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Comparative Study of the Safety and Chemical Composition of Commercially Available Fruit Juices and Soft Drinks in Southwest Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aims: Fruits juices and soft drinks are among the most important and convenient foods which are commonly consumed to quench thirst, and as sources of micronutrients. However, most fruit juices commercially sold in Nigeria are not pure juice but contain additives which may affect the safety and quality attributes of the product. This study therefore, evaluated the chemical composition and microbiological safety of some commercially sold fruit juices and drinks and compared their quality with pure fruit juices.
Methodology: Twenty commercially sold fruit juices and soft drinks were analyzed for physicochemical properties, vitamins and minerals composition, and microbiological quality using standard analytical procedures.
Results: Pure fruit juices contain similar pH, total titratable acidity, and specific gravity as the commercial fruit juices and soft drinks, but significantly higher total solid contents. The total soluble solid recorded for the pure pineapple (22 g/100ml) and watermelon juice (25.9 g/100ml) were significantly higher than the values (11.1 – 15.5g/100ml) recorded for the commercial fruit juices.

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The vitamin C content of the commercial soft drink ranged from 22.94 to 26.14 µg/100g, and that of commercial fruit juices and pure fruit juices ranged from 14.89 to 22.81µg/100g with pure fruit juice having the lowest value.
Conclusion: The physicochemical properties of the pure fruit juices and commercial fruit and soft drinks were similar except for total solids and Brix level. Commercial fruit juices and soft drinks contain higher vitamins and minerals than pure fruit juices due to addition of synthetic vitamins and minerals. All the commercial fruit juice samples and soft drinks were free of microbial loads and would not cause any health problems if properly handled after purchase. The study however, recommends the consumption of hygienically prepared pure fruit juices because they are free from synthetic additives.

Keywords: Fruit juice; soft drinks; physicochemical properties; vitamin contents; mineral composition; microbiological safety.

1. INTRODUCTION

Fruit juices are rich sources of nutrients such as vitamins, minerals and other naturally occurring phytochemicals that are of health and therapeutic benefits [1], hence, they have recently become indispensable part of people's diet. Generally, fruits contain high levels of vitamins (A, C, B), minerals, crude fibre and moisture, but low fat and protein [2]. Fruits are beneficial for healthy human living due to their high antioxidant contents which translate to protective factors against oxidative destruction [3]. In addition, several studies have also been conducted on the development of nutrient-rich drinks from legumes. For instance, nutrient-rich drinks were produced from blends of soymilk and walnut milk [4]. In another study, soymilk was enriched with pawpaw puree in order to increase the vitamin contents of the drink [5].

Soft drinks are non alcoholic carbonated or non carbonated beverages. Intake of soft drinks has raised lots of arguments as concern effects on human health and government policy. Several past studies on possible links between soft drinks consumption and health problems have been challenged [6].

In Nigerian, soft drink is the most commonly consumed beverages because of its availability in different flavours, sweetness, sizes, brands [7] and cheap prices. Soft drinks are mostly consumed to quench thirst, replenish energy following laborious work or exercise, as food adjunct and as refreshment during leisure time, picnics, or parties [8].

In general, the desirable properties of soft drinks are mainly due to their major constituents which include sugar, carbonated water, flavouring agents. These major ingredients are responsible for the sweetness, thirst quenching and flavor of the drinks. On the other hand, the minor constituents; acids, vitamins, antioxidants etc. are of nutritional and health importance [7].

A number of fruit drinks and soft drinks are sold and consumed worldwide, Nigeria inclusive. In Nigeria, the general belief is that commercial fruit juices and soft drinks consist of only sugar, flavour, colorants and in the case of juice, concentrate, without any nutrients. The objectives of this study were to investigate the quality attributes and microbial safety of fruit juices and soft drinks sold in Southwest, Nigeria.

2. MATERIAL AND METHODS

2.1 Materials

Twenty (20) samples of fruit juices and drinks were purchased from big retail shops and supermarkets in Ogbomoso and Ibadan city, Oyo state, Southwest, Nigeria. Matured ripe watermelon, pineapple, orange fruits were purchased from local markets in Ogbomoso. The experiment was carried out at Food Chemistry laboratory, Ladoke Akintola University of Technology, Ogbomoso, and in a private analytical laboratory in Ibadan, Oyo state.

2.2 Methods

2.2.1 Production of orange, pineapple and watermelon fruit juices

The fresh matured fruits were sorted and washed twice with distilled water containing hypochlorite solution (5%) in order to eliminate microbial contaminants. Washed fruits were rinsed twice with water and the pericarps and flesh were removed with a kitchen knife. Peeled fruits were placed separately into juice extractor

(B616 Ilοytron, 23438, UK) to extract the juice. Extracted juices were filtered separately using a muslin cloth to obtain orange, pineapple and watermelon juices. The filtered juice samples were blanched at 75°C for 5 min and packaged immediately in sterilized screw cap bottles, and refrigerated (-5°C) until further analysis.

2.3 Physicochemical Analysis

The total solid, pH, soluble solid, titratable acidity (TTA), and specific gravity of the fresh and commercial juice, and the soft drink samples were analysed according to AOAC [9], and Bolarinwa et al. [10]. The total solid contents of the samples were determined using the oven method. The pH of the juice was determined using a digital pH meter (pHs-2F, Harris, England) after its initial standardization to 4.0 and 7.0. The soluble solid (°Brix) was determined using a hand-held refractometer. TTA was determined by titrating the beverage samples (10 ml) against NaOH (0.1N) to a pink end point using phenolphthalein indicator. The relative amounts of total acidity of the samples were calculated as follows:

$$\%\,Titratable\ acidity\ = \frac{Titre\ value\ x\ Normality}{Weight\ of\ sample} \times\ 100 \quad (1)$$

The samples specific gravity values were determined at 20 °C with a density bottle [9], and estimated as:

$$Sp = \frac{(weight\ of\ sample + density\ bottle) - weight\ of\ empty\ bottle}{(Weight\ of\ distilled\ water\ and\ density\ bottle) - weight\ of\ empty\ bottle} \quad (2)$$

Where Sp is Specific gravity.

2.4 Determination of Mineral Contents of Fruit Juices and Drinks

The mineral contents profile of the juices and drinks were evaluated following the procedures described by Adedeye and Adewoke [11]. The juice/drink samples (1 g) were digested with hydrochloric acid (2.5 ml of 0.03N), and the digest was boiled (5 min), cooled and transferred into volumetric flask, made up to 50 ml mark with distilled water, and filtered (Whatman No.1 filter paper). The resulting filtrate from the juice and drink samples were analyzed for phosphorus, calcium, magnesium, and potassium contents using AAS (Flame Atomic Absorption Spectrophotometer; Buck Scientific model 205, USA) with recommended standard wavelengths. Values obtained were adjusted for HCl-extractability for the respective ions, and values of each mineral element were extrapolated from their respective standard curves. Analysis was performed in triplicates for each mineral element.

2.5 Determination of Vitamin Contents of the Fruit Juice and Drinks

2.5.1 Vitamin A

Beta-carotene contents of the juice and drinks samples were analysed following the procedure described by Bolarinwa et al. [12]. Briefly, the juice and drinks samples (5 ml) were placed in acetone (10 ml) and some anhydrous sodium sulphate crystals were added to the samples, mixed and allowed to sediment. Supernatant from the sediment was decanted into a separatory funnel. The supernatant was mixed with 10 ml petroleum ether (10 ml) and allowed to separate into two layers consisting of upper and lower layers. The upper layer was collected while the lower layer was discarded. The 100 ml volumetric flask containing the upper layer was made up to 100 ml with petroleum ether. The OD (optical density) of the diluted upper layer solution was determined at 452 nm. Petroleum ether was used as blank for the determination.

Calculation:

$$B - carotene = OD\ x \frac{13.9x10000x100}{weight\ of\ sample\ x\ 560\ x\ 1000} \quad (3)$$

Where, OD = Optical density of the solution at 452 nm

2.5.2 Vitamin B1

The B vitamins of the juice and drinks were determined by the spectrophotometric method described by Okwu [13]. Each sample (5 ml) was homogenized with ethanolic sodium hydroxide (1N; 50 ml) and the solution was filtered to obtain clear solution (the filtrate) for further analysis. The filtrate (10 ml) was treated with potassium dichromate solution (0.1N) in a volumetric flask. 0.5 M of standard thiamine solution was prepared and an aliquot of the thiamine solution was also treated with potassium dichromate solution (10 ml) in a separate flask. Blank was prepared by treating ethanolic sodium hydroxide (l0 ml) with potassium dichromate solution. Sample and standard absorbance were read on a spectrophotometer at a wavelength of 360 nm.

Vitamin B1 (thiamine) content was estimated as;

$$\text{Vitamin } B_1 \frac{mg}{100g} = \frac{100}{w} \times \frac{Au}{As} \times \frac{C}{1} \times \frac{Vf}{Va} \times D \qquad (4)$$

Where:

W = Weight of sample analyzed
Au = Absorbance of sample
As = Absorbance of standard solution
C = Concentration (mg/ml) of standard solution
Vf= Total volume of filtrate
Va = Volume of filtrate analyzed
D = Dilution factor where applicable

2.5.3 Vitamin B_2

The samples (1 ml) were weighed and diluted with deionized water (100 ml) in a beaker. The mixture was thoroughly shaken, heated for 5 min, cooled and filtered. Filtrate (1.5 ml) was pipetted into cuvettes and the absorbance of the vitamin was determined at 242 nm using a spectrophotometer.

$$Vitamin\ B2\ conc. (mg/100g) = \frac{A\ X\ D.F\ X\ vol.of\ cuvette}{E} \qquad (5)$$

Where A = Absorbance
E = Extinction co-efficient = 25 for B_1 and B_2
DF = Dilution factor

2.5.4 Vitamin C

Vitamin C contents of the beverage samples were determined following the procedures described by Okwu and Josiah [14]. Each sample (10 ml) was extracted with EDTA/TCA (50 ml), an extracting solution for 1 h, filtered (Whatman filter paper) into a volumetric flask (50 ml) and made up to the mark with the extracting solution. The extract (20 ml) was pipette into a conical flask (250 ml) and 30% potassium iodide (10 ml) and distilled water (50 ml) were added to the solution, followed by 1% starch indicator (2 ml). The solution was titrated against $CuSO4$ (10ml) solution to a dark end point.

$$\text{Vit C } \left(\frac{mg}{100g}\right) = 0.88 \times \frac{100}{5} \times \frac{Vf}{20} \times \frac{T}{1} \qquad (6)$$

Where: Vf = Volume of extract
T = Sample titre – blank titre.

2.6 Microbiological Analysis

The microbiological qualities of the beverages were determined by the procedure described in AMPH [15] and Harrigan and Mc Cance [16]. Serial dilution of the drinks and fruit juices samples were prepared by withdrawing 1 ml of each sample aseptically and adding it into 9ml of distilled in a sterile test tube to produce 10^{-1} solution of the sample. The 10^{-1} solution was then used for further dilution to 10^{-2}. This was either used directly or further diluted prior to microbial analyses.

2.6.1 Total plate count

1 ml of the serially diluted mixture of each sample was aseptically poured into each sterilized plate containing nutrient agar with the aid of a sterilized pipette. The plate was then incubated (27^{o}C; 48 h). The colonies were counted using a scientific colony counter after 48 h of incubation. The counts were done in duplicate.

2.6.2 Total coliform count

One (1) ml of the serially diluted mixture of each sample was aseptically poured into each sterilized plate containing Mac Conkey's agar with the aid of a sterilized pipette. The plate was then incubated at 37^{o}C for 24 h. The colonies were counted with a scientific colony counter after 24 h of incubation. The counts were done in duplicate.

2.7 Statistical Analysis

Data obtained were statistically analysed using ANOVA (analysis of variance) of the statistical software (SPSS version 17.0). Means were separated using Duncan's multiple range tests, and significant differences among the samples were determined at $p < 0.05$.

3. RESULTS AND DISCUSSIONS

3.1 Physicochemical Properties of Commercially Soft Drinks

The results of the physicochemical characteristic of soft drinks samples used in this study is presented in Fig. 1.

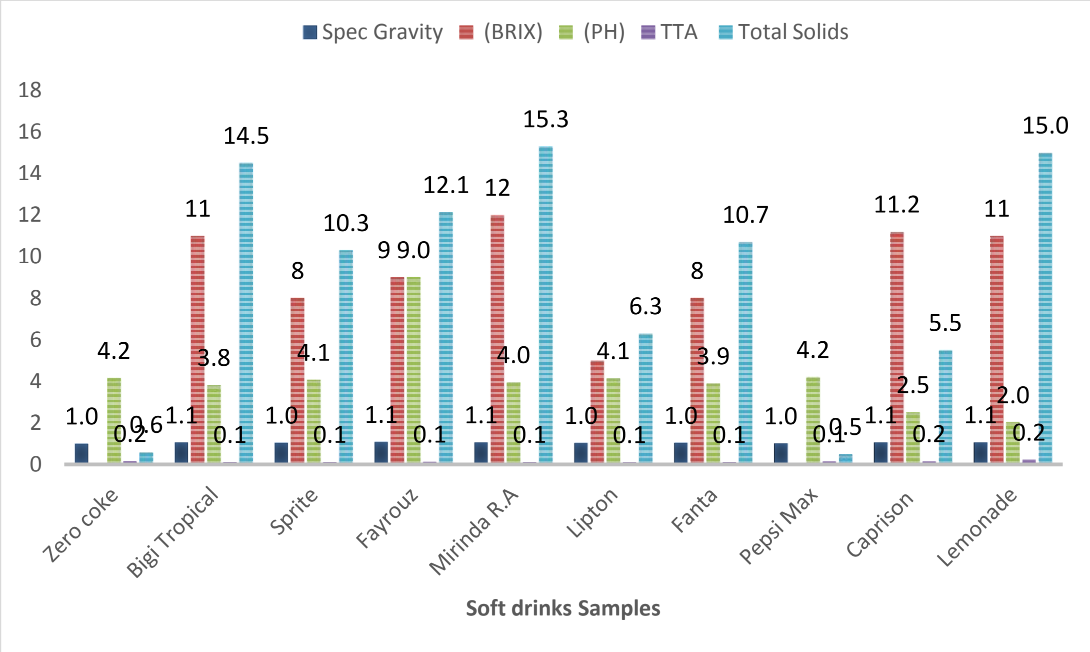

Fig. 1. Physicochemical properties of soft drink samples

3.1.1 Specific gravity

Specific gravity of beverages is a measure of level of sugar/fruit present in a beverage sample. The higher the sugar/fruit content in a beverage, the higher the density of the beverage. The commercially sold drink samples maintained the specific gravity between 1.077 and 1.001. Fayrouz had the highest value of 1.077 specific gravity while the lowest specific gravity 1.001 was recorded for zero coca-cola. The result was relative amongst other soft drinks samples, 1.057 was recorded for Wilson's Old (Lemonade) drink, 1.056 g/cm^3 was recorded for Mirinda Red Apple drink, 1.052 was recorded for Caprison (Orange), 1.051 was recorded for Bigi Tropical drink, 1.045 was recorded for Sprite drink, 1.035 was recorded for Fanta drink, 1.029 was recorded for Lipton drink and 1.007 was recorded for Pepsi max. The results of the specific gravity showed that other particulates and substances are present in the samples apart from water which had a specific gravity of (1.000). The specific gravity of the soft drinks was similar to the recommended specific gravity (1.0-1.07) for carbonated beverages and soft drinks [17]. Due to the high water contents of soft drinks, they are generally regarded as low dense beverages.

3.1.2 Brix value (Total soluble solid)

Brix is a measure of the approximate amount of soluble sugars present in beverages. The result reflected that Mirinda Red Apple had the highest Brix value of 12% while Lipton had the lowest Brix value of 5%. The Brix values of Caprison, Lemonade and Bigi tropical drink are significantly different (Fig. 1). The Brix level of Sprite and Fanta drinks are the same (8%). Meanwhile, Zero Coca-Cola and Pepsi Max recorded zero (0) Brix values, respectively. This indicates that these drinks do not contain sugar; however, it is possible that they contain non-caloric sweeteners. Standards Brix are categorized as weak and watery when the total soluble solids are <7 g/100ml solution [18]. Thus, the soft drinks samples containing >7 g/100ml Brix level are not watery drinks. The Brix level of the soft drinks recorded for the selected commercial drinks in these study are close to the range of 9.15 – 14.25% reported by Ndife et al. [19] for different brands of soft drinks. In general, the sugar constituents of soft drinks have been reported to be in the ranges of 6 to 10%, comprising of sucrose, maltose, fructose or glucose [20]. Thus, most commercial soft drinks sold in Southwest Nigeria contains more than the recommended sugars for soft drinks.

3.1.3 pH value

The pH is a determining factor in the ability of food to be preserved. The pH of the soft drinks ranged between 2.02 – 4.20. The pH of the soft drinks showed that the drinks are all within the acidic region. There was no statistically significant difference between Zero Coke, Pepsi Max Sprite, Mirinda and Lipton. The pHs of the soft drinks are within the average pH (3.6) of soft drinks [21]. However, low pH (2.61 – 4.03) could cause enamel loss [22]. Past study has reported that low pH foods or drinks with high acidity could be responsible for tooth decay [23]. On the other hand, food that contains low pH can be stored for a longer period without microbial contamination. In contrary, low acidic foods or drinks has the potential of minimizing the risk of tooth erosion. Thus, this makes the soft drinks relatively safe for consumption.

3.1.4 Total Titratable Acidity (TTA)

The TTA of the soft drinks ranged between 0.1 to 0.2 g/100ml. (1- 2 mg/ml). These values are close to the range of TTA (3-8 mg/ml) reported for Nigeria soft drinks. However, TTA of 1.1 – 7.7 mg/ml have been reported to cause enamel loss [22]. The results of the titratable acidity is in agreement with that of the pH reported in section 3.1.3 (above); that is, the lower the pH value, the higher the titratable acidity. Indicating that soft drinks become more acidic at a lower pH value [19].

3.1.5 Total solids (TSS)

The TSS recorded for the soft drinks varies from 15.30% to 0.60%. Mirinda Red Apple had the highest total solid value (15.30%) compared to Pepsi Max which recorded the lowest TSS value of 0.50%. This indicates that there is significant variation in TSS content of the commercial soft drinks sold in Southwest Nigeria.

3.2 Physicochemical Properties of Pure Fruit Juices and Commercially Sold Juices

3.2.1 Specific gravity

The specific gravity of the commercial fruit juice and the natural fruit juice samples are not statistically significantly different. The specific gravity values ranged from 1.07-1.00. Chivita active fruit juice had the highest value of (1.07) specific gravity while the lowest specific gravity 1.00g/cm was recorded for Nylahs pineapple lemonade. The result was relatively high for laboratory prepared pineapple juice (1.07) compared with other laboratory prepared fruit juices (1.01, 1.05). The results of the specific gravity showed that other particulates, possibly fruit pulps are present in the juice samples. The specific gravity of the fruit juices is within the range of recommended specific gravity (1.03 – 1.07) for fruit juice and ready to drink juice [17].

3.2.2 Brix Value

The Brix was used to measure the levels of soluble sugars in the fruit juices (laboratory prepared and commercially made). Hence the result reflected that laboratory prepared pineapple juice had the highest brix value of 16% while Chivita active (12.4%), Five Alive (11%) and Chivita exotic juice (11%). These results indicate that the commercial fruit juices may not contain added sugar. Similar results on commercially made fruit juices were reported by Gbarakoro et al. [24]. All the orange juice samples conformed to the Brix value for orange juices which range from 9. 15 – 14.25% [19]. However, laboratory prepared watermelon juice sample had lower (5.4%) Brix level compared to the Brix value for watermelon juice beverages, which ranges from 9-15%.

3.2.3 pH Value

The pH is a determining factor in determining the storage stability of food. Thus, a pH of higher than 6 is very favourable to the growth of yeasts and moulds while lower pH inhibits bacteria growth. In general, the pH values of the commercial fruit juice samples is between 2.1 – 4.4 while that of the pure fruit juices are between 3.7 – 4.8. These results indicate that the pH of commercial fruit juices and pure fruit juices are similar. This observation is in congruent with the report of Gbarakoro et al. [24], who reported pH values of 3.6 - 4.5 for commercial fruit juices in Port Harcourt, Nigeria.

Generally, pure fruit juices had higher pH values compared to soft drinks, and most fruit juices (commercial and laboratory prepared) had accepted standard pH values (2.2- 5.8) recommended by FAO [25].

Fig. 2 shows some physicochemical properties of laboratory prepared 100% fruits juice and commercially sold fruit juice samples.

3.2.4 Total Titratable Acidity (TTA)

The TTA of all the samples is between 0.1 to 0.2 mg/100ml. These values are similar to TTA of soft drinks recorded in section 3.14 (above). Similar TTA values recorded for the pure fruit juices and the commercially sold fruit juices indicate that the commercial samples are produced with fruit pulp and may not contain a high amount of concentrate or other additives.

3.2.5 Total solids

The TSS recorded for the pure pineapple (22 g/100 ml) and watermelon juice (25.9 g/100ml) were significantly higher than the values (11.1 – 15.5g/100ml) recorded for the commercial fruit juices. Thus, there is significant variation in the content of TSS of the fruit juice samples. This could be due to clarifying process that some commercial juice is subjected to prior to packaging. This is because some consumers prefer clear juice to cloudy juice; thus, in order to satisfy consumers', manufacturers of juice may decide to clarify the juice by removing most of the fruit fibres or pulp.

Generally, the total solid contents of fruit juices (laboratory prepared and commercially-made fruit juices) are higher than those of soft drink samples. This could be because the total solid contents in fruit juice is a factor of the fruit pulp and the level of sugar in the fruit.

3.3 Mineral Composition of Fruit Juice

The mineral composition of the natural fruit juice and commercial juice is shown in Table 1. The phosphorous content of the natural fruit juice and commercial juice were significantly different ($p<0.05$), and ranged from 13.43 to 1834.10 mg/100ml with sample M (Frutta (pineapple fruit) having the lowest value while sample L (Chivita active) had the highest value. Surprisingly, pure fruit juices contain lower phosphorus compared to commercial fruit juice. This could be due to the fact that most of the commercial fruit juices are produced from different blends of fruit and could contain other additives. However, the phosphorus contents of the pure fruit juices and the commercial fruit juices reported in this study are within the normal range of phosphorous (34.78-123 mg/100ml) reported for natural fruit juice from different fruit [19], orange juice (446 mg/100ml) and mango juice (213 mg/100ml) mango juice [26].

The calcium content of the juice ranged from 111.53 to 228.08 mg/100ml with sample L (Chivita active) having the lowest value while sample C (Chivita exotic) had the highest value.

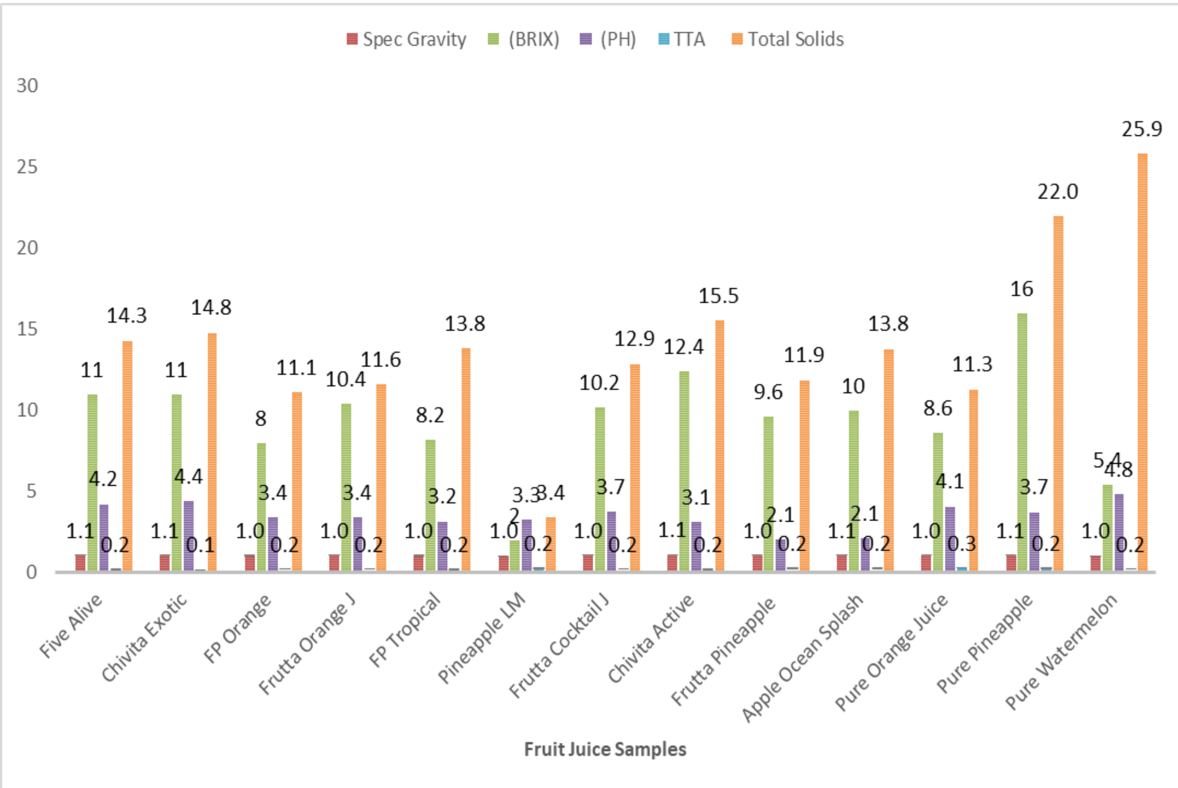

Fig. 2. Physicochemical Properties of Laboratory prepared and Commercially sold fruit Juices Samples

Table 1. Mineral composition of fruit juice

Sample	Phosphorous (mg/100ml)	Calcium (mg/100ml)	Magnesium (mg/100ml)	Potassium (mg/100nl)
A	385.77±0.10[f]	211.60±0.10[c]	1.52±0.02[d]	550.33±0.58[a]
B	236.77±0.10[i]	230.83±11.40[a]	2.51±0.01[b]	500.33±0.58[b]
C	236.77±0.10[i]	228.08±0.13[b]	1.51±0.02[d]	300.33±0.58[d]
D	656.77±0.10[c]	200.53±0.04[e]	1.52±0.02[f]	100.02±0.02[e]
E	136.77±0.10[l]	132.26±0.23[i]	1.52±0.02[d]	350.14±0.12[c]
F	325.40±0.12 [g]	200.47±0.03[e]	1.02±0.01[e]	100.14±0.12[e]
G	136.74±0.12 [b]	132.33±0.58[i]	1.07±0.05[e]	100.02±0.02[e]
H	443.43±0.17[e]	141.60±0.10[g]	1.60±0.10[d]	50.15±0.13[f]
I	563.4±0.12[d]	177.00±1.00[f]	2.60±0.10[a]	300.67±0.58 [c]
J	1553.5±0.35[b]	126.60±0.10[j]	0.57±0.06[f]	50.11±0.19[f]
K	41.00±1.00[m]	126.33±0.58[j]	1.02±0.01[e]	50.08±0.12[f]
L	1834.10±0.13[a]	111.53±0.058[k]	0.57±0.06[f]	50.08±0.07[f]
M	13.43±0.10 [a]	141.00±1.00[g]	1.02±0.01[e]	51.00±1.00[f]
N	146.77±0.10[k]	207.60±0.10[d]	1.60±0.10[c]	301.00±1.00[d]
O	251±1.00[h]	138.00±1.00[h]	2.60±0.10[a]	301.67±1.53[d]
P	171.33±1.53[j]	138.00±1.00[h]	2.60±0.10[a]	301.00±1.00[d]

Means with different superscripts are significantly different (P < 0.05). A= Five alive; B = Chivita exotic; C= Pure Orange juice; D= Pure Pineapple juice; E= Pure Watermelon juice; F= Farm pride (orange); G= Frutta (orange juice); H= Farm pride (tropical blast); I= Nylahs pineapple lemonade; J= Frutta (cocktail juice); K= Chivita active; L = Frutta (pineapple fruit); M = Cran apple juice (ocean splash); N= Caprisun (orange); O= Wilsons old fashioned (fresh lemons never from concentrate).

There is no significant difference (P>0.05) between the calcium contents of some of the samples while pure orange juice and watermelon juice had similar calcium contents as some of the commercial juice. The calcium content of the juice samples in this study (111.53 to 228.08 mg/100ml) is higher than that of the findings of Dosumu et al. [27], who reported calcium contents of 73-93 mg/100ml for Nigerian packed fruit juices. The high levels of calcium in the commercial juice are a good indication that the juice can increase the calcium intake of consumers and possibly reduce the mineral deficiency. The calcium contents of most of the commercial juice are higher than the daily calcium requirement of 80 to 120mg/L [28]. This could be due to supplementation of the juice with calcium.

The magnesium content of the juice ranged from 0.52 to 2.60 mg/100gml with sample J (Nylahs pineapple lemonade) having the lowest value while juice samples from the citrus family (samples I, O and P) had the highest value. The magnesium contents of the commercial juice and pure juice samples reported in this study are lower than the value corresponding to 407mg/100ml reported by [29] for jackfruit juice.

The potassium content of the juice ranged from 50.08 to 550.33 mg/100g with sample K (Frutta-cocktail juice) having the lowest value while sample A (Five alive) had the highest value. The potassium composition of the fruit juice and commercial soft drinks reported in this study is within the value (200 mg/100g) reported by USDA [26] for fruit juice. Sairi et al. [30] reported the level of potassium in pineapple juice to be 128 -160 mg/100ml. This value is within the range of the potassium contents of pure fruit juices or commercial fruit juices reported in this study. In addition, the potassium contents of most of the commercial fruit juices are lower than the recommended daily intake (3510 mg/day) [31], however it can contribute to the daily intake of potassium from food.

3.4 Mineral Composition of Commercial Soft Drinks

The macro-mineral contents of the soft drinks are presented in Table 2. The Phosphorous content of commercial soft drinks ranged from 100.00 to 946.77 mg/100ml with sample C (Sprite) having the lowest value while sample A (Coca-cola zero sugar) had the highest value. This could be due to differences in the ingredients used for the production of the soft drinks [32].

Table 2. Mineral composition of commercial soft drinks

Sample code	Phosphorous (mg/100ml)	Calcium (mg/100ml)	Magnesium (mg/100ml)	Potassium (mg/100ml)
A	946.77±0.10[a]	140.53±0.03[c]	1.03±0.021[b]	50.10±0.11[e]
B	112.00±1.00[e]	140.20±0.27[c]	0.67±0.153[c]	50.07±0.06[e]
C	100.00±1.00[f]	165.37±0.15[b]	0.57±0.115 [d]	100.14±0.16[d]
D	506.77±0.10[b]	168.17±0.15[b]	0.52±0.029[d]	150.09±0.11[b]
E	143.43±0.10 [d]	135.60±0.10[c]	0.52±0.021[d]	50.07±0.06[e]
F	201.00±1.00[c]	164.13±0.23[b]	1.04±0.026[b]	110.14±0.12[c]
G	113.00±1.00[e]	228.17±0.25[a]	2.03±0.020[a]	350.07±0.12[a]

Means with different superscripts are significantly different (P < 0.05). A= Coca-cola zero sugar; B= Bigi tropical; C= Sprite; D= Fayrouz; E= Mirinda red apple flavour; F= Lipton; G = Pepsi max

The calcium content of commercial soft drinks ranged from 135.60 to 228.17 mg/100ml with sample E (Mirinda red apple flavour) having the lowest value while sample G (Pepsi max) had the highest value. There is no significant difference (P≥0.05) between the calcium contents of samples A (Coca-cola zero sugar) and sample B (Bigi tropical), C (Sprite), D (Fyrouz), and F (Lipton).

The magnesium content of the commercial soft drinks were significantly different (p<0.05). The levels of magnesium in the drinks ranged from 0.52 to 2.03 mg/100g with sample D (Fayrouz) having the lowest value while sample G (Pepsi max) had the highest value. The magnesium contents (0.52 to 2.03 mg/100ml) of the soft drinks reported in this study is within the value of magnesium levels (1.03 mg/100ml) in some Nigerian packed fruit juices, concentrate and local beverages [27].

Potassium contents of the commercial soft drinks ranged from 50.07 to 350.07 mg/100ml with sample E (Mirinda red apple flavor) having the lowest value while sample G (Pepsi max) had the highest value. There is no significant difference (P>0.05) between sample A (Cocacola zero sugar), B (Bigi tropical) and E (Mirinda red apple flavour). However, potassium contents of the pure fruit juices and the commercial fruit juices were significantly (p<0.05) higher than the potassium contents of most of the commercial soft drinks.

In general, the mineral composition of pure fruit juice and commercial fruit juices are higher than the mineral composition of soft drinks. This could be due to high mineral contents in fruit pulp which are used for the production of juices. Unlike soft drinks whose major ingredients are water and sugar [33].

3.5 Vitamin Composition of Natural Fruit Juice and Commercial Juice

The vitamin composition of natural fruit juice and commercial juice is presented in Table 3. The vitamin C contents of the natural fruit juice and commercial juice ranged from 14.89 to 22.81µg/100ml with sample C (pure orange juice) having the lowest value while sample A (Five alive) had the highest value. In general the vitamin C contents of the commercial juices are higher than the vitamin C contents of the pure fruit juices. This could be due to fortification of the commercial juices with vitamin C and other vitamins. There was no significant difference in the vitamin B_1 and B_2 contents of most of the commercial juice samples and the pure juice samples. This could be due to the similarity in vitamin B_1 and B_2 composition of the fruits used for the preparation of the commercial juices. On the other hand, the vitamin A contents of sample A (Five Alive) was highest (1.16 µg/100ml), followed that of sample E (pure watermelon, 0.76 µg/100ml) and sample C (pure orange, 0.39 µg/100ml) fruit juices. The higher vitamin A value recorded for sample A could be because the juice is produced from different blends of fruits, some of which probably contains high beta-carotene (a precursor of vitamin A). The vitamin A contents of watermelon was the second-highest among all the fruit juices because watermelon pulp contains high beta-carotene. According to Maakelo et al. [33], the beta-carotene content of watermelon is 0.3 mg/100ml.

Table 3. Vitamin composition of natural fruit juice and commercial juice

Sample	Vitamin C (μg/100ml)	Vitamin B_1 (μg/100ml)	Vitamin B_2 (μg/100ml)	Vitamin A (μg/100ml)
A	22.81±0.91[a]	0.19±0.00[a]	0.19±0.00[a]	1.16±0.02[a]
B	22.79±0.40[a]	0.19±0.00[a]	0.19±0.00[a]	0.05±0.01[e]
C	14.89±1.48[e]	0.19±0.00[a]	0.16±0.01[b]	0.39±0.01[c]
D	17.08±2.84[e]	0.19±0.01[a]	0.16±0.01[b]	0.15±0.01[d]
E	17.33±1.95[e]	0.19±0.00[a]	0.16±0.00[b]	0.76±0.01[b]
F	17.49±2.96[e]	0.19±0.00[a]	0.16±0.00[b]	0.04±0.00[e]
G	18.22±1.66[d]	0.19±0.00[a]	0.16±0.00[b]	0.18±0.00[d]
H	18.39±1.51[d]	0.19±0.00[a]	0.16±0.00[b]	0.12±0.01[d]
I	16.52±0.79[d]	0.17±0.04[b]	0.16±0.00[b]	0.02±0.01[e]
J	16.50±1.89[d]	0.19±0.00[a]	0.16±0.00[b]	0.02±0.00[e]
K	17.94±0.51[e]	0.19±001[a]	0.16±0.00[b]	0.31±0.00[c]
L	16.97±1.92[f]	0.19±0.01[a]	0.16±0.00[b]	0.01±0.01[e]
M	16.11±1.69[f]	0.19±0.01[a]	0.16±0.01[b]	0.01±0.00[e]
N	19.82±0.88[c]	0.19±0.00[a]	0.16±0.00[b]	0.06±0.01[e]
O	20.28±0.72[b]	0.19±0.00[a]	0.16±0.00[b]	0.00±0.00[f]

Means with different superscripts are significantly different (P < 0.05). A= Five alive;B = Chivita exotic; C= Pure Orange juice; D= Pure Pineapple juice; E= Pure Watermelon juice; F= Farm pride (orange); G= Frutta (orange juice); H= Farm pride (tropical blast); I= Nylahs pineapple lemonade; J= Frutta (cocktail juice); K= Chivita active; L = Frutta (pineapple fruit); M = Cran apple juice (ocean splash); N= Caprisun (orange); O= Wilsons old fashioned (fresh lemons never from concentrate).

Table 4. Vitamin composition of commercial soft drink

Sample	Vitamin C (μg/100g)	Vitamin B_1 (μg/100g)	Vitamin B_2 (μg/100g)	Vitamin A (μg/100g)
A	26.14±0.38[a]	0.19±0.00 [a]	0.19±0.00[a]	0.01±0.00[a]
B	25.83±0.61[b]	0.19±0.00 [a]	0.18±0.00[a]	0.03±0.01[a]
C	25.64±0.40[b]	0.19±0.00 [a]	0.17±0.00[a]	0.07±0.01[a]
D	25.82±0.25[b]	0.19±0.00 [a]	0.19±0.00[a]	0.01±0.01[a]
E	25.76±0.28[b]	0.19±0.00 [a]	0.19±0.00[a]	0.04±0.00[a]
F	24.92±0.33[c]	0.19±0.00 [a]	0.18±0.00[a]	0.06±0.01[a]
G	22.94±0.21[e]	0.19±0.00 [a]	0.19±0.00[a]	0.06±0.01[a]
H	23.82±0.35[d]	0.19±0.00 [a]	0.19±0.00[a]	0.01±0.00[a]

Means with different superscripts are significantly different (P < 0.05). A= Coca-cola zero sugar; B= Bigi tropical; C= Sprite; D= Fayrouz; E= Mirinda red apple flavour; F= Lipton; G= Pepsi max; H= Fanta

3.6 Vitamin Composition of Commercial Soft Drink

The vitamin contents of the commercial soft drinks are presented in Table 4. In general, vitamin compositions of most of the soft drinks are not significantly different except for vitamin C. This could be because soft drinks are produced from similar ingredients including vitamins. Variation in the vitamin C contents of the soft drinks could be due to differences in the quantity of the vitamin used in fortifying the drinks. According to Adams et al. [32], In addition to sugar and carbonated water, other constituents of soft drinks are; acids, phosphates, antioxidants, vitamins etc., which are of health and nutritional importance.

The vitamin C content of the commercial soft drink ranged from 22.94 to 26.14 μg/100ml with sample G (Pepsi max) having the lowest value while sample A (Coca-cola zero sugar) had the highest value.

3.7 Microbiological Components of Soft Drinks

Table 5 shows the microbiological quality of the commercially available soft drinks analysed in this study. The microbial loads that were determined are total aerobic microbial count, total yeast, mold count and total coliform count.

Total aerobic microbial count was used to determine the aerobically grown bacterial

Table 5. Microbiological loads of the soft drinks

Soft Drinks	TAMC	TYMC	TCC
Zero coke	Nil	Nil	Nil
Bigi Tropical	Nil	Nil	Nil
Sprite	Nil	Nil	Nil
Fayrouz	Nil	Nil	Nil
Mirinda Red Apple	Nil	Nil	Nil
Lipton	Nil	Nil	Nil
Fanta	Nil	Nil	Nil
Pepsi Max	Nil	Nil	Nil
Caprison (Orange)	Nil	Nil	Nil
Wilson's Old (Lemonade)	Nil	Nil	Nil

TAMC - Total Aerobic Microbial Count; TYMC - Total Yeast and Mold Count; TCC - Total Coliform Count

Table 6. Microbiological Components of fruit juice

Fruit Juice	TAMC	TYMC	TCC
Five Alive	Nil	Nil	Nil
Chivita (Exotic)	Nil	Nil	Nil
Farm Pride (Orange)	Nil	Nil	Nil
Frutta Orange Juice	Nil	Nil	Nil
Farm Pride (Tropical blast)	Nil	Nil	Nil
Nylahs Pineapple Lemonade	Nil	Nil	Nil
Frutta (Cocktail Juice)	Nil	Nil	Nil
Chivita (Active)	Nil	Nil	Nil
Frutta (Pineapple fruit)	Nil	Nil	Nil
Apple Juice Ocean Splash	Nil	Nil	Nil
Laboratory prepared Orange Juice	1.1×10^3	1.6×10^3	Nil
Laboratory prepared Pineapple Juice	2.2×10^3	1.5×10^3	Nil
Laboratory prepared Watermelon Juice	1.1×10^3	1.3×10^3	Nil

TAMC= *Total Aerobic Microbial Count* ***TYMC=*** *Total Yeast and Mold Count;* ***TCC=*** *Total Coliform Count*

population in the samples. All the soft drinks had no aerobic microbial counts. This could be due to the acidic nature of the drinks and the presence of carbondioxide in the drinks. The combination of carbondioxide and low pH of the drinks will inhibit microbial growth, hence the reason for the absence of aerobic microbial counts, total yeast, mold and coliform count.

3.8 Microbiological Loads of the Fruit Juices

Table 6 shows the microbiological load of laboratory prepared (pure fruit juices) and commercially made fruit juices analysed in this study. The composition includes Total Aerobic Microbial Count (TAMC), Total Yeast and Mold Count (TYMC) and Total Coliform Count (TCC). Results of the microbial analyses showed that all the commercial fruit juices are free from microbial loads. This could be high temperature short time processing methods employed for their preparation. However, TAMC and TYMC were detected in the pure fruit juices. This could be due to contamination during processing and possibly storage. Among the pure fruit juices samples analysed, the pure pineapple juice had the highest count of the microbial contaminant of 2.2×10^3 compared to pure orange juice (1.1×10^3 CFU/ml) and watermelon juice (1.1×10^3 CFU /ml). However, the microbial loads in the pure fruit juices are below the level that can be harmful. Microbial load of $<10^6$ CFU /ml are for ready-to-eat foods [34, 35].

4. CONCLUSION

Commercial juices and soft drinks contain better mineral and vitamin composition compared to fresh juices. And they have also nil microbiological loads. Hence, they can be used for quenching thirst and improve energy during stressful conditions but they cannot replace natural juices. Further study should be done on the stability, microbial quality and degradation of micronutrients in commercially available fruit juices and soft drinks opened and stored under different storage conditions.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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