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Review Article

The Emerging Nutricitical Benefits of the African Wonder Nut (Garcinia Kola Heckel): A Review

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ABSTRACT

Garcinia kola also called bitter kola and African wonder nut has been shown to contain vitamins, minerals, proteins and carbohydrates in varying quantities and phytochemicals such as alkaloids, flavonoids, tannins, cyanogeinic glycosides, saponins among many others that give its characteristics nutritional and pharmaceutical properties. The use of *Garcinia kola* as a nutritional plant will depend on the nutritive value of the seed and other parts, its overall effect on animals performance and human health as well as market forces affects on its demand and supply. This Paper reviews published data on the nutritive and pharmaceutical values of *Garcinia kola* as it affects the health and performance of human beings and animals.

Keywords: Emerging Nutricitical, African Wonder, Garcinia Kola

INTRODUCTION

New initiatives in the livestock and pharmaceutical industries are seeking to promote the use of alternative materials that combine the effects of nutritional and medicinal properties, simultaneously. This is expected among others benefits to reduce the high cost of production in the livestock industry as a result of the reduction in dual costs of feed and drugs. One important component of this approach is to research into indigenous fruit trees or plants that possesses both nutritional and medicinal properties. While a lot of research attention has been paid to the pharmaceutical benefits of these plants, little attention has been paid to their potential as feed ingredient in the livestock industry, although research has been carried out to

assess the nutrient compositions of some of them. Earlier studies at our station have shown that leaves from *Alchornia cordifolia* (Udedibie and Opara, 1998) and *Azadirchta indica* (Esonu *et al*., 2005; Obikaonu, 2009) could be of value in poultry diets.

Garcinia kola (bitter kola) also known as African wonder nut belongs to the family *guttiferae* and grows in coastal rainforests in the South-Western and South-Eastern parts of Nigeria. Traditionally, the nuts of *Garcinia kola* are chewed as masticatory substance to stimulate the flow of saliva (Leakey, 2001). The kernels of the nuts are widely traded and eaten as a stimulant (Omode *et al*., 1995; Leakey, 2001). *Garcinia kola* is also highly valued because of its medicinal benefits (Hertog *et al*., 1993). The nuts are chewed for aphrodisiac effect or used to cure cough, dysentery or chest cold in herbal medicine (Irvine, 1961).

This review seeks to aggregate current information on the characteristics of *Garcinia kola* both as a nutritional and medicinal plant of emerging importance.

Taxonomy of *Garcinia kola*

Bitter kola known as *Garcinia kola heckel* is scientifically classified as follows:

Kingdom: *Plantae*
Division: *Magnoliophyta*
Class: *Magnoliopsida*
Order: *Theales*
Family: *Clusiaceae or guttiferae*
Genus: *Garcinia*
Species: *G. kola*
Binomial name: *Garcinial kola, Heckel.*

About 400 species of *G. kola* are found in tropical regions especially in Asia and in South Africa (Mabberly, 1987). Some of these species are: *Garcinia cambogia, gaudichaudii, hanburyi, huillensis, indica, kola, latissima, mangostana, morella, oliveri* and *polyantha.* Other species of *Garcinia* found in Nigeria as well as generally across the humid low land plains of West Africa extending from Sierra Leone to Zaire according to Vivian and Faure (1996) and Angola (Keay,1989) include; *Garcinia livingstonei, gnetoides, standtii, smeath emanii, ovalivolia, brevipediellata* and *manni*

Origin and distribution of *Garcinia kola*

Bitter kola has also been recognized as an indigenous medicinal plant found in rain forest of central and western Africa, especially Benin, Cameroon, Democratic Republic of Congo, *Cote d'Ivoire*, Gabon, Ghana, Liberia, Nigeria, Senegal and Sierra Leone. Its natural habitat is thus the subtropical or tropical moist lowland forests. It is usually found in the coastal areas and low land plains up to 300 m above sea level with an average of 2500 mm of rainfall per annum. The major places where the plant would be found growing in the wild are forest reserves and free areas of the rain-forest or it is planted or conserved in on-farm oil-palm, cocoyam plantations. These growing regions have low altitude with annual temperature ranging from 32.15^{o}C to 21.4^{o}C and a relative humidity of 76.34% (Ntamag, 1997). In the coastal rainforests of south-western and south-eastern parts of Nigeria the nut is chewed and readily served to visitors as a sign of goodwill. Bitter kola is enjoyed by the three major ethnic groups in Nigeria (i.e. the Yoruba's, the Igbo's and the Hausa's), from whom it derived the local names *agbilu* in Igbo and *Orogbo* in Yoruba languages.

The local market for bitter kola extends beyond the southern production areas to the northern parts of the country. In Nigeria, its trade is as important as that of kola nut (*Cola nitida and C. acuminata*) in major towns and cities in southern parts of the country where the tree is endemic.

Botanic and Agronomic Characteristics

According to an earlier description by Heckel and Schlagdenhauffen (1884), bitter kola is a tree of variable aspect, well branched, ever-green and grows to a height of about 12m. Towards the base of the branches are large opposite leaves (12" long by 7" broad), with short petioles, while at the extremity of the branches, the leaves are much smaller (5" by 2"). The leaves are oval, slightly dilated at the base, full green on the upper surface and greenish underneath. Ladipo (1995) reported that the tree produces reddish yellowish or orange colored fruit, with each fruit containing two to four yellow seeds and a sour tasting pulp. The seeds when consumed have bitter astringent taste. The fruit is classified a berry, the size of an apple with a rugos epiderm covered entirely with rough hairs.

As a tropical fruit tree species, it is characterized by slow rate of growth (Ladipo, 1995). Cultivation of the plant is limited because of poor germination and the length of time it takes (about 10 - 15 years) to reach reproductive phase. In Nigeria, the demand for bitter kola is high but the production is limited due to problem of seed dormancy; untreated seeds are difficult to germinate. Farmers believe that germination of bitter kola takes about six to twelve months and that only a few seeds germinate. There is also the problem of setting up nurseries. However, Anegheh *et al.* (2006) developed a pre-nursery treatment to break dormancy and enhance germination. This work revealed that seed cutting (nicking) was very effective in enhancing germination of *Garcinia kola*. The seed is first raised in the nursery and then transplanted to the field.

Fruiting commences in July and ends in October, while harvest continues as ripe fruits fall and are collected for the extraction of seeds. Ladipo (1995) reported that a mature fruit tree of 10 to 15 years produces 85 to 1717 fruits, with 208 to 6,112 seeds. Taking the mean of these values at 834 fruits and 2,627 nuts per tree he projected a fruit production of 26 tonnes per ha per annum with 278 trees per hectare at 6 x 6m spacing.

When ripe, the green pericarp of the fruit turns reddish yellow color and the fruit falls. The fruits are gathered, broken and stored in an open cool place to allow for fermentation of the pericarp and pulpy mesocarp. Thereafter, they are threshed to release the seeds which are washed to remove the sticky mucilaginous material that sheaths them. The seeds or nuts that are not sold fresh are air dried and stored in baskets lined with jute bags. According to Ofor *et al.* (2010) storage of bitter kola in polyethene bags is favored in terms of shelf life and palatability.

Cultivation of *Garcinia kola*

According to *Ingenieurs Sans Engineers Frontieres without Boarders Cameroon* (2009). *Garcinia kola* is cultivated either by seeds or by cutting. Seed cultivation involves preparing a suitable seed bed measuring 3 x 4m ($12m^2$) on a flat ground inside a shade house to protect the little plants from direct radiation of the sun and strong rains. The shade is usually built from local materials like bamboo, stakes cut in forest or palm tree branches. Seeds that germinated easily are usually those from matured ripe fruits that fell to the ground before the seeds are removed.

To achieve pre-nursery germination, two or three banana or plantain tree trunks are cut and large holes made on the level of their bases to allow for destruction of the central bud (meristem) of the cut plant. Seeds are thereafter inserted into the trunks of the banana tree and the two ends of each trunk attached firmly. Trunks are then arranged hermetically closed under a hanger. After three months the binding wires are detached to recover the seeds which had already germinated.

The germinated seeds are carefully sown inside polyethylene bags with $^2/_3$ of it filled with a mixture of black soil and sand. The pots of young seedlings are then laid out in the seed bed, and maintained by watering every two days, weeding, application of 3g of N.P.K 20:10:10

fertilizer every 3 months and fighting off fungal and insect attacks with the appropriate fungicides and insecticides. After 12 months, the seedlings are planted in the field, usually at the beginning of the rainy season with a standard spacing of 10 x 10m. In the field, further agronomic practices are observed, and production of fruit will begin approximately after 7 years.

Cultivation by cutting is usually done using bitter kola cuttings obtained from very tender branches and stems with young healthy leaves and vertical branches looking upwards. Preferably, cuttings are best cut very early in the morning and just after rain to avoid drying. This is transferred into a wet plastic bag, which is tightly closed and kept under shade from where they are transferred directly to the propagator. Cutting are usually about 12cm. The young seedlings that germinate are carefully inserted into polyethylene bags filled with mixture of black soil and sand up to $^{2}/_{3}$ level. After insertion of the young seedlings, the polyethylene bags are filled with soil to the brim and sprinkled lightly with water. The pots of seedling are thereafter transferred to the seed bed and finally to the field as in propagation by seeds. *Garcinia kola* usually produces fruits between the months of July and October.

Traditional uses of *Garcinia kola*

Garcinia kola is cultivated throughout West Africa for its edible fruit and seeds which are used as rejuvenating agent for masticatory purposes and as a general antidote (Ibiblio, 1983). Among the Igbos of Nigeria it is presented to visitors as a sign of peace and welcome. It is also used to entertain guests during ceremonies and festivities. Again, it is popularly used among other Nigerian groups for nervous alertness and induction of insomnia when chewed.

Traditionally, the nuts of *Garcinia kola* have used as sialegogue to stimulate the flow of saliva (Leakey, 2001). The kernels of the nuts are widely traded and eaten as a stimulant (Omode *et al.,* 1995; Atawodi *et al.,* 1995; Leakey, 2001). It is believed to clean the digestive system, without side effects such as abdominal problems, even when a lot of it is eaten (Onochie and Stanfield, 1960). In traditional medicine, the dried nut is ground and mixed with honey to make a traditional cough mixture. The ground nut may also be mixed with water and given to new born babies to relieve stomach cramps.

Experimentations using *Garcinia kola* kernels as hop substitutes in several indigenous alcoholic drinks as well as flavour enhancer in the beverage industry also exist (FDA, 1999). Ofor *et al.* (2004) identified several ethno-botanical uses to which the indigenes of Imo state in South–eastern Nigeria put the *Garcinia kola* seeds. These include as an antidote to snake bites, poison and overdose, for cough, vomiting and as a snake repellent. The seeds which serve as a bitter stimulant also serve as a snake repellent when they are placed round the compound (Nair, 1990). The seed is used in the treatment of diarrhoea (Braid, 1991), bronchitis and throat infections (Orie and Ekon, 1993; Adesina *et al.,* 1995), liver disorders (Iwu *et al.,* 1990) and enjoys a folk reputation in Africa as a poison antidote (Kabangu *et al.,* 1987). According to Farombi *et al.* (2005), the seeds of *Garcinia kola* have pharmacological uses in treating coughs, throat infections, bronchitis, hepatitis and liver disorders.

The Plant

Every part of the *Garcinia kola* plant has been useful in traditional practice ranging from the root of the plant to its seed. The root of the plant serves as a bitter chewing stick in West Africa, while the stem serves as a chewing stick for many people in southern Nigeria (Olabanji *et al.,* 1996; Uko *et al.,* 2001; Okwu and Ekeke, 2003). The products of three *Garcinia kola* species are widely used in Ghana and 70% of its use is as chewing sticks. These are brought into urban markets as an alternative to tooth paste and brush (Adu-Tutu *et al.,* 1979). The raw stem bark serves as purgative, the powdered bark is applied to malignant tumours, the sap is used for curing parasitic skin diseases and the latex or gum is used against

gonorrhea infection and applied externally on fresh wounds to prevent bacterial contamination.

Other by-products of *Garcinia kola* plants are also useful to mankind. The wood makes excellent fuel source. Its dense rounded crown makes it an ideal tree for shade around homesteads. The branches are used as chewing stick because of its taste and anti-bacterial activities of its extract (Taiwo *et al.,* 1999).

Nutrient composition of *Garcinia kola* nuts

Garcinia kola contains nutrients such as proteins, carbohydrates, fiber, minerals, fat and oils. Ibekwe *et al.* (2007) reported that *Garcinia kola* seed has poor nutrient composition but highly valued in trado-medicine due to its useful active phytochemical composition.

Contrary to the nutrient compositions of *Garcinia kola* reported by Ibekwe *et al* (2007) in table 1, Esiegwu and Udedibie (2009) reported nutrient compositions of *Garcinia kola* as shown in table 2. Odebunmi *et al.* (2009) reported the moisture content of the seeds to be 60.48 $\pm$ 0.06%, dry matter of 39.52 ± 0.06%, crude fat of 4.51 ± 0.56%, crude protein of 2.48 ± 0.10%, ash content of 0.79 ± 0.005%, crude fiber of 5.23 ± 0.16% and total carbohydrates (+ fiber) of 35.64%. These values are different from what had previously been reported for bitter kola. Eleyinmi *et al.* (2006) reported a protein content of 3.95%, lipid of 4.33%, ash of 1.14% and a crude fiber content of 11.4% in the seed.

Table 1: Nutrient composition of Garcinia kola (% of dry matter)

Components	Amount%
Moisture	14.60
Crude protein	0.58
Crude fiber	0.10
Ether extracts	3.00
Ash	5.00
Nitrogen-free extract	91.32

Adapted from Ibekwe *et al*. (2007)

Table 2: Nutrient composition of *Garcinia kola* (% of dry matter)

Composition	Amount%
Dry matter	7.30
Crude protein	2.64
Crude fiber	20.51
Ether extracts	9.47
Ash	1.07
Nitrogen free extracts	57.54

Adapted from Esiegwu and Udedibie (2009).

Chemical composition of *Garcinia kola*

Chemical analysis of *Garcinia kola* seed in Nigeria as reported by Okwu (2005) showed that it contains a wide range of vitamins and minerals as shown in tables 3 and 4. According to Odebunmi *et al.* (2009), *Garcinia kola* has 722.10 mg/100g of potassium (K), 67.07±0.12 mg/kg DM of calcium (Ca), 114.83±3.47 mg/kg DM of magnesium (Mg), 6.10±0.43 mg/Kg DM of iron (Fe), 2.30±0.08 mg/kg DM of zinc (Zn), and 188.57±0.37 mg/kg DM of phosphorus (P).

Asaolu (2003) also reported that the fresh seeds of bitter kola (wet weight) contains high moisture content of 75.50% and dry weight of 24.50, while the ash content was found to be 5.90%, crude fat was 14.50%, carbohydrate was 10.85%, crude fat was 14.50% and crude

protein was found to be very low (4.25%). Dosunmi and Johnson (1995) in comparing the nutritive value of the fresh fruit from Nigeria showed that crude protein was higher in the mesocarp (7.8%) than in the pericarp (3.9%), while the pericap was richer in crude fiber (13.9% - 16.5%). The mesocarp was also richer in crude lipid (6.9% - 8.7%). Unsaturated fatty acids (linoleic acid, 40.5%, oleic acid, 30.8%) are the main components of the lipids (4.5%) found in the seeds of this species (Essien *et al.*, 1995; Omode *et al.*, 1995).

Table 3: Vitamin composition of *Garcinia kola* seeds (dry weight basis)

Vitamins	Amount (mg/100g)
Thiamin (vit. B1)	0.5 ± 40.30
Riboflavin (vit. B2)	0.22 ± 0.01
Niacin (nicotinic acid)	1.60 ± 0.01
Ascorbic acid (Vit. C)	23.10 ± 0.02

Adapted from Okwu (2005).

Table 4: Mineral composition of *Garcinia kola* seeds (dry weight basis)

Mineral	Amount (mg/100g)
Macro elements	
Magnesium	0.42 ± 0.30
Calcium	0.80 ± 0.40
Potassium	2.50 ± 0.10
Phosphorus	0.33 ± 0.10
Sodium	0.72 ± 0.10
Micro elements	
Iron	17.75 ± 0.30
Zinc	2.30 ± 0.01
Copper	0.78 ± 0.20
Manganese	2.01 ± 0.50
Chromium	0.00
Cobalt	0.55 ± 0.20
Cadmium	0.29 ± 0.10

Adapted from Okwu (2005).

Phytochemical Constituents of *Garcinia kola*

The role of phytochemicals in enhancing body cell immunity against diseases in the body cannot be overemphasized. The active constituents contributing to the protective effect of *Garcinia kola* on animals is attributed to the presence of phytochemicals, vitamins and minerals (Okwu and Ekeke, 2003). Phytochemicals exhibit a wide range of biological activities as a result of the anti-oxidant properties of some of these chemicals. Several types of polyphenols (phenolic acid, hydrolysable tannins and flavonoids) show anti-carcinogenic and mutagenic effects (Uruquiaga and Leighton, 2000). Okwu (2005) and Esiegwu and Udedibie (2009) reported the phytochemical values as shown in table 5 and 6.

Table 5: Phytochemical constituents of *Garcinia kola* seeds (Dry weight basis).

Constituents	Amount (mg/100g)
Phenols	0.11±0.20
Alkaloids	0.36 ± 0.10
Tannins	0.26 ± 0.20
Flavonoids	1.98 ± 0.20

Adapted from Okwu (2005).

Table 6: Phytochemical constituents of *Garcinia kola* seeds (dryweight basis)

Constituents	Amount (mg/100g)
Cyanogenic glycosides	0.54
Tannins	0.34
Saponins	10.06
Alkaloids	4.93

Adapted from Esiegwu and Udedibie (2009).

Garcinia kola stem has been shown to contain a complex mixture of phenolic compounds such as biflavonoids, xanthones and benzophenone (Iwu and Igboko, 1982) which have anti-microbial activity as kolanone (Hussain *et al.,* 1982), kola flavonone and garcinia flavonone (Iwu, 1993). Phytochemical studies have shown that the seeds constituents include biflavonoids, xanthones and benzophenones. Thus, the seeds of *Garcinia kola* are known to have a general antidote effect in traditional medicine in Africa. These possibly explain its reported aphrodisiac properties and in the treatment of catarrh and abdominal colicky pain. In addition, their use is believed to improve singing voice and relieve cough (Irvin, 1961).

The feed value of *Garcinia kola* for farm animals

Although *Garcinia kola* is eaten by many Nigerians and in most parts of Africa as an aphrodisiac, for the medicinal value or for pleasure, not much work has been done to determine its feed value for animals in terms of feed intake, growth rate and feed conversion ratio. However, Uko *et al.* (2001) reported that water extract from *Garcinia kola* administered to growing winstar rats in three doses of 0, 10, 20 mg/100g body weight of rats daily to respective group of 15 rats for a period of 70 days showed depressive effect on appetite and water intake with resultant poor feed utilization efficiency and weight gain of rats in a dose-dependent manner.

Contrary to the report of Uko *et al.* (2001), Esiegwu and Udedibie (2009) reported that *Garcinia kola* seed meal in broiler diets at 0, 2.5, 5.0 and 7.5% levels fed to groups of 30 broiler chicks for 8 weeks recorded no significant differences in feed intake among the groups but the group on 2.5% *Garcinia kola* diet had significantly heavier body weight and superior feed conversion ratio than the other groups. *Garcinia kola* has being reported to improve digestibility when chewed in small pieces before any meal (Kafaru, 1998). Improved digestibility could enhance intake and consequent gain in weight. In a very recent study Esiegwu *et al.,* (2012) reported that there was no treatment effect on body weight, feed intake, feed conversion ratio and egg quality indices of laying hens fed graded levels of *Garcinia kola*. However, histological alterations of the kidney, liver and gizzard were observed.

Effect of *Garcinia kola* on haematological and serum biochemical indices.

Uko *et al.* (2001) reported that water extract from *Garcinia kola* administered to rats did not cause any significant differences between blood samples from the control and experimental rats for HB, PVC, RBC and erythrocyte indices. However, there was a general inverse relationship between the erythrocyte values (HB, PVC and RBC) and increased doses of the plant extract. There was also a significant increase in total leucocytes count of blood samples from the experimental rats, which depended on the doses of the extract. The work also showed that bitter kola extract decreased total plasma proteins, albumin concentrations but slightly increased total and conjugated bilirubin levels.

Similarly, Adedeji *et al.* (2005) reported the effect of different dietary inclusion levels of bitter kola on blood profiles of rats. The rats were placed on diets containing 0% (w/w), 5% (w/w), 10% (w/w) and 20% (w/w) levels of *Garcinia kola* for six weeks. It was observed that there was no significant difference between rats fed control diet and those in various dietary groups for all the blood parameters checked with the exception of the lymphocyte count

which had a significant difference in all dietary groups less than the control. According to Esiegwu and Udedibie (2009), there were no significant differences among the groups fed *Garcinia kola* in most of the haematological indices; however, the control group had more RBC than the *Garcinia kola* groups but significantly lower WBC.

Effect of Garcinia kola on organ characteristics

Uko *et al.* (2001) reported that water extract from *Garcinia kola* fed to rats did not significantly influence the organ of the control and experimental rats; however, there was a dose-related decrease in size of livers, lungs and hearts of rats fed the plant extract. The organs (testes, kidney, liver, heart, lungs and brain) did not show any microscopic alterations across treatment groups. It has also been reported by Braid (1989) that male rats fed diets containing 10% (w/w) dry powdered seeds of *Garcinia kola* for six weeks showed marked inhibition of gastro-intestinal motility, were protected against castor oil induced diarrhoea, exhibited prolonged pentobarbital sleeping time, marked retardation of growth but did not record organ weights effects compared to pair fed controls.

However, the report of Braid and Grill (1990) revealed some histological alterations in the liver, kidney and duodenum of rats fed diets containing 10% (w/w) dry powdered bitter kola for six weeks. The main cellular changes included vacuolation of duodenal villous epithelial cells, numerous intracytoplasmic vacuoles in hepatocytes and mild hydropic degeneration in cells of the renal proximal tubular epithelium. Contrary to the report of Braid (1989) and Uko *et al.* (2001), Esiegwu and Udedibie (2009) reported significantly heavier livers in *Garcinia kola* groups than the control group for broiler chicks placed on similar treatments for 8 weeks at 0, 2.5, 5.0, and 7.5% dietary levels.

Effect of *Garcinia kola* on reproduction

A Garcinia kola seed contain biflavonoid capable of having anti-inflammatory properties (Braid, 1993) and is a natural anti-oxidant (Olatunde *et al.*, 2002; Terashima *et al.*, 2002). The importance of the anti-inflammatory property of *Garcinia kola* is necessary because ovulation, an important process in female reproductive function, is believed to be an inflammatory process (Epsey, 1980; Epsey, 1994). Ovulation is brought about by a luteinising hormone (LH) surge. This surge of LH causes the follicle to rupture and hence ovulation. According to Gaytan *et al.* (2002), ovulation can be blocked experimentally by high doses of anti-inflammatory drugs administered before the LH surge because once the level starts to rise, it may not be stopped by any drug.

Akpantah *et al.* (2005) reported that *Garcinia kola* seed extract administered to rats at 200 mg/kg body weight altered oestrous cycle in rats, partly inhibited ovulation as evidenced by the reduced number of ova in the oviduct compared to the control, with a significant decrease in the weight of foetuses from the treated rats. Also 7% of the foetuses from pregnant rats which received treatment for the first five days of gestation had malformed left upper limb or morphological anormalies. It was also reported by Uko *et al.* (2001) that rats fed *Garcinia kola* seed extract exhibited increased libido (sexual instinct) for the male rats justifying the use of *Garcinia kola* by natives as an aphrodisiac, but did not improve pregnancy rates in female rats as a measure of the male fertility index.

The anti-inflammatory property of *Garcinia kola* seed may be responsible for the observed effect in blocking ovulation when administered to rats before the surge of luteinsing hormone (Freeman, 1988). The anti-inflammatory property of flavonoids is believed to result from inhibition of cyclo-oxygenase enzyme (Liang *et al.*, 1999). Akpantah *et al.* (2005) suggest that *Garcinia kola* seed may block ovulation by inhibiting cyclo-oxygenase activity and prostaglandin synthesis. Some flavonoids suppress the formation of cyclo-oxygenase – 2, thus playing an important role in the prevention of cancer and inflammation. This property has

been tried because of its chemo-prevention potentials against human cancers as many types of cancer cells use cyclo-oxygenase – 2 to propagate (Liang *et al.,* 1999). Similarly, cyclo-oxygenase – 2 (COX-2) deficient mice suffer from defect in reproductive functions such as ovulation and fertilization (Lim *et al.,* 1997).

Anti-microbial activities of *Garcinia kola*

Extracts from the bark, stem and seed of *Garcinia kola* have been reported to inhibit the growth of *plasmodium falciparum* by well over 60% *in vitro* at a concentration of 6 mg/ml (Tona *et al.,* 1999). The antimicrobial activities of aqueous extract of three Nigerian medicinal plants, *Vernonia amygdalina* (bitter leaf, BL), *Garcinia kola* (Bitter kola, BC) and *Gongronema latifolium* (Utazi, UT) and their blends were evaluated against several test organisms, *staphylococcus aureus, Bacillus subtilis*, *Escherichia coli* and *streptococcus salivanus* by Oshodi *et al.,* (2004). The study revealed that media containing a crude extract of UT showed no zone of growth inhibition against *Escherichia coli* and *Streptococcus salivanus,* while BC had no effect on *Escherichia coli* at all. UT: BL: BC and BL: BC blends were the most active blends while BL was the most active single plant extract.

A study by Akoachere *et al.* (2002) to investigate the anti-bacterial activity of bitter kola *(Garcinia kola)* and ginger *(Zingiber officianale)* on four respiratory tract pathogens, viz *Staphylococcus aureus, Streptococcus pyogens, Streptococcus pneumoniae and Haemophilus influenza* revealed that the extract from ginger and *Garcinia kola* exhibited anti-bacterial activity against the pathogens. A study by Elekwa (2003) on the effect of aqueous extracts of *Garcinia kola* seeds on membrane stability of human erythrocytes showed the possible use of the extract for the management of sickle cell crisis.

The seed of *Garcinia kola* has shown anti-inflammatory, anti-bacterial, anti-microbial, and anti-viral properties (Ebana *et al.,* 1991; Akoachere *et al.,* 2002). According to Esiegwu and Udedibie (2009), *Garcinia kola* seed meal fed to broiler chicks at 5.0 and 7.5% dietary levels suppressed the growth of *Salmonella species* in the birds but had no effect on *Escherichia coli.* In laboratory tests, bitter kola was found to halt the deadly disease caused by Ebola virus in its tracks, compounds from the plant have also proved effective against some strains of flu, a contagious respiratory disease also called influenza (Iwu, 1993). The seed of *Garcinia kola* has also shown a mild bronchodilator effect (Orie and Ekon, 1993). A study to investigate the anti-ulcerogenic and gastric acid lowering effects of *Garcinia kola* seeds in male albino rats containing 25%, 50% and 75% by weight of bitter kola showed a dose-dependent inhibition of gastric acid secretions and indomethacin-induced ulceration (Ibironke *et al.,* 1996).

Aniche and Uwakwe (1990), compared the chemical, brewing and anti-microbial properties of *Garcinia kola* with traditional hops and found that hops had higher concentration of organic acid than *Garcinia kola*. Laboratory brewing trials with *Garcinia kola* and hops gave beers with similar chemical properties, while organoleptically, *Garcinia kola* beer was as acceptable to tasters as hopped beer except that it had improved bitterness. Again, *Garcinia kola* and hop extracts exerted similar anti-microbial effects on two beer spoilage micro-organisms *(Lactobacillus delbruckii and Candida vini).*

Pharmacological mechanisms of *Garcinia kola* in animal models

The pharmacodynamic mechanism of *Garcinia kola* is anchored on kolaviron (Farombi *et al.,* 2000; Farombi, 2004; Adaramoye *et al.,* 2005), which is a yellow solid when extracted and is a mixture of Garcinia biflavonones GBI, GB2 and kola flavanone (KF). According to Iwu *et al.,* (1990), Kolaviron is a type of biflavonoids obtained from *Garcinia kola* seeds and produces significant hypoglycemic effects when administered intraperitoneally to normal and alloxan diabetic rabbits at a dose of 100 mg/kg. The fasting blood sugar in normoglycaemic

rabbits is reduced from 115 to 65 mg/100ml after 4 hours and in alloxan diabetic rabbits, while the blood sugar is lowered from 506 to 285 mg/ml after 12 hours (Iwu *et al.,* 1990).

Kolaviron, has also been shown to modulate the hepatoxicity of carbon tetrachloride, galactosamine, aminata toxin, paracetamol thioacetamide and 2-acetyl-aminofluorene in various experimental models. The hepatoprotective effect of the seed extract was investigated in rats treated with high doses of paracetamol. When administered at 100 mg/kg three times daily for 5 consecutive days the extract reduced paracetamol – (800, 1000, 1200 mg/kg), induced lethality from 50, 90, and 100% to 0, 20 and 40%, respectively (Akintowa and Essien, 1990).

In addition, the anti-hepatotoxic properties of *Garcinia kola* have been evaluated using four experimental toxins, namely carbon tetrachloride, galactosamine, alpha amanitin and phalloidin. Kolaviron, a fraction of the defatted ethanol extract and two billabongs of *Garcinia kola* seed (GB1 and GB2), significantly modified the action of this hepatitis. At 100mg/kg orally, the test substances reduced thiopental-induced sleep in CC14 poison rats and protected microsomal enzymes against phalloidin toxin (Iwu *et al.,* 1987). Kolaviron from *Garcinia kola* seeds reduced lethal poisoning of mice by phalloidin. The biflavanones GB1, GB2 and kolaflavanone were isolated as the active constituents (Iwu, 1985).

Kolaviron, has also been shown to prevent lipid peroxidation products and protect biomembranes against oxidative damage by acting as *in vivo* anti-oxidant in animal studies (Farombi *et al.,* 2000). *Garcinia kola* inhibited *in vitro* lipid peroxidation of rat liver homogenate in a dose-dependent manner (Adegoke *et al.,* 1998). Possible anti-atherogenic effects of kolaviron (a *Garcinia kola* seed extract) in hypercholesterolaemic rats were investigated and it was revealed that kolaviron reduced plasma cholesterol levels and the relative weight of the heart in cholesterol fed animals (Adaramoye *et al.,* 2005).

Garcinia kola clinically appears to have a significant analgesic/anti-inflammatory effects in knee osteoarthritis patients. According to Olayinka *et al.* (2008), it is effective in improving locomotors function and significant pain reduction in patients with knee osteoarthritis. Again, extracts from the seeds of *Garcinia kola* have been shown to exhibit excellent bactericidal properties (Okwu, 2004).

Safety of *Garcinia kola*

Garcinia kola is safe consumed with or without other foods. Its consumption an hour before or after meals may help to increase the absorption of key ingredients.

Food does not affect the metabolism of *Garcinia kola* and may suffer the effects of mild indigestion (Iwu, 1986). Kolaviron does not appear to have a pronounced effect on drug metabolizing enzymes (Farombi *et al.,* 2000) and no known interaction with orthodox medications has been reported (Okoli, 1991).

CONCLUSION

This review has shown that bitter kola has enormous health benefits that could be explored by adding it to animal feeds. It has shown that *Garcinia kola* is not deleterious to the health of animals. It has however, indicated that few studies have been carried out on the nutrient and phytochemical compositions of *Garcinia kola*.

Further studies are needed to fully understand its nutritional mechanisms in animal feeding and how it could best be utilized for this purpose.

REFERENCE

Adaramoye, O.A., E.O. Farombi, E.O. Adeyemiand and G.O. Emerole. 2005. Comparative study on the antioxidant properties of flavonoids of *Garcinia kola* seed. *Pak. J. Med. Sci*. 21:331–339.

Adaramoye, O. A., V.O. Nwaneri, K.C. Anyanwu, E.O. Farombi and G.O. Emerole. 2005. Possible anti-atherogenic effect of kolaviron (a *Garcinia kola* seed extract) in hypercholesterolaemic rats. *Clinical and Experimental Pharmacology and Physiology*. 32 (1-2):40–46.

Adedeji, O.S., G.O. Farinu, S.A. Ameen and A.O. Oyewope. 2005. The effects of different dietary inclusion levels of bitter kola (*Garcinia kola*) on blood profiles of laboratory rats. *Tropical Veterinarian*. 23(23):56–60.

Adegoke, G.O., M.V. Kumar, K. Sambaiah, and B.R. Lokesh. 1998. Inhibitory effect of *Garcinia kola* on lipid peroxidation in rat liver homogenate. *Indian J. Exp. Biol*. 36(9):907-910.

Adesina, S.K., Z.O. Gbile, O.A. Odukoya, D.D. Akinwusi, H.C. lloh, and A.A. Jayeola. 1995. Survey of indigenous useful plants of West Africa with special emphasis on medicinal plants and issues associated with their management. The United Nations University programmed on natural resources in Africa. 2nd edn. 84-85.

Adu-Tutu, M., Y. Afful, K. Asante-Appiah, D. Lieberman, J.B. Hall and M. Elvin-Lewis. 1979. Chewing stick usage in southern Ghana. *Econ. Bot*. 33:320-328.

Akintonwa, A. and A.R. Essien. 1990. Protective effects of *Garcinia kola* seed extract against paracetamol induced hepatoxicity in rats. *J. Ethnopharmacol*. 29:207-211.

Akoachere, J.F., R.N. Ndip, E.B. Chenwi, L.M. Ndip, T.E. Njock and D.N. Anong. 2002. Antibacterial effect of *Zingiber officinale* and *Garcinia kola* on respiratory tract pathogens. *East Afr. Med. J*. 79(11):588 - 592.

Akpantah, A.O., A.A. Oremosu, C.C. Noronha, T.B. Ekanem and A.O. Okanlawon. 2005. Effects of *Garcinia kola* seed extract on ovulation, oestrus cycle and foetal development in cyclic female spraque-dawley rats. *Nig. J. phys. Sci*. 20(1-2):58–62.

Anegbeh, P.O., C. Iruka and C. Nkiruka. 2006. Enhancing germination of bitter kola (*Garcinia kola*): prospects for agroforesty farmers in the Niger Delta. *Scientia Aficana*. 5(1):1118-1981.

Aniche, G.N. and G.U. Uwakwe. 1990. Potential use of *Garcinia kola* as substitute in lager beer brewing. *World J. Microbial. Biotech*. 6:323-327.

Asaolu, M.F. 2003. Chemical composition and phytochemical screening of the seeds of *Garcinia kola* (Bitter kola). *Pakistan Journal of Scientific and Industrial Research*. 46(3):145-147.

Atawodi, S., P. Mende, B. Pfundstein, R. Preussmann and B. Spiegelhalder. 1995. Nitrosatable amines and nitrosamide formation in natural stimulants, cola acuminate, C. nitida and *Garcinia kola*. *Food Chem. Toxicol*. 33(8):625-630.

Braide, V.B. and V. Grill. 1990. Histological alterations by a diet containing seeds of *Garcinia kola*. Effect on liver, kidney and intestine in the rats. *Gegenbaurs Morphol Lab*. 136:95-101.

Braid, V.B. 1989). Pharmacological effects of chronic ingestion of *Garcinia kola* seed in rat. *Willey Interscience*. 4(1):39–41.

Braide, V.P. 1991. Antihepatotoxic biochemical effects of kolaviron, a biflavonoid *of Garcinia kola* seeds. *Phytotheraphy Res*. 5:35-37.

Braide, V.B. 1993. Anti-inflammatory effect of kolaviron, a biflavonoid extract of *Garcinia kola*. *Fitoterapea., LXIV*: 433 - 516.

Dosunmu, M.I. and E.C. Johnson. 1995. Chemical evaluation of the nutritive value and changes in ascorbic acid content during storage of the fruit of bitter kola (*Garcinia kola*). *Food Chem*. 54:67-71.

Ebana, R.U., B.E. Madunagu, E.D. Ekpe and I.N. Otung,. 1991. Microbiological exploitation of cardiac glycosides and alkaloids from *Garcinia kola, Borreria, ocymoides, Kola nitida and Citrus aurantifolia. J. Appli. Bacteriol*. 71(5):398–401.

Elekwa, I., M.O. Monanu, and E.O. Anosike. 2003. Effects of Aqeous extracts of *Garcinia kola* seeds on membrane stability of HbAA, HbAS and Hbss human erythrocytes. Global Journal of medical sciences Vol. 2. No. 2.

Eleyinmi, A.F., D.C. Bressler, I.A. Amoo, P. Sporns and A.A. Oshodi, 2006. Chemical composition of bitter kola (*Garcinia kola*) seed and hulls. *Polish J. Food Nutr. Sci.* 15(4):395–400.

Epsey, L.L. 1980. Ovulation as an inflammatory process - A hypothesis. *Biol. Reprod*. 22: 73 - 106.

Epsey, L.L. 1994. Current status of the hypothesis that mammalian ovulation is comparable to an inflammatory reaction. *Biol. Reprod*.,49:233-238.

Esiegwu, A.C. and A.B.I. Udedibie. 2009. Growth performance of and anti-microbial activities in broilers fed supplementary bitter kola (*Garcinia kola*). *Animal Production Research Advances*. 5(1):20-24.

Esiegwu, A.C., A.B.I. Udedibie, I. C. Okoli, and O.O. Emenalom. 2012. The Value of *Garcinia Kola* (Bitter Kola) as feed Ingredient and Anti-Microbial Agent for Layers and Rabbits. Ph.D Thesis.

Essien, E.U., G.J. Esenowo, and M.I. Akpanabiatu. 1995. Lipid composition of lesser known tropical seeds. *Plant Foods Hum. Nutr*. 48:135–140.

Esonu, B. O., O.O. Emenalom, A.B.I. Udedibie, G.A. Anyanwu, U. Madu, and A.O. Inyang. 2005. Evaluation of neem (*Azadirchta indica*) leaf meal on performance, carcass characteristics and egg quality of laying hens. *Intl. J. Agric. Rural Devt*. (6):208–212.

Farombi, E. O., J.G. Tahnteng, O.A. Agboola, J.O. Nwankwo and G.O. Emerole. 2000. Chemo-prevention of 2-acetylamino fluorine induced hepatoxicity and lipid peroxidation in rats by kolaviron - a *Garcinia kola* seed extract. *Food Chem. Toxicol*. 38:535–541.

Farombi, E.O. 2004. Diet related cancer and prevention using anti- carcinogens. *African. J. Biotechnology*. 3:651-661.

Farombi, E.O., B.F. Adepoju, O.E. Oladavies, and G.O. Emerole. 2005 Chemoprevention of aflatoxin B1-induced genotoxicity and hepatic oxidative damage in rats by kolaviron, a natural biflavonoid of *Garcinia kola* seeds. *Eur. J. Cancer Prev*. 14 (3):207–214.

FDA. 1999. FDA/CFSAN/OPA: Agency Response Letter: GRAS Notice No: GRN000025 on the use of *Garcinia kola* seed in distillation http:/Ivm.cfsan.fda.gov/rdb/opag025.html.

Freeman, M.E. (1988). *Physiology of Reproduction*, Vol. 2, Raven Press New York. 1899 - 1900.

Gaytan, E., E. Trradas, C. morales, C. Bellido and J. Sanchez-Criado. 2002. Morphological evidence for uncontrolled proteolyses activity during the ovulatory process in indomethacin-treated rats. *Reprod*. 123:639-649.

Heckel, E. and F. Schlagdenhauffen. 1884. Some African kolas, in their botanical, chemical and therapeutical aspects: edited by John, M. and Maisch, M.B. in *American Journal of Pharmacy*. 56:586.

Hertog. M.G.I., E.J.M. Fejkeen, C.H. Hokmanand and A. Katan. 1993. Dietary antioxidant flavonoids and risk of coronary heart disease, de zutphen elderly study. *Lancet*. 342:2007–1011.

Hussain, R.A., A.G. Owe-Gby, P.P. Arimoo, and P.G. Waterman. 1982. Kolanone, a novel polyisoprenylated benzophenone with antimicrobial properties from the fruit of *Garcinia kola*. *Planta Med*. 44:78–81.

Ibekwe, H.A., M.U. Eteng, and E. Antigha. 2007. Proximate and Phytochemical composition of *Garcinia kola* and *Vernonia amygdalina*. *Proceedings of the 32nd Annual Conf. of the Nig. Soc. for Anim. Prod*., Calabar, March 18 – 21, 2007, pp: 255 – 258.

Ibiblio, J.O. 1983. *Some Medicinal Plants of Nigeria*. Ibadan publishers Nig. Ltd. pp:132 -133.

Ibironke, G.F., S.B. Olaleye, , O. Balogun, and A. Aremu. 1996. Effects of diets containing seeds of *Garcinia kola* on gastric acidity and experimental ulceration in rats. J. Wiley Interscience, I: I (abstract).

Ingenieurs Sans Engineers Frontiers without Borders Cameroon. 2009. Practical Guide - Bitter Kola - pdf. (www.isf-cameroon.org). www.pdfio.com/k-1340472html.

Irvine, F. R. 1961. *Woody Plants of Ghana*. Oxford University press, Oxford, pp:146–147.

Irvine, F. R. 1961. *Woody Plants of Ghana with Special Reference to Their Uses*. Oxford University press, London.

Iwu, M.M. and O. Igboko, 1982. Flavonoid of *Garcinia kola* seeds. *J. Nat. prod*. 45:650–651.

Iwu, M.M. 1985. Antihepatoxic constituents of *Garcinia kola* seeds. *Experientia*. 41(5):699–700.

Iwu, M.M. (1986). Biflavanones of *Garcinia;*pharmacological and biological activities. In: Cody, V., Middleton, E. and J.B. Harbone (editors) Plant Flavonoids in Biology and Medicine. New York, *Alan R. Liss*. 485 - 488.

Iwu, M.M., O.A. Igboko, U.A. Onwuchekwa, and C.O. Okunji. 1987. Evaluation of the antihepatotoxic activity of the biflavonoids of *Garcinia kola seeds. J. Ethnopharmacol*. 21(2):127– 38.

Iwu, M.M., O.A. Ogboko, C.O. Okunji and M.S. Tempesta. 1990. Antidiabetic and aldose reductase activities of biflavanones of *Garcinia kola*. *J. Pharm Pharmacol*. 42:290–292.

Iwu, M.M. 1993. *Handbook of African Medicinal Plants.* CRC Press. London. pp:183–184.

Iwu, M.M. 1993. *Handbook of African Medicinal Plants.* Boca Raton. CTA Press. p:437.

Kabangu, L., C. Gleffi, E. Aonzo, M. Nicoletti, and I. Messana. 1987. New biflavone from the bark of *Garcinia kola*. *Planta Medica*. 11:275–277.

Kafaru, G. 1998. National Health Column. Nig. Tribune, p: 20.

Keay, R.W. 1989. *Trees of Nigeria*. Clarendon Press. Oxford. p: 476.

Ladipo, D.O. 1995. Physiological/morphological growth rate and fruit/nut yields in *Garcinia kola* tree on acid soil of Onne, Port Harcourt. ICRAF In-House Report.

Leakey, R. 2001. Potential for novel food production from agroforestry trees: A Review. http://www.wanatca.org.au/acotanc/papers/leakey_l.

Liang, Y.C., Y.T. Huang, S.H. Tsau, S.Y. Lin-Shiau, C.F. Chen and J.K. Lin. 1999. Suppression of inducible cycloxygenase and inducible nitric acid synthase by apigenin and related flavonoid in mouse macrophages. *Carcinogenesis*. 20:1945-1952.

Lim, H., B. Paria, S. Das, J. Dinchuk, R. Langenbach, J. Trzaskos, and S. Dey. 1997. Multiple female reproductive failures in cyclo-oxygenase -2 deficient mice. *Cell*. 17:197-208.

Mabberly, D.J. 1987. *The Plant Book. A Portable Dictionary of the Higher Plants.* Cambridge University press. Cambridge.

Nair, P.K.R. 1990. The prospects for agroforestry in the tropics. Technical Paper 131, Nairobi, ICRAF.

Ntamag, C.N. 1997. Spatial distribution of non-timber forest production collection: A case study of South Cameroon. MSc. Thesis, Wageningen Agricultural University.

Obikaonu, H.O. 2009. Production Performance of and Anticoccodial Effects in Deep litter Managed Chickens Fed Neem Leaf Meal. Ph.D Thesis, Federal University of Technology. Owerri. Nigeria.

Odebunmi, E.O., O.O. Oluwaniyi, G.V. Awolola and O.D. Adediji. 2009. Proximate and nutritional composition of kola nut *(Cola nitida)*, bitter cola (*Garcinia kola*) and alligator pepper *(Afromomum melegueta)*. *African Journal of Biotechnology*. 8(2):308-310.

Ofor, M.O., C.A. Ngobili, and M.I. Nwufo. 2004. Ethno-botanical uses and trade characteristics of *Garcinia kola* in Imo State, Nigeria. *Int. J. Agric. Rural Dev*. 5:140-144.

Ofor, M.O., M.I. Nwufo, I.J. Ogoke, A.A. Ngwuta, I.I. Ibeawuchi and C.I. Duruigbo. 2010. Post harvest storage characteristics of bitter kola (*Garcinia kola*, Heckel). In Imo State, Nigeria. *New York Science Journal*. 3(3):6-9.

Okoli, U.J. 1991. An investigation into the hypoglycemic activity of GBI biflavonoids of *Garcinia kola.* B. Plarm. Project., University of Nigeria. Nsukka.

Okwu, D. E. and O. Ekeke. 2003. Phytochemical screening and mineral composition of chewing sticks in south-eastern Nigeria. *Global J. Pure and Applied Sci*. 9:235–238.

Okwu, D. E. 2004. Phytochemcial and vitamin contents of indigenous spices of south-eastern Nigeria. *J. Sustain. Agric. Environ*. 6:30–34.

Okwu, D.E. 2005. Phytochemical, vitamin and mineral contents of two Nigerian medicinal plants. *International Journal of Molecular Medicine and Advance Sciences*. 1(4):375–381.

Olabanji, S.O., O.V. Makanj, D.C.M. Haque, M.C. Buoso, D. Ceccato, R. Cherubini and G. Moschini. 1996. PIGE – PIXE Analysis of chewing sticks of pharmacological importance. *Nuclear Instruments and Methods in Physics Research*.113:368–372.

Olatunde, F.E., O.O. Akanmi and G.O. Emerole. 2002. Anti-oxidant and scavenging activity of flavonoid extract (kolaviron) of *Garcinia kola* seeds. *Pharmaceut. Biol*. 40:107-116.

Olayinka, O.A., A.A. Saburi, O.I. Thomas, C. Oluwakemi, A.O. Oyesiku and O.I. Ezekiel. 2008. Clinical effects of *Garcinia kola* in knee osteoarthritis. *J. Orthopaedic Surgery and Research*. 2:34.

Omode, A.A., O.S. Fatoki and K.A. Olaogun. 1995. Physicochemical properties of some underexploited and non-conventional oilseeds. *J. Agric. Food Chem*. 43:2850–2853.

Onochie, C.F.A. and D.F. Stanfield. 1960. *Nigerian Trees*. Gov. Printer, Lagos, Nigeria. pp: 5-10.

Orie, N.N. and E.U. Ekon. 1993. The bronchodilator effect of *Garcinia kola*. *East Afri. Med. J*. 70(3):143–145.

Oshodi, A.A., A.A. Isiaka, and F.E. Afolabi. 2004. The anti-microbial activity of Nigerian medicinal plants potentially usable as hop substitutes. *MBAA TQ*. 41(4): 398–402.

Taiwo, O., H.X. XU and S.E. Lee. 1999. Antibacterial activities of extracts from Nigerian chewing sticks. *Phytoter Res*. 13(8): 675-679.

Terashima, K., Y. Takaya and M. Niwa. 2002. Powerful antioxidative agent based on garcinoic acid from *Garcinia kola*. *Bio. Org. Med. Chem*. 10(5):1619–1625.

Tona, L., N.P. Ngimbi, M. Tsakala, K. Mesiak, K. Cimanga, S. Apers, T.D.E. Bruyne, , L. Peters, , J. Totte, and A.J. Vlietinck, 1999. Antimalarial activity of 20 crude extracts from nine African medicinal plants used in Kinshasa, *Congo. J. Ethnopharmacol*. 15(68):193–203.

Udedibie, A.B.I. and C.C. Opara. 1998. Response of growing broilers and laying hens to the dietary inclusion of leaf meal from *Alchornia cordifolia*. *Anim. Fd. Sci. Tech*. 71:157–164.

Uko, O.J., A. Usman, and A.M. Ataja. 2001. Some biological activities of *Garcinia kola* in growing rats. *Vet. Arhiv*. 71:287–297.

Uruquiaga, I. and F. Leighton. 2000. Plant polyphenol antioxidants and oxidative stress. *Biological Research*. 33: 159–165.

Vaithyanathan, S. and R. Kumar. 1993. Relationship between protein precipitating capacity of fodder tree leaves and their tannin content. *Anim. Fd. Sci. and Tech*. 44: 281-287.

Vivien, J. and J.J. Faure. 1996. Fruitiers savages. d'Afrique: especes du Cameroon. Ministere de la cooperation/CTA, Paris/Wageningen.p: 416.