

Evaluation of the Phytonutrients, Mineral and Vitamin Contents of Some Varieties of Yam (*Dioscorea* sp.)

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Abstract: The phytonutrients, vitamins and mineral contents of seven varieties of yams (*Dioscorea* sp.) were investigated. All the species studied were found to contain bioactive compounds comprising saponins (2.98-19.46 mg 100⁻¹ g), alkaloids (0.38-1.68 mg 100⁻¹ g), flavonoids (1.10-9.94 mg 100⁻¹ g), tannins (4.4x10⁻²-9.0x10⁻² mg 100⁻¹ g) and phenols (2.4x10⁻³-5.0x10⁻³ mg 100⁻¹ g). These yams contained vitamins such as ascorbic acid, niacin, riboflavin and thiamin. Appreciable quantities of calcium, magnesium, phosphorus, potassium and sodium were detected in the tubers. The importance of these chemical constituents is discussed with respect to the role of these *Dioscorea* species in herbal medicine in Nigeria.

Key words: *Dioscorea* sp., bioactive compounds, vitamins, minerals, herbal medicine

INTRODUCTION

The yams (*Dioscorea* sp.) are the most important tuber crops in West Africa. They are among the root and tuber crops, which are widely distributed through out the tropics with only a few members in the temperate regions of the world^[1,2].

Yams are grown in the tropical region and consumed as primary, secondary or supplementary staple. Yams can be eaten boiled, roasted, baked or fried. The tubers are used as livestock feed, while man consumes livestock products. Yam starch or flour is incorporated by food industries into food products for human consumption. Yam tuber may be dried, ground into flour and stored for use. The flour can be moistened, molded, boiled and then pounded into fufu and eaten with soup. Yam flour (from *Dioscorea*) is definitely preferred to the cassava analogue and have been mechanized and commercialized in tropical African countries^[3]. It is however considered uneconomical to feed yam to livestock but yam peels, which are often discarded is of great value as animal feed^[1].

Apart from food, yams are mainly used for medicinal purposes for the sapogenins, aglycons of yam saponins are important mainly because of their steroid structure. They are precursors for the hemisynthesis of birth control pills (with progesterone and estrogen) as well as similar hormones and corticosteroids^[4].

In Nigeria, some yam species are used in herbal medicine for the treatment of infertility in man^[5].

Yams like higher plants have a complex phytochemical profile. The most predominant

phytochemical characteristic of yam is the presence of dioscorine alkaloid and diosgenin saponin. Although dioscorine and diosgenin are traditionally considered toxic, such toxicity is removed by washing, boiling and cooking^[1].

Some yam cultivars cannot be eaten raw because of itchiness, bitterness or toxicity of the raw tuber. The bitterness or acute toxicity in yams may be due to its alkaloid content while the saponins and sapogenins may constitute the pharmaceutical agent. The pigments found in certain yams may be due to the presence of flavonoids and carotanooids.

This study investigates the fundamental scientific basis for the use of *Dioscorea alata*, *Dioscorea cayenensis*, *Dioscorea bulbifera*, *Dioscorea rotundata* and *Dioscorea dumetorum* in herbal medicine. The contents of phytonutrients, vitamins and minerals present in the *Dioscorea* species were determined.

MATERIALS AND METHOD

Collection of plant materials: The yam varieties were collected from the Root and Tuber Section of the National Root Crop Research Institute Umudike Abia State, Nigeria except *Dioscorea cayenensis* that was purchased from Ndioru Market, in Ikwuano Local Government Area of Abia State, Nigeria.

Sample preparation: The yam tubers were peeled, washed and sun-dried for four days. After drying, the samples were ground into powder and stored in airtight bottles before analysis.

Chemical analysis: The major elements comprising calcium, phosphorus, sodium, potassium and magnesium were determined according to the method of Shahidi *et al.*,^[6]. The ground plant samples were sieved with a 2 mm rubber sieve and 2 g of each of the plant samples were weighed and subjected to dry ashing in a well-cleaned porcelain crucible at 550°C in a muffle furnace. The resultant ash was dissolved in 5 mL of HNO₃/HCl/H₂O (1:2:3) and heated gently on a hot plate until brown fumes disappeared. 5 mL of deionized water was added to the remaining material in each crucible and heated until a colorless solution was obtained. The mineral solution in each crucible was transferred into a 100 mL volumetric flask by filtration through a Whatman No 42 filter paper and the volume was made to the mark with deionized water. This solution was used for elemental analysis by atomic absorption spectrophotometer. A 10cm-long cell was used and content in the sample was calculated on percentage of dry matter.

Phosphorus content of the digest was determined colorimetrically according to the method described by^[7] 0.5 mL of the dilute digest, 4 mL of demineralised water, 3 mL of 0.75M H₂SO₄, 0.4 mL of 10% (NH₄)₆ Mo₇O₂₄, 4H₂O and 0.4 mL of 2% (w/v) ascorbic acid were added and mixed. The solution was allowed to stand for 20 min and absorbance readings were recorded at 660 nm. The content of phosphorus in the extract was determined.

Preparation of fat free sample: 2 g of the plant sample were defatted with 100 mL of diethyl ether using a soxhlet apparatus for 2hrs.

Saponin determination: The samples were ground. 20g of each plant samples were dispersed in 200 mL of 20% ethanol. The suspension was heated over a hot water bath for 4 hrs with continuous stirring at about 55°C. The mixture was filtered and the residue re-extracted with another 200 mL of 20% ethanol. The combined extracts were reduced to 40 mL over water bath at about 90°C. The concentrate was transferred into a 250 mL separator funnel and 20 mL of diethyl ether was added and shaken vigorously. The aqueous layer was recovered while the ether layer was discarded. The purification process was repeated. 60 mL of n-butanol extracts were washed twice with 10 mL of 5% aqueous sodium chloride. The remaining solution was heated in a water bath. After evaporation the sample were dried in the oven into a constant weight. The saponin content was calculated in percentage^[7].

Alkaloid determination: 5 g of the sample were weighed into a 250 mL beaker and 200 mL of 20% acetic acid in ethanol was added and covered to stand for 4 h. This was

filtered and the extract was concentrated using a water bath to one-quarter of the original volume. Concentrated ammonium hydroxide was added drop wise to the extract until the precipitation was complete. The whole solution was allowed to settle and the precipitation was collected by filtration and weighed^[8,9].

Determination of total phenols: For the extraction of the phenolic component, the fat free sample was boiled with a 50 mL of ether for 14 min. 5 mL of the extract was pipette into a 50 mL flask, then 10 mL of distilled water was added. 2 mL of ammonium hydroxide solution and 5 mL of concentrated amyl alcohol were also added. The samples were made up to mark and left to react for 30 min for colour development. The absorbance of the solution was read using a spectrophotometer at 505 nm wavelengths^[8,9].

Tannin determination: 500 mg of the sample was weighed into 100 mL plastics bottle, 50 mL of distilled water was added and shaken for 1hr in a mechanical shaker. This was filtered into a 50 mL volumetric flask and made up to the mark. Then 5 mL of the filtrate was pipette out into a tube and mixed with 3 mL of 0.1M FeCl₃ in 0.1N HCl and 0.008M potassium ferrocyanide. The absorbance was measured in a spectrophotometer at 120 nm wavelengths within 10 min. A blank sample was prepared and the colour also developed and read at the same wavelength. A standard was prepared using tannin acid to get 100 ppm and measured^[10].

Flavonoid determination: 10 g of the plant samples were extracted repeatedly with 100 mL of 80% aqueous methanol at room temperature. The whole solution was filtered through Whatman filter paper No. 42 (125 mm). The filtrate was later transferred into a crucible and evaporated to dryness over a water bath and weighed^[11].

Determination of thiamin: 50 g of the sample were homogenized with ethanolic sodium hydroxide (50 mL). It was filtered into a 100 mL flask. 10 mL of the filtrate was pipette and the color developed by addition of 10 mL of potassium dichromate and read at 360 nm. A blank sample was prepared and the colour also developed and read at the sample wavelength.

Determination of niacin: 5 g of the sample was treated with 50 mL of 1N sulphuric acid and shaken for 30 min. 3 drops of ammonia solution were added to the sample and filtered. 10 mL of the filtrate was pipette into a 50 mL volumetric flask and 5 v potassium cyanide was added. This was acidified with 5 mL of 0.02N H₂SO₄ and absorbance measured in the spectrophotometer at 470 nm wavelengths.

Determination of riboflavin: 5 g of the sample was extracted with 100 mL of 50% ethanol solution and shaken for 1h. This was filtered into a 100 mL flask. 10 mL of the extract was pipette into 50 mL volumetric flask. 10 mL of 5% potassium permanganate and 10 mL of 30% H₂O₂ were added and allowed to stand over a hot water bath for about 30 min. 2 mL of 40% sodium sulphate was added. This was made up to 50 mL mark and the absorbance measured at 510 nm in a spectrophotometer.

Determination of ascorbic acid (vitamin C): 5 g of the sample was weighed into an extracted tube and 100 mL of EDTA/TCA (2:1) extracting solution were mixed and the mixture shaken for 30 min. This was transferred into a centrifuge tube and centrifuged at 3000 rpm for about 20 min. It was transferred into a 100 mL volumetric flask and made up to 100 mL mark with the extracting solution. 20 mL of the extract was pipette into a volumetric flask and 1% starch indicator was added. These were added and titrated with 20% CuSO₄ solution to get a dark end point^[12].

RESULTS AND DISCUSSION

The phytonutrient content of the various yam species are shown in Table 1. The saponin and alkaloid content are considered important due to their toxicity in yams. These toxic metabolites occur in varying concentrations in yam tubers. *D. rotundata* hybrid (TDr 95/18922) have the highest saponin content of 19.46 mg 100⁻¹g, followed by *D. Cayensis* which have 16.48 mg 100⁻¹g of saponin while *D. dumentorum* contained 14.76 mg 100⁻¹g of saponin. *D. alata* hybrid (TDa 117) have the least quantity of saponin (2.98 mg 100⁻¹ g).

A good amount of alkaloids were found in the *Dioscorea* species apart from saponins. *D. dumentorum* had the largest amount of alkaloids with 1.68 mg 100⁻¹g. This was followed by local *D. alata* (0.92 mg 100⁻¹g) while *D. bulbifera* had 0.88 mg 100⁻¹g of alkaloid.

Large deposits of alkaloids were also present in *D. cayensis*, *D. rotundata* (hybrid) and *D. rotundata* (local) containing 0.68 mg 100⁻¹g, 0.48 mg 100⁻¹g and 0.38 mg 100⁻¹g of alkaloids, respectively. Other phytonutrients important in the pharmacological characteristics relating to yams include the flavonoids. They were found in good quantities in the tubers. Flavonoids were more in *D. dumentorum* (9.94 mg 100⁻¹ g) followed by *D. bulbifera* (8.04 mg 100⁻¹ g), while *D. rotundata* (hybrid) and *D. cayensis* contained 6.50 mg 100⁻¹g and 5.76 mg 100⁻¹ g of flavonoid respectively. Tannins and phenolic compounds are in smaller quantities than other phytonutrients determined in the yam tubers.

Table 2 shows the vitamin constituents of the *Dioscorea* sp. The tubers are relatively rich in ascorbic acid, niacin, riboflavin and thiamins. *D. dumentorum* and *D. bulbifera* contained the largest quantity of ascorbic acid with 1.93 mg 100⁻¹ g and 1.67 mg 100⁻¹ g, respectively, *D. alata* both local and hybrid contained 0.70 mg 100⁻¹g and 0.44 mg 100⁻¹g of ascorbic acid.

Table 3 shows the mineral composition of the yam tubers. They are rich in calcium, potassium and magnesium, *D. dumentorum* have the highest calcium content (2.41 mg 100⁻¹g), followed by *D. alata* (local) and hybrid of *D. rotundata* which, respectively contain 2.0 mg 100⁻¹g of calcium. The local *D. rotundata* have the lowest calcium content of 1.20 mg 100⁻¹ g.

Yams, particularly *D. Dumentorum* and *D. cayensis* have been well respected by the herbalist community for generations due to their potency in enhancing fertility in males. This may be due to the presence of steroidal saponins such as diosgenin, which have been isolated from yams^[4,13]. Diosgenin from yams have been used as precursors for the synthesis of hormones and corticosteroids which improves fertility in males^[4,13]. It should be noted that toxic saponins are removed by washing the tubers before consumption^[1].

Some of the general properties of saponins include formation of foams in aqueous solution, hemolytic activity and cholesterol binding properties and bitterness^[14]. Saponins natural tendency to ward off microbes makes them good candidates for treating fungal and yeast infections. These compounds served as natural antibiotics, which help the body to fight infections and microbial invasion^[14]. These compounds also appear to greatly enhance the effectiveness of certain vaccines. Plant saponins help humans to fight fungal infections, combat microbes and viruses, boost the effectiveness of certain vaccines and knock out some kinds of tumor cells, particularly lung and blood cancers^[12]. They also lower blood cholesterol thereby reducing heart disease. The most outstanding and exciting prospects for saponins are how they inhibit or kill cancer cells. They may also be able to do it without destroying normal cells on the process, as is the mode of some cancer fighting drugs. Cancer cells have a more cholesterol-type compounds on their membranes than normal cells. Saponin therefore bind cholesterol and thus interfere with cell growth and division^[16].

Alkaloids in *Dioscorea* sp. have been reported to contain dihydrodioscorine^[13]. This compound is a convulsant alkaloid and it causes central nervous system paralysis in animals^[13]. An extract of dihydrodioscorine produces a long lasting hypotension and contraction of the smooth muscle fibers of the intestine both *in vivo* and

Table 1: Phytochemical composition of different varieties of *Dioscorea species* on dry weight basis (mg 100g⁻¹)

<i>Dioscorea</i> sp.	Common name	Saponins	Flavonoids	Alkaloids	Phenol	Tannin
<i>D. alata</i> TDa 1176	Water yam	2.98± 0.0	1.10±0.30	0.74±0.10	0.00±0.10	0.044±0.10
<i>D. cayenensis</i>	Yellow yam	16.48±0.10	5.78±0.11	0.68±0.02	0.0024±0.11	0.0047±0.20
<i>D. bulbifera</i>	Aerial yam	14.88±0.10	8.04±0.20	0.88±0.11	0.004±0.10	0.08±0.10
<i>D. rotundata</i> TDr 95/18922	White yam	19.46±0.20	6.50±0.02	0.48±0.20	0.005±0.20	0.004±0.10
<i>D. dumentorum</i>	Bitter yam	14.78±0.11	9.94±0.10	1.68±0.01	0.003±0.10	0.09±0.20
<i>D. rotundata</i> (local)	White yam	2.90±0.01	3.10±0.11	0.38±0.12	0.005±0.22	0.05±0.10
<i>D. alata</i> local	Water yam	7.78±0.20	1.78±0.20	0.29±0.02	0.005±0.11	0.06±0.20

Results are means of five determinations on dry weight basis±standard deviation

Table 2: Vitamin content of different varieties of *Dioscorea species* on dry weight basis (mg/100g⁻¹)

<i>Dioscorea</i> species	Common name	Ascorbic acid	Niacin	Riboflavin	Thiamin
<i>D. alata</i> TDa 1176	Water yam	0.44±0.10	0.03±0.20	0.008±0.10	0.008±0.20
<i>D. cayenensis</i>	Yellow yam	1.23±0.11	0.13±0.21	0.004±0.11	0.007±0.10
<i>D. bulbifera</i>	Aerial yam	1.67±0.22	0.01±0.2	0.009±0.12	0.009±0.20
<i>D. rotundata</i> TDr 95/18922	White yam	1.10±0.10	0.31±0.12	0.009±0.20	0.01±0.20
<i>D. dumentorum</i>	Bitter yam	1.93±0.20	0.01±0.10	0.011±0.2	0.009±0.11
<i>D. rotundata</i> (local)	White yam	0.97±0.11	0.03±0.21	0.006±0.11	0.008±0.10
<i>D. alata</i> Um 680	Water yam	0.70±0.11	0.04±0.12	0.006±0.10	0.009±0.11

Results are means of five determinations on dry weight basis±standard deviation

Table 3: Mineral content of different varieties of *Dioscorea species* on dry weight basis (mg 100g⁻¹)

<i>Dioscorea</i> species	Common name	Magnesium	Calcium	Potassium	Sodium	Phosphorus
<i>D. alata</i> Tda 1176	Water yam	0.49±0.12	1.80±0.10	0.50±0.20	0.18±0.11	0.28±0.10
<i>D. cayenensis</i>	Yellow yam	0.73±0.20	1.60±0.11	0.75±0.10	0.19±0.11	0.29±0.20
<i>D. bulbifera</i>	Aerial yam	0.85±0.21	1.80±0.20	1.00±0.11	0.22±0.11	0.36±0.10
<i>D. rotundata</i> TDr 95/18922	White yam	0.49±0.11	2.00±0.11	0.60±0.20	0.24±0.10	0.17±0.21
<i>D. dumentorum</i>	Bitter yam	0.85±0.10	2.41±0.10	0.85±0.20	0.14±0.10	0.26±0.20
<i>D. rotundata</i> (local)	White yam	0.85±0.20	1.20±0.11	0.39±0.10	0.14±0.11	0.20±0.10
<i>D. alata</i> local	Water yam	1.10±0.11	2.00±0.10	0.66±0.20	0.18±0.10	0.16±0.11

Results are means of five determinations on dry weight basis±standard deviation

in vitro when administered to animals^[13]. This explains the reason behind the use of *Dioscorea* species for the preparation of poison bait for fishing, hunting and preparation of insecticides.

The availability of alkaloids in the tubers of *Dioscorea* species indicates that yam tubers cannot be eaten raw. This is because raw yams causes itchiness and the compound isolated from *D. dumentorum* is toxic to man, as it has caused the death of some people during famine in Sudan after they had eaten it^[13]. Despite their convulsant and nerve poison activities; they can be of use to the pharmaceutical industries in the production of drugs due to the analgesic effects of alkaloids. However, the high content of alkaloids in *D. dumentorum* lends credibility to the reports of toxicities associated with its use^[1]. This variety of yam tuber is therefore thoroughly cooked before consumption.

Flavonoids are widely distributed group of polyphenolic compounds, characterized by a common benzopyrone ring structure, that have been reported to act as antioxidants in various biological systems. The biological functions of flavonoids apart from its antioxidant properties include protection against allergies, inflammation, free radicals, platelet aggregation, microbes, ulcers, hepatoxins, viruses and tumors^[17,19]. Flavonoids reduced cancers by interfering with the enzymes that

produce estrogen, for example flavonoids inhibits estrogen synthetase, an enzyme that binds estrogen to receptors in several organs^[19,20]. Some flavonoids behave as a powerful protective agent against inflammatory disorders. They reduce edema formation and prevent platelet stickiness and hence platelet aggregation.

The trace quantities of phenolic compounds help to prevent the death of the crop; since phenolic compounds from plant extracts act as anti-microbial agent^[21]. In some species of yam tubers, browning reactions occur when the tissues are injured and exposed to air. This type of browning is due to the oxidation of phenolic constituents, especially o-hydroxy or trihydroxy phenolics, by a phenol oxidase present in the tissue^[22]. The presence of phenols^[20] indicates that *Dioscorea* species could act as anti-inflammatory, anti-clotting, antioxidant, immune enhancers and hormone modulators^[19].

The bitter principle of *D. dumentorum* and *D. bulbifera* may be due to the presence of tannins in them. The trace quantities of tannin available in yam tubers act as a repellent against rots in yams.

Ascorbic acid activates the functions of all the cells. It is powerful antioxidants. It favors the absorption of iron in the intestine, protects against infections, neutralizes blood toxins and intervenes in the healing of wounds^[23]. In the process of washing, cooking

and pounding, a large amount of the vitamins, minerals and phytonutrients are lost.

It is significant to note that *Dioscorea species*, which have been, regarded as non-edible food by people as a result of culture, religion, belief from folk stories or due to chemical constituents of such yams have been observed from this study to be edible. These yams not only contain vitamins and minerals but also phytonutrients that help to fight against most diseases of man.

Dioscorea species contains important nutritive, health promoting substances, which prompted their use as food and drug in herbal medicine.

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