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Nutritional and physicochemical characteristics of natural fruit juice formulated from papaya (*Carica papaya*), pineapple (*Ananas comosus*) and beetroot (*Beta vulgaris*)

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Maintaining optimal nutrition and healthy population continues to be a global priority. The group of liquids and beverages plays an important role in human nutrition. Most beverages consumed are artificial and contain an array of chemical molecules that can be harmful to the health of consumers. Papaya, pineapple and beetroot are the most popular fruits and legumes in Cameroon with several therapeutical effects. This study aimed to develop natural fruit juices from the combination of papaya, pineapple, and beetroot. Four different mixed fruit juices were made and analysed for various physicochemical and nutritional properties. The results of the study showed levels of pH (4.79-5.26), carotenoid (0.01 mg/100 mL), and vitamin C (23.56-50.85 mg/100 mL) in studied juices. The moisture, carbohydrate, soluble sugar, fat and protein contents varied from 91.4-94.36%, 4.38-7.16%, 1.19-1.73%, 0.12-0.26%, and 0.51-1.24%, respectively. The minerals ranged from 0.89-1.29 mg/100 mL, 5.28-6.32 mg/100 mL and 5.26-8.13 mg/100 mL, respectively for Fe, Ca, and Mg. Amongst the four juices, J4 was shown to be the most nutritive. Juices of this study could be used as food formulation material for infants and young children to prevent iron deficiency anemia. Also, post harvest loss fruits can be reduced by converting fruit into attractive mixed juice which increase value of the product.

Key words: *Carica papaya, Ananas comosus*, *Beta vulgaris*, juices mixed, nutritional characteristics.

INTRODUCTION

Fruits and vegetables are of great importance in human nutrition (Garg et al., 2019) as their consumption maintains good health and replaces the losses in nutrients by the body (Ohwesiri et al., 2016). It is recommended for an average adult to consume about 400 g of fruits and vegetables per day to maintain good health (FAO, 2021). Fruits are good sources of essential elements which are very important for our body to make body function properly, such as water, vitamins (A, B1, B2, C, D and E), minerals (Ca, Mg, Zn, Fe, K, etc.), and organic compounds (Begum et al., 2018). Fruits and legumes are also great sources of antioxidants which are responsible for scavenging free radicals (Ravimannan and Nisansala, 2017). In rural Cameroon, fresh fruits are consumed within short periods of seasonal availability after picked from wild trees or after harvesting. Depending on the processing technology, natural beverages may include juices or smoothies. They are produced with minimal processing and are usually consumed fresh, or soon after (Butu and Rodini, 2019).

Papaya (*Carica papaya*) is a tropical fruit with a unique flavour, aroma and pleasant sour sweet taste, a good source of carotenoid, vitamin C, and dietary fiber. It is a woody herb, growing up to 10 to 12 feet and is relatively short lived. Fruit particularly papaya, are difficult to keep for long time and are utilized either as fresh or processed into juice and specialist products due to being susceptible to bacterial and fungal contamination. Papaya juice is better for increment of acidity, thus can increase the acidity and improve the stability of juice (Patil et al., 2021). Papaya juice can enhance the flavour of juice by increasing acidity (Ewenetu and Molla, 2022).

Pineapple (*Ananas comosus*) is a widely consumed fruit grown in many tropical and subtropical regions (Debnath et al., 2021; Sun et al., 2016). Pineapple and its products are known for their pleasant aroma and flavor. The fruit is rich in certain vitamins, minerals, polyphenol antioxidants, and other phytochemicals (Ali et al., 2020). Approximately, 60% of fresh pineapple is edible, resulting in 45 to 55% of the mass of fresh fruit being discarded as waste in commercial processing operations (Da Silva et al., 2013). Phytochemical screening of the pineapple revealed the presence of saponin, glycoside, flavonoid, tanins and vitamins such as B1, B2, B3, B5, B6, B9 and C. Minerals such as calcium, magnesium, phosphorous, potassium, sodium and zinc have also been identified in the fruit. The fruit juice helps digestion (Frank and Jackson, 2014; Ikeyi et al., 2013).

Beetroot (*Beta vulgaris* L.) is a herbaceous biennial plant classified as one of the Chenopodiaceae family. The taproot found either in yellow pulp color or red where the red root utilized in salad, juice, food coloring, and as a medicine that emerged along the mediterranean coast (Kale et al., 2018; Biondo et al., 2014). Beets are considered as one of the most effective vegetables, they are a source of betalain pigment in addition to phenolic acids such as gallic, syringic, and caffeic acids and flavonoids. Beetroot is also considered as a good source of minerals such as iron, calcium, phosphorus, potassium, sodium, and zinc, in addition to vitamins like biotin, niacin, and folate. It has anti-inflammatory and antioxidant effects, which scavenge free radical from the cells promoting cancer prevention by inhibiting the tumor cells proliferation, reducing the risk of cardiovascular diseases, and expelling kidney stones (Abdo et al., 2020; Kale et al., 2018).

According to shaheel et al. (2015), the blending of fruits improve the nutritional and organoleptic qualities of the blends by synergistically contributing to human well-being when the benefits of all the fruits are combined. Juice blending has the potential to combine their individual functional characteristics to combat iron deficiency anemia. Therefore, the aim of this study was to assess the nutritional and physico-chemical characteristics of natural mixed fruit juices formulated from papaya (*C. papaya*), pineapple (*A. comosus*), and beetroot (*B. vulgaris*).

MATERIALS AND METHODS

Sample collection

The fully matured, ripe, freshly harvested papaya, pineapple and beetroot were purchased from the local market of Yaounde and then identified at the National Herbarium by comparison with the material of Betti Jean de Lagarde 243 using the specimen collection N°66220HNC for the papaya, the material of Daniel Dang 89 using the specimen collection N°18648/SRF/CAM for the pineapple, and finally with the material of Daniel Dang N°351 using the specimen collection N°25664/SRF/CAM for the beetroot.

Preparation of sample juice extraction and formulation

Preparation of papaya juice

Fresh and properly ripe papaya fruits were washed manually to remove any dust or foreign particles on their surface. After washing, the papaya were peeled and the glitches were removed. The peeled papaya were cut into small pieces and then blended in an electric blender.

Preparation of pineapple juice

For preparation of pineapple juice, fresh and ripe pineapple were used and washed with potable water. After washing, the pineapple were peeled and the cores and crown were removed. The pineapple were cut into small pieces and then blended in an electric blender.

Preparation of beetroot juice

Fresh fully ripe sound beetroot were used for extraction of pulp. After washing properly with potable water, the fruits were peeled by using knife. The beetroot were cut into small pieces and then blended in an electric blender.

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Table 1. Formulation of mixed fruit juice

Juice code	Ingredients			Total (mL)
	Papaya	Pineapple	Beetroot	
J1	33	33.5	33.5	100
J2	17	17	66	100
J3	17	66	17	100
J4	66	17	17	100

J1 = 33:33.5:33.5; J2 = 17:17:66; J3 = 17:66:17; J4 = 66:17:17 (papaya/pineapple/beetroot juice blends).
Source: Authors

Formulation and preparation of mixed fruit juice

Table 1 shows the formulation of natural mixed fruit juice with different combination of papaya juice, pineapple juice and beetroot juice. It appeared that the sample J1 contained 33% papaya juice, 33.5% pineapple juice, and 33.5% beetroot juice. The sample J2 contained 17% papaya juice, 17% pineapple juice, and 66% beetroot juice. The sample J3 contained 17% papaya juice, 66% pineapple juice and 17% beetroot juice. The sample J4 contained 66% papaya juice, 17% pineapples juice, and 17% beetroot juice. Mixed fruit juices were prepared in according to the method described by Kimouche (2008). The juice obtained was pasteurized at 90°C for 10 min. It was allowed to cool for 45 min and filled into sterile labbelled bottles and stored at -18°C. For future analysis, all four drinks were freeze-dried and stored.

Analysis of formulated mixed fruit juices

Physicochemical analysis: pH

For the measurement of the pH, the standard method of AOAC (1990) was used. The pH was determined in 10 ml of the juice dispensed into a beaker after calibration with phosphate buffer of pH 4.0 and 7.0.

Proximate analysis

The fresh mixed fruit juices were analyzed for the moisture, total nitrogen, crude lipid, crude fiber, ash, carbohydrates, and soluble sugars using the method described by the Association of Official Analytical Chemist (AOAC, 2005). Moisture content was determined gravimetrically. Approximately, 2 g of lyophilizate was weighed using a precision balance ("Sartorius"). They were dried in a "Memmert" oven at a temperature of 105°C for 24 h. Weighing was carried out regularly until a constant weight was obtained. Ash content was determined by calcination in a furnace at 550°C until it was properly ashed. The final weight of the ash was taken and ash content was calculated and analysed by dry ashing method (AOAC, 2005). The total nitrogen was determined after mineralisation of the samples according to the Kjeldahl method, followed by determination by the method of Devani et al. (1989) and then the protein content was calculated by multiplying result by 6.25. Fat content was evaluated by Soxhlet extraction according to the method described by AOAC (2005), using hexane as the extractor. Soluble sugars were extracted and determined by the 3,5-dinitrosalycilic acid (DNS) described by Fischer and Stein (1961). The total fiber content was determined gravimetrically. Carbohydrate content was determined mathematically by subtracting from 100, the percentage moisture, ash, protein, fat, and crude fiber.

% carbohydrate = 100 – (% moisture + % Protein + % fat + % ash + crude fiber).

The energy value (E) per 100 g of juice was obtained using Atwater conversion (Merill and Watt, 1955) factors as follows:

E (Kcal) = Proteins (%) × 4 + carbohydrate (%) × 4 + lipids (%) × 9 (Menezes et al., 2004).

Mineral analysis

Mineral content (Ca, Mg, Fe) of mixed fruit juices was done using atomic absorption spectrophotometric method described by Benton and Vernon (1990). In the Teflon capsules, 0.5 g of samples and 8 mL of concentrated nitric acid (97%) were introduced. After sealing, these capsules were placed in an oven at 105°C for 1 h and then cooled. After cooling, these capsules were inserted into mineralizing bombs, which were then well sealed and placed on a hot plate (130°C) for 2 h. 12 h after cooling, the mineralizations were collected in 50 mL volumetric flasks and the volumes were made up to the mark with double distilled water. The apparatus measured by directly drawing in the minerals from the stock solution. The contents were expressed in mg/100 g dry matter. After washing the capsules with distilled water, they were soaked for 12 h in a 10% nitric acid solution. They were then rinsed three times with demineralised water and dried in an oven at 60°C until completely dry.

Determination of antinutritional factors in juices

The phytate content was determined by titration with iron III solution after acid digestion (Olayeye et al., 2013). Tanins were performed using ferric reagent in an acidic alcoholic medium and gallic acid as standard (Ndhlala et al., 2007). The standard solution consisted of catechin (2 mg/mL) prepared in 70% (v/v) ethanol. After 20 min in the dark, the optical density was read at 500 nm against the blank. The tanin contents were deduced from the calibration line and expressed as mg catechin equivalent/100 mL juice. Saponin content was determined by weight difference after extraction in solvent (Koziol, 1990). Oxalate levels were determined by the method described by Aina et al. (2012). One gram of lyophilizate juices was weighed and introduced into an Erlenmeyer flask; 75 mL of H_2SO_4 (3 mol/L) was added. The mixture was magnetically stirred for 1 h followed by filtration. 25 mL of the filtrate obtained was collected and heated to 90°C and kept above 70°C at all times; the hot sample was titrated continuously with 0.05 mol /L $KMNO_4$ until a persistent pale pink color was obtained (15 s minimum). The oxalate content was then calculated by taking 1 mL of 0.05 mol/L of $KMNO_4$ as equivalent to 2.2 mg of oxalates. The results were expressed in mg/100 mL of drink.

Determination of vitamin C and carotenoids

Vitamin C content was determined with the 2,6-dichlorophenol-indophenol (DCPIP) described by AOAC (2005) with a slight modification. Standardization of 5 mL DCP with ascorbic acid. 9.7 mg of pure vitamin C was accurately weighed out, dissolved with 50 mL of distilled water and stirred enough to dissolve all of the ascorbic acid. 5 mL of the DCP was accurately pipetted into a 50 mL Erlenmeyer flask, 1 drop of acetic acid (30%) was added to change the blue colour of DCP to a pink colour. Ascorbic acid solution was used to titrate the DCP to a colourless endpoint (or equivalence point) using burette. The volume of ascorbic acid used was recorded and the titration repeated. The quantity of vitamin C that changed the color of DCP was then calculated. Standardization process was repeated by replacing ascorbic acid solution with 5 ml of juice made up to 10 mL with distilled water. After repeating the titration 2 times, the vitamin C content was calculated from standard volume and expressed as mg ascorbic acid/100 ml of juice.

Carotenoid contents were evaluated according to the method described by Rodriguez-Amaya and Kimura (2004). Carotenoids are pigments whose color results from the presence in their structure of a multiple sequence of double bonds that absorb light between 440 and 490 nm.

Statistical analysis

The statistical analyses were carried out using R version 4.0.3 (2022-11-02) for Windows. The results of the analyses were represented as mean ± standard deviation, the tests were performed in triplicate. The significance threshold was set at 5% based on an Analysis of Variance (ANOVA) coupled with a Post Hoc test (Tukey). The principal component analysis (PCA) was used to highlight the different correlations between nutrients.

RESULTS

Physicochemical properties of juices

The results of the pH analysis of the formulated juices showed that pH ranged from 4.79 in J4 to 5.26 in J2. There was no significant difference (p>0.05) in the pH. Vitamin C content of the juice varied from 23.56 to 50.85 mg/100 mL, respectively for J2 and J4. Total carotenoid contents were 0.01 mg/100 ml for all juices.

Proximate and mineral analysis of juices

Proximate analysis and mineral content of juices are listed in Table 3. The value for moisture content ranged between 91.46 and 94.36% for J3 and J2 samples, respectively. Protein content of juices ranged from 0.51 to 1.24% with maximum value for J4 and least value for J1.

The fat content ranged from 0.12 g/100 mL in J1 to 0.26 0.14 g/100 g (J1) to 0.23 g/100 g (J3). The crude fiber content of the juice was found to be higher in the sample J2 (0.03 mg/100 g). The soluble sugar content varied from 1.09 g/100 g (J3) to 2.34 g/100 g (J2). The carbohydrate content ranged from 4.38% in J2 to 7.16% in J1. Generally, the juices were low in protein, fat, and fibre but rich in moisture. The mixed fruit juices were analysed for the presence of certain minerals such as calcium, iron, and magnesium. The iron content varied from 0.89 mg/10 0mL (J3) to 1.29 mg/100 mL (J4). Calcium content of juices ranged from 5.28 to 6.32 mg/100 mL with maximum value for J2 and least value for J3. The drinking J3 was found to have the highest amounts of magnesium (8.13 mg/100 mL).

The antinutritional factors of the juices are shown in Table 4. It appeared that oxalate, phytic acid, tanin and saponin contents were low in all the four juices. The tanin contents varied from 0.67 mg/100 g (J1) to 0.84 mg/100 g (J2). Oxalate content ranged from 1.1 mg/100 g (J2) to 2.49 mg/100 g (J3). Phytate content varied from 0.05 (J2) to 0.06 mg/100 g (J1 and J3). For the saponin contents of the four juices, they varied from 0.05 (J1) to 0.23 mg/100 g (J2). There was a significant difference between the oxalates and phytate at 95% confidence interval (p<0.05). The variables used to classify fruit juices based on their nutrient contents were performed using Principal Component Analysis (Figures 1 and 2). These figures helped to visualize the four major classes according to their nutrient formation. The variables are organized in two principal components, which express 87.75% of total variability. The axis F1 explains 51.30% of information and the second axis F2 explains 36.45% of information. It noticed that J4 is highly correlated with Fe, Mg, ash and vitamin C. On the other hand, J2 is highly correlated with the moisture and Ca analyzed in this study. J1 and J3 are in the same class, they are highly correlated with the carbohydrates, phytates, and oxalates.

DISCUSSION

Although the potential benefits fruit juices are enormous, the need to evaluate their nutritional constituents cannot be underestimated so as to provide information that may influence their choice and selection for human consumption (Owolade and Arueya, 2016). The acidic pHs are believed to be mainly due to the presence of the pineapple drink in each formulation which gives the drinks a sour taste. In the literature, pineapple has a pH of 3.5 while papaya has a pH of 4.5 and beets have pH of 5. These results are similar to those obtained by Bhavya et al. (2019) on the mixture of pineapple, beetroot, and orange drinks which varied from 3.8 to 5. The low pH is associated with the microbial stability of food because it inhibits the growth and proliferation of contaminants and thereby preserving the drink against possible microbiological alterations, for good conservation (Nwachukwu and Ezeigbo, 2013).

Total carotenoid contents were 0.01 mg/100 ml for all drinks. This result can be attributed to the composition of each drink (Bhavya et al., 2019). The carotenoid content

Table 2. Physicochemical properties of juices.

Property	J1	J2	J3	J4
pH	4.86±0.00[a]	5.26±0.00[a]	4.87±0.57[a]	4.79±0.00[a]
Carotenoids (mg/100mL)	0.01±0.00[a]	0.01±0.00[a]	0.01±0.00[a]	0.01±0.00[a]
Vitamin C (mg/100mL)	36.32±0.00[c]	23.56±0.05[a]	32.67±0.00[b]	50.85±0.01[d]

Values are means ± SD of triplicate determinations. Means within the same line with different superscripts significantly different at p<0.05. J1 = 33:33.5:33.5; J2 = 17:17:66; J3 = 17:66:17; J4 = 66:17:17 (papaya/pineapple/beetroot juice blends).
Source: Authors

Table 3. Proximate analysis and mineral content of juices

Characteristics	J1	J2	J3	J4
Moisture (%)	92.05±0.94[ab]	94.36±0.50[b]	91.46±1.43[a]	92.25±0.34[ab]
Proteins (%)	0.51±0.02[a]	0.87±0.02[a]	0.99±0.01[a]	1.24±0.45[b]
Fat (%)	0.12±0.02[a]	0.21±0.01[b]	0.23±0.01[b]	0.26±0.01[b]
Ash (%)	0.14±0.02[a]	0.15±0.01[a]	0.22±0.01[b]	0.20±0.01[b]
Fibers (%)	0.02±0.00[a]	0.03±0.00[b]	0.02±0.00[a]	0.02±0.02[ab]
Soluble sugars (%)	1.73±0.02[c]	2.34±0.04[d]	1.09±0.02[a]	1.19±0.03[b]
Carbohydrates (%)	7.16±0.01[d]	4.38±0.01[a]	7.08±0.01[c]	6.03±0.01[b]
Energy (Kcal)	31.76	22.89	34.35	31.42
Fe (mg/100 mL)	0.95±0.05[b]	0.96±0.05[b]	0.89±0.05[a]	1.29±0.05[c]
Ca (mg/100 mL)	6.03±0.06[b]	6.32±0.00[c]	5.28±0.00[a]	6.03±0.05[b]
Mg (mg/100v mL)	6.13±0.05[b]	5.26±0.05[a]	8.13±0.05[d]	7.87±0.01[c]

Values are means ± SD of triplicate determinations, Means within the same line with different superscripts significantly different at p<0.05. J1 = 33:33.5:33.5; J2 = 17:17:66; J3 = 17:66:17; J4 = 66:17:17 (papaya/pineapple/beetroot juice blends).
Source: Authors

was significantly lower than that of mango nectar (2.1 mg/100 mL) (Kumar et al., 2015). Carotenoid protect cell against free radical damage (Omoregie and Osagie, 2012).

With regard to vitamin C, a significant difference is observed at the 5% threshold between the different drinks. This high content of ascorbic acid observed in J4 could be due to the high vitamin C content of the different fruits, which were used in the formulation of these drinks in addition to the contribution of each proportion. The vitamin C contents of J1, J2, J3, and J4 are similar to those found in mandarin (32.06 mg/10 mL) and soursop (20.50 mg/100 mL) drinks (Nwozol et al., 2017). However, the vitamin C content of J4 was higher than that content of the mandarin and soursop drinks. However, the levels of vitamin C in our drinks are lower than those found in orange (125.40 mg/100 mL) and lime (87.90 mg/100 mL) nectars (Chuku and Akani, 2015). Vitamin C is an extremely important nutrient for the body where it performs various functions. It helps maintain the proper functioning of the immune system to ensure the body's defenses protect cells against oxidative stress and intervenes during iron absorption. The consumption of vitamin C has also been reported to improve the rate of transformation of cholesterol, to prevent cancers and disorders associated with a lack of collagen (Fenech et al., 2019). Water is the major constituent of beverages and plays an important role in the expression of their organoleptic qualities (texture, flavor, behavior of aromas) (Ihadadene and Mahfouf, 2017). There is a significant difference at the 5% threshold between the drinks J2 and J3 shown in Table 2. This difference could be due to the proportion of fruits in each drink formulation. These values are in agreement with the FDA standard (2016). According to the latter, the water content of drinks must be greater than 80%. Moreover, our results are similar to those obtained by Tiencheu et al. (2021) on fruit drinks which varied from 79.31 to 96.84 mg/100 g. Beverages are good sources of hydration for the body.

Protein contents of our drinks ranged from 0.51 to 1.64 g/100 g. A significant difference at the 5% threshold is observed between (J1, J2, J3) and (J4). The variations observed in these values can be associated with the difference in the types of fruit used. The protein content of our different drinks was higher than that of orange (0.74 g), pineapple (0.62 g) and papaya (0.43 g) nectars (Ogbonnal et al., 2013). The general low protein content of fruit juices has also been reported for orange and pineapple drink mixed and fresh beet drink (Ohwesiri et al., 2016; Emelike et al., 2015). Proteins and their

Table 4. Antinutritional factors analysis.

Characteristics	J1	J2	J3	J4
Tanins (mg/100 g)	0.67±0.05^{a}	0.70±0.00^{a}	0.70±0.07^{a}	0.84±0.31^{a}
Oxalates (mg/100 g)	2.12±0.33^{bc}	1.10±0.22^{a}	2.49±0.33^{c}	1.54±0.12^{ab}
Phytates (mg/100 g)	0.06±0.01^{a}	0.05±0.02^{a}	0.06±0.01^{a}	0.05±0.01^{a}
Saponins (mg/100 g)	0.05±0.00^{a}	0.23±0.06^{b}	0.12±0.03^{ab}	0.21±0.03^{ab}

Values are means ± SD of triplicate determinations. Means within the same line with different superscripts significantly different at p<0.05. J1 = 33:33.5:33.5; J2 = 17:17:66; J3 = 17:66:17; J4 = 66:17:17 (papaya/pineapple/beetroot juice blends).
Source: Authors

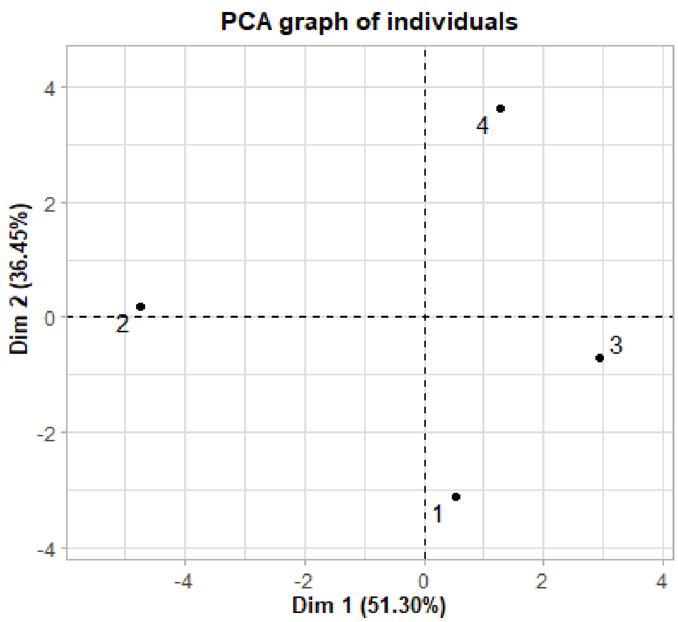

Figure 1. Distribution of the natural fruit juices formulated from papaya, pineapple and beetroot on the axis system (F1× F2).
Source: Authors

hydrolysates are important organic substances, and mineral chelating peptides have the ability to enhance the bioavailability of minerals (Guo et al., 2014). The lipid contents were from 0.12 g/100 g (J1) to 0.26 g/100 g (J4). Statistical analysis revealed a significant difference (P<0.05) between J1 and the other juices. These results are similar to those of orange (0.21 g), pineapple (0.12 g), and papaya (0.36 g) nectars (Ogbonnal et al., 2013), and lower than those of mandarin (0.86 g) and soursop (0.35 g) (Nwozol et al., 2017). This could be explained by the low lipid content of fruits of the present study. The ash contents varied from 0.14 g/100 g (J1) to 0.23 g/100 g (J3). The ash contents of juices of the present study were low to the range of 0.64-1.32% for different brands of orange juice (Ndife et al., 2013). The difference could be explained by the degree of maturity of the fruit and the growing medium conditions (temperature, irrigation and soil composition). The crude fiber contents of drinks of the present study varied from 0.02 g/100 g for drinks (J1, J3 and J4) to 0.03 g/100 g for J2. There is no significant difference (P<0.05) between these drinks. The fiber content is due to the proportion of vegetable contained in each drink. These values are lower than the value of crude fiber content of papaya (0.27 g) and pineapple (0.16 g) nectars (Ogbonnal et al., 2013). Due to its fiber content, drinks made from fruits and vegetables facilitate digestion. Crude fiber accelerates the transit of food through the digestive system and promotes the regularity or evacuation of stools (Alayande et al., 2012). Total carbohydrate contents ranged from 4.38 to 7.16 g/100 g. Carbohydrate contents (Table 2) is lower than a reported range of 8.16 to 16.19% (Ohwesiri et al., 2016) for orange and pineapple drink mixes and 7.3% (Emelike et al., 2015) for fresh beet drink. They are similar to 5.50 to

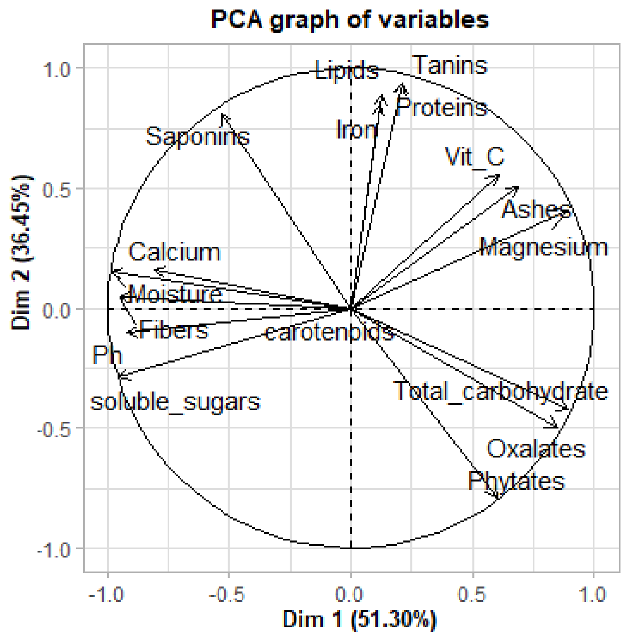

Figure 2. Correlation circle of the variables of the natural fruit juices formulated from papaya, pineapple and beetroot in the principal component analysis axis.
Source: Authors

11.80% obtained for different brands of orange drink samples (Ndifie et al., 2013). The variations observed in these values can be associated with the difference in the types and proportions of fruits used. The soluble sugar contents varied from 1.09 g/100 g (J3) to 2.34 g/100 g (J2). These values may be due to the proportion of fresh fruits contained in each drink. Sugars are the constituents that determine the sweet taste of a food, especially fruit.

In addition to providing great energy value, they play an essential role in the preservation of food products through to the osmotic pressure they exert on microorganisms and the lowering of the water activity of the food (Achir and Hammar, 2010).

The iron contents of the drinks varied from 0.89 mg/100 mL (J3) to 1.29 mg/100 mL (J4). These iron contents were high compared to beetroot, beet-pineapple and pineapple drinks mixed which were 0.214, 0.175, and 0.195 mg/100 mL (Owolade and Arueya, 2016). Iron plays a major role in cell-mediated immunity, in the control of hematopoiesis during infections and in respiratory exchanges. It is also a component of hemoglobin. Indeed, iron is important in the diet of both pregnant and breastfeeding women and children because it helps prevent iron deficiency anemia and associated diseases (Kumar et al., 2022). The iron content obtained in J4 is within the range of the RDA of iron (0.27 to 27 mg/day) (Danso et al., 2019). J4 could be recommended for optimal iron intake. In addition, through to its high vitamin C content, the non-heme iron it contains can be better absorbed. This would increase its bioavailability. The calcium content of the drinks varied from 5.28 mg/100 mL (J2) to 6.32 mg/100 mL (J3). The average calcium content of these juices is explained by the degree of maturation of our fruits and vegetables. These values are higher than those obtained by Owolade and Arueya (2016) in Nigeria on a beetroot, beetroot pineapple and pineapple drinks mixed which were 0.136, 0.182, and 0.253 mg/100 mL, respectively. Calcium is known as a macronutrient necessary for the development of teeth, bones and the release of hormones. The magnesium contents of the drinks varied from 5.26 mg/100 mL (J2) to 8.13 mg/100 mL (J3). The high magnesium content of J3 and J4 would be explained by the high magnesium content in the vegetable and the different proportions of those, which were used in the formulation of these different beverages. Magnesium is a mineral necessary for enzymes using adenosine triphosphate which contributes to DNA and RNA synthesis during cell proliferation. Magnesium deficiency causes convulsions and irritability (Achu et al., 2021). These values are higher than those obtained by Owolade and Arueya (2016).

The tanin contents of the different drinks show a significant difference at the 5% threshold. J1 had the lowest tannin content (0.67 mg/100 g). The results of this study are lower than those obtained by Nwozol et al. (2017) on the average composition of fruit drinks in Nigeria. These authors demonstrated that the tannin contents varied from 3.73 to 67.06 mg/100 g. Similarly, the tannin contents of the different drinks are much lower than the safe dose, which is 150 to 200 mg/day (Gafar et al., 2012). This means that these drinks can be consumed without any effects. The oxalate contents varied from 1.1 mg/100 g (J2) to 2.49 mg/100 g (J3) with a significant difference at the 5% threshold. The oxalate content of J4 is lower (1.54 mg/100 g) than that contained in J1 and J3. These results were similar to those obtained by Nwozol et al. (2017) on fruit drinks in Nigeria, their oxalate contents varied from 0.05 to 2.48 mg/100 g. The presence of oxalates in food causes irritation in the mouth and interferes with the absorption of divalent minerals. These levels are much lower than the safe dose of oxalates, which is 200 to 500 mg/day (Gafar et al., 2012). Phytate levels varied from 0.05 mg/100 g (J2 and J4) to 0.06 mg/100 g (J1 and J3). These levels are low compared to that of soursop nectar (19.28 mg/100 mL) (Nwozol et al., 2017). Phytates (salts of phytic acid) represent a category of natural compounds that can have a significant influence on the functional and nutritive properties of foods of plant origin. The phytate levels in our drinks are much lower than the safe dose, which is between 2000 and 2600 mg/day (Danso et al*.,* 2019). The saponin contents of drinks of the present study varied from 0.05 mg/100 g (J1) to 0.23 mg/100 g (J2). Statistical analysis showed a significant difference ($P<0.05$) between these results. These values are similar to those obtained by Nwozol et al*.* (2017) which ranged from 0.03 to 3.19 mg/100 g. Saponins reduce the absorption of certain nutrients such as glucose and cholesterol in the intestine by intraluminal physicochemical interactions. The low saponin content observed could be explained by the fact that the various fruits and vegetables of the present study contain traces of antinutrients. The principal component analysis showed that J4 (66:17:17) would be the one that have high correlation with iron, vitamin C, and magnesium. Juices of the present study could play an important role in the management of iron deficiency anemia. Considering these correlations, J4 would be the one that facilitate the intestinal absorption of non-heme iron. In addition, a study by Kana et al. (2015) proves that iron and zinc supplementation can improve the biovailability of provitamin A from papaya.

Conclusion

Pineapple/Beetroot/Papaya mixed fruit juices were successfully produced and analysed for physical and chemical and properties. These juices studied here had high nutritional properties especially in terms of minerals (iron, Mg^{2+} and Ca^{2+}) moisture vitamin C and fibers. Amongst the four best formulated, juice J4 (17% pineapple, 17% beetroot, and 66% papaya) has the best content in iron, vitamin C ashes and Mg^{2+}. Combining natural fruit juices could be a good alternative to the artificial products that abound in our markets and have a negative impact on the health of the population. Our drinks could also prevent the occurrence of pathologies related to nutritional deficiencies such as iron deficiency anaemia, especially in children. These drinks are also a good alternative for processing of our products while preventing post-harvest losses.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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