academicJournals

Vol. 8(6), pp. 342-350, June 2014
DOI: 10.5897/AJFS2014.1161
Article Number: DD92FA346001
ISSN 1996-0794

http://www.academicjournals.org/AJFS

African Journal of Food Science

Full Length Research Paper

Nutritional composition of *Detarium microcarpum* fruit

Florence Inje Oibiokpa[1]*, Godwin Ichekanu Adoga[2], Abubakar Ndaman Saidu[1] and Kudirat Oluwatosin Shittu[1]

[1]Department of Biochemistry, Federal University of Technology, Minna, Niger State, Nigeria.
[2]Department of Biochemistry, University of Jos, Jos, Plateau State, Nigeria.

Received 26 March, 2014; Accepted 17 June, 2014

The pulp of *Detarium microcarpum* fruit was extracted and samples were analyzed for the proximate, vitamin, mineral and anti-nutrient composition using standard methods. Crude protein content obtained in *D. microcarpum* fruit was 4.68% while the crude fat content was 2.23%. The fruit also contained 4.47% moisture, 4.47% ash, 11.06% crude fibre and 65.38% total carbohydrates. The mineral composition of the fruit pulp showed that potassium was the most abundant (908.10 mg/100 g) and cadmium was the least abundant (0.03 mg/100 mg). Vitamin analysis showed that the fruit is rich in vitamin C (55.10 mg/100 g). The fruit was also discovered to contain 12.44 mg/100 g, vitamin E, 4.20 mg/100 g vitamin B_2 and 0.17 mg/100 g folic acid. The anti-nutrient compositions of *D. microcarpum* were phytate (0.41 mg/100 g), cyanide (0.07 mg/100 g), tannin 0.17 mg/100 g, oxalate 1.06 mg/100 g, saponin (2.73 mg/100 g). *D. microcarpum* fruit is a good source of carbohydrates, fibre, minerals and vitamins and could also contribute to the daily requirements of protein and fats. The anti-nutrient contents of the fruit pulp are lower than established toxic levels.

Key words: *Detarium microcarpum*, nutritional composition, proximate, antinutrient.

INTRODUCTION

In most developing countries, food shortage is becoming evident as a result of population growth, competition for fertile land and poverty. The diet of many rural and urban dwellers is deficient in protein and high in carbohydrate, the implication is high incidence of malnutrition and increased dietary disease, a situation in which children and lactating women are most vulnerable (Sadik, 1991). While every measure is being taken by various levels of government to boost food production by conventional agriculture, a lot of interest is currently being focused on the possibilities of exploiting the vast number of less familiar plant resource of the wild (Anwhange et al., 2004; Abdullahi and Abdullahi, 2005) .

Many of such wild plants have been identified but lack of data on their chemical composition has limited the prospects of their utilization (Baumer, 1995). Many reports on some lesser known seeds and fruits indicate that they could be good sources of nutrients for both man and livestock (Elemo et al., 2002).

Detarium microcarpum is a locally common plant often left when a farmland is cleared and left to fallow. It is a plant genus of the family Fabaceae (Legume family). *D. microcarpum* is widely distributed in semi-arid sub-Saharan Africa which include Benin, Burkina Faso,

Corresponding author. E-mail: florence@futminna.edu.ng

Cameroon, Central African Republic, Ghana, Guinea, Guinea Bissau, Niger, Nigeria, Senegal and Togo.

Detarium microcarpum fruit is edible and rich in vitamin C, the leaves and seeds are used for cooking, the roots, stem bark and stems are also used to treat ailments like meningitis, tuberculosis, itches and diarrhea (Eromosele et al., 1994). The seed coat of the fruit has also been shown to possess antimicrobial activity due to the presence on steroidal saponins and flavonoids (Ebi and Afieroho, 2011). The stem bark has been shown to contain heavy metals at concentration levels higher than tolerable limits (Ehianeta et al., 2013). Also, Wahedi and David (2013) reported that *D. microcarpum* fruit pulp, when included in the diet of rats had effect on haematological parameters and body weight of rats, they concluded that prolonged consumption of the fruit by humans affect haematological parameters and body weight at excess medicinal doses.

Many food crops also contain natural chemical substances known to have effects on the nutritional status of food. Some of these natural occurring toxicants are antinutrients such as cyanogenic glycosides, phytates, oxalates lectin, saponins, alkaloids, chymotryp-sin inhibitors, etc. Chronic exposure to these natural substances through intake of foods rich in them may lead to the problem of toxicity (Conn, 1979; Nartey, 1980; Rosling, 1987).

Tannins are polycyclic hydrocarbons found in high amounts in tea leaves and spinach. They inhibit the absorption of iron probably by forming water insoluble iron-tannin complexes.

Oxalates inhibit the absorption of iron and calcium by forming insoluble and calcium complexes. Thus, the presence of phytates, tannins and oxalates in plant foods make iron and calcium unavailable. Hydrogen cyanide does not occur free but in combination with sugars to form nontoxic compounds known as cyanogenic glycolsides. Hydrogen cyanide is known to inhibit the respiretory chain at cytochrome oxidase level. The lethal dose for hydrogen cyanide in man is 50-60 mg/kg body weight.

Saponins are steroids or triterpenoid glycosides which are characterized by their bitter astringent taste, foaming properties and their effect on red blood cells (Osagie and Effiong, 1998).

The determination of nutritional value of food is fundamental to theoretical and applied investigations in nutrition. This is often the basis of establishing the nutriational value and overall acceptance of the food from the consumer's stand point (Wilson, 1979).

This study is aimed at determining the nutritional composition of the *D. microcarpum* fruit pulp, thus will encourage the use of *D. microcarpum* as food.

MATERIALS AND METHODS

Sample collection

The fruits of *D. microcarpum* were collected in March in Otukpo Local Government area of Benue State, Nigeria. The pulp of the fruit was extracted by removing the thick bark of the fruit and scrapping the pulp off using a spatula. The pulp was blended into fine powder using a blender. The pulp obtained from each fruit was weighed.

Proximate composition determination

For moisture determination, a moisture meter was used. 5 g of sample was weighed and placed on a moisture plate. The sample was placed on a moisture meter which operates at a temperature of 140°C and runs for 10 min. The moisture content was noted.

The ash content was obtained using the dry ashing method. The weight of crucible was taken on a weighing balance and noted as W_1. 5 g of sample was weighed in a crucible of known weight using a weighing balance and weight noted as W_a. The sample was ashed in a muffle furnace at a temperature of 600°C for 6 h. The ash obtained was cooled in a desiccator. The weight of crucible + ash was obtained using a weighing balance (W_3) and % ash content was calculated.

$$\text{Ash (\%)} = \frac{W_3 - W_1}{W_2} \times 100$$

The crude protein content was determined using the Kjedahl method (1883). A Foss digestor 2006 model was used to digest the sample and a Kjeltic distiller (Foss) 2100 model was used to extract ammonia. 1 g of sample was transferred into a digestion tube. 12 ml of concentrated H_2SO_4, 7 g of potassium sulphate and 0.08 g of copper sulphate were weighed and transferred into the digestion tube. The mixture in the digestion tube was digested at 400°C.The digest was allowed to cool and 75 ml of water was added to dilute the acid. 60 ml of alkaline solution was added to the sample in digestion tube (sodium thiosulphate, sodium hydroxide and water). The sample was then distilled in a Kjeltic distiller using 25 ml of 4% boric acid to trap ammonia which was titrated against HCl, till a pink colour was obtained.

Moles of HCl = Moles of NH_3 = Moles of nitrogen in the sample.

A blank (sucrose) was used also to titrate substrate reagent nitrogen from sample.

$$\text{Crude protein (\%)} = \frac{(\text{Titre value} - \text{Blank Titre value}) \times \text{Normality of acid} \times 14.01 \times 6.25 \times 100}{1000}$$

Where 14.01 is the atomic weight of nitrogen and 6.25 is the factor used to convert percent nitrogen to crude protein.

The crude fat content was determined using soxhlet extraction method. A 2050 soxtec auto extraction machine was used to extract the total lipid content. 3 g of sample was weighed in cellulose thimbles and noted as w1. Empty cups were weighed and the weights noted as w_2. 60 ml of hexane was added into the cups. Hexane was used to extract the oil from the sample. The thimbles and the cups were placed in the right positions in a soxhlet extraction unit. Complete extraction takes about 1 h and the process includes heating at 20°C. The extracted oil in the cups were further dried in an oven for 30 min at a temperature of 105°C to ensure complete evaporation of hexane. Cups containing extracted oils were then allowed to cool in a desiccator and weighed. The weight obtained was noted as w_3.

$$\text{Fat (\%)} = \frac{w_3 - w_1}{w_2} \times 100$$

The crude fibre was analyzed using the method described by Onwuka, 2005. 2 g of defatted sample was weighed in a beaker and noted as w_1. 100 ml of a mixture of trichloroacetic acid, nitric acid and

glacial acetic acid and water (20 g trichoroacetic acid, 50 ml nitric acid, 450 ml glacial acetic acid, and 500 ml water) mixture was placed on a reflux condenser and allowed to reflux for 1 h. After which the sample was filtered into a round bottom flask through a filter paper placed on a funnel. The residue obtained on the filter paper was transferred into a crucible. The crucible was then transferred into an oven and allowed to dry for 24 h at a temperature of 110°C. After 24 h, the crucible was allowed to cool in a desiccator and the weight of extract + crucible was noted as w_2. The sample was then incinerated in a muffle furnace for 6 h and then cooled in a desiccator and noted as w_3.

Crude fibre (%) = $w_2 - w_3 / w_1 \times 100$

Total carbohydrate was obtained by difference having estimated all other fractions:

Available carbohydrate (%) = 100 – (% moisture + % ash + % protein+ % lipids + % fibre)

Determination of anti-nutrient composition

The total oxalate content was determined using the method of Dye (1956). Exactly 1.5 g of sample was weighed in a volumetric flask. The sample was digested with a mixture of 190 ml distilled water and 10 ml of 6 N hydrochloric acid. it was incubated in a water bath at 90°C for 5 h. The mixture was then centrifuged and filtered into a 250 ml volumetric flask.50 ml of the filtrate was mixed with 25 ml of 6 N HCL and the mixture evaporated to about 25 ml on a hot plate. The brown precipitate was filtered off and washed with hot water. The filtrate was titrated with concentrated ammonia until a pink colour was observed. The solution was then heated on a hot plate to about 90°C, oxalate was precipitated with 10% (w/v) calcium chloride solution. The mixture was then kept overnight and then filtered, the precipitate was washed with distilled water and sodium hydroxide until calcium free. The precipitate was then washed with 25% (v/v) sulphuric acid solution and the filtrate was then heated to 90°C and titrated with 0.05 N potassium permanganate solution.

1 cm^3 of 0.05 N $KMnO_4$ = 2.2 mg oxalate

The phytate content was determined using Reddy et al. (1982) method. 4 g of sample was weighed out and soaked in 10 ml of 2% hydrochloric acid for 4 h and was shaken vigorously and then filtered. 25 ml of filtrate was measured and transferred into a conical flask and 5 cm^3 of 0.3% ammonium thiocyanate solution was added to the sample. The mixture was then titrated with a standard solution of iron (III) chloride until a brownish yellow colour which persisted for 5 min.

1 cm^3 of 0.02 M $FeCl_3$ = 0.601 mg phytate

The tannin content was determined using Allen et al. (1974) method. 0.5 g of sample was weighed into a 100 ml conical flask. 50 ml of distilled water was added and allowed to boil gently for 1 h on a hot plate. The solution was filtered and the residue washed with distilled water and made up to 50 ml with distilled water. 0.05, 1.0, 1.5, 2.0 and 3.0 ml of standard tannic acid was measured (corresponding to 0.05, 0.1, 0.15, 0.25, 0.3 mg of tannic acid) and transferred into a volumetric flask. To both standards and sample, distilled water was added to make up to 25 ml, 2.5 ml Folin Denis reagent was measured into each flask, followed by 2.5 ml sodium carbonate and the mixtures were diluted to 50 ml mark with distilled water. These samples were then allowed to stand in water bath at 25°C for 5 min. The optical densities (absorbance) were taken at 760 nm wavelength. The calibration curve was drawn to obtain concentration of tannins in food sample.

$$\text{Soluble Tannins (\%)} = \frac{\text{Concentration from graph} \times \text{extract volume}}{100 \times \text{sample weight}}$$

The saponin content was determined using Hudson and El-Difrawi (1979) method. 10 g of sample was weighed and mixed with 100 cm^3 of 20% aqueous ethanol and agitated with a magnetic stirrer for 12 h at 55°C. The solution was then filtered using whatmann no.1 filter paper and the residue re extracted with 300 cm^3 of 20% aqueous ethanol. Both extracts were combined and reduced to about 40 cm^3 under vacuum using a rotary evaporator. The extract and 20 cm^3 diethyl ether were transferred into 250 cm^3 separating funnel and shaken vigorously. The aqueous layer was discarded and the process continued until a colourless aqueous extract was obtained. The aqueous extract was adjusted to pH 4.5 using 4 g of sodium dichloride and the solution shaken with butanol. The butanolic extract was washed twice with 10 cm^3 of 5% (w/v) sodium chloride and evaporated to dryness in a fume cupboard to give saponin which was weighed and expressed as a percentage.

The cyanide content was determined using alkaline picrate method (AOAC, 1980).10 g of sample was soaked in a mixture of 200 ml distilled water and 10 ml orthophosphoric acid, the mixture was left to stand for twelve hours to release all bound hydrogen cyanide. A drop of tannic acid was then added and the solution distilled until 150 ml of the distillate was collected in a conical flask and diluted with 40 ml of distilled water. 8 ml 0f 6 mole/dm^3 ammonium hydroxide and 2 ml of 5% potassium iodide solution were added. The mixture was titrated with 0.02 mol/dm^3 silver nitrate solution using a micro burette until a faint but permanent turbidity was observed.

1 ml of 0.02 mol/dm^3 of $AgNO_4$ = 1.08 HCN

Determination of mineral composition

The wet ashing procedure similar to that of AOAC method 975.03 (1990) was used to extract the minerals from the sample. 2 g of sample was weighed in a beaker. 5 ml of nitric- perchloric acid was added continually to the beaker and allowed to digest in a fume cupboard at a temperature of 100°C until frothing stopped and the sample became colourless. The digested sample was transferred to 50 ml volumetric flask and made up to the 50 ml mark with deionized water. Inductively coupled plasma spectrophotometer was used to determine the concentration of these minerals, As, Ba, Co, Cr, Cu, Fe, I, K, La, Mg, Mn, Mo, Na, Ni, P, Pb, S, Sb, Sc, Se, Ti, V and Zn, in the sample. The mineral content of the sample was quantified against standard solutions of known concentrations which were analysed concurrently.

Determination of vitamin composition

The vitamin content was determined using a modified method of Nielsen (2002). 2 g of sample was weighed and transferred into a beaker, 20 ml of methanol was added to the beaker containing sample. The mixture was heated in a water bath at 40°C for 30 min and vitamin A, B_2, E, C and folic acid content were obtained using a UV-VIS spectrophotometer 2550 shimadzu model. The absorbance was read for both samples and standard solutions of all the vitamins and concentration of vitamins in the sample determined. The wavelengths used were 478.5 nm for vitamin C determination, 273 nm for folic acid determination, 186.15 nm for vitamin E determination, 324.5 nm for vitamin A determination and 261 nm for Riboflavin determination.

Table 1. Proximate composition of *D. microcarpum* fruit pulp.

Nutrient	Composition (%)
Moisture	11.06±0.00
Ash	4.47 ± 0.00
Crude fat	2.23 ± 0.04
Crude fibre	12.19 ± 0.01
Crude protein	4.68 ± 0.00
Total carbohydrate	65.38 ± 0.05

Mean ± standard deviation for 3 determination.

Table 2. Anti-nutrient composition of *D. microcarpum* fruit pulp.

Antinutrients	Composition (mg/100 g)
Phytates	0.41 ± 0.01
Cyanide	0.07 ± 0.01
Tannins	0.17 ± 0.01
Oxalate	1.06 ± 0.01
Saponins	2.73 ± 0.09

Mean ± standard deviation for 3 determinations

Statistical analysis

The analysis was performed in triplicates. The mean values and standard deviation were calculated (mean ± SD) using SPSS package16

RESULTS AND DISCUSSION

The dehulled seed pulp of *D. microcarpum*, as reported by Akpata and Miachi (2001) contained 3.5% ash, 2.9% crude fibre and 39% carbohydrates. Abdalbasit et al. (2009), compared different sources of *D. microcarpum* fruit pulp in Sudan and found that those from Abu Gibaiha had 40-42% carbohydrates; 29-30.9% protein. Samples from Abu Gibaiha had the highest amounts of protein and carbohydrates in comparison with other samples from Ghibaish and Omdurman. They also reported that *D. microcarpum* fruit contained minerals, with K, Na, Mg and Ca, being the predominant elements. Anhwange (2004) also determined the proximate composition of *D. microcarpum* seed and reported that the moisture content of seed is 4.68%, ash content is 2.77%. The organic matter content was found to be 97.23% and the seed has a protein content of 35.96%. Kouyate and Van Damme (2006) recorded that the fruit pulp contains 4-6 g/100 g protein and 3 mg/100 g ascorbic acid. Olafedehan et al., (2010) reported that *D. microcarpum* pulp contained 0.023% tannin, saponin, phytate, oxalate and hydrogen cyanide were not detected. Umar et al. (2007), reported that *D. microcarpum* fruit pulp from Zamfara State, north-eastern Nigeria, contained 593.7 mg/100 g potassium, 438.5 mg/100 g sodium, 20.5 mg/100 g magnesium and 90.0 mg/100 g calcium. Umar et al. (2007), reported that *D. microcarpum* contained 13.50% oxalate, 2.13% phytate, 12.10% saponin and 3.54% tannin. Obun et al. (2011), worked on the effect of dietary inclusion of raw *D. microcarpum* seed meal on the performance of broiler chicks. Results of the proximate and anti-nutrient contents of the seed meal showed that *D. microcarpum* seed contains 89.42% dry matter, 26.54% crude protein, 11.11% crude fibre, 15.18% ether extract and 3.49% ash (Tables 1 and 2). Igbadul et al. (2012) suggested that fermentation of the seed of the fruit could lead to an increase its crude protein and crude fibre content.

The moisture content of the fruit pulp was found to be 11.06%. This value is lower than that reported for the seed by Awhange (2004), this may suggest that the pulp contains more moisture than its seed. Moisture content of food is of great importance as a number of biochemical and physiological changes in food depend very much on their moisture content. Of great importance is its effect on the stability and quality of food during storage (Onwuka, 2005). The moisture content falls below the maximum 15% moisture required as safe storage limit for food materials (Sena et al., 1998). Thus, the fruit of *D. microcarpum* can be stored for long without fear of deterioration.

The ash content of the fruit pulp was observed to be 4.47%. Olafedehan et al. (2010), evaluated *D. microcarpum* fruit pulp as a feed ingredient in rabbit's diet and found the ash content to be 3.40%, this value is lower than those obtained in this research and variations could be due to differences in environmental factors such as soil and genetic differences. Obun et al. (2011) reported that the seed of *D. microcarpum* fruit contained 3.49% ash, showing that the seed and pulp have similar ash contents and are both good sources of minerals.

The crude fibre content of the fruit pulp was found to be 12.19%. Akpata and Miachi (2001) reported that the dehulled seed flour of *D. microcarpum* contained 2.9% crude fibre. Also Obun et al. (2011) reported that the seed meal contained 11.11% crude fibre, this result may suggest that the seed and pulp contain similar amounts of crude fibre. The fruit of *D. microcarpum* as described by Kouyate and Van Damme (2006) has tangled fibres and is not fleshy, this may suggest or explain its high fibre content. Liberal consumption of dietary fibre from a variety of foods help protect against colon cancers and help normalize blood lipids and thereby reduce the risk of cardiovascular disease (Vahouny and Kritchevsky, 1986). Certain types of fibres slow down glucose absorption and reduce insulin secretion, this is of great importance to diabetics and non-diabetics. Dietary fibres help prevent constipation and diverticular disease. *D. microcarpum* fruit could therefore be a good source of fibre, hence be of great therapeutic value.

Table 3. Mineral composition of fruit pulp of *D. microcarpum* (mg/100 g).

Mineral	Composition (mg/100 g)
Calcium	70.97
Cobalt	0.06
Chromium	0.44
Copper	0.59
Iron	78.71
Iodine	2.77
Potassium	908.10
Magnesium	113.50
Manganese	5.95
Sodium	15.09
Molybdenum	6.39
Phosphorus	204.5
Sulphur	37.24
Selenium	ND
Zinc	31.7
Arsenic	0.44
Cadmium	0.03
Lanthinium	0.09
Nickel	1.57
Strontium	0.25
Scandium	ND
Titanium	0.36
Vanadium	ND
Barium	0.58
lead	0.002

ND- not detected.

The crude fat content of *D. microcarpum* fruit pulp was observed to be 2.23%. The average fat composition as stated by the National academy of science (1993) of staple food crops are usually low, ranging from 1-2% in legumes to 3-4.5% in cereals. This may suggest the low crude fat content of *D. microcarpum* fruit pulp. The results obtained by *Obun* et al. (2011) suggest that the seed of *D. microcarpum* may be a better source of crude fat.

The total carbohydrate content of the pulp of *D. microcarpum* fruit obtained was 65.38%. Abdalbasit (2009) reported that the fruit pulp from Abu Gibaiha contained 29.1 – 30.9% carbohydrate, while those obtained from Omburdan contained 29.6% total carbohydrates. Fruits from Ghibaish contained 29.4% carbohydrates. These values are lower than the value obtained as total carbohydrate content. Ogundung, (2006) stated that the pulp *D. microcarpum* fruit is used as a source of food for man and livestock, as it contains high level of carbohydrates.

The crude protein content of the fruit pulp was found to be 4.68%. This value falls within the range reported by Kouyate and Van Damme (2006) as the crude protein content of the fruit pulp. The value obtained for crude protein in this study is low as compared to the analysis carried out by Abdalbasit et al. (2009). Olafedahan (2010) found the crude protein content of the fruit pulp to be 6.61, this value is close to those reported by Kouyate and Van Damme (2006) and those of this study.

Differences in nutrient contents of legumes have been shown to be dependent on variety and location (Swaminathan and Jain, 1973).

The mineral composition of the pulp was determined with potassium being the most abundant (908.1 mg/100 mg) followed by phosphorus (204.5 mg/100 g). The pulp also contains a high amount of magnesium (113.57 mg/100 g), iron (78.7 mg/100 g) and sulphur (37.2 mg/100 g) (Table 3). The sodium content was (15.1 mg/100 g). Umar et al. (2007) compared the mineral composition of *D. microcarpum* fruit pulp, seed and pericarp. The pulp, seed and pericarp had high amounts of potassium with the pulp containing the highest amounts of potassium (1,593.75 mg/100 g). This variation may be due to differences in environmental factor. *D. microcarpum* fruit analyzed by Umar et al. (2007) was obtained from kwatarkwashi Local Government Area, Zamfara State. The high potassium content of pulp is characteristic of plant foods (Olaofe and Sanni, 1988). Abdalbasit et al. (2009) determined the mineral composition of *D. microcarpum* fruit pulp from different sources in Sudan. The fruit pulp from Abu Gibaiha had the highest concentration (1475.75 mg/100 g).This value is higher than that obtained in this study. Potassium is a systemic electrolyte and is essential for coregulating ATP with sodium. Potassium is a major intracellular cation that maintains intracellular osmotic pressure. The depolarization and contraction of heart require potassium (Vasudevan and Sreekumari, 2007), its RDA is 4700 mg (Lippard et al., 1994). This shows that *D. microcarpum* fruit is a good source of potassium.

The phosphorus content of the pulp was observed to be 204.5 mg/100 g.Umar et al. (2007) did not detect phosphorus in their analysis of the fruit pulp but phosphorus was detected in the seed (170 mg/100 g). Abdalbasit et al. (2009) found *D. microcarpum* fruit pulp from Abu Gibaiha to contain 1.17 mg/100 g, while those from Omdurman and Ghibaish contained less amount of phosphorus (1.09 mg/100 g, 1.06 mg/100 g, respectively). Phosphorus is a component of bones and teeth. As phosphate ion, it is required for formation of teeth and bones, production of high energy compounds such as ATP, creatine phosphate, etc. it is also required for synthesis of coenzymes such as NAD^+ and $NADP^+$, DNA and RNA synthesis and activation enzymes by phosphorylation (Vasudevan and Sreekumari, 2007). The required daily allowance (RDA) of phosphorus is 700 mg (Vasudevan, 2007), suggesting that the fruit may be a good source of phosphorus.

Magnesium content of *D. microcarpum* fruit pulp was obtained to be 113.5 mg/100 g. Umar et al. (2007) reported the magnesium content of the pulp to be 20.56

mg/100 g. This value is low as compared to that obtained in this study. Magnesium is an activator of enzymes requiring ATP. alkaline phosphatase, hexokinase, phosphorfructokinase etc. its RDA is about 400 mg for men and 300 mg for women (Vasudevan, 2007). Results obtained from this study also suggest that *D. microcarpum* may also be a good source of magnesium.

The iron content of the fruit pulp was found to be 78.7 mg/100 g.Umar et al. (2007) reported the iron concentration in the pulp to be 2.11 mg/100 g which is low as compared to the result obtained. Abdalbasit et al. (2009) reported that iron concentration of the fruit pulp obtained from Abu-Gibaiha is 3.22 mg/100 g. Ehianeta et al. (2013) reported a value of 218.9 mg/kg for iron concentration of the stem bark *of D. microcarpum*, showing that the fruit may contain more iron than the stem bark of the plant. Iron is a component of many proteins and enzymes, notably hemoglobin and cytochrome P_{450}. Deficiency of iron could lead to iron deficiency anaemia which is more common in menstruating females and pregnant women (Devlin, 2006). The RDA of iron in adults is between 15, 20-30 mg for children, and 40 mg for pregnant women (Vasudevan, 2007). Hence *D. microcarpum* fruit could contribute greatly to the daily requirement of iron.

Calcium content of *D. microcarpum* fruit pulp was observed to be 70.97 mg/100 g, the result obtained by Umar et al. (2007) is 160 mg/100 g, and this value is higher as compared to those obtained in this study. Abdalbasit et al. (2009) reported 141.11 mg/100 g for *D. microcarpum* fruit obtained from Abu-Gibaiha. Calcium is a very important mineral. It is a structural component of bones and teeth. It contributes to physical strength of bones and teeth. Calcium is also required in muscle contraction, blood coagulation, nerve impulse transmission, etc. The RDA of calcium is about 1000 mg (Lippard, 1994). *D. microcarpum* is thus a good source of calcium.

D. microcarpum fruit pulp analyzed contained 31.74 mg/100 g zinc. Umar et al. (2007) obtained a value of 0.34 mg/100 g. This value is very low as compared to that obtained in this study. Abdalbasit et al. (2009) also obtained a low value. Ehianeta et al. (2013) mentioned that the stem bark of *D. microcarpum* contained 48.9 mg/kg, zinc. Zinc is a component of metalloenzymes like carbonic anhydrase; alkaline phosphatase. Zinc is also a component of Zn – Cu superoxide dismutase which destroys superoxides and free radicals. Deficiency of zinc has been associated with poor wound healing, poor growth, impairment of sexual development and decreased acuity (Devlin, 2006).The RDA of zinc is 11 mg (Lippard, 1994). *D. microcarpum* may therefore be a good source of zinc.

D. microcarpum fruit pulp was found to contain 15.09 mg/100 mg sodium. Umar et al. (2007) reported that the fruit pulp contained 438.5 mg/100 g.This value is higher than that obtained in this study. Abdalbasit et al. (2009) reported 424.5 mg/100 g to be the sodium composition of *D. microcarpum* fruit pulp from Abu–Gibaiha. Sodium is an electrolyte present in extracellular fluid and is essential for coregulating ATP with potassium (Lippard, 1994).Sodium (sodium bicarbonate) is also important in the regulation of acid-base balance (Vasudevan and Sreekumari, 2007). The RDA for sodium is 1,500 mg (Lippard, 1994). *D. microcarpum* fruit pulp may contribute to the daily requirement of sodium.

The iodine content of *D. microcarpum* fruit pulp obtained was 2.77 mg/100 g. Iodine is required for synthesis of thyroid hormones, thyroxine and triiodothyronine, needed to prevent goitre. Iodine deficiency has been associated with mental retardation and stunted growth in children. The RDA of iodine is 150 µg (Linder, 1991). *D. microcarpum* fruit pulp could also be a good source of iodine.

Chromium content of the fruit pulp was found to be 0.80 mg/100 g.Chromium is a component of chromodulin, a low molecular weight protein which potentiates the effect of insulin by facilitating its binding to its receptors. The chief symptom of chromium deficiency is impaired glucose tolerance, a result of decreased insulin effectiveness. Supplementation with chromium appears to improve glycemic control in type 2 diabetes (Devlin, 2006). *D. microcarpum* may also be a good source of chromium. Ehianeta et al. (2013), did not detect chromium in the stem bark of *D. microcarpum* plant.

Copper content in *D. microcarpum* fruit pulp was found to be 0.59 mg/100 g. Umar et al. (2007) reported 0.33 mg/100 g for copper, which is lower than what was obtained in the study. Copper content of *D. microcarpum* fruit from Abu–Gibaiha, Ghibaish and Omdurman as reported by Abdalbasat et al. (2009) was 0.43 mg/100 g, 0.35 mg/100 g, 0.32 mg/100 g, respectively. Copper is required for a number of redox reactions. It is a component of many enzymes including cytochrome C oxidase (electron transport), dopamine β hydroxylase (norepinephrine synthesis), lysyl oxidase (collagen crosslinking), superoxide dismutase, C_{18}, desaturase (addition of double bonds to long chain fatty acid). The RDA of copper is 900 µg (Devlin, 2006). The pulp of *D. microcarpum* fruit may also be a good source of dietary copper. Cobalt content of the fruit was found to be 0.59 mg/100 g. This is low as compared to the value reported by Umar et al. (2007) (3.7 mg/100 g) and also lower than the values reported by Abdalbasat et al. (2009).

Manganese content in the fruit pulp was found to be 5.95 mg/100 g. This value is greater than those reported by Abdalbasat et al. (2009) and Umar et al, (2007), although Ehianeta et al. (2013) reported that the stem bark contains 139 mg/kg of manganese.

D. microcarpum fruit pulp was also found to contain 6.39 mg/100 g molybdenum. Molybdenum is a component of oxidases; xanthine oxidase involved in degradation of purines, aldehyde oxidase and sulphite oxidase required for catabolism of sulphur containing amino acids. Deficiency of molybdenum results in decreased urinary uric

Table 4. Vitamin composition of *D. microcarpum* fruit pulp.

Vitamins	Composition (mg/100 g)
Vitamin A	ND
Vitamin B_2	4.20
Vitamin C	55.10
Vitamin E	12.44
Folic acid	0.17

ND- not detected.

acid excretion and enhanced loss of xanthine/hypoxanthine (Linder, 1991). The RDA for molybdenum is 45 µg, thus *D. microcarpum* fruit is a good source of molybdenum.

Cadmium content of the fruit pulp was observed to be 0.03 mg/100 g. Abdalbasat et al. (2009) reported 0.001 mg/100 g as the cadmium content of the fruit. These values a very low to cause acute toxicity of cadmium.

Selenium was not detected, this may suggest that the fruit may not be a good source of selenium. *D. microcarpum* fruit pulp had 37.24 mg/100 g sulphur. Sulphur accounts for 0.25% of the human body weight. It is involved in protein synthesis. Sulphur increases hair glossiness and smoothness and maintains a clear youthful appearance. *D. microcarpum* fruit is thus a rich source of sulphur.

Nickel content was determined and found to be 1.57 mg/100 g. Abdalbasit et al. (2009) detected only 0.001 mg/100 g in the *D. microcarpum* fruit obtained from Ghibaish. Nickel was not detected in fruits from Abu-Gibaiha and Omdurman. Nickel has been discovered as an essential element for higher animals. It has been demonstrated through human and animal studies to play a role in hormone and lipid metabolism. It can act as an activator of certain enzymes and may be involved in glucose metabolism (Linder, 1991). Nickel can be toxic in high levels. The oral dose is about 1000 times the amount consumed in food. Human requirement for Nickel probably does not exceed 100 mg/day.

Differences in mineral content as reported by Abdalbasat et al. (2009) may be due to variations in environmental factors, like soil and also genetic variations. The type of soil found in the guinea savannah is the loamy soil, which retains water and nutrients (Kaufmann and Cutler, 2008). This may explain why *D. microcarpum* fruit obtained from Sudan and Zamfara State have lower mineral contents as compared those obtained from Benue State

Five different vitamins were analyzed; these are vitamin A, E, C, B_2 and folic acid. Amongst the vitamins analyzed, vitamin C had the highest concentration in the fruit pulp (55.1 mg/100 g) (Table 4). The RDA for vitamin C is 75 mg-90 mg/day (Devlin, 2006). This shows that the fruit is a good source of vitamin C. Kouyate and Van Damme (2006) reported that *D. microcarpum* fruit contained 3 mg/100 g of vitamin C. This value is lower than that obtained in this research. Vautier et al. (2007), reported that the *D. microcarpum* fruit is rich in vitamin C. Vitamin C is required to maintain a healthy connective tissue. It is also required for the synthesis of carnitine. Vitamin is an antioxidant that aids absorption of iron by reducing it to ferrous state in the stomach. As an antioxidant, it spares vitamin A, E and some B vitamins. Vitamin C is required for wound healing. The use of mega doses of vitamin C has been reported to moderate the symptoms and shorten the duration of common cold (Devlin, 2006). Hence intake of the this fruit may help prevent deficiency symptoms of vitamin C.

Vitamin E content of the fruit was found to be 12.44 mg/100 g. Vitamin E is a naturally occurring antioxidants. Antioxidants play a crucial role in prevention of chronic ailments such as heart disease, cancer, diabetes, stroke and Alzheimer disease by combating oxidative stress (Lako et al., 2007). The dietary intake of fruit has a strong inverse correlation with the risk of developing coronary disease and cancer. *D. microcarpum* fruit may also contribute to the daily requirement of vitamin E.

Vitamin B_2 was detected in *D. microcarpum* fruit and was found to contain 4.2 mg/100 g vitamin E. The RDA for this vitamin is 1.5 mg and so, the fruit may be a good source of vitamin B_2.The active forms of vitamin B2 are flavin adenine dinucleotide (FAD) and flavin mononucleotide; these are coenzymes of a wide variety of redox reactions required for energy production and cellular respiration, amongst which are succinate dehydrogenase, xanthine oxidase, glutathione reductase, monoamide oxidase. FAD is a coenzyme involved in synthesis and degradation of fatty acids. Riboflavin is also required for iron mobilization and riboflavin deficiency may contribute to anaemia when iron intake is low (Devlin, 2006).

D. microcarpum fruit pulp contained 0.17 mg/100 g of folic acid. The RDA is about 100 µg for pregnant and lactating women, the RDA is as high as 600-800 µg (Devlin, 2006). Folic acid in the form of tetrahydrofolate is required for synthesis of glycine, serine, choline, methionine, purines and deoxythymidine monophosphate. Folic acid and vitamin B12 are required for the conversion of homocysteine to methionine. Methionine is converted to S-adenosyl methionine which is used in many methylation reactions, including DNA methylation. Deficiency of folic acid has been associated with megaloblastic anaemia (Devlin, 2006). Deficiency of folic acid is common in pregnant and lactating women due to increased need or demand for folate.

D. microcarpum fruit pulp was found to contain 0.17 mg/100 g tannin. Olafadehan et al. (2010) reported that the fruit pulp meal contains 0.023% tannin. Phytates, saponins, oxalates and hydrogen cyanide were not detected.

The fruit pulp was also found to contain 0.41 mg/100 g

phytates, 0.07 mg/100 g oxalates and 2.73 mg/100 g saponins. Fruits of *D. microcarpum* were analyzed alongside 15 more wild fruits in Adamawa State by Umar et al. (2007),the results showed that the pulp contained 3.54% tannin which is higher than the value obtained in this study (0.17 mg/100 g). Umar et al. (2007) also reported the fruit to contain 13.50% oxalate, 2.13% phytate and 12.10% saponin. The results obtained by Obun et al. (2011), suggest that the seed contain a higher amount of anti-nutrients suggesting that the fruit pulp are better sources of nutrients as compared to the seed. The anti-nutrients contained in *D. microcarpum* fruit are lower than the established toxic levels; hence they can be consumed without restriction.

CONCLUSION AND RECOMMENDATIONS

In conclusion, the results of the study show that *D. microcarpum* may be a good source of carbohydrate, fibre, minerals, vitamin C, vitamin B_2, folic acid and could also contribute to the daily requirement of proteins and fats. *D. microcarpum* is a wild plant that has been endangered by bush burning. The potential of this fruit as a good source of nutrient should be made known to the public by nutrition agencies as this may discourage the felling and burning of *D. microcarpum* trees and also encourage consumption and planting of *D. microcarpum* trees like any other conventional fruit. The results also suggest that *D. microcarpum* contains an insignificant amount of commonly known anti-nutrients, hence the fruit is not toxic. More research should therefore be done on fatty acid profile, amino acid profile and vitamin content of the fruit pulp.

Conflict of Interests

The authors did not declare any conflict of interests.

REFERENCES

Abdalbasit A, Mohamed ESM, Ahmad BU (2009). Detarum microcarpum Guill and Perr fruit proximate chemical analysis and sensory characteristics of concentrated juice and jam. Afr. J. Biotechnol. 8(17):4217-4221.

Abdullahi SA, Abdullahi GM (2005). Effect of Boiling on the proximate composition of Raw *Delonix regia* seeds. Niger. Food J. 23:128-132.

Akpata MI, Miachi OE (2001) .Proximate composition and selected functional properties of *Detarium microcarpum*. Plant Foods Hum. Nutr. 57:297-302.

Allen SE, Grimshaw HE, Parkison JA, Quarmby C (1974).Chemical analysis of Ecological Materials. Blackwell Scientific Publications, London. pp. 67-89.

Anwhange BA, Ajibola VO, Oniye SJ (2004). Amino acid composition of seeds of *Moringa oleifera*(Lam) *Detarium microcarpum*(Guill and Sper) and *Bauhinia monandra* (Linn). ChemClass J. 9-13

AOAC (1980). Official Methods of Analysis (13th edition). Association of Analytical Chemists, Washington DC.

AOAC (1990). Official Methods of Analysis (15th edition). Association of Analytical Chemists, Washington DC.

Baumer M (1995). Nutrition and Dietics Health Care 9th edition Churchill Livingstone, New York. 92-100.

Conn EE (1979). Cyanide and cyanogenic glycosides. In : Herbivores : Their interaction with secondary metabolites. Rosenthal GA and Janzen, DH (eds.) Academic Press, New York. pp. 387 – 412.

Devlin TM (2006).Textbook of Biochemistry with Clinical Correlations.6th edition. John Wiley 7 sons, Inc, Publication. pp.1094-1116.

Ebi GC, Afieroho OE (2011).Phytochemical and antimicrobial studies of *Detarium microcarpum* Guill and Sperr (*Caesalpinioceae*) seeds coat. Afr. J. Biotechnol.10 (3):457-462.

Ehianeta T, Anyakora C, Mustapha B (2013). Heavy metals content in the stem bark of *Detarium microcarpum* determined by atomic absorption spectrophotometer. Afr. J. Biotechnol. 12(11):1236-1238.

Elemo BO ,Elemo GN, Oladimeji OO, Komolafe YO(2002). Studies on the composition of some nutrients and antinutrients of sheanut. Niger. Food. J. 20:69-73.

Eromosele JN, Eromosele CO, Akintoye AO, Komolafe TO (1994).Characterisation of Oils and Chemical analysis of the seeds of wild plants. Plant Foods Hum. Nutr. 46:361-365

Hudson BJ, El- Difrawi EA (1979). The Sapogenins of seeds of four lupins species. J. Plant Foods 3:181-186.

Igbadul BD, Idukwu HO, Inyang CU (2012).Effect of fermentation on some functional properties of Mucuna sloanei and *Detarium microcarpum*. J. Food Technol. 10(3):83- 86.

Kaufmann RC, Cutler JC (2008). Environmental Science. Mc Graw Hill. ISBN 978-0-07-298429-5.318-319

Kouyate AM, Van Damme P (2006).*Detarium microcarpum* Guill and Perr In: Schmelzer, G.H. and Gurib-fakin,A (Editors) Preta 11(1):Medicinal plants/*Plantes medicinates*.1.(CD-Rom) PROTA. Wageningen, Netherlands.

Lako J, Trenerry VC, Wanlquist M, Wattanapenpaiboon N, Sotheswaran S, Premier R (2007). Phytochemical flavonols, carotenoid and antioxidant properties of wide selection of Fijian fruits, vegetables and other readily available foods. Food Chem.101:1727-1741.

Linder MC (1991).Nutritional Biochemistry and Metabolism with Clinical applications. 2nd edition.Aplleton and Lange. pp. 215-269.

Nartey F (1980). Toxicological aspects of cyanogenesis in tropical foodstuffs. In: Toxicology in the tropics. Smith RL and Bababumni EA. Taylor and Francis Ltd, London. pp. 53-73.

National Academy of Science (1993). Tropical Legumes. Resource for the future. 5-85.

Nielsen SS (2002). Introduction to chemical analysis of foods. CBS Publishers 4596/1-A Daryagani, New Delhi 110 032 (India). pp. 95-115.

Obun CO, Yahaya MS, Kibon A, Ukim C (2011). Effect of dietary inclusion of raw *Detarium microcarpum* seed meal on the performance and carcass and organ weights of broiler chicks. Am. J. Food Nutr. 1(3):128-135.

Ogundun NJ (2006). Appraisal of Major Minerals in blood serum of goats fed *Detarium microcarpum* fruits and *Panicum maximum* hay. Proc 11th annual conference of animal science association of Nigeria.18-24th Sept 2006.Ibadan, Nigeria .114-116.

Olafedehan OA, Obun CO, Yahaya SM, Kibon AA, Alison SD (2010). Evaluation of Detarium microcarpum pulp meal as feed ingredient in rabbits diets. Electronic J. Environ. Agric. Food Chem. 1579-4377.

Olaofe AU, Offiong UE (1988).Mineral contents of agricultural products. Food Chem. 30:73-77.

Onwuka GI (2005). Food analysis and Instrumentation theory and practice.1st edition, Napththali prints, Nigeria. pp. 64-145.

Osagie AU, Effiong (1998). Nutritional Quality of Plant foods. AmBIK press. 53-274.

Reddy NR, Sathe SK, Salurikhke DK.(1982).Phytates in legumes and cereals. Adv. Food Res. 28:1-92.

Rosling H (1987). Cassava toxicity and food security. Tryck Kontakt, Uppsala.

Sadik N (1991). Population growth and food crises. Nutr. Agric.1:3-6

Sena LP, Vanderjagt C ,Rivera AT, Mahamadu O,Millson M, Pastuszym A, Glew RH(1998). Analysis of nutritional components of eight famine foods of Republic of Niger. Plant Food Hum Nutri. 52(1):17-30.

Swaminathan MS, Jain HK (1973).Food legumes in Indian Agriculture.

In: Nutritional improvement of food legumes by breeding. Protein Advisory Group, United Nations. New York. pp. 69-82.

Umar KJ, Hassan LG, Ado Y (2007). Mineral composition of *Detarium microcarpum* grown in kwatarkwashi, Zamfara State, Nigeria. Int. J. Pure Appl. Sci. 1(2):43-48.
Vahouny GV, Kritchevsky D (1986).Dietary Fibre: Basic and Clinical Aspects. Plenum Press, New York.
Vasudevan DM, Sreekumari S (2007).Textbook of Biochemistry for Medical Students. Jaypee Brothers Publisher Ltd. New Delhi. pp. 313-329
Vautier H, Sanon M, Moctar S (2007). *Detarium microcarpum* Guill and Perr. Seed leaflet No. 122.
Wahedi JA, David LD (2013). Effect of *Detarium microcarpum fruit pulp* on haematological indices of rats in Mubi, Adamawa State, Nigeria. GJBAHS 2(3):76-80
Wilson ED (1979). Principles of Nutrition,John Wiley and Sons, New York. pp. 44-99.