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Odeyemi EF
 Value Addition Research Department,
 Cocoa Research Institute of Nigeria,
 Ibadan, Oyo State, Nigeria

Ajewole AO
 Value Addition Research Department,
 Cocoa Research Institute of Nigeria,
 Ibadan, Oyo State, Nigeria

Ogunsowo AO
 Value Addition Research Department,
 Cocoa Research Institute of Nigeria,
 Ibadan, Oyo State, Nigeria

Olorundare BO
 Value Addition Research Department,
 Cocoa Research Institute of Nigeria,
 Ibadan, Oyo State, Nigeria

Arowolo ST
 Value Addition Research Department,
 Cocoa Research Institute of Nigeria,
 Ibadan, Oyo State, Nigeria

Adesokan MA
 Value Addition Research Department,
 Cocoa Research Institute of Nigeria,
 Ibadan, Oyo State, Nigeria

Raji MO
 Value Addition Research Department,
 Cocoa Research Institute of Nigeria,
 Ibadan, Oyo State, Nigeria

Olalekan-Adeniran MA
 Value Addition Research Department,
 Cocoa Research Institute of Nigeria,
 Ibadan, Oyo State, Nigeria

Akinola CO
 Value Addition Research Department,
 Cocoa Research Institute of Nigeria,
 Ibadan, Oyo State, Nigeria

Atanda JF
 Value Addition Research Department,
 Cocoa Research Institute of Nigeria,
 Ibadan, Oyo State, Nigeria

Jayeola CO
 Value Addition Research Department,
 Cocoa Research Institute of Nigeria,
 Ibadan, Oyo State, Nigeria

Corresponding Author:
Ogunsowo AO
 Value Addition Research
 Department, Cocoa Research
 Institute of Nigeria, Ibadan,
 Oyo State, Nigeria

Nutritional and medicinal values of black plum, *Vitex doniana* sweet

Odeyemi EF, Ajewole AO, Ogunsowo AO, Olorundare BO, Arowolo ST, Adesokan MA, Raji MO, Olalekan-Adeniran MA, Akinola CO, Atanda JF and Jayeola CO

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Abstract

Vitex doniana Sweet known as Black plum is a tree crop in the family Lamiaceae. It is commonly used for food and food products as well in traditional medicine for the management and treatment of various ailments such as malaria, diarrhea, rheumatism, hypertension, cancer, and inflammatory diseases. It is also used in treating colds and coughs in children, while the bark is employed in the treatment of sterility, treating colds and coughs in children. This review examines the nutritional and medicinal importance of black plum fruit, the antinutritional factors and highlights potential areas for future research. The review is based on literature collected from studies conducted over the past two decades and included some products developed by the Cocoa Research Institute of Nigeria, Ibadan, Oyo State, Nigeria after its incorporation as a mandate crop of the institute. The phytochemical and the bioactivity profiles of this plant collectively contribute to its therapeutic potentials, thus, supporting its traditional use in the management of various ailments.

Keywords: *Vitex doniana*, phytochemicals, ethno-medicinal uses, proximate composition

Introduction

Black plum, also known as African olive (*Vitex doniana* Sweet), is a tree crop belonging to the family Lamiaceae and the genus *Vitex*. It is considered one of the most prevalent species within the genus. The fruits of *V. doniana* are plum-like, edible and sweet. They are green at maturity and turn dark brown when ripe, with a starchy, black pulp. Embedded within the pulp is a hard, stone like structure that encloses the seeds. *Vitex doniana* is widely distributed across Nigeria, particularly in the Northern, Eastern, and Western regions. It is known by various local names: *Dinyar* (Hausa), *Galbihi* (Fulani), *Orinla* (Yoruba), and *Ucha koro* (Igbo). According to ^[1], fully matured fruits that have naturally fallen (rather than being hand-plucked) are commonly used in the production of wine and juice. Similarly, ^[2] developed jam from black plum fruits and reported that sensory evaluation by untrained panelists indicated good consumer acceptability. Domestically, the fruit is also processed into candies known as *Alewa* by the Hausa people in Nigeria, as well as into syrups that compare favorably with other nutritive sweeteners. Traditionally, various parts of the plant (including the leaves, stem bark, twigs, and fruits) are used in the management of several health conditions across Nigeria and other parts of Africa. ^[3] reported that *V. doniana* is utilized in the treatment and management of ailments such as rheumatism, hypertension, cancer, and inflammatory diseases. It is also used in treating colds and coughs in children, while the bark is employed in the treatment of sterility. Several studies have investigated the nutritional and phytochemical properties of *V. doniana*, including its proximate composition, mineral content, sugar profile, and anti-nutritional factors. This review therefore examines the nutritional and medicinal importance of black plum fruit and highlights potential areas for future research. This review is based on literature collected from studies conducted over the past two decades and included some products developed by the Cocoa Research Institute of Nigeria, Ibadan, Oyo State, Nigeria after the incorporation of the plant (*V. doniana*) into her former five mandate crops (Cocoa, Cashew, Coffee, Tea and Cola) to make it six now. It provides a systematic analysis and synthesis of existing literature on the traditional uses, nutrient profile, bioactivities, phytochemical

constituents, antinutritional factors and products derived from *Vitex doniana*. Relevant studies were identified through electronic databases such as Google Scholar and Research Gate using appropriate keywords. The selected articles span approximately the last two decades.

2. Nutrient Profile of *Vitex doniana*

Nutrient profile refers to detailed characterization of nutritional constituents of food. This is essential for evaluating health benefits or potential risks associated with consumption of such food substance.

2.1. Proximate Composition of *Vitex doniana*

This provides an overview of fundamental nutritional makeup of a food, offering valuable insight into its nutritional and medicinal potential. This analysis is crucial for understanding significance of a food in growth support and total health of an organism. Components assessed in proximate analysis include crude fibre, crude protein, fat, carbohydrate, moisture, and ash content. Studies have investigated the proximate composition of *V. doniana*, focusing on different plant parts like fruit pulp, seeds, and leaves [4, 5, 6]. However, there is currently limited information available on the proximate composition of the stem bark. Table 1 presents a summary of the proximate composition of black plum fruit, seeds, and leaves. From Table 1, the leaf part has higher moisture content compared with the other parts. This is supported by a report by [7] which states that leafy vegetables have more moisture content than the other parts. This has been attributed to active photosynthetic engagement of leaves and constant transpiration which makes them hold more water [8]. Similarly, the crude protein value of the leaf is quite greater than that of the fruit and the seed. [9] corroborated this by stating that leaf proteins are much higher than that of the seeds.

Table 1: Proximate compositions of the black plum fruit, leaf and seed

Parameters	Plant parts	Values (%)	References
Moisture content	Fruit	10.00	[6]
	Leaf	10.87	[4]
	Seed	0.21±0.01	[5]
Crude fibre	Fruit	4.50	[6]
	Leaf	2.49	[4]
	Seed	0.00	[5]
Crude protein	Fruit	0.60	[6]
	Leaf	7.85	[4]
	Seed	0.26 ± 0.02	[5]
Ash	Fruit	18.00	[6]
	Leaf	1.04	[4]
	Seed	5.00 ± 0.22	[5]
Carbohydrate	Fruit	43.20	[6]
	Leaf	73.44	[4]
	Seed	Nil	[5]
Fats	Fruit	23.70	[6]
	Leaf	4.31	[4]
	Seed	11.0 ± 0.73	[5]

2.2. Mineral Composition of *Vitex doniana*

Minerals are essential inorganic elements required in small quantities for various biological functions in the body in living organisms. The mineral composition of *Vitex doniana* has been investigated in different plant parts, particularly the fruit pulp, leaves, and seeds. Studies have reported that *V. doniana* contains appreciable amounts of both macro- and

micro-elements (notable in leaves than fruits and seeds because of roles played in photosynthesis and assimilation), including calcium (Ca), potassium (K), magnesium (Mg), sodium (Na), phosphorus (P), iron (Fe), zinc (Zn), and manganese (Mn) [4, 5] with K and Ca recording significantly high concentrations which is indicative cardioprotective and osteoprotective potentials. The presence of iron and zinc (trace elements) are essential for haemoglobin formation, immune function, and enzymatic activities.

However, variations in mineral composition across studies may arise due to differences in geographical location, soil composition, environmental conditions, and methods of analysis. Overall, the mineral profile of *V. doniana* indicates that it can serve as a valuable dietary source of essential minerals.

2.3. Vitamin Profile of *Vitex doniana*

Vitamins are organic compounds required in minute quantities for normal metabolic functions, growth, and overall health maintenance. The vitamin composition of *Vitex doniana* contributes significantly to its nutritional and therapeutic potential. Available studies have reported the presence of vitamins such as vitamin C (ascorbic acid), vitamin A (in the form of provitamin A carotenoids), and some B-complex vitamins in the fruit and leaves of *V. doniana* [5, 6]. Vitamin C, an antioxidant, is particularly abundant in the fruit pulp. Provitamin A carotenoids present in the plant are important for vision, skin health, and immune support. Additionally, B vitamins contribute to energy metabolism and proper functioning of the nervous system. These vitamins contribute significantly to the nutritional and medicinal value of *V. doniana*.

3.4. Phytochemical Constituents of *Vitex doniana*

Phytochemicals are bioactive compounds naturally present in plants and plant-derived foods, widely recognized for their significant health-promoting properties. For instance, plants and plants parts like *cola*, *cocoa*, *cashew*, *coffee*, *tea* and their products have been proven scientifically to have most of these phytochemicals with antioxidant, anti-inflammatory, anticancer and antidiabetic properties which are significant medicinal values [10, 11, 12, 13]. Black plum has been reported to be rich in phenolics like flavonoids (such as flavonols, flavan-3-ols, anthocyanins, tannins), terpenoids, alkaloids, glycosides, oxalates and saponins [14, 15, 16]. The fruit pulp of black plum also contains beta carotene, vitamin A and C, calcium, magnesium, sodium, potassium, [15]. These compounds are key contributors to plants' medicinal values. Flavonoids and phenolic compounds are known for their strong antioxidant activity, curbing oxidative stress and cellular damage [17]. Tannins possess antimicrobial and astringent properties, while saponins are associated with cholesterol-lowering and immune-boosting effects. Alkaloids, also have been proven to be of great biological importance to humans for ages with their significant potentials as anti-inflammatory, anticancer, antimicrobial, local anaesthetic and pain relief as seen in the case of morphine [18, 19]. Steroids are also significant for their anti-inflammatory potentials on peripheral and central nervous systems [20]. Terpenoids are secondary metabolites resulting from enzyme-catalyzed reactions on amino acids, vitamins, sugars etc and they have significant therapeutic potentials like anticancer, antimalaria etc [21].

These phytochemicals collectively contribute to the therapeutic potential of *V. doniana*, supporting its traditional use in the management of various ailments such as inflammation, infections, and chronic diseases. Table 2 below summarizes the qualitative phytochemical compounds present in *Vitex doniana* plant.

Table 2: Qualitative Phytochemical Constituents of *Vitex doniana* Plant

S/N	Compounds	References	Plant Parts
1	Alkaloids	[6, 22]	Fruit pulp
2	Saponins	[6, 22, 23]	Fruit pulp, leaf
3	Flavonoids	[6, 22]	Fruit pulp,
4	Phenolics	[16]	Fruit pulp,
4	Terpenoids	[6, 22]	Fruit pulp,
5	Steroids	[6, 23, 24]	Fruit pulp, leaf
6	Cardiac glycosides	[6, 24]	Fruit pulp,
7	Reducing sugars	[6, 23, 24]	Fruit pulp, leaf
8	Tannins	[6, 23, 24]	Fruit pulp, leaf

3. Bioactivities of Black Plum (*Vitex doniana* Sweet)

Drawbacks and side effects associated with the prolonged use of conventional drugs have intensified the search for safer yet potent ethnomedicinal plants [25]. *Vitex doniana* Sweet is widely recognized for its extensive medicinal and nutritional value in West Africa [26]. It has reportedly been utilized in the traditional management of various diseases, including jaundice, diarrhoea, anaemia, leprosy, and rheumatism [27].

3.1. Antioxidant Activity of *Vitex doniana*

Leaves, fruits, and bark of *V. doniana* have been reported to possess strong antioxidant activity thereby combating oxidative stress related diseases. Several studies, including [28], have documented high concentrations of polyphenols, flavonols, and oleanolic acid in the ethanol and ethyl acetate extracts of *V. doniana* leaves and fruits, which account for their potent antioxidant capacity.

3.2. Antimicrobial Activity of *Vitex doniana*

Studies, including (29), have demonstrated the efficacy of *V. doniana* extracts against pathogenic microorganisms, highlighting their antimicrobial potential. According to [29], both aqueous and methanolic extracts of *V. doniana* leaves and stem bark exhibited significant inhibitory effects against clinical pathogens and this may be attributed to the diverse bioactive compounds present in the plant.

3.3 Anti-inflammatory Effects of *Vitex doniana*

Inflammation plays a critical role in the progression of many diseases. In this context, [30] reported the anti-inflammatory potential of aqueous, ethyl acetate, petroleum ether, and n-hexane leaf fractions of *V. doniana* in which ethyl acetate fraction exhibited highest anti-inflammatory activity by inhibiting proteinase, xanthine oxidase, and 5-lipoxygenase (5-LOX), as well as preventing protein denaturation.

3.4 Antidiabetic and Hypoglycemic Effects of *Vitex doniana*: According to the International Diabetes Federation, over 41 million people worldwide currently suffer from diabetes, with projections rising to 70 million by 2025 due to the global increase in diabetes mellitus cases (31). Notably, the hypoglycemic potential of various parts of *V. doniana* has been extensively studied and documented across different experimental models [27, 32].

3.5 Antimalarial Effect of *Vitex doniana*

Vitex doniana is traditionally used in the management of fever and malaria by treating with decoctions prepared from different plant parts to reduce fever and alleviate malaria symptoms [33, 34, 35]. Scientifically, *V. doniana* has been shown to possess significant antimalarial activity, particularly its stem bark and leaf extracts, which are effective against *Plasmodium falciparum* [33, 35]. Moreover, the phenolics, flavonoids, and alkaloids present in the plant have been reported to disrupt parasite metabolism and replication, making it a promising natural source for antimalarial drug development.

4. Antinutritional constituents of *Vitex doniana*

4.1 Antinutritional Factors in Black Plum (*Vitex doniana*)

Antinutritional factors (ANFs) are known for their potential influence on nutrient bioavailability, food safety, and suitability of food for organisms' consumption. ANFs are naturally occurring compounds emanating from normal metabolic processes of plants, which may interfere with nutrient digestion, absorption, or metabolic utilization, thereby exerting effects contrary to optimal nutrition [36].

The leaves of *Vitex doniana* have been evaluated vegetable and as feed resource. Studies have revealed the presence of cyanide, nitrate, oxalate, tannins, phytate, alkaloids, and trace amounts of cardiac glycosides, reflecting part-specific variation in antinutritional profiles [3, 37]. [37] reported the following concentrations in dried leaves: oxalate (19.200 mg/ml), nitrate (287.670 mg/ml), tannins (91.100 mg/ml), cyanide (228.382 mg/ml), and phytate (20.420 mg/ml). These compounds are typical of leafy vegetables and are nutritionally relevant due to their potential effects on mineral absorption and protein utilization. The pulp is especially rich in alkaloids, saponins, tannins, phenols, cardiac glycosides, and flavonoids [6]. The peel exhibits higher concentrations of phenolic compounds compared to the pulp and is frequently discarded [17]. While phenolics provide antioxidant and antimicrobial benefits, elevated levels can exert antinutritional effects by binding proteins and minerals. Data on the seeds remain limited; however, available studies report the presence of phenolics such as tannins and a hard seed coat, indicating greater antinutritional constraints and reduced suitability for direct consumption without processing [17, 38].

Processing methods have been shown to influence ANF levels in *V. doniana* fruits. Juicing and dilution significantly reduce ANF concentrations, while heat treatment and simmering resulted in insignificant reductions, particularly in saponins [39]. However, there remains a need for further investigation into alternative processing techniques such as drying, fermentation, and enzymatic treatments to optimize nutrient availability and safety.

Toxicological assessments indicated that *V. doniana* fruit is generally safe for consumption. Acute toxicity studies in Sprague-Dawley rats with *Vitex doniana* fruit extract demonstrated no mortality and no neurobehavioral or autonomic nervous system alterations at doses ranging from 100 to 3000 mg/kg body weight, with an estimated LD₅₀ greater than 3000 mg/kg body weight indicating its safety at typical level of consumption despite the presence of ANFs [38]. Oxalate a known antinutrient which possess chelating property on divalent minerals like calcium and magnesium. Its high intake has been linked to increased risk of kidney stone, electrolyte imbalance and gastrointestinal irritation [40].

Similarly, ^[41] reported that oxalates can form complexes with proteins, thereby reducing peptic digestion. However, the oxalate levels reported in *V. doniana* leaves are relatively low and unlikely to pose significant health risks when consumed in moderate amounts ^[37]. Phytate also contributes to reduced mineral absorption due to its strong chelating properties and may lead to micronutrient deficiencies if consumed in large amounts without proper processing. Nevertheless, the phytate content of *V. doniana* leaves falls within acceptable limits and can be significantly reduced through common processing methods such as boiling or fermentation ^[36]. Oxalate and phytate levels suggest limited mineral chelation potential in properly processed leaves.

Despite the role of excessive tannins and nitrate in slowing protein digestibility via formation of complexes with dietary protein and digestive enzymes and impaired oxygen transportation in the blood, their concentrations in *V. doniana* leaves are tolerable and comparable to those found in edible leaves ^[37]. The same goes for the concentration of cyanide, which is also reported to be fall within non-lethal limits and safe for consumption and it is in alignment with the report of the role drying and cooking process in the reduction of cyanogenic compounds in leafy vegetables ^[42]. Although the *V. doniana* leaves have been documented to contain several antinutrients, having them within the safe consumption limits accrue to its suitability as feed source with application of appropriate processing methods ^[37].

4.3. Nutritional and Biological Implications

Vitex doniana has been evaluated to contain certain antinutritional factors in relation to their concentrations, processing methods and intake levels which at low concentration levels, tannins and saponins may have significant therapeutic effects including antioxidant and hypocholesterolemic activities ^[43]. Furthermore, they are associated with reduced risk of liver cancer, normoglycaemic effect, modulation of hypercalciuria, acute lead poisoning e.t.c. ^[1, 44]. Some other studies on *V. doniana* stem bark have proven it to be therapeutical based on the presence of some phytochemicals like alkaloids, tannins, saponins and flavonoids ^[45].

Generally, at low concentrations, these compounds may confer health benefits, whereas at higher levels they may impair nutrient utilization. Common processing methods, particularly juice extraction and dilution significantly reduce antinutrient concentrations in fruit products ^[44], while levels present in the leaves remain within acceptable safety limits ^[37]. These findings support the nutritional suitability of black plum fruits and leaves for human consumption and underscore their potential for broader applications in food systems and animal feed program.

5.0. Derived Products from Black Plum (*Vitex doniana*)

Evolution of advanced food processing techniques has led to the development of various value-added products based on the fact that fruit-based products plays vital role in human nutrition because of the significant vitamins and minerals found in them ^[46]. The rich composition of black plum in therapeutic bioactive ingredients make it highly suitable for conversion into diverse products ^[47].

The perishability of the fruit remains a driving force in processing it into stable forms with longer shelf-life ^[48], this in turn enhances its marketability and revenue opportunities for farmers.

For instance, jam (Plate A) is made by cooking the fruit pulp with sugar and pectin resulting in a thick, spreadable gel. Reports have shown that jams produced from black plum fruit presents desirable sensory qualities like colour, taste, spreadability and physicochemical properties as well as phenolic contents to aid preservation ^[2].

Beverages represent another important category of derived products. Fresh juice extracted from *V. doniana* fruit can be processed into nectar, traditional beverages like pasteurized drinks (Plate B). These products retain high levels of vitamin C and antioxidants, making them healthier alternatives to sugar-sweetened beverages ^[49]. More so, ^[44] produced juice from both *V. doniaina* fresh and dried fruit pulp.

A concentrated syrup (Plate C) can also be produced by continuous boiling of the juice, resulting reducing sugar-rich concentrate (approximately 51.7%) that can serve as natural, non-toxic at tested levels sweetener and characteristic aromatic compounds identified through techniques such as hydro-distillation and GC-MS ^[50].

In wine production, black plum juice or mashed fruits can undergo controlled, spontaneous fermentation using *Saccharomyces cerevisiae*, yielding wines with alcohol contents of approximately 10.5% (controlled fermentation) or 5% (spontaneous fermentation) (Plate D and E). Studies in Nigeria have shown that black plum wine possesses acceptable chemical composition, enhanced antioxidant properties, and a pleasant fruity flavour, thereby offering commercial potential ^[51].

Additionally, the seeds can be roasted, ground, and brewed into a coffee-like beverage, providing a caffeine-free alternative with nutty flavour characteristics and residual mineral content ^[52]. Recent studies from Côte d'Ivoire have confirmed the high phenolic content and sensory acceptability of such seed-based coffee substitutes ^[53]. These derived products (Plate A - G) capitalize on the fruit's bioactive composition to deliver nutritional and functional benefits, including improved digestion due to high fibre content and reduced oxidative stress through antioxidant activity. Processing also mitigates issues related to seasonality and perishability, enabling the development of small-scale enterprises in jam production, juice processing, and winemaking.

6. CRIN Developed Products from Black Plum



a)



b)



c)



d)



e)



f)



g)

- **Plate A:** *Vitex doniana* jam
- **Plate B:** *Vitex doniana* drink
- **Plate C:** *Vitex doniana* Syrup
- **Plate D:** Naturally fermented *Vitex doniana* wine made from mashed fruit
- **Plate E:** Fermented bottled wine made from *Vitex doniana* mashed ripe fruit
- **Plate F:** *Vitex doniana* Jelly
- **Plate G:** *Vitex doniana* 3-in-1 beverage

Conclusion

The present study highlights the importance of the different parts of *Vitex doniana* Sweet both as a potential material in pharmaceutical and food industries. *Vitex doniana* yields a wide range of nutritious derived products; from jams, syrups, and beverages to wine and seed-based drinks, highlighting its significance as a sustainable African resource for nutrition security and agro-industrial development. The phytochemical and the bioactivity profiles of this plant collectively contribute to its therapeutic potentials, thus, supporting its traditional use in the management of various ailments such as inflammation, infections, and chronic diseases. It is therefore necessary to create awareness of the immense benefits embedded in *Vitex doniana* to enhance its popularity and to safeguard it from extinction the rising rate of uncontrolled deforestation. Proximate composition of *Vitex doniana* stem bark needs exploration as information on it is limited. There is equally need to carry out further research on the isolation of pure compounds from the different parts of this plant that can be used as pharmaceuticals in combating various diseases affecting humanity.

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