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Investigation of Chemical Composition and Proximate Properties of Bush Mango (*Irvingia wombulu)* Production Management and Ethno-medicinal Benefits of Rural Dwellers

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Abstract. The chemical analyses of bush mango (*Irvingia wombulu*) was conducted in order to identify the bioactive content, proximate composition as well as to establish the vitamin composition in bush mango production. The extraction processes were carried out with the aid of different solvents and techniques. The analyses was conducted with aqueous extract of the milled seed of *Irvingia wombulu* which found the bioactive components present in form of tannins, saponin, flavonoids, steroid, protiens, anthraquinnones, protein, reducing sugar, cardiac glycoside, terpenopid, phenolic compounds and alkaloids. Flavonoid, cardiac glycoside andalkaloids were moderately present (+) while tannis, saponins, steroids, protein and reducing sugar were heavily present(++). Further, the results from the analyses displayed the proximate composition in *Irvingia wombulu* leaves, peels, seeds and seed coats samples. The moisture contents in seeds, leaves, peels and seed coats of *Irvingia wombulu* were 1.4±0.41%, 22.2±0.11%, 38.7±0.01%, and 57.6±0.90% respectively. The test found that the mineral contents of *Irvingia wombulu* in the seed coats had the highest concentration of iron (0.395±0.00 mg/kg) and 0.040±0.02mg/kg was found in the seed. The trend in the level of concentration of sodium in *I. wombulu* revealed that leaves has more sodium than seeds and seeds more than seed coats, peels is the least. For calcium, the analyses revealed that the level of concentration in the seed coats had higher mineral content of 4.992±0.01 mg/kg as compared to the lower level of concentration in the seeds at 3.278±0.01 mg/kg. The analyses further showed vitamin B2 composition known riboflavin as one of the 8 -B vitamins. The value of vitamin B2 was high in *Irvingia wombolu* at 0.17mg/100g with vitamin B6 content having 0.14gm/100g. The production of these chemical components would contribute to health benefits of the rural dwellers. The high bioactive content potential and the presence of proximates, mineral content, vitamins produced at different levels in bush mango (*Irvingia wombulu*) should be utilized to develop drugs and supplements for its ethno-medicinal benefits and to generate internal revenue for the FRIN biomedical department.

Keywords: Bioactive Components, Metabolites, Phytonutrients, Vitamins, Milled Kernel, Production

1. Introduction

Irvingia wombulu (AubryLecomte ex. O'Rorke) Baill. commonly known as 'African mango' or 'bush mango' is a tree of 15–40 m, with a bole slightly buttressed. *Irvingia wombulu* has many biological potentials and some antioxidants properties when properly used (Ejiofor, 2004). *Irvingia wombulu* (Bush mango) fruit is a largely ellipsoid drupe, yellowish and having very juicy fibrous pulp when ripe.The plant is a wild forest tree with dark green foliage and yellow fragrant flowers and occurs in the wild lowland forest; two to three trees occur together and in some areas, it is reported to be widespread. *Irvingia wombulu* is largely distributed in Africa. The average length, width and thickness of the nut are (43.3×30.62×22.11) mm respectively (Abreu *et al.*, 2008). The seeds are sold round the year in all markets where food stuffs are sold in Nigeria. The

fruit comprises a fleshy part and the nut, which consists of a hard shell and the kernel/seed. Its seeds have an outer brown tester (hull) and two white cotyledons (Ekpe *et al*., 2007). It is an edible African indigenous fruit tree that produces edible fruits and seeds (Atangana *et al*., 2002).

The lipids component of irvingia gabonensis seeds have been traditionally extracted with organic solvents and more recently an enzymatic method for extracting the lipid components was developed. On the other hand, the polymeric component of the seed has been extracted from aqueous dispersion using petroleum ether or diethyl ether. The extraction, screening and identification of the medicinally active substances found in plants is referred to as phytochemical screening (Keay *et al*., 2013). Bush mango fruit is a full source of protein, ascorbic acid, potassium, carbohydrate, dietary fibre, iron, vitamin C, water, energy, sodium, amino acids, calcium, phosphorus and magnesium (Anhwange *et al*., 2004).

Irvingia wombulu contains lipids and polymer extractives that can be a good source of excipient for oral pharmaceutical formulations. The seeds of bush mango constitute an important part of the rural diet in Nigeria. The sun-dried seeds are ground into flour and used as soup thickeners (Ekpe *et al*., 2007). The white cotyledons are roasted and eaten in the Bwemba community of Uganda; roasted seeds confer flavour and aroma on foods especially vegetables (Alonge and Idung, 2015). It is understood that there might be about 4,000 phytochemicals confined in the fruit can be used in preventing, minimizing and also remedy for medical conditions such as metabolic syndrome, strokes, or cancer. From previous results obtained by scientific researchers have establish that the use of phytochemical supplements supports longterm healthy living as well as consuming the actual fruits, grains and vegetables from which they were taken (Farasat *et al*., 2014).

In addition to its nutritional and economic benefits, *I. wombulu* is highly valued for its health and medicinal benefits (Ndoye *et al*., 1997) and agricultural potentials. Past studies have shown that seed extract of *I. wombulu* caused a significant reduction in body weight among obese people in Cameroon (Onakpoya *et al*., 2013). Similarly, earlier studies have shown that consumption of fruits and vegetables reduce the risk of diseases such as cancer, cardiovascular disease, cataracts, and brain and immune dysfunction (Boakye *et al*., 2015). This positive influence of fruits in human health is attributed to natural antioxidant phytochemicals inherent in them (Venket Rao *et al*., 2013). Interestingly, Matsinkou *et al*. (2012) showed that *I. wombulu* seeds possess antioxidant phytochemicals. Phytochemicals such as alkaloids, saponins and tannins have been shown to be very important in agriculture; known to protect plants against microorganisms, and also possess allelopathic properties (Matsinkou *et al*., 2012; Boakye *et al*., 2015).

1.1 Problem Statement

Bush mango (*Irvingia wombulu*) is a fruit found in many homes in Nigeria for domestic consumption and the processed kernel is locally called “Ogbono”. *Irvingia wombulu* is a common fruit in most families in Nigeria and its processed kernel has become everyday recipe for soup preparation. The rate at which ogbono is consumed beats imagination and many consumers from interactions had submitted that it has health benenfits. Notwithstanding the majority of consumers are not aware of its benefits but believe that it is palatable and has organoleptic acceptance for consumption. However, the submissions have not been validated scientifically because most domestic end users could not pin-point the main benefits derived from the consumption of the fruit in terms of its nutrients and minerals composition. This dearth of studies on the nutritional, medicinal and agricultural potentials of the mesocarp may have been fueled by the general attitude of rural people. Although local people who harvest the fruits sometimes eat the fresh fruits (Atangana *et al*., 2002), however, the common practice among the majority is to split the fruit for its kernel while the fleshy mesocarp is thrown away and left to rot (Ayuk *et al*., 1999). Therefore, this study was necessitated and poised to investigate the chemical composition and proximate analyses of the bush mango (*Irvingia wombulu*). The specific objectives were to investigate the bio-active content of bush mango (*Irvingia wombulu*), determine the proximate composition of bush mango (*Irvingia wombulu*) a*nd* investigate the vitamin composition in bush mango (*Irvingia wombulu)* production management and ethno-medicinal benefits of rural dwellers .

2. Materials and Methods

2.1 Study Area

The investigation was carried out at the Federal College of Forestry Ibadan. Ibadan is located in the South-western Nigeria. It lies within the latitude 7º19´08´´and 7º29´25´´north of the equator and longitude 3º47´50´´and 4º0´20´´. The city covers a total land area of 3,080 square kilometres (1,190 square miles). It is the third most populous city in

Nigeria after Lagos and Kano respectively. The total population of the city as estimated in the year 2021was over 6 million people. The study area is located in the rainforest vegetation of South West Nigeria with a mean rainfall of about 1300/1500mm and average relative humidity of about 80-85% (FRIN, 2013).

2.2 Collection of Sample

Fresh *Irvingia wombulu* seed (Ogbono) were bought from the market in Ibadan, Oyo State. The leaves were also collected from the botanical garden at the Forestry Research Institute of Nigeria, Ibadan.The leaves and the fresh seeds were immediately taken to the biotechnology laboratory of the National Horticultural Research Institute for proper authentication and identification by the Principal Scientist in Organic Chemistry who conducted the comparative analyses with the voucher specimen present in Herbarium of the Institute.

2.3 Preparation for Extract A

Substantial quantity of fresh *Irvingia wombulu* seed was collected, thoroughly washed with clean water separately accordingly, based on how they were collected. They were oven dried until a constant weight was achieved then was spread out on laboratory bench for inspection. They were then grounded using electric blender to fine powder and passed through a 24 mesh sieve. 100g of the sample was weighed using a rough mechanical beam balance and allowed to air dry 24 hours at room temperature.

2.4 Extraction of Plant Material

The powdered sample (100g) of *Irvingia wombulu* was successfully extracted with 500ml of distilled water, using magnetic stirrer and stirred for 3 hours. Then it was filtered using Whatmann filter paper. Again, the residue was dissolved with 100ml of distilled water and stirred for 2 hours. The solvent containing the extract is dried under reduced pressure. The supernatant was boiled up to minimum volume. The extract obtained was kept in sterile sample tube and store.

2.5 Methods of chemical Screening

The freshly and dried prepared crude extract was quantitatively tested for the presence of biochemical constituent, phytonutrient screening and antioxidant properties of aqueous of dried and fresh *Irvingia wombulu*. The chemical screening of the extract of the seed of *Irving wombulu* showed the presence of numerous secondary metabolites of which flavonoid, cardiac glycoside and alkaloids are moderately present while tannis, saponins, steroids, protein and reducing sugar were heavily present, the phytochemical screening of seeds of *Irvingia wombulu*, which revealed the presence of alkaloids, flavonoids, tannins, terpenoids and anthraquinones in the extract.

2.6 Test for Tannins

To 1 ml of the extract, equal volume of bromine water was added. The formation of a greenish to red precipitate was taken as the presence of tannins.

2.7 Test for Saponins

1 ml of the extract was boiled with 5 mls of distilled water for 5 minutes and decanted while hot. 4 mls of distilled water was added to 1 ml of the filtrate before it was shaken vigorously for observation of stable froth on standing.

2.8 Test for Flavonoids

0.5 g of the extract was added, in a test tube and 10 mls of distilled water, 5 mls of dilute ammonia solution were added to a portion of the aqueous filtrate of the extract followed by addition of 1 ml concentrated H_2SO_4. Indication of yellow color shows the presence of flavonoid in each extract.

2.9 Test for Alkaloids

1 ml each of the extract was shaken with 5 mls of 2% HCl on a steam bath and then filtered. To 1 ml of the filtrate, Wagner`s reagent (iodine in potassium – iodide solution) was added and reddish brown precipitates was observed for positive result.

2.10 Test for Steroids

Half (0.5 g) gram of the extract was dissolved in 10 mls anhydrous chloroform and filtered. The filtrate was divided into two equal portions for the following tests. The first portion of the solution above was mixed with one mL of acetic anhydride followed by the addition of 1 ml of concentrated sulphuric acid down the side of the test tube to form a layer underneath. The test tube was observed for green colouration as indicative of steroids.

2.11 Test for Terpernoids

1 gram of seed sample was shaken in a test tube with 10 mls of methanol, and then filtered. 5 mls extract

was then mixed with 2 mls of chloroform and 3 mls of sulphuric acid was added. Formation of reddish brown color indicates the presence of terpenoids in the selected plants.

2.12 Cardiac Glycosides

One mL of the seed extract was dissolved in 2 mls of chloroform in a test tube. 1 ml concentrated H_2SO_4 was carefully added to the test tubes through the side and was observed for a red or reddish brown colouration at the interphase, which indicates positive result.

2.13 Test for Phlobatannins

1 percent aqueous hydrochloric acid was added to the seed extract in a test tube (about 2 mls), and then boiled with the help of Hot plate stirrer. Formation of red coloured precipitate confirmed a positive result.
Test for Phenolic Compounds
To 2 mls of the seed extract, 1% $FeCl_3$ was added and observation was made for blue, violet, purple, green or red-brown colour.

2.14 Test for Protein

Five drops of 1% hydrated copper sulphate was added to 2 ml the seed extract in a test tubes. Two mL of 40% NaOH was also added, and the test tube was shaken vigorously to mix the content and presence of purple colouration indicated the presence of proteins.

2.15 Test for Reducing Sugars

1 ml of ethanol was mixed with 2 mls each of the plant extract, after which 1 ml each of Fehling solution A and B were added to the test tubes. The test tubes were heated to boiling while observation was made for presence of reddish brown colouration which indicates positive results.

2.16 Test for Anthroquinones

1 gram of the seed extract was placed in a dry test tube and 20 mls of chloroform was added. This was heated in steam bath for 5 min. The extract was filtered while hot and allowed to cool. To the filtrate was added with an equal volume of 10% ammonia solution. This was shaken and the upper aqueous layer was observed for bright pink colouration, which for the presence of anthraquinones. This was repeated with all the plant samples.

2.17 Preparation of Aqueous Extract

10 gram of the milled seeds was extracted by maceration in 50 mls of water for 3 days with frequent agitation at a speed of 280 rpm at 28°C in dark. Between extractions, the sample was centrifuged for 10 min with 2000 rpm. The combined supernatants were collected, filtered through Whatman No. 1 filter paper and concentrated in vacuum. It was kept in a vacuum desiccator for complete removal of solvent. The yield extract was thus used for some of chemical screening, GCMS analysis and assessment of antioxidant activity.

2.18 Aqueous Extract of Seed of *Irvingia wombulu*

Aqueous extract of seed of Irving wombulu showed the presence of the various chemicals; saponin, flavonoids, steroid, protiens, anthraquinnones, tannins, protein, reducing sugar, cardiac glycoside, terpenopid, phenolic compounds and alkaloids. The presence of flavonoid, cardiac glycoside andalkaloids are moderately present while tannis, saponins, steroids, protein and reducing sugar were heavily present. These bioactive components are naturally occurring in *Irvingia wombulu* and known to possess interesting biological activities.

2.19 Proximate Analysis

Samples were analyzed for percentage moisture, ash, crude lipid, crude protein, carbohydrates and crude fiber using AOAC 2016 methods. Moisture was determined by drying to constant weight while protein was determined using Kjeldahl method. Ash content was determined with Loss-on-Ignition method.

3. Results and Discussion

Table 1 reveals that the concentrations of the various bioactive components of milled bush mango (*Irvingia wombulu*) production. The implication of the signs revealed the various concentration levels of the bioactive ingredients present through chemical analyses of the *Irvingia wombulu* for ethno-medicinal benefits in the study area. The sign (++) shows high concentration; and (+) moderate concentration of bioactive ingredients while (-) shows absence of active ingredients for the ethno-medicinal parameters of *Irvingia wombulu* analysed.

Tannins: The milled seed of bush mango (*Irvingia* species) had high concentration of (++) of tannins which implies a very strong bio-active component of the phytonutrient available in *I. wombulu*.

Saponins: The milled seed of the *Irvingia* species had high concentration of (++) of saponnins which indicates a very strong bio-active component of the phytonutrient available in *I. wombulu*.

Flavonoids(antioxidant): The milled seed of the *Irvingia* species had moderate concentration of (+) of flavonoids which implies average bio-active component of the phytonutrient available in *I. wombulu*.

Alkaloids: The milled seed of the *Irvingia* species had moderate concentration of (+) of alkaloids which implies average bio-active component of the phytonutrient available in *I. wombulu*.

Steroids: The milled seed of the *Irvingia* species had high concentration of (++) of steroids which implies very strong bio-active component of the phytonutrient available in *I. wombulu*.

Terpernoids: The milled seed of the *Irvingia* species had no concentration of (-) of terpernoids which implies absence of bio-active component of the phytonutrient available in *I. wombulu*.

Cariac glycosides: The milled seed of the *Irvingia* species had moderate concentration of (+) of cariac glycosides which implies average bio-active component of the phytonutrient available in *I. wombulu*.

Phlobatannins: The milled seed of the *Irvingia* species had moderate concentration of (+) of phlobatannins which implies average bio-active component of the phytonutrient available in *I. wombulu*.

Phenolic compounds: The milled seed of the *Irvingia* species had no concentration of (-) of phenolic which implies absence of bio-active component of the phytonutrient available in *I. wombulu*.

Proteins: The milled seed of the *Irvingia* species had high concentration of (++) of protein which implies very strong bio-active component of the phytonutrient available in *I. wombulu*.

Reducing sugar: The milled seed of the *Irvingia* species had moderate concentration of (+) of reducing sugar which implies average bio-active component of the phytonutrient available in *I. wombulu*.

Anthroquinones: The milled seed of the *Irvingia* species had no concentration of (-) of anthroquinones which implies absence of bio-active component of the phytonutrient available in *I. wombulu.*

Table 1: Qualitative Phytonutrients Screening of Bioactive Components in *Irvingia wombulu*

Parameters	Milled Bush Mango (*Irvingia wombulu*)
Tannins	++
Saponins	++
Flavonoids	+
Alkaloids	+
Steroids	++
Terpernoids	–
Cariac glycosides	+
Phlobatannins	+
Phenolic compounds	–
Proteins	++
Reducing sugars	+
Anthroquinones	–

Note: ++: Phytonutrients present in high concentration; +: phytonutrients present in moderate concentration; -: phytonutrients absence

Field Survey, 2023

Table 1.2 shows the *I. wombolu* leaves, seeds, peels and seed coats. The results revealed the presence of alkaloids, tannins, flavonoids, terpenoids, steroids, saponins and glycosides in all the specimens of *Irvingia wombulu* in varying quantities. These compounds are known to be biologically active and therefore aid in the antimicrobial activities. Chemicals like alkaloids, flavonoids, terpenoids, steroids, saponins are present in both extracts (aqueous and methanolic) of the *Irvingia wombulu* analyzed. There are flavonoid units with several degrees of condensation. The flavonoid pigments are water soluble. According to Etukudo *et al.* (2015) bush mangoes possess antioxidants which helps to reduce menopausal symptoms, osteoporosis, increased blood flow and oxygenation of the cells and tissue. Flavonoids provide beneficial effects on capillaries and absorb oxygen radicals that cause skin

oxidation through their antioxidant properties. Flavonoids in general help to reverse age related declines in cognitive function (brain function) by increasing the number of connections among neurons which could help prevent and treat a variety of neurogenerative disorder (Williams & Spencer, 2012).

Furthermore, the experiment from the aqueous extract of the milled seed of *Irvingia wombulu* revealed the presence of the various chemicals; tannins, saponin, flavonoids, steroid, protiens, anthraquinnones, protein, reducing sugar, cardiac glycoside, terpenopid, phenolic compounds and alkaloids. The presence of flavonoid, cardiac glycoside andalkaloids are moderately present while tannis, saponins, steroids, protein and reducing sugar were heavily present. These bioactive components are naturally occurring in *Irvingia wombulu* and known to possess interesting biological activities. Many research material posited a diet rich in fruit and vegetables with an important role in decimating diseases occurrences. Thus some of these preventive actions have been related to the presence of bioactive substances such as polyphenols. Flavonoids are characterized by a common benzopyrene ring structure (Havsteen, 2002). The bio-importance of flavonoids, apart from its antioxidant properties arefree radicals, defense against allergies, hepatoxins, platelet aggregation, inflammation, microbes, ulcers, viruses and tumors. Flavonoids are of great interest in the reduction of cancer by interfering with the enzymes that produce estrogen (Williams *et al*., 2005). The chemical screening of the extract of the milled seed of *Irvingia wombulu* showed the presence of numerous secondary metabolites of which flavonoid, cardiac glycoside and alkaloids are moderately present while tannis, saponins, steroids, protein and reducing sugar were present in high concentrate as shown in Table 1.2. In addition, the result corroborates the findings of Srivastava *et al.* (2011), on the phytochemical screening of milled seeds of *Irvingia gabonensis*, which revealed the presence of alkaloids, flavonoids, tannins, terpenoids and anthraquinones in the extract. Tiwari *et al*. (2009) reported that the availability of tannis, saponins, steriods, alkaloids and flavonoids are present more in seed oil and it has an effective antioxidant and radical scavenging activity. Several studies have reported a close relationship between total phenolic content and high antioxidant activity (Havsteen, 2002). However, some researchers also examined the seed plants and the relationship between antioxidant activity and polyphenol content. Polyphenol compounds are reported to be a good source of natural antioxidants (Abreu *et al.,* 2008). This revealed that plant phenols represent one of the major bioactive compounds acting as primary antioxidants or free radical terminators. Therefore, it was important to determine the total amount of bioactive compounds in *Irvingia wombulu* extracts (Altemimi *et al.,* 2017).

More so, the natural antioxidants mainly come from plants in the form of phenolic compounds such as flavonoid, phenolic acids, tocopherols etc. (Altemimi *et al*., 2017). Flavonoids are hydroxylated phenolic substances known to be synthesized by plants in response to microbial infection and they have been found to be antimicrobial substances against wide array of microorganisms in vitro and they are also very effective antioxidant showing strong anticancer activities (Lawal *et al.,* 2007). The phenolic compounds are one of the largest and most ubiquitous groups of plant metabolites (Mamari, 2021). Also, Mamari, (2021) elucidated that the antioxidant properties of medicinal plants are rich in phenolic compounds. Therefore, the results of the bioactive components in *Irvingia wombulu* indicate that it has a varied antioxidant concentrates from high to moderate beneficial ethno-medicinally and adequate for human consumption.

Table 1.2: Results for Phytochemical Screening of *Irvingia wombulu* Aqueous Extract (AE) and Methanolic Extract (ME)

		Leaves		Seeds		Peels		Seed coats	
Parameters	Tests	AE	ME	AE	ME	AE	ME	AE	ME
Alkaloids	Wagner's test	+	+	+	+	+	+	+	+
	Meyer's test	++	+	+	+	+	+	+	+
Flavonoids	Ferric chloride test	++	+	+	+	+	+	+	+
	10%Lead acetate test	+	+	+	-	++	+	+	+
Tannins	5%Lead acetate test	+	+	+	+	-	+	-	-
	HCl tes	+	+	-	-	-	+	-	-
Cardiac glycosides	Keller Killiani	++	-	-	+	+	+	+	++
Terpenoids	Salkowski	+	+	+	+	+	-	+	+
Saponins	Water	+	-	+	+	++	++	++	+
	Olive oil	+	+	+	+	++	++	++	+
Steroids	Salkowski					++	-	+	+

Note: - chemical not detected, + moderate intensity of precipitate/colour indicating presence of chemical and ++ high intensity of precipitate/colour indicating presence of chemicals in *Irvingia wombulu*

Table 2 shows the proximate composition in *Irvingia wombulu* leaves, peels, seeds and seed coats samples. The moisture contents in seeds, leaves, peels and seed coats of *Irvingia wombulu* were 1.4±0.41%, 22.2±0.11%, 38.7±0.01%, and 57.6±0.90% respectively. *Irvingia wombulu* has a higher moisture content. High moisture content in fruits is an index of its water activity which is a measure of stability and susceptibility to microbial contamination (Brooker *et al.* 2000). The ash contents in peels and seed coats of *I. wombulu* were 0.75±0.11% and 6.8±0.12% respectively. The leaves and seed coats had the same ash contents of 2.4±0.12%. Ash content of *Irvingia wombulu* in this study was higher compared to the submission of Ekundayo *et al.* (2003) where ash content ranged from 3.30% to 2.43% and that of Adeyeye *et al.* (2013) with ash content of 2.4% and 2.5% in *I. wombulu* and also related to the work of Efosa *et al*. (2017). The ash content in fruit is the inorganic residue left after the removal of moisture and organic matter. It provides the measure of the total amount of minerals within the fruit. The proximate analyses from this study revealed higher ash contents in the peels and seed coats of *I. wombulu*. The bush mangoes showed higher value of crude fat. This indicates high presence of dietary fat which is a major source of energy. However, the daily recommended value of not more than 30 calories should not be exceeded to avoid obesity, diabetes and heart diseases. Crude fiber contains indigestible cellulose which helps to absorb water, provide roughage and better functioning of the alimentary system. Protein contents contribute positively to the requirement for biomolecules needed for repair and maintenance of the body tissues as well as synthesis of vital hormones for the body (Soetan *et al.,* 2010; Gatar *et al.,* 2011). The seed of *I. wombulu* had the highest carbohydrates content. Therefore, when it is consumed, a lot of energy is acquired.

Table 2: Proximate Composition of Bush Mangoes (*Irvingia wombulu*)

Percentage (%)	**Leaves**	**Peels**	**Seed**	**Seed coat**
Moisture	22.2±0.11	38.7±0.0	1.4±0.11	57.6±0.10
Ash	2.4±0.12	0.75±0.11	6.8±0.12	2.4±0.12
Crude lipid	2.1±0.01	1.6±0.12	7.9±0.01	1.59±0.12
Crude fibre	11.8±0.02	19±0.21	21.6±0.45	16.7±0.12
Crude protein	98±0.11	7.7±0.12	5.6±0.20	6.65±0.11

Field Survey, 2023

The results in Table 3 shows the mineral contents of *Irvingia wombulu* leaves, peels, seeds and seed coats. The highest concentration of iron in *I. wombulu* was found in seed coats (0.395±0.00 mg/kg) and 0.040±0.02mg/kg was found in the seed. Thus *I. wombulu* has a higher concentration of iron in the seed than in the peels and the leaves. This indicates the reason for consumption preference of its fruits than other parts. The concentration of sodium in *Irvingia wombulu* reveals variability from one part to another. The trend in the level of concentration of sodium in *I. wombulu* reveals that leaves has more sodium than seeds and seeds more than seed coats, peels is the least. For calcium, the analyses reveals that the level of concentration in the seed coats has higher mineral content of 4.992±0.01 mg/kg as compared to the lower level of concentration in the seeds at 3.278±0.01 mg/kg in *I. wombulu.* Past studies revealed that iron had highest concentration in the seed coats (0.395±0.00 mg/kg) while the lowest was found in the seeds (0.040±0.00 mg/kg). The same trend was observed in *I. wombolu* seed coats (0.565±0.01 mg/kg) and seeds (0.304±0.00 m/kg). I. wombolu had a higher concentration of iron. The level of iron in this study contradicts the submission of Ujowundu *et al*. (2010) that found low iron (Fe) in the seeds of Dacryodes edulis but corroborates Ibrahim *et al*. (2017). Therefore, bush mango could be recommended for eating due to its high iron content. Furthermore, *I. wombolu* contained higher concentration of sodium. The trend in the level of concentration of sodium in I. wombolu was higher in peels more than seed coats, seed coats more than leaves, and leaves more than seeds. For calcium, the level of concentration was higher in the seed coats (4.912±0.01 mg/kg) and lower in the seeds (3.278±0.01 mg/kg), while the highest concentration was in the seeds (6.373±0.01 mg/kg) and the lowest concentration was in the seed coats (3.772±0.02 mg/kg). The level of calcium in the study agreed with the findings of Ujowundu *et al*. (2010). For most of the minerals determined, *I. wombolu* had the lower concentrations in this study than what was obtained in the past. The result of the mineral concentration in this study was lower when compared with the findings of Adeyeye which had sodium (26.2 mg/kg), calcium (35.1mg/kg) and zinc (6.20 mg/kg). This outcome might be as a result of post harvest handling of bush mangoes.

Table 3: Mineral composition of Bush mangoes (*Irvingia wombulu*)

Mineral composition (mg/kg)	Leaves	Peels	Seed	Seed coat
Iron	0.280±0.02	0.237±0.01	0.040±0.02	0.395±0.00
Magnesium	41.138±0.00	4.911±0.01	27.944±0.02	4.176±0.01
Zinc	3.829±0.02	2.984±0.01	2.937±0.02	3.466±0.01
Sodium	8.977±0.02	5.263±0.01	7.297±0.02	5.372±0.02
Calcium	4.222±0.02	3.928±0.01	3.278±0.01	4.992±0.01

Field Survey, 2023

The results in Table 4 reveal the vitamins composition in *Irvingia wombolu* cotyledon. The vitamin B2 known riboflavin is one of the 8 -B vitamins. All the B vitamins help the body to convert carbohydrate into glucose, which invariably helps in producing energy needed by human body. Also, it is often referred to as B-complex vitamins which help the body to metabolize fats and protein. They are necessary for a healthy liver, skin, hair eye and proper functioning of the nervous system. Riboflavin works as an antioxidant, fights damage particles in the body known as free radical. It is also needed to help the body change vitamin B6 and folate into forms it can be used. In addition, it is important red blood cell production. The value of vitamin B2 is high in *Irvingia wombolu* (0.17mg/100g). Past studies suggested that riboflavin might help prevent cataracts damage to the lens of the eye, B2 along with other nutrients is important for normal vision. It is important for cardiovascular, digestive, immune, muscular, and nervous system function. Furthermore, the analyses reveals the vitamin B6 content in *Irvingia wombolu* (0.14gm/100g). The B6 vitamin is needed for proper developing and function and to make the hormones serotonin and norepinephrine, which affect mood of men. It is also important in helping regulate your internal clock values and the indigestible cellulose that may absorb water and provide roughage for better functioning of the alimentary system as well as combine with intestinal cholesterol for excretion in the faeces as reported by Adeseko *et al.* (2022). It has been reported that intake of dietary fibre can lower cholesterol level, risk of coronary heart disease, hypertension, diabetes and breast cancer (Adegoke *et al*., 2006).

Table 4: Vitamins composition of Dry Ogbono (*Irvingia wombolu*)

Parameter content	*Irvingia wombolu*		
	Sample	Sample	Mean±SD
B-ca1rotene (ppm)	11.3	6.7	8.98±3.22
Vitamin B2(mg/100g)	0.17	0.1	0.16±0.02
Vitamin B6(mg/100g)	0.18	0.1	0.14±0.06

Field Survey, 2023

4. Conclusion

In summary, this study revealed the bioactive components of *Irvingia wombulu* production which are the antioxidants through the chemical screening and these bioactive components are metabolites such as tannins, saponin, flavonoids, steroid, protiens, anthraquinnones, protein, reducing sugar, cardiac glycoside, terpenopid, phenolic compounds and alkaloids. The presence of flavonoid, cardiac glycoside andalkaloids are moderately present while tannis, saponins, steroids, protein and reducing sugar were heavily present. The results obtained revealed that *Irvingia wombulu* contain high to moderate bioactive components.Furthermore, the analyses revealed that the proximate compositions of *Irvingia wombulu* leaves, peels, seeds and seed coats samples contain varied moisture contents, ash, crude lipid, crude fibre and crude protein, and this translate to high concentration of dietary composition which is a major source of energy, effective functionality of human bowel system, and repair and maintenance of the body tissues as well as synthesis of vital hormones for the body. The results of the analyses and calculations showed that *I. wombolu* were good sources of fat, protein, fibre and carbohydrate, essential minerals, and moderate source of vitamins. The study showed that the samples contained nutritionally valuable mineral and useful quantities of vitamins. Finally, the analyses of *Irvingia wombulu* showed higher antioxidant activity that qualify the fruit in helping lowering the risk of oxidative stress related diseases like cardiovascular illness, stroke, aging and so on.

5. Recommendations

Based on the findings, this research study recommends that bush mango (*Irvingia wombulu*) should be consumed widely by many especially

people that are obese. The biomedical department of Forestry Research Institute of Nigeria (FRIN) should transform the *Irvingia wombulu* fruits into more refined products as drugs and supplements for wildspread distribution and use nationally and internationally to generate internal revenue for the FRIN biomedical department. Also, efforts should be geared towards wide production and conservation of existing *Irvingia wombulu*, and patents for pills produced from *I. wombulu*. Finally, more concerted efforts should be put forward through serious awareness and advocacy in reassurance of its utilization and domestication among the various stakeholders and the end users.

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