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Minerals and antinutrients in fluted pumpkin (*Telfairia occidentalis Hook f.*)

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Abstract

Studies were conducted to determine the biochemical composition of fluted pumpkin (*Telfairia occidentalis Hook f.*) at different stages of growth. Analyses were carried out at 12 and 50 weeks after planting on stems, leaves and roots, while seeds were analysed 8 and 32 weeks, respectively, after antethesis. Proximate moisture and carbohydrate content decreased in stems, leaves, roots and seeds with age, while ash, crude fibre and crude fat increased with age in stems, leaves, and roots but not in seeds. Elemental composition generally increased with age. In older stems, magnesium (50.5 mg/100 g) and calcium (40.5/100) were highest, while phosphorus (10.6 mg/100) and zinc (6.80 mg/100 g) were highest in older leaves compared to their younger ones. Young leaves, however, had highest magnesium (8.69 m/100 g) and iron (3.60 mg/100 g). Older seeds were richer in phosphorus (954 mg/100 g), potassium (632 mg/100 g) and iron (9.82 mg/100 g) while older roots had higher potassium (883 mg/100 g), calcium (150 mg/100 g) and magnesium (103 mg/100 g) than their younger counterparts. Young roots, however, had higher levels of iron (24 mg/100 g) and copper 2.24 mg/100 g). Antinutrients increased with age in the stems, roots and seeds. Young leaves, which are often preferred for human consumption, were higher in cyanide (60.1 mg/100 g.DM) and tannin content (40.6 mg/100 g DM) than older ones. Oxalate content (10.0 mg/100 gDM) and phytate content (48.8 mg/100 gDM) were higher in the older leaves than the younger ones. Some of the antinutrients in the leaves were above safety limits for human consumption. The authors suggest that young leaves be properly cooked in order to remove antinutrient effects before consumption. Old fluted pumpkin roots had very high levels of antinutrients: oxalate (2600 mg/100 gDM), cyanides (84.2 mg/100 gDM), tannins (60.1 mg/100 gDM) and phytates (84.4 mg/100 gDM) and may constitute potent human poisons. Younger pumpkin seeds may be nutritionally preferred for consumption since they contain less antinutrients than older seeds. However, mature pumpkin seeds contain high potassium, iron and crude fat (56.24%) and hence could be further developed to increase world vegetable oil production. © 2000 Elsevier Science Ltd. All rights reserved.

1. Introduction

Fluted pumpkin (*Telfairia occidentalis Hook f.*) belongs to the family cucurbitaceae. It is a leafy green vegetable that has been widely accepted as a dietary constituent among peasants in Nigeria and it is more popular in the south eastern states of Nigeria. The tender leaves and vines are consumed by man as vegetables as well as by livestock (sheep, pigs and goats) as forage, while the young seeds are eaten as human food (Akoroda, 1990; Badifu & Ogunsua, 1991; Hutchinson & Dalziel, 1954). The pumpkin seeds contain about 53% oil and the crop could potentially become another source of vegetable oil in the world market.

Oyolu (1980) observed that vegetables will continue to remain the primary source of proteins, minerals and vitamins in African countries. He noted that leaves and edible shoots of fluted pumpkin together contain 85% moisture, while the dry portion of what is usually consumed contains 11% crude protein, 25% carbohydrate, 3% oil, 11% ash and as much as 700ppm iron. Oyenuga (1968), has documented the mean chemical composition of fluted pumpkin tender vines and leaves on dry weight basis as follows: crude protein 11%, carbohydrate 25%, ether extract 3.0%, phosphorus 0.58%, potassium (K) 4.32%, magnesium (Mg) 0.56%, calcium (Ca) 0.47% and 700 ppm iron (Fe). Achinewhu, Ogbona and Hart, (1995) have also characterized the chemical composition for other leafy vegetables. Okigbo (1977) observed that the protein content of dry fluted pumpkin leaf was 37.3%.

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The contribution of vegetables to minerals, vitamins and proteins in human nutrition is limited due to the presence of antinutrients which render some of the micro-nutrients and protein unavailable for human nutrition (Camus & Laporte, 1979). The most common anti-nutritional factors in leafy vegetables are oxalic acid, tannins, phytic acid and hydrocyanic acid. The distribution of anti-nutrients in some vegetable crops and their effects on other nutrients has been documented (Broadhurst & Jones, 1978; Desphande & Cheryan, 1985; Marks, Glyphis & Leighton, 1987; Oke, 1966; Udosen & Ukpana, 1993). A daily intake of 450 mg of oxalic acid has been reported to interfere with metabolism. Munro and Bassir (1969) estimated oxalate toxicity levels at 2–5 g/100 g (Scholfield et al., 1990). High oxalate levels in food may reduce the bioavailability of such metals as calcium (Okoro, 1989). The cyanide level in cassava has been reported to affect human nutrition, while Oke (1969) has reported toxic limit as 35 g/100 g in foods. Phytic acid intake of 4.00–9.00 mg/100 g decreases iron absorption by 4–5-fold in humans (Hurrel, Juillert, Reddy, Lynch, dassenko & Cook, 1992).

Extracts of the roots of fluted pumpkin, which are not eaten by man, have been reported to contain resins, alkaloids and saponins; they have been shown to be lethal to rats and mice. Akubue, Kar and Nnchetta (1980) and Taylor, Fetuga and Oyenuga (1983) have documented that fluted pumpkin seeds are a good source of four minerals required in human nutrition. Their report showed that the seed contained 29% oil and 30% protein. Asiegbu (1987) reported fluted pumpkin seed to contain 47% oil and 31% protein. The protein was said to be markedly deficient in the sulphur amino acids. Longe, Rarinu and Fetnoa (1983) reported that fluted pumpkin seeds had 53% fat, 22% protein, 3% fibre, 15% carbohydrates and 2% ash. The other major and micronutrients in pumpkin seeds have also been reported (Badifu & Ogunsua 1991; Okoli & Mgbeogu, 1983). Although the cultivation and consumption of fluted pumpkin has been widespread in Nigeria, the mineral and antinutrient composition of the crop has not been thoroughly investigated. This study was therefore undertaken to provide more information to consumers, regarding safety levels of various age groups and both edible and non-edible parts.

2. Materials and methods

Fluted pumpkin seeds were sown in April 1996, at the University of Uyo Teaching and Research Farm. The seeds were planted in four plots each measuring 3×3m with a spacing of 90×90 cm. The study involved destructive sampling. Fluted pumpkin stands were harvested at 12 weeks after planting (12 WAP) and at 50 weeks after planting, respectively. The fruits were harvested for seeds at 8 weeks after anthesis (8 WAA; and approximately 33 WAP) and at 32 weeks after anthesis (32 WAA; approximately 57 WAP). The harvested plant parts were washed and separated into their component parts, leaves, stems, roots and seeds. These parts were subjected to biochemical analysis.

Proximate compositions for nutrients were determined using the AOAC (1984) method. The moisture content of the clean samples was determined by drying the sample to a constant weight at 60°C in a vacuum oven. Protein was calculated from the Kjeldahl nitrogen using the conversion factor 6.25. Lipid was estimated by exhaustively extracting a known weight of sample with petroleum ether (BP 60°C) using a Tecator Soxhlet apparatus. Ash content was determined by ignition in a muffle furnace for 4 h at 525°C. Fibre content was estimated from the loss in weight of the crucible and its content on ignition. Carbohydrate was determined when the sum of the percentages of moisture, ash, crude protein, either extract and crude fibre were subtracted from 100.

Mineral elements were estimated using the AOAC (1984) method. The atomic absorption spectrophotometer was used to determine Ca, Mg, K, Zn, Cu and Fe. Phosphorus (P) was measured by converting phosphates into phosphorus molybdate blue pigment and assayed at 700 nm.

Oxalate was analysed using the Dye (1956) method. Hydrogen cyanide was determined using the AOAC (1984) method. The Burns (1971) method was used to estimate tannins while the Wheele and Ferrel (1971) method was adopted to determine phytic acids.

3. Results and discussion

3.1. Proximate analysis

3.1.1. Stems

The young fluted pumpkin stems harvested at 12 WAP were higher in percentage moisture, crude protein, crude fat and carbohydrate than older stems harvested at 50 WAP. However, older stems were higher in crude fibre than young stems (Table 1). The young stems contained about 28.2% (DM) crude protein. This is good because these sometimes serve as fodder for animals.

3.1.2. Leaves

The older leaves harvested at 50 WAP were higher in percentage crude protein, crude fat, ash and crude fibre, than younger leaves harvested at 12 WAP (Table 1). The young leaves were, however, higher in moisture and carbohydrate contents. Older leaves contained 39.4% crude protein compared to 22.4% for younger leaves.

Table 1
Proximate composition (%) DM) of fluted pumpkin stems, leaves, roots and seeds at two stages of growth[a]

Proximate composition	Stems		Leaves		Roots		Seeds	
Matter (DM) (%)	Weeks after planting		Weeks after planting		Weeks after planting		Weeks after anthesis	
	12	50	12	50	12	50	8	32
Moisture	82.20 ± 0.02	23.36 ± 0.02	84.48 ± 0.04	75.55 ± .06	88.60 ± 0.03	80.05 ± 0.08	92.24 ± 0.05	33.37 ± 0.20
Crude Protein	28.2 ± 0.10	14 ± 0.16	22.4 ± 0.20	39.4 ± 0.10	20.2 ± 0.20	18.4 ± 0.12	24.4 ± 0.09	24.2 ± 0.10
Crude Fat	2.40 ± 0.06	1.88 ± 0.04	10.10 ± 0.10	11.46 ± 0.04	12.30 ± 0.05	25.74 ± 0.03	2.10 ± 0.04	56.24 ± 0.52
Ash	3.40 ± 0.20	32.6 ± 0.30	12.4 ± 0.40	12.6 ± 0.30	14.6 ± 0.20	16.5 ± 0.12	2.42 ± 0.02	1.60 ± 0.11
Crude Fibre	3.60 ± 0.20	34.82 ± 0.24	14.20 ± 0.20	14.72 ± 0.10	16.80 ± 0.08	19.31 ± 0.04	1.36 ± 0.04	1.80 ± 0.13
Carbohydrate	62.4 ± 0.40	16.7 ± 0.30	40.7 ± 0.40	21.8 ± 0.60	21.8 ± 0.24	21.9 ± 0.36	69.8 ± 0.15	16.1 ± 0.20

[a] Each value represents the mean ± standard for triplicate determinations.

Ironically, peasant consumers often prefer the young tender leaves to the older ones. Okoli and Mgbeogu (1983) reported that fluted pumpkin leaves had a protein content of 21.2%. Oyenuga (1968) and Oyolu (1980) both reported 11% protein for fluted pumpkin leaves. These authors did not specify the age at which the leaves were analysed nor stipulate their cultivation environmental factors.

3.1.3. Roots

The fluted pumpkin roots harvested at 12 WAP had slightly higher percentages of moisture, crude protein and carbohydrate than those harvested at 50 WAP (Table 1). The percentage crude fat, ash and crude fibre were, however, higher in older roots. It was of interest to observe that fluted pumpkin roots contained as much as 20.2% crude protein at 12 WAP. While these are not eaten by man, their extracts are sometimes used in medicinal concoctions.

3.1.4. Seeds

The young seeds harvested at 8 weeks after antheses (8 WAA; approximately 33 WAP) contained about 92.2% moisture and were high in crude protein (24.4%) but low in crude fat (Table 1). The seeds are edible. At 32 weeks after antethesis (32WAA; approximately 57 WAP), the seeds showed a decrease in percentage moisture content but significant increase in the crude fat content (56.24%). Asiegbu (1987), in his analysis of fluted pumpkin seeds, observed an oil content of 47%. The high crude fat content in mature fluted pumpkin seeds compares well with other oil crops like *Helianthus annus* (48.2–56.5%), *Curcurbita pepo* (48.6%) *Arachis hypogea* (50.9). *Glyaine mase* (18.2%) and *Eleais guneensis* (45.50%) (Langstraat, 1976; Onyenuga & Fetuga, 1975; Robinson, 1975). They are thus potential sources of vegetable oils. The seeds were, however, low in ash and crude fibre content, which will assist quality control of the extracted oil.

3.2. Mineral composition

3.2.1. Stems

The fluted pumpkin stems harvested at 50 WAP had higher percentages of K, Mg, Ca, Fe, P, Cu, and Na than stems harvested at 12 WAP (Table 2). The stems were significantly rich in Mg and Ca.

3.2.2. Leaves

The fluted pumpkin leaves harvested at 50 WAP had higher percentages of most of the mineral elements than those harvested at 12 WAP (Table 2). The older leaves were specifically higher in phosphorus and zinc while Mg and Fe were higher in younger leaves. Phosphorus and zinc play crucial roles in actively metabolising cells, particularly in relation to energy metabolism; photosynthesizing leaves play key roles in the energy cycle. Magnesium and iron are components of chlorophyll. Vegetables are known to supply the needed vitamins, iron, calcium, magnesium, zinc and other minerals important for human health and they are the most affordable source of minerals and vitamins for African families (Anne, 1979; Schultink, West & Pepping, 1987). The relatively high concentration of iron in the young fluted pumpkin leaves (Table 2), may perhaps provide the basis for which fluted pumpkin leaf extract is traditionally administered as a blood tonic to convalescing patients (Akoroda, 1990).

3.2.3. Roots

Fluted pumpkin roots harvested at 50 WAP had higher concentrations of mineral elements than the younger ones harvested at 12 WAP. The highest mineral elements in older roots were potassium (882 mg/100 g DM), calcium (50.5 mg/100 g DM), magnesium (103 mg/100 g DM) and sodium (30 mg/100 g DM).

3.2.4. Seeds

The matured pumpkin seeds harvested at 32 WAA had higher proportions of minerals than those of the

Table 2
Elemental nutrient composition (mg/100 g DM) of fluted pumpkin stems, leaves, roots and seeds at two stages of growth[a]

Elemental nutrient	Stems		Leaves		Roots		Seeds	
Composition in	Weeks after planting		Weeks after planting		Weeks after planting		Weeks after anthesis	
mg/100 g DM	12	50	12	50	12	50	8	32
Potassium (K)	6.60 ± 0.12	29.68 ± 0.24	2.50 ± 0.03	3.05 ± 0.10	624.4 ± 0.36	88.3 ± 0.54	3.40 ± 0.10	632 ± 0.54
Magnesium (Mg)	6.40 ± 0.10	50.5 ± 0.18	8.69 ± 0.04	0.78 ± 0.10	84.6 ± 0.36	103 ± 0.34	6.80 ± 0.04	89.0 ± 0.13
Calcium (Ca)	2.50 ± 0.04	40.6 ± 0.20	1.75 ± 0.50	3.20 ± 0.12	139 ± 0.24	150 ± 0.32	1.24 ± 0.06	80.9 ± 0.24
Iron (Fe)	3.40 ± 0.05	13.6 ± 0.13	3.60 ± 0.10	2.73 ± 0.10	24.8 ± 0.12	23.7 ± 0.12	6.64 ± 0.11	9.82 ± 0.12
Copper (Cu)	0.52 ± 0.01	2.14 ± 0.08	0.68 ± 0.01	0.92 ± 0.08	2.24 ± 0.10	1.89 ± 0.02	1.20 ± 0.10	1.38 ± 0.06
Phosphorus (P)	0.60 ± 0.02	15.0 ± 0.16	0.65 ± 0.01	10.6 ± 0.15	18.4 ± 0.12	20.2 ± 0.11	8.40 ± 0.10	954 ± 0.58
Zinc (Zn)	6.10 ± 0.10	8.40 ± 0.10	4.20 ± 0.01	6.80 ± 0.11	8.10 ± 0.13	30.9 ± 0.14	2.40 ± 0.06	7.80 ± 0.07
Sodium (Na)	0.82 ± 0.04	23.3 ± 0.34	0.52 ± 0.03	2.30 ± 00.09	28.9 ± 0.24	30.9 ± 0.16	1.52 ± 0.04	24.8 ± 0.10

[a] Each value represents the mean ± standard deviation for triplicate determinations.

young seeds harvested at 8 WAA (Table 2). Potassium, phosphorus, magnesium and calcium distributions are relatively very high in the matured seeds (Table 2). It appears evident from this study that minerals may be stored in mature fluted pumpkin seeds preparatory for growth of new plants. Similar results for fluted pumpkin seed minerals were obtained by Longe et al. (1983), whereas lower proportions of the different minerals were reported by Badifu and Ogunsua (1991). This latter report did not, however, specify the age of the fluted pumpkin seeds.

3.3. Antinutrient Composition

3.3.1. Stems

The fluted pumpkin stems harvested at 12 WAP had high proportions of antinutrients such as oxalates, cyanides, tannins and phytates (Table 3). These increased with age except cyanide which decreased with age. Oxalates were the highest (62. 2mg/100 g DM) in older stems, followed by tannins (44.6 mg/100 g DM). These appear to be within the safe limits for consumption.

3.3.2. Leaves

The young leaves of fluted pumpkin harvested at 12 WAP were relatively higher in cyanide and tannin content than the older leaves, harvested at 50 WAP, whereas the older leaves were higher in oxalate and phytate than the younger leaves (Table 3). The younger fluted pumpkin leaves are more tender and succulent and are usually preferred for human consumption than the older, more mature ones. The high cyanide content (60.1 mg/100 g DM) indicates that the younger leaves of fluted pumpkins may affect human nutrition if consumed in a large quantity. Hydrogen cyanide is known to be harmful to the body. According to IITA (1990), the safe limit of cyanide in garri, as specified by the Nigerian Food and Drug Administration is 1 mg HCN per 100 g of garri. The amount of cyanide in fluted pumpkin younger leaves was observed to be above the safety dose given by IITA (1990) or even above the toxic limit of 35 mg 100 g DM reported by (Oke, 1969). The authors suggest that younger leaves of fluted pumpkin be properly cooked in order to remove the antinutrient effects before human consumption.

Tannins, oxalates and phytates are also known to affect human nutrition and metabolism. For example, high oxalate reduces bioavailability of Ca. Munro and Bassir (1969) reported that oxalates form insoluble complexes with Ca, Mg, Zn and Fe, thereby interfering with utilization of these mineral elements. Tannic acid is associated with lower nutritive value of protein foods. Singleton and Kratzer (1969) reported that higher intake of tannic acid has been associated with carcinogenic

Table 3
Antinutrient composition (mg/100g DM) of fluted pumpkin stems, leaves, roots and seeds at two stages of growth

Anti-Nutrient	Stems		Leaves		Roots		Seeds	
Composition in	Weeks after planting		Weeks after planting		Weeks after planting		Weeks after anthesis	
mg/100 g DM	12	50	12	50	12	50	8	32
Oxalates	8.08 ± 0.08	62.8 ± 0.19	7.04 ± 0.05	10 ± 0.20	1083 ± 0.48	2600 ± 0.52	2.42 ± 0.16	59 ± 0.52
Cyanides	54.8 ± 0.18	30.2 ± 0.10	60.1 ± 0.30	0.18 ± 0.04	68.4 ± 0.12	84.2 ± 0.18	0.10 ± 0.02	28.9 ± 0.18
Tannins	40.4 ± 0.12	44.6 ± 0.09	40.6 ± 0.13	38.2 ± 0.13	48.6 ± 0.11	60.1 ± 0.14	1.48 ± 0.10	48.2 ± 0.14
Phytates	38.2 ± 0.40	48.2 ± 0.10	38.4 ± 0.13	48.8 ± 0.16	52.3 ± 0.13	84.4 ± 0.20	1.30 ± 0.08	36.4 ± 0.12

effects in man, poor protein utilization, liver and kidney toxicity. According to Hurrel et al. (1992), phytic acid intake of (4–9 mg/100 g DM) is said to decrease iron absorption by 4–5 fold in humans. High levels of antinutrients, such as oxalate, phytic acid and HCN, are known to be very poisonous to humans. It is, however, established by Dunu, Eka, Tfon and Essien, (1986) that most of these toxicants are eliminated during processing and cooking; hence the leaves and stems of fluted pumpkins might not be as harmful to humans as this study suggests. However, diarrhoea might result when large quantities of young fluted pumpkins are eaten, depending on the constitution of the individual.

3.4. Roots

The highest concentrations (almost 100-fold for oxalates) of all the antinutrients were found in the roots of fluted pumpkin (Table 3). Roots harvested at 50 WAP were significantly higher in antinutrients than those harvested at 12 WAP. Oxalate content was very high in both young (1083 mg/100 g DM) and old roots (2600 mg/100 g DM). The present findings indicate the possibility of partial transportation and storage of hydrocyanic glycosides and other antinutrients from leaves and stems into the roots. Singha and Nair (1967) reported that cyanoglucosides varied in different parts of cassava plants and HCN content in tubers increased until maturity. Ramanujam, Indira and Rjandran (1984) reported significant positive correlation between the distribution of HCN in leaves and tubers. The high concentrations of antinutrients in fluted pumpkin roots further suggest that these roots contain potent human poisons. Akubue et al. (1980) reported that the extracts of fluted pumpkin roots contain resins, alkaloids and saponins and have been shown to be lethal to rats and mice.

3.4.1. Seeds

The young fluted pumpkin seeds harvested at 8 WAA were significantly lower in all the antinutrients compared to those harvested at 32 WAA which had about 10 times higher levels. Mature seeds contained as much as (28.9 mg/100 g DM) cyanide which could cause food poisoning when eaten in large quantity. The results also indicate that the antinutrients are possibly translocated into the older seeds for storage. Younger seeds (8 WAA) are therefore nutritionally preferable for consumption since they contain less antinutrients and are also sweeter to taste than the matured seeds.

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