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Physicochemical properties, antioxidant activity and sensory qualities of *Pentadesma butyracea* fruit pulp nectar and pineapple (*Ananas comosus*) juice blend

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Abstract

In Benin, the *Pentadesma butyracea* fruit pulp undergoes significant post-harvest loss due to its low valorization. For valorizing this pulp, mixed fruit juices were produced from the blends of *Pentadesma butyracea* and pineapple (*Ananas comosus*) fruit and pasteurized at 65°C for 20 min. The aim of this study was to identify the quality characteristics of *Pentadesma butyracea* fruit pulp nectar and pineapple (Ananas comosus) juice blend. The physical properties studied included pH, titratable acidity, total sugar and total solid with value ranges of 3.01-3.96, 0.11-0.62%, 0.70-13.89% and 7.38-14.67%, respectively. Chemical composition of the juice blends showed moisture content with a range of 83.37-98.95%, crude protein 0.75-0.89%, ash 0.51-0.92%, Fe 0.39-0.50mg/ml, Zn 5.59-6.77mg/ml, Ca 17.57-47.89mg/ml, Mn 0.16-7.21mg/ml, total phenolics content (TPC) 0.81-22.86mg/ml dw and vitamin C with a range of 32.89-47.12mg/100g, respectively. The antioxidant activity result showed that the *P. butyracea* fruit pulp is a valuable source of antioxidant pigments. Coliforms are absents in juice blends and the aerobic mesophilic bacteria, yeasts and moulds, and *Staphylococcus aureus* were below detection level in the juices. The panelists preferre the formulas C (50% *P. butyracea*, 50% Pineapple) and D (30% *P. butyracea*, 70% Pineapple) of *P. butyracea* fruit pulp/pineapple juice blends.

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Introduction

Fruit juices are well appreciated by consumers because of their taste, nutritional value, and availability at the right time. Also, they are an important part of the modern diet in many countries (Vantarakits *et al.*, 2011). In spite of these potential benefits offered, concerns over their safety and quality have been raised. Food and Drug Administration (FDA) estimated that about 140 juice related illnesses that can be prevented yearly. Soil, faeces, food ingredients and processing chain might be sources of contamination in the food chain. Sporulation of spore forming bacteria is occurring in very diverse environments (Carlin, 2011). Escherichia coli O157:H7 was detected in four of the juices samples (3.34%), and *Staphylococcus aureus* was detected in four different samples (Vantarakis, *et al.*, 2011). According to the 2007 World Health Report unbalanced diets with low fruit intake and low consumption of dietary fiber are estimated to cause some 2.7 million deaths each year, and were among the top 10 risk factors contributing to mortality (Dias, 2011).

Fruits and vegetables are abundant during their various seasons, with over 50% lost to wastage due to deterioration under tropical conditions due to the high ambient temperatures, humidity, pest and disease infestations, poor handling and storage facilities. It implies that fruits, most often, do not attain their maximum market value thereby leading to less return to the grower as an individual and economic loss to the nation as a whole. Processing of fruits and vegetables to juices and other value-added products are the alternative ways in which excess fruits and vegetables can be utilized to reduced wastage and bring economic returns to farmers (FAO, 2011). Pineapple or Ananas comosus (L.) Merr., holds the third rank in the world tropical fruit production only preceded by banana and citrus (De Poel *et al.*, 2009). Pineapple juice contributes to healthy living because it is a good source of vitamins, phenols, organic acids and carbohydrate (Zheng & Lu, 2011).

P. butyracea Sabine (Clusiaceae) is a ligneous forest species with multipurpose uses. It is widely distributed in Africa from Guinea-Bissau to the west of the Democratic Republic of Congo. It is found in the centre and northern part of Benin in forest galleries and along waterways (Avocèvou-Ayisso *et al.*, 2011). *P. butyracea* fruits have a great importance for the populations of rural zones. These fruits are exploited for their nut which contains an almond rich in butter. *P. butyracea* butter is mostly used by rural populations for food preparation, cosmetic and therapeutic applications (Ayegnon *et al.*, 2015). It is characterized by a yellow colour, a hard texture, a relatively sweet taste and a bright appearance (Ayegnon *et al.*, 2015). In Central Africa, notably in Gabon, the sweet mesocarp of mature fruits is used to make fruit juice (White *et al.*, 1996). During the *P. butyracea* butter extraction, the fruit pulp undergoes significant post-harvest loss due to its low valorization. In spite of butter potential application in food and cosmetic industries, very little is known about the nutritional quality of *P. butyracea* fruit pulp. The valorization of *P. butyracea* fruit pulp will be avoided the post-harvest loss during the *P. butyracea* butter production. Therefore, to produce mixed fruit juice from the blends of *P. butyracea* fruit pulp/pineapple fruits is the objective of this research and to compare the physical, chemical, microbioogical, antioxidant activity and sensory properties of the resultant product with already existing.

Materials and methods

Materials

Fresh pineapple (*Ananas comosus*) was procured locally. The *P. butyracea* fruits were collected in various localities in Northern of Benin between 10 May and 25 Juine, 2020. Only undamaged ripe fruits with no symptoms of visible discoloration and infection were used. They were stored in cooler boxes and transported to School of Nutrition and Sciences and Food Technologies of Agronomic Sciences Faculty of University of Abomey-Calavi.

Methods

Preparation of P. butyracea fruit pulp nectar

The *P. butyracea* fruits were washed and rinsed thoroughly with potable water. The skin was peeled using knife and the kernels were removed for obtaining the fruit pulp.

The fruit pulps were blended with water at the ratio 1 :3 (w/v) to obtain *P. butyracea* nectar. The *P. butyracea* juice was homogenized in a blender and filtered with the use of readymade double muslin cloth. The juice obtained was bottled in sterilized glass bottles with an airtight screw cap and refrigerated at 5°C prior to analysis.

Preparation of Pineapple fruit Juice

The pineapple were washed with a little amount of detergent and rinsed repeatedly with clean water to remove any trace of the detergent. The fruit was peeled and unwanted specks removed. The pieapple flesh was then cut into smaller pieces with a sterile knife. The pieces of pineapple flesh were put into sterile extractor (Kenwood, JE 500) and the extracted juice was filtered by passing through sterile muslin cloth into sterile conical flasks in accordance to the method reported by Abalaka *et al.* (2013). The juice was bottled in an airtight screw cap sterilized glass bottles and refrigerated at 5°C prior to analysis.

Preparation of P. butyracea fruit pulp nectar/Pineapple Juice Blends

The *P. butyracea* fruit pulp nectar was blended with pineapple juice in varying proportions respectively such as A [100:0], B [70:30], C [50:50], D [30:70] and E [0:100]. The samples blends were homogenised, bottled and pasteurised at 70°C for 15 min in a thermostatically controlled water bath with agitator, cooled to room temperature (27°C) and finally stored in a refrigerator at 5°C until analysed.

Physical Properties

pH and titratable acidity

The pH was determined using a digital pHmeter (HI8418 ; Hanna instruments, Limena, Italy) calibrated with buffers at pH 4.0 and 7.0 (WTW, Weilheim, Germany). The acidity titration, expressed as lactic acid, was carried out using the method described by Nout *et al.* (1989).

Total Sugar Content

The hand held sugar refractometer (VWR-International bvba, B-3001 Lewen : Belgium) was used. The prism of the refractometer was cleaned and a drop of the juice was placed on the prism and closed. The total sugar content (°Brix) was read off the scale of the refractometer when held close to the eye according to the method of AOAC (2012).

Total Solid

The total solid content of the treated juice samples was determined using the air oven method described by Akusu *et al.* (2016). Aluminium dishes were washed; dried in the oven for 10min and kept in the desiccator to cool, after which their weights were taken. Three grams (3g) of the treated juice samples were weighed into the dishes and weight of the dish plus samples were taken. The dishes were placed in the oven for 1h at 105°C. The dishes were removed after cooling. The total of solid content was calculated.

Colour measurement

The colour measurement was performed by using a chromameter (CR410, Konica Minolta, Japan) to obtain values of L*, a*, b* and ΔE. The colour coordinates of the white ceramic standard are: Y = 86.10, x = 0.3194, y = 0.3369. A 50ml sample of juice was placed in an optical cell with a path length of 20 mm (Hunter Lab setting) for the measurement.

Chemical Composition

Moisture content, crude protein and ash content of the juice was determined according to the AOAC (2012) method. Mineral elements (Ca, Mn, Zn, and Fe) were measured by an atomic absorption spectrophotometer (AAS, Shimadzu Instruments, Inc., SpectrAA-220, Kyoto, Japan) after the digestion of an H_2SO_4, HNO_3 and $HClO_4$ mixture. The vitami C content was determined based upon the quantitative discoloration of 2,6-dichlorophenol indophenol titrimetric method as described in AOAC (2000, Chap. 45). All the determinations were done in triplicate.

Microbiological characteristics

Fruit juices samples were analyzed for total bacterial count, total coliforms, thermotolerant coliforms, yeasts and moulds and *Staphylococcus aureus* according to standard methods of APHA (2001). Briefly, 10 g of fruit juices were weighed into sterile bags and homogenized in 90ml of sterile peptone water (0.1%) and NaCl (0.85%). Serial dilutions were made in BPW. Aerobic mesophilic bacteria were analysed using plate count agar after incubation at 30°C for 72h, total coliforms were enumerated on violet red bile agar after incubation at 30°C for 24 h), thermotolerant coliforms on Violet Red Bile Agar at 44°C for 24 h, yeasts and moulds on malt extract agar at 25°C for 72 h. *S. aureus* determined on Baired Parker agar supplemented with egg yolk and the plates incubated at 37 °C for 48 h.

Preparation of extracts for the determination of total phenolics and antioxidant capacity

Samples were extracted in methanol/HCl (99:1 (v/v) following the method described by Kayodé *et al.* (2007). Fifty milligrammes (50mg) of each sample were extracted at room temperature with 1.5mL of solvent under agitation using a magnetic stirrer for 30 min. The mixtures were centrifuged at 2500g for 10 min and the supernatants were collected. The residues were re-extracted twice under the same conditions, resulting in 3mL crude extract. All extracts were used as they were after centrifugation for various analyses.

Total phenolics determination

Total phenolics were measured following the method of Singleton and Rossi (1965) modified by Kayodé *et al.* (2007) as follows: to 300µL of extract, 4.2mL of distilled water, 0.75mL of Folin-Ciocalteu's reagent (Merck, Germany) and 0.75mL of sodium carbonate solution (200g/l) were added. After incubation for 30 min, the optical density was measured at 760nm against a blank. Gallic acid was used as standard and the results were expressed as gallic acid equivalent (GAE) per g of sample DM.

Antioxidant Activity Determinations

The antioxidant activity was measured using DPPH (2,2-diphenyl-1-picrylhydrazyl). The DPPH method was conducted by adaptation as described by Scherer and Godoy (Scherer *et al.*, 2009). Equal volumes (100µL) of DPPH (50 µM) and plant extracts (12,5mg.ml^{-1}) were mixed and incubated for 20–30 min in the dark at room temperature. Then, the absorbance was read at 517nm and the blank was a mixture of methanol and DPPH (v : v). This activity was given as% DPPH scavenging and calculated using equation 1:

$$\%\ \text{Inhibition DPPH}^{\cdot} = \frac{A_{control} - A_{sample}}{A_{control}} \times 100 \quad (1)$$

where $A_{control}$ is absorption of DPPH solution, and A_{sample} is absorbance of the test sample. The half maximal effective concentration (EC_{50}) is the amount of sample necessary to decrease the absorbance of DPPH by 50%. It was determined graphically using a calibration curve in the linear range by plotting the extract concentration and the corresponding scavenging effect. Ascorbic and gallic acids were used as positive controls. All the analyses were carried out in triplicate.

Sensory evaluation

The sensory analysis was carried out using fifty untrained consumers (29 males and 21 females of age between 20 and 40), randomly recruited among staff and graduating class students of the School of Nutrition and Sciences and Food Technologies of Agronomic Sciences Faculty of University of Abomey-Calavi. The organoleptic attributes evaluated for were : Colour, Flavour, Taste and Overall acceptability. The juices were served with clean gasses to individual panelist. The order of presentation of samples to the panel was randomized, Portable water was provided to rinse the mouth between evaluations. Each sensory attribute was on a 9 – point Hedonic Scale with 1 = disliked extremely while 9 = liked extremely as reported by Iwe *et al.* (2010).

Statistical analysis

All data were expressed as mean ± standard deviation (n= 3 replicates). Data were analyzed using one-way ANOVA using SPSS 16.0. Duncan's multiple-range test was used to determine the difference between means. A significant difference was considered at the level of $p \leq 0.05$.

Results and discussion

Physical Properties of the juices blends

Physical Properties of the *P. butyracea* fruit pulp/pineapple juice blends are presented in Table 1. The pH of the *P. butyracea* fruit pulp/pineapple juice blends samples range from 3.01 to 3.96.

The low pH of the juice samples blends would not create favorable conditions for many organisms to sporulate and multiply (Akubor *et al.*, 2017). This would enhance the storage stability of the juice (Akubor *et al.*, 2017). Sample E had the highest pH value of 3.96. The reverse was observed in the results for acidity, in which sample A had the highest value of 0.62%, while samples B, C, D and E had 0.32, 0.16, 0.11 and 0.47%, respectively. This indicates that juices get more acidic at a decreased pH value. These pH value were in close relationship with the range of 3.50 – 3.97 reported by Akusu *et al.* (2016) for different orange/pineapple juice blends. There were no significant difference ($p>0.05$) in the pH values for samples C, D and E (3.48, 3.69 and 3.96), respectively. Similar results have been reported by Mahgoub, *et al.* (2015) who found that the pH of juices examined ranged between 2.96 and 3.73. pH is an important factor in fruit processing industry (Moneruzzaman *et al.*, 2008). The total titratable acidity values of all the samples ranged between 0.11 and 0.62, with pineapple juice having the least (0.47) and *P. butyracea* fruit pulp nectar having the highest (0.62) value. The increase in the proportion of *P. butyracea* fruit pulp nectar in the blends had no effect on the pH. However, incorporation of *P. butyracea* fruit pulp nectar in the blends increased the total titratable acidity of the juice. This may be due to the increase in the acid content of *P. butyracea* fruit pulp nectar which contributed to the increase in the total titratable acidity in the juice blends. The low pH and high acidity for these juices mainly *P. butyracea* fruit pulp nectar was due to the organic acids inthe fruit pulp (Onimawo *et al.*, 2003). Moreover, ANOVA showed that there was a significant difference ($P < 0.001$) between the *P. butyracea* fruit pulp/pineapple juice blends in terms of total solid. Thus, the juices C, D and E have the highest value, while the lowest value was recorded for juices A and B which contained 100% and 70% of *P. butyracea* fruit pulp nectar, respectively. For all the *P. butyracea* fruit pulp/pineapple juice blends prepared, the total solids value was considerably lower than the orange/pineapple juice blends formulated by Akusu *et al.* (2016), which ranged from 11.75 to 17.53%. This may be attributed to the fine filtration methods used. This agrees with the report of Densupsoontorn *et al.* (2002) that most differences in fine filtration and centrifugation means that most of the components that make up total solids in the packaged juices are most likely desired additives.

Table 1. Physical properties of *P. butyracea* fruit pulp/pineapple juice blends.

Samples	pH	Titratble acidity (%)	Total sugar (%)	Total solid (%)
A	3.01±0.02a	0.62±0.08d	0.70±0.10a	7.38±0.02a
B	3.17±0.00a	0.32±0.04b	4.77±0.05b	8.57±0.01b
C	3.48±0.07b	0.16±0.04a	6.87±0.23c	11.35±0.15c
D	3.69±0.07b	0.11±0.03a	8.27±0.05d	12.13±0.14d
E	3.96±0.01b	0.47±0.11c	13.89±0.21e	14.67±0.03e

[1]Mean ± Standard deviation; values with the same letter in the same column, are not significantly different at $p< 0.05$.

The statistical analysis revealed that there were significant difference ($p<0.001$) in the total sugar for all the *P. butyracea* fruit pulp/pineapple juice blends samples. The values for total sugar ranged of 0.70 – 13.89%. The total sugar was highest in sample E (13.89%) and lowest in sample A (0.70%). This is in close relationship with the range of 10.20 – 14.88% reported by Akusu *et al.* (2016) for different brands of orange juice. The total sugars to a large extent determine the sweetness of juices and beverages. It could be used for masking the astringency derived from organic acids (Adeola and Aworh, 2010). This is higher compared to the range of 7.22 – 9.28% for cocktail juices (Adubofuor *et al.*, 2010), 8.17 – 9.91% for soy-carrot flavoured with beetroot (Banigo *et al.*, 2015) and 9% for fresh beetroot juice reported by Emelike *et al.* (2015). This could be attributed to the blends of different fruit types.

Mean values for the colour parameters of fruits juices samples are presented in Fig. 1. The measurement of colour is important for the quality assessment of juice. No significant difference ($p>0.05$) was detected in the lightness (L*), redness (a*) and the total colour difference (ΔE) of the juices samples. This result is in agreement with the data recorded during the sensory evaluation of the juices samples. The lightness of the *P. butyracea* fruit pulp/pineapple juice blends samples obtained in this study were higher than thoses found in apple juice (3.71 to 6.10), guava juice (49.53 to 64.21), mango juice (23.46 to 48.10), pineapple juice (22.96 to 30.90), orange juice (27.58 to 50.72) reported by Mahgoub *et al.* (2015). Moreover, there was significant different *(p< 0.001)* between the juices in yellowness (b*) value. Thus, the highest value was observed in sample A (100% *P. butyracea* fruit pulp nectar), while the lowest value of b* was recorded for the sample E (100% pineapple juice). A yellow colour corresponds to the natural colour of *P. butyracea* fruit pulp nectar, and when the juice is also bright the juice is more attractive.

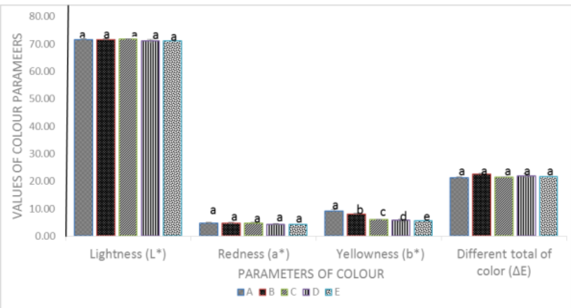

Fig. 1. Colour of *P. butyracea* fruit pulp/pineapple juice blends.

Chemical properties of the juice blends

The moisture content of the juice blends ranged from 88.37 to 98.95% and there was significant difference (p< 0.05) between juices samples. The highest moisture content was found in the sample A (100% *P. butyracea* fruit pulp nectar) while the lowest value proceeded from the sample E (100% pineapple juice) and also other juices samples were significantly higher as shown in chemical composition of *P. butyracea* fruit pulp/pineapple juice blends shown in Table 2. This is within the acceptable range of 80 – 95% for fruit and vegetable juices (Kirk *et al.*, 1997). Other fruit juices that fall within this range are cocktail juices (90.72 – 92.78%), fresh beetroot juice (91%) and 89.31 – 92.10% for soy-carrot-beetroot drinks (Banigo *et al.*, 2015 ; Emelike *et al.*, 2015 ; Adubofuor *et al.*, 2010). The ash content of *P. butyracea* fruit pulp/pineapple juice blends ranged from 0.51 to 0.92%. There was significant difference (p< 0.05) between juices samples in terms of their ash content, the highest value was recorded to the sample A (100% *P. butyracea* fruit pulp nectar) while the lowest value was found in juice sample E (100% pineapple juice). The ash content of the juice blends samples was relatively lower than that of mango fruit juice (1.5%) (Akubor *et al.*, 2017) but higher than 0.44% dry weight reported in pineapple fruit juice (Oyeleke *et al.*, 2013). This is an indication that the juice of *P. butyracea* fruit pulp contains nutritionally important mineral elements. The vitamin C content of the juice blends ranged from 32.89 to 47.12mg/100ml. The vitamin C value was higher in the 100% *P. butyracea* fruit pulp nectar and lower in the 100% pineapple juice and there was significant difference (p<0.05) between juices samples. This value was lower than that of the pulp which was 78mg/100 g but higher than those of banana (9mg/100ml), avocado (18mg/100ml), orange (46mg/100ml), pawpaw (52mg/100ml) and pineapple (54mg/100ml) but lower than those of guava (300mg/100ml) and cashew apple (250mg/100ml) juices reported previously by Ogbonna *et al.* (2013). Crude protein content of *P. butyracea* fruit pulp/pineapple juice blends was low, ranging from 0.75 – 0.89%. Sample E (100% pineapple juice) was observed to have significantly higher value compared to other samples. Emelike *et al.* (2015) equally observed a low value for protein content of fresh beetroot juice. Low protein content is a general characteristic of fruit juice. The minerals profile of the juice blends result was presented in Table 2. Calcium was the most abundant (17.57 – 47.89mg/l) element followed by zinc (5.59 – 6.77mg/l) and then iron (0.39 – 10.50mg/l).

The calcium content of *P. butyracea* fruit pulp nectar was higher when compared with others juices samples and that of round pumpkin fruit pulp (13.18mg/100ml) reported by Adubofuor *et al.* (2016) and mango fruit juice (160mg/100ml) (Akubor *et al.*, 2017). The high level of calcium in the juices improved those of the *P. butyracea* fruit pulp nectar. In addition, the zinc content of *P. butyracea* fruit pulp nectar was higher than that of *Sclerocarya birrea* fruit juice (2.96mg/100cm^3) (Hassan *et al.*, 2010) and mango fruit juice (1.3mg/100ml) reported by Akubor *et al.* (2017). The juice blends also contains a reasonable amount of manganese (0.16 – 7.21mg/l), which was higher than that of *Sclerocarya birrea* fruit juice (6.60mg/100cm3) reported by Hassan *et al.* (2010). This is an indication that, the *P. butyracea* fruit pulp/pineapple juice blends could supplement the body with both macro and microelements.

Table 2. Chemical composition of *P. butyracea* fruit pulp/pineapple juice blends.

Parameters	A	B	C	D	E
Moisture (%)	98.95± 1.15d	96.28± 0.03c	94.60± 0.15b	93.73± 0.10b	83.37± 0.21a
Ash (%)	0.92± 0.01d	0.85± 0.04c	0.53± 0.01a	0.68± 0.03b	0.51± 0.02a
Vitamin C (mg)	47.12± 0.13d	36.77± 0.03c	35.67± 0.07b	34.88± 0.04b	32.89± 0.21a
Crude proteins (%)	0.75± 0.05a	0.76± 0.12a	0.81± 0.27b	0.87± 0.72b	0.89± 0.11e
Fe (mg/L)	0.46± 0.05b	0.42± 0.11a	0.50± 0.57c	0.39± 0.34a	0.40± 0.73a
Zn (mg/L)	6.12± 0.21b	5.59± 0.37a	6.07± 0.34b	6.51± 0.53b	6.77± 0.44c
Ca (mg/L)	47.89± 0.04d	44.37± 0.47c	31.54± 0.63b	18.45± 0.21a	17.57± 0.77a
Mn (mg/L)	0.16± 0.56a	0.18± 0.44b	0.88± 0.71c	3.53± 0.34d	7.21± 0.64e

[1]Mean ± Standard deviation; values with the same letter in the same line, are not significantly different at p< 0.05.

Microbiological qualities of P. butyracea fruit pulp/pineapple juice blends

All juice samples were tested for microbial growth on four different culture media (PCA, MEA, VRBA, and Baird Parker) to determine hygiene quality of fruits juices samples (table 3). The aerobic mesophilic bacteria counts in fruit juices varies from 1.70 to 1.95 log10 CFU/g. There is no significant difference in the aerobic mesophilic bacteria counts between the juices (p>0.05). yeast/mold counts in juices ranged from 1.53 to 1.87 log10 CFU/g, with significant different (*p< 0.001*) between the juices samples. This result is in agreement with Vantarakis *et al.*, (2011) in Greece, who evaluated the microbial quality of different fruits juices. This is due to the acidic nature of fruit juices which probably favours the growth of yeasts. Yeasts were the predominant contaminants ranging from <1.0 to 6.83 log10 CFU/ml. Moreover, the *P. butyracea* fruit pulp/pineapple juice blends are free of coliforms. The absence of coliforms was probably as a result of proper hygienic condition observed in the processing of juices and absence of faecal contaminations.The pH of *P. butyracea* fruit pulp/pineapple juice blends range from 3.01 – 3.96 recorded for the fruit juices conform to the standard description for acid foods (pH 3.0 – 4.60) (Oranusi *et al.*, 2012). The low pH, mostly of juice sample A (100% *P. butyracea* fruit pulp juice) may have inhibited the growth and proliferation of the contaminants. Sugar concentration in fruit juice is not high enough to inhibit bacterial growth, the inhibiting factor for bacteria appear to be acidity rather than sugar. Furthermore, the results indicated that *Staphylococcus aureus* were not detected in any of the samples tested. Fruit juices should not contain organisms that can cause disease for human being (EC, 2013). These results are in agreement with the microbiological data obtained in the pineapple juices samples by Abalaka *et al.* (2013).

Table 3. Microbiological qualiies of *P. butyracea* fruit pulp/pineapple juice blends.

Microorganisms	Microbiological qualiies of juices				
(log_{10} UFC/g−1)	A	B	C	D	E
Aerobic mesophilic bacteria	1.93± 0.12a	1.91± 0.11a	1.95± 0.02a	1.95± 0.12a	1.70± 0.13a
Total coliforms	Absence	Absence	Absence	Absence	Absence
Faecal coliformes	Absence	Absence	Absence	Absence	Absence
Yeast and mould	1.87± 0.05b	1.73± 0.03b	1.67± 0.21a	1.55± 0.01a	1.53± 0.03a
Staphylococcus aureus	<1	<1	<1	<1	<1

[1]Mean ± Standard deviation; values with the same letter in the same line, are not significantly different at p< 0.05.

Antioxidant pigments in the P. butyracea fruit pulp/pineapple juice blends

Total phenolic content (TPC) of *P. butyracea* fruit pulp/pineapple juice blends was expressed as gallic acid equivalent (GAE) per g of DM (table 4). The TPC of the juices ranged from 0.81 to 22.86mg/ml dw, it varied significantly between juices (*p≤0.001*). The highest values of TPC were found in juice sample A (100% *P. butyracea* fruit pulp nectar), while the lowest values were observed in juice sample E (100% pineapple juice). These results are in agreement with the TPC obtained in the pineapple fruit by Lu *et al.* (2014), which ranged from 31.48 to 77.55mg gallic acid equivalents (GAE) /100g fresh weight (FW). In comparison with apple and spine grape, which contained TPC ranging from 105.4 to 269.7mg GAE/100 g FW (Vieira *et al.*, 2009), and 157 to 365mg GAE/100 g FW (Meng *et al.*, 2012), respectively, *P. butyracea* fruit nectars in this study showed significantly higher TPC. Furthermore, compare with avocado and pitaya, which contained TPC 21.86 and 27.52mg GAE/100 g, respectively (Fu *et al.*, 2011), *P. butyracea* fruit pulp nectar indicated significantly higher TPC. However, the TPC of the juice blends were significantly (*p≤0.001*) lower than the 100% *P. butyracea* fruit pulp nectar. The reduction in value of TPC recorded for the blend samples may be due to interaction between the phenolic compounds and carbohydrate which reduced the extractability of the phenolic compounds. Furthermore, Phenolic compounds possess significant antioxidant activity due to their ability to adsorb, neutralize and quench free radicals (Onimawo *et al.*, 2012).

Table 4. Parameters of free radical scavenging activity by DPPH and Total phenolics of *P. butyracea* fruit pulp/pineapple juice blends.

Samples	TPC (mg/ml dw)	EC_{50} (mg/ml DPPH)	% (DPPH) remaining
A	22.86±0.02d	0.10±0.12a	10±0.98a
B	2.13±0.01C	0.12±0.34b	12.17±0.03b
C	1.08±0.11b	1.10±0.23C	22.83±0.07C
D	0.93±0.04b	1.37±0.03d	25.04±0.01d
E	0.81±0.03a	1.35±0.21e	37.54±1.23e
Ascorbic acid	-	0.0018±0.0014	7.48±0.01
Gallic acid	-	0.0020±0.0001	9.83±0.03

[1]Mean ± Standard deviation; values with the same letter in the same column, are not significantly different at p< 0.05.

The antioxidant capacity of fruits and vegetables is an important indicator of health promoters, and many methods have been developed to evaluate this particular capacity (Meng *et al.*, 2012). In this study the anti-radical properties of the juices was performed by DPPH radical scavenging assay. EC_{50}, the effective concentration of the extracts (mg antioxidant /mg DPPH) required to scavenge 50% of DPPH radical are presented.

Significant difference in EC_{50} between the juices was observed (*p≤ 0.001*). The juice sample E (100% pineapple juice) showed the highest EC_{50} value whereas the juice sample A (100% *P. butyracea* fruit pulp juice) was found to have the lowest EC_{50} value. A lower value would reflect greater antioxidant activity of sample. This result suggests that *P. butyracea* fruit pulp plays an important role in the scavenging of free radical. In citrus, the value obtained through DPPH assay varied from 2.66 to 4.57 µmol TE/g FW (Barros *et al.*, 2012), indicating *P. butyracea* fruit pulp had relative high antioxidant capacity. Many studies have demonstrated correlations between bioactive compounds and antioxidant activities in numerous fruits and vegetables. However, little information is known concerning these types of correlations in *P. butyracea* fruit pulp. In this study, a significant correlation was found between the DPPH assay and TPC (r = 0.703; p < 0.01). Moreover, the remaining DPPH in the extract from juices ranged from 10.00 to 37.54%. The pineapple juice E (100% pineapple) value was higher than DPPH levels in juice sample A (100% *P. butyracea* fruit pulp juice). Clearly, the *P. butyracea* fruit pulp is a valuable source of antioxidant pigments that can be valorised to increase the economic value of this plant.

Sensory Properties of P. butyracea fruit pulp/Pineapple Juice Blends

Table 5 showed the mean sensory score and the significant difference among quality attributes of the blended juice. The evaluations were done on all the data for color, flavor, taste and overall acceptability. ANOVA showed that there were no significant difference (p>0.05) in the colour of all *P. butyracea* fruit pulp/pineapple juice samples. This is an indication that pineapple juice and *P. butyracea* fruit pulp nectar have the same coulour (yellow). The value for juice colour ranged between 6.78 – 7.68; these values were similar, but the high value was found in sample E (100% pineapple juice) and the low in sample A (100% *P. butyracea* fruit pulp). The sensory scores for colour in this study is in close agreement with the report of Ndife *et al.* (2013), who reported a range of 5.14-8.35 for different brands of orange juice samples. But high than the report of Akusu *et al.* (2016), who reported a range of 4.40-6.85 for orange juice/pineapple juice blends. Flavour is a combination of various sensations derived from foods. The preference of the panel members for the juices in term of flavour was not significantly different (P >0.05). However, there was a significant difference (P <0.001) between the juices in terms of sugar taste, acid taste and overal acceptability. Clearly, the members of the panel noticed that juice samples A (100% *P. butyracea* fruit pulp) and B (70% *P. butyracea*, 30% Pineapple) were acid and less sweetened than others juices samples (C, D and E). The juices samples A and B showed the least acceptability in all the sensory attributes such as colour, flavour, taste and overall acceptability. The panelists preferre the formulas C (50% *P. butyracea*, 50% Pineapple) and D (30% *P. butyracea*, 70% Pineapple) of *P. butyracea* fruit pulp/pineapple juice blends.

Table 5. Sensory properties of *P. butyracea* fruit pulp/pineapple juice blends.

Samples	Colour	Flavour	Sugar taste	Acid taste	Overal acceptability
A	6.78± 1.12a	6.11± 1.76a	2.45± 1.45a	7.86± 1.03b	4.01±1.33a
B	6.87± 1.27a	6.19± 1.54a	4.45± 1.45b	7.73± 1.49b	4.75±1.43a
C	7.19± 1.07a	7.13± 0.92a	6.31± 1.26c	6.56± 0.99a	7.4±30.65b
D	7.56± 0.78a	7.38± 0.85a	7.00± 1.03d	6.56± 1.41a	7.56±0.78b
E	7.68± 0.53a	7.43± 0.67a	7.31± 0.21d	6.41± 1.72a	7.66±0.87b

[1]Mean ± Standard deviation; values with the same letter in the same column, are not significantly different at p< 0.05.

Conclusions

The results of this study showed that the highest antioxidant activity and total phenolic content were exhibited by the extracts obtained from *P. butyracea* fruit pulp juice. It has been reported that *P. butyracea* fruit pulp contains relatively larger quantity of non-polar antioxidant compounds. In addition, the *P. butyracea* fruit pulp/pineapple juice blends is rich in nutriments, it could supplement the body with both macro and microelements. *P. butyracea* fruit pulp juice reduced the sugar content and increases the vitamin C content of the juice blends.

The panelists preferre the formulas C (50% *P. butyracea*, 50% Pineapple) and D (30% *P. butyracea*, 70% Pineapple) of *P. butyracea* fruit pulp/pineapple juice blends, respectively. Furthermore, the juice blends have hygiene quality.

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Declaration of interest

There is no conflict of interest among authors regarding the submission of this research work.

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