Technical paper

Vitamins, phytochemicals and toxic elements in the pulp and seed of raphia palm fruit (*Raphia hookeri*)

Marc Nwosu OGBUAGU*

Chem. Dep., Michael Okpara Univ. Agric., Umudike, PMB 7267, Umuahia, Abia State, Nigeria
ogbuagumn@yahoo.com

* *Correspondence and reprints*

Fruits, 2008, vol. 63, p. 297–302

DOI: 10.1051/fruits:2008025
www.fruits-journal.org

RESUMEN ESPAÑOL, p. 302

Vitamins, phytochemicals and toxic elements in the pulp and seed of raphia palm fruit (*Raphia hookeri*).

Abstract — **Introduction**. The raphia palm tree is found in abundance in the southern part of Nigeria, especially in the southeastern part. It is grown mainly for its production of palm wine. It also bears fruits (*Raphia hookeri*) whose pulp is considered edible in some parts of the country and not edible in other parts. **Materials and methods**. Conventional methods of analysis were used to investigate the vitamin, phytochemical and toxic element composition of the pulp and seed of the fruit. **Results**. The investigation shows that the pulp has higher concentrations of vitamin E (1.04 $mg \cdot 100\ g^{-1}$), niacin (0.2 $mg \cdot 100\ g^{-1}$), alkaloid (5 $g \cdot kg^{-1}$), saponins (3.6 $g \cdot kg^{-1}$), flavonoids (4 $g \cdot kg^{-1}$) and phenols (4.1 $g \cdot kg^{-1}$) than the seed, but the seed has higher values of vitamin A (0.16 $mg \cdot 100g^{-1}$), thiamine (0.07 $mg \cdot 100\ g^{-1}$), riboflavin (0.07 $mg \cdot 100\ g^{-1}$), nitrates (3.05 $mg \cdot 100\ g^{-1}$) and nitrites (0.29 $mg \cdot 100\ g^{-1}$), and of the toxic elements: lead (0.03 $\mu g \cdot g^{-1}$), mercury (0.04 $\mu g \cdot g^{-1}$), arsenic (0.23 $\mu g \cdot g^{-1}$) and cadmium (0.04 $\mu g \cdot g^{-1}$) than the pulp. **Conclusion**. The pulp and seed of *R. hookeri* are non-toxic and can serve as food as well as in medicine.

Nigeria / *Raphia hookeri* / fruits / fruit pulps / chemical composition / vitamins

Vitamines, composés phytochimiques et éléments toxiques dans la pulpe et la graine des fruits du palmier *Raphia hookeri*.

Résumé — **Introduction**. Le palmier *Raphia hookeri* se trouve en abondance dans la région méridionale du Nigéria, particulièrement au sud-est du pays. Il est principalement exploité pour sa production de vin de palme. Il donne également des fruits dont la pulpe est considérée comestible dans certaines parties du pays et non comestible dans certaines autres. **Matériel et méthodes**. Une étude de la composition en vitamines, composés phytochimiques, et éléments toxiques de la pulpe et de la graine du fruit a été faite à l'aide des méthodes d'analyses conventionnelles. **Résultats**. Nos travaux ont montré que la pulpe avait des concentrations plus élevées que la graine en vitamine E (1.04 $mg \cdot 100\ g^{-1}$), niacine (0.2 $mg \cdot 100\ g^{-1}$), alcaloïdes (5 $g \cdot kg^{-1}$), saponines (3.6 $g \cdot kg^{-1}$), flavonoïdes (4 $g \cdot kg^{-1}$) et phénols (4.1 $g \cdot kg^{-1}$), alors que la graine avait des valeurs plus élevées que la pulpe en vitamine A (0.16 $mg \cdot 100g^{-1}$), thiamine (0.07 $mg \cdot 100\ g^{-1}$), riboflavine (0.07 $mg \cdot 100\ g^{-1}$), nitrates (3.05 $mg \cdot 100\ g^{-1}$), nitrites (0.29 $mg \cdot 100\ g^{-1}$), et en éléments toxiques: plomb (0.03 $\mu g \cdot g^{-1}$), mercure (0.04 $\mu g \cdot g^{-1}$), arsenic (0.23 $\mu g \cdot g^{-1}$) et cadmium (0.04 $\mu g \cdot g^{-1}$). **Conclusion**. La pulpe et la graine de *R. hookeri* sont non-toxiques ; elles peuvent être consommées et être utilisées en pharmacopée.

Nigeria / *Raphia hookeri* / fruits / pulpe de fruits / composition chimique / vitamine

1. Introduction

The Raphia palm tree (*Raphia hookeri*) is a representative of the family of Palmae or Palmacea. There are about 30 species of the tree within the tropical and sub-tropical regions in the world. In Nigeria, it is represented by about five species: *Raphia hookeri* Mann. and Wendl., *Raphia sudanica* Chev., *Raphia vinifera* Beauv., *Raphia regalis* Becc. and *Raphia faminifera* (Gaertn) Hylander [1]. However, *Raphia hookeri* is commonly found in West Africa and is abundant in the south of Nigeria, especially in the southeastern parts. The species is a large tree with a beautiful feathery appearance that doubles its height. One leaf holds up to 360 arching leaflets that are up to 5 cm wide and waxy [2]. The massive palm has its natural habitat in the swampy areas in forest regions extending from Guinea to Gabon and from Southeast Nigeria to Cameroon [3].

The trees normally reproduce by seed but some species can propagate by suckers. The seeds germinate after a period of dormancy, which varies from 6 months to 3 years. Raphia fruits usually mature very slowly. It takes 2–3 years from anthesis to ripening [4]. The flowering and fruiting period is usually between February and July.

The raphia palm tree is grown for various purposes with major economic products including palm wine, piassava fibre, raphia fibre, and raphia trunk and leaves, which can be used for pulp and paper manufacture. Fresh palm wine is a sweet, nutritious and refreshing drink, which contains some water-soluble vitamins such as ascorbic acid (vitamin C), thiamine, riboflavin and pyridoxine [5]. Fermented palm wine serves as a base for the distillation of home-made gin.

The palm is classified into the male and the female types. The female type produces palm wine while the male type produces flowers and fruits (*R. hookeri*). The fruits of raphia palm are usually oblong-ellipsoid in a scaly cone comprised of rhombus triangular reddish-brown scales. Each fruit has an irregular grooved single seed. A bunch of fruit may contain as many as 400 fruits [1]. The fruit pulp is considered edible in some parts of the country and is eaten. The yellow oily pulp has been reportedly used as bitter flavouring or occasionally as food, particularly when fresh. It can be eaten raw or after boiling but the taste is more agreeable when it is boiled than when it is raw. The pulp is normally consumed with boiled and sliced cassava. The fruit pulp has been reportedly used as medicine and has stomachic and laxative properties and as well as being used as liniment for various pains [1]. However, it is considered toxic and inedible in some parts of the country, and, as such, is treated as waste.

The proximate compositions as well as some of the mineral elements in the peel, and raw and cooked pulp of the fruit have been reported [6]. Some toxicants such as tannin, HCN, phytic acid, oxalates (total, soluble) and the vitamin C content of the fruit have been determined. The fatty acid distribution in the mesocarp oil, seed lipids and pollen lipids has also been reported [7].

Our paper reports the presence of phytochemicals, vitamins (A, E, thiamine, riboflavin and niacin) as well as some toxic elements (Pb, Hg, Cd and As) in the pulp and seed of the fruit.

2. Materials and methods

The test sample was collected from professional palm wine tappers in the Ikwuano local government area of Abia State (Nigeria) where the university is located.

One kg of very sound and mature fruits from ten different bunches was sorted out and used for the tests. The fruit was cracked open to reveal the pulp and the seeds. The seeds were separated from the pulp and peeled to obtain the kernel. Both the pulp and seed kernel were dried in the oven at 65 °C and ground to obtain the powdery samples for the tests.

The alkaloid, saponin and flavonoid contents were determined by the gravimetric methods described by Harbone [8]. Phenol was determined by the Folin method described by Pearson [9]. Nitrate and nitrites were determined by the method described by Follet and Ratcliff [10].

Vitamins A and E were determined according to the method of the *Association of*

Vitamin Chemists described by Kirk and Sawyer [11]. Thiamine, riboflavin and niacin were determined according to the method of Barakat *et al.* [12].

The toxic elements were determined by the dry ash acid extract of the sample using an atomic absorption spectrophotometer as described by James [13].

3. Results and discussion

3.1. Vitamins A and E, niacin, riboflavin and thiamine contents

The values of thiamine and riboflavin in the seed (*table I*) are quite reasonable and higher in comparison with mango fruit, with reported values of 0.02 mg thiamin·100 g^{-1} and 0.03 mg riboflavin·100 g^{-1}, and with guava fruit, with values of 0.06 mg thiamin·100 g^{-1} and 0.04 mg riboflavin·100 g^{-1}. However, the pulp contains lower values of thiamine and riboflavin than mango and guava fruits. The niacin contents of the fruit and pulp are lower than the reported values of 0.39 mg·100 g^{-1} for mango fruit and 1 mg·100 g^{-1} for guava fruit [14]. This B-complex group of vitamins forms co-enzymes for biochemical reactions in the body; for instance, thiamine forms the co-enzyme thiamine pyrophosphate (TPP) which functions in aldehyde group transfer. Niacin forms nicotinamide adenine dinucleotide (NAD) or the phosphorylated species [NAD(P)] which functions in oxidation-reduction reaction. Flavin forms the co-enzymes flavin mononucleotide (FMN) and flavin adenine dinucleotide (FAD) which participate in redox reactions in the body [15].

Vitamin A is present in fruits in the form of carotenes (α, β, γ). The pulp has a vitamin A content of 0.15 mg·100 g^{-1}, while the seed has a value of 0.16 mg vitamin A·100 g^{-1} (*table I*). These values are higher than that of 0.005 mg vitamin A·100 g^{-1} reported in citrus fruits [16]. Vitamin A helps with good vision (eyes), clear skin, and healthy bones, hair and teeth. It is also important for reproduction.

The fruit pulp has a higher value of vitamin E 1.04 mg·100 g^{-1} than the seed (0.68 mg·100 g^{-1}). This vitamin plays a role as an anti-oxidant and protects red blood cells and unsaturated fatty acids from oxidation damage. It also plays a part in maintaining the stability of biological cell membranes.

3.2. Phytochemical contents

The phytochemical screening reveals the presence of alkaloids, saponins, flavonoids and phenols in higher concentration in the pulp than in the seed. Among these phytochemical contents, alkaloids have the highest concentration in the pulp, while phenols have the highest concentration in the seed. Seeds have higher concentrations of nitrates and nitrites than the pulp (*table II*).

The saponin content of the pulp, 0.36% (3.6 g·kg^{-1}), and of the seed, 0.23% (2.3 g·kg^{-1}), are quite reasonable. Saponins are known to be high in legumes. The saponin content of the pulp and seed, although lower than that of soyabean, (6.5 g·kg^{-1}), is however, in the pulp, higher than that of chickpea (2.3 g·kg^{-1}) [17]. Saponins are characterised by foaming in aqueous solutions. This action is extremely useful in reducing inflammation of the upper respiratory passage; saponins are also used as emulsifying agents [18]. They inhibit growth of cancer cells and cause a depletion of body cholesterol by preventing its re-adsorption; they provide active immunity to the system,

Table I.
Vitamin A, vitamin E, thiamine, riboflavin and niacin contents (mg·100 g^{-1}) in the fruit pulp and seed of *Raphia hookeri*.

Part considered	Vitamin A	Vitamin E	Thiamine	Riboflavin	Niacin
Fruit pulp	0.15	1.04	0.01	0.01	0.27
Seed	0.16	0.68	0.07	0.07	0.14

Table II.
The phytochemical contents of the fruit pulp and seed of *Raphia hookeri.*

Part considered	Alkaloids	Saponins	Flavonoids	Phenols	Nitrates	Nitrites
	(%)				$mg \cdot g^{-1}$	
Fruit pulp	0.50	0.36	0.40	0.41	2.70	0.21
Seed	0.35	0.23	0.24	0.36	3.05	0.29

serve as natural antibiotics and boost energy [19]. Saponins are also useful in the treatment of cardiovascular diseases and other health-related problems [20]. Toxicity studies indicate that only very low levels of saponin absorption occur. Saponin toxicity is presumably due to their ability to disrupt membranes and cause haemolysis of red blood cells. However, they can be used in medicines.

Most (but not all) alkaloids are toxic to animals. Many have been exploited as drugs. In spite of the medicinal uses of alkaloids, they cause gastro-intestinal upsets and neurological disorders.

Flavonoids have been shown to be the main components of folk remedies used for the treatment of thyroid and other hormonal disorders. Studies have indicated that natural flavonoids are able to induce goiter. Together with an increase in thyroid weight, a reduced iodine organification was obtained [21]. Flavonoids act as anti-oxidants and have strong anti-cancer activities, and even help to lower the risk of heart diseases [20]. Flavonoid-containing plants have been reported to have diuretic, antibacterial and anti-fungal properties [22].

The phenol content of both the pulp (0.41%) and the seed (0.36%) is quite significant. Phenols and other derivatives of phenol such as 2,4,6–trichlorophenol have antibacterial activities and are therefore used as antiseptics. Phenol is effective in killing bacteria but it is also very corrosive to the skin [23].

Nitrates and nitrites are present in foods naturally. The chief danger associated with nitrates is that they are converted into nitrites during digestion. The values of 2.7 mg nitrate$\cdot g^{-1}$ in the pulp and 3.05 mg nitrate$\cdot g^{-1}$ in the seed are lower than the 45 mg nitrate$\cdot g^{-1}$ reported as the maximum concentration of nitrate safe for human health [24]. The nitrite composition of the pulp, 0.21 $mg \cdot g^{-1}$, and of the seed, 0.29 $mg \cdot g^{-1}$, is, however, very low. These values imply that the fruit pulp and seed are free from nitrate/nitrite toxicities. Nitrite is, however, an additive to foods and prevents the growth of certain bacteria in foods. It is also used to produce characteristic flavour, texture and pink colour in food [25].

3.3. Toxic element contents

Arsenic content is higher in both the pulp (0.14 $\mu g \cdot g^{-1}$) and the seed (0.23 $\mu g \cdot g^{-1}$) than the other elements (*table III*).

Lead has concentrations of 0.01 $\mu g \cdot g^{-1}$ in the fruit pulp and 0.03 $\mu g \cdot g^{-1}$ in the seed. The baseline concentration of lead in some plants in remote and rural environments has been given as 0.18 $\mu g \cdot g^{-1}$. The value is, however, higher in highly concentrated urban environments. The lead values measured in *R. hookeri* pulp and seed are lower than this value. They are, however, comparable with lead values of some foods such as citrus fruit (0.01 $\mu g \cdot g^{-1}$), apples, cherries and pears (0.02 $\mu g \cdot g^{-1}$), while peanut butter has a higher value of (0.06 $\mu g \cdot g^{-1}$) and peas have a value of 0.03 $\mu g \cdot g^{-1}$ [17]. Values above 80-90 $\mu g \cdot dL^{-1}$ (approx. 0.08–0.09 $\mu g \cdot g^{-1}$) in the blood of children and 100 $\mu g \cdot dL^{-1}$ (approx. 0.1 $\mu g \cdot g^{-1}$) in the blood of adults cause acute nervous system toxicities. Levels above 60 $\mu g \cdot dL^{-1}$ (approx. 0.06 $\mu g \cdot g^{-1}$) and 30 $\mu g \cdot dL^{-1}$ (0.03 $\mu g \cdot g^{-1}$) in the blood of adults and children, respectively, cause frank anaemia. However, calcium and iron protect the body against lead toxicity [26].

Table III.
Toxic element contents (µg·g^{-1}) of the fruit pulp and seed of *Raphia hookeri.*

Part considered	Lead (Pb)	Mercury (Hg)	Arsenic (As)	Cadmium (Cd)
Fruit pulp	0.01	0.03	0.14	0.02
Seed	0.03	0.04	0.23	0.04

In *Raphia hookeri*, arsenic contents range from 0.14 µg·g^{-1} in the fruit to 0.23 µg·g^{-1} in the seed. These values are lower than the range of permissible values of 0.03–1 µg·g^{-1} as reported for fruit. In Japan, 1 µg·g^{-1} arsenic, as AS_2O_3, is allowed in fruits and vegetables. Most authorities allow 0.05 µg·L^{-1} in drinking water [17]. Arsenic, though considered as poisonous, may be less toxic than the essential trace element selenium with which it counteracts in the body. Recent studies on rats suggested that arsenic might be essential. However, minute quantities are likely to be more beneficial than toxic, but excessive quantities may be toxic; yet, cases of arsenic poisoning in man are rather infrequent [26].

The mercury levels of the fruit pulp (0.03 µg·g^{-1}) and seed (0.04 µg·g^{-1}) are higher than the tolerance level of 50 µg·kg^{-1} as set by the FAO / WHO [17]. Toxicities of mercury occur at three levels depending on the chemical form of the metal [27]. Mercury in all chemical forms is toxic if absorbed by the system but the order of toxicities is: methyl mercury > mercury metal vapour > Hg(II) salts. However, selenium protects people from Hg toxicities. Foods containing both Hg and selenium in one food may also provide some protection against Hg in other foods [26].

The cadmium levels in the fruit pulp (0.02 µg·g^{-1}) and seed (0.04 µg·g^{-1}), though higher than the reported values for Australian apples (0.002–0.019 µg·g^{-1}) and Federal Republic of Germany apples (0.009 µg·g^{-1}) [28], may not be considered as toxic. It has been reported that about 3 mg of cadmium can be ingested by an adult without causing adverse effects. However, ingestion of drinks with concentration above 15 mg·L^{-1} may cause symptoms of food poisoning. Mild cadmium toxicity can be counteracted by such essential elements as calcium, copper, iron, manganese, selenium and zinc.

A high value of the [Cd:Zn] ratio in the body or tissues is a better indicator of Cd poisoning [26].

4. Conclusion

The raphia palm fruit is a rich source of phytochemicals, thiamine, riboflavin, niacin, and vitamins A and E. The concentrations of these important substances are higher than in some common (popular or conventional) fruits used as food.

Therefore, the fruit can serve as food and in medicine. The fruit pulp has been reported to have stomachic and laxative properties [1]. This could be because of the presence of saponins.

References

[1] Irvine F.R., Woody Plants of Ghana with special reference to their uses, Oxford Univ. Press, London, UK, 1961, 868 p.

[2] Keay R.W., Hepper F.N., Flora of west tropical Africa, Crown agents, Millbank, London, 1953, pp. 104–107.

[3] Keay, R.W., Trees of Nigeria. Oxford Press Ltd., New York, USA, 1989, 445 p.

[4] Otedoh M.O., The Nigerian field, Int. Field Stud., J. West Afr. 42 (2) (1977) 58.

[5] Anon., Raw materials sourcing for manufacturing in Nigeria, RMRDC, Lagos, Nigeria, 1990, 8 p.

[6] Edem D.O., Eka O.U., Ifon E.T., Chemical evaluation of the nutritive value of the raphia palm fruit (*Raphia hookeri*), Food Chem. 15 (1984) 9–17.

[7] Opute F.I., Mesocarp, seed and pollen lipids of *Raphia* palms, J. Sci. Food Agric. 29 (1978) 115–120.

[8] Harbone J.B., Phytochemical method: a guide to modern techniques of plants analysis, Chapman and Hall, New York, USA, 1973.

[9] Pearson D., The chemical analysis of foods, Churchill Livingstone, Edinburgh, UK, 1976.

[10] Follet M.J., Ratcliff D.W., Determination of nitrate and nitrite in meat products, J. Sci. Food Agric. 14 (1963) 138–144.

[11] Kirk R.S., Sawyer R., Pearson's composition and analysis of foods, Longman Sci. Tech. Group, 9th ed., London, UK, 1991.

[12] Barakat M.Z., Shehab S.K., Daswish N., Zahermy E.I., Determination of ascorbic acid from plants, J. Anal. Biochem. 53 (1973) 225–245.

[13] James C.S., Analytical chemistry of foods, Chapman and Hall, New York, USA, 1995.

[14] Onyenuga V.A., Nigeria's foods and feeding stuffs: their chemistry and nutritive value, 3rd ed., Ibadan Univ. Press, Ibadan, Nigeria, 1968.

[15] Lehninger A.L., Biochemistry, 3rd ed., Worth Publ. Inc., New York, USA, 1985.

[16] Anon., Chemistry and technology of citrus fruits, citrus products and by products, United State Dep. Agric. (USDA), Agric. Handb. 98, 1962, 99 p.

[17] Macrae R., Robinson R.K., Sadler M.J., Encyclopedia of food science, food technology and nutrition, Acad. Press, London, UK, 1993.

[18] Stary F., The natural guide to medicinal herbs and plants, Tiger Books Int., London, UK, 1998.

[19] Lipkin R., Do proteins in cells make computations?, Sci. Serv. Inc., Sci. News vol. 148, Wash., DC, USA, 1995.

[20] Del-Rio A., Obudulio B.G., Costillo J., Mann F.G., Otuno A., Uses and properties of citrus flavonoids, J. Agric. Food Chem. 46 (1997) 4505–4515.

[21] Köhrle J., Spanka M., Imscher K., Hesch R.D., Flavonoids effects on transport, metabolism and action on thyroid hormones, in: Cody V., Middleton E., Harbone J.B., Beretz A. (Eds.), Plant flavonoids in biology and medicine, vol. 11, Alan R. Liss, New York, USA, 1988, pp. 323–340.

[22] Sofowora E.A., Medicinal plants and traditional medicine in Africa, 2nd ed., John Wiley and Sons Ltd., New York, USA, 1982, 440 p.

[23] Hill G.C., Holman J.S., Chemistry in context, ELBS Ed., London, UK, 1978, 459 p.

[24] Anon., Root and tuber crops, plantains and bananas in developing countries: challenges and opportunities, FAO plant production and protection pap. No. 87, Rome, Italy, 1988, 83 p.

[25] Minist. Agric. Fish. Food, Nitrate, nitrites and N-nitroso compounds, in: Food Surveill. Pap. No. 20, UK, 1999.

[26] Ensminger A.H., Ensminger M.E., Konlande J.L., Robson J.R.K., Concise encyclopedia of foods and nutrition, CRC Press, Boca Raton, Fla., USA, 1995.

[27] Ademoroti C.M.A., Environmental chemistry and toxicity, Foludex Press Ltd., Ibadan, Nigeria, 1996, pp. 171–204.

[28] Reilly C., Metal contamination of foods, 2nd ed., Elsevier, London, UK, 1991.

Vitaminas, compuestos fitoquímicos y elementos tóxicos en la pulpa y la semilla de los frutos de la palma *Raphia hookeri*.

Resumen — Introducción. La palma *Raphia hookeri* se encuentra en abundancia en la región meridional de Nigeria, sobre todo en el sureste del país. Se explota principalmente por su producción de vino de palma. Asimismo aporta frutos cuya pulpa se considera comestible en ciertas partes del país y no comestible en ciertas otras. **Material y métodos**. Se realizó un estudio, con la ayuda de los métodos de análisis convencionales, de la composición en vitaminas, compuestos fitoquímicos, y elementos tóxicos. **Resultados**. Nuestros estudios mostraron que mientras que la pulpa contenía concentraciones más altas que la semilla en vitamina E (1.04 mg·100 g^{-1}), niacina (0.2 mg·100 g^{-1}), alcaloides (5 g·kg^{-1}), saponinas (3.6 g·kg^{-1}), flavonoides (4 g·kg^{-1}) y fenoles (4.1 g·kg^{-1}), la semilla, sin embargo, contenía valores más elevados que la pulpa en vitamina A (0.16 mg·100g^{-1}), tiamina (0.07 mg·100 g^{-1}), riboflavina (0.07 mg·100 g^{-1}), nitratos (3.05 mg·100 g^{-1}), nitritos (0.29 mg·100 g^{-1}), así como en elementos tóxicos: plomo (0.03 µg·g^{-1}), mercurio (0.04 µg·g^{-1}), arsénico (0.23 µg·g^{-1}) y cadio (0.04 µg·g^{-1}). **Conclusión**. La pulpa y la semilla de *R. hookeri* son no-tóxicas; pueden consumirse y emplearse en farmacopea.

Nigeria / *Raphia hookeri* / frutas / pulpa de frutas / composición quimica / vitaminas