4, respectively. This result is in contrast with those obtained by Adams (1996) who reported that the pH values of most fruit juice is estimated to be within the range of 2.5-4.4. This report is similar to the findings of Ashurst (1995), who reported that the pH values of pure undiluted pineapple juice is estimated to range between 3.7 and 4.5. The water melon juice could have its acidity restored by addition of citric acid, malic acid and tartaric acid. The reduction in pH within the period of study is accepted because juice spoilage is mainly by yeast fermentation which is also evident in higher tendencies toward acidity, this agrees with the report of Frazier and Westhoff (1988). Food acids dictate the dominant microflora in foods and to a large extent will determine the shelf stability of the juice. The more acidic the juice, the less susceptible to bacterial action but the more susceptible to the action of yeasts and moulds (Ndife *et al.*, 2013). Anvoh *et al.* (2009) reported that fruit acids influence colour, flavor and gustative characteristics of juice products.

However, the commercially packaged juice (ST) had a higher titratable acidity (0.57 mg L^{-1}) than the freshly made juice samples, WM and WO (0.09 and 0.37 mg L^{-1} , respectively) and this correlates with the pH values as well. The high acidity in packaged juice may be attributed to addition of acidifying agent (Oluseyi, 2003). This could be as a result of the much lower pH (higher acidity) of orange juice (Ameh *et al.*, 2015).

The total solid was higher in freshly made juice than in the commercially packaged juice. This could be attributed to local sieving process by using Muslin cloth compared to high filtration methods used in the packaged juice. This agrees with the report of The Federal Institute of Industrial Research, Oshodi, FIIRO (2005) that most differences in juice quality are as a result of differences in production processes. The high amount of total solids in water melon (WM) and water melon/orange juice mix (WO) could also be attributed to the conversion of polysaccharides and other constituents of the juice. The analysis of data showed that different storage intervals had a significant effect on the total solids of all the juice samples. The total solids in WM juice decreased from 10.12-7.55% after 14 days and that of WO decreased from 11-9.55% over the same period. The decrease in total solids in WM and WO juice samples is an indication that there is high sugar to acid ratio in the juice samples as compared to that of commercially packaged juice (ST). The total solids and juice content are used in characterizing the quality of juice and other beverage products (Adubofuor *et al.*, 2010).

The ash contents were higher in freshly made juice than in the commercially packaged juice and this agrees with the report of Harker *et al.* (2003) who observed similar results. This implies that the juice samples could serve as a potential good source of minerals required by the body. It has been reported by Adelakun *et al.* (2009) that ash content is an indication of mineral contents in food.

The vitamin C content in commercially packaged juice (ST) was higher than the vitamin C content in freshly made juices (WM and WO). This confirms the assertion that most juice producers add ascorbic acid during production process (Oluseyi, 2003). The mixing of orange juice with the watermelon juice increased the vitamin C content of the juice (WO). This increase in vitamin C content could be due to the high citric acid of orange juice, the high citric acid was also reported by Nagy and Attaway (1980). The vitamin C of the freshly made water melon juice samples was high (18-23 mg/100 for WM and 30.0-40.0 mg/100 for WO). This is of great health significance and implies that the juice samples are high in vitamin C and can take care of vitamin C deficiency

related ailment like scurvy (Edem and Miranda, 2011). Despite the losses in vitamin during heat processing, the residual amounts were of appreciable quantities that could still meet the Recommended Daily Intake (RDA) of 30 mg/65 kg b.wt., for an adult man, the excess of which could be excreted from the body by urination (Adedeji *et al.*, 2014). Vitamin C loss is known to increase with exposure to heat (as in pasteurization), light and oxygen. Vitamin C is involved in protein metabolism, collagen synthesis and an important physiological antioxidant (Li and Schellhorn, 2007). It also plays an important role in immune function, improves absorption of non-heme iron and participates in biosynthesis of glucocorticoids (Gershoff, 1993). It was observed that the vitamin A content varied among the different juice brands. Vitamin A content was higher in watermelon juice than watermelon/orange juice mix and commercially packaged juice had the least vitamin A content. Fruit juices are important in the delivery of body fluids and essential micronutrients such as vitamins (Landon, 2007) and the nutritional significance of food nutrients is related to their contribution to the Recommended Dietary Allowance (RDA) (Ndife *et al.*, 2013).

The fat content in freshly made juice (WM: 0.45-0.50% and WO: 0.89-1.00%) was higher than that of ST (0.38-0.45%). This agrees with the report of Ebuehi and Avwobobe (2006) that most citrus family such as water melon contains more fat than any other fruit. The low fat content observed in the juice samples is an indication that the juice produced can keep for long periods at right temperature and moisture without spoilage by oxidative rancidity (Adedeji *et al.*, 2014).

The crude protein contents were higher in the freshly made juice samples than in the commercially packaged juice. This is an indication that the water melon juice and water melon/orange juice mix had moderate protein content which implies that the freshly made juice samples may be enough to prevent protein malnutrition. The protein content is adequate enough to meet the FAO/WHO recommended daily allowance of protein of 0.59 g kg⁻¹ b.wt., for children aged 1-10 years as reported by Ghana Standard Board (1995). Also, it could serve as an ideal diet for a select people with liver problems (hepatic cirrhosis, hepatitis or hepatoma) who need little or no protein in their menu and the obese or those watching weights (Adedeji *et al.*, 2014).

The mineral composition of the juice samples are shown in Fig. 1. Potassium was the most abundant element in the juice samples followed by phosphorus and calcium. This is in agreement with the results reported by Dosumu *et al.* (2009). Natural fruits and vegetables are good sources of potassium. Inadequate intake of micronutrients (minerals) has been associated with severe malnutrition, increased disease conditions and mental impairment (Dosumu *et al.*, 2009; Ndife *et al.*, 2013).

The total aerobic counts of all juice samples increased, particularly those of freshly made juice, during the period of storage. The same applies to proliferation of coliforms in the freshly made juice. Microorganisms isolated from this juice samples include; *Bacillus* sp., *Staphylococcus aureus*, *Klebsiella* sp. and *Pseudomonas* sp. *Bacillus* species were more frequently encountered. This agrees with the report of Splttstoesser *et al.* (1994) that *Bacillus* is a major spoilage organism in juices. The presence of *Staphylococcus aureus* in the juice could be attributed to its wide spread in the environment. It could also be as a result of contamination from handlers. *Staphylococcus aureus*, a mesophile has been implicated in food poisoning outbreak of some food materials (Dai *et al.*, 2006). The occurrence of *Klebsiella* sp. could have been contamination from equipment since it is a common equipment contaminant. *Pseudomonas* sp are commonly found on the fruit surfaces which can end up in the juice during production. They are able to grow on a wide variety of organic substrates and are regular components of food spoilage (Adams and Moss, 1995). The molds and yeasts isolated were *Mucor* sp., *Aspergillus niger*, *Aspergillus flavus* and *Saccharomyces* sp., Splttstoesser *et al.* (1994) implicated fungi as contaminants of fresh fruits especially in the

presence of injuries. These microorganisms had been earlier reported to be isolated from water melon juice (Ogunbanwo *et al.*, 2013). In addition, the ability of these organisms to survive in acidic juices at both ambient and refrigerated temperature (8°C) and low pH value has been documented (Ogunbanwo *et al.*, 2013). Water and environment may play a major role in fungi contamination of watermelon especially during washing of the fruits (Nwachukwu *et al.*, 2008). The presence of *Saccharomyces* sp. is expected due to its preference for sugar. Besides, lower pH highly favors yeast proliferation (Adams and Moss, 1995).

The high magnitude of members of coliforms in these juices could be due to the high water activity of ready-to-serve juices. Products with high water activity possess good amount of unbound water molecule that supports growth and survival of microorganisms (Antony and Chandra, 1997; Ferrati *et al.*, 2005). Asha *et al.* (2014) reported that high microbial counts may be due to various factors like poor quality of water used for dilution, unhygienic conditions related to washing of utensils and maintenance of premises, poor personal and domestic hygiene and peeling of fruits beforehand.

The overall acceptability of any food product is one of the very important and basic criteria for the acceptance or rejection of a food product (Alim-un-Nisa *et al.*, 2012). Francis (1995) stated that color influences other sensory characteristics, which subsequently accounts for food acceptability, choice and preference. It is the most obvious change that occurs in many fruits during storage (Yau *et al.*, 2010). The sensory evaluation results revealed that the commercially packaged juice (ST) recorded the highest score in terms of taste, flavor and overall acceptability, this was followed by the water melon juice (WM), which was more preferred in terms of color probably due to the presence of lycopene which gives water melon its natural colour (Erhardt *et al.*, 2003). In addition, microorganisms such as bacteria, yeasts and molds implicated in spoilage of fruit drink caused reduction in organoleptic and quality of the substance which makes them unacceptable to consumers (Jideani and Jideani, 2006; Ogunbanwo *et al.*, 2013). The sweeter taste in commercially packaged juice was as a result of the sweetening agent added during production (Oluseyi, 2003).

CONCLUSION

The freshly made watermelon juice and watermelon/orange juice mix samples contained high amount of nutrients and the presence of high ash content, total solids and acidic pH encouraged the proliferation of microorganisms which strongly opposed the commercially packaged juice with lower pH. The commercially packaged juice had longer shelf life in the study than the freshly made juice samples which nearly lost their nutritional qualities prior to the expiration date of the study (14 days). The production of juice from water melon is important in that it will reduce wastage of the fruits by farmers and provide vitamins, minerals and the anti-oxidant compound (lycopene) to their respective consumers. It also reduces loss to economy of the country. The results suggest that water melon juice contains some beneficial nutrients and therefore, its production should be encouraged.

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