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Chemical composition of *Cola acuminata* and *Garcinia kola* seeds grown in Nigeria

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The proximate analysis and the determination of the minerals of *Cola acuminata* and *Garcinia kola* were carried out. Both types of seed have comparable values for dry matter, crude protein, ether extract and carbohydrate. High levels of crude fibre and total ash were observed in *Cola acuminata*. Mg, Na, K and P were higher in values in *Cola acuminata* and therefore can serve as a better source for such minerals. Cr was not detected in both samples. Pb was present in both samples probably as a result of environmental pollution. Since man does not require Pb in the body, consumers of the seeds should avoid large consumption of them. *Garcinia kola* substantially induces gastric acid secretion; it is therefore advisable that peptic ulcer patients should not eat *Garcinia kola* seeds.

Introduction

Kola, a member of the chocolate family sterculiaceae (from which nuts are obtained) (Encyclopedia Americana, 1988), has a long history in West Africa. Johannus Leo Africanus (Russel, 1955) was the first to refer to the kolanut in 1556.

The early records did not distinguish between the two commercial species of kola – *Cola nitida* (Ventenat) Schott and Endlicher, and *Cola acuminata* (Beauvoir) Schott and Endlicher (Opeke, 1982). The major centres for *C. nitida* for a long time were Sierra Leone, Benin Republic, Ghana and Côte d'Ivoire (Bontekoe, 1950; Nzekwu, 1961). By 1908, the cultivation of *C. nitida* had been firmly established in Nigeria. By the middle of the twentieth century, the cultivation of *C. nitida* had spread from its centre of origin westwards to the southern border of Senegal with Gambia, eastwards into Zaire and also overseas to the Caribbean islands (especially Jamaica) (Opeke, 1982). *C. acuminata* has its original area of distribution stretching from Nigeria to Gabon and it has been extensively planted in the southern part of Nigeria since 1912 (Longe, 1984a). *C. acuminata* also spread to other parts of West Africa. The estimated production of kolanuts in the major producing areas (1966 and 1976) is shown in Table 1. It must be noted that production increased by almost 24% between 1966 and 1976.

C. nitida is easily distinguished by its nuts of two cotyledons. There are colour varieties – white, red and pink. *C. acuminata* has three to six cotyledons. *C. nitida* is of more economic importance and farmers therefore grow more of *C. nitida* than of *C. acuminata* (Longe, 1984a). The main area of kola production in Nigeria is the rain forest zone lying within latitude 6–7°N (Longe, 1984b).

There are three distinct stages in the kola trade. These are the trade in unprocessed wet nuts, the bulk sale of processed nuts and the retail trade in both unprocessed and processed nuts. *C. nitida* is the kola of commerce and it features prominently in the three levels of trade in kola. *C. acuminata* is only of local importance especially among the Yoruba tribe of West Africa and again demonstrates the three stages of the kola trade (Opeke, 1982). Unprocessed

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Table 1. Estimated production of kolanuts in 1966 and 1976 (tonnes wet weight) (Opeke, 1982)

Country	1966	1976
Côte d'Ivoire	14 500	17 000
Guinea	4 342	5 500
Cameroun, Benin, Togo	11 000	13 000
Ghana	14 000	16 000
Sierra Leone	4 000	5 000
Nigeria	120 000	150 000
Liberia	4 000	5 000
South America	3 000	4 500
Total	174 842	216 000

nuts are sold in two forms. The nuts can be sold in the intact pods. This practice is very common among farmers with small quantities of kola and it is also common with *C. acuminata*. Nuts are also sold after they have been extracted from the pods before skinning. Unskinned nuts sell for a much higher price than nuts in the pods. Kola traders also prefer to buy unskinned nuts for bulk processing and storage. The main function of the primary kolanut buyers (apart from personal consumption) is processing and storage. After processing and storage (period indefinite, depending on price movements in the kola market) the primary kola buyers sell their graded nuts in bulk and in multiples of 100 to the secondary kola buyers who are itinerant kola traders (Opeke, 1982). At the processed kola market, the nuts are sold in bulk to the kola retailers or the kola exporters. The kola retailers buy such quantities as they can sell within 1–1½ months, after which they replenish their stock by buying more. Kola exporters deal in fresh nuts only for sale to countries within or neighbouring West Africa. Overseas markets demand dried kolanuts (Opeke, 1982).

Bitter kola (*Garcinia kola*) belongs to the family Guttiferae and genus garcinia. *G. kola* is native to South West African countries where it is found wild. It has not attracted the attention of plant breeders to put it to cultivation and improve the wild strain. However, the plant has gained recognition in West Africa, although it is not yet a crop of commerce (Fatunsi, personal communication, 1992). The *G. kola* seeds (nuts) are embedded in the centre of the fruit with some soft juicy pulp surrounding them. Between one and four seeds (nuts) are buried in each fruit. The nuts have a very bitter taste which attracts consumers (Fatunsi, 1992). When the fruits are harvested they are beaten to open them and packed in containers filled with water. The pericarp of the fruit will decay, releasing the seeds during the process. The seeds are then washed in the water to improve the pulp. They are stored in the basket lined with fresh leaves in just the same way as the common kola is stored.

The use of kolanuts, the major product of kola, is intimately interwoven with the various cultures of the peoples of West Africa. Kola has been used in many ways: industrial, local and traditional. The kola can be divided into three parts: the nut (seed), the pod and the testa. Industrially the kolanut is used (1) for the preparation of kola-type beverages, such as Coca-cola, Pepsi Cola, kola wine; (2) in the preparation of choca-cola, a type of chocolate containing cacao and kola powder in cocoa bufferfat; and (3) as a source of alkaloids (caffeine and threobromine) in pharmaceutical preparations (Opeke, 1982).

The use of kolanuts features prominently in religious, social and ritual activities of West Africa. They are used during ceremonies related to marriage, child naming, funerals and in sacrifices made to the various gods and goddesses of African mythology (Opeke, 1982). Kolanuts are traditionally used as masticatory agents for their stimulating effects. It has been claimed by kolanut consumers that kolanuts suppress hunger, thirst and sleep. It is a common custom among long distance drivers in Nigeria to chew considerable quantities of kolanuts en route. It is also said that kolanuts strengthen dental gums and suppress gout and related diseases (Opeke, 1982). Some of the nuts are used as a source of dye. The kola pod is used in making jams and preservatives as well as fertilizer and feeding stuff for animals. The pod husk, mixed with certain ingredients, is used in traditional concoctions to reduce pain. The following products are obtainable from kola testa: decaffeinated powder and kola chocolate; caffeine used in pharmaceutical and food preparations; tannins, food colours and dyes; fertilizer and feeding stuff (Ogutuga, 1975).

G. kola is a popular seed eaten on social and other occasions in most parts of Nigeria and West African countries and constitutes an

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important ingredient in medicinal preparations (Nwafor & Oghenecaga, 1992). The nuts are eaten raw as a stimulant to resist hunger and sleep. *G. kola* seeds are used for the treatment and management of cough and asthma (Nwafor & Ogheneaga, 1992). The stalk roots are used as a chewing stick and for medicinal purposes such as curing a cough.

Both *C. acuminata* and *G. kola* are eaten raw at any time of the day. Both are cherished by their consumers. It is the aim of this work to provide more information about the nutritionally valuable minerals of the two different nuts and their other contributions as food supplement.

Materials and methods

C. acuminata and *G. kola* were obtained from the market at Ayedun-Ekiti, Ondo State of Nigeria. The dried mature nuts (without testa) were ground in the laboratory before use. All chemicals used were of analytical grade.

Moisture, ash, ether extract (EE) and crude fibre (CF) were determined by the methods of the Association of Official Analytical Chemists (1990) while nitrogen was determined by the micro-kjeldahl method described by Pearson (1976) and the percentage nitrogen was converted to crude protein (CP) by multiplying by 6.25. The crude fibre was determined by the method of Southgate (1976) and carbohydrate was obtained by difference.

The minerals were analysed from solutions obtained by first dry-ashing the seeds at 550°C and dissolving the ash in flasks using distilled deionised water. Zinc, cobalt, manganese, calcium, iron, magnesium, sodium, potassium, copper, chromium and lead were determined by means of atomic absorption spectrophotometer (Pye Unicam Sp 9 Cambridge, UK) while phosphorus was determined colorimetrically by Spectronic 20 (Gallenkamp London, UK) using the phosphovanado molybdate method (AOAC, 1990). The data generated were analysed statistically (Steel & Torrie, 1960).

Results and discussion

The proximate composition of the samples varied depending on the sample, as shown in Table 2. For the *C. acuminata* the CP was 11.95%, CF was 14.80%, total ash was 3.95%,

Table 2. Proximate composition (%) of *Cola acuminata* and *Garcinia kola*

Parameter	*Cola acuminata* Mean	±SD	*Garcinia kola* Mean	±SD
Moisture	3.39	0.16	7.04	0.08
Dry matter (DM)	96.62	0.16	92.96	0.08
Crude protein (CP)	11.95	0.35	10.27	1.03
Total ash	3.95	0.07	1.23	0.25
Ether extract (EE)	15.72	0.69	18.93	0.38
Crude fibre (CF)	14.80	0.28	1.85	0.11
Carbohydrate	50.20	1.56	60.69	1.86

Means are for duplicate determinations.
±SD = standard deviation.

carbohydrate was 50.20% and EE was 15.72% while the results for *G. kola* were CP (10.27%), CF (1.85%), total ash (1.23%), carbohydrate (60.69%) and EE (18.93%). The dry matter (DM) for *C. acuminata* was 96.62% while DM for *G. kola* was 92.96%. The percentage of dry matter usually drops by about 5% during the first few weeks after harvest and then gradually rises depending on the conditions of storage (Van Eijnatten, 1966). Dried kolanuts have been analysed on various occasions (Table 3).

A look at Tables 2 and 3 will show that comparable results were obtained for kolanuts in the following parameters: carbohydrates, crude protein, total ash and fibre. The value for ether extract is substantially different in the two different tables; this may be due to their different sources and extraction methods. It should also be noted that 16% of the dry matter was left unaccounted for in Table 3.

Table 3. Chemical analyses of kolanuts. Contents expressed in percentage of dry matter

Parameter	*Chevalier & Perrot (1911)*	*Opeke (1982)*
Cellulose (fibre)	9.00	8.10
Carbohydrates	53.10	52.40
Fats	1.60	1.60
N-containing substances	10.80	11.10
Tannins	3.90	4.40
Ash	3.50	3.40
Caffeine	2.50	3.20
Total	84.40	84.20

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Observation of Table 2 shows that both *C. acuminata* and *G. kola* have very low moisture content, which is good for their long preservation since it will prevent early spoilage. It is also beneficial to the buyers of both *G. acuminata* and *G. kola* since most sellers sell by volume and not by weight. The CP for the two samples is about the same in value. The CF is relatively high in *C. acuminata* whereas it is relatively low in *G. kola*. Vegetable and fruit fibre have been found to have hypocholesterolemic properties (Selvendran *et al.*, 1979), hence *C. acuminata* may be exploited for this purpose. *C. acuminata* and *G. kola* are high in carbohydrates. Carbohydrates are quick sources of energy and are also needed in the diet to ensure efficient oxidation of fats (Mudambi & Rajagopal, 1983). The ether extract in both samples is relatively high and, since it may contain essential oils (Adeyeye, 1989), it could be an additional source of such oils in the diet.

Interest in the physiologically active agents in kolanuts led to the identification of alkaloids. It is considered that in fresh kolanuts an unstable complex occurs as kolatin (a tannin) and caffeine glycosides. This complex oxidises and hydrolyses to form kola-red and free caffeine under the influence of enzymes, when the nuts are drying out. If these enzymes are inactivated prior to drying the seeds, for instance with heat treatment, then this process does not occur and the dried seeds are said to retain their physiological action. It has, however, been stated that the caffeine occurs partly free and partly in the above-mentioned complex (Boelman, 1940; Chevalier & Perrot, 1911; Mascre & Paris, 1946). The tannoids (kolatin) is 5–10% kola and it is made up of catechol and epicatechol (Trease & Evans, 1983). The caffeine (1, 3, 7-trimethylxanthine) content of kolanuts ranges from 1.50 to 3.20% of the dry weight. In addition kolanuts contain very small quantities of the alkaloids threobromine (3, 7-dimethylxanthine) which ranges from 0.02 to 0.08% (Chevalier & Perrot, 1911; Paula, 1938) and theophylline (1, 3-dimethylxanthine). Chemically, these alkaloids closely resemble metabolically important compounds such as the purines, xanthine and uric acid (Graham, 1978).

Pure caffeine is odourless, has a distinctly bitter taste and is stable at the temperature, PH and salt concentrations normally encountered in food processing (Graham, 1978). There are no significant uses of caffeine other than in food and drugs. As normally ingested from food sources, caffeine produces a variety of biological effects that are listed in Table 4. The number of known effective and safe stimulant compounds is small in relation to many well known depressant compounds. Thus, caffeine is widely used for its stimulant properties in dietary beverages, in self-medication with over-the-counter drugs, and in a number of prescription drugs containing a combination of acetylsalicylic acid, phenacetin and caffeine and in Darvon (Graham, 1978). It and related methylxanthines serve a number of specific medicinal purposes as listed in Table 5. Definitive tests have shown that caffeine is not adaptive, i.e. regular consumption does not diminish its stimulant effects. However, caffeine-withdrawal headache is well documented. Double blind experiments showed that caffeine was effective in preventing attention lapses after the first hour and the effect persisted for 2–3 hours. The subjects also felt more alert and physically active. Performance of physical tasks, particularly ones involving speed, improved; but there was no demonstrable effect on objectively measured intellectual performance (Stephenson, 1977); Select Committee on GRAS Substances,

Table 4. Biological effects of caffeine (Graham, 1978)

Diuretic
Cardiac muscle stimulant
Central nervous system stimulant
Smooth muscle relaxant
Stimulates gastric acid secretion
Elevates plasma free fatty acids and glucose
Pharmacologically active dose 200 mg
Probably not mutagenic for man

Table 5. Pharmacological uses of caffeine and related compounds (Graham, 1978)

Desired action	*Preferred compound*
Cerebral stimulation	Caffeine
Coronary dilation	Theophylline
Diuresis	Theobromine
Respiratory stimulant for premature infants	Caffeine

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1976). High levels of caffeine may clearly become toxic (Graham, 1978). The possible relationship between caffeine and the pathogenesis of peptic ulcers has long been debated. Stimulation of gastric secretion by caffeine has been shown with several experimental animals and with human subjects in single experiments. A variety of feeding studies, however, have failed to establish a clear-cut cause and effect relationship between caffeine ingestion and induction or exacerbation of peptic ulcer (Select Committee on GRAS Substances, 1976).

It has been shown by Fraser *et al.* (1976) that sex, kolanut consumption, haemoglobin concentration in women and height in men were statistically significant predictors of antipyrine half-life. Half-life was shorter in women, decreased with an increase in height in men, and was prolonged by kolanut consumption.

Nwafor & Ogheneaga (1992) carried out a study to determine the nature of acid secretion effect of *G. kola* on albino rats. They found that *G. kola* significantly induced gastric acid secretion. They therefore suggested that consumption of large quantities of *G. kola* in man may lead to stimulation of copious secretion of gastric acid. Since increased acid secretion is associated with peptic ulceration, it seems likely also that *G. kola* might increase the incidence of peptic ulcer in subjects who consume large quantities.

The mineral contents of *C. acuminata* and *G. kola* are shown in Table 6. The major elements determined were Ca, Na, K, Mg and Fe. Other trace elements determined were Zn, Co, Mn, Cu and Cr. The determination of Pb is to screen for environmental pollution. Phosphorus was also determined. Sprecher Von Bernegg (1934) studied the mineral composition of kolanuts and the average contents of the various important minerals are listed in Table 7. Table 6 shows that the highest mineral concentrations are Na, K and P in that order in both *C. acuminata* and *G. kola*. The metals Mg, Ca and Fe occupy equivalent positions in the two samples. The same values were recorded for Cu in both samples. Co (0.15 mg/kg) is the least in *C. acuminata* but Co shares the same position with Cu as the least (0.33 mg/kg) concentrated in *G. kola*. Cr was not detected in either sample. On a comparative basis *C. acuminata* is a better source for the following elements: Zn, Ca, Mg, Na, K, Fe and P whereas *G. kola* is a better source for Co and Mn.

Table 6. Mineral composition (mg/kg) of *Cola acuminata* and *Garcinia kola*

Parameter (mineral)	*Cola acuminata*		*Garcinia kola*	
	Mean	*±SD*	*Mean*	*±SD*
Zn	0.60	0.15	0.43	0.03
Co	0.15	0.01	0.33	0.02
Mn	0.50	0.02	0.67	0.01
Ca	3.57	0.21	2.62	0.01
Mg	14.68	0.16	5.53	0.21
Na	202.50	0.35	67.50	0.32
K	87.00	0.07	21.60	0.04
Fe	2.50	0.01	1.56	0.10
Cr	ND	–	ND	–
Cu	0.33	0.00	0.33	0.01
Pb	2.66	0.20	2.33	0.10
P	53.00	1.53	31.67	0.22

Means are for duplicate determinations.
±SD = standard deviation.
ND = not detected.

Both Ca and Mg are chiefly found in the skeleton. In addition to its structural role, Mg also activates enzymatic processes. Na and K control water equilibrium levels in body tissues and are also involved in the transport of some non-electrolytes. Fe is an essential component in the transfer of oxygen (a component of cytochromes) and is the element most closely associated with anaemia. Cu, Co, Zn and Mn have been associated with enzyme systems, particularly oxidation processes. Co is present in vitamin B12 while Cr plays an important part in carbohydrate metabolism, together with insuline (Crosby, 1977). Manganese activates enzymes involved in the transfer of phosphate and hydroxyl groups as well as some dehydrogenation reactions.

Results in Table 6 show a favourable comparison with those in Table 7 on the basis of

Table 7. Mineral content of kolanuts in percentages of dry matter (Sprecher Von Bernegg, 1934)

Parameter	*Congo*	*Guinea*	*Nigeria*
N	1.31	2.09	1.32
P	0.15	0.20	0.10
K	0.92	1.47	1.01
Ca	0.09	0.08	0.07
Mg	0.20	0.27	0.21

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concentration trends. Results in Table 6 show that both *C. acuminata* and *G. kola* are rich in most of the essential minerals and could therefore serve as additional sources of such minerals. Table 6, when related to the daily requirement of minerals (Table 8), shows that *C. acuminata* and *G. kola* could serve as good supplementary sources for such essential minerals in the diet. In village communities, mangoes and guavas are eaten locally as fresh fruit throughout the fruiting season. Comparisons of Tables 2, 6 and the analytical results for mangoes and guavas (Table 9) show that *C. acuminata* and *G. kola* are better sources of protein, fat, fibre, total ash and carbohydrate than mangoes and guavas but that both mangoes and guavas are better sources of supplementary water, phosphorus, iron, calcium and potassium. However, many mangoes and guavas are wasted through spoilage and early harvesting in conditions where adequate marketing and processing facilities are not available (Food and Agriculture Organization of the United Nations, 1990), hence they are usually available only for a short period.

The quantity of Pb in *C. acuminata* is 2.66 mg/kg while it is 2.33 mg/kg in *G. kola*. The Pb concentration looks high in the two samples and it is an indication of an onset of Pb pollution in Nigeria (Mombeshora *et al.*, 1983). The source of this problem is the use of leaded gasoline and Nigeria is still one of the countries using high levels of tetraethyl lead as an anti-knock agent in gasoline (Osibanjo & Ajayi, 1980). Pb is known to inhibit active transport mechanisms involving adenosine triphosphate (ATP), to depress the activity of the enzyme

Table 8. Daily requirement (mineral) adults (Bogert *et al.*, 1973)

Name of mineral	*Amount*
P	0.8 g
K	2.5 g
Ca	0.89 g
Mg	0.36 g
Na	2.5 g
Fe	11.2 mg
Zn	6.23 mg
Cu	2 mg
Mo	0.102 mg
Mn	6.79 mg

Table 9. Nutrient composition of mango (edible portion) (Watt & Merrill, 1963) and guava (Wenkam & Miller, 1965). Values per 100 g

Parameter	*Mango*	*Guava*
Water (%)	81.7	84.35
Protein (g)	0.7	0.28
Fat (g)	0.4	0.1
Total carbohydrate (g)	16.8	14.79
Fibre (g)	0.9	2.38
Ash (g)	0.4	0.48
Calcium (mg)	10	14.6
Phosphorus (mg)	13	15.5
Iron (mg)	0.4	0.29
Sodium (mg)	7	ND
Potassium (mg)	189	ND

ND = not determined.

cholinesterase, to suppress cellular oxidation-reduction reactions, and to inhibit protein synthesis (Waldron & Stofen, 1974). Efforts should therefore be more seriously pursued by the Federal Environmental Protection Agency (FEPA) to reduce or completely eliminate Pb in our environment since it is damaging to human physiological processes.

The potential commercial uses of kola

Soreat (1971) had proposed a combination of naturally occurring amino acids (essential and non-essential) and a fresh stabilised kolanut extract. The proposed composition afforded food products containing 0.50 and 4.00% essential or non-essential amino acids and 0.40–5.00% freshly stabilised kolanut extract (which contains 2.00–15.00% caffeine) which can be in the form of syrups, pellets or powders and can be added to soda water, soluble coffee powders etc.

Two condensed proanthocyanidins have been isolated from the fresh fruit of *C. acuminata*. Condensed proanthocyanidins are colourless substances consisting of two C_{15} units which on warming with mineral acid are split into an anthocyanidin and another flavonoid (Karl & Klans, 1965).

Many plants produce substances to discourage insects from feeding on them; these include toxins and bitter-tasting substances. Nathanson (1984) found that tea leaves and coffee grounds incorporated in the food of

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tobacco hornworm larvae inhibited their feeding and caused hyperactivity, tremors and stunted growth. Nathanson (1984) found that purified methylxanthines (obtained from seeds and leaves of tea, coffee, cocoa and kola) showed similar effects. In vertebrate animals, methylxanthines are known to inhibit phosphodiesterase (PDE) enzymes, which are involved in the vital cyclic adenosine monophosphate (AMP) pathway by inhibiting the breakdown of cyclic AMP. Nathanson (1984) suggests that methylxanthines (which may be obtained from kolanuts, etc.) or other PDE inhibitors could find uses in pest control as synergists.

Conclusion

The findings of this study suggest that both *C. acuminata* and *G. kola* have comparable nutritionally valuable minerals. Their proximate compositions have better values when compared to values obtained for mangoes and guavas. The Pb values in the two samples must have been due to environmental pollution, although the obtained values (2.33–2.66 mg/kg) are not easily consumed and the tolerance level of Pb (0.43 mg/day) (WHO, 1974) cannot be reached by consumers since consumption is very casual. The high crude fibre concentration in the *C. acuminata* could be advantageous since it may possess hypocholesterolemic properties. Stimulation of gastric secretion has been reported for both samples and since this might increase the incidence of peptic ulcer, large quantities of the samples should not be consumed and ulcer patients should avoid consumption altogether. Reduced consumption will also reduce Pb consumption from this source. *G. kola* possesses many properties common to kolanuts in terms of traditional use, taste and components. It can be still further exploited for more useful applications.

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