Journal of Diseases and Medicinal Plants
2022; 8(3): 55-60
http://www.sciencepublishinggroup.com/j/jdmp
doi: 10.11648/j.jdmp.20220803.12
ISSN: 2469-8202 (Print); ISSN: 2469-8210 (Online)

Comparative Study of the Chemical Composition of Three Mango Stem Bark

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To cite this article:

Victoria Bennett, Azibaola Kesiye Inengite. Comparative Study of the Chemical Composition of Three Mango Stem Bark. *Journal of Diseases and Medicinal Plants*. Vol. 8, No. 3, 2022, pp. 55-60. doi: 10.11648/j.jdmp.20220803.12

Received: June 12, 2022; **Accepted**: July 7, 2022; **Published**: July 20, 2022

Abstract: Mango (*Mangifera indica*) tree is an evergreen domestic plant with immense nutritional and medicinal properties. African mango leaf and root extracts have been reported to have inhibitory activity against several bacteria and fungi. Mango has different species but, this study was focused on the bark of three species (*Mangifera indica L.*, *Irvinga gabonensis* and *Mangifera indica*). Samples were collected from Toru-Orua and Ebedebiri Communities in Sagbama Local Government Area of Bayelsa State, Nigeria, and a comparative study of the proximate, mineral and bioactive compounds in the bark was carried out. Proximate analysis of the bark of *Mangifera indica L.*, *Irvinga gabonensis* and *Mangifera indica* showed 59.73%, 65.07%, 64.44% moisture content, 1.98%, 4.09%, 2.03% ash content, 1.93%, 1.30%, 1.73% protein content, 5.56%, 6.09%, 7.12% fat content, 0.90%, 0.74%, 2.50% fibre content, and 29.90%, 22.71%, 22.19% carbohydrate content respectively, Result shows that the bark of Irvinga gabonesis contains more moisture, hence will be more vulnerable to microbial contamination and high degree of perishability. The bark of Mangifera indica contains about three times fiber content than the bark of Mangifera indica L. and Irvinga gabonensis; implying that the bark of Mangifera indica could be a good source of fiber. The value observed for Irvinga gabonensis was insignificantly low compared to the fibre content in the seed as reported in the literature. Mineral concentrations of 0.3304%, 0.2296%, 0.2950% K, 0.0056%, 0.0024%, 0.0080% Fe, 0.0050%, 0.0004%, 0.0005% Mn, 1.2163%, 1.1659%, 1.0151% Ca, 0.1684%, 0.2417%, 0.1785% P were analysed respectively. Gas chromatography-mass spectrometry (GC-MS) analysis of methanolic extract of the bark of *Mangifera indica L, Irvinga gabonensis* and *Mangifera indica* showed fifteen, nine and ten bioactive compounds respectively. GC-MS results of the three mango bark species indicate that bioactive compounds are peculiar to a species. Performic acid has been shown to have strong bactericidal and sporicidal effect. Result shows that a significant amount of performic acid, 89.8% is contained in the bark of *Mangifera indica* L. affirming its use in folk medicine. All the analysed compounds have different biological activities justifying the use of *Mangifera indica L, Irvinga gabonensis* and *Mangifera indica bark* in traditional medicine for the treatment of malaria, thyphoid and COVID-19.

Keywords: Mango, Proximate, Mineral, Phytochemicals

1. Introduction

The extensive survey of literature revealed that Mangifera indica is an important source of many pharmacologically and medicinally chemicals such as mangiferin, mangiferolic acid, hydroxy-mangiferin, polyphenols and carotenes. Many different pharmacological activities, antioxidant, radio protective, immunomodulatory, anti-allergic, anti-inflammatory, antitumor, anti-diabetic, lipolytic, antibone resorption, monoamine oxidase-inhibiting, antimicrobial and anti-parasitic, have been reported for mangiferin [1]. All parts are used to treat abscesses, jackal bite, tumor, snakebite, stings, datura poisoning, heat stroke, miscarriage, anthrax, blisters, wounds in the mouth, tympanitis, colic, diarrhea, glossitis, indigestion, bacillosis, bloody dysentery, liver disorders, excessive urination, tetanus and asthma. Mango fruit, seed, leaves, bark and roots have been studied to have

diverse phytochemical constituents including polyphenolic antioxidants, flavonoids, triterpenoids, and micronutrients. Flavor of mango fruits contain volatile organic molecules including terpenes, furanones, lactones and esters. Mango leaves contains multiple minerals and vitamins [2]. African mango leaf and root extracts have documented inhibitory activity against several bacteria and fungi [3, 4]. Potential mechanisms of action include membrane disruption by terpenoids and inactivation of microbial adhesion, enzymes, and cell envelope transport proteins by ellagic acid-like compounds [4].

Rats were fed a normal diet and 1 mL of African mango oil or water over 4 weeks. Abdominal fat was lower, plasma HDL cholesterol and triglyceride levels were higher, and LDL: HDL and total cholesterol: HDL ratios were lower in rats administered the oil.

Blood glucose levels were also lower in rats administered the oil [5]. Irvingia gabonensis (IG) seeds and seed extracts have been shown to have hypoglycemic properties as well as antihyperglycemic properties. [6]. The mechanism appears to be associated with (1) down-regulated expression of adipogenictranscription factors or PPAR-gamma and adipocyte-specific proteins, such as leptin, and (2) up-regulated expression of adiponectin. Adiponectin has anti-atherogenic, anti-inflammatory, and antidiabetic activity.

A 50% ethanolic extract of the leaves produced a significant hypoglycemic effect at a dose of 250 mg/kg, both in normal and streptozotocin-induced diabetic animals [7]. The stimulation of β-cells to release insulin was thought to be part of the mechanism of action. The effect of the aqueous extract of the leaves on blood glucose level in normoglycaemic, glucose induced hyperglycemic and streptozotocin (STZ)-induced diabetic rats has been assessed. The results indicate that the aqueous extract of the leaves of MI possess hypoglycemic activity. The stem-bark of aqueous extract was used to examine the anti-inflammatory, analgesic and anti-diabetic properties. The different chemical constituents of the plant, especially the polyphenolics, flavonoids, triterpenoids, mangiferin, and other chemical compounds present in the plant may be involved in the observed anti-inflammatory, analgesic, and hypoglycemic effects of the plant's extract [7]. Diabetic animals eating diets containing 5, 10 and 15% mango flour showed significant decrease in blood glucose level [8].

African mango reduces body weight, body fat, waist circumference, blood sugar, triglycerides, and cholesterol [9]. Patients received either 150 mg of African mango seed extract or placebo 30 minutes before lunch and dinner. Patients receiving the extract improved both weight reduction (body weight, body fat, waist circumference) and metabolic parameters (plasma total cholesterol, LDL cholesterol, blood glucose, and C - reactive protein, adiponectin, and leptin levels). Numerous studies exist on the potential industrial application of African mango in food, cosmetic, and pharmaceutical products [10-16]. The seeds are ground into a paste, also known as dika bread, which is valued for its food-thickening properties [17]. Margarine-based African mango oil may provide an alternative to trans-fatty acids obtained during hydrogenation used in oil technological applications [18]. Oral administration of an African mango methanol extract at a dose of 150 and 250 mg/kg significantly ($P < 0.0021$) lowered plasma glucose levels in diabetic rats within 2 hours after treatment. The mechanism of action may involve extract stimulation of pancreatic beta-cell function or hypoglycemic activity via an extra-pancreatic mechanism [9].

Although, manifold studies on the phytochemical composition of different Mango species have been reported in the literature, a comparative study of the biochemical components of the bark of different mango species is yet to be reported.

2. Materials and Methods

2.1. Materials

All chemicals used were of analytical grades and obtained from BDH, Labtech chemicals and used without further purification.

2.2. Methods

Samples of Mangifera indica L., Irvinga gabonensis and Mangifera indica bark were collected from Toru-Orua and Ebedebiri Communities in Sagbama Local Government Area of Bayelsa State, Nigeria and properly identified at the Biological Sciences Department of the University of Africa, Toru-Orua. Mangifera indica L bark were air dried for fourteen days and pulverized manually and electronically, and stored in a desiccator for analysis.

2.2.1. Proximate Analysis

Standard procedures as described by the Association of Official Analytical Chemists [19] were used in the determination of moisture, Fat, Ash, Crude fibre, Crude Protein and Carbohydrate Content.

2.2.2. Mineral Analysis

Standard procedures as described by the Association of Official Analytical Chemists [19] were used to determine Manganese (Mn), Iron (Fe), Calcium (Ca), Phosphorus (P) and Potassium (K).

2.2.3. Bioactive Chemicals

GC-MS analysis of methanol extract of Mangifera indica L bark was performed with GC (Agilent 6890) and MS (5973 MSD) equipped with Restek capillary column (30 m × 0.53mm; film thickness 0.12μm), using Helium as the carrier gas with a flow rate of 1 mL/min.

3. Results

Results of the various analyses carried out on the bark of Mangifera indica L., Irvinga gabonensis and Mangifera indica are presented as follows:

Table 1. *Proximate Analyses.*

Proximate Principles (%)	Mango species	Mean ± S.D
Moisture	Mangifera indica L.	59.73±01
	Irvinga gabonensis	65.07±01
	Mangifera indica	64.44±01
Ash	Mangifera indica L.	1.98±01
	Irvinga gabonensis	4.09±01
	Mangifera indica	2.03±01
Protein	Mangifera indica L.	1.93±0.1
	Irvinga gabonensis	1.30±0.1
	Mangifera indica	1.73±0.1
Fat	Mangifera indica L.	5.56±0.1
	Irvinga gabonensis	6.09±0.1
	Mangifera indica	7.12±0.1
Fibre	Mangifera indica L.	0.90±0.1
	Irvinga gabonensis	0.74±0.1
	Mangifera indica	2.50±0.1
Carbohydrate	Mangifera indica L.	29.90±0.1
	Irvinga gabonensis	22.71±0.1
	Mangifera indica	22.19±0.1

Table 2. *Mineral analysis of 3 species of mango barks per 100 grams.*

Parameters (%)	Mango Variety	Mean ± S.D
Potassium (K)	Mangifera indica L.	0.3304±0.1
	Irvinga gabonensis	0.2296±0.2
	Mangifera indica	0.2950±0.1
Iron (Fe)	Mangifera indica L.	0.0056±0.2
	Irvinga Gabonensis	0.0024±0.2
	Mangifera indica	0.0080±0.1
Manganese (Mn)	Mangifera indica L.	0.0050±0.1
	Irvinga gabonensis	0.0004±0.1
	Mangifera indica	0.0005±0.1
Calcium (Ca)	Mangifera indica L.	1.2163±0.1
	Irvinga gabonensis	1.1659±0.2
	Mangifera indica	1.0151±0.1
Phosphorus (P)	Mangifera indica L.	0.1684±0.2
	Irvinga gabonensis	0.2417±0.2
	Mangifera indica	0.1785±0.1

Table 3. *GC-MS analysis of bioactive components in the bark of Mangifera indica L. (German/Opiororo) powder.*

S/N	Retention time (Min)	Name of Bioactive compound	Molecular formula	Molecular Weight	Peak area Percent (%)
1.	1.902	Performic acid	$C_4H_{10}O_3Si$	134	89.8
2.	6.571	Fluoroacetic acid	$C_6H_9FO_4$	164	0.89
3.	7.000	Cyclohexane, 1-ethenyl-1-methyl-2-(1-methylethenyl)-4-(1-methylethylidene)-	$C_{15}H_{24}$	204	83.4
4.	7.251	Caryophyllene	$C_{15}H_{24}$	204	56.1
5.	7.314	Naphthalene, 1,2,3,4,4a,5,6,7-octahydro-4a,8-dimethyl-2-(1-methylethenyl)-	$C_{15}H_{24}$	204	67.1
6.	7.560	1,4,7,-Cycloundecatriene, 1,5,9,9-tetramethyl-, Z,Z,Z	$C_{15}H_{24}$	204	11.5
7.	8.509	Humulene	$C_{15}H_{24}$	204	12.2
8.	8.926	Naphthalene, 1,2,3,4,4a,5,6,8a-octahydro-4a,8-dimethyl-2-(1-methylethenyl)-, [2R-(2α,4aα,8aβ)]-	$C_{15}H_{24}$	204.	57.0
9.	9.280	Cyclohexanemethanol	$C_7H_{14}O$	114	89.0
10.	9.480	Aromandendrene	$C_{15}H_{24}$	204	47.4
11.	9.538	2-Naphthalenemethanol	$C_{11}H_{10}O$	158	77.0
12.	9.646	1-Naphthalenemethanol	$C_{11}H_{10}O$	158	20.2
13.	9.720	Valerena-4,7(11)-diene	$C_{15}H_{24}$	204	44.8
14.	11.178	α-Guaiene	$C_{15}H_{24}$	204	2.86
15.	11.824	(1R,4aR,7R,8aR)-7-(2-Hydroxypropan-2-yl)-1,4a-dimethyldecahydronaphthalen-1-ol	$C_{15}H_{28}O_2$	240	91.4

Table 4. *GC-MS analysis of bioactive components in the bark of Irvingia gabonensis (African bush mango) powder.*

S/N	Retention time (Min)	Name(s) of Bioactive compound	Molecular formula	Molecular Weight	Peak area Percent (%)
1.	1.908	psi.,psi.-Carotene	$C_{41}H_{58}O$	566	22.0
2.	4.417	2,7-Diphenyl-1,6-dioxopyridazino [4,5:2',3'] pyrrole[4',5'-d]pyridazine	$C_{20}H_{13}N_5O_2$	328	19.4
3.	6.103	Exo-norbornanol dimethyl(pentafluorophenyl)silyl ether	$C_{15}H_{17}F_5OSi$	426	19.7
4.	7.560	α-D-Glucofuranose 6-O-(trimethylsilyl)-, cyclic 1,2:3,5-bis(butylboronate)	$C_{17}H_{34}B_2O_6Si$	587	7.80
5.	7.749	2-Hexadecanol	$C_{16}H_{34}O$	228	14.7
6.	9.715	1-Hexadecanol-2-methyl	$C_{17}H_{36}O$	154	6.67
7.	12.132	β-Acorenol	$C_{15}H_{26}O$	334	5.54
8.	12.944	Patchoulene	$C_{15}H_{24}$	734	4.47
9.	18.196	17-Pentatriacontene	$C_{35}H_{70}$	668	7.53

Table 5. *GC-MS analysis of bioactive components in the bark of Mangifera indica (Yellow mango) powder.*

S/N	Retention time (Min)	Name of Bioactive compound	Molecular formula	Molecular Weight	Peak area Percent (%)
1.	0.656	Benzo[b]fluoranthene	$C_{20}H_{12}$	252	62.1
2.	1.896	Methane-d, trichloro	CCl_3D	119	99.0
3.	3.068	Benzo[e] pyrene	$C_{20}H_{12}$	252	63.5
4.	7.114	Benzo[k]fluoranthene	$C_{20}H_{12}$	252	13.0
5.	12.944	1,2,3-Triazol, 2-(E-4,4-dicyano-3-N-methylanilino-1,3-butadien-1-yl)-4-(methoxycarbonyl)-	$C_{17}H_{14}N_6O_2$	334	98.4
6.	13.304	2-(E-4,4-Dicyano-1-N-methylanilino-1,3-butadien-1-yl)-4-(methoxycarbonyl)-1,2,3-triazole	$C_{17}H_{14}N_6O_2$	334	0.98
7.	14.178	Cyclodecasiloxane	$C_{20}H_{60}O_{10}Si_{10}$	740	97.7
8.	15.544	Octasiloxane,1,3,3,5,5,7,7,9,9,11,11,13,13,15,15-hexadecamethyl	$C_{16}H_{50}O_7Si_8$	578	0.97
9.	16.847	28-Nor-17α(H)-hopane	$C_{29}H_{50}$	262	95.9
10.	17.407	28-Nor-17β(H)-hopane	$C_{29}H_{50}$	398	3.84

4. Discussion

Results of the various analyses carried out on the flesh and seeds of Treculia africana are presented as follows.

Table 1 shows the primary metabolites in the bark of Mangifera indica L., Irvinga gabonensis and Mangifera indica. The moisture content of the bark of Mangifera indica L., Irvinga gabonensis and Mangifera indica were 59.73%, 65.07% and 64.44% respectively. Analysis indicate that the bark of Irvinga gabonesis contains more moisture, hence will be more vulnerable to microbial contamination and high degree of perishability [20]. The moisture content of the bark of Irvinga gabonensis was lower compared to the ethanol and distilled Water Extract of the cotyledon of Irvinga gabonensis, 84.31%, 94.41% [21]. The ash contents of the bark of Mangifera indica L., Irvinga gabonensis and Mangifera indica were 1.98%, 4.09% and 2.03% indicating that the bark of Irvinga gabonesis contains higher organic matter than the barks of Mangifera indica L and Mangifera indica. The observed value of ash content in the bark of Irvinga gabonensis was significantly higher than in the ethanol extract of the cotyledon, 0.14% [21]. The protein content of the bark of Mangifera indica L., Irvinga gabonensis and Mangifera indica were 1.93%, 1.30% and 1.73% respectively. The value for Irvinga gabonensis was higher than the value of the ethanol extract of the cotyledon of Irvinga gabonensis, 0.14% [21].

The fat content of the bark of Mangifera indica L., Irvinga gabonensis and Mangifera indica were 5.56%, 6.09% and 7.12%. This result indicates that the bark of Mangifera indica contains more fat than the barks of Mangifera indica L. and Irvinga gabonensis. The fiber content of the bark of Mangifera indica L., Irvinga gabonensis and Mangifera indica were 0.90%, 0.74% and 2.50%. The bark of Mangifera indica contains about three times fiber than the barks of Mangifera indica L., Irvinga gabonensis; hence, the bark of Mangifera indica is a good source of fiber. The value observed for Irvinga gabonensis was insignificantly low compared to the amount of fibre in the seed as reported in literature [22]. The carbohydrate content of the bark of Mangifera indica L., Irvinga gabonensis and Mangifera indica were 29.90%, 22.71% and 22.19% respectively. Carbohydrate content in the bark of Irvinga gabonensis was significantly higher than the values observed in the cotyledon [21].

Table 2 presents the mineral content of the bark of Mangifera indica L., Irvinga gabonensis and Mangifera indica. The concentrations of K in the bark of Mangifera indica L., Irvinga gabonensis and Mangifera indica 0.3304%, 0.2296% and 0.2950% respectively, indicating higher potassium (K) concentration in the bark of Mangifera indica L., than in the bark of Irvinga gabonensis and Mangifera indica. The concentrations of iron (Fe) in the bark of Mangifera indica L., Irvinga gabonensis and Mangifera indica were 0.0056%, 0.0024% and 0.0080% respectively. Higher concentrations in the pulp of Mangifera indica were reported in literature [23]. The concentrations of Mn in the bark of Mangifera indica L., Irvinga gabonensis and Mangifera indica were 0.0050%, 0.0004% and 0.0005% respectively. The concentration of Mn in the bark of Mangifera indica L. was lower than the concentration in the

seed kernel [24] The concentrations of Ca in the bark of Mangifera indica L., Irvinga gabonensis and Mangifera indica were 1.2163%, 1.1659% and 1.0151% respectively. The body needs a constant supply of calcium to provide bone strength against compression [25]. The concentration of Ca in the bark of Mangifera indica L. was moderately higher than the concentration in the seed kernel [24]. The amount of P in the bark of Mangifera indica L., Irvinga gabonensis and Mangifera indica were 0.1684%, 0.2417% and 0.1785% respectively. The bark of Irvinga gabonensis has higher P concentration than the bark of Mangifera indica L. and Mangifera indica. Phosphorus is important to build strong bony structure [26]. The present comparative study confirms the fact that the bark of Mangifera indica L., Irvinga gabonensis and Mangifera indica contain minerals that are important for various body functions.

The analysis of the Gas chromatography-Mass spectrometry (GC-MS) of the methanol extracts of the bark of Mangifera indica L., Irvinga gabonensis and Mangifera indica are presented in Tables 3 – 5. The Bark of Mangifera indica L. (German/Opiororo) shows Fifteen phytochemicals with their retention time, molecular weight, molecular formular and peak area percentage, Table 3. The phytochemicals include: Performic acid, 89.8%, Cyclohexane, 1-ethenyl-1-methyl-2-(1-methylethenyl)-4-(1-methylethylidene)-, 83.4%, Caryophyllene, 56.1%, Naphthalene, 1,2,3,4,4a,5,6,7-octahydro-4a,8-dimethyl-2-(1-methylethenyl)-, 67.1, Cyclohexanemethanol, 89.0%, Aromandendrene, 47.4%, 2-Naphthalenemethanol, 77.0% and (1R,4aR,7R,8aR)-7-(2-Hydroxypropan-2-yl)-1,4a-dimethyldecahydronaphthalen-1-ol, 91.4%. The maximum peak, 91.4% was shown by 2-Naphthalenemethanol, 77.0% and (1R,4aR,7R,8aR)-7-(2-Hydroxypropan-2-yl)-1,4a-dimethyldecahydronaphthalen-1-ol and the lowest peak, 0.89% was shown by Fluoroacetic acid. The bioactive components whose peak area percentages were less than 5% were considered to be insignificant Caryophyllene is one of the chemical compounds that contribute to the sweet smell of the bark of Mangifera indica L. Caryophyllene has been given GRAS (generally regarded as safe) designation by the FDA and is approved by the FDA for use as a food additive, typically for flavoring [20].

A significant amount of Performic acid in the bark of Mangifera indica L confirms its use in folk medicine. Performic acid has proven strong bactericidal and sporicidal effect [27]. All the different phytochemicals identified from the bark of Mangifera indica L were found to possess biological properties such as anti-microbial, anti-cancer, anti-inflammatory and anti-malaria activities which corroborates the use of the bark of Mangifera indica L. in folk medicine.

Nine phytochemicals were analysed in the bark of Irvingia gabonensis (African bush mango), Table 4. These include: psi.,psi.-Carotene, 22.0%, 2,7-Diphenyl-1,6-dioxopyridazino[4,5:2',3'] pyrrole[4',5'-d]pyridazine, 19.4% and Exo-norbornanol dimethyl(pentafluorophenyl)silyl ether, 19.7%. Maximum peak (22.0%) was shown by psi.,psi.-Carotene and minimum peak (4.47%) by Patchoulene. Carotenoid pigments present in fruits and vegetables are the main dietary source of Vitamin A [28].

Ten phytochemicals were analysed from the bark of Mangifera indica (Yellow mango), Table 5. The maximum peak, 99.0% was shown by Methane-d, trichloro, 99.0% and minimum peak, 0.97% was shown by Octasiloxane, 1,3,3,5,5,7,7,9,9,11,11,13,13,15,15-hexadecamethyl. The GC-MS analyses of the bark of Mangifera indica shows bioactive components different from the bioactive components analysed from the bark of Irvingia gabonensis and Mangifera indica L. These bioactives corroborate their use in folk medicine in curing malaria, thyphoid and COVID-19.

5. Conclusion

Comparative study of the Proximate, minerals and bioactive components in methanol extract of the bark of Mangifera indica L., Irvingia gabonensis and Mangifera indica was conducted. Results indicate that the bark of Irvinga gabonensis contains more moisture, ash and fat than the bark of Mangifera indica L. and Mangifera indica. Moisture content plays a significant role in the physical appearance, shelf-life and resistance to bacterial contamination of species. Minerals result revealed that the bark of Irvinga gabonensis is richer in calcium than the bark of Mangifera indica L. and Mangifera indica. Gas chromatography-mass spectrometry (GC-MS) analysis of methanolic extract of Mangifera indica L., Irvingia gabonensis and Mangifera indica presented 15, 9 and 10 biochemicals. The bark of Mangifera indica L. contains a significant amounts of Performic acid and Caryophyllene. The bark of Irvingia gabonensis contains a moderate amount of psi.,psi.-Carotene. Methane-d, trichloro, 1,2,3-Triazol, 2-(E-4,4-dicyano-3-N-methylanilino-1,3-butadien-1-yl)-4-(methoxycarbonyl)-, cyclodecasiloxane and 28-Nor-17α(H)-hopane. GC-MS results imply that the bark of Mangifera indica L, Irvingia gabonensis and Mangifera indica contain variant bioactive components. All the analysed compounds have different biological activities justifying their use in traditional medicine for the treatment of malaria, thyphoid and COVID-19.

6. Recommendation

Extracts of mango stem bark have been used locally to cure COVID-19. This study therefore recommends isolation of the different identified bioactive compounds for medicinal and pharmacological application.

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