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Chemical evaluation of the nutritive value and changes in ascorbic acid content during storage of the fruit of 'bitter kola' (*Garcinia kola*)

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The nutritive value of the pericarp and mesocarp of *Garcinia kola* was evaluated using chemical analysis. The pericarp was richer than the mesocarp in crude fibre and in macro elements other than phosphorus and nitrogen. The mesocarp was richer than the pericarp in protein, crude lipid and ascorbic acid. Levels of toxic substances in both the mesocarp and pericarp were low, but the juice was highly acidic. The effects of traditional and refrigerated storage on ascorbic acid content were monitored. This study revealed that it was better to store the fruits at 10°C, while the seeds could be better stored by the traditional method in layers of red clay soil (Ikoneto).

INTRODUCTION

Garcinia kola, known as 'efiari' by the Efiks of southern Cross River State in Nigeria, is a large species of spreading forest trees commonly found in the rain forest region of West Africa. In Nigeria it is found in Ijebu Ode, Benin, Calabar and Ikom (Keay *et al.*, 1964). *G. kola* belongs to the family Gultiferae. It flowers between December and January, and the fruits mature in June or July. The fruit, which is the size of an orange, is smooth and reddish yellow with peach-like skin and yellow pulp. It contains three or four seeds covered with brown seed coats.

Though the fruits and seeds of 'bitter kola' are generally eaten in Nigeria, very little work has been done on its fruit. Irvine (1961) reported on its medicinal uses. Eka (1984*a*,*b*) determined the chemical composition and possible use of the seeds as a substitute for hops in the brewing industry.

The method of storage of the fruit of *G. kola* by the peasant farmer is dependent on his interest. If the seeds are needed, the fruits will be stored in air-tight containers to aid bacterial activity and rupture of the cell walls of the mesocarp, thus facilitating the release of seeds. If, on the other hand, the fruit is needed they will be stored in baskets or on wooden planks. The peasant farmer stores excess 'bitter kola' seeds between layers of red clay in the ground from June, when they are harvested, until January. He withdraws from his 'store' as occasion demands, though usually he starts withdrawing from this 'store' around November, when the rain has subsided, until January, when all the remaining seeds are dug up. In this way the texture, sensory and nutritional attributes of the seed are believed to be retained. Because modern storage systems are not yet widely available in Nigeria, most of the fruit is eaten within a few weeks of harvest, but the use of cool storage can result in an extended period of availability. Since the condition of storage is known to affect the vitamin C level in fruits and vegetables (Dudek *et al.*, 1980; Stafford, 1983), this work set out to investigate changes in vitamin C content of the fruit of *G. kola* stored by both traditional and modern storage systems.

MATERIALS AND METHODS

Sample collection

The 'bitter kola' fruits used in this study were obtained from a private plantation in Ikot Okon Okpo, Akpabuyo LGA, south east of the University of Calabar, in Cross River State. The fully ripe fruits with unbroken pericarp were obtained from six different sets of trees randomly chosen and carried in six polythene bags to the laboratory within an hour of harvesting. Each analysis was carried out separately.

Sample preparation

Each fruit was washed with deionised distilled water and wiped with kitchen tissue. Two fruits were removed from each of the six groups of samples and used in the analysis. The rest were reserved for experiments on optimum storage conditions. The fruits were cut into two halves and the seeds removed with a steel-bladed knife. The seeds and fruits were peeled and the seed, fruit peel and mesocarp individually chopped. Portions were taken for determination of moisture, ascorbic and hydrocyanic acids. The rest was dried in a hot air circulating oven (Gallenkamp DV 330) at 65°C to constant weight (18–24 h). The dried samples were ground in using an electric blender with steel blades and stored in screw-capped bottles at 4–6°C.

Analysis

Moisture content was determined by drying about 3 g of the fresh sample to constant weight in a hot air circulating oven at 100°C. Proximate composition, which included percentage moisture, fat, crude protein, fibre and ash, was determined according to the standard method of the AOAC (1984). The nitrogen-free extractives (total carbohydrates) were calculated by difference. The calorific value was the sum of the multiplied value of percentage crude protein, crude lipids and nitrogen-free extractives (NFE) with the Atwater factors of 4, 9 and 4 kcal/g, respectively. The determination of sodium, potassium, calcium, magnesium, copper, iron, zinc, cobalt and cadmium was by the Atomic Absorption Spectrophotometer (Pye Unicam 2900), according to the procedure of the AOAC (1984) on dry sample. Phosphorus was estimated from the dry sample using the vanadomolybdate colorimetric method (AOAC, 1984).

Ascorbic acid was determined by titrating ascorbic acid extract prepared from 30 g of fresh sample against *N*-bromosuccinimide by the method of Haddad (1977). Total reducing sugar was determined by the method of Miller (1959) while sucrose, glucose, fructose and mannose were determined by the AOAC (1984) method from the dry sample. The pH was determined in an aliquot of juice of fresh fruit sample with a Corning Model 240 pH meter. The toxicants determined were phytic acid by the method of McCance and Widdowson (1953), hydrocyanic acid from fresh sample by the AOAC (1984) method, tannins by the method of Burns (1971), oxalate by the method of Dye (1956) and caffeine by the method of Weaver (1974). Samples dried to constant weight were used for all determinations, unless otherwise indicated.

For the determination of the variation in ascorbic acid content of these fruits with storage, the fruits were divided into three groups of 120 fruits each. A group comprised 20 fruits from each polythene bag. The first group was placed in a large covered cane basket, and the second was placed on a large wooden table with a rectangular wooden wedge about 6 cm high. The wedges confined the fruits to the table top, thus reducing the risk of their falling off. These two groups were placed in an air-conditioned storage (26 ± 2°C) container which was opened only when samples were withdrawn for analysis. The third group was stored in sealed polythene bags and kept at 10°C. At different time intervals, six fruits were withdrawn for the determination of ascorbic acid content.

Six fruits were taken from each of the six polythene bags and separated as before into the seeds and mesocarp, and the seeds were divided into three groups. The first group was wrapped individually with the leaves of *Cryptosperma senegalensis* (Ikong Idim) and placed at 10°C. The second group was sealed in polythene bags and stored at the same temperature. The third was buried in a damp place in a bed of red clay (Ikoneto) where the shade was provided by large trees. The samples to be analysed in each case were taken between 08:00 and 10:00 h.

RESULTS AND DISCUSSION

Table 1 shows the proximate composition and the energy content. The moisture content (fresh weight) for the pericarp (74·2%) and the mesocarp (84·1%) and the metabolisable energy for the mesocarp (378 kcal) compared favourably with those of other Nigerian fruits such as *Chrysophyllum albidum* (447 kcal; Edem *et al.*, 1984) and *Cola rostrata* (375 kcal; Dosunmu & Eka, 1989). The fruit contained less crude lipid (6·9–8·7%) than *C. albidum* (12·4–15·1%) but more than *C. rostrata* (0·12–0·68%). The crude protein ranged from 3·90–7·8%, compared to the 6·1–8·1% of *C. albidum* and the 0·44–0·94% of *C. rostrata*.

The edible mesocarp was rich in some macro elements (Table 2), such as nitrogen, potassium, phosphorus, magnesium and calcium.

The pericarp (peel) had higher amounts of mineral elements except nitrogen and phosphorus. Only a trace of chromium was found. Cobalt was not detected. The pericarp is not consumed by man but its proximate composition would suggest it could form part of the diets of ruminants.

Table 3 shows the sugar content of the mesocarp of the fruit of 'bitter kola'. The order of sugar concentrations is as indicated: glucose > fructose > sucrose > mannose. This fruit is usually not very sweet when compared with the taste of fruits such as *C. rostrata.*

Table 1. Proximate composition (g/100 g dry sample) and calorific value of pericarp and mesocarp of *Garcinia kola* fruit[a]

	Moisture (wet weight)	Crude fibre	Crude lipid (ether extract)	Crude protein (Kjeldahl N × 6·25)	Ash	Nitrogen-free extractives	Energy content (kcal/100 g dry matter)
Pericarp (peel)	74·2 ± 0·8	16·5 ± 0·6	6·9 ± 0·5	3·9 ± 0·5	4·0 ± 0·3	68·7 ± 0·8	—
Mesocarp	84·1 ± 1·0	13·9 ± 0·3	8·7 ± 0·3	7·8 ± 0·8	2·4 ± 0·2	67·2 ± 1·0	378 ± 2·1

[a]Mean (of six determinations) ± standard error.

Table 2. Mineral content of *Garcinia kola* (mg/100 g of dry powder)

	Na	K	Ca	Mg	N	Fe	P	Zn	Cu	Cr	Co
Pericarp (peel)	18	990	200	170	624	150	520	4	1·3	1·1	—
Mesocarp	1·8	499	100	166	1248	4·2	720	3·5	2·5	0·2	—

Table 3. Sugar content of the mesocarp of *Garcinia kola* fruit (g/100 g dry sample)[a]

Total sugar	18·1 ± 0·4
Glucose	6·20 ± 0·2
Fructose	5·02 ± 0·3
Sucrose	4·07 ± 0·3
Mannose	2·83 ± 0·2

[a]Mean (of four determinations) ± standard deviation.

Table 4. Ascorbic acid, acidity and toxic substances (mg/100 g) in the pericarp and mesocarp of *Garcinia kola* fruit[a]

	Pericarp	Mesocarp
Ascorbic acid[a]	93·3 ± 1·5	127 ± 1·1
Tannins	15·3 ± 0·9	11·4 ± 1·1
Hydrocyanic acid[b]	7·3 ± 0·7	6·1 ± 0·4
Phytic acid	1·1 ± 0·1	0·9 ± 0·2
Total oxalate	210 ± 1·3	167 ± 1·6
H_2O-soluble oxalate	101 ± 1·5	44 ± 0·8
H_2O-soluble oxalate (% of total oxalate)	48·1%	26·3%
pH	—	3·0 ± 0·1[c]

[a]Mean (of four determinations) ± standard error.
[b]Wet sample.
[c]Mesocarp juice.

This perhaps might be due to the fact that its total sugar content (18·1%) is camouflaged by its acid content.

In Table 4 the ascorbic acid, acidity and toxic substances present in the mesocarp and pericarp are presented. The concentration of ascorbic acid in the mesocarp was fairly high. Thus, about 25 g of the fruit will supply the FAO Recommended Daily Allowance (30 mg for an average mature man) of this vitamin (FAO, 1968). This is about the mesocarp of two average-sized fruits.

Total oxalates in the mesocarp is 167 mg/100 g of dry matter. Since only 26% of this amount was water-soluble, there will not be much oxalate influence on the uptake of available calcium and phosphorus (Ifon & Bassir, 1979). The amounts of other toxic substances such as tannins, phytic and hydrocyanic acids were very low in the pericarp and mesocarp of 'bitter kola'.

The pH of the fruit juice was found to be 3. This low pH value might be due to the presence of other acids besides ascorbic acid. The type and quantity of acid is being studied in a separate project. As a result of the high acidity this fruit is not recommended for patients that are prone to gastrointestinal ulcer (Grunne Stratton, 1976; Smith & Smith, 1982), nor those with weak enamel of the teeth, as persistent consumption without proper dental hygiene may erode the molecules of the enamel (Wagman & Ferguson, 1982).

Optimum storage conditions

From Table 5, it can be seen that the water content of seeds buried in clay soil increased steadily in the rainy season from 75 to 89·5% within 120 days, with the highest increase in water corresponding to the period of highest rainfall (August). With decrease in rainfall there was also a gradual decrease in the water content of the seeds from 88·9% in September to 70·8% in March. The peasant farmer would not store his seeds after January because moisture would be rapidly lost and this might change the texture, sensory and nutritional attributes of the seed. Refrigeration steadily reduced the moisture content of 'bitter kola' seeds from 75 to 60% within 300 days of storage. There was no significant difference in water content between polythene-wrapped and leaf-wrapped samples. After 300 days the seed lost its texture and became very tough and the pericarp was easily separated from the rest of the seed.

Table 6 shows that, in 42 days, the ascorbic acid content of both the pericarp and mesocarp decreased considerably at 26°C, but the deterioration was more in the pericarp (basket, 50·4%; wood top, 51·6%) than the mesocarp (basket, 31·0%; wood top, 32·2%). Within the first 63 days, fruits kept at 10°C had their ascorbic acid content reduced by 12·9% (pericarp) and 10·2% (mesocarp). From 70 to 91 days there was an increase in ascorbic acid content of both the pericarp (8·2%) and the mesocarp (5·4%). This gave an overall deterioration in ascorbic acid content of 5·0% in the pericarp and 5·3% in the mesocarp. There was negligible deteriora-

Table 5. Moisture content (g/100 g of fresh weight) of seeds of *Garcinia kola* under different storage conditions[a]

Post-harvest time (days)	Clay soil	Refrigerator (10°C ± 1)	
		Polythene-wrapped	Leaf-wrapped
1	75·0 ± 0·3	75·0 ± 0·3	75·0 ± 0·3
30	78·2 ± 0·4	73·5 ± 0·6	73·5 ± 0·5
60	82·5 ± 0·5	72·8 ± 0·4	72·9 ± 0·4
90	88·7 ± 0·3	71·0 ± 0·2	71·1 ± 0·3
120	89·5 ± 0·4	69·1 ± 0·7	69·2 ± 0·4
150	88·9 ± 0·5	68·7 ± 0·4	68·7 ± 0·3
180	86·3 ± 0·9	66·9 ± 0·5	66·8 ± 0·4
210	80·1 ± 0·2	65·2 ± 0·2	65·3 ± 0·5
240	76·1 ± 0·7	63·9 ± 0·7	63·7 ± 0·6
270	74·6 ± 0·8	62·1 ± 0·7	62·1 ± 0·7
300	70·8 ± 0·6	60·1 ± 0·9	60·1 ± 0·7

[a] Mean (of six determination) ± standard error.

Table 6. Ascorbic acid content of *Garcinia kola* fruit (mg/100 g of wet matter) under different storage conditions[a]

Fruit							Seed			
Post-harvest time (days)	Pericarp			Mesocarp			Post-harvest time (days)	Clay Soil	Refrigerator (10°C ± 1)	
	Basket (26 ± 2·0)	Wood top (26 ± 2·0)	Refrigerator (10°C ± 1)	Basket (26 ± 2·0)	Wood top (26 ± 2·0)	Refrigerator (10°C ± 1)			Polythene-wrapped	Leaf-wrapped
1	93·3 ± 1·5	93·3 ± 1·5	93·3 ± 1·5	127·1 ± 1·5	127·1 ± 1·1	127·1 ± 1·1	1	27·2 ± 0·8	27·2 ± 0·8	27·2 ± 0·8
7	79·1 ± 0·8	80·1 ± 1·1	91·8 ± 0·7	120·8 ± 0·8	119·3 ± 1·0	125·3 ± 0·9	30	26·3 ± 0·8	28·1 ± 0·5	28·3 ± 0·4
14	67·6 ± 0·9	69·3 ± 0·7	90·7 ± 0·8	108·5 ± 0·7	106·1 ± 0·8	123·0 ± 0·6	60	24·6 ± 0·9	29·4 ± 0·6	29·3 ± 0·4
21	55·2 ± 1·0	54·3 ± 0·5	89·2 ± 0·5	99·3 ± 0·5	94·9 ± 0·9	122·9 ± 0·5	90	22·9 ± 0·7	30·0 ± 0·7	30·1 ± 0·3
28	48·2 ± 0·4	52·3 ± 0·6	88·8 ± 0·9	89·4 ± 0·6	88·6 ± 1·2	121·0 ± 0·3	120	21·3 ± 0·5	31·3 ± 0·4	31·5 ± 0·6
35	46·3 ± 0·8	45·2 ± 0·8	87·3 ± 0·3	87·6 ± 0·8	86·1 ± 0·7	119·1 ± 0·6	150	19·4 ± 0·6	32·7 ± 0·4	32·8 ± 0·6
42			85·2 ± 0·6			117·5 ± 0·5	180	20·3 ± 0·3	33·1 ± 0·5	33·1 ± 0·4
49			84·1 ± 0·3			116·1 ± 0·3	210	21·1 ± 0·4	34·4 ± 0·7	34·4 ± 0·4
56			83·6 ± 0·7			114·1 ± 0·5	240	21·9 ± 0·2	35·8 ± 0·8	35·8 ± 0·5
63			81·9 ± 0·9			114·2 ± 0·5	270	22·3 ± 0·7	36·4 ± 0·4	36·5 ± 0·2
70			83·7 ± 0·8			115·2 ± 0·4	300	23·6 ± 0·3	36·9 ± 0·3	36·9 ± 0·4
77			85·4 ± 0·6			116·3 ± 0·6				
84			87·2 ± 0·3			117·2 ± 0·7				
91			88·6 ± 0·5			120·3 ± 0·6				

[a]Mean (of six determinations) ± standard error.

tion in ascorbic acid content during storage at 10°C. Stafford (1983) cited cases of increase in ascorbic acid content during storage. In the present study, increase was observed from 63 to 91 days. Fruits kept in the basket and wood top became very soft after 35 days, while those in the refrigerator were still firm after 91 days. There is no difference between the two traditional methods of storage. Storage at 10°C should only be encouraged if fruits are to be stored for more than 35 days, provided that the cost of cold storage in the locality is not higher than the proceeds from the fruit.

The seeds of 'bitter kola' were stored in clay soil and at 10°C, as indicated in Table 6. There was an initial decrease in ascorbic acid content from 27·2 to 19·4 mg (28·7%) in the first 150 days. This decrease corresponded with an increase in water content of the seeds observed during the same period. There was a significant increase in ascorbic acid content (21·6%) from 180 to 300 days. This did not compensate for the initial loss but corresponded to only 13·2% deterioration in ascorbic acid content. Refrigeration increased ascorbic acid content of both polythene-wrapped and leaf-wrapped seeds from 27·2 to 36·9 mg (35·5%) in 70 days. Neither of these two methods had an advantage over the other. There was no significant change in the ascorbic acid content of refrigerated leaf-wrapped and polythene-wrapped seeds.

CONCLUSION

The fruit of 'bitter kola' is a reasonably good source of ascorbic acid, though those suffering from diseases that could be affected by acid food should be wary of this fruit. Farmers should be advised that, for these fruits, though storage at 10°C preserves them longer, the traditional method is effective for short-term preservation to cut down cost. For 'bitter kola' seeds, the traditional method of storage is better and should be recommended, provided the period of underground preservation is not extended to the dry season, when the seeds lose enough moisture to change their texture and some even show signs of germination.

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