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Comparative evaluation of the nutritional and sensory quality of different brands of orange-juice in Nigerian market

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The physico-chemical properties, vitamins, minerals, microbial and sensory qualities of four different brands of orange-juice (samples A, B, C and E) in the Nigerian market were evaluated to determine their overall quality. Results of the physico-chemical properties obtained show the following range of values for acidity (0.40 - 1.06%), total solids (5.50 - 11.80%), total sugar (9.15 - 13.39%) and fruit juice content (14.28 - 45.63%). The sweetness index for the juice samples A, B, C and D were 11.0, 9.66, 8.65 and 7.80, respectively. Sample D had the highest benzoic acid content of 217.21 ppm as preservative. The vitamin and mineral contents vary among the different orange juice samples. Samples D and B had the highest contents of vitamin A (140.12 IU) and C (42.57 mg), respectively. While samples A and C had the lowest values for potassium (119.10 mg) and sodium (5.65 mg) contents. The viable microbial counts for the juice samples were very low (1.0 x 10^2 to 5.2 x 10^2 cfu/100 ml). There were no coliform contaminations in all the samples. Sample D was adjudged the best in overall acceptance (8.45). Generally, the juice samples were within the regulatory specifications, and are fit for consumption

Key words: Orange, juice, vitamins, mineral, microbial and sensory quality.

INTRODUCTION

Fruits have been a part of human diet over the years. They are also considered as food supplements and are recommended internationally as essential to healthy nutrition, because they contain high quantity and quality of water, sugars, vitamins and minerals (Wardlaw, 2004; Potter and Hotchkiss, 2006). Fruit consumption has been reported to contribute to the prevention of degenerative processes, particularly lowering the incidence and mortality rate of cancer and cardio-cerebro-vascular diseases (Wenkam, 1990; Wardlaw, 2004; Mannay and Shadaksharaswany, 2005). They also contain phytochemicals which act against oxidative reactions in the human body (Vanamala et al., 2006; Okwu and Emenike, 2006). Orange fruits have been reported as a rich source of these phytochemicals such as flavonoids, especially flavanones, which have been shown to posses several physiological properties which can help inhibit cell proliferation and promote cell differentiation (Vanamala et al., 2006; Ndife and Abbo, 2009). However, due to the perishable nature of fruits and vegetables, high post harvest losses occur immediately after harvest, during distribution and marketing (Mannay and Shadaksharaswany, 2005; Potter and Hotchkiss, 2006), resulting from lack of cold storage facilities on the farms, improper handling and inadequate processing facilities (Alaka et al., 2003; Landon, 2007; Adubofuor et al., 2010). Reports show that the post harvest losses for oranges range between 31-50% (Alaka et al., 2003;

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Landon, 2007). One of the ways of preserving these fruits and vegetables from deterioration and subsequent loss is to process them into fruit juices (Wenkam, 1990; Vanamala et al., 2006).

During the processing, a large part of the quality cha-racteristics of the fresh fruits under-go remarkable changes which could reduce the nutritional value of the products (Wenkam, 1990; Landon, 2007). Moreover, the fruit juices may be stored for several months in un-favourable conditions before consump-tion, thus leading to undesirable quality changes due to the influence of temperature, time, oxygen content, light exposure and packaging material (Mannay and Shadaksharaswany, 2005; Landon, 2007; Averbeck and Schieberle, 2010).

The consumption of fruit juices is popular in Nigeria because of their health and invigorating benefits (Alaka et al., 2003; Okorie et al., 2009). Though some fruit juices are produced locally, most of the fruit juices and drinks found in the market are imported (Dosumu et al., 2009; Okorie et al., 2009).

Valid data are not available on the extent to which these commercial juice and drinks are either mislabeled, adulterated or of inferior quality (Dosumu et al., 2009). This is due to the fact that laboratories' testing capabilities are limited, and tests are expensive to conduct (Landon, 2007).

The objective of this study was therefore, to evaluate and provide information on the nutritional, microbial and sensory quality of the different brands of orange juice available in the Nigerian market with the aim of attracting the attention of the regulatory authorities and helping the un-informed consumers to make a healthful choice. The implications for the industry are also discussed.

MATERIALS AND METHODS

Four most popular brands of orange juice were purchased off the shelf from different supermarket in Kaduna town, of Northern Nigeria. Three of the different brands of juice were produced in Nigeria and were labeled A, B, C and D for the imported brand. All the juice samples were stored at ambient temperature, in sample bottles with tight-fitting lids, during the period of analytical investigation.

Physico-chemical analysis

The pH, brix (soluble solids) and specific gravity of the juice samples were measured using instrumental methods (Jacobs, 1999). The fruit juice content, benzoic acid content, acidity were determined by the method described by Ayo and Agu, (2012) with some modifications; while, the total sugar was determined by Lane Eynon method as described by Mehmoud et al. (2008). The sweetness and astringency indexes were calculated as the ratio of soluble solids to acidity and vice versa (Wardy et al., 2009).

Vitamin assay

The ascorbic acid (vitamin- C), B-carotene (vitamin -A), riboflavin (vitamin- B_2), vitamin-E and folic acid (niacin-vitamin-B_3) contents of the orange juice samples were determined by the method described by Nielsen (2003) with some modifications using UV-VIS spectrophotometer.

Mineral assay

The orange juice samples were digested by the wet ashing method prior to mineral content determination using atomic absorption spectrophotometer for Ca, Mg, and Fe and Corning 400 flame photometer for K and Na (Abulude et al., 2005). While the phos-phorus content was determined colorimetrically with Jenway 6100 spectrophotometer using the method described by Nielson (2003).

Microbiological assay

The determination of the microbial quality (mesophilic aerobic bacteria, coliforms, yeasts and mold counts) of the products were performed by the method outlined in compendium of methods for the microbiological examination of foods (AMPH, 1992) with some modifications.

Sensory analysis

Sensory evaluation of the orange juice samples were carried out by 25 panelists on a 9 point hedonic scale for different parameters such as colour, aroma, taste, texture and overall acceptability as described by Iwe (2010).

Statistical analysis

The sensory evaluation data was statistically analyzed using the analysis of variance (ANOVA) and the Duncan Multiple range test with significance level at $p<0.05$ (Ihekoronye and Ngoddy, 1985).

RESULTS AND DISCUSSION

Physico-chemical analysis

The results obtained from the physico-chemical analysis of the different brands of orange juice samples are presented in Table 1.

The moisture content in the different brands of orange juice analyzed ranged from 88.20 to 94.50%. Sample D (imported brand) had the lowest value of 88.20%. The moisture content has an inverse relationship with the total fruit juice content.

The pH of the orange juice samples range from 3.40 to 4.08. Sample A had the highest pH value of 4.08. The reverse was observed in the results for acidity, in which sample D had the highest value of 1.06%, while samples A, B and C had 0.40, 0.68 and 0.85%, respectively. Kareem and Adebowale (2007) reported that the dominant acid in orange juice is citric acid.

Food acids dictate the dominant microflora in foods and to a large extent will determine the shelf stability of the juice (Ezeama, 2007). The more acidic the juice, the less susceptible to bacterial action but the more susceptible to the action of yeasts and moulds (Jay, 2000). Moreover

Table 1. Physico-chemical analysis of different brands of orange juice samples.

Parameter	Juice sample			
	A	B	C	D
Moisture (%)	94.50±3.01	91.83±3.11	90.22±3.05	88.20±3.03
pH	4.08±0.15	4.01±0.18	3.40±0.10	3.23±0.16
Acidity (%)	0.40±1.10	0.68±1.00	0.85±1.04	1.06±1.07
Specific gravity	1.03±0.50	1.02±0.55	1.04±0.53	1.08±0.55
Soluble solids (°Brix)	4.40±0.85	6.57±1.00	7.35±0.90	8.27±0.95
Total solids (%)	5.50±1.12	8.17±1.20	9.78±1.24	11.80±1.20
Total sugar (%)	13.39±2.04	14.25±1.95	9.15±2.06	10.76±1.98
Fruit juice content (%)	14.2±2.25	22.6±2.16	37.60±2.32	45.63±2.30
Sweetness Index	11.00±0.55	9.66±0.50	8.65±0.48	7.80±0.50
Astringency Index	0.09±0.01	0.10±0.03	0.12±0.01	0.13±0.02
Benzoic acid (ppm)	185.41±3.30	170.80±3.10	195.60±3.21	217.21±3.16

[a]Data are mean values of duplicate determinations ± standard deviation.

Anvoh et al. (2009) reported that fruit acids influence colour, flavour and gustative characteristics of the juice products.

The specific gravity for the orange juice sample ranges from 1.02 to 1.08, with sample B recording the lowest value of 1.02. While the Brix values ranges from 4.40 to 8.27°. Sample A had the lowest Brix of 4.40°. The Brix values of orange juices should be between 4 - 9° (Kareem and Adebowale, 2007). Also, the total solids content of the fruit juices were: 5.50, 9.60, 1.70 and 11.10% for samples A, B, C and D, respectively. The total (soluble and non-soluble) solids are used as indicators of the fruit juice content which ranged from 14.2 to 45.63% in the orange juice samples. The total solids and juice content are used in characterizing the quality of juice and other beverage products (Egbekun and Akubor, 2007; Adubofuor et al., 2010).

The total sugar was highest in sample B (14.25%) and lowest in sample C (9.15%). The total (reducing and non-reducing) sugars to a large extent determine the sweetness of juices and beverages. It could be used for masking the astringency derived from organic acids (Anvoh et al., 2009; Adeola and Aworh, 2010). When compared with the recommended dietary allowances (RDA) of 130 g/day (El-Sheikha et al., 2010), for total sugars, the orange juice samples will contribute to the average 15.40%. Wardlaw (2004) reported that frequent consumption of sugar sweetened beverages may be associated with larger weight gain and increased risk of type 2 diabetes.

The sweetness index for samples A, B, C and D were 11.0, 9.66, 8.65 and 7.80, respectively. Sweetness index (SI) and the astringency index (AI) are used for the prediction of flavours in juices (Wardy et al., 2009; Adeola and Aworh, 2010). The ratio of sugars to acids and vice-versa gives an accurate prediction of the tartness and sweetness of acid foods which affects organoleptic perception (Wardy et al., 2009; Averbeck and Schieberle, 2010). Fruit juices with sweetness index greater than 19 are regarded as sweet and with less acid by taste (Wardy et al., 2009).

Benzoic acid was detected in all the brands of orange juice, with values that ranged from 170.80 to 217.21 ppm. Benzoic acid is particularly used as a preservative against yeasts and moulds for long term storage (Mehmood et al., 2008).

Table 2 shows the result of the analysis of the vitamin content of the orange juice samples. It was observed that the vitamin contents vary among the different brands of orange juices. Sample D had the highest vitamin A (140.12 IU) while sample B had the highest content of vitamin C (42.57 mg). The vitamin B_1 (Thiamine) and vitamin B_2 (Riboflavin) contents were lowest in sample C with values of 0.90 and 0.43 mg, respectively. Sample A had the highest value of vitamin B_3 (Niacin) content (7.23 mg). Fruit juices are important in the delivery of body fluid and essential micro-nutrients such as vitamins (Landon, 2007) and the nutritional significance of food nutrients is related to their contribution to the recommended dietary allowance (RDA) (Wardlaw, 2004). Ascorbic acid content of fruit juices is the most prominent quality index of fruit juices due to its health significance as a vitamin and cellular antioxidant (Landon, 2007). The fruit juices will contribute on the average, 40% to the recommended dietary intake of vitamin C. More so, when compared when the recommended dietary allowances (RDA), the orange juice samples A, B, C and D will contribute 44.75, 51.30, 27.72 and 32.90% to vitamin A requirements. Thus, confirming that the different brands of orange juice are good sources of essential vitamins.

The mineral compositions of the orange juice samples are shown in Table 3. Potassium is the most abundant element in all the orange juice samples, with an average value of 143.28 mg, followed by calcium (14.12 mg) and

Table 2. Vitamin analysis of different brands of orange juice samples.

Parameter	Juice sample (mg/100 g)				
	A	B	C	D	RDA (mg/day)
Vitamin-A (IU)	91.23±3.10	108.34±3.16	132.55±3.28	140.12±3.10	750-900
Vitamin-C	37.14±2.10	42.57±2.15	23.01±2.18	27.28±2.25	75-90
Vitamin-B_1	1.04±0.11	1.10±0.15	0.90±0.18	1.03±0.15	1.1-1.2
Vitamin-B_2	0.86±0.05	1.0±0.03	0.43±0.05	0.65±0.04	1.1-1.3
Vitamin-B_3	7.23±1.05	11.14±1.10	4.38±1.14	5.15±1.08	14-16

*RDA- Recommended dietary allowance; [a]data are mean values of duplicate determinations ± standard deviation.

Table 3. Mineral analysis of different brands of orange juice samples.

Parameter	Juice sample (mg/100 g)				
	A	B	C	D	RDA (mg/day)
Sodium	10.35±1.50	13.82±1.36	5.65±2.10	8.47±1.85	1000-1500
Potassium	119.10±2.00	128.31±1.53	155.28±1.91	170.42±1.64	4000-4700
Calcium	16.81±0.42	18.54±0.25	10.10±0.22	11.01±0.36	800-1100
Magnesium	13.32±0.10	15.36±0.14	10.01±0.20	11.63±0.16	110-300
Iron	1.22±0.04	3.43±0.08	1.70±0.06	3.50±0.08	8-22
Phosphorus	11.83±2.11	9.41±0.18	7.32±2.00	9.35±1.17	380-1055
Ash (%)	0.98±0.10	1.32±0.11	0.64±0.10	0.75±0.12	-

*RDA- Recommended dietary allowance; [a]data are mean values of duplicate determinations ± standard deviation.

Table 4. Microbial analysis of different brands of orange juice samples.

Parameter	Juice sample (cfu/100 ml)				
	A	B	C	D	[*]SON
Total aerobic counts	5.2±0.25x10^2	3.6±0.20x10^1	1.5±0.14x10^2	1.0±0.12x10^2	<2.0x10^3
Total coliform counts	Nil	Nil	NIL	NIL	3
Total yeast and mould counts	1.1±0.13x10^1	2.3±0.15x10^1	4.7±0.20x10^1	3.5±0.18x10^1	50

[a]SON-Standards Organization of Nigeria maximum allowable counts; [b]Data are mean values of duplicate determinations ± standard deviation.

magnesium (12.58 mg), while iron is present in trace amounts (2.46 mg). This is in agreement with the result reported by Dosumu et al. (2009). Natural fruits and vegetables are good sources of potassium and are low in sodium, an advantage reported to protect against arterial hypertension (Nnam and Njoku, 2005). Inadequate intakes of micronutrients (minerals) have been associated with severe malnutrition, increased disease conditions and mental impairment (Mannay and Shadaksharaswany, 2005; Dosumu et al., 2009).

In comparison with the RDA (Wardlaw, 2004), the orange juice samples would contribute on the average: 0.96, 3.58, 1.80, 11.44, 30.75 and 2.50% for Na, K, Ca, Mg, Fe, and P, respectively. The results from this study show that the orange juice samples would need to be supplemented with other mineral sources in the diet to meet up with the RDA requirements for a healthy nutrition.

Microbial analysis

The results of microbial analysis of the different orange juice samples are presented in Table 4. The results obtained for total aerobic counts were low in all the orange juice samples (<1.5 x 10^2 cfu/100 ml). They were also below the maximum limit in the SON (2008) specification for commercial fruit juices (<2.0 x 10^2 cfu/100

Table 5. Microbial analysis of different brands of orange juice samples.

Parameter	Juice sample			
	A	B	C	D
Appearance	5.83[b]	5.14[b]	7.65[a]	8.35[a]
Flavour	6.75[b]	6.15[b]	8.50[a]	7.72[a]
Residual after taste	7.55[a]	8.31[a]	5.68[a]	5.23[a]
Aroma	5.61[b]	5.45[b]	7.89[a]	8.51[a]
Overall acceptability	6.44[b]	6.21[b]	7.90[a]	8.45[a]

*Means within a row with different letters are significantly different at P<0.05.

ml). However, the aerobic plate counts were found to be higher in the sample C (1.2 x 10^2 cfu/100 ml) than in the other orange juice samples. The acid and sugar content, are critical to the survival of microbes and will ultimately affect the shelf stability and sensory quality of the orange juice samples (Jay, 2000; Ezeama, 2007).

There were no observable coliform growths from all the orange juice samples. This eliminates the possibility of faecal contamination in the different brands of orange juice samples, which is a pointer to good manufacturing and handling practice (Ezeama, 2007). This also conforms to the regulatory specification of <3 cfu/ml for total coliform counts in fruit juices (SON, 2008). The total mould and yeasts counts in the orange juice samples range from 1.1 x 10^1 to 4.7 x 10^1 cfu/100 ml. While the highest mould and yeasts counts (4.7 x 10^1 cfu/100 ml) were observed in sample C. This is slightly lower than the standard specification of 5.0 x 10^1 cfu/100 ml for fruit juices (SON, 2008). The low microbial counts in orange juice samples could also be due to the use of benzoic acid as a preservative. Benzoic acid is known to have antimicrobial properties due to the low pH. The results show that the different brands of orange juices are safe for human consumption as the range is below the upper limit of 10^3 (cfu/100 ml) of total bacteria counts, considered safe for foods (ICMSF, 1998).

Sensory analysis

Table 5 summarizes the results for the sensory evaluation and overall acceptability of the different brands of orange juice samples. The statistical analysis revealed that there were significant difference (p<0.05) among the orange juice samples in the sensory attributes observed. Sample D (imported brand) had the highest score (8.35), while sample B had the lowest score (5.14) for appearance. The appearance was based on how the colours appeal to the panelists. Browning in the beverages could have been due to Maillard-type reactions (Potter and Hotchkiss, 2006) resulting from the presence of reducing sugars, proteins and amino acids, also, due to the effect of severe heating during processing on the quality attributes (Mannay and Shadaksharaswany,2005).

Similar trends were observed for the sensory ratings of flavour and aroma in the orange juice samples, sample B had the lowest scores (6.15 and 5.45) followed by sample A (6.75 and 5.61). Acidity contributes to the development of flavour through a proper sugar-acid ratio thereby modifying the sweetness of sugar (Adeola and Aworh, 2010).

The residual after taste was characterized by perceived bitterness after swallowing the orange juice samples by the panelists. This bitter perception was prominent in samples A (7.55) and B (8.31). The panelists affirmed that this was responsible for their low scores on flavour and aroma. Mannay and Shadaksharaswany (2005) reported that the inclusion of additives could impact on the organoleptic qualities of food products. Orange samples C and D had the best overall acceptability ratings of 7.90 and 8.45, respectively.

Conclusion and recommendation

The difference in the quality attributes of the different brands of orange juice may be attributed to the different processing procedures employed and storage conditions. Consumption of these beverages is desirable as they would serve as good sources of vitamins and body electrolytes. The results from this study show that the orange juice samples would need to be supplemented with other nutrient sources in the diet to meet up with the RDA requirements for a healthy nutrition. The results also show that the different brands of orange juices are safe for human consumption considering their low microbial content. The orange samples C and D had the best overall acceptability.

Therefore, the regulatory authorities such as Standards Organization of Nigeria (SON) and National Authority for Food Drugs Administration and Control (NAFDAC) and Consumers Protection Agency (CPA) should ensure that foods are safe, wholesome, and honestly labeled, by periodically inspecting production facilities and occasionally sampling and testing products on the shelf, to ensure they conform to specified standards.

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