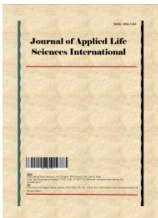

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Proximate and Mineral Composition of the Fruit of *Ficus polita*

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Authors' contributions

This work was carried out in collaboration among all authors. Authors AN, FIJ and IUM designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors KIM, AIY, AU, ZAS, HS and NMN managed the analyses of the study and literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The proximate and mineral analyses were conducted in the Department of Biochemistry Laboratory, Faculty of Basic Medical Sciences, Bayero University Kano, Nigeria, in May 2019. The study was carried out to determine the proximate and mineral composition of the fruit of *Ficus polita* using standard analytical methods. The fruit on dry weight basis (DW) contains moisture (9.12 %), ash (1.30 %), crude lipid (20.51 %), crude fibre (56.69 %), crude protein (1.19 %), available carbohydrates (11.40 %), and calorific value (234.98 Kcal/100 g). The fruit also contains potassium (324.46 mg/100 g), sodium (164.78 mg/100 g), calcium (91.09 mg/100 g), magnesium (70.06 mg/100 g), iron (3.39 mg/100 g), zinc (0.46 mg/100 g), manganese (0.37 mg/100 g), copper (0.23 mg/100 g), and cobalt (0.11 mg/100 g). The study revealed that *F. polita* fruit contains an

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appreciable amount of calorific value, crude fibre, crude lipid, available carbohydrate, and crude protein. The fruit was also found to be rich in minerals such as potassium, sodium, calcium, magnesium and iron. The fruit should be recommended as a good source of energy, fibre, lipid, carbohydrate, protein, potassium, sodium, calcium, magnesium, and iron.

Keywords: Proximate; mineral; Ficus polita; fruit.

1. INTRODUCTION

Ficus polita is a tropical African evergreen shrub or small tree, a member of a family Moraceae which is often growing up to 15 metres tall, and sometimes to 30 metres tall [1]. It is greatly branched with dense rounded crown on which abscission can occur during storm or wind [2]. This perennial plant is grown in villages primarily to provide shade around houses [3]. The leaves of *Ficus polita* tree are harvested to feed ruminant animals by farmers in most Nigerian rural settings, and they have been reported to have anti-nutritional factors such as phytate, oxalate, saponin, hydrogen cyanide, and tannin [4,5]. Its fig or fruits are green when ripe and are found on the major stem or branches. The leaves are sometimes harvested from the wild for food. Like most other *Ficus* species, the fruits are occasionally eaten as aphrodisiac and stimulant. The plant is commonly known as Hartblaarvy, Heart-leaved fig, polish fig, rubber plant, wild rubber fig, wild rubber tree [1]. Locally it is called durumi in Hausa, jammeizalazrak in Shuwa all in northern Nigeria [6].

Fruit is part of a plant responsible for bearing of seeds and is considered as a healthy food supplement because it comprises of considerable amount of carbohydrates, lipids, proteins, water, vitamins, and minerals such as potassium, sodium, calcium, magnesium, zinc, iron, and copper [7].

In Nigeria, wild fruits are commonly consumed by both urban and rural dwellers, especially in dry season, when most cultivated fruits are inadequate [8]. Wild and semi wild fruits are commonly consumed in rural communities as another source of essential nutrients [9]. There are more than 30,000 comestible plants used by humans with about 30% of these providing over 90% of the body's dietary requirement [10]. Although they may be eaten raw, cooked alone or part of preparations, regardless of the method of consumption, they are not only nutritionally beneficial, but are relatively cheap to obtain [10].

A large volume of literature is available on the other ficus species, However, not much study has been directed towards this locally abundant fruit of *F. polita.* The fruit of *F. polita* is rarely used as source of food. Thus, this study will showcase the potential nutritional parameters and elemental composition of the fruit, and to know if the fruit can be utilised to help in solving the problem of under nutrition and malnutrition resulting from ever increasing global population growth. The study was aimed to determine the proximate and mineral composition of *F. polita* fruit.

2. MATERIALS AND METHODS

2.1 Collection and Preparation of the Fruit of *Ficus polita*

Fresh fruits of *F. polita* were obtained from Kofar Marusa New Lay-out, Katsina, Nigeria in May 2019. The fruits of *Ficus polita* were identified at the Department of Biological Sciences, Umaru Musa Yar'adua University Katsina, Nigeria. The proximate and mineral analyses were carried out in the Department of Biochemistry Laboratory, Faculty of Basic Medical Sciences, Bayero University Kano, Nigeria, in May 2019. The fruits were dried under shade for two weeks and ground into fine powder using a pestle and mortar. The powdered fruits were packaged and appropriately labeled.

2.2 Proximate Analysis

Ten gram (10g) of the powder was soaked in 100 ml of pre-boiled distilled water, which was boiled in a water bath. The solution was shaken vigorously and allowed to stand for 24 hours. It was then filtered using Whatman's No. 1 filter paper and concentrated by freeze-drying to solvent free extract. The proximate analysis of the fruit extract for moisture, ash, crude lipid, crude fibre, crude protein and available carbohydrate contents were determined as described by AOAC standard assay method [11]. Calorific value was determined by using a formula: CV (kcal/100 g) = (CHO x 4) + (CL x 9) + (CP x 4) [12]. CV = calorific value, CHO = Total carbohydrate, CL = Crude lipid, CP= Crude protein.

2.3 Elemental Analysis

Five gram (5.0 g) of the prepared powdered sample was placed in quartz crucibles for dry ashing and mineralised thermally in a muffle furnance at 450º C for 12 hours. The mineralised sample was then acid digested by dissolving in 20ml of 1:1 (v/v) concentrated HNO_3 and HCl acids in a 100 ml volumetric flask. The flask was then heated in an electro thermal heater with gentle swirling till digestion was completed by evolution of white fumes. The cooled digest was filtered through Whatman No 1 filter paper into a 50 ml volumetric flask and diluted to 50 ml mark with de-ionised water. The mineral composition of the sample was determined using the atomic absorption spectrophotometer (AAS) and calculated using the relation $y = mx + c$ from calibration of each metal standard [11].

3. RESULTS AND DISCUSSION

3.1 Results

The results of the proximate and mineral composition of *F. polita* fruit investigated are shown in Table 1 and Table 2 respectively.

3.2 Discussion

The result of proximate composition presented in Table 1 shows that the moisture content of the fruit of *Ficus polita* was 9.12 ± 0.02 %. The value was high compared to (5.23 %) of the same fruit, reported by Otu [6]. The value is almost similar to that of *Ficus sycomorus* (9.65 ± 0.01 %) reported by Okoronkwo et al. [13]. Generally, fruits are known for their high moisture composition which is accountable for their vulnerability to microbial attack during storage [12].

The Ash content of *Ficus polita* fruit was 1.30 ± 0.00 %. The value was low compared to (11.88 %) of the same fruit, reported by Otu [6]. The value was also lower than that of *Ficus sycomorus* (7.24 ± 0.006 %) reported by Okoronkwo et al. [13]. The ash content is an indication of mineral content [14]. This shows that, fruit of *Ficus polita* contains low levels of minerals.

The crude lipid content of *F. polita* fruit was found to be 20.51 ± 0.56 % and was higher than that of the same fruit (2.09 %) reported by Otu [6]. The value was however lower than that of *Ficus sycomorus* (31.52 ± 0.03 %) reported by Okoronkwo et al. [13]. Nevertheless, since the fruit is rich in crude lipid, it could be a good source of edible vegetable oil if well utilised, and could supplement conventional sources. Lipids supply the body with more energy; approximately twice that of carbohydrate and protein and eases intestinal absorption and transfer [15].

The crude fibre of the fruit was found to be 56.69 ± 0.50 %, and this was by far higher than that of the same fruit (10.42 %) reported by Otu [6]. The value was also high compared to that of *Ficus sycomorus* (3.02 ± 0.017 %) reported by Okoronkwo et al. [13]. The fibre in the diet lessens serum cholesterol level [16]. And if in very high amount assimilates essential trace elements in the gut [16]. Fiber aids bowel regularity, assists maintain blood sugar levels, decreases constipation, and also averts heart diseases [17].

Table 1. Proximate compositions of *F. polita* fruit (%) dry weight (DW)

Parameter	Fruit
Moisture	9.12 ± 0.02
Ash	1.30 ± 0.00
Crude lipid	20.51 ± 0.56
Crude fibre	56.69 ± 0.50
Crude protein	1.19 ± 0.02
Available carbohydrate	11.40 ± 0.55
Calorific value (Kcal/100 g)	234.98 ± 6.32

The data are mean ± standard deviation (SD) of three replicates

Table 2. Minerals composition of *F. polita* fruit (mg/100 g DW)

Mineral	Fruit
Potassium	324.46 ± 5.25
Sodium	164.78 ± 1.52
Calcium	91.09 ± 4.45
Magnesium	70.06 ± 3.30
Iron	3.39 ± 2.10
Zinc	0.46 ± 0.20
Manganese	0.37 ± 0.16
Copper	0.23 ± 0.06
Cobalt	0.11 ± 0.02

The data are mean ± standard deviation (SD) of three replicates

The crude protein was found to be low (1.19 ± 0.02 %) compared to that of the same fruit (9.44 %) reported by Otu [6]. The crude protein content was also lower than that of *Ficus sycomorus* (9.23 ± 0.01 %) reported by Okoronkwo et al. [13]. Protein is a crucial source of amino acids and is required for development and maintenance of the body [18]. Protein deficiency may lead to growth retardation, abnormal swelling of the belly, muscle wasting, and collection of fluids in the body [19].

The available carbohydrate content of *Ficus polita* was 11.40 ± 0.55 % and this was lower than that of *Ficus sychomorus* (39.34 ± 0.029 %) reported by Okoronkwo et al. [13]. The function of carbohydrate is for provision of energy. Carbohydrates also add to the sweetness, appearance and textural attributes of many foods [20].

The calorific value of *F. polita* fruit was 234.98 ± 6.32 Kcal/100 g which was high compared to 136.27 ± 0.00 Kcal/100 g reported, for the same fruit, by Otu [6]. This is an indication that the fruit of *F. polita* can be an important source of dietary calories.

The result of minerals composition presented in Table 2 shows that the fruit is rich in macro elements. Among the macro elements potassium is the most abundant (324.46 mg/100 g) followed by sodium (164.78 mg/100 g), calcium (91.09 mg/100 g) and magnesium (70.06 mg/100 g). Iron is the most abundant micro element present in the fruit, followed by trace amount of zinc (0.46 mg/100 g), manganese (0.37 mg/100 g), copper (0.23 mg/100 g), and cobalt (0.11 mg/100 g).

Potassium is essential in the maintenance of cellular water balance, regulation of pH in the body, and it is also associated with carbohydrate and protein metabolism as well as accountable for nerve action and functioning of the muscles [21]. It is also the main intracellular cation that maintains intracellular osmotic pressure [22]. Low potassium in the blood is a life-threatening problem [23]. Potassium was found to be 324.46 ± 5.25 mg/100 g. The value was much higher than that of *Ficus sycomorus* (5.84 ± 0.02 mg/100 g) reported by Okoronkwo et al. [13]. The value was also high when compared to that of *Strychnos innocua* (256.33 ± 12.47 mg/100 g) reported by Hassan et al. [24].

Sodium is an electrolyte present in extracellular fluid and is crucial for coregulating ATP with potassium [22]. The value of sodium 164.78 ± 1.52 mg/100 g was much higher than that of *Ficus sycomorus* (3.48 ± 0.00 mg/100 g) reported by Okoronkwo et al. [13]. The value was also high when compared to that of S*trychnos innocua* (153.33 ± 12.47 mg/100 g) reported by Hassan et al. [24].

Calcium is very crucial in blood clotting, muscle contraction and for the activity of certain enzymatic processes [25]. Calcium is a crucial component of a healthy diet, and it is necessary for life. It plays an important role in building healthy and dense bones and teeth, blood clotting, and for normal functioning of the heart, muscles, and nervous system [26]. The level of calcium was found to be 91.09 ± 4.45 mg/100 g. The value was lower than that of *Ficus sycomorus* (390.77 ± 0.01 mg/100 g) reported by Okoronkwo et al. [13]. The value was high compared to that of *Strychnos innocua* (6.67 ± 0.47 mg/100 g) reported by Hassan et al. [24].

Magnesium activates enzymatic systems credited with calcium metabolism in bones and in the nerves' electrical potential [27]. The value of magnesium (70.06 ± 3.30 mg/100 g) was low compared to that of *Ficus sycomorus* (300.67 ± 0.021 mg/100 g) reported by Okoronkwo et al. [13]. However, the value is higher than that of *Strychnos innocua* (10.67 ± 0.47 mg/100 g) reported by Hassan et al. [24].

Iron is used, in the body, for transportation of oxygen to the tissue and for melanin formation [28]. It is also a vital element in the diet of pregnant women, nursing mothers, infant, convulsive patients and elderly to avert anemia and other related diseases. However, continued consumption, over time, results in liver failure [28]. The value obtained for iron was 3.39 ± 2.10 mg/100 g. The value was lower than that of *Ficus sycomorus* (11.64 ± 0.031 mg/100 g) reported by Okoronkwo et al. [13]. The result was also low compared to that of *Strychnos innocua* (9.77 ± 0.05 mg/100 g) reported by Hassan et al. [24].

Zinc is known to play a vital role in gene expression, regulation of cellular growth and participates as a co-factor of enzymes responsible for proteins, carbohydrates, and nucleic acid metabolism [29]. Zinc is basic for activation of specific enzymes. Zinc possessing organic compounds is employed as anti-fungal and astringent agent. It facilitates wound healing and metabolism [30]. Zinc deficiency in the developing countries is becoming a cause of worry because it has been shown that zinc deficiency is associated with, not only, decreased growth, but also increased morbidity and impaired immune function [31]. The value of zinc (0.46 ± 0.20 mg/100 g) was low compared to that of *Ficus sycomorus* (9.56 ± 0.02 mg/100 g) reported by Okoronkwo et al. [13]. The value was also much lower than that of *Strychnos innocua* (28.73 ± 0.06 mg/100 g) reported by Hassan et al. [24].

Manganese is desirable in the body as it helps the immune system, regulates blood sugar levels, and it is involved in the production of energy in the cell. It also works with vitamin K to aid blood clotting, and also aids to mitigate the effect of stress [32]. Birth defects could possibly result when a mother does not get enough of this vital element [32,33], Manganese is a metallo-enzyme involved in pyruvate metabolism and is also required for glucose exploitation. The manganese content of the fruit of *F. polita* (0.37 ± 0.16 mg/100 g) was low compared to that of *Strychnos innocua* (10.67 ± 0.47 mg/100 g) reported by Hassan et al. [24].

Copper deficiency leads cardiovascular disorders, as well as anemia and disorders of the bone and nervous systems [34]. The value of copper was found to be 0.23 ± 0.06 mg/100 g which was lower than that of *Ficus sycomorus* (1.52 ± 0.021 mg/100 g) reported by Okoronkwo et al. [13], and also lower than that of *Strychnos innocua* (2.37 ± 0.09 mg/100 g) reported by Hassan et al. [24].

Cobalt is an essential trace element by worth of its function as component of vitamin B_{12} (cyanocobaltamin) [24]. The value of cobalt (0.11 ± 0.02 mg/100 g) was low compared to that of S*trychnos innocua* (1.20 ± 0.01 mg/100 g) reported by Hassan et al. [24].

4. CONCLUSION

The study revealed that *F. polita* fruit contains an appreciable amount of calorific value, crude fibre, crude lipid, available carbohydrate, and crude protein. The fruit was also found to be rich in minerals such as potassium, sodium, calcium, magnesium and iron. Therefore, the fruit should be recommended as a good source of energy, fibre, lipid, carbohydrate, and protein. The fruit can also be recommended as a good source of macro elements such as potassium, sodium, calcium, magnesium and iron.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. SANBI. Observations in the Species: *Ficus polita* subsp. Polita; 2015. Available:http://www.ispotnature.org/speciesdictionaries/sanbi/Ficus%20polita%20subsp.%20polita [Accessed 17.11.2015].
2. Raghavendra AS. Physiology of Trees. John Willy and Sons Inc; 1991.
3. Gibbon D, Pain A. Crops of the Drier Regions of the Tropics. Longman, England. 1985;70-71.
4. Njidda AA. Chemical composition, fibre fraction and anti-nutritional substances of semi-arid browse forages of North-Eastern Nigeria. Nigerian Journal of Basic and Applied Science. 2010;18(2):181-188.
5. Ndamitso MM, Jacob JO, Idris S, Jimoh T. Prospects in the use of *Ficus polita* as a local ruminant feed. African Journal of Biotechnology. 2010;9(21):3116-3121.
6. Otu OC. Proximate study, amino acids and phyto-constituents of raw and boiled *Ficus polita* Vahl fruits. Chemistry Research Journal. 2017;2(5):38-43.
7. Umar KJ, Hassan LG, Usman H, Wasagu RSU. Nutritional composition of the seeds of wild melon (*Citrulluse cirrhosus*). Pakistan Journal of Biological Sciences. 2013;16(11):536-540.
8. Hassan LG, Sokoto AM, Ngaski MA, Anka SA, Chanchangi BM, Umar KJ, et al. Nutritional and anti-nutritional analyses of *Hura crepitans* seeds cultivated in Sokoto North L.G.A, North-Western Nigeria. Bayero Journal of Pure and Applied Sciences. 2018;11(1):126-130.
9. Muhammad S, Umar KJ, Sani NA, Muhammad S. Evaluation of nutritional and anti -nutritional profile of gingerbread plum (*Neocarya macrophylla*) seed kernel from Sokoto State, Nigeria. International Journal of Science and Technology. 2015;4:361-367.
10. Hassan LG, Bagudo BU, Aliero AA, Umar KJ, Abubakar L, Sani NA. Evaluation of nutrient and anti-nutrient contents of *Parkia biglobosa* (L.) flower. Nigerian Journal of Basic and Applied Science. 2011;19(1):76-80.
11. AOAC. Official Methods of Analysis International, 18th edition, Association of Official Analytical Chemists, Washington DC.USA. 2005;6-8.
12. Hassan LG, Muhammad MU, Umar KJ, Sokoto AM. Comparative study on the

proximate and mineral contents of the seed and pulp of sugar apple (*Annona squamosa*). Nigerian Journal of Basic and Applied Sciences. 2008;16(2):179-182.

13. Okoronkwo CU, Ogwo PA, Udensi EA, Agu RO. Nutritional and phytochemical composition of Utu (*Icacina senegalensis*) and Sycamore (*Ficus sycomorus*) Seeds. Journal of Environmental Science, Toxicology and Food Technology. 2014; 8(7):49-53.
14. Aberoumand A, Deokule SS. Proximate and mineral composition of wild coco (*Eulophia ochreata* L.) tubers in Iran. Asian Journal of Food and Agro-Industry. 2009; 2(02):203-209.
15. Dreon DM, Vranizan KM, Krauss RM, Austin MA, Wood PD. The Effects of polyunsaturated fat and monounsaturated fat on plasma, lipoproteins. Journal of American Medical Association. 1990;263: 2462.
16. Abolaji OA, Adebayo AH, Odesanmi, O.S. Nutritional qualities of three medicinal plant parts (*Xylopia aethiopica, Blighia sapida* and *Parinari polyandra*) commonly used by pregnant women in the western part of Nigeria. Pakistan Journal of Nutrition. 2007;6(6):665-668.
17. Wasagu RSU, Lawal M, Shehu S, Alfa HH, Muhammad C. Nutritive values, mineral and antioxidant properties of *Pistia stratiotes* (water lettuce). Nigerian Journal of Basic and Applied Science. 2013;21(4): 253-257.
18. Pugalenthi M, Vadivel V, Gurumoorthi P, Janardhanan J. Comparative nutritional evaluation of little known legumes, *Tamarindus indica*, *Erythrina indica* and *Sesbania bispinosa.* Tropical and Subtropical Agroecosystem. 2004;4:107-123.
19. Zarkada CG, Voldeng HD, Vu UK. Determination of the protein quality of three new northern adapted cultivars or common and mico types soya beans by amino acids analysis. Journal for Agricultural and Food Chemistry. 1997;45: 1161-1168.
20. Umi Kalsum HZ, Mirfat AHS. Proximate composition of Malaysian underutilized fruits. Journal of Tropical Agriculture and Food Science. 2014;42(1):63–72.
21. Onibon VO, Abulude FO, Lawal LO. Nutritional and antinutritional composition of some Nigerian fruits. Journal of Food Technology. 2007;5(2):120-122.
22. Oibiokpa FI, Adoga GI, Saidu AN, Shittu KO. Nutritional composition *Detarium microcarpum* fruit. African Journal of Food Science. 2014;8(6):342-350.
23. Allen LH. Intervention for micronutrient deficiency control in developing countries: past, present and future. Journal of Nutrition. 2003;133:3875-3878.
24. Hassan LG, Abdulmumin U, Umar KJ, Ikeh PO, Aliero AA. Nutritional and Anti nutritional composition of *Strychnos innocua* Del. (Monkey Orange) fruit pulp grown in Zuru. Nigerian Journal of Basic and Applied Science. 2014;22(1&2):33-37.
25. Atasie VN, Akinhanmi TF, Ojiodu CC. Proximate analysis and physico-chemical properties of groundnut (*Srachis hypogaea* L.). Pakistan Journal of Nutrition. 2009; 8(2):194-197.
26. Idris S, Iyaka YA, Ndamitso MM, Paiko YB. Nutritional composition of the leaves and steams of *Ocinum gratissium*. Journal of Emerging Trends in Engineering and Applied Sciences. 2011;2(5):801-805.
27. Ishida H, Suzuno H, Sugiyama N, Innami S, Todokoro T, Maekawa A. Nutritional evaluation of chemical components of leaves stalks and stems of sweat potatoes (*Ipomoea batatas* Poir). Food Chemistry. 2000;68:359-367.
28. Linder MC. Nutritional Biochemistry and Metabolism: With Clinical Applications. 2nd ed., Aplleton and Lange. 1991;215-269.
29. Camara F, Amaro CA. Nutritional aspects of zinc availability. International Journal of Food Sciences and Nutrition. 2003;54:143-152.
30. Sharma N, Gupta PC, Rao CV. Nutrient content, mineral content and antioxidant activity of *Amaranthus viridis* and *Moringa oleifera* leaves. Research Journal of Medicinal Plants. 2012;6(3):253-259.
31. Agomuo JK, Akajiaku LO, Alaka IC, Taiwo M. Mineral and antinutrients of fresh and squeezed-washed bitter leaf (*Vernonia amygdalina*) as affected by traditional de-bittering methods. European Journal of Food Science and Technology. 2016;4(2): 21-30.
32. Anhwange BA, Ajibola VO, Oniye SJ. Chemical studies of the seeds of *Moringa oleifera* (Lam) and *Detarium microcarpum* (Guill and Sperr). J. Biol. Sci. 2004;4:711-715.
33. Abitogun AS, Borokini FB, Ashogbon AO. Nutritional and chemical composition of ripe and unripe *Vitex glandifolia.* Journal of

Research in National Development. 2010; 8(1):1-8.

34. Mielcarz GW, Howard AN, Williams NR, Kinsman GD, Moriguchi Y, Mizushima S, et al. Copper and zinc status as a risk factor for ischemic heart disease: A comparison between Japanese in Brazil and Okinawa. Journal of Trace Element Experiment of Medicine. 1997;10: 29-35.

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