Food Chemistry **14** (1984) 303–311

Chemical Evaluation of Nutritive Value of the Fruit of African Starapple (*Chrysophyllum albidum*)

D. O. Edem, O. U. Eka & E. T. Ifon

Department of Biochemistry, University of Calabar,
Calabar, Nigeria

(Received: 6 February, 1984)

ABSTRACT

The nutritive value of African starapple, Chrysophyllum albidum, *was evaluated chemically. Chemical analyses were carried out on the peel and the edible pulp. The peel was shown to contain 58·9% moisture, 6·1% protein, 12·4% lipid, 4·6% ash, 62·4% carbohydrate and 14·5% crude fibre. The pulp contained 67·5% moisture, 8·8% protein, 15·1% lipid, 68·7% carbohydrate, 4·0% crude fibre and 3·4% ash.*

Analysis of the fruit for minerals showed the peel to contain (in mg/100 g dry matter): calcium, 250; potassium, 1175; sodium, 12; copper, 2·0; magnesium, 90; zinc, 3·8; iron, 200; and phosphorus, 76·8. The pulp contained (in mg/100 g dry matter): calcium, 100; potassium, 1175; sodium, 10; copper 2·0; magnesium, 75; zinc, 3·2; iron, 10; and phosphorus, 75·4. The peel contained ascorbic acid 239·1 mg/100 g and the pulp, 446·1 mg/100 g. Some toxicants were shown to be present. The peel contained 264 mg/100 g tannins and the pulp, 627 mg/100 g.

The total oxalate content in the peel was 211 mg/100 g and in the pulp, 167 mg/100 g. The hydrocyanic acid content was 5·4 mg/100 g in the peel and 6·8 mg/100 g in the pulp. The phytic acid content was 0·8 mg/100 g in the peel and 1·6 mg/100 g in the pulp.

The contribution of the fruit of African starapple to the nutrient requirements of consumers is discussed as well as other possible uses for the fruit.

INTRODUCTION

Nigeria is abundantly rich in fruits which are distributed around the various climate zones of the country. Most of the fruits are common while

Food Chemistry 0308-8146/84/$03·00

some are concentrated in certain localities. For instance, African pear, banana, paw-paw, oranges, guava, and mango are found in commercial quantities in the Southern States of Nigeria while date palm, *kaele*, *atile*, baobab and *dabino* are mostly found in the Northern States. Nutritional and toxicological studies have been carried out on most of these fruits (FAO, 1968; Oyenuga, 1968; Eka, 1977*a*,*b*; Addy, 1978; Chakraborty & Eka, 1978; Ekabua & Eka, 1978; Addo, 1980; Addy & Eka, 1981). There are, however, some lesser known fruits consumed in certain localities. The African starapple is an example of such a fruit. This fruit abounds in the Southern and North Central States of Nigeria.

The African starapple tree, *Chrysophyllum albidum* is a native of many parts of tropical Africa. The tree is a representative of the family Sapotaceae and is a common feature in closed forest; also it is frequently planted in villages. This tree inhabits the lowland forest of Nigeria and fruit of the tree is eaten throughout the country. In the Northern States, it is found in the Plateau region (Dalziel, 1955; Hutchison & Dalziel, 1963; Keay *et al.*, 1964).

The African starapple tree is an evergreen tree, up to 40 m high and about 2 m in girth. It has a straight and long fluted bole with small buttresses at the base. The bark is thin and light brown, and on slashing exudes a gummy latex. The tree flowers between April and June. The fruits, each with five flattened shiny seeds, are pale-orange in colour and slightly pointed at the apex. They are large and are more than 4 cm wide, shaped like an orange or apple; they start appearing in July and ripen between December and March. A cross-section of the fruit shows five brown seeds arranged in the form of a star in yellowish pulp. The seeds are used as anklets and necklaces by traditional dancers.

The sweet, pleasantly acid fruit pulp is the edible portion. Sometimes the skin is also consumed. The feasibility of producing table wine from the pulp of the starapple is receiving attention (Eka & Otu, 1983). There is no available information in the literature on the nutritive value of the African starapple. The present study was aimed at its evaluation by chemical analysis.

EXPERIMENTAL

Collection and treatment of samples for analysis

Samples of African starapple were purchased from the local markets in Calabar and Uyo, Cross River State. The fruits were cut open and the seeds removed and discarded. The samples were sorted into two groups for analysis of the peel and the edible pulp. The samples were cut into smaller pieces to allow for effective drying. They were then dried at 60 °C for 12 to 24 h in an air-circulating oven (Astell–Hearson), and ground in a steel-bladed grinding mill (National Model Mr 308, Japan) into a fine powder which passed through a 30 mesh sieve (Joslyn, 1970; AOAC, 1975).

The methods used for analysis were the standard methods of Joslyn (1970) and the recommended methods by the Association of Official Analytical Chemists (AOAC, 1975).

Ash was determined by incineration of the sample in a muffle furnace at 600 °C for 24 h and the percentage of the material burnt off was regarded as the organic matter. Crude lipid was estimated by exhaustive extraction of a known weight of dried sample with petroleum ether (bp 40–60 °C) using a Soxhlet apparatus. The micro-Kjeldahl method was used for the determination of crude protein. Crude fibre was obtained from the loss in weight on ignition of dried residue remaining after digestion of fat-free sample with 1·25 % H_2SO_4 and 1·25 % NaOH solutions under specified conditions. The carbohydrate content (excluding fibre) was obtained by subtracting the sum of protein, fat, ash and fibre from the total dry matter. The caloric value was obtained by multiplying the mean values of the crude protein, lipid and carbohydrate by Atwater factors of 4, 9 and 4, respectively, and taking the sum of the products expressed in kilocalories.

Mineral element composition was determined using an atomic absorption spectrophotometer. The alkaline titration method was used in the estimation of HCN (AOAC, 1975). The method of Burns (1971) was used for the estimation of tannin, and that of Dye (1956) for the estimation of oxalate. The method of McCance & Widdowson (1953) was used for the estimation of phytic acid. Carotene was estimated by the colorimetric method of AOVC (1966) and ascorbic acid was determined by the method of Roe & Kuether (1943) as modified by Scharffert & Kingsley (1955).

The results were statistically analysed using the t-test (Armitage, 1974).

RESULTS AND DISCUSSION

Table 1 shows the proximate composition of African starapple expressed as percentage dry weight of materials, as well as the energy expressed in calories per 100 g of the materials.

TABLE 1
Proximate Composition (Mean ± standard error)[a] of the African Starapple (% Dry Matter)

	Peel	*Pulp*
Food energy (cal)	385·5 ± 1·6	447·0 ± 1·8
Moisture content (fresh weight)	58·9 ± 0·6	67·5 ± 1·3
Crude protein	6·1 ± 0·1	8·8 ± 0·4
Ether extract	12·4 ± 0·4	15·1 ± 0·3
Crude fibre	14·5 ± 0·1	4·0 ± 0·1
Ash	4·6 ± 0·2	3·4 ± 0·1
Carbohydrate	62·4 ± 0·5	68·7 ± 0·3

[a] Mean of 6 determinations in triplicate.

The moisture content (fresh wt) was 58·9 % for the peel, and 67·5 % for the pulp. The moisture content in the two parts of the fruit was high, ranging between 55 and 70 %. This is within the range expected of most fruits (FAO, 1968). The metabolisable energy was found to range between 380 and 450 kcals and this agrees with findings in fruits such as African bread-fruit (Edet *et al.*, 1983) and baobab fruits (Addy & Eka, 1981). The calorie value can be considered adequate. The crude protein was low (6 to 9 %) when compared with values for protein-rich seeds such as cowpea and soya bean but it was richer than the protein content of tubers like cassava and yam. Fruits in general are usually not considered as excellent sources of proteins. The lipid (ether extract) ranged between 12 and 16 % and this can be considered high.

The crude fibre content of the samples was high for the peel (14·5 %) but not so high for the pulp (4·0 %). The amount of crude fibre may influence the digestibility of the fruit but may also help to maintain the normal internal distention of the intestinal tract and thus aid peristaltic movements. The ash content of the samples ranged between 3 and 5 % and this can be considered high for fruits (Joslyn, 1970) and may be an indication of content of high molecular weight elements. Carbohydrate content was high, being between 62 and 69 %; hence the fruit can be considered as a good source of carbohydrate.

Table 2 shows the elemental composition of the samples in mg/100 g dry material. Among the macro-elements, potassium was very high in the samples (1175 mg/100 g). It was followed by calcium; 250 mg/100 g and

TABLE 2
Minerals of the African Starapple (mg/100 g dry matter)[a]

Mineral elements	*Peel*	*Pulp*
Calcium	250	100
Magnesium	90	75
Potassium	1 175	1 175
Sodium	12	10
Phosphorus	76·8	75·4
Iron	200	10
Copper	2	2
Zinc	3·8	3·2
Chromium	0	0
Cobalt	0	0

[a] Results are the average of 2 determinations in triplicate.

100 mg/100 g, in the peel and pulp, respectively. Other macro-elements were below 100 mg/100 g. Thus the fruit can be considered as a rich source of potassium and calcium. The micro-nutrient levels showed iron to be very high in the peel (200 mg/100 g) while it was only 10 mg/100 g in the pulp. There was no detectable chromium and cobalt in the samples. However, copper (2·0 mg/100 g for the peel and pulp) and zinc (3·8 mg/100 g for the peel and 3·2 mg/100 g for the pulp) were present. Thus the fruit can serve as a good source of iron, copper and zinc.

Table 3 shows the ascorbic acid and the carotene content of the fruit samples. The ascorbic acid ranged from 239 mg/100 g in the peel to 446 mg/100 g in the pulp. This can be considered high; hence the fruit is an excellent source of ascorbic acid and this may account largely for its acidic

TABLE 3
Levels of Ascorbic Acid and Carotene in the African Starapple (Mean ± standard error)[a]

Samples	*Ascorbic acid (mg/100 g dry matter)*	*Carotene (μg/100 g dry matter)*
Peel	239 ± 2·5	35·2 ± 1·1
Pulp	446 ± 2·5	15·6 ± 3·7

[a] Mean of 4 determinations in triplicate.

taste. The amount is comparable to that in baobab fruit (Addy & Eka, 1981). The carotene content of the fruit samples was also high, particularly in the peel (35·2 μg/100 g). The carotene content of the pulp was 15·6 μg/100 g. The starapple can thus be consumed as a good source of carotene. The carotene may account at least in part for the yellow colour of the ripe fruit.

Table 4 shows the levels of some toxicants in the samples of the starapple. The tannin content was very high in the fruit samples, being 264 mg/100 g in the peel and 627 mg/100 g in the pulp. Tannins are known

TABLE 4
Levels of Some Toxicants in the African Starapple (mg/100 g dry matter) (Mean ± standard error)[a]

Toxic substances	*Peel*	*Pulp*
Tannin	264 ± 1·9	627·0
HCN	5·4 ± 0·1	6·8 ± 0·3
Phytic acid	0·8 ± 0·1	1·6 ± 0·2
Total oxalate	211 ± 6·6	167 ± 4·2
Soluble oxalate	174 ± 2·6	44·0 ± 5·2
Soluble oxalate (%) of total oxalate	82·3	26·3

[a] Mean of 4 determinations in triplicate.

to bind irreversibly to proteins and render them indigestible by intestinal enzyme (Godstein & Swain, 1965). The effect of such a high tannin content on the consumers of a large amount of the fruits should be considered.

The hydrocyanic acid (HCN) level ranged from 5 to 7 mg/100 g dry sample. A level of HCN of below 25 mg/100 g dry sample is classified as being of very low toxicity for cows (Oke, 1969). A dose of 35 mg of HCN is considered as being lethal to man; hence a very large amount of the fruit will have to be consumed to attain the lethal dose. The level of phytic acid ranged from 0·8 to 2 mg/100 g in the samples. Phytic acid is known to interfere with the absorption and utilisation of calcium, magnesium and iron. It may also influence the availability of phosphorus. Thus phytic acid can influence bone calcification. The toxic level of phytic acid is not well established.

The total oxalate content of the fruit samples was 211 mg/100 g for the peel and 167 mg/100 g for the pulp. The soluble oxalate is known to be the type of oxalate toxic to animals. The content of soluble oxalates was 174 mg/100 g for the peel and 44·0 mg/100 g for the pulp giving percentages of 82·3 and 26·3, respectively. The toxic or lethal dose of soluble oxalate is given as 2–5 g (Munro & Bassir, 1969); thus one must consume a large quantity of the pulp to reach the lethal level. Oxalic acid is also known to precipitate as calcium salts in the coniferous tubules of the kidney in the form of granules or stones, thus leading to oxaluria. Soluble oxalate may also interfere with the utilisation of other elements such as magnesium and iron.

In view of the fact that the starapple is usually consumed fresh and raw without further processing, the levels of the toxicants in the fruits require particular consideration.

CONCLUSION

The results of chemical evaluation of the nutritive value of African Starapple show that the fruit is a good source of carbohydrate, lipid, ascorbic acid, protein, potassium, calcium, iron, copper and zinc. It contains some toxicants such as tannin, hydrocyanic acid, oxalic acid and phytic acid. Though these toxicants occur at non-toxic levels, their interfering effect on the utilisation of essential nutrients is worth noting, particularly since the fruit is usually consumed raw. There is a need for further study to establish the amino acid composition of the proteins and also the fatty acid composition of the fats. It may be desirable to carry out feeding and toxicological tests on experimental animals to demonstrate that the fruit is safe for human consumption. The feasibility of producing table wine from starapple pulp has been investigated (Eka & Otu, 1983). Other possible uses for the fruit should be sought.

ACKNOWLEDGEMENT

The authors are grateful to Mr L. Lawal of the Institute of Agricultural Research, Ahmadu Bello University, Zaria, Nigeria, for helping with the elemental analysis.

REFERENCES

Addo, A. A. (1980). *Seasonal availability of dietary ascorbic acid (vitamin C) in Zaria District of Kaduna State, Nigeria.* PhD Thesis, Ahmadu Bello University, Zaria, Nigeria.

Addy, E. O. H. (1978). *Studies on the nutritive value of leaves and fruits of baobab tree.* MSc Thesis, Ahmadu Bello University, Zaria, Nigeria.

Addy, E. O. H. & Eka, O. U. (1981). Nutritive value of pulp of baobab fruit. *Nigerian J. Sci.*, **13**, 6.

AOAC (1975). *Methods of analysis.* (12th edn). Association of Official Analytical Chemists, Washington DC.

AOVC (1966). *Methods of Vitamin Assay.* (3rd edn). Association of Vitamin Chemists, Interscience, New York.

Armitage, R. (1974). *Statistical methods in medical research.* John Wiley and Sons, New York, p. 119.

Burns, R. E. (1971). Methods of estimation of tannin in the grain sorghum. *Agron. J.*, **63**, 511.

Chakroborty, R. & Eka, O. U. (1978). Studies on hydrocyanic, oxalic and phytic acid contents of foodstuffs. *West Afr. J. Biol. Appl. Chem.*, **21**, 42.

Dalziel, J. M. (1955). *The useful plants of West Africa.* (2nd Reprint.) Crown Agents for Overseas Governments and Administrations, London.

Dye, W. B. (1956). Studies on *Halogeton glomeralus. Weeds*, **4**, 55.

Edet, E. E., Eka, O. U. & Ifon, E. T. (1983). Chemical evaluation of the nutritive value of the seeds of African bread fruit tree—*Treculia africana. Nigerian J. Sci.* (in press).

Eka, O. U. (1977*a*). Studies on the nutrient composition of fruits of an African pear tree (*Pachylobus edulis*). *West Afri. J. Biol. Chem.*, **20**, 3.

Eka, O. U. (1977*b*). Studies on the levels of oxalic acid and phytic acid in tradition foods of Northern Nigerians. *West Afr. J. Biol. Appl. Chem.*, **20**, 45.

Eka, O. U. & Otu, E. O. (1983). *Preliminary studies on the production of wine (Udara wine) from starapple*—Chrysophylum albidium. BSc. Project, University of Calabar, Calabar, Nigeria.

Ekabua, C. & Eka, O. U. (1978). Studies on tannic acid produced by *Psidium guajava. J. Pharm. Med. Sci.*, **2**, 47.

FAO (1968). *Food composition table for use in Africa.* Food and Agricultural Organisation of the United Nations, Rome, Italy.

Godstein, J. L. & Swain, T. (1965). The inhibition of enzymes by tannins. *Phytochemistry*, **4**, 185.

Hutchison, J. & Dalziel, J. M. (1963). *Flora of West Tropical Africa.* Hepper, F. N. (Ed.) Crown Agents for Oversea Governments, London.

Joslyn, M. A. (1970). *Methods of food analysis.* (2nd edn). Academic Press, New York.

Keay, R. W. J., Onochie, C. F. A. & Stanfield, D. P. (1964). *Nigeria trees, 2.* Department of Forest Research, Ibadan, Nigeria.

McCance, R. A. & Widdowson, E. M. (1953). Phytic in human nutrition. *Biochem. J.*, **29**, 2694.

Munro, A. & Bassir, O. (1969). Oxalate in Nigeria vegetables. *West Afr. J. Biol. Appl. Chem.*, **12**, 14.

Oke, O. L. (1969). Role of hydrocyanic acid in human nutrition. *World Rev. Nutr. Dietetics*, **11**, 170.

Oyenuga, V. A. (1968). *Nigerian foods and feedingstuffs* (3rd edn), Ibadan University Press, Ibadan.

Roe, J. A. & Kuether, U. A. (1943). The determination of ascorbic acid in whole blood and urine through the 2,4-dinitrophenyl-hydrazine derivative of dehydroascorbic acid. *J. Biol. Chem.*, **147**, 339.

Scharffert, R. R. & Kingsley, G. R. (1955). A rapid method for the determination of reduced dehydro- and total ascorbic acid in biological materials. *J. Biol. Chem.*, **212**, 59.