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ARTICLE

Antioxidant, physicochemical and mineral evaluations of *Spondias mombin* crude fruit juice

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ABSTRACT Edible fruits have potential health benefits regarding their richness in minerals, nutrients, vitamins and antioxidant. In view of the medicinal potential of the leaves and stem bark extracts of *Spondias mombin*, this study aimed to determine the antioxidant, physicochemical and mineral contents of the crude fruit juice of *S. mombin* for its employment in health promotion and traditional use for medicine. Free radical scavenging power of 93.97 ± 64.8 µmol (TE) and Ferric reducing power (FRAP) of 11.8 ± 0.2 µmol (AAE) were observed *in vitro* from the crude fruit juice. The physicochemical property of the crude fruit juice yielded proximate compositions of protein (6.03 ± 0.44), fat (1.85 ± 0.03), pH (3.63 ± 0.11), fibre (0.64 ± 0.02), moisture (80.60 ± 0.22%), ash (0.54 ± 0.03), carbohydrate (11.61 ± 0.34) and titratable acidity (28.52 ± 0.14). Trace elements from the crude fruit juice are in the amounts of 276.27 ± 2.65 for potassium, 1.15±0.01 (manganese), 0.121 ± 0.32 (copper), 4.45 ± 1.42 (sodium), 136.42 ± 1.35 (zinc), 12.36 ± 0.03 (magnesium), 0.01 ± 0.00 (lead), 28.22 ± 1.02 (phosphorus), 13.04 ± 0.53 (calcium) and 0.48 ± 0.01 (iron).

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Introduction

In Nigeria, large numbers of underutilized wild fruits are widely distributed throughout the country. Most of these wild fruits are consumed mainly by rural duelers, who appreciate them in quenching of thirst and supplement for food without knowledge about their health importance and medicinal values. The Nigeria climate has favorable potency for the production of tropical fruits. These tropical fruits are seasonal and some are cultivated for their health benefits, while others are readily available as wild in the forests uncultivated by man. Fruits are important sources of many nutrients and have served as integral part of the human diet as they supply vitamins, minerals and other vital constituents essential for human health (Akhtar et al. 2010). Fruits are believed to occupy a modest place as a source of trace elements due to their high water content. However, consumers look for variety in their diets and therefore opt for fresh fruits because of the health benefits. Fruits are special food sources that are rich in potassium (K), calcium (Ca) and magnesium (Mg). These minerals among others are nutrient requirements of which their intake is associated with reduced risk of, *e.g.*, cardiovascular diseases, cataracts, and age-related functional decline (Willett 1994, 1995; Temple 2000; Aberoumand and Deokule 2010). Higher amounts of antioxidants such as vitamin A, C, E, lycopene, polyphenols and carotene are present in fresh fruits, than when prepared into juice and beverages these components are often reduced.

Numerous studies have shown that fruits are rich sources of nutrients, as well as non-nutrient molecules with antioxidants or other physiological effects that are important constituents of a healthy diet. The health promoting properties of plant-based foods have largely been attributed to their wide range of phytochemicals, of which many are present at relatively high levels (Ali et al. 2011).

Normal physiological processes *in vivo* result in the production of free radicals. Oxidative stress created when there is an insufficient capacity of the biological system to neutralize excess free radicals. This may result in aging and disease conditions as reported by Sahreen et al. (2014). Fruits and other foods are known to contain antioxidants that are linked to *in vivo* protection from oxidative stress (Jensen et al. 2008). Different studies have shown that free radicals present in the human organs, cause oxidative damage to various bio-molecules, such as lipids, proteins and nucleic acids, and

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thus are involved in the initiation phase of certain degenerative diseases. Phenolic and other phytochemical antioxidants found in fruits and vegetables capable of neutralizing free radicals and may play a major role in the prevention of certain diseases (Kaur and Kapoor 2001).

Numerous epidemiological investigations have pointed out that a lack of essential mineral elements in food can result an increase in sensitivity to illness, leading to suboptimal health or an enhancement of disease occurrence. Among others iodine, selenium, zinc, iron, copper, manganese and chromium were recognized as essential mineral elements indispensable for maintaining normal life activities. All these mineral elements can be obtained from the consumption of certain foods. It was also recognized decades ago that green and natural foods of plant origin are of important sources of these minerals. These metals are commonly found in trace amounts in various plants as they easily take up them from the environment. At the same time, different parts of a plant could contain different concentration of these elements. In spinach, *e.g.*, the amount of Mn in the tip of the leaf was higher than in the other parts, or Co and Zn were mainly accumulated around the main veins (Xin et al. 2009).

Spondias mombin is a tree having habitat in several tropical forests in the world. In Nigeria, it is widely distributed in all geographical regions as wild plant. It is called *Iyeye* by the Yorubas, Ichikara, or *Uvuru* by the Ibos, and *Tsaadar lamarudu* by the Hausas. Names of this plant in some other parts of the world are *Bala* (Costa Rica), *Jobito* (Panama), *Jobo blanco* (Colombia), *Jobo corronchoso* (Venezuala). *Hoeboe* (Surinam), *Acaiba*, *Caja*, *Pau da taperra* (Brazil, Ubo (Peru), and *Hobo* (Mexico). For its ethno-medicinal uses, the fruit juice is consumed as a diuretic, febrifuge and laxative. The aims of this study were to analyze the antioxidant activity, physicochemical properties and mineral composition of *S. mombin*. The long-term goal is to promote and increase the utilization and consumption of edible wild fruits.

Materials and Methods

Collection and preparation of fruit juice

Ripe fruits of *S. mombin* were harvested from its tree at the town of Ado Ekiti (Nigeria). The fruit was identified by a botanist in the Department of Biological Sciences, Afe Babalola University (Ado Ekiti, Nigeria). The fruits were washed with 3% sodium hypochlorite and rinsed severally in distilled water. The fruits were pressed for juice to be extracted. The extracted crude juice was filtered through No 1 Whatman filter paper and the filtered juice was kept in a sterile bottle at 4 ^{o}C before use.

Determination of radical scavenging capacity with 1,1-diphenyl-2-picrylhydrazyl (DPPH)

DPPH radical scavenging activity was determined according to Cavin et al. (1998). Two milliliters of the crude fruit juice was added to 1 ml of DPPH solution (0.04 mg/ml in methanol). The mixture was vigorously shaken and incubated in the dark for 20 min. Thereafter, the reduction of DPPH absorption was measured at 517 nm. A calibration curve was prepared by measuring the reduction in absorbance of the DPPH solution in the presence of different concentrations of Trolox (0-400 µM). Results were expressed as µmol of Trolox equivalents (TE)/mg wet extract. All determinations were performed in triplicate.

Determination of ferric reducing activity (FRAP)

The ferric reducing activity of the fruit juice was estimated based on the FRAP assay (Benzie and Strain 1996). The solutions for this assay are 300 mmol/L acetate buffer, 10 mmol/L TPTZ (2,4,6- tris(2-pyridyl)-s-triazine) in 40 mmol/L of HCl and 20 mmol/L $FeCl_3$ (6 H_2O). From this 25 ml acetate buffer was mixed with 2.5 ml of TPTZ solution and 2.5 ml $FeCl_3$ (6 H_2O). The assay was performed by adding 1 ml of the FRAP reagent to 2 ml of diluted fruit juice. Absorbance reading at 593 nm was recorded after 20 min of the reaction. The change in absorbance was related to the absorbance change in ascorbic acid as the standard solution tested in parallel. Results were expressed as micromole of ascorbic acid equivalents (AAE)/mg of wet weight of the fruit juice. All determinations were performed in triplicate.

Determination of total phenol

Total phenol concentration of the crude fruit juice was determined by spectrophotometric method, according to the Folin-Ciocalteu colorimetric method of Singleton and Rossi (1965), using caffeic acid as the standard and expressing the results as µmol equivalents of caffeic acid (CAE)/mg of wet weight of fruit juice.

Determination of total flavonoids content

Total flavonoids from the crude fruit juice were estimated by colorimetric method using the criteria of Sakanaka et al. (2005). Aliquot of fruit juice was mixed with 400 µl of distilled water and 30 µl of a 5% sodium nitrite solution. After 6 min, 10% aluminium chloride solution (30 µl) was added and the mixture was allowed to stand for 5 min. Then 200 µl of 1M NaOH solution and 240 µl of distilled water were added and the absorbance was measured at 510 nm. Rutin was used as standard solutions. All determinations were done in

Table 1. Antioxidant profile of the crude fruit juice of *S. mombin*.

Antioxidant	Mean ± SD
Free radical scavenging activity (DPPH) (µmol TE)	93.97 ± 64.8
Ferric reducing activity (FRAP) (µmol AAE)	11.8 ± 0.24
Total flavonoids (RE/mg wet fruit juice)	14.5 ± 0.04
Total phenol (CAE/mg wet weight fruit juice)	155.126 ± 12.546

triplicate and values were calculated from a calibration curve obtained with rutin. Final results were expressed as µmol of rutin equivalents (RE)/mg wet fruit juice.

Determination of physicochemical properties

The standard methods of Association of Official Analytical Chemists, (AOAC 2005) was used to analyze the physicochemical properties of the *S. mombin* crude fruit juice. All analysis were made in triplicate.

Determination of mineral contents

Wet ashing method was used to digest the crude fruit juice and the quantification was by atomic spectroscopy and mass spectrometry (ICP-MS, Spectro Analytical Instruments GmbH, Germany) according to the AOAC methods 997.15 and 990.08 (AOAC 2005). The results were expressed in mg/100 g. All analysis were performed in triplicate.

Statistical analysis

The results were expressed as mean ± standard deviation (SD) and subjected to one way analysis of variance (ANOVA). The least significant difference (LSD) was performed for the pairwise mean comparisons to determine the significant treatment dose at 95% level of confidence. Values were considered statistically significant at (P<0.05).

Results and Discussion

Antioxidants capacity of the crude fruit juice of S. mombin

Free radical scavenging power of 93.97 ± 64.8 µmol (TE) and ferric reducing power (FRAP) of 11.8 ± 0.2 µmol (AAE) were measured as reasonable amounts of the juice ability in *in vitro* antioxidant capacity (Table 1). The total antioxidant activity shown by the crude fruit juice of *S. mombin* reflects substantial free radical scavenging ability and reductive potential.

Free radicals are frequently generated in the living system and could be responsible for cell and tissues damage. As a consequence, research is focused on exploring for safe and effective antioxidants and also to encourage the consumption of natural antioxidants from food supplements and traditional medicines (Yazdanparast and Ardestani 2007). Antioxidant compounds, such as phenolic acids, carotenes and vitamins have been reported to be naturally present in fruits, vegetables, nuts, herbs and spices (Ali et al. 2008; Vasco et al. 2008; Schinella et al. 2009; Sreeramulu and Raghunata 2010; Lu et al. 2011). The results obtained in this study, indicates that the crude fruit juice of *S. mombin* is a good source of antioxidants, that could be of help to alleviate oxidative stress. Based on the evaluated antioxidant properties by Adewale et al. (2015), Famobuwa et al. (2016a; 2016b) on some Nigerian fruits, the result obtained allows us the insight that the crude fruit juice of *S. mombin* possessed antioxidant activity above average. Along with some fruits, such as pineapple, banana, watermelon, and orange and vegetables such as tomato and carrot, that are commonly consumed on daily bases by the populace. Also, the report of free radical scavenging activity (71.5%) and ferric reducing potential (1.94%) from the leaves of *S. mombin* as reported by Awogbindin et al. (2014) were less value to what was obtained from the crude fruit juice of *S. mombin* in this study.

The amounts of phenolic compounds and flavonoids contents of *S. mombin* in this study suggest its high antioxidant capacity. Phenolic compounds of plants fall into several categories; chief among these are the flavonoids, which have potent antioxidant activities (Tadhani et al. 2007). Flavonoids derivatives have shown a wide range of antibacterial, antiviral, anti inflammatory, anticancer, and anti-allergic activities (Di Carlo et al. 1999; Montoro et al. 2005). Flavonoids, have been shown to be highly effective scavengers of most oxidizing molecules, including singlet oxygen and various free radicals implicated in several diseases (Nabayi et al. 2008).

As *S.mombin* fruit juice exhibited significant levels of phytochemicals, which make it a potent source of antioxidant agents. This fruits can be vital help especially in such rural and urban areas where modern health facilities are not accessible due to poor state of living. Recent studies have also shown the advantages of natural antioxidants in foods, as opposed to synthetic additives (Shalini 2012).

Physicochemical properties of the fruit juice of S. mombin

The most important physicochemical properties of the crude *S. mombin* fruit juice were also determined. Thes values are displayed in Table 2.

The nutritional and energy values of foods are known through proximate analysis, but this gives a certain insight to the food quality. Earlier, Adepuju (2009) reported higher values for Nigerian *S. mombin* fruit juice (g/100 g) in moisture (82.3), lipid (2.0), crude fibre (4.2) and ash (1.0) then our values. From Brazil, Tiburski and co-workers (2011) reported moisture (83.66), fat (0.62), fiber (1.87), ash (0.76), total acidity (20.85), protein (1.06), carbohydrate (13.90) and pH (2.83) values, which are not significantly different from those we measured in this study.

Table 2. Physicochemical properties of the fruit juice of *S. mombin*.

Physicochemical properties	Mean ± SD
pH	3.63 ± 0.01
Moisture (g/100 g)	80.66 ± 0.02
Protein (g/100 g)	6.03 ± 0.04
Fiber (g/100 g)	0.64 ± 0.02
Ash (g/100 g)	0.54 ± 0.03
Fat (g/100 g)	1.85 ± 0.02
Total titratable acidity	28.52 ± 0.04
Carbohydrate (g/100 g)	11.61 ± 0.04

Mineral composition of the crude fruit juice of S. mombin

Ten trace elements (potassium, manganese, cupper, sodium, zinc, magnesium, lead, phosphorus, calcium, and iron) were determined from the crude fruit juice of *S. mombin*. The measured concentrations are displayed in Table 3. Some of these values are higher than what are reported for apricots, apple, banana, blackberry, grape fruit, cherries, lemon, lime, pear, pineapple, watermelon and other common and frequently consumed fruits (Cunningham et al. 2001; Emsley 2001; Decuypere 2005).

Table 3. Mineral content of the crude fruit juice of *S. mombin*.

Minerals	Mean ± SD (mg/100 g)
Sodium (Na)	4.45 ± 1.42
Magnesium (Mg)	12.36 ± 0.03
Phosphorous (P)	28.22 ± 1.02
Potassium (K)	276.27 ± 2.65
Calcium (Ca)	13.04 ± 0.53
Manganese (Mn)	0.15 ± 0.01
Iron (Fe)	0.48 ± 0.01
Copper (Cu)	0.121 ± 0.32
Lead (Pb)	0.01 ± 0.00
Zinc (Zn)	136.42 ± 1.35

Minerals or trace elements are either essential or non-essential, depending on whether or not they are required for human nutrition and have metabolic roles in the body (Reilly 2002). Fruits generally have in their composition a great variety of vitamins and essential minerals, which makes them beneficial to our diet. In this study, low levels of manganese, iron, sodium, copper and lead were observed in the crude *S. mombin* fruit juice though higher content of magnesium, phosphorus, potassium and zinc have been reported present in some other edible fruits. Albino et al. (1999), described *S. mombin* as a fruit with high content of potassium, along with jackfruit, soursop, jenipapo (*Genipa americana*) and mangaba (*Hancornia speciosa*). The phosphorus content of *S. mombin* as found in this study is one of the highest among the commonly consume fruits with levels close to those of Ceriguela (*Spondias purpurea*), Pequi (*Caryocar brasiliense*) and Passion fruit (NEPA-UNICAMP 2006).

Same mineral contents evaluated from *S. mombin* fruit juice by Adepoju (2009), cannot be compared because of the different methods used in analysis. Though several researchers have evaluated and reported different mineral contents of *S. mombin*, the differences can be attributed to the origin of the fruit. It may be dependent on the environmental conditions of each region (Leterme et al. 2006), since the minerals are absorbed from the soil. Furthermore, genetic factors, the use of fertilizers (Sanchez-Castillo et al. 1998) and the maturity stage of the tree that produces the fruits could also affect these results. The mineral contents of sodium, magnesium, potassium and phosphorus reported by Tiburski et al. (2011) from Brazil, were a bit higher than what was obtained in our study, while we measured higher calcium, manganese, iron, copper, lead, and zinc levels.

Conclusions

The level of antioxidant in fresh fruits are in wholesome than the preserved in the commercial fruit juices. Many of these compounds are heat sensitive, which are destroyed during the industrial processing of juices. Additionally, these antioxidants frequently used for preservative purposes and are synthetic additives in the product. We are of the opinion that consumption of fresh *S. mombin* fruit juice will promote a better health status as the antioxidants, physicochemicals and minerals analyzed are vital and valuable than some of the many recognized fruits. The analysis of the crude fruit juice of *S. mombin* in this study is in support of the several reports of health benefits and medicinal value of this edible fruit.

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