PROXIMATE AND MINERAL COMPOSITION OF SELECTED YAM CULTIVARS GROWN IN GHANA

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ABSTRACT

This study evaluated the proximate and mineral composition of 23 yam cultivars (*Dioscorea spp*). The samples were bought from Konkomba yam market, Makola, Madina and Malamata markets all based in Accra in the Greater Accra region of Ghana. The following parameters were determined for each cultivar: moisture, fat, protein, ash, crude fiber, starch, carbohydrate, energy, phosphorus, calcium and iron. The samples were found to be sources of carbohydrate and energy but very poor source of fat. The samples were also found to have high crude fibre (1.83-2.24 g/100g) and calcium (6.30-30.50 mg/100g) contents. Compositions were in the following ranges: moisture (50.20-72.0 g/100g); ash (0.90-1.60 g/100g); fat (0.16-0.31 g/100g); protein (1.60-4.20 g/100g); starch (6.00-26.1 g/100g); iron (0.50-1.30 mg/100g) and phosphorous (3.70-29.20 mg/100g).

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1.0 INTRODUCTION

Yams, *Dioscorea* genus are Angiosperms or flowering plants and are monocotyledons (Norman *et al.*, 1984). There are about 600 species and have an annual life cycle which is characterized by five phases. The cycle starts with sprouting of the dormant tuber. The function of the tubers is to store food reserves mainly carbohydrates to ensure continuity in the life cycle of the plant. The growth of the new plant leads to the development of a rhizome or tuber from which stems and roots emerge. Expansion of the new tuber is accumulation of starch reserves. The stem climbs by twining, carry petiolate leaves and dioeceois flowers. The fruit develops from the flowers in the form of trilocular capsules. Maturity of the tuber is characterized by the death of the plant shortly after which the tuber goes into a dormant state.

Yam is the most popular staple food that cuts across the whole of West Africa. The many cultivars of the *Dioscorea Cayenensis - Dioscorea rotuncla complere* are among the relatively few truly West African domesticated plants. Yams are also used as food in Asia, Oceania, and other parts of Africa, America and beyond. Yams are the most nourishing plant in the diet of many inhabitants of inter-tropical regions. It provides 18 million tons of food a year to the people of West Africa.

Within the tropics, species of *Dioscorea* are found everywhere that the rainfall pattern can support their growth. The edible yams are provided by ten *Dioscorea* species namely; *D. Rotunduta* Poir, *D. Capenensis* Lam, *D. Dumetorum* Pax, *D. Hispida* Dennst, *D Alata* L., *D. Esculante (Lour)* Burk, *D. Bulbifera* L., *D. Opposita* Thunb, *D. Japonica* Thunb., and *D. Trifida* L. (Coursey, 1967). Of the inedible yams, seven species are used for making drugs.

The great importance of yam civilization in West Africa and parts of Asia is indicated by the number and importance of cultural and superstitious practices associated with the cultivation of the crop. In Ghana, Yam Festivals cut across almost all the ethnic and cultural groups in the country.

Dioscorea have been neglected for a long time despite the economic role yams play in the lives of many. Yams have been the object of isolated research work. However interest in research work sparked out about 20 to 25 years ago due to the discovery of species containing steroids which rendered them valuable for the hemi-synthetic production of sex hormones and anti-inflammatory medicines.

1.1 MAIN OBJECTIVE

The present study was undertaken to investigate the nutritional composition of yam cultivars widely grown and utilized in Ghana.

1.2 SPECIFIC OBJECTIVES

The specific objectives of the study are to:

i. determine the proximate composition (moisture, ash, fat, protein and crude fibre), starch, carbohydrate and energy contents of the yam varieties under study.

ii. iron, phosphorus and calcium content of the yam varieties under investigation.

2.0 LITERATURE REVIEW

2.1 COMPOSITION OF YAM

The food value of yam is based on the composition of the cultivars. This includes carbohydrates, proteins, amino acids, vitamins and minerals. The amounts of lipids are negligible in terms of food value. The distribution of assimilating (starch, sugars) or non-assimilating (Cellulose and Hemicelluloses) carbohydrates varies from one extremity of the tuber to another.

Starch contains 50% - 80% of the dry matter and this is distributed heterogeneously throughout the tuber. The yam starch contains mainly amylose and amylopectin and these improve with age of the tuber. The amylose content is related to the granular morphology. Other carbohydrate related components like heterisicles have a direct major effect on the food value, either in the taste or colour.

Protein content of yam is about 1% of the dry matter content. The ash content of yam makes it rich in minerals. The amount varies but the variations are considerable. Yam has relatively high quantity of ascorbic acid. The amount in *D. Alata* and *D. Cayenensis roendata* ranges from 4 to 12 mg per 100g. Vitamin B is also present. Canotenoids are the source of the yellow coloring of *D. Cayenensis*, *D.Bulbifera* (partially) and probably *D. Dometorum* and *D. hispida* tubers. Martin and Ruberte (1975) found between 0.4 –1.4mg /100g of ß-Carotene (Provitamin A) and *D. Cayenensis*.

2.2 OTHER CONSTITUENTS

Tannins may contribute to the acidity and typical bitterness of *D. Cayenensis* Rotundata.

Sugars make up between 2 and 15 % of the dry matter content of a few species including *D. Trifida* and *D. Esculanta*. Some have been found to contain rhamnose, galactose, arabinose and xylose (Bouret, 1973).

However the sugar most commonly found are malose, glucose, fructose and sucrose. Bitter substances can have an effect on the tubers acceptability depending on the amount. The bitterness of *D. Cayenensis* Rotandata varies to some degree and is more acute in cultivars with yellow flesh. It is caused by a Leucoanthocyanachine (Martin, Roberts, 1975). The bitterness and toxicity of many species may be caused by high levels of Sapoins.

2.3 MEDICINAL VALUE

Dioscoria opposita is in the Chinese medical manual of the Shen-Nung and Shan-Hai-King Empire's in about 2700 BC. Diosgenin, the main Sapogenin, Aglycons of yam Saponins is the predominate source for the Hemi synthesis of birth control pills (with Progesterone and Oestrogen as well as similar Hormones) and Corticosteroids (Crabbe, 1979).

2.4 TRADITIONAL USES AND TECHNOLOGIES

Yam is source of food for mankind since time immemorial. In the Philippines cultivars of *D. alata* with violet tubers have been used to produce ice- cream. The toxic properties of some yams are used as insecticides. The toxic properties of the *D. piscatonem* are used to protect rice in Malaysia. *D. deltoidca* is used for producing anti-lice shampoos in India. It is also used in

medication cases of dermatology, gastroenterology and traditional human and veterinary gynecology in Asia, Africa and the America's (Coursey, 1967).

The presence of tannins account for the impatrecibility of certain cultivars, this is manifested in the fibers and skin which are used in making handicrafts in South East Asia. In Guyana, cultivars whose tubers contain anthocyanins are used to prepare the beer Kala (*D. trifida)* or the Wayapi Kalali (Grenand, 1980). In the Philippines, the most popular preparation is ice- cream, jellies and yam based candies (Brown, 1951). The toxicity of some wild species of yam that renders their consumption as food hazardous has been put to use in the manufacturing of poisons for hunting or for criminal purposes. The Zulus of South Africa use *D. dumetorum* and *D. dregeana* mixed with bait for catching monkeys which are stupefied by eating the yam.

The *D. hispida* has been used as tiger poison by certain tribes in the Himalaya and as a fish and food poison in Indonesia and various parts of Africa. It is used in Asia and Africa for the preparation of arrow poisons (Prain and Burkill, 1936; Corkill, 1948; Watt and Breyer-Brandwijk, 1962; Chevalier, 1947 and Cheney, 1931).

3.0 MATERIALS AND METHODS

3.1 MATERIALS

Twenty three locally cultivated yam cultivars were bought from retailers in Accra. These were in their local names:

- Kangbringa
- Baayeri
- Manchisi
- Nyuwogu
- Gun-Gonsanli
- Fugla
- Chama
- Friginli
- Chenchito Sabinli
- Kpuringa
- Baanyegu
- Dakpaan
- Mogni- Nyuga
- Kpuno
- Dangba
- Bonbe- Tingye
- Zongo
- Labrako

- Ghenchito
- KuKulga
- Zuglangbo
- Kiki
- Geonyeni

They were thoroughly cleaned to remove dirt, peeled, sampled and crushed into paste with a laboratory motor and pestle. The sample paste was then packed into sample containers and analysis performed either immediately or samples were stored in the freezer at a temperature of -18 ^{o}C for later analysis.

3.2 METHODS

3.2.1 Moisture

Moisture contents of the samples were determined using the Air-Oven method (AOAC, 1990). Moisture dishes were dried in the moisture oven and allowed to cool to room temperature in a desiccator. These were weighed soon after reaching room temperature.

About 3.0 g of well-mixed test sample was weighed using an analytical balance in the pre-weighed moisture dishes. The dishes with content were dried for 4 hours in the moisture oven maintained at 103 ± 2°C. (4 hrs drying period began when oven temperature was actually 103 ± 2°C). The dishes with contents were transferred to the

desiccator to cool. The weights were taking soon after reaching room temperature. The loss in weight was reported as moisture.

Calculations:

$$\text{Moisture (\%w/w)} = \frac{[(\text{wt of dish + fresh sample}) - (\text{wt of dish + dried sample})]}{[(\text{wt of dish + fresh sample}) - (\text{wt of dish})]} \times 100$$

3.2.2 Ash

Ash contents of the samples were determined using the dry ashing method (AOAC, 2000). The crucibles were placed in the muffle furnace (Carbolite Bamfohd, England) and ignited at 550 $\pm$ 10°C for 20 minutes and cooled in a desiccator to room temperature. About 3 g of well-mixed test portion was weighed into the pre-heated crucibles. The muffle furnace was ignited at about 550°C for 8 hrs. The furnace was allowed to drop to at least 250°C and the crucible removed into a desiccator. Weight was taken soon after reaching room temperature (wt after ashing)

Calculations:

$$\%\text{Ash} = \frac{(\text{wt of crucible after incineration}) - (\text{wt of empty crucible})}{(\text{wt of crucible and sample}) - (\text{wt of empty crucible})} \times 100$$

3.2.3 Fat

The fat content of the samples were determined using the Soxhlet method (AOAC, 2000). About 3.0 g dried well-mixed test sample was weighed onto a filter paper, folded and placed into extraction thimbles and stuffed with grease-free cotton. Empty round-bottomed flasks were dried, cooled and weighed before extraction. The thimbles were placed in the extraction chamber of the soxhlet apparatus and 240 ml petroleum ether was measured into the pre-weighed round-bottomed boiling flask. Extraction was carried out for 12 hours at a condensation rate of 5 – 6 drops /s. The solvent was evaporated and distilled off. The flasks with the extracted fat were dried in the oven at 103 ± 2°C for 1 hour, cooled and weighed. A blank was carried out using the same procedure but without samples.

Calculations:

$$\%\text{Fat} = \frac{[(\text{wt of flask + fat} - \text{wt of empty flask}) - \text{Blank}]}{\text{wt of sample}} \times 100$$

Blank = wt of flask without sample after extraction – wt of empty flask

3.2.4 Protein

Protein content of the samples were determined using the Kjedahl method. Based on the A.O.A.C. 984.13 (2000) Kjedahl procedure, the method follows the application

notes for the determination of nitrogen using the Tecator Kjeltec Systems (Copyright 2000 Foss Tecator AB). Determinations were done in duplicates.

3.2.5 Crude fibre

Samples were assessed for their crude fibre levels according to Pearson (1990). The weight of sample was taken between 2.7 to 3.0g. The samples were defatted through extraction with petroleum spirit by stirring, settling and decanting three times. They were then air dried and transferred to a 1000ml conical flask. 200ml 0.255N Sulfuric Acid measured at ordinary temperature was added and brought to boiling point. Boiling was done for exactly 30 minutes in order to mix the contents and remove particles from the sides.

A circular piece filter paper was placed in a Buchner funnel and boiling water poured onto it to cover the holes in the funnel. The hot water was drained by applying suction. After boiling for 30 minutes, the acid mixture was allowed to stand for one minute and then poured immediately into a shallow layer of hot water under gentle suction in the prepared funnel. Filtration of the bulk of the 200ml was completed within 10 minutes.

The insoluble matter was washed with boiling water until the washings are free from acid and then washed back into the original flask by means of a wash bottle containing 200ml 0.313N Sodium Hydroxide solution measured at ordinary temperature and brought to boiling point. The mixture was boiled for 30 minutes with the same precautions as those used in the earlier boiling and treatment. It was filtered immediately

through a pre-weighed ashless filter paper and washed first with boiling water; then with 1% hydrochloric acid, and finally with boiling water until free from acid. The filter paper was then washed twice with alcohol and then three times with ether. The ashless filter paper dried at 100°C to a constant weight.

The weight of the ashless filter paper and residue was weighed. The ashless filter paper and content were incinerate to an ash at a dull red heat

Calculation:

The weight of the ash is subtracted from the increase in weight on the paper due to the insoluble material, and report the difference as fibre.

$$\text{Crude fibre} = \frac{(\text{weight of paper + residue}) - (\text{weight of ash})}{\text{weight of sample}} \times 100$$

3.2.6 Carbohydrate and Energy

Carbohydrate content of the samples were obtained by difference while energy was calculated using the Atwater factor (Nielsen, 1998).

3.2.7 Minerals

Iron and phosphorous contents of the samples were determined by spectrophotometry while calcium was done by permanganate titration method (James, 1995). The ashes of the sample were dissolved in 5N HCl and filtered into 50 ml volumetric flasks. 10 ml of

this solution was taken and analyzed for Iron using 2.2-Bipyridyl Colorimetric method. For phosphorous, a volume of 1.0 ml of the ash solution was taken and analyzed for phosphorus using Fogg and Viking method.

4.0 RESULTS AND DISCUSSION

A summary of results from proximate analysis, energy and minerals is presented in Table 1. .Moisture levels varied from 50.20g/100 in *Chamba* to 72.0g/100g in *Mogni-Nyuga*. Moisture levels in yam varieties in Ghana have been documented to range from 58.5g/100g to 70.0g/100g (Eyeson and Ankrah, 1975). Fourteen out of the twenty three varieties studied had moisture levels outside this range with two varieties having values on the higher side. The differences seen in the moisture levels can be attributed to storage time and inter-varietal differences in the samples. The ash contents of the yam varieties were all within the literature values of 0.9-2.2g/100g according to Eyeson and Ankrah (1975). The lowest ash level was found in *Fugla* (0.90g/100g) while the highest was observed in *Zuglango, Zongo* and *Nyowugo* (1.60g/100g).

Yams are poor source of fat. The varieties had fat values ranging from 0.16g/100g in *Kagbringa* to 0.31g/100g in *Bayeeri*. The protein content of the yam varieties ranged from 1.60 - 4.20g/100g for *Machinsi* and *Kagbringa* respectively. The literature values of protein content of yams in Ghana (1.8-2.4g/100g) reflect the content of most of the varieties studied. But varieties like *Kukulga*, *Zuglango* and *Kagbringa* have values on the high side (≥4.0g/100g). Crude fiber levels in the samples (1.83-2.24g/100g) investigated were extremely high compared to the literature values (0.2-0.8g/100g). These varieties are, therefore, a better source of crude fibre. Starch content varied from 6.0g/100g for *Mogni-Nyuga* to 26.60g/100g in *Chamba*. These values are typical of starchy foods.

Table 1. Proximate and mineral composition of 23 cultivars of yam grown in Ghana

Cultivar	Carbohydrate (g/100g)	Energy (kcal/100g)	Moisture (g/100g)	Fat (g/100g)	Protein (g/100g)	Ash (g/100g)	Crude Fibre (g/100g)	Starch (g/100g)	Calcium (mg/100g)	Phosphorous (mg/100g)	Iron (mg/100g)
KANGBRINGA	34.44	156.00	57.80	0.16	4.20	1.20	2.2	14.30	11.10	12.30	1.10
BAAYERI	28.64	126.55	65.30	0.31	2.30	1.30	2.15	18.30	6.30	9.90	1.30
MANCHISI	23.28	101.86	71.90	0.26	1.60	1.00	1.96	13.60	16.50	20.40	1.10
NYUWOGU	26.08	117.90	67.10	0.22	2.90	1.60	2.10	10.90	21.00	31.10	1.00
GUN-GONSANLI	33.76	147.90	60.20	0.19	2.70	1.30	1.85	15.70	30.50	29.20	0.50
FUGLA	36.09	159.41	58.40	0.25	2.30	0.90	2.06	13.60	16.70	18.00	1.10
CHAMBA	43.22	187.75	50.20	0.23	3.20	1.00	2.15	26.60	20.70	26.40	1.10
FRIGINLI	22.89	103.94	70.80	0.22	2.60	1.50	1.99	10.50	7.10	9.60	0.50
CHENCHITO SABENLI	33.31	145.26	60.30	0.18	2.60	1.00	2.21	12.00	8.50	5.30	0.70
KPURINGA	38.81	164.24	56.10	0.20	1.80	1.20	1.89	13.50	25.80	6.60	0.50
BAANYEGU	28.70	125.93	65.20	0.17	2.40	1.30	2.23	18.30	6.30	9.90	1.30
DAKPAAN	37.11	159.71	57.00	0.23	2.30	1.20	2.16	11.40	17.00	6.00	0.80
MOGNI - NYUGA	22.03	100.06	72.00	0.26	2.40	1.00	2.31	6.00	16.40	23.00	0.90

Table 1.(cont'd)

Cultivar	Carbohydrate (g/100g)	Energy (kcal/100g)	Moisture (g/100g)	Fat (g/100g)	Protein (g/100g)	Ash (g/100g)	Crude Fibre (g/100g)	Starch (g/100g)	Calcium (mg/100g)	Phosphorous (mg/100g)	Iron (mg/100g)
KPUNO	41.69	169.70	51.60	0.18	3.30	1.40	1.83	11.70	20.20	6.80	0.60
DANGBA	29.93	134.95	63.40	0.27	3.20	1.10	2.10	7.90	19.50	7.60	0.50
BONBE - TINGYE	42.27	182.39	51.30	0.19	2.90	1.10	2.24	12.20	24.00	3.70	0.80
ZONGO	32.75	142.14	61.00	0.26	2.20	1.60	2.19	8.00	22.20	8.70	1.10
LABAAKO	42.40	178.29	52.60	0.21	1.70	1.00	2.09	13.10	24.30	4.20	0.80
GHENCHITO	31.75	142.62	61.20	0.18	3.50	1.20	2.17	14.50	9.50	4.90	0.50
KUKULGA	36.95	166.81	55.70	0.29	4.10	0.90	2.06	8.40	10.60	3.80	1.20
ZUGLANGO	32.74	138.98	59.60	0.18	4.00	1.60	1.88	11.70	12.50	23.60	1.00
KIKI	34.42	146.64	60.00	0.24	1.70	1.30	2.14	14.40	16.40	9.30	1.00
GEONYENI	44.06	187.38	50.30	0.26	2.20	1.20	1.98	15.10	26.70	9.50	1.00
KPUNO	41.69	169.70	51.60	0.18	3.30	1.40	1.83	11.70	20.20	6.80	0.60
DANGBA	29.93	134.95	63.40	0.27	3.20	1.10	2.10	7.90	19.50	7.60	0.50
BONBE - TINGYE	42.27	182.39	51.30	0.19	2.90	1.10	2.24	12.20	24.00	3.70	0.80

Yam is a rich source of energy and carbohydrates as seen from values obtained in this study. As high as more than 40 g/100g of some varieties are carbohydrates yielding more than 160 kcal/100g. The varieties studied are very high in calcium. On the one hand, most of the varieties have levels of this mineral exceeding the range (4-10 mg/100g) found earlier by Eyeson and Ankrah (1975). On the other hand, phosphorous levels were below the literature values (18-62 mg/100g). A few varieties of the yams, however, had values in the range of 20.70-30.50 mg/100g and could be considered as a good source of phosphorous. However, levels of iron in the samples were mostly within the range of literature values.

4.1 CONCLUSION

Most of the results obtained in this study are consistent with earlier studies conducted in Ghana. The yam varieties studied were found to be rich in fibre and calcium apart from their high carbohydrate and energy contents. They were, however, very poor sources of fat.

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