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Review

A review of the origin, morphology, cultivation, economic products, health and physiological implications of raphia palm

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Several species of the *Raphia* palm exists and are largely confined to tropical Africa, south of the Sahara, from sea level of about 2000m altitude. In Nigeria, it is found in the south-south geopolitical zone. It provides material for furniture, house construction, food, clothing, edible oil, and so on. *Raphia* palm is one of the most useful palms economically. The *Raphia* palm leaves are the largest amongst the palms in Africa. It produces sap which is drunk by millions of people in Africa. Over the last decade, the sap has attracted a lot of research interest. Consequently, the sap has been preserved. Useful nutrients have been detected in the sap, which could play active roles in human physiology and health. Products from the sap have been developed, which could be rehydrated and drunk like the original sap. The products could also act as sweeteners in food preparations. Increased cultivation of the palm could provide good income for small, medium and large scale farmers, as every part of the palm is useful.

Key words: *Raphia* palm, origin, cultivation, products, palm sap/wine, physiological.

INTRODUCTION

The *Raphia* palm is among the eleven indigenous genera of the palms found in Nigeira. The palms include: *Borassus, Elaeis, Hyphaene, Phoenix, Raphia, Ancistrophyllum, Calamus, Eremospatha, Oncocalamus, Podococcus, Sclerosperma*.

The detailed morphology, distribution, products and uses of the different species of palms mentioned above have been discussed by McCurrach (1960), Ressell and Tulley (1965), Corner (1966), Hartley (1967) and Otedoh (1972, 1974, 1975, 1976). Only the first five of the above palms are tapped for wine (Otedoh, 1981). Otedoh (1976) reported that the *Raphia hookeri* is the highest yielder of palm sap or palm wine followed by *Raphia vinifera*. The *Raphia* palm is hapazanthic, that is, after a period of vegetative growth, it produces flowers and fruits only once and dies.

The flower is signalled by the simultaneous appearance in the crown of more than one expanded spear leaves. It is usually at this stage that the palm is tapped for sap/wine (Obahiagbon and Osaige, 2007) . This paper review is being presented as an update on the research finding on *Raphia* palm.

ORIGIN AND TAXONOMY

The historical background and origin of the *Raphia* palm had been reported by researchers, like Otedoh (1976); Ndon (2003); Pena P. and de Lobel (1970); Bauhin and Cherou (1650); Gaertuer (1789), Palisot de Beauvois (1806), Mann and Wendland (1864), Kingsley (1897), Beccari (1910), Chevalier (1932), Dalziel (1937), Russel (1965), Keay et al. (1964) and Moor (1973). Palisot de Beauvois (1906) was the first to give the name *Raphia* to palms bearing the type of fruits described by Gaertner (1989) as reported by Ndom (2003). After a- four-year research work along the West African coast (1859 - 1863), Mann and Wendland (1864) presented five species of *Raphia* palms, which included *Raphia hookeri.*

The taxonomy of *Raphia* palm had been described as awkward because of its trunk which is large and the leaves being the greatest in the plant kingdom (Russel, 1965). Scientific reports and investigations on *Raphia* palms have shown that its origin is traceable to West Africa, particularly along the swampy area of the tropical forest (Moore, 1973; Otedoh, 1974, 1975; Keay et al., 1964; Ndon, 2003). The *Raphia* palm is a tropical tree crop, which requires for adequate growth, high rainfall, high temperature, high relative humidity and prolonged sunshine hours (Otedoh, 1976; Ndon, 2003).

CULTIVATION

The soils supporting the growth of *Raphia* palm has been reported by authors like Aghimien et al. (1984), Jungerius (1964) and Obahiagbon (2008). Aghimien (1984) reported that hydromorphic soils are quite suitable for the growth of the palms.

Obahiagbon (2008) found that there was no significant difference between the yield of saps by *Raphia vinifera* palms grown on hydromorphic and non- hydromorphic soils. However, Obahiagbon recommended that prospective *Raphia* palms grower could use both soils, depending on the soil fertility and climatic conditions.

Ndon (2003) also reported that *Raphia* palm does best in hydromorphic soils, which are in part permanently or seasonally flooded for considerable part of the year. Such soils occur dominantly along the coast, valleys and spill plains of the major rivers. In Nigeria, hydromorphic soils occur for almost 17% of the total land area. Along the coastal fringes, the salt water swamps support mangrove forest and other salt- tolerant species, but the fresh-water swamps and inland valleys support fresh water plant species. *Raphia vinifera* tolerates some level of salts where *Raphia hookeri, Raphia sudanica* and *Raphia africana* can only withstand fresh-water swamps. However, soils supporting *Raphia* palms are developed mainly on arenaceous sedimentary rocks, sandstones and coastal palm sands with less area on basic igneous rocks. Aghimien (1983) reported on surface soils (0 – 20 cm depth) of 21 locations in the tropical rain forest zones, which support the growth of *Raphia* palms. The characteristics of the soils were: acidic; pH range between 4.3 and 5.3; low buffering capacity indicated by low CEC parameters; low base saturation (51% average); varied nitrogen levels (0.084 - 0.60%); varied organic matter level (0.04 - 22.92%); low sequioxides content, except one site which was developed on basalt. Total P ranged from 105 to 1785 mg/kg. Organic P ranged between 26 and 276 mg/kg and formed between 4 and 54% of total P. The soils were inherently low in total P with fairly high proportion in the active and residual fractions. Iron bonded P was dominant over aluminium-bonded P while calcium-bonded P was of little significance (Ndon, 2003).

ECONOMIC PRODUCTS

Like *Elaeis guinensis* (oil palm), every part of *Raphia* palm are useful economically (Otedoh, 1976). Authors like Otedoh (1974, 1976) and Ndon (2003) have reported on the economic importance of *Raphia* palm to include the following:

Leaves

From the leaves of *Raphia* palm, the following products are deriveable: piassava, bamboo, raffia, brooms.

Brooms

The mid-ribs of mature *Raphia* palm leaflets can be used in making two types of brooms, for sweeping the floor and removal of cobwebs from walls and ceiling. A quan-tity of the processed midribs is tied together in bundles with piassava or cane and filted with a stick about 4 ft long for sweeping purposes.

Bamboo

This is made-up of the petiole and the principal midrib of the front without the leaflets. The bamboo or pole is useful in the construction of thatch houses; for construction of native bridges, ladder for climbing *Raphia* palms during tapping or harvesting of the fruits. They are also used, when tied together as framework for mud houses particularly in the rural or riverine areas.

Piassava

The coarse fibre could be found at the leaf-bases of *R. hookeri* palm. It is used locally for the weaving of fish traps, hats, and so on. It is also useful in the manufacturing of climbing roles and for tying purposes of animals, such as goat, sheep and fowls as well as canoes to post. In the riverine area, most fishermen use the container made from piassava in the conveyance of the catch to their homes or market places.

Raffia

This is the epidermal strip of the unexpanded 'spear' leaflet. The raffia is a long thin strip of fibre as soft as silk, about half feet wide and five feet long. When twisted it is used as twine to weave mats, baskets, hats, shoes, school bags, conference bags, among others.

Roofing mats

The leaflets of *Raphia* palm can be used for the manufacturing of roofing mats used in thatch houses construction in rural environments. The mats can also serve as ceiling materials for houses and for relaxation.

Trunk

The trunk of *Raphia* palm is used as building materials, for construction of local houses, fire wood and as a habitat for raising maggots or insect larvae. Three types of maggots have been identified in *Raphia* palm (Otedoh, 1976):

Ukolo: The first is locally called *Ukolo* (*Rhynchophorus sp.*). It has a bright orange colour, barrel-shaped larva, characteristically found in a live *Raphia* palm and which eventually destroys the palm. This is the most delicious of all the maggots found in *Raphia* palm. It contains a lot of fat. They are usually fried and eaten with tapioca, garri and rice.

Edon: This is the second kind of maggot found in the dead trunk of *Raphia* palm. Like the Ukolo, they are found in large numbers during the rains and are very scarce during dry season. They are also fried before consumption, eaten with tapioca, garri and rice. In Nigeria, the maggots are eaten mostly by the Urhobos, Ijaws, Itsekiris, Ibos, Ibibios and some other tribes (Otedoh, 1976).

Ugbaen: This is the third type of larva or maggot found in dead *Raphia* palm. It is not as sweet as the *Ukolo* or *Edon*. It is the larval stage of a *Rhinoceros* bettle, *Oryiles sp.* It is eaten with garri or starch when used in the preparation of 'banga' soup.

PALM SAP/WINE

The palm sap/wine is the major product from the *Raphia* palm. The production of palm sap/wine forms one of the most important occupational engagements of the rural inhabitants in the Nigerian belt. The palm wine tapping activities is done indiscriminately (Obahiagbon and Osagie, 2007) . To obtain the sap, the *Raphia* palm is tapped daily in the traditional manner described by Tulley (1964). Some native tappers in the south-south of Nigeria apply heat to stimulate the flow of the sap at the panel where the receiver is hung (Otedoh, 1990). The sap of *Raphia* palm is drunk by millions of people in Africa, as a beverage. The sap ferments within few hours and turns to an alcoholic drink referred to as palm wine in Nigeria (Bassir, 1962). The sap is colourless and very sugary/ sweet (Obahiagbon et al., 2007).

The drinking of palm wine signals the start and end of all social activities undertaken by 50 million people of southern Nigeria. The *Raphia* palms alone contribute about 20% of the palm wine drunk in its unfermented as well as fermented states, depending on the choice of the consumer (Obahiagbon and Osagie, 2007).

Due to the significance of *Raphia* palm sap/wine in ceremonies like obituary, marriage and for general entertainment, attempts to preserve the product was initiated by Levi and Oruche (1957), but was not successful. Okafor (1975) examined the suitability of sorbic acid, sodium metabisulphite and diethyl pyro-carbonate (DEPC) in palm wine preservation. He concluded from the studies that sorbic acid was most suitable for palm wine preservation because of its wider spectrum of bactericidal action and its tolerance in fairly large quantity by man, inspite of its insolubility in palm wine and colour impartation. The change in colour of palm wine from the normal white did not allow the acceptance of this product by the Nigerian populace. Esechie (1978) also carried out studies on the prese-rvation of the palm wine by using sodium metabisulphite, potassium sorbate and extract of *Saccoglottis gabonesis* and followed with heat treatment (pasteurization at $70^{O}C$ for 40 min) . For all the trials, pasteurization of fresh palm wine at 70°C /40 min was recommendended and could only preserve the product for up to 9 months.

Eapen (1982) in his palm wine preservation studies recommended the use of sodium metabisulphite alongside with pasteurization at 70°C/40 min, but this method could not preserve the product for more than 12 months.

Obahiagbon and Oviasogie (2007) extended the shelf-life of *Raphia* palm sap to 24 month by pasteurizing at 75°C for 45 min without any chemical preservative. The vital nutrients in the sap were all retained at the end of the 24^{th} month, without deterioration. This method of *Raphia* palm sap preservation has completely eliminated the health hazards of preservatives in foods e.g. the sodium metabisulphite which is carcinogenic and had been recommended for use in palm wine preservation for decades.

Nutrient composition

The nutrient composition of the fresh sap has been reported by several workers (Bassir, 1968; Esechie, 1978; NIFOR, 1970/71; Obahiagbon, 2007). The fresh palm sap is composed of sugars, proteins, titrable organic acids, alcohol, vitamins (ascorbic acid, thiamine, riboflavin etc) mineral elements and water.

Derived products

Two major products have been derived from the sap of *Raphia* palm (the syrup and freeze dried products) as reported by Obahiagbon et al. (2007). These products were alternative methods achieved for the preservation of the palm sap, as earlier methods e.g. the use of refrigeration could only delay the rate of fermentation and did not favour the consumer in rural areas where electricity was not available (Levi and Oruche, 1957).

Additionally, other attempts to preserve the palm sap made use of chemical preservative and pasteurization which only provided a maximum shelf-life of 9 and 12 months, respectively (Esechie, 1978; Eapen, 1982). The syrup and freeze dried products have a shelf-life of over

24 months. They could be rehydrated and drunk like the original fresh palm sap. The above products could also serve as sweetners in food preparations (Obahiagbon et al., 2007).

Health implication

The health implication of the sap had been reported by Bassir (1968). His report indicated that the palm sap could be used for the cure of malaria, measles, and jaundice. It also aids the flow of milk in nursing mothers. The active ingredients in the palm sap responsible for the above roles are yet to be identified.

Eleven elements that the body cannot synthesize which were recommended by the National Academy of Sciences/National Research Council (2001) for the maintenance of good health are detectable in the sap of *Raphia hookeri* (Obahiagbon *et al.* 2007). Arising from the detection of the above elements and other dietary constituents in the sap of *Raphia* palm, Obahiagbon et al. (2007) developed a Recommended Dietary Allowances (RDAs) Table, which could serve as a nutritional norm for planning and assessing intake and the level of intake of essential nutrients considered fit or adequate to meet the requirement for healthy individuals.

The RDAs for vitamins, amino acids and minerals and other nutritional elements for optimum nutrition in infants, children, adults and pregnant women differ in most cases. Dr. Alfred Harper, when introducing the vision of the recommended daily allowances in 1974, stated that "requirements may differ with a body size; among individuals of the same body size owing to differences in genetic makeup; with the physiologic individual-growth rate, pregnancy, lactation and with sex".

The elements detectable in the sap of *Raphia hookeri* palm include: Cl, Na, K, Ca, Mg, Fe, Cu, Mn, Zn, P, and N. The health and physiological roles of these elements detected in the sap of *Raphia* palms are as follows:

Electrolytes

Physiologically, chlorine, sodium and potassium acts as electrolytes in body fluid. They help to maintain osmotic pressure and regulate acid-base equilibrium. Chloride and sodium help to control the passage of nutrients into the cells and movement of waste products out of the cells (McDowell, 1992). Ammerman and Goodrick (1983) had reported that chloride is essential for the activation of intestinal amylase. Chloride is the major anion of extracellar fluid, while sodium is the major cation. The principal intra cellular cation is potassium and it functions as a cofactor in several enzyme systems, involved in the transmission of nerve impulses and in the regulation of heartbeat (Thompson, 1978). Muscular weakness, paralysis, mental confusion, cardiae arrest and small bowel ulcer are some of the deficiency diseases on symptoms of potassium (McDowell, 1992).

Magnesium

Magnesium has many diverse physiological functions. The integrity of bones and teeth is maintained by the magnesium in the skeleton. After potassium, magnesium is the second most plentiful cation of intracellular fluids. Magnesium is predominantly associated with the mitochrondria, intracellularly. It functions principally in this respect as enzymes activator (Wacker, 1969). Magnesium plays notable roles in the metabolism of carbohydrates and lipids as a catalyst of a wide array of enzymes.

This element is an active component of several enzyme systems in which thiamine pyrophosphate (TPP) is a cofactor. In the absence of magnesium, oxidative phosphorylation is greatly reduced. Magnesium activates pyruvic acid carboxylase, pyruvic acid oxidase and the condensing enzyme for the reactions in the Krebs cycle (McDowell, 1992). Watson et al. (1980) reported that magnesium is involved in protein synthesis through its action on ribosomal aggregation and its roles in binding DNA. Additionally, it is essential for the formation of cyclic AMP and other second messangers.

Iron

Iron plays an essential role in the tricarboxylic acid (Krebs) cycle as all of the 24 enzymes in this cycle contain iron either at their active centres or act as essential cofactors (McDowell, 1992). Iron exists in animal bodies in complex forms bound to protein (hemoprotein) as heme compounds.

The synthesis of heme is impaired in iron deficiency because of substrate insufficiency for ferrocatalase and also in copper deficiency owing to decreased activity of the copper-dependent enzyme cytochrome oxidase, which reduces Fe^{3+} to Fe^{2+} before incorporation into the porphyrin molecule (Williams et al., 1976).

Apart from iron, copper is necessary for the synthesis of haemoglobin. Copper is not contained in haemoglobin, but a trace of it is necessary to serve as a catalyst before the body can utilize iron for haemoglobin formation. Anaemia can result with either iron or copper deficiency. Copper deficiency can result in an apparent delay in maturation and shortened life span of red blood cells (Baxter and Vanwyk, 1953).

Several studies have shown the effects of copper deficiency on lipid metabolism. Altered heart function of rats fed with low copper is associated with alteration in lipid and long-chain fatty acid metabolism (Cunnane et al., 1987), which may be attributed to the predominant role of copper in the superoxide dismutase enzyme system.

Reproductive failure is commonly associated in mammals fed copper-deficient diet (Underwood, 1977).

Copper is required for cellular respiration, bone formation, proper cardiac function, connective tissue development, myelination of spiral cord, keratinisation and tissue pigmentation.

Manganese

Physiologically, manganese can function both as an enzyme activator and as a constituent of metalloenzymes, like other essential trace elements.

Manganese deficient bones are shortened and thickened as exemplified by most species studied. The first signs of manganese deficiency observed were on the effects on reproduction. Testicular degeneration has been reported in manganese deficient rats, mice and rabbits (Leach, 1978). Manganese is involved in the bio-synthesis of choline and has a role in cholesterol biogenesis (Davies et al., 1990) and plays a role in immunological function (Hurley and Keen, 1987). Manganese deficiency or toxicity can affect brain function (Hurley, 1984).

Zinc

The human deficiency of zinc was first noticed in 1961 and as a result research was stimulated into this vital nutrient (McDowell, 1992). Zinc play important roles in enzymes, both as constituent of the molecule and as an activator. Structurally, zinc stabilise the quaternary structure of the enzymes (Prask and Plocke, 1971).

WATER SOLUBLE VITAMINS, SUCROSE AND PROTEINS

Three water vitamins (Thiamine, Ribofavin and Ascobic acid) have been detected by Obahiagbon et al. (2007) in the sap of *Raphia* palms, with ascorbic acid having the highest concentration, followed by thiamine and riboflavin, respectively. The source of the vitamins was linked to the yeast, *Saccharomyces cerevisiae* that is present in the sap, being one of the major agents of fermentation of the latter. The physiological roles and health implications of these vitamins are discussed below:

Thiamine

The active form of thiamine, thiamine pyrophosphate, functions as the cocarboxylase in the oxidative decarboxylation of pyruvic acid. As a consequence of thiamine deficiency, pyruvic acid accumulates. Some of the accumulated pyruvic acid is converted to lactic acid, with little release of energy. The presence of thiamine in human nutrition is necessary to ensure that pyruvic acid catabolism can precede via the Citric acid cycle and the electron transport chain (Rankin et al., 1976). Thiamine deficiency in human nutrition causes the disease condition known as beri-beri, a neurological disorder resulting from carbohydrate-rich/low-thiamine diets (Mayes et al., 1993; Lehninger, 1990).

Riboflavin

The physiological roles of riboflavin includes its formation of the prosthetic group of flavoproteins which function as hydrogen carriers in the oxidation sequences of respiration resulting in the release of hydrogen into the electron transport chain and subsequently combines with oxygen to form water. Deficiency symptoms of riboflavin include: angular stomatitis, cheilosis, seborrhoea and photophobia (Mayes et al., 1993).

Activation Energies of thamine and riboflavin

The activation energies of thamine and riboflavin extracted from the sap of *Raphia* palm have been reported by Obahiagbon et al. (2007). The calculated activated energies for the vitamins (thamine and riboflavin) extracted from the *Raphia* palm sap were 4.0 ± 0.1 and 32.0 $kJmol^{-1}$ ± 0.1 respectively.

Ascorbic acid

The health benefits of ascorbic acid include collagen formation in teeth, bone, connective tissue and blood vessels. It may be useful in the resistance against infection. Deficiency syndrome of ascorbic acid is scurvy (breakdown of skin, blood vessels and teeth) (Mayes et al., 1993).

Sucrose

A study on sucrose production by Raphia palms has been reported by Obahiagbon and Osagie (2007) and showed that, sucrose is the major sugar present in the sap of *Raphia hookeri.* The sweet taste of *Raphia* palm sap is a characteristic of the amount of sucrose present. In humans, carbohydrates are utilised as major sources of biological energy through their oxidation in the cells. Carbohydrates also function as organic precursors for the biosynthesis of many cell compartments. In human nutrition, sucrose is considered as a macronutrient that yields a quick source of energy.

Protein

The protein content of the *Raphia* palm sap has been reported as very low (Ndom, 2003). The health implication of protein consumption include: the involvement of its essential and nonessential amino acids as building blocks in protein biosynthesis, not only for the growth of infants and children but also for the constant replacement and turnover of body proteins in adults.

SUMMARY

The *Raphia* palm was identified in the 19th Century. They are a genus of twenty species of palms native to tropical regions of Africa, Central and Southern America. The *Raphia* palm is characterized by their compound pinnate leaves which distinguished them among other palms, as having the largest leaves in the plant kingdom. The specie, *Raphia regalis* has a leave length of 65 feet.

Evidences are already available that the *Raphia* palm can produce good volume of sap when grown on either hydromorphic or non-hydromorphic soils. However, the palm grows best in swampy soils having high rain fall, high temperature (22 - 33^{0}C), sunshine of not less than 5 - 7 h and high relative humidity. The morphology of *Raphia* palms is not identical as also exemplified in their vegetative growth. Like *Elaeis guineesis*, the entire parts of *Raphia* palm are all useful economically and for domestic purposes. The leaves and trunk are used for the construction of thatch houses and for making local furniture, apart from serving as fire wood. The hard fibre, piassava is useful in making gun powder, carpet, baskets, and so on. On the other hand, the soft fibre raffia is used for making baskets, shoes, bags, masque-rade dresses among others. Paper making is already deriving its raw materials from the *Raphia* pulp obtained from its trunk, bamboo and others. The palm sap or palm wine (fermented sap) is the most popular of all the economic products. It has been preserved in its original state with a shelf-life of twenty-four months. Two useful products have been derived from its sap which could be rehydrated and drunk like the original sap. The nutritional contents of the sap suggest several roles in human phy-siology and good health. For example, eleven elements which the human body cannot synthesize have been detected in the sap of *Raphia* palm, apart from three water soluble vitamins and proteins. The sap of *Raphia* palm is made up of over 90% water. The sap/palm wine is useful in the cure of jaundice, measles and flow of mammalian glands in nursing mothers. The derived products from the sap could serve as another source of sweetener in food and pharmaceutical preparations. The calculated activated energies for the vitamins (thamine and riboflavin), extracted from the *Raphia* palm sap are 4.0±0.1 and 32.0kJmol^{-1}±0.1 respectively.

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