Proximate and Mineral Compositions of Spondias mombin, Canarium schweinfurthii, and Citrus sinensis Fruits

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ABSTRACT

Background: *Fruits are well known for being nourishing. In Nigeria, some are used and eaten to their full potential, while others go underutilized. A preference for their usage in nutrition may result from elucidating the nutritional benefits of certain fruits.*

Objective: *This study investigated the proximate and mineral composition of fruits from Spondias mombin (Hog plum), Canarium schweinfurthii (Bullet pear), and Citrus sinensis (Orange) trees in Abakaliki, Ebonyi State, Nigeria.*

Methods: *Fruits were collected, washed, peeled, and carefully pressed into pulps. The pulp was investigated for proximate and mineral compositions following standard methods of the Association of Official Analytical Chemists. At $p<0.05$ level of significance, Analysis of Variance (ANOVA) was used to compare the mean.*

Results: *The proximate and mineral compositions of the fruits were significant ($p < 0.05$). The protein levels in the fruits were 2.60 ± 0.12 to 3.74 ± 0.01 percent. Carbohydrate content was C. schweinfurthii: 33.43 ± 0.026; S. mombin: 1.01 ± 0.12; and C. sinensis: 2.37 ± 0.15. The ash contents of the fruits were low (1.34 - 2.86g/100 g). Citrus sinensis has the least amount of fat (0.55), while C. schweinfurthii has the highest (1.57). The minerals present in the fruits were in the order of K > Na > Ca > Mg > Fe > Zn > P > Cu > Mn > nitrate.*

Conclusion: *The fruits have ample nutrients, therefore, lack of nutritional information on the moderately utilized and underutilized fruits may be responsible for the peoples' preferred choice of well-utilized fruits.*

Keywords: Spondias mombin, Canarium schweinfurthii, Citrus sinensis, Proximate, Underutilized fruits

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INTRODUCTION

A variety of food-producing plant species have historically been underused due to a lack of information about the particular nutritional aggregates they contain (Kader et al., 2001). In addition to being used to make functional meals, several of these plants offer substantial economic and nutritional advantages (Valvi and Rathod, 2011). By providing food security or availability, these plants aid in the fight against poverty in the majority of rural regions. These underused crops are abundant in Nigeria and might be used to produce foods with nutritional value as well as health and physiological advantages. Additionally, foods that are native to or underused offer crucial micronutrients for human health (Agulanna, 2020).

The population growth, lack of arable land, high pricing for the basic foods that are available, and limits on food imports are all contributing to the worsening food situation in the majority of developing tropical nations (Bhandari and Banjara, 2015). Children and women, particularly those who are pregnant or nursing, are at risk due to the high frequency of hunger and malnutrition (Kruczek,2005). For instance, in Nigeria, stunting now affects 31.5% of children, whereas wasting now affects 10.8% of youngsters (UNICEF, 2018).

Based on present population growth rates, forecasts for future food consumption highlight how serious the problem is (San, 2009). Food security is necessary to end hidden hunger and malnutrition in a population that is expanding, but it will be particularly challenging in Africa, where the population is projected to double to 2.5 billion people by 2050 (Temu et al., 2016). It's interesting to note that fruits are said to be a rich source of many nutrients that may be used to supplement meals during times of food shortage (Adepoju, 2009), yet many of them have been overlooked and underutilized (Bhandari and Banjara, 2015).

Spondias mombin, Canarium schweinfurthii, and Citrus sinensis, three fruits used to several degrees in Nigeria, were examined for their proximate and mineral compositions in the current study. Hog plum or Spondias mombin, a plant belonging to the Anacardiaceae family that grows in tropical areas of North and Northeastern America, Asia, and Africa, as well as in Brazil, is another name for this fruit (Tiburski et al., 2011). It is referred to in Nigeria by several names, including Ogheghe, Okighan in Edo; TsáádàrMásàr in Hausa; Ijikara, Ngulungwu, Isikala in Igbo; Iyeye, Ekikan, Olosan in Yoruba; and Nsukakara in Ibibio (Aigbokhan et al., 2014). S. mombin's fruits haven't been used much in Nigeria, but other portions have been well-researched here (Ayoka et al., 2008). The fruit has a thin yellow peel and a sour-sweet flavor (Duru et al., 2017). It is a tiny, oval drupe that is between 3 and 5 cm long (Bosco et al., 2000). The tropical fruit Canarium schweinfurthii, often known as the bullet pear, belongs to the Burseraceae family (Obeta et al., 2020). Primarily found in East, West, and Central African equatorial forests (Orwa et al., 2009). According to Ayoade et al. (2017), the fruit of C. schweinfurthii is known as ubeokpoko in Igbo, atili in Hausa, and origbo in Yoruba in Nigeria. It is produced in comparable amounts in other states of northern Nigeria and is widely available, with commercial quantities found in the central and southern Plateau, as well as in the north-central and south-eastern regions of Nigeria (Chomini et al., 2021). After blanching, C. schweinfurthii pulp is frequently eaten raw or dipped in sugar, fish sauce, salt, pepper, or other seasonings (Rashid et al., 2021). The most frequently grown fruit tree in the world is Citrus sinensis, also known as the sweet orange (Oikeh et al., 2013). It belongs to the Rutaceae family, which also contains sweet oranges, mandarins, limes, and lemons (Karoui and Marzouk, 2013). The leaves are oval, alternately arranged, and have crenulated edges. They range in length from 4 to 10 cm (Agbayayo et al., 2018). Citrus fruits are the most valuable in terms of economic value and are the most produced fruits (Oikeh et al., 2013). Due to its sweet flavor and seeming abundance, the orange fruit is one of the most popular fruits in Nigeria. It is also said to help in food digestion and offer protection from certain ailments. The cost of orange fruits has increased recently as a result of this dependence. Finding a range of little-known but nutrient-dense fruits have thus become a primary focus to provide a profile alternative to the escalating expense of moderately used fruits.

MATERIALS AND METHODS

Sample collection

The fresh fruits of Spondias mombin (Hog plum) (underutilized), Canarium schweinfurthii (Bullet pear) (moderately-utilized), and Citrus sinensis (Orange) (well-utilized) which are eaten as foods were plucked, using long sticks, from their trees in Abakaliki, Ebonyi State in August 2019. The fruits, numbering 10-20 pieces each, were collected and kept in wash-hand bowls before sample preparation.

Methods

Preparation of fruit samples

The fruits were individually washed with distilled water, sliced to remove the seeds, and pressed into pulps. The pulps were poured into beakers and stored in the refrigerator to precede with the analysis. Also, preparations were carefully done to avoid loss of samples and possible contamination and cross-contamination.

Analysis of proximate compositions of fruit samples

Freshly prepared fruit pulps without seeds were used for proximate analysis. Moisture, crude protein, crude fat, ash, and crude fiber content were analyzed using the AOAC (2000) protocol adopted by Maxwell et al. (2020).

Mineral analysis of fruit samples

The mineral analysis was carried out according to the procedure of the Association of Official Analytical Chemists (AOAC, 2000) according to Maxwell et al. (2020). The minerals covered in the course of this work were analyzed by a spectrophotometric method except for calcium, which was determined by precipitation as oxalate by titrating with potassium permanganate solution (Abulude et al., 2005; Maxwell et al., 2020).

Statistical analysis

The data generated from the samples of chemical analysis were subjected to Analysis of Variance (ANOVA) procedures. Duncan's Multiple Range Test (DMRT) was used to differentiate between the mean values. All the analysis was done using Graph pad prism 5 and statistical Package for Social Science (SPSS) software version 20.

RESULTS

The proximate and mineral composition of C. sinensis, C. schweinfurthiiand S. mombin fruits were presented in Figures 1 and 2, respectively. The results showed no significant ($p>0.05$) difference in the moisture content of S. mombin and C. sinenesisfruits, while the moisture content of C. schweinfurthii was significantly ($p<0.05$) lower compared to the moisture contents of S. mombin and C. sinenesis. No significant ($p<0.05$) difference in the ash content of C. sinenesis and C. schweinfurthii fruits was observed, while the ash content of S. mombin fruit was significantly ($p<0.05$) lower compared to the ash content of C. sinenesis and C. schweinfurthii fruits. The oil content of S. mombin fruit was observed to be significantly ($p<0.05$) higher, followed by the oil content of C. schweinfurthii fruit, and least was the oil content of C. sinenesis fruit. The crude fiber content of C. schweinfurthiifruit was significantly ($p<0.05$) higher than the crude fiber content of S. mombin fruit, while zero crude fiber was observed in C. sinenesis fruit. The protein content of C. schweinfurthiifruitwas observed to be significantly ($p<0.05$) higher followed by the protein content of S. mombin fruit and the least was the oil content of C. sinenesis fruit. There was no significant ($p<0.05$) difference in the carbohydrate contents of S. mombin and C. sinenesis fruits, while the carbohydrate content of C. schweinfurthiifruit was significantly ($p<0.05$) higher than the carbohydrate contents of S. mombin and C. sinenesis fruits.

The results of mineral analysis of the fruits showed no significant ($p<0.05$) difference in the copper levels of S. mombin and C. schweinfurthii fruits, while the copper level of C. sinenesiswas significantly ($p<0.05$) lower than the copper level of S. mombin and C. schweinfurthii fruits, as shown in Figure 2. The phosphorus and calcium levels of C. schweinfurthiifruit were significantly ($p<0.05$) higher than the phosphorus and calcium levels of S. mombin, while the least phosphorus and calcium levels were observed in C. sinenesisfruit (Figure 2). There was no significant difference ($p<0.05$) in the nitrate levels of S. mombin and C. schweinfurthiifruits, while the nitrate level of C. sinenesis fruit was significantly ($p<0.05$) lower than the nitrate levels of S. mombin and C. schweinfurthiifruits (Figure 2). A significantly ($p<0.05$) higher levels of sodium and potassium were recorded in C. schweinfurthii fruit relative to the sodium and potassium levels of S. mombin and C. sinenesis fruits, while no significant ($p<0.05$) difference in the levels of sodium and potassium of S. mombin and C. sinenesis fruits were observed (Figure 2). The result of mineral analysis also reveals that there was no significant ($p<0.05$) difference in the zinc level of S. mombin and C. sinenesis fruits, while the zinc level of C. schweinfurthii fruit was significantly ($p<0.05$) lower than the zinc level observed in C. sinenesis and Mombin and C. sinenesis fruits, as shown in Figure 2. No significant ($p<0.05$) difference in iron levels between C. schweinfurthii and C. sinenesis fruits, while the iron level of S. mombin fruit was significantly ($p<0.05$) lower than the iron levels observed in C. schweinfurthii and C. sinenesis fruits, as shown in Figure 2.

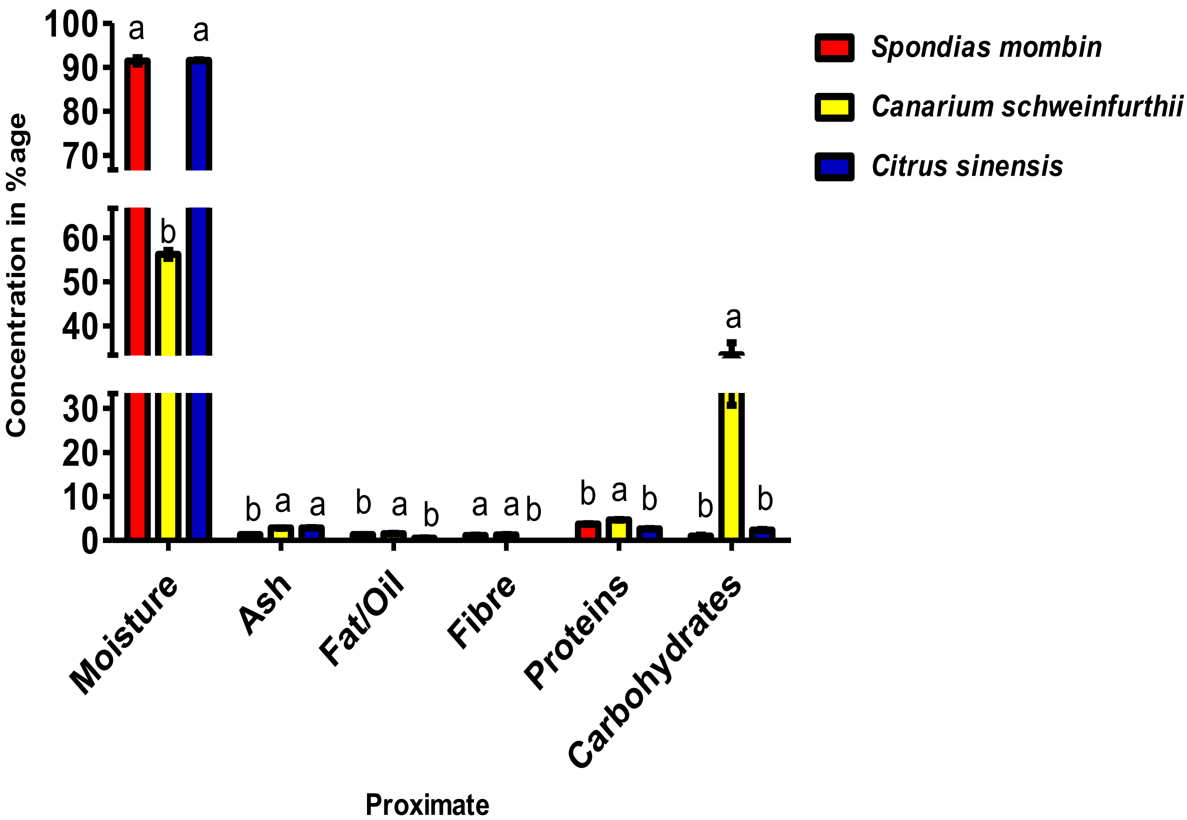

Figure 1: Proximate Compositions in *Citrus sinensis*, *Canarium schweinfurthii*and *Spondiasmombin* Fruits. Data are shown as mean ± S.D (n = 3). Mean values with different alphabets showed significant differences at p<0.05

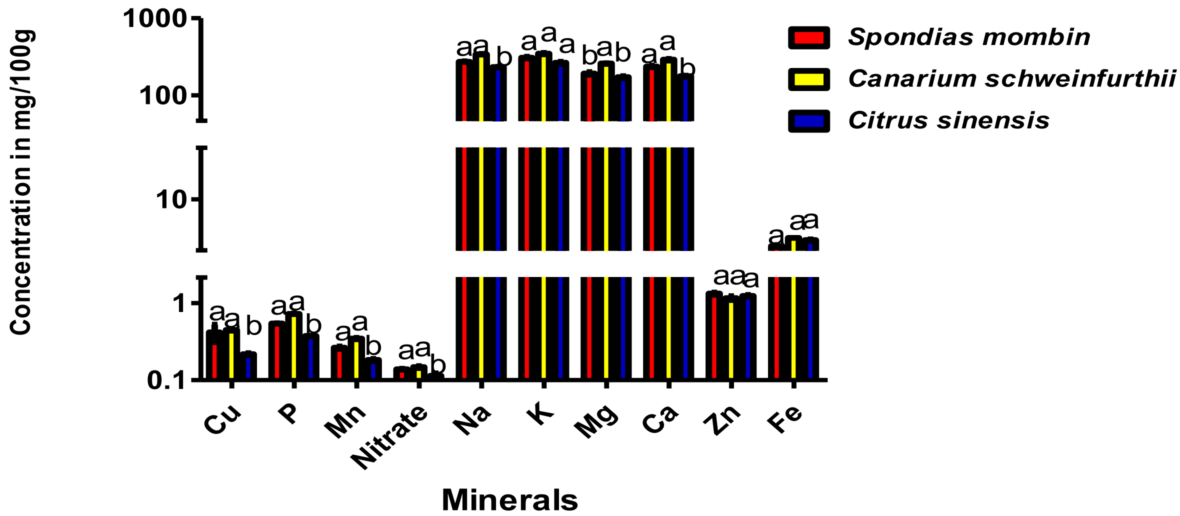

Figure 2: Minerals Compositions in *Citrus sinensis*, *Canarium schweinfurthii*and *Spondiasmombin* Fruits. Data are shown as mean ± S.D (n = 3). Mean values with different alphabets showed a significant difference at p<0.05.

DISCUSSION

Fruits are significant in human nutrition because they include essential nutrients that the body needs to operate correctly. The present analysis showed that a range of essential minerals was present in fruits of *S. mombin, C. schweinfurthii,* and *C. sinensis*. All of the fruits had a noticeable quantity of moisture, according to the results of the proximate analysis, with *S. mombin* and *C. sinensis* having much more moisture than *C. schweinfurthii*. In addition to ash, fat, and oil, fruits also include fiber, proteins, and carbohydrates. Although the concentrations of ash, fiber, fat, and oil in both fruits were relatively low, they were sufficient for normal body function. The fiber concentration could be useful in food enrichment. This is especially true given that fruit fiber is thought to be of higher quality than plant fiber. This is due to increased total and soluble fiber content, water and oil holding capacity, and colonic fermentability, as well as decreased phytic acid content and caloric value (Figuerola*et al*., 2005; Oikeh*et al*., 2013). The proximate analysis results show that *C. schweinfurthii* has a relatively high carbohydrate content (33.43 ± 0.026) when compared to *S. mombin* (1.01 ± 0.12) and *C. sinensis* (2.37 ± 0.15), indicating a promising and preferential application in the production of high-energy foods. Low-carbohydrate fruits, on the other hand, should be considered when planning a meal for diabetic and hypertensive patients who require low-sugar diets. Thus, *S. mombin* and *C. sinensis* may provide a therapeutic advantage over other fruits.

Furthermore, the high moisture content observed in *C. sinensis* and *S. mombin* is consistent with previous studies that reported moisture content of 86.75% - 87.12% in *C. sinensis* (USDA, 2014) and 82.03g/100 g in *S. mombin* (Sanusi *et al*., 2017). Foods with a high moisture content have been shown to promote microbial growth. As a result, water content is an important determinant of the levels of other food components (Greenfield and Southgate, 2003), implying that the product has a shorter shelf life. As a result, *C. schweinfurthii* would have a longer shelf life than *C. sinensis* and *S. mombin* due to its lower moisture content. In other words, *C. schweinfurthii* would have greater storage capacity than *C. sinensis* and *S. mombin*.

The ash content of the fruits is generally low (1.34 - 2.86g/100 g). This may be due in part to their low mineral composition (Oyoyede, 2005), particularly nitrate, Cu, and P. *CanariumSchweinfurthii* has a low ash content, which corresponds to several studies that reported values ranging from 1.86% to 2.5%g/100 g. (Agbo*et al*., 1992; Vunchi*et al*., 2011). Similarly, Njoku and Akumefula (2007) discovered that *S. mombin* leaf has a low ash content. The percentage of ash in fruits indicated the inorganic content of the fruits, from which the mineral content could be derived. As a result of their high ash content, *C. sinensis* and *C. schweinfurthii* have high concentrations of various mineral elements, and they are expected to speed up metabolic processes and improve growth and development.

The proximate analysis also reveals that fruits contain fat and oil. *Citrus sinensis* has the least amount of fat (0.55), while *C. schweinfurthii* has the most (1.57). It implies that *C. sinensis* has a low-calorie content when compared to other fruits. Low-fat diets are associated with a lower risk of obesity and cardiovascular disease (Onimawo and Egbekun, 2003). However, according to Koudou (2005), the fat content of *C. schweinfurthii* is very healthy because it contains essential oil, which has been shown to have antimicrobial potential. Other research suggests that *C. schweinfurthii* essential oil may be a natural antimicrobial and antioxidant agent (Obame *et al*, 2007; Dzotam *et al*., 2015).

The low fiber content (1.14 ± 0.01) of *S. mombin* observed in this study fell within the range of values of 1.00 - 1.87 g/100 g reported in several studies (Brasil, 2002; Dias *et al*., 2003). Although *C. schweinfurthii* has the highest fiber level (1.28), it is lower than the values obtained for bullet pear (10.44%g/100 g) (Ehrim*et al*., 2015) and African pear (17.90%g/100 g) (Omoti and Okiy, 1987). Adequate fiber consumption has been shown to benefit the muscles of the large and small intestines (Fisher and Beider, 1977). Other benefits of high-fiber diets include weight loss, prevention of diverticular diseases, constipation relief, lower cholesterol levels, and blood sugar control in diabetics (Onimawo and Egbekun, 2003). The protein levels in the fruits ranged from 2.60 ± 0.12 to 3.74±0.01 percent. This finding is consistent with previous research on similar fruits: *C. schweinfurthii* (5 - 7% g/100 g); *C. Sinensis* (0.94-90% g/100 g) (Agbo*et al*., 1992; Vunchi*et al*., 2011; USDA, 2014). Proteins are a necessary component of animal and human survival diets, and their primary function is to supply adequate amounts of required amino acids for nutrition.

Protein deficiency impairs growth and causes muscle wasting, edema, abnormal belly swelling, and fluid accumulation in the body (Perkins-Veazieet *al*., 2005). The minerals found in the fruits studied include copper (Cu), phosphorous (P), manganese (Mn), sodium (Na), potassium (K), magnesium (Mg), calcium (Ca), zinc (Zn), iron (Fe), and nitrate. There was a relatively low concentration of nitrate among these elements, while there was a high concentration of Na, K, Mg, and Ca, and a moderate concentration of Zn, Fe, Cu, P, and Mn. The minerals present in the fruits are concentrated in the following order: K > Na > Ca > Mg > Fe > Zn > P > Cu > Mn > nitrate. Surprisingly, *C. schweinfurthii* has the highest concentration of all minerals, followed by *S. mombin* and *C. sinensis*. Although the nitrate content of the fruits is lower than that reported by Valvi and Rathod (2011) in some wild edible fruits from the Kolhapur district, the authors found the highest concentration of potassium in all 8 fruits they analyzed, which is consistent with the present study. Adepoju (2009) investigated the mineral composition of wild fruits in Nigeria. They chose three wild fruits, including *Spondiasmombim*, *Diallumguineese*, and *Mordiiwhytii*. Magnesium was found to be more abundant in all fruits, with *S. mombin* fruit having the highest levels of magnesium (465.0 ± 21.21), sodium (400.0 ± 12.43), and copper (1.0 ± 0.14). *Mordiiwhytii*, on the other hand, is high in potassium (410.0 ±12.20), calcium (300.0 ± 12.20), phosphorus (170.0 ± 7.50), zinc (2.2 ± 0.12), and manganese (6.2 ± 0.15). All mineral values in the present study, however, are lower than those reported by the previous author (Appendix A: Supplementary Data). According to Valvi and Rathod (2011), the observed disparity could be attributed to geographic, climatic, and seasonal variation, as well as fertilization intensity (Kruczek, 2005). Other factors could include soil type, maturity stage, topography, and cultivar variety (Ani and Abel, 2017). Similarly, Agrahar-Murugkar and Subbulakshmi (2005) investigated the nutritional value of wild edible fruits, berries, nuts, roots, and spices consumed by India's Khasi tribes. They examined eight fruits and discovered that *Solanum indicum* is high in calcium, *Solanum gilo* is high in phosphorus and magnesium, iron is higher in *Prunus nepalensis*, manganese is higher in *Viburnum corylifolia*, and *Solanum xanthocarpum* is high in sodium and copper. *Vangeria spinosa* contains more zinc. Potassium is abundant in *Gomphogyne cissiformis*. Again, our findings show a higher concentration of potassium in all three fruits studied, which is consistent with the previous study by Smith *et al*. (1953), who examined the mineral content of 5 samples of 24 Valencia oranges to fruit age and some fertilization practices from plots of 12 trees each. The authors reported that potassium was the most abundant element in the fruit as it matured. Potassium is well-known for its role in fluid balance and nerve impulse transmission. In general, the importance of minerals in human nutrition and metabolism cannot be overstated. Calcium, for example, is a structural component of bones and teeth; it also plays a role in cellular processes such as muscle contraction, blood clotting, and enzyme activation (Gropper *et al*., 2005), and a significant amount is present in both fruits. Calcium is also thought to be an important factor in determining fruit storage quality (Lechaudelet *al*., 2005) because it delays ripening and senescence and reduces storage disorders (Ferguson,1984; Bangeruh,1979).

The sodium concentration in both fruits is much higher than the phosphorus concentration, though it is lower than that reported by Ani and Abel (2017) in *Citrus maxima* peel extract. As a result, we recommend more research on the peel extract of these fruits, particularly the *C. schweinfurthii* and *S. Mombin* fruits, which have been neglected for many years. The phosphorus content of the fruits (0.54 ± 0.004 mg/100 g in *S. mombin*, 0.73 ± 0.009 mg/100 g in *C. schweinfurthii*, and 0.37 ± 0.005 mg/100 g in *C. sinensis*) was comparable to that reported by Valvi and Rathod (2011) in *Ziziphus rugosa* (0.45 ± 0.03) and *Glycosmis pentaphylla* (0.94 ± 0.037). The sodium content (Appendix A: Supplementary Data) observed in this study, however, did not match the values (10 mg/100 g) reported by Dipak and Ranajit (2004). Sodium is the most abundant positive ion (cation) in extracellular fluid and plays an important role in fluid balance. Phosphorus is involved in the formation of several biologically important compounds, including bone mineralization, energy transfer and storage, nucleic acid formation, cell membrane structure, and acid-base balance (Gropper *et al*., 2005). Other minerals found in these fruits (iron and magnesium) are also essential to human nutrition. Iron is required for proper immune system function, cognitive development, temperature regulation, energy metabolism, and work performance (Baynes, 2000). Magnesium is essential in a variety of biochemical and physiological processes (Schrauzer, 2000). Finally, the presence of these constituents may explain why fruits are used to prevent and treat a variety of illnesses, such as hypertension, intestinal atony, chronic constipation, gastrointestinal tract inflammation, dyspepsia, stomach pain, cancer, scurvy, diabetes, dysentery, and stroke (Ogbonna *et al.*, 2018).

CONCLUSION

The results of this study suggest that two of the most overlooked fruits (*S. mombin* and *C. schweinfurthii*), have stocks of potentially beneficial proximate minerals that may help lower the risk of chronic illnesses and support physiological processes. In order to lessen overdependence on *C. sinensis* and the concomitant rise in its market price, we support enhanced utilization of *S. mombin* and *C. schweinfurthii*.

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Conflict of interest

The authors declared that there was no conflict of interest of any kind that has the potential to interfere with the data reported in this work.

Consent to publication

All the authors agreed to publish this version of the article.

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