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Functional potential of yellow mombin (*Spondias mombin* L.) grape, fruit from a neglected and underutilized species

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Abstract

Consumption of plant foods, including fruits and vegetables, has been associated with a lower risk of some diseases. Besides food constituents, such as fibre or beta-carotene, other bioactive plant compounds such as polyphenols have been suggested to contribute to this protective effect. Yellow mombin (*Spondias mombin* L.) is a tropical fruit with increasing acceptance in both national and international fruit markets. However, it remains a neglected and underused species. Neglected and underutilized species (NUS), also known as minor crops or 'orphan' crops, can help solving some global issues, such as hunger, poverty and adaptation to climate change. In this review, we have highlighted the functional potential of the fruit of *Spondias mombin*. Particular emphasis has been placed on polytphenols, vitamins and minerals.

Keywords: Neglected and Underutilized Species; *Spondias mombin*; Functional Foods; Valorization.

1. Introduction

The interest in functional foods continues to grow, powered by progressive research efforts to identify properties and potential applications of nutraceutical substances, coupled with public interest and consumer demand. The principal reasons for the growth of the functional food market are current population and health trends. Across the globe, populations are aging. Life expectancy continues to rise, as does the contribution made by older individuals to the total population [1].

Several pathologies are more and more recurrent in Africa. These are mainly cardiovascular diseases including obesity, high blood pressure, and arteriosclerosis [2].

In addition, hunger and malnutrition remain global scourges that affect thousands of people, the majority of whom live in developing countries where food security and access to modern medicine are almost a luxury.

Despite the commitment made at the International Conference on Nutrition (ICN) in 1992 and at the World Food Summit in 1996 to eliminate or drastically reduce micronutrient malnutrition, unacceptably high rates of micronutrient

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malnutrition still persist. Hunger and malnutrition threaten millions of people in sub-Saharan Africa and it is estimated that in many countries in this region approximately 20% or more of the inhabitants experience food insecurity [3].

In recent years, the place of diversification in peasant strategies has been widely recognized, particularly in sub-Saharan Africa [4-5]. The continent is home to thousands of food plants, but only a small number are valued in traditional medicine, agriculture and scientific research. Yet many farmers, especially in marginal areas, rely on neglected and underutilized species like those of the genus Spondias for their subsistence. These plants therefore have considerable potential for increasing food production, guaranteeing food security for populations, ensuring coverage of primary health care needs, and contributing to the poverty reduction effort [6-7]. But various species of this group of plants are threatened with extinction due to the lack of interest of the scientific community, decision-makers and agro-industrial groups, and the disappearance of their habitats. However, there is growing international recognition that neglected species play a crucial role in traditional medicine, food and nutritional security and even health care, and constitute income opportunities for small farmers. Unfortunately, their expansion and commercialization are limited by their ignorance and the absence of a related value chain.

The yellow mombin is a very a neglected and underutilized species common tree in tropical countries despite its food virtues. However, it can play an important part in alleviating hunger and malnutrition in sub-Saharan Africa. The yellow mombin is an important source of substances with functional properties such as polyphenols [8] and micronutrients including vitamins A and C, iron and other nutrients and are sometimes better nutritional sources than the modern vegetables [9]. The objective of this study is to highlight the potential of *Spondias mombin* fruit as a functional food useful in the fight against malnutrition and the regulation of chronic diseases.

2. Botanical data and food uses

Spondias mombin is a small deciduous tree up to 20 m (66 ft) high and 1.5 m (4.9 ft) in girth, and is moderately buttressed. It is a tree with a gray and brown bark, thick and rough. Its leaves, very green, are alternate and pinnate. The very small white or yellow flowers are grouped in panicles. Its bark is thick, corky, and deeply fissured [10].

Very fragrant, they attract bees. Its clusters of small green fruits that turn golden yellow at maturity. The fruits, the monbin plum are edible. With a very particular odor, its thin skin contains a large nucleus surrounded by a fragrant, juicy and tangy yellow pulp. Mummbin plum is eaten raw, in juice, in jam or in ice cream. The extracted juice is used to prepare ice cream, cool beverages and jelly in Costa Rica and Brazil. In Amazon, the fruit is used mainly to produce wine sold as “Vinho de Taperiba”, while in Guatemala; it is made into a cider-like drink. It is used in Panama, Peru and Mexico in fairly large quantities as jams [11]. The fruit is macerated in rum with possibly other fruits to make punch. The juice, fermented and distilled, gives an alcohol [12]. Figure 1 shows yellow mombin tree (A) and fruit (B).

Source: https://www.tahitiheritage.pf/prunier-mombin-de-tahiti/

Figure 1 Yellow mombin tree (A) and fruit (B)

3. Major compounds with functional activity in *Spondias mombin* grapes

3.1. Polyphenols and their beneficial effects on health

3.1.1. Polyphenols content of Spondias mombin

Several studies have focused on polyphenols from *Spondias mombin.* These studies have shown that polyphenols are the most abundant secondary metabolites of yellow mombin [13]. Accordind to [14], in yellow mombin fruits, the content of total extractable polyphenols varied from 29.12 mg.100g^{-1}, for ungrafted genotype G9, to 102.88 mg.100g^{-1}, for clone genotype G4. A study of [9] showed that yellow mombin pulp presented a total phenolic content of 260.21±11.89 mg GAE/100g. These values are higher than those found for buriti pulp (9.46 mg.100g^{-1}) and to that found in most fruit pulps consumed in Brazil. The following phytochemicals tannin, flavonoids, glycosides, alkaloids, steroids, terpenoids, resins and oil were found to be present in the leaves and fruits of *Spondias mombin* in different concentration [11]. In comparison with other exotic fruits, the yellow mombin has a higher total phenolic content than mamey (Pouteria sapota Jacq. H.E. Moore & Stearn), which was reported to be 28.5±0.6 mg GAE/100 g [15].

Despite the diversity of these compounds, several classes of polyphenols can be grouped according to the number of phenol rings and to the structural elements that bind these rings identified. Two main groups of polyphenols, termed flavonoids (flavonones, flavones, dihydroflavonols, flavonols, flavan-3-ols, anthocyanidins, isoflavones, and proanthocyanidins) and non-flavonoids (simple phenols, benzoic acids, hydrolysable tannins, acetophenones and phenylacetic acids, cinnamic acids, coumarins, benzophenones, xanthones, stilbenes, chalcones, lignans, and secoiridoids), have been traditionally adopted [16-17]. Some of those are specific to some species or genus of plants [16].These compounds and are usually related to defense against ultraviolet radiation or aggression by pathogens or insects [18].

3.1.2. Beneficial effects of polyphenols on health

In recent years, several studies have highlighted the health benefits of polyphenols, and special attention has been paid to their beneficial effects against cardiovascular disease, the leading cause of death in the world today [19-20-21]. Epidemiological observations suggesting an inverse correlation between foods containing polyphenols consumption and the incidence of cardiovascular diseases have been well established [22-19-20-21]. Accordind to [23], *Spondias mombin* supplementation attenuated cardiac remodelling process induced by tobacco smoke. Phenolic acids and flavonoids, although are not essential for survival, may provide protection against a number of chronic diseases over the long term consumption. The phenolic acids potentially involved in these beneficial effects are gallic acid, hydroxycinnamates including coumaric acid, caffeic acid, and derivatives such as chlorogenic acid [24-25]. Ethanol-water extract of *Spondias mombin* has shown endothelium-dependent vasorelaxant activity (EC50 of 90 mg / L) [21].

Furthermore, it is likely that various polyphenols, including flavonoids, act similarly to dietary antioxidants. Polyphenols have antioxidant activity and, based on their antioxidant function, these compounds possess anti-atherosclerotic, anti-inflammatory, antitumor, antithrombotic, anti-osteoporosis, and antiviral activities [17-13] (Rosa et al., 2009; da Silva et al., 2012). Finally, flavonoids may protect vitamin E in lipid oxidation by being oxidized themselves in preference to vitamin E or by delaying the initiation of lipid peroxidation. Also, flavonoids may inhibit LDL oxidation by scavenging superoxide anions, hydroxyl radicals, or lipid peroxyl radicals. Alternatively, flavonoids may chemically modify LDL and such modification results in LDL being less susceptible to oxidation [26].

Table 1 presents the main polyphenolic compounds of *Spondias mombin* as well as their potential benefit for human health

Table 1 Polyphenolic compounds of *Spondias mombin* and their potential benefit for human health

Extract	Isolated compound	Potential benefit	Country	References
Ethanolic extract	6-alkenyl-salicylic acid	antibacterial and molluscicidal activity	Belgium	[27]
Hexane	Anacardic Acid derivative	beta-lactamase inhibitory properties	United Kingdom	[28]
Cyclohexane fraction of SHEETS	3- [3-methyl-2- (1-methylhexyl) octyl] phthalic acid 2-hydroxy-6 - [(8'E, 11'e, 14'E) -2-hydroxydocosa-8 ', 11', 14'-trienyl] benzoic acid.	Involvement in vasodilating activity endothelium-dependent	Benin	[8]
Hydromethanolic extract of the leaves	Ellagic acid	Antioxidant, and antimicrobial activities	Brasil	[13]
Methanol:water	Gallic acid	Antioxidant, and antimicrobial activities	Nigeria	[29]
Methanol:water	Coumaroyl	Antioxidant, and antimicrobial activities	Nigeria	[29]
Methanol:water	Quercetin	Antioxidant, and antimicrobial activities	Nigeria	[29]
Methanol:water	*β*-caryophyllene	Antioxidant, and antimicrobial activities	Nigeria	[29]

3.2. Nutrients in yellow mombin fruit and their beneficial effects on health

3.2.1. Vitamins in yellow mombin

There are a large number of vitamins, most of them are not yet listed. There are currently 13 which are classified into two categories according to their solubility. Two types of vitamins are necessary for the proper functioning of the human organism, the water-soluble vitamins (B1, B2, PP, B5, B6, B8, B9, B12 and C) and the fat-soluble vitamins (A, D, E and K). These are organic substances with low molecular weight, without energy value, essential for the growth, reproduction and functioning of the organism which cannot synthesize them itself.

They must therefore be provided by food, except vitamin D synthesized by the skin under the action of the sun and vitamins B3 and K, part of which is synthesized by the bacterial flora of the large intestine [30].

Several studies have determined the vitamin content in *Spondias mombin* grapes (Table 2). Vitamins are mainly known for their functional roles in the body [31-32-33-34]. Thus, the importance of vitamin D on the induction of hepatic cytochrome P450 involved in detoxification-cytoprotection and in insulin resistance has been demonstrated [33-31]. Vitamin A has a beneficial effect against cerebral aging (Pallet, 2011). According to [34], vitamins C and E have an ameliorative effect on the rabbit epididymis (*Orictolagus cuniculus*), treated with lambda-cyhalothrin.

Otherwise, deficiency in ascorbic acid (vitamin C) have been reported to be associated with pains in the joint and defect in skeletal calcification, anemia, manifestation of scurry hemorrhage from mucous membrane of the month and gastrointestinal rack [35]. This function of ascorbic acid accounts for its demand for normal wound healing. There is also an interesting ability of ascorbic acid as an antioxidant, to prevent or at least minimize the formation of carcinogenic substances from dietary material [35]. The role of vitamin A in vision no longer needs to be demonstrated. It also helps

maintain the integrity of the epithelial surfaces, which plays important roles in immunity, reproduction, growth and development [36]. Apart from these roles, it acts mainly through its metabolite retinoic acid which, by binding to nuclear receptors, regulates the expression of genes in target tissues.

3.2.2. Mineral in yellow mombin

Minerals are inorganic elements that remain behind in the ash when food is incinerated [37]. The yellow plum contains mineral matter that has no energy value but essential for the proper functioning of the organism namely: macro-elements and trace elements. Macro-elements are substances necessary in large quantities to the body. They include: sodium, chlorine, potassium, calcium, phosphorus and magnesium while trace elements are involved in very low doses in metabolism and are present in very small quantities in the body; however, they are essential for growth and its normal functioning. This term is generally reserved for iron, iodine, zinc, copper, selenium and fluorine [38]. According to [39], regarding the macro-minerals, Na, Mg, P, K and Ca, the pulp showed low levels of sodium and calcium, minerals normally found in low concentrations in fruits. There was a high content in magnesium, potassium and phosphorus in comparison with other fruits.

[40] Confirmed the yellow mombin as a fruit with a high content of potassium, along with jackfruit, soursop, jenipapo (*Genipa Americana*) and mangaba (*Hancornia speciosa*). The phosphorus content is one of the highest among the fruits with levels close to those of ceriguela (*Spondias purpurea*), pequi (*Caryocar brasiliense*) and passion fruit. The magnesium content was lower than the one found by [41], 24.33 mg/100 g, although higher than that reported by [42], 12 mg/100 g.

The result of the mineral composition clearly shows that *Spondias mombin* leaves contains rich source of mineral elements this result become so important when the usefulness of such mineral like Ca, Mg, P, K and Na in the body are considered. However, the lower Na content (0.1g) in *Spondias mombin* is an added advantage because of the direct relationship of sodium intake with hypertension in human [35].

3.2.3. Functional effect of nutrients in the body

Vitamins are important for health, each providing its essential nutrients for the body. They are essential to fight against a lack of carbohydrates, lipids or proteins. A deficiency in these substances can lead to serious illness, physical fatigue, skin problems or abnormal hair loss.

Mineral salts for their part all have basic roles in the body: cardiac activity, maintenance of the hair or skin or even blood circulation regulator. The role varies depending on the mineral salt concerned (Table 2). In all cases, they are essential for the body and must be provided in an adequate quantity [43-44].

Table 2 *Spondias mombin* micronutrient and functions

Minerals	**Functional effect**	**Content**	**Country**	**Reference**
Calcium (mg/kg)	May reduce the risk of osteoporosis	1562.20 ± 0.40	Nigeria	[45]
		318.0 ± 4.20	Nigeria	[46]
		110.38 ± 7.67	Brazil	[39]
		130.4 ± 5.30	Nigeria	[47]
Calcium (%)		1.310	Nigeria	[35]
Magnesium(mg/kg)	Supports maintenance of normal muscle and nerve function and immune health	21081.1±282.80	Nigeria	[45]
		4650.0 ± 212.10	Nigeria	[46]
		150.95 ± 8.63	Brazil	[39]
		123.6 ± 0.30	Nigeria	[47]
Magnesium (%)		0.30	Nigeria	[35]
Manganese(mg/kg)		10.80 ± 0.20	Nigeria	[45]
		2.0 ± 0.10	Nigeria	[46]

	Activator of pyruvate carboxylase and other enzymes	0.25 ± 0.01	Brazil	[39]
		1.5 ± 0.10	Nigeria	[47]
Iron(mg/kg)	Fix anemia	145.90 ± 2.20	Nigeria	[45]
		32.0 ± 1.40	Nigeria	[46]
		3.27 ± 0.01	Brazil	[39]
		4.8 ± 0.1	Nigeria	[47]
Copper(mg/kg)	Constituting many oxidoreductases, role in iron metabolism	5.40 ± 0.20	Nigeria	[45]
		10.0 ± 1.40	Nigeria	[46]
		1.18 ± 0.37	Brazil	[39]
		1.21 ± 3.20	Nigeria	[47]
Zinc(mg/kg)	Growth, prevention of anemia and wound healing necessary for the metabolism of sugars	10.80 ± 0.20	Nigeria	[45]
		2.0 ± 0.10	Nigeria	[46]
		1364.20 ± 13.50	Nigeria	[47]
Sodium (mg/100g)	Body hydration, muscle contraction	5.551±2.352	Brazil	[39]
		4.45 ± 1.42	Nigéria	[47]
Sodium (%)		0.100	Nigeria	[35]
Phosphorous (mg/100g)	Constituting bones and teeth in the form of phosphate	32.849±2.401	Brazil	[39]
		28.22 ± 1.02	Nigeria	[47]
Phosphorous (%)		0.200	Nigeria	[35]
Potassium (mg/100g)	May reduce the risk of high blood pressure and stroke, in combination with a low sodium diet	288.276±23.895	Brazil	[39]
		276.27 ± 2.65	Nigeria	[47]
Potassium (%)		2.550	Nigeria	[35]
Carotenoids (µg/g)	Help eliminate toxic cells that damage the general health of the body. Carotenoids are also said to be valuable allies for the skin and eyes, helping to regulate UV absorption and neutralizing free radicals	17.3 ± 2.0	Brazil	[48]
		22.86 ± 3.76	Brazil	[49]
		38.56 ± 0.13	Brazil	[50]
		48.69 ± 1.57	Brazil	[51]
		4869.5±157.7	Brazil	[39]
α-carotene (µg/100 g)	It also promotes iron absorption and appears to play a role in the regulation of inflammatory responses. The body can convert certain carotenoids from plants into vitamin A. These carotenoids are referred to as provitamins A	340±5.7	Brazil	[39]
β-carotene (µg/100 g)		314±9.9	Brazil	[39]
Pro-vitamine A (RE/100 g)		223±3	Brazil	[39]
Ascorbic acid mg/100 g)	Is involved in major body functions: defense against viral and bacterial infections, protection of the blood vessel wall, iron assimilation, antioxidant action (capture of free radicals), healing	11.06	Brazil	[52]
		20.80	Brazil	[53]
		23.72	Brazil	[50]
		20.18	Brazil	[54]

4. Conclusion

Many neglected and underutilized species are highly nutritious. When these species are included in a varied diet, they contribute to the fight against malnutrition, hidden hunger, overweight and obesity. This study investigated the functional potential of *Spondias mombin* fruits. It revealed that these fruits contain significant proportions of phenolic compounds, vitamins and minerals. It then becomes necessary for research and development to help improving its value chain and promote its consumption with a view to its development.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors agree no conflict of interest.

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