
Review

Neocarya macrophylla (Sabine) Prance: Review on taxonomy, ethnobotany, phytochemistry and biological activities

Amina Jega Yusuf^{1,*}, Musa. Ismail Abdullahi¹, Abubakar Alhaji Muhammad², Kasimu Ghandi Ibrahim^{3,4}

¹Department of Pharmaceutical and Medicinal Chemistry, Usmanu Danfodiyo University, Sokoto, Nigeria

²Department of Pharmaceutical and Medicinal Chemistry, Ahmadu Bello University, Zaria, Nigeria

³Department of Physiology, Faculty of Basic Medical Sciences, College of Health Sciences, Usmanu Danfodiyo University, Sokoto, Nigeria

⁴Centre for Advanced Medical Research and Training, Usmanu Danfodiyo University, Sokoto, Nigeria

*Correspondence: amina.yusuf@udusok.edu.ng; Tel.: +2348036386793

Abstract: *Neocarya macrophylla* (Sabine) Prance (Nm, Chrysobalanaceae) is used traditionally as food, for medicinal spiritual and industrial purposes. It is also used as soap, dye, glue, fodder, termite repellent, firewood and for structural materials. Few studies on the physicochemical, nutritional contents, phytochemical and pharmacological activities have validated the benefits of Nm to humanity as food, in cosmetics and pharmaceutical products. The major bioactive constituents identified in the plant so far are steroids and flavonoids (such as stigmaterol, quercetin, catechin and its related glycosides). Extracts of the plant have shown good antivenom, antimicrobial, analgesic, anti-inflammatory, antimycobacterial, anthelmintic and antioxidant activities. Acute toxicity studies conducted have confirmed the plant to be toxic. More studies on the plant are required in order to exploit other biological activities as claimed by traditional healers and also to isolate more bioactive compounds. In addition, the safety and tolerability assessment of Nm should be undertaken due to its widespread usage.

Keywords: *Neocarya macrophylla*; Chrysobalanaceae; antivenom; analgesic; anti-inflammatory; antimicrobial; antioxidant; catechin; stigmaterol

1. Introduction

Neocarya macrophylla (Nm) (Sabine) Prance (formerly *Parinari macrophylla* Sabine, Pm) is a West African species commonly known as gingerbread plum which belongs to the Chrysobalanaceae family [1]. The plant has found a variety of applications as food, medicine, for spiritual and industrial uses as well as soap, dye, glue, fodder, soap, termites repellent (in Gambia), firewood, and structural materials [2,3]. Extensive literature search on Nm revealed that there was no critical review on the therapeutic applications of the plant; hence, this article will focus on the detailed botanical, phytochemical, pharmacological, and scientific applications of Nm.

2. Botanical description

Neocarya is a genus in the Chrysobalanaceae family as described by Prance ex White in 1976 and it contains only one known species *Neocarya macrophylla* (Figure 1) native to western and central Africa from Senegal to Nigeria and South Sudan [4-5]. The plant family is composed of 17 genera and about 525 species that are mainly woody plants, shrubs and trees mostly found in tropical and subtropical regions [6]. The wood has little advantage over other types of wood due to high silica content while most of the species have edible fruits [7, 8]. Flowers are seen almost all year round, but most commonly in the second part of the dry season [2].



Figure 1: *N. macrophylla* in its natural habitat

2.1. Scientific classification

Kingdom: Plantae
Phylum: Magnoliophyta
Class: Angiospermae
Category: Fabids
Order: Malpighiales
Family: Chrysobalanaceae
Genus: Neocarya
Species: *Neocarya macrophylla*

2.2. Common names

English: Ginger bread plum or Neou oil tree
Hausa: Gawasa or Farar rura
Fulfulde: Naawdi
Nupe: Kobenci



Figure 2: Fruit(a) and seeds(b) of *N. macrophylla*

3. Morphology

Nm is a shrub or small tree that grows up to 6 – 10 m high. It usually has a bole with short branches that are twisted with an open crown [2]. The fruit (Figure 2) is an ellipsoid drupe, glabrous, yellowish-brown with grey warts on the surface and it is 4 – 5 cm long and 2.5 – 3.5 cm across with a hard stone embedded in a thick pulp. The bark is fissured or rough and appear thick and brittle with blackish and red slash. The stems are densely pubescent russet-brown in color. The plant has stipules which are linear in the leaf axils. Leaves (Figure 3) are alternate, ovate or elliptic and they are 10 – 25 cm long and 5 – 15 cm across, coriaceous and downy beneath. There exists a blade with a rounded and sometimes acuminate apex and cordate or rounded base [9]. Nm nerves are pinnate, midrib brown and downy on both surfaces with 13 – 20 pairs of prominent lateral nerves fusing near the apex. The petiole is thick and 3 – 7 mm long, brown, tomentose with 2 small glands at the top up to 30 cm long. Flowers are tomentose except for the 5 white to pink petals that are 12 – 20 mm in diameter [2, 9].



Figure 3: Leaves of *N. macrophylla*

4. Habitat and Distribution

Nm grows in fringing forests and forest edges in the Sudanese and Guinean lowlands, on sandy soils. The trees also grow in arid and semiarid regions of the western part of Africa and Central America, particularly Panama [1]. The plant is widely distributed along coastal savannahs from Senegal to Liberia, woody savannahs of southern Mali, Niger and northern Nigeria [1].

5. Traditional uses of Nm

5.1 Use as food

The fruits and the kernels inside the seeds of Nm are eaten fresh or boiled with cereal. A tangy tasting gruel is made from the fruits by pounding it in water to form a colorful red liquid which can be thickened with flour (either from maize or cassava). The gingerbread nuts are usually roasted and eaten like cashews or almonds. The nuts are also consumed as snacks or mixed into dishes and sometimes a few are pressed to obtain cooking oil [10, 11]. The fruits are used to prepare fragrant syrups that are used to make strong fruit juices [1]. In Sierra-Leone, Senegal and northern Nigeria, the fruits are a popular treat among the people, where they are sold in the local markets. The flesh of the fruits is soft and yellowish when fresh with distinct and peculiar flavor while the rind from the fresh fruits is used to impart a pleasant scent to ointments [3].

5.2 Use as medicine

Nm is used extensively in the Northern parts of Nigeria in ethno-medicine to treat numerous diseases such as asthma, skin infections, wounds, dysentery, inflammations, pulmonary troubles, ear and eye infections [3, 12]. The stem bark is used to treat conjunctivitis, pain, tooth decay, breathing disorders [2], cancer and snake bites [11]. The decoctions of the leaves and bark are used as mouth wash, internal troubles and for inflamed eyes [13]. The leaves are also chewed and applied topically for the relief of pain [1, 11]. In Senegal, branches of gingerbread plum are burnt and the smoke is inhaled as remedy for snakebite [14]. The roots are used as antivenom, haemostatic agents and in the treatment of circumcision and wounds [2]. In Nigerian traditional medicine, the fruit is used to treat diarrhoea while the seeds are used as purgative and anthelmintic agents [2, 15].

5.3 Other uses

The fruits of Nm have numerous magico-religious uses (talismans, spells, sacerdotal ornaments) and the seeds are used as ointments (oils), soap and as vermifuge sometimes planted, left to grow or favoured in fields. Nm roots are also used for protection against curses and spirits. The hard brown timber from the plant is used for building construction, pirogues, firewood and charcoal [2]. The villagers use the tree as dye, glue, fodder, soap, termite repellents (in Gambia), firewood, and structural materials [3]. The seed oil of gingerbread plum can be used for the production of soap [25].

6. Phytochemistry

6.1 Physicochemical, nutritional and elemental contents

The physicochemical, nutritional and elemental contents of Nm from different locations have been adequately documented. Recent studies indicated that the refined gingerbread plum kernel oil from Niger and Guinea contained free fatty acid (0.18 and 0.20 %), acid value (0.35 and 0.39 mgKOHg⁻¹), peroxide value (34.65 and 48.87 mgO₂.kg⁻¹), iodine value (31.08 and 34.59 gI₂.100g⁻¹) and saponification value (157.18 and 168.48 mgKOHg⁻¹) [16]; the oil contained α -tocopherol (88.39 and 54.29 %), β -tocopherol (3.17 and 34.49 %) and δ -tocopherol (8.44 and 11.22 %) [16]. Nm seed cake have been reported to have moisture content (12.32 %), ash content (6.53 %), carbohydrate content (13.19 %), crude protein (56.04), crude fat (4.51 %), crude fibre (7.41 %), dry matter (87.68 %) and calorific energy value of 317.48 kcal/100g [17].

The gingerbread plum seed flour and defatted gingerbread plum seed flour had moisture (10.57 and 10.00 %), ash (4.43 and 6.43 %), carbohydrates (8.64 and 12.10 %), crude protein (20.27 and 61.71 %), fat (47.28 and 2.14 %) and crude fibre of 8.70 and 7.37 %, respectively. The flour also contained oleic (47.15 %), linoleic (19.10 %) and arachidonic (17.64 %) acids [1].

A Study confirmed that unrefined gingerbread plum kernel from Niger and Guinea has oil content (56.15 and 60.60 %), iodine value (34.90 and 39.12 gI₂.100g⁻¹), saponification value (153.34 and 162.69 mgKOHg⁻¹), oleic acid (0.33 and 0.34 %) and peroxide value (41.28 and 54.06 mgO₂.kg⁻¹), respectively [18].

Diaby et al. [20] reported that gingerbread plum kernels paste from Niger and Guinea contained protein (18.41 and 19.56 %), ash (2.41 and 2.41 %), fat (56.18 and 60.60 %), moisture (2.82 and 3.17 %) and carbohydrate contents of 20.18 and 14.16 %, respectively while the flour from the two locations contained protein (47.14 and 53.71 %), ash (6.25 and 6.59 %), fat (10.54 and 11.36 %), moisture (11.94 and 10.44 %) and carbohydrates contents of 24.13 and 17.89 %, respectively.

Gingerbread plum seed kernel from Sokoto state in Nigeria had moisture (12.55 %), ash (5.52 %), crude protein (23.24 %), crude fibre (7.67 %), crude lipid (50.50 %), carbohydrate (6.04 %) and energy value of 571.62 kcal/100g [21].

Gingerbread plum kernel oil from Niger and Guinea contained saturated fatty acids (15.57 and 15.29 %), monounsaturated (51.41 and 49.47 %) and polyunsaturated fatty acids (33.06 and 35.29 %) [16]. In another study, the kernels from Niger and Guinea contained saturated fatty acids (15.90 and 17.18 %), monounsaturated (48.31 and 42.51 %) and polyunsaturated fatty acids (35.08 and 40.40 %) while α -tocopherol, β -tocopherol and δ -tocopherol were also found in the kernels [18]. A golden yellow gingerbread plum seed oil contained acid value (12.97 mg KOH/g), free fatty acid (15.10 % Oleic), iodine value (32.07 I2/100g), saponification value (153.30) and peroxide value (meq H₂O₂) of 45.48 [25]. The oil also contained oleic acid (40 %), eleostearic acid (31 %), linoleic acid (15 %), palmitic acid (12 %) and stearic acid (2 %) in addition to sterol A and B [50].

Essential amino acids (such as histidine, threonine, valine, methionine, phenylalanine, isoleucine, leucine and tryptophan) and nonessential amino acids (such as tyrosine, cysteine-s, aspartic acid, glutamic acid, serine, glycine, arginine, alanine and proline) were detected in the flour and paste of gingerbread plum from Niger and Guinea as well [20]. Studies have shown that, hydrolysis time has a positive effect on the nutritional and functional properties of protein hydrolysates from gingerbread plum seeds (reference). Amino acids and protein contents alongside other biological parameters of the protein hydrolysates were significantly affected as the time of hydrolysis increased [24]. The seeds also contained leucine, threonine, valine, isoleucine, methionine, cysteine, lysine, phenylalanine, tyrosine, glycine, alanine, serine, aspartic acid, glutamic acid, proline, arginine and histidine [21]. Thiamine B1 (13.16 and 5.56 mg/100g), riboflavin B2 (0.56 and 0.37 mg/100g), pyridoxine B6 (1.15 and 0.83 mg/100g) and biotin H (235.50 and 130.80 mg/100g) were identified as the major vitamins from gingerbread plum kernel flours of Niger and Guinea, respectively [20].

In terms of mineral elements, the paste and flour of gingerbread plum were shown to predominantly contain calcium, phosphorus, magnesium, sodium, potassium, iron, copper, zinc and manganese, which varied between locations [20]. Elemental composition of the gingerbread plum seed flour include magnesium, potassium, calcium copper, iron and manganese [1]. The seed kernel from Sokoto state was shown to contain mineral elements such as sodium, potassium, calcium, phosphorus, manganese, iron, copper and zinc [21]. In another study, the root bark of Pm contained copper, cadmium, lead, manganese, iron, magnesium, zinc, potassium, calcium and sodium [28].

Antinutritional contents including trypsin inhibitor (24.49 and 22.77 mg/g), phytic acid (3.19 and 4.51 g/100g) and tannin (1.92 and 1.82 g/100g) were identified in the flour from Niger and Guinea [20]. Total oxalate (46.91 mg/100gDW), tannin (112.78 mg/100gDW), phytate (390.42 mg/100gDW) and saponin (3.35 mg/100gDW) were reported for the seed kernels from Sokoto state [21]. Gingerbread plum kernel protein fractions contained glutelin (80.2 %), albumin (75.1 %), globulin (53.7 %) and prolamin (2.0 %). Total phenolic contents for the protein hydrolysates ranged from 14.6 – 40.7 μ g/mL GAE [50].

Amza et al. [26] studied how different extraction, isolation and drying techniques can affect the physicochemical and functional properties of gingerbread plum seed protein by defatting, vacuum drying and freeze drying the samples. The freeze dried and vacuum dried gingerbread plum seed protein isolate contained 90 % protein while the defatted gingerbread plum flour contained 56.72 %. Thus, the method of drying can significantly affect the physicochemical parameters and functional characteristics of the isolates.

Gingerbread plum seed had a good solubility profile with pH 4 – pH 10 and it contained protein efficiency ratio of 2.35 % and amino acid score of 65.53 %. It recorded a water holding capacity of 3.01 and 3.12 g/g and forming capacity and stability of 145 mL/100 mL and 110 mL/100 mL, respectively [27]. It had emulsifying capacity (29 %) and bulk density (0.30 g/mL) [27]. The pulp of Nm was shown to contain approximately 60 % water in addition to proteins, lipids, vitamin C and other mineral elements [29].

Biodiesel from the seed oil had density (0.60 g/cm³), water and sediment content (0.42 %), saponification value (84.20 mg/KOH), acid value (0.45 mg/KOH), iodine value (75 mg I₂/100g), cetane number (94.24 min) and heating value of 49 MJ/Kg [19].

6.2 Bioactive constituents

There are few researches that revealed the chemical composition of Nm. The bioactive constituents of the plant which contribute to its pharmacological or therapeutic actions are mainly steroids, flavonoids and glycosides (Figure 5).

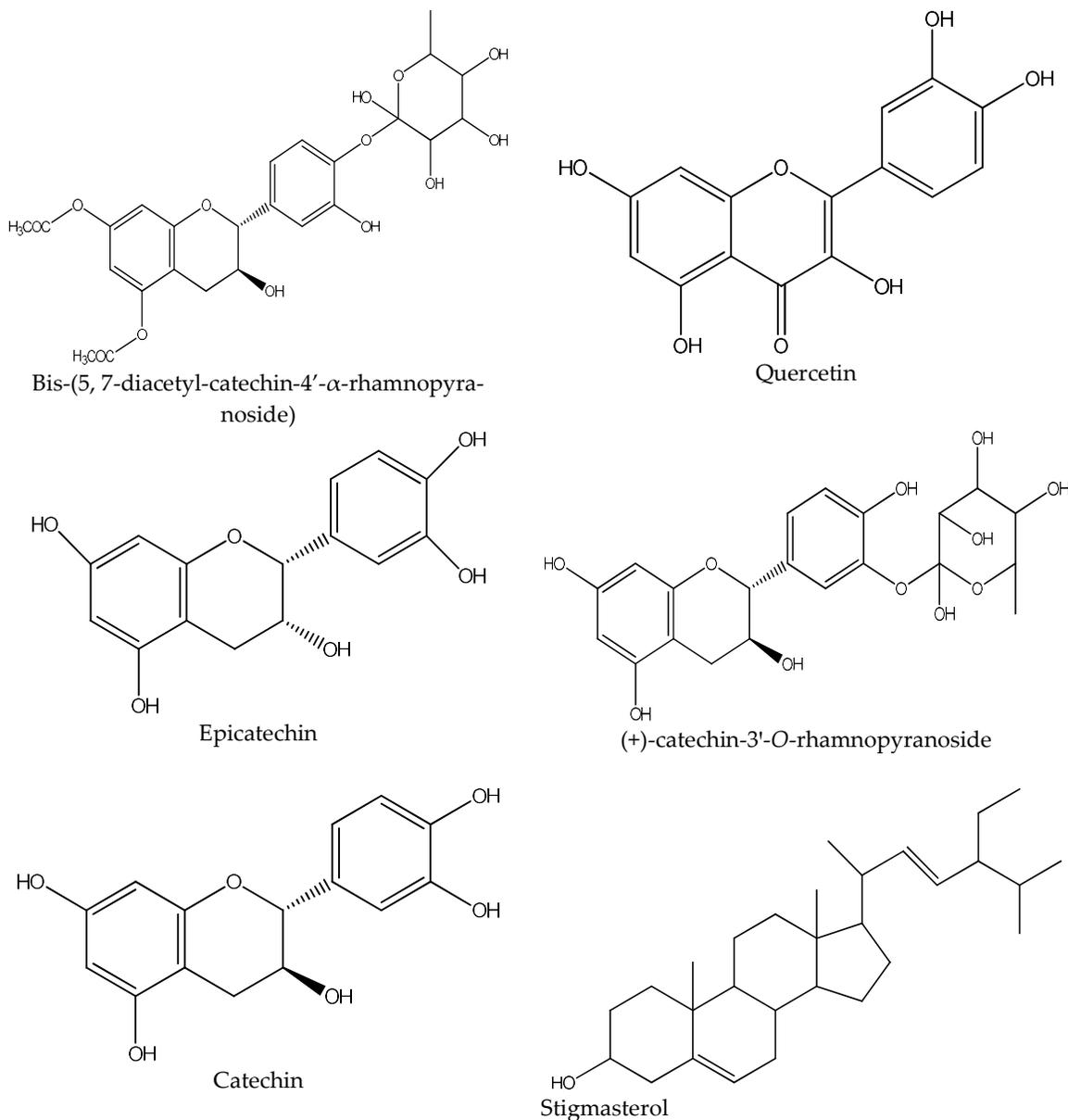


Figure 5: Chemical constituents of *N. macrophylla*

6.2.1 Steroids

Stigmasterol has been isolated from the n-hexane soluble fraction of the methanol stem bark extract of the plant [11].

6.2.2 Flavonoids

Nm is composed of majorly polyphenolic compounds of the flavanol type in their simple or dimeric forms. Cook et al. [35] reported the presence of a flavonoid glycoside in the plant. Bis-(5, 7-diacetyl-catechin-4'- α -rhamnopyranoside) [11], epicatechin [31], (+)-catechin-3'-O-rhamnopyranoside [32] and catechin [33] were isolated from the ethylacetate soluble fraction of the methanol stem bark extract of the plant while quercetin [30] was isolated from the leaves of Nm.

Aside from the isolation and characterization of constituents from Nm, an appreciable amount of research on the phytochemical screening to identify the presence of secondary metabolites has been adequately documented. There are slight variation in the constituents from the different parts of Nm which could possibly be due to genetic, environmental and harvest condition of the plant. The plant has been reported to contain sugar, protein and steroid [13]. Mann et al. [36] also reported that the crude methanol extract of Nm contains alkaloids, saponins, steroids, carbohydrates, and tannins.

The root bark of the plant has been reported to contain tannins, flavonoids, steroids, alkaloids, cardiac glycosides and anthraquinones [28]. Alkaloids, flavonoids, saponins, steroids, phenols and tannins were found in the ethanol and methanol root bark extracts of Nm. These constituents were similarly found in the fractions (n-hexane, chloroform and ethyl acetate) which varied depending on the polarity of the solvent [39].

The ethanol leaf extract of Nm indicated the presence of flavonoids, steroids, palmitoleic acid, alpha tocopherol, beta tocopherol, tannins and glycosides [38]. The fruits and stem of Nm contained glycosides, steroids and alkaloids [12]. Gingerbread plum seed oil was shown to contain alkaloids, tannins, saponins, flavonoids, steroids and terpenoids as the major secondary metabolites [3]. Nm seed cake contains tannins, flavonoids and alkaloids [17]. Carbohydrates, alkaloids, flavonoids, anthraquinones tannins, saponins, glycosides, steroids and triterpenes were reported to be present in the methanol stem bark extract of Nm [37].

Gingerbread plum (Nm) seed oil contained fatty acids such as myristic acid, palmitic acid, stearic acid, palmitoleic acid, elaidic acid, oleic acid, erucic acid, behenic acid, heneicosanoic, icosatetraenoate and eicosatrienoic acid [40]. The FT-IR analysis of the oil showed an absorption band at 3475.84 cm⁻¹ which corresponds to O-H of carboxylic acid. Other functional groups include -CH₂, -CH₃, -CH, C-O etc [40]. Biodiesel from Nm contained methyl-9-octadecanoate, methyl-12-octadecanoate, methyl-hexadecanoate esters, octadecanoic and oleic acids [19].

7. Biological and pharmacological properties of Nm

Extensive review on the pharmacological actions of Nm is presented in this section with additional information in Table 1.

Table 1: Overview on pharmacological actions of *Neocarya macrophylla*

Plant part	Extract/Compound	Activity	References
Stem bark	n-Hexane, Methanol	Antimycobacterial	Mann <i>et al.</i> , 2009

	Methanol	Antimicrobial Toxicity, Analgesic Antivenom	Yusuf <i>et al.</i> , 2015b Yusuf <i>et al.</i> , 2015c Yusuf <i>et al.</i> , 2015d
	Saponin-rich fraction	Toxicity, Analgesic, Anti-inflammatory	Yusuf <i>et al.</i> , 2019d
	Stigmasterol	Antimicrobial	Yusuf <i>et al.</i> , 2018
	Ethylacetate	Antivenom, Phospholipase A ₂ assay	Yusuf <i>et al.</i> , 2020
	<i>n</i> -Butanol	Nociceptive, Anti-inflammatory	
	Catechin		
	(+)-catechin-3'- <i>O</i> -rhamno- pyranoside	Antivenom, Phospholipase A ₂ assay Nociceptive, Anti-inflammatory, Antimi- crobial	Yusuf <i>et al.</i> , 2019c
Root bark	Ethanol	Antimicrobial	Halilu <i>et al.</i> , 2010
	Saponin-rich fraction	Toxicity, Analgesic, Anti-inflammatory	Yusuf <i>et al.</i> , 2019d
	Ethanol, <i>n</i> -hexane	Antimicrobial	Datti <i>et al.</i> , 2020
	Chloroform, Ethylacetate, Methanol		
Leaves	Ethanol	Anthelmintic Antibacterial	Barnabas <i>et al.</i> , 2010 Isaka <i>et al.</i> , 2017
	Methanol	Antibacterial, Antibiofilm Antivenom, Phospholipase A ₂ assay	Olowo-okere <i>et al.</i> , 2018 Yusuf <i>et al.</i> , 2019a
	Ethylacetate	Antibacterial, Antibiofilm Antivenom, Phospholipase A ₂ assay	Olowo-okere <i>et al.</i> , 2018 Yusuf <i>et al.</i> , 2019a
	<i>n</i> -Butanol	Antibacterial, Antibiofilm Antivenom, Phospholipase A ₂ assay	Olowo-okere <i>et al.</i> , 2018 Yusuf <i>et al.</i> , 2019a
Fruits	<i>n</i> -Hexane, Ethylacetate, Methanol	Cytotoxic, Antimicrobial	Audu <i>et al.</i> , 2005
Seeds	Oil	Toxicity	Ajayi <i>et al.</i> , 2019
	Cake	Toxicity	Emmanuel <i>et al.</i> , 2017
Kernels	Oil	Antioxidant Antioxidant	Amza, 2013 Diaby <i>et al.</i> , 2016a

7.1 Antimycobacterial and antimicrobial activities of Nm

Antimycobacterial activity of Nm have previously been reported [36]. The *n*-hexane and methanol extracts of Nm did not show any significant effect against Mycobacterium tuberculosis [36].

The antibacterial property of the ethanol root bark extract of Nm and its fractions (*n*-hexane, chloroform, ethylacetate and methanol) against *K. pneumoniae* have been reported with mean zone of inhibition (MIC) ranging from 9 – 15 mm [29].

The methanol stem bark extract of Nm showed good antimicrobial effect against some clinical isolates including *S. pyogenes*, *S. feacalis*, *B. subtilis*, *B. cereus*, *E. coli*, *P. fluorescens*, *C. albicans* and *C. krusei* with MIC and MBC/MFC values ranging from 2.5 – 5.0 mg/mL and 5 – 20 mg/mL, respectively [37]. Moreover, stigmasterol from the stem bark of Nm exhibited a broad-spectrum antimicrobial activity against methicillin-resistant *S. aureus* (MRSA), vancomycin-resistant enterococci (VRE), *S. aureus*, *S. faecalis*, *E. coli*, *S. typhimurium*, *P. fluorescens*, *K. pneumoniae*, *C. albicans* and *C. krusei* with MIC and MBC/MFC values ranging from 6.25 – 25 µg/mL and 12.5 – 50 µg/mL, respectively [41]. In an *in vitro* antimicrobial study of (+)-catechin-3'-*O*-rhamnopyranoside from Nm stem bark, it was shown to possess a good broad spectrum of antimicrobial activity against *S. aureus*, VRE, *S. faecalis*, *E. coli*, *P. aeruginosa*, *P. vulgaris*, *C. albicans*, *C. tropicalis* and *C. krusei* with MIC values ranging from 6.25 – 25.0 µg/mL and MBC/MFC ranging from 12.5 – 50 µg/mL [32].

The ethanol leaf extract of Nm also recorded good antibacterial effect against some selected microorganisms (*E. coli*, *K. pneumoniae* and *S. aureus*) in a concentration dependent manner with MIC value ranging from 2.5 -5.0 mg/mL [38]. The methanolic leaf extract and the ethylacetate and n-butanol fractions of Nm exhibited good antimicrobial activity against *P. aeruginosa* and *S. aureus* with MIC and MBC values ranging from 3.125 – 37.5 mg/mL and 6.25 – 75 mg/mL, respectively. The ethylacetate and n-butanol fractions also demonstrated very good biofilm inhibition activities against *S. aureus* (92 %) and *P. aeruginosa* (80.33 %) respectively [42].

7.2 Analgesic and anti-inflammatory activity of Nm

Based on the ethnomedicinal claim of the use of Nm to relieve pain, the analgesic property of the methanol stem bark extract of the plant was studied *in vivo*. The extract showed analgesic effect by significantly reducing the number of abdominal constrictions induced by acetic acid [43]. (+)-catechin-3'-O-rhamnopyranoside from Nm stem bark was also able to diminish the nociceptive response induced by formalin, which suggests that it possesses a central acting analgesic effect with shorter onset and duration of action [43]. It was also able to decrease the inflammation induced by formalin and the mechanism of action was related to the inhibition of histamine, serotonin and related substances, as well as the inhibition of prostaglandin synthesis [32]. Similar results were obtained for saponin-rich fractions from the stem bark and root of Nm where both fractions had significant ($p < 0.05$) analgesic and anti-inflammatory activities in animal model [44]. Moreso, catechin from the stem bark of Nm significantly ($p < 0.05$) reduced the nociceptive response induced by formalin in both phase 1 and 2 and there was remarkable inhibition of formalin-induced inflammation at the 1st, 2nd and 3rd hours, though the effect was not statistically significant compared to the control [33].

7.3 Antivenom activity of Nm and phospholipase A2 assay

Nm stem bark has demonstrated significant antivenom activity against *Naja nigricollis* venom [45]. In another study, (+)-catechin-3'-O-rhamnopyranoside from the stem bark of Nm showed an impressive antivenom activity against *N. nigricollis* venom in mice with maximum protection (100 %) against venom-induced lethality. It was also able to inhibit the action of *N. nigricollis* PLA2 enzyme activity [32]. Similar antivenom effect against *N. nigricollis* venom was observed for the ethylacetate and n-butanol soluble fractions of the stem bark of Nm and catechin isolated from the ethylacetate fraction [33].

A more recent *in vitro* study revealed that the methanol leaf extract of Nm and its ethylacetate and n-butanol fraction significantly protected mice against venom-induced lethality with 100 % survival rate and a remarkable inhibition of the poisonous effects of PLA2 enzyme by the extract and its fractions was also observed [30].

7.4 Antioxidant and anthelmintic activity

Cook et al. [35] reported the *in vitro* antioxidant potential of the fruit/shell of Nm which was attributed to the presence of in the plant which may be a flavonoid glycoside. In another study, the antioxidant activity of gingerbread plum kernel proteins was reported [24]. Gingerbread plum kernel protein fractions hydrolysates (albumin, globulin and glutelin) had indicated a very good antioxidant effect [51]. The fresh whole gingerbread plum kernels from Niger and Guinea exhibited good DPPH radical scavenging activity and reducing power in a dose-dependent manner [18]. Nm leaf has also demonstrated moderate anthelmintic activity with slow recovery weight [46].

7.5 Cytotoxicity of Nm

In vitro cytotoxic effect of the n-hexane, ethylacetate and methanol fruit and stem extracts of Pm have been reported with IC₅₀ values of 201, 242 and 500, respectively [12]. Further fractionation of the ethylacetate extract yielded 6 major fractions of which A, C and F had IC₅₀ values of 20, 125 and 300, respectively [12].

7.6 Toxicity

Due to the widespread usage of Nm in traditional medicine, an acute toxicity study was conducted to determine the median lethal dose of the methanol stem bark extract of the plant. The intraperitoneal LD₅₀ of the extract in mice was found to be 283 mg/kg suggesting the extract to be toxic [43]. There was no significant change in the haematological and biochemical parameters of the experimental animals that were fed with Nm seed cake [17].

Ajayi et al. [47] reported the acute and sub-chronic toxicological effect of Nm seed cake supplemented diets on albino rats. Ajayi et al. [48] reported the short term toxicological effect of Nm seed oil and concluded that in moderate quantities, it is suitable for human consumption.

A moderate LD₅₀ value of 2154 and 1265 mg/kg was reported for the saponin-rich fractions of the stem bark and root of Nm [44]. According to a study by Yusuf et al. [30], the methanol leaf extract produced an LD₅₀ value of 288 mg/kg while 565 and 141 mg/kg were obtained for ethylacetate and n-butanol fractions indicating that the extract and its fractions are toxic.

7.7 Others

The structure of natural stands of Nm (Sabine) Prance, a woody species used for food in the Dallol Bosso region of Niger have been documented [49]. The results of this study have provided a better picture of the status of this specie, which points to the need to introduce sustainable management strategies [49].

8. Critique and Suggestions for Future Work

This review focused on literature search on the available scientific knowledge on Nm ranging from its botanical description, uses, physicochemical, phytochemical and pharmacological actions. Despite the wide usage of the plant in traditional medicine and other uses, the findings revealed the paucity of research conducted in the aspect of phytochemical and pharmacological studies. Few studies addressed some aspects of the ethnomedicinal claim of the use of the plant in the treatment of snakebite, microbial infections, pain and inflammation among others as well as the phytochemical constituents. Different authors have concluded that, most of the pharmacological actions of the plant might be attributed to the presence of the secondary metabolites detected in the plant. However, isolation and characterization of these bioactive constituents from the plant will improve the studies.

The fruits of Nm are widely consumed in northern part of Nigeria and West Africa as a whole in its natural raw form but there is no report yet on the isolation and characterization of its constituents, though antioxidant effect using solvent extracts have been conducted. It would be important to conduct researches that are close to reality and will have more impact on humans due to its widespread usage. Preliminary acute toxicity studies conducted intraperitoneally on the plant Nm revealed that, the plant is toxic. However, sub-chronic and chronic toxicity of the plant is yet to be reported. Effect of administration of the plant orally is yet to be validated scientifically. It is important to note that, there are a number of ethnomedicinal uses of the different parts of Nm that a yet to be studied and validated. More studies on the isolation and characterization of bioactive compounds would also be more desirable.

9. Conclusion

In conclusion, the available data on Nm has shown that it has quite a number of medicinal properties that are yet to be studied and validated scientifically. Additionally, Nm could also be used as a constituent of diets, a source of nutrients, in biodiesel production, as a source of oil and in food supplementation.

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