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Review Article

Properties and Potentials of *Cola milenii* K. Schum: A Review

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ABSTRACT

Cola millenii K. Schum, is a wild plant of tropical and sub-tropical countries. It grows vigorously, and it is called Monkey Cola in English and Atewo-edun in Yoruba language or achi okokoro in Igbo language. C. millenii belongs to the Sterculiaceae family, genus Cola and species millenii. Cola millenii produce edible fruits of varying characteristics and sweetness. It is widely distributed throughout tropical Africa, from Senegal to Cameroon. The plant is nutritionally-rich and various parts of the plant contain bioactive substances such as alkaloids, saponins, tannins, glycosides, flavonoids and terpenoids. It also has varying degrees of antimicrobial activity against human pathogenic organisms due to its phytochemical properties and can be used for the treatment and management of diseases. The plant is highly under-utilized in Nigeria and a critical look at the composition and potentials of the plant suggests that it may be exploited by the scientific community for the production of different useful products for economic growth and national development.

1. INTRODUCTION

Medicinal plants are described as those plants whose parts contain bioactive substances that can be used for therapeutic purposes or serve as precursor for the synthesis of useful drugs (Nwokocha and Williams, 2018). Medicinal plants contain biologically active chemical substances (phytochemicals) such as saponins, tannins, essential oils, flavonoids, alkaloids, and other compounds which have preventive or curative properties (Nwankwo, 2017). These chemical substances generally occur as secondary plant metabolites in these plants and are of enormous use to humanity (Ganiyat *et al.*, 2010). Higher plants have traditionally been used in folk medicine as well as in the extension of the shelf life of foods in the case of those with antimicrobial activity (Hulin *et al.*, 1998).

All over the world, hundreds of plants have been identified as good sources of medicinal agents and are used in traditional medicine for different purposes, including the treatment of bacterial and fungal infections (Obafemi *et al.*, 2006). Ethnopharmacological uses of plants feature strongly among Nigerians. It has been pointed out that plants continue to play a prominent role in primary health-care of about 80% of the world's population (Baker *et al.*, 1995). Monkey Cola (*Cola millenii*) belongs to the genus *Cola* under the family Sterculiaceae. The genus *Cola* contains many species numbering up to 50 in West Africa. Of these, only a few are fruit-bearing, while majority are woody species of economic importance. The few fruit-bearing species are notably: *Cola nitida,* otherwise known as gbanja or goro (Yoruba), ojiawusa (Ibo), *Cola acuminate,* Obi gidi or Obi abata (Yoruba), ojiigbo (Ibo), *Cola verticillata,* Obi Olooyo or the slimy Cola (Yoruba), *Cola millenii* also known as Obi edun in Yoruba, Uto (Igbo), Ivyureanchere (Ebira).

Cola millenii is a wild plant of tropical and sub-tropical countries whose place of origin is unknown, but probably from Indonesia (Nwankwo, 2017). As a tree, it grows vigorously and produce edible fruits of varying characteristics and sweetness. It is widely distributed throughout tropical Africa, from Senegal to Cameroon (Michel, 2004). It is common in southern Nigeria where they are eaten as edible fruits by the peasant farmers during the peak season. The pulp is licked as a dessert and it is used in the management of stomach aches. This review is therefore carried out to bring to the attention of the scientific community the enormous potentials in this under-utilized plant.

2. DESCRIPTION OF THE PLANT

The plant is a shrub or tree which may grow up to 7 – 10 m high. It is somewhat twisted and branchy, with rounded and open crown. The bark is thin, washed pale brown, peeling off in thin linear scales, with red-brown fibrous slash. The stem is pubescent, grey to brown, lenticellate. The leaves are alternate, 2-ranked, 1.5-2.5 cm long 1-5 cm across, narrowly elliptic or oblong, odoriferous when crushed. Blade pubescent, are mainly beneath, becoming more or less glabrous, with a pointed or rounded, mucronate apex and a rounded or slightly cordate base. Flowers are solitary or in groups of two or three, in leaf axils, pale yellow, 1.5 mm in diameter, with 6 petals curled into blade, connected at the base. The fruit is composed of several ellipsoid carpels, 5 cm long 2.5 cm across, swollen and star-shaped, orange to red when ripe, with several seeds in a whitish pulp (Michel, 2004).

2.1. Taxonomy of the Plant

Cola millenii K. Schum, is one of 125 species from the genus Cola, in the family Sterculiaceae (Ratsch, 2005). Sterculiaceae is a botanical name for a group of flowering plants at the rank of family. The circumscription, status and placement for the taxon varies with taxonomic point of view. The family name is based on the genus *Sterculia*. As traditionally circumscribed, the Sterculiaceae, Malvaceae, Bombacaeae, and Tiliaceae comprise the "core Malvales" of the croquist system and the close relationship among these families are generally recognized (Watson and Dallwitz, 1992). The genus was formerly classified in the family Malvaceae, subfamily Sterculioideae, and was later transferred into the separate family Sterculiaceae (Sonibare, 2009). Cola is one of the most popular genera in the family of about 70 genera, totaling 1,500 species of tropical trees and shrubs. It is related to the genus Theobroma which is also part of the family (Orisakeye and Olugbade, 2012).

2.2. Distribution of the Plant

The earliest record on Cola was that of Johannus Leo Africanus, who was the first person to refer to Cola nut in 1556 as reported by Russel (1995). The Portuguese Odoardo Lopez recorded the occurrence of Cola trees in Congo in 1591, followed by the record of Andre Alvares, who saw Cola trees in Gambia and Guinea in 1594 (Borokini *et al.*, 2014. Van Eijnatten, (1969) stated that Cola tree was recorded all along the West Coast of Africa from Gambia to Angola. West Africa is generally known to be the origin of Cola, particularly in the rain forest area of Code d'Ivoire and Ghana. This area was for a long time the traditional source of gbanja Cola nuts (*C. nitida*) which was mainly obtained from spontaneously occurring trees. Ghana has since ceased to be a major producer of Cola because of the preference for cocoa. Cultivation and trade in Cola have been established in countries like the Caribbean Islands, Mauritius, Sri Lanka and Malaysia (Russel, 1955). During the slave trade, its cultivation extended to tropical South and Central America and to the West Indies.

2.3. Cola Propagation

Cola is propagated both sexually and asexually. The sexual propagation is through the use of nuts which are sown to raise the seedlings which are eventually transplanted in the field, while the asexual or vegetative propagation is through the use of ramets as planting materials. The age-long practice by the local farmers is to plant the nuts at stake (directly) in the field where they are subjected to vagaries of weather and other environmental conditions (FAO, 2000). With the advent of modern methods of farming, seedlings are first raised in the nursery for about six to twelve months before transplanting into the field during the early rains (April – June). Also, few farms, especially government or institution owned ones, are established through ramets, obtained from rooted cuttings, budding, grafting or marcotting which are also provided with intensive nursery care, preparatory to their being transplanted. In any of these two basic approaches, several factors come into play to determine the degree of success attainable; a good deal of which have prevented timely provision of adequate propagates with desirable characteristic for successful field establishment (Bosch *et al*., 2002).

2.4. Growth and Yield

After germination, Cola seedlings continue to grow until maturity when they start to fruit. The relationship between nut weight and the growth performance of *Cola* seedlings was studied by Mahomoodally (2013). His findings showed that there was a significant correlation between nut weight and all the growth parameter of *Cola* seedlings. The first obvious difference between a Cola seedling and mature tree is in the pattern of growth and canopy. Cola seedling exhibits monopodial growth marked with several flushing periods in a year while the adult tree assumes dome-shaped sympodial growth, characterized by two main flushing periods in a year. Cola trees are traditionally grown in the rain forest areas where they form under storey layer (Bodard, 1962; Russel, 1995)

Inflorescence and flower production in Cola vary in terms of sex ratio, spatial and chronological distribution vis-à-vis the overall number of the inflorescence produced and the sex ration complexity as well as species difference (Russel, 1955; Bodard, 1962). Bodard (1955) pointed out the existence of three types of inflorescence and how they vary with age of plant and location on the plant part. Main flower production lasts about three months during which time 80.90 % of the total number of flowers produced emerges. In Nigeria, this is the period of January to March for *C. millenii*. In Zaire, Van Eijnatten (1977), reported that flowering of *C. millenii* occurs around November to January of the following year.

Some Cola trees may have only male flowers, other may have up to 50 % of hermaphroditic flower. The number of hermaphroditic flowers per tree is positively correlated with yield (Dublin, 1965). In contrast, Russell (1955) reported that trees with many hermaphrodite flowers had few fruits. The yield of Cola nut amounts to less than 0.1% of the potential because of flower bud drop, flower drop, low pollination efficiency, self-incompatibility, fruit abortion, due to insect attack or physiological abscission, nutrient deficiency and other environmental stresses.

Cola tree starts to lose its production potential first through a great loss in the number of flushes or newly formed branches. This is followed by bud drop which has been reported to be very high (Bodard, 1962). Compounded with these, is the report of the same author, Bodard (1962), that only 1% of the opened flowers fruited naturally. The chances of fertilization occurring in a successfully pollinated flower are beset by the complexity of self-incompatibility and environmental factors. Russell (1955) reported that self-incompatibility is predominant in Nigerian Cola, while Bodard (1962) reported the opposite in Cote d'Ivoire. It takes 135 to 150 days from pollination or 120 to 135 days from fertilization to maturity of Cola fruit (Michel, 2004). Within this period, quite a lot can and do happen to Cola fruits. Considerable fruit abscission (drop) has been reported as early as two weeks after pollination and by the end of the tenth week, fruit drop stops (Russell, 1955; Dublin, 1965).

2.5. Nutritional Profile of the Plant

All members of the Cola species contain caffeine, koletein and kolatin alkaloids, pro- anthocyanin, magnesium, sodium, potassium bromide, cobalt, caesium, zinc and selenium (Nwankwo, 2017). Recent researches have shown that *C. millenii* also contains sugar, starch, crude fat, crude protein, ascorbic acid, iron, manganese (Nwokocha and Williams, 2018). Borokini *et al.* (2014) reported the crude protein, crude fibre, crude fat, ash content, moisture content and carbohydrate in the seed to be 5.76 ± 0.49 g/100 g, 2.22 ± 0.65 g/100 g, 43.0 ± 0.71 g/100 g, 2.76 ± 0.49 g/100 g, 6.90 ± 0.89 g/100 g and 10.46 ± 0.68 g/100 g respectively while the crude protein, crude fibre, crude fat, ash content, moisture content and carbohydrate in the pulp were; 4.10 ± 0.85 g/100 g, 2.83 ± 0.71 g/100 g, 30.03 ± 1.00 g/100 g, 2.83 ± 0.25 g/100 g, 9.80 ± 0.73 g/100 g and 13.79 ± 1.67 g/100 g respectively. The carbohydrate content of the seed and pulp of *C. millenii* was moderate and it was suggested that this might be ideal for diabetic and hypertensive patients requiring low sugar diet. The high fat content is evident from the high calorific value of the seed and pulp. The ash content was moderate and similar to the values reported for some Nigerian fruits which means that the fruit may be a good source of essential minerals needed for good body development and normal functioning of the body system (Reid *et al.*, 2005). The fibre content reported for the seed and pulp of *C. millenii* is higher than those reported for orange, mango and avocado fruits. Fibre has been known to reduce cholesterol level in the body according to Oluyemi *et al.* (2006). The level of fibre in *C. millenii* is adequate and can meet the daily required allowance in human diet therefore it might be desirable to be incorporated in weaning diet.

The reported mineral concentration in the *C. millenii* seed were 168.73 mg/100 g, 417.72 mg/100 g, 140.99 mg/100 g, 310.26 mg/100 g, 446.56 mg/100 g, 359.47 mg/100 g, 100.02 mg/100 g, and 9.90 mg/100 g respectively for Calcium, Potassium, Sodium, Zinc, Iron, Magnesium, Manganese and copper while that of the pulp were 394.78 mg/100 g, 356.47 mg/100 g, 187.15 mg/100 g, 481.53 mg/100 g, 1901.75 mg/100 g, 610.29 mg/100 g, 555.23 mg/100 g and 7.80 mg/100 g respectively. Calcium helps in muscle contractions, transmits nerve impulses and help in bone formation. The recommended dietary allowance (RDA) for Calcium is 800 mg/day (Reid *et al.*, 2005), which means that about 68 g dry weight of *C. millenii* pulp would provide the RDA for Calcium. This shows that this fruit part could be a better source of Calcium than some conventional fruits, especially in pregnant women that require high calcium content food for bone development of the foetus (Barker, 1996). These values were higher than 310.00 mg/100 g, 33.00 mg/100 g and 16.00 mg/100 g for Locust seed bean, sweet Orange and Pineapple respectively as reported by Ihekoronye and Ngoddy, (1985). Potassium was the second most abundant in the seed, though the value was high in the pulp. The values in both seed and pulp were higher than 168, 152 mg/100 g and 213 mg/100 g reported for grape fruit juice, Orange and Pineapple pulp respectively (Chai and Liebman, 2004).

Magnesium plays a major role in relaxing muscles along the air way to the lung, thus allowing asthmatic patients to breathe easier. It also plays a fundamental role in most reactions involving phosphate transfer which is believed to be essential in the structural stability of nucleic acid and intestinal absorption (Barker, 1996). However, deficiency of magnesium in man is responsible for severe diarrhea, hypertension, cardiomyopathy, atherosclerosis and stroke (Barker, 1996; Appel, 1999). The concentration obtained for seed and pulp was evidence of good source of magnesium. Iron was higher in the pulp than the seed, this implies that the intake of the pulp might make it a good source of Iron. It should be realized that Iron is required for blood formation and also important for normal functioning of the central nervous system (Oluyemi *et al.*, 2006). The daily allowance of iron for men is 7 mg/day and 12-16 mg/day for women during pregnancy. For RDA of Iron to be provided by *C. millenii*, the ingestion of 8.0 g only would be required to meet the RDA requirements. Zinc concentration was reportedly high in both seed and pulp of *C. millenii*. Zinc is said to be essential trace element for protein and nucleic acid synthesis and for normal body development. It plays a central role in growth and development and vital role during period of rapid growth such as infancy, adolescence and recovery from illness. Moreover, zinc deficiency has been largely attributed to high phytic acid content of diets leading to poor growth, impaired immunity and increased morbidity from common infectious, diseases and increased mortality (Oliveri, 2003; Melaku, 2005).

2.6. Phytochemical Constituents of *Cola millenii*

Adewumi and Arije (2017) reported the presence of alkaloids, saponins, tannins, glycosides, flavonoids and terpenoids in seed and pulp of *C. millenii*. However, Ubon *et al.* (2017) did not find flavonoids, tannins and anthraquinones in *C. milenii* seed that they examined, while Giwa *et al.* (2012) did not find flavonoid and anthraquinones in the seed and pulp of *C. millenii* they screened. Ajayi and Ojelere (2013) also reported the presence of terpenoids in the seed of *C. millenii.* Alkaloids are believed to be one of the most effective and therapeutically significant plant substances (Okwu, 2005). They are reported to be pharmacologically active and their actions are felt in different parts of the body system, such as the nervous system, blood vessels, promotion of diuresis, respiratory system, gastrointestinal tract, uterus, malignant diseases and malaria (Trease and Evans, 1989; Borokini and Omotayo, 2012). This may explain the use of the plant parts especially the seed, pulp and leaf in treating several disease conditions (Adeniyi *et al.,* 2004; Sonibare *et al.,* 2009a). Alkaloids have analgesic, antiplasmodiac and bactericidal effects (Okwu and Okwu, 2004) as well as marked physiologic effects on animals (Edeoga and Eriata, 2001). This supports the folkloric use of the *C. millenii* pulp in treatment of various diseases in monkeys.

Saponins have hypotensive and cardiac depressant properties according to Olaleye (2007), and have been shown to possess beneficial properties by lowering the cholesterol level, have anti-diabetic and anticarcinogenic properties as well as being used as an expectorant and emulsifying agent (Edeoga *et al.,* 2006; Borokini and Omotayo, 2012). The high percentage of saponins in the leaf, stem bark, seed and pulp of *C. millenii* indicates that the plant may be useful in the treatment of diabetes and management of heart conditions (Ayodele *et al.*, 2000).

Terpenoids was found in the leaf, stem bark and seed of *C. millenii*. They possess anti-hepatoxic properties, thus helping to prevent liver damage (cirrhosis); they equally have antimicrobial or anti-septic properties (Borokini and Omotayo, 2012). Moreover, glycosides were found in seed and pulp of *C. millenii* albeit significantly high only in seed extract, and this was in line with the reports of Giwa *et al.* (2012), Ajayi and Ojelere (2013) and Ubon *et al.* (2017). Glycosides are reported to possess clinical effects on congestive heart failure (Borokini and Omotayo, 2012). They are also said to be active on the heart muscles and increase renal flow (diuresis) (Olaleye, 2007). All these are pointers to the potential ability of the plant part especially the seed to manage several degenerative diseases.

2.7. Antimicrobial Properties of *Cola millenii*

Giwa *et al.* (2012) reported the antimicrobial activities of the pulp and seed of *C. millenii,* where the extracts were found to exhibit important inhibitory activities against the growth of certain bacteria and fungi. In their investigation, the ethanolic extracts of seed and pulp of *C. millenii* showed inhibitory activity against all the selected test bacteria and mold, with zone of inhibition varying from 0.13 ± 0.05 cm for *Pseudomonas aeruginosa* at 30 mg/ml, 0.86 ± 0.11 cm for *Salmonella typhi* at 100 mg/ml (in pulp), and 0.17 ± 0.12 cm at 30 mg/ml concentration and 1.73 ± 0.06 cm at concentration of 100 mg/ml for *Aspergillus niger,* in seed extract. The aqueous extracts of the plant seed and pulp were reported to possess weaker effect even at its high concentration (Giwa *et al.*, 2012). In their study, Orisakeye and Ojo (2013) reported that *C. milleni* leaves were active against *Pseudomonas aeruginosa* and *Bacillus subtilis,* with inhibition zone of 6.5 mm, but not active against *Escherichia coli* and *Staphylococus aureus*.

Odugbemi (2006) observed that the leaves of *C. milleni*are used in the treatment of ringworm, scabies, gonorrhoea, dysentery and ophthalmic. The antimicrobial property and its phytochemistry of the ethanol leaf extract of *C. milleni* against human pathogenic strains were also reported (Sonibare *et al.*, 2009b). According to Adeniyi *et al.* (2004), only the leaf and stem bark of *C. milleni* were reported not to be active at the highest concentration of 1000 ug/ml. Only the methanol extract of the root bark of *C. milleni* was found to be potent against both *Mycobacterium bovis* and strains of *Mycobacterium vaccae*. In spite of the popularity of the plant in traditional application, previous phytochemical and antimicrobial studies have been limited to the leaf and stem bark.

3. CONCLUSION

From the present review, it is evident that *C. millenii* is a tropical tree with enormous potential. The various parts of the plant can be exploited for different purposes. The seed contain enough nutritional value to be considered for incorporation into human diet or at least animal feed. The bioactive substances inherent in the leaf, bark and pulp of the plant make it an ideal source of alternative therapy and for the formulation of antimicrobials for the management of infectious diseases. If fully exploited, this plant has the potential to contribute immensely to the Nigerian economy.

4. CONFLICT OF INTEREST

There is no conflict of interest associated with this work.

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