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Assessment of Nutritional and Bioactive Components of Garcinia kola Chips

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Abstract
Garcinia kola otherwise known as bitter kola has been used in traditional African medicine for centuries, and is considered to have many beneficial properties. The study was aimed at assessing the nutritional and bioactive components of bitter kola chips. Freshly harvested seeds of Garcinia kola were purchased from local markets in Ado Ekiti, Nigeria. The seeds were thoroughly washed with clean water, de-husked, sliced and fast-dried at room temperature under high air current, to obtain bitter kola chips. The dried bitter kola chips were ground into fine powder using an electric blender. The fine powder was then analysed for its proximate, minerals, vitamins, phytochemicals and essential oil content. The results showed low moisture content (8.47 %), moderate levels of protein (12.7 %), fat (6.27 %), ash (7.47 %) and crude fibre (6.27 %), as well as very high levels of carbohydrate (58.77 %) and metabolizable energy (3000 Kcal/Kg). The micronutrients present in bitter kola consists of Fe^{2+}, Zn^{2+}, Mg^{2+}, Ca^{2+}, K^{+}, PO^{3-}, ascorbic acid, thiamine, niacin, and riboflavin at concentrations of 9.37, 0.23, 23.33, 238.33, 26.67, 323.33, 18.23, 0.27, 0.13 and 0.60 mg/100g respectively. The bitter kola chips contained high levels of alkaloids (628.33±10.41 mg/100g), saponins (161.67±7.64 mg/100g), and tannins (233.33±7.64 mg/100g); moderate levels of flavonoids (58.33±5.41 mg/100g), phytates (63.33±2.89), oxalates (90.00±5.00) and oxygen radical absorption capacity (13.23±0.25); while the anti-protease activity and cyanogenic glycosides levels were very low. GCMS analysis of the oil components of G. kola chips showed the presence of molecules such as Trichloroacetic acid, Ar-tumerone, Tumerone, which are of significant importance to human health. Sensory evaluation showed high preference for the bitter kola chips than the fresh seeds.
Key words: *Garcinia kola chips, nutrition, phytochemicals.*

INTRODUCTION

Garcinia kola is a species of flowering plant in the Clusiaceae family, having its natural habitat in subtropical or tropical moist lowland forests. *Garcinia kola* plant is an evergreen tree that can grow up to 30 metres tall (Fern, 2014). The fruit, seeds and bark of the plant have been used for centuries in folk medicine to treat ailments ranging from coughs to fever. The seeds have been found useful in treating bronchitis, throat infections, colic, head or chest colds, and cough (Iwu *et al*., 1999; Fern, 2014). There is high demand for the seeds, without ethnicity or religious bias, sold in local markets and occasionally exported to ethnic populations living abroad. The seeds have a bitter taste, followed by a slight sweetness when consumed (Burkil, 2004; Fern, 2014).

The use of medicinal plants in the treatment and management of human health is gaining prominence globally, especially in developing countries as a cost effective and their relative availability associated with few and transient side effect (Pandey *et al., 2*011; Sofowora *et al*., 2013; Okiki *et al*., 2022). Therapeutic and pharmacological active compounds are abundantly present in most medicinal plants; these compounds may act independently or in synergy to improve human health. Some of these compounds found in the plants are alkaloids, flavonoids carbon compounds, hydrogen, nitrogen, glycosides, essential oils, fatty oils, resins, mucilage, tannins, gums and others (Igbinosa et al., 2013; Kovarovič *et al*., 2017; Okiki *et al*., 2021).

These plants are believed to prevent, delay or manage various diseases or illness and their associated complications via different mechanisms which could be established through their antioxidative, antimicrobial, anti-inflammatory, hypoglycaemic, anticancer, hypolipidemic, hypocholesterolemic, cytotoxic activities as well as their ability to inhibit or slow the formation of free alkyl radicals, serve as metal chelators, singlet oxygen quenchers, scavenge free radicals and inhibit the activities of α-amylase and α-glucosidase (Lee *et al*., 2004; Kumar *et al*., 2011; Tamokou *et al***.,** 2013; Yin *et al*., 2014; Ashraf *et al*., 2015; Al-Dhabi *et al.,* 2015; Okiki *et al.,* 2022). *Garcinia kola* is one of such plants that has been used extensively in traditional medicine and as food (Okwu, 2005; Okiki *et al*. 2015). This study was aimed at producing bitter kola chips for export and to evaluate the nutritional and bioactive components.

MATERIAL AND METHODOLOGY

Collection of samples and processing of *Garcinia kola* seeds chips:

Garcinia kola seeds (Plate 1) were purchased from retailers in markets in Ado Ekiti, and authenticated at the Department of Botany, Ekiti State University, Ado-Ekiti, Nigeria.

Bitter kola seeds were washed, peeled, sliced, dehumidified, decontaminated under UV-light and packaged as bitter kola chips (Plate 2).

Plate 1: Bitter kola seeds

Plate 2: Packed bitter kola chips

Analysis of bitter kola chips

The dried bitter kola chips were ground into fine powder using an electric blender. The fine powder was then analysed for the proximate, minerals and vitamins, phytochemicals and essential oil content of bitter kola chips. Fresh bitter kola seeds were equally analysed and served as control.

Analysis for nutritional compositions

Proximate analysis was carried out on the powdered *Garcinia kola* to determine the presence of moisture, protein, ether extract (fat), ash, crude fibre and carbohydrate using standard analytical methods as described by AOAC (2012). Minerals and vitamin such as iron, zinc, magnesium, calcium, potassium, phosphate, ascorbic acid, thiamine, niacin and riboflavin contents of *Garcinia kola* were determined using methods described by Marcano and Hasenawa (1991).

Analysis of phytochemicals, antioxidant and anti-protease components of *Garcinia kola*

Quantitative analyses were carried out for phytochemicals, antioxidant and anti-protease components of pulverized Garcinia kola chips following the methods described by Harbone (1998) and Mayuri (2012).

GC-MS analysis of essential oil of *G. kola*

Oil was extracted from the fine powder of bitter kola using N-Hexane as solvent. Gas Chromatography Mass Spectroscopy (GC-MS) analysis was performed on the extracted oil using a QP2010 mass spectrometer fitted with a GC-17A gas chromatograph (Shimadzu; Kyoto, Japan).

Sensory analysis

The bitter kola chips produced were evaluated by a trained panel consisting of ten lecturers and ten students of the Department of Biological Sciences, ABUAD. The bitter kola chips were tested for texture and taste, in comparison with fresh bitter kola seeds (Géci *et al., 2017*)

Statistical analysis

All data were expressed as mean ± Standard deviation. The quantitative values of the chemical constituents of the bitter kola chips were compared with those of fresh bitter kola seeds by Chi square statistic using the IBM SPSS window 20.

RESULTS

The results showed that bitter kola chips possess high levels of carbohydrate (12.7±0.15%) and metabolizable energy (3000.00±2.55 Kcal/Kg); moderate amounts of protein (12.7±0.15%), fat (6.27±0.21%), ash

(7.47±0.15%) and crude fibre (6.27±0.15%); as well as low level of moisture (8.47±0.15%). Fe^{2+}, Zn^{2+}, Mg^{2+}, Ca^{2+}, K^{+}, PO_4^{3-}, ascorbic acid, thiamine, niacin, and riboflavin were present in appreciable quantities in bitter kola chips (Table 1). The nutritional compositions of the bitter kola chips were significantly higher than those of fresh bitter kola seeds. However, the fresh bitter kola seeds have significant higher contents of ascorbic acid, niacin and moisture than bitter kola chips ($p \leq 0.05$).

Table 1: Comparative nutritional compositions of bitter kola chips and seeds

Analyte	Bitter kola Chips	Fresh bitter kola seeds
Moisture (%)	8.47±0.15[a]	52.27±0.15[b]
Protein (%)	12.7±0.15[a]	3.53±0.21[b]
Fat (%)	6.27±0.21[a]	0.63±0.06[b]
Ash (%)	7.47±0.15[a]	2.13±0.12[b]
Crude fibre (%)	6.27±0.15[a]	2.90±0.10[b]
Carbohydrate (%)	58.77±0.65[a]	38.53±0.32[b]
Metabolizable Energy (Kcal/Kg)	3000.00± 2.55[a]	1739.10±3.18[b]
Fe^{++} (mg/100g)	9.37±0.21[a]	3.56 ±0.25[b]
Zn^{++} (mg/100g)	0.23±0.06[a]	0.13 ±0.01[b]
K^{+} (mg/100g)	26.67±2.89[a]	12.34 ±1.78[b]
PO_4^{3-} (mg/100g)	323.33±2.89[a]	301 ±4.23[a]
Ascorbic Acid (mg/100g)	18.23±0.15[a]	32.23 ±1.67[b]
Thiamin (mg/100g)	0.27±0.06[a]	0.05 ± 0.01[b]
Niacin (mg/100g)	0.13±0.06[a]	1.37 ±0.02[b]
Riboflavin (mg/100g)	0.60±0.10[a]	0.07 ±0.01[b]

[a,b]Values along rows with different superscripts are significantly different ($p \leq 0.05$)

The bitter kola chips contained high levels of alkaloids (628.33±10.41 mg/100g), saponins (161.67±7.64 mg/100g), and tannins (233.33±7.64 mg/100g); moderate levels of flavonoids (58.33±5.41 mg/100g), phytates (63.33±2.89), oxalates (90.00±5.00) and oxygen radical absorption capacity (13.23±0.25); while the anti-protease activity and cyanogenic glycosides levels are very low.

Table 2: Comparative phytochemicals, antioxidant and anti-protease contents of bitter kola chips and seeds

Analytes	Bitter kola chips	Fresh bitter kola seeds
Alkaloids (mg/100g)	628.33 ± 10.41[a]	681.67 ±12.34[a]
Cyanogenetic Glycosides (mg/100g)	0.05 ±0.01[a]	0.05 ±0.01[a]
Phytates (mg/100g)	63.33 ± 2.89[a]	71.21±4.43[a]
Tannins (mg/100g)	233.33 ± 7.64[a]	351.67±13.21[b]
Saponins (mg/100g)	161.67 ± 7.64[a]	363.33±17.76[b]
Oxalates (mg/100g)	90.00 ± 5.00[a]	102.43±7.37[b]
Total Flavonoids (mg/100g)	58.33 ± 5.41[a]	210.00±19.56[b]
Anti-Protease Activity (mg/100g)	0.43 ± 0.06[a]	0.98 ±0.03[b]
Oxygen Radical Absorption Capacity (% Inhibition)	13.23 ± 0.25[a]	51.73 ±3.10[b]

[a,b]Values along rows with different superscripts are significantly different ($p \leq 0.05$)

The result of GCMS analysis of oil component of bitter kola is represented in Figure 1, and Table 3. Twelve major peaks were obtained in the spectra (Figure 1). The major compounds identified were Trichloroacetic acid, Ar-tumerone, Tumerone, beta-d-Lyxofuranoside, 1-Hexadecanol; 3-Eicosene and Oleic Acid among others (Table 3).

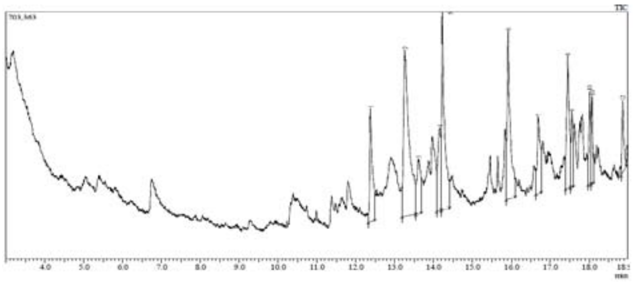

Figure 1: Spectra of GC-MS analysis *of Garcinia kola* oil

Table 3: Composition of oil extracted from bitter kola as revealed by the GC-MS analysis

Peak#	R.Time	Area %	Height %	Name	Formula
1	12.376	7.63	8.60	Trichloroacetic acid, tetradecyl ester	$C_{16}H_{29}Cl_3O_2$
2	13.257	23.84	12.57	Ar-tumerone	$C_{15}H_{20}O$
3	13.610	5.41	4.18	Tumerone	$C_{15}H_{22}O$
4	14.156	6.77	6.26	beta.-d-Lyxofuranoside, O-nonyl-	$C_{14}H_{28}O_5$
5	14.229	14.41	14.99	1-Hexadecanol	$C_{16}H_{34}O$
6	15.917	12.70	12.71	3-Eicosene, (E)-	$C_{20}H_{40}$
7	16.692	6.03	5.82	Cyclic octaatomic sulfur	S_8
8	17.453	8.81	10.01	Oleic Acid	$C_{18}H_{34}O_2$
9	17.561	3.78	5.71	8,11,14-Eicosatrienoic acid, (Z,Z,Z)-	$C_{20}H_{34}O_2$
10	18.014	3.95	6.69	5,8,11,14-Eicosatetraenoic acid, methyl ester, (all-Z)-	$C_{21}H_{34}O_2$
11	18.076	3.22	6.69	2H-Pyran, 2-(7-heptadecynyloxy)tetrahydro	$C_{22}H_{40}O_2$
12	18.865	3.45	5.41	Pentafluoropropionic acid, heptadecyl ester	$C_{16}H_{27}F_5O_2$
Total		**100**	**100**		

The sensory perception of bitter kola chips

All the panellists showed high preference for the bitter kola chips to the fresh seeds; most importantly with respect to taste.

DISCUSSION

The moisture content of fresh bitter kola seeds was more than six times higher than the chips. High moisture contents in leaves and seeds of medicinal plants make them highly perishable and susceptible to microbial spoilage during storage. The relatively low moisture content in *G. kola* chips in this study was within the expected range, and would prevent the growth of microorganisms and therefore prolong its storage/shelf life (Gqaza *et al*., 2013).

Dietary proteins are important for natural synthesis and maintenance of body tissues, enzymes and hormones as well as other substances required for healthy functioning (Hayat *et al*., 2014). The protein value obtained suggests that *G. kola* chips can effectively contribute to the daily protein needed. Plant food that provides more than 12 % of its caloric value from protein is considered a good source of protein (Gqaza *et al*., 2013).

A diet providing 1–2 % of its caloric of energy as fat is said to be sufficient to human beings as excess fat consumption is implicated in certain cardiovascular disorders such as atherosclerosis, cancer and aging. The ether extract (Fat) content of bitter kola chips reported in this study is very moderate. Dietary fats function in the increase of palatability of food by absorbing and retaining flavours (Antia *et al*., 2006).

High ash content in food is a measure of high deposit of mineral contents (Akpabio and Ikpe, 2013). The value obtained in this study suggests that the *G. Kola* chips are rich in mineral elements. Although crude fibre has little nutritional value, all the same, adequate intake of dietary fibre can lower the serum cholesterol level and aids absorption of trace elements in the gut as well as reduced the risk of coronary heart disease, diabetes, constipation, hypertension, colon and breast cancer (Gqaza *et al*., 2013; Hayat *et al*., 2014; Asuk *et al*., 2015). The fibre content of *G. kola* in this study was adequate in relation to diet.

Generally, carbohydrates add to the bulk of the diets, they play a pivotal role as they provide energy to cells such as brain, muscles and blood. They contribute to fat metabolism and spare proteins as energy source and act as mild laxative for human beings (Eze and Ernest, 2014). The carbohydrate content of *G. kola* chips was very high and suggests that the chips could be a good supplement as well as a source of energy (Adesuyi *et al*., 2012). The contribution of energy from seeds is important, since sufficient supply of energy in the diet is required for protein to be fully utilized. The high calorie content of *G. kola* can contribute significantly to the daily caloric requirement of the body (Akpabio and Ikpe, 2013).

Fe^{2+} is essential for the synthesis of haemoglobin and myoglobin, its deficiency results could in anaemia. To prevent anaemia and other related diseases in infants, pregnant and nursing women as well as elderly people, diet rich in Fe should be taken regularly. Added to this, Fe also plays a pivotal role in immune function, cognitive development, temperature regulation and energy metabolism (Asuk *et al*., 2015). Zinc is crucial for the production of carbonic anhydrase and insulin in the body. The zinc content of *G. kola* is an indication that it can play an important role in the management of diabetes, which results from deficiency in insulin secretion, insulin action or both (Okwu, 2005).

The results of the analyses of the mineral profiles of *G. Kola* seeds reveals that the chips are rich source of mineral elements with abundance of Fe^{2+}, Mg^{2+}, Ca^{2+}, K^{+} and $PO4^{-3}$. The K^{+}, Mg^{2+} and Ca^{2+} levels compare favourably to most values reported for medicinal plants in literatures. K^{+} is very important in regulation of water and electrolyte balance and acid-base balance in the body, as well as responsible for nerve action and functioning of the muscles. Deficiency of potassium leads to muscle paralysis (Akpabio and Ikpe, 2013). Mg^{2+} is required in over 300 enzymes that use adenosine triphosphate. It contributes to DNA and RNA synthesis during cell proliferation. It is also important for nerve and heart function as well as release of insulin and ultimate insulin action on cells. It decreases blood pressure by dilating arteries and preventing abnormal heart rhythm. Deficiencies in animals lead to irritability, convulsion and even death. In like manner, Ca^{2+} along with PO_4^{-3} is required for formation and maintenance of bones and teeth. It is also required in blood clotting and muscle contraction (Asuk *et al*., 2015).

The results obtained for the selected vitamins, namely ascorbic acid, thiamine, niacin and riboflavin are in agreement with that previously reported for *G. Kola* (Okwu, 2005). Vitamins are essential in the body as their deficiencies affect metabolism in the body. Ascorbic acid is an excellent antioxidant and free radical scavenger, capable of protecting the cells from oxidative damage by oxidants. It's required for connective tissue metabolism especially the scar tissues, bone and teeth. Added to this, it prevents scurvy and enhances iron absorption from the intestine (Gafar and Itodo, 2011).

Thiamin is an essential nutrient for humans, its deficiency causes beriberi, which disturbs the central nervous and circulatory systems (Ahn *et al*., 2005). Niacin and riboflavin, though in trace amount are important for the body metabolism. Niacin prevents pellagra. Riboflavin is unique among the water-soluble vitamins; riboflavin deficiency has been implicated as a risk factor for cancer, although this has not been satisfactorily established in humans (Powers, 2003; Okwu, 2005).

The *Garcinia* kola chips were found to possess alkaloids, cyanogenetic glycosides, phytates, tannins, saponins, oxalates, total flavonoids in appreciable quantities and satisfactory value of oxygen radical absorption capacity (ORAC), free radical destroying or neutralising power) The tannins, saponins, oxalates, total flavonoids and ORAC contents of bitter kola chips were significantly lower than the fresh bitter kola seed; however, there was no significant difference in the alkaloids, cyanogenetic glycosides and phytates contents of the two.

Phytochemicals possess biological functions which include anti-inflammatory, antioxidative, antiviral, and anti-carcinogenic properties (flavonoids). Some act as pain relievers and tranquilizers (alkaloids) while some confer protection against platelet aggregation and oxidative damage as a result of free radicals (Adesuyi *et al*., 2012; Okwu, 2005). The anti-protease activities of the chips were very low compared to that of fresh seeds, indicating that the chips will have less interference with digestive enzymes when consumed.

Many of these biomolecules of the oil components of bitter kola have been suggested to be useful as anti-inflammatory, immune-stimulant, antitumour, antioxidant and flavour enhancers in cosmetic production. Ar-tumerone has been reported in microglia activation, a property that can be employed in treating neurogenerative diseases (Hucklenbroich *et al*., 2014). Trichloroacetic acid is useful in cleansing of dead skin cells to reveal newer and smoother skin layer below and have been employed in topical applications in dermatological cases. Oleic acid is a fatty acid that occurs naturally in various animal and vegetable fats and oils. Small amounts of oleic acid are used as an excipient in pharmaceuticals, and it is used as an emulsifying or solubilizing agent in aerosol products (Smolinske, 1992). Knowing consumer's behaviour, his/her preferences and reactions provide company with better chance to establish itself in trade (Géci *et al*., 2017). All the panellists showed high preference for the bitter kola chips to the fresh seeds; most importantly with respect to taste.

CONCLUSION

The various results obtained in this study demonstrate that *Garcinia kola* could contribute immensely towards meeting human nutritional requirement for normal growth and development if taken as a supplement as well as offer adequate protection by preventing or delay oxidative stress/damage that has been implicated in the pathogenesis of various diseases or illness. Furthermore, because of its active bioconstituents which could offer immunomodulatory activities, *Garcinia kola* chips/ seeds could also be explored in the production of immunoprophylactic drugs in disease prevention.

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Conflict of Interest

The authors declared no conflict of interest.

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