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ORIGINAL RESEARCH PAPER

Proximate, vitamin and GC-MS profiling of *Kigelia africana* fruit powder

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Abstract: Phytochemicals come from plants and are generally recognized as safe which make them good candidates to be used as feed additives in livestock production. These compounds are non-toxic, effective, environmentally friendly and it performs several biological activities viz: antimicrobial, antifungal, antioxidant, immune-stimulatory, hepato-protective, antiviral amongst others. This study was carried out to examine the proximate, vitamin and bioactive profiling of *Kigelia africana* fruit powder. Results on proximate of the sample revealed the presence of moisture 10.33%, dry matter 89.67%, crude protein 7.98%, crude fibre 2.71%, ether extract 2.10%, ash 5.49% and carbohydrate 72.06%. Vitamin composition of *Kigelia africana* fruit powder showed that it contained vitamin A 4.24 iu/100 g, vitamin B1 82.9 mg100 g, vitamin B2 25.1 µg/100 g, vitamin B3 49.6 µg/100 g, vitamin B6 143.1 µg/100 g, vitamin B9 6.70 µg/100 g, vitamin B12 3.90 µg/100 g, vitamin C 5.86 µg/100 g, vitamin D 124.4 iu/100 g, vitamin E 44.2 mg/100 g and vitamin K 39.2 iu/100 g. Bioactive profiling by GC/MS revealed the presence of 19 compounds. These compounds have different therapeutic properties with 2-Dimethylsilyloxytetradecane 27.42% as a major compound followed by 3,7-dimethyl- Pentaerythritol 22.08%, 9-Octadecenoic acid 14.84%, Cyclopropaneoctanal 12.60%, Allyl fluoride 4.50%, 2-hydroxy-Propanenitrile 3.80%, 9-Octadecenoic acid 3.60%, 2-octyl- 6-Octadecenoic acid 2.48%, 2- Chloropropionic acid 2.42%, 1-Tricosene 2.19%, 13-Octadecenal 1.28%, Dimethyl Urethane 1.19%, 2,2-dimethyl-Cyclohexanol 0.57%, 1-Butanol, 3-methyl-, acetate 0.40%, Hexanoic acid 0.30%, 2-Chloroethyl 1-propynyl sulfoxide 0.12%, 10-Azido-1-decanethiol Cyclopentaneundecanoic acid 0.10%, Isopropylcyclobutane 0.10% and Cyclopentaneundecanoic acid 0.01%. It was concluded that *Kigelia africana* fruit powder is loaded with several nutrient and could be used as a natural alternative to antibiotics in animal production.

Keywords: *Kigella africana* fruit; phytochemicals; proximate; vitamins; chemicals.

1. Introduction

Medicinal plants have been and continue to be valuable natural treasures, providing an important source of nutrients and therapeutic agents (Singh et al., 2022). Plants have the ability to produce a wide variety of chemical substances that are eco-friendly, safe and effective (Shittu; Alagbe, 2020). These chemicals are divided into primary and secondary metabolites. Primary metabolites such as sugar and fats are found in all plants, but secondary metabolites are produced in a small range of plants that have specific functions (Shittu; Alagbe, 2020). Secondary metabolites are recognized for their medicinal value, and they are very interesting and powerful natural products due to the presence of phytochemicals (Edeoga et al., 2005).

Today, they are widely used as antibacterial, anticancer, antidiabetic, anti-inflammatory, antimicrobial, antioxidant, blood pressure regulator, and sedative drugs, amongst others (Mangrove et al., 2014).

Kigelia africana is an evergreen deciduous tree belonging to the family Bignoniaceae which is widely distributed in many parts of Africa, including South, Central, and West Africa (Bello et al, 2016). The tree can grow up to o 25 m in height and has a dense, rounded crown.

The bark is gray and peels off in older trees (Imran et al., 2021; Agyare et al, 2013). There are called different names in different parts of Africa, for instance, Muratina (Kikuyu, Kenya); Worsboom (Afrikaans, South Africa); Jago (Luo, Uganda); Nufuten, Nufutsen (Twi, Ghana); Mvongonya (Swahili, Southeast Africa); Orora, and Uyan (Yoruba, Nigeria) (Bello et al., 2016).

The fruits are large grey-green and sausage-like, about 30-60 cm long, and hang on stalks from the tree. Each fruit can weigh above 5 kg while the leaves are opposite or whorled, and pinnately compound up to 60 cm long (Oyelami et al., 2012). The leaves, roots and stem bark of the plants are rich in several phytochemicals and are generally used for the treatment of genital infections, gynecological disorders, renal ailments, fainting, epilepsy, rheumatism, sickle-cell anemia, psoriasis, eczema and fever (Bharti et al., 2006).

Previous studies have shown that *K. africana* fruit methanolic and ethanolic extract contains some essential minerals such as; Calcium, Phosphorus, Manganese, Zinc, Iron and Copper at significant quantities, all necessary for the activities of enzymes in the body (Oseni; Williams, 2018). The same author reported that *K. africana* fruit contained moisture (9.70%), crude protein (16.31%), crude fibre (21.09%), ash (7.57%) and carbohydrate (36.10%).

Conversely, Chivandi et al. (2011) recorded a crude protein of 11.06 %, carbohydrate (45.16%), crude fibre (12.33%) and ash (8.77%). These inconsistencies in result suggests that the chemical composition in *K. africana* fruit can be influenced by climate, location, harvest stage and storage conditions (Jan, 2020).

Therefore, this study was carried out to investigate the proximate, vitamin and GC-MS profiling of *Kigelia africana* fruit powder.

2. Material and Methods

2.1 Site of the experiment

The study was carried out at the laboratory Unit of the Department of Animal Nutrition and Biotechnology, Ladoke Akintola University of Technology Ogbomoso, Oyo State, located in the derived savannah area, latitude (8o 08'N) and latitude (4o 15'E) at an altitude of 347 meters (Ojediran et al., 2021).

2.2 Source, collection and processing of Kigelia africana fruit powder

Fresh *K. africana* fruit was harvested from within Ladoke Akintola University Teaching and Research Farm, Ogbomoso and transferred to the Department of Biological Sciences of the same institution where it was identified and authenticated by a certified taxonomist and assigned a voucher specimen number TT/008A/2023. Harvested fruit was sliced into smaller fractions and air dried for 14 days until a constant weight was obtained. Dried fruit was milled with an electrical blender into powder, kept in a labeled air tight polythene bag and taken to the laboratory for further examination.

2.3 Proximate analysis of Kigelia africana powder

Proximate analysis of *K. africana* powder was carried out using Foss automated near infra-red analyzer (NIRSTM Model DS2500F, Netherlands). 100 g of *K. africana* powder is passed through the entry tray of the machine, parameters to be examined are selected on the visual display unit before pressing the 'compute bottom' before results were displayed in 60 s. To ensure exceptional accuracy the machine was adjusted at a wave length of 850 to 2500 nm, optical band length of 8.75 nm and spectral resolution of 0.5 nm.

2.4 Bioactive profiling of Kigelia africana powder using gas chromatography-mass spectrometry

Characterization of bioactive compounds in *K. africana* powder was carried out using Photolab® 7000 series UV-*Vis* spectrophotometer with a photometric accuracy of -0.003 E for E < 0.600; 0.5% of values for 0.600 < E < 2.000 and coupled with a monochrometer with grating and step motor reference beam and tungsten halogen to be able to scan at a speed of 700 – 2000 nm/minutes, wavelength accuracy (± 1nm/0.5 nm) with 16 mm round, 10 mm, 20 mm, 50 mm rectangular cuvette with automatic detection. Result interpretation is aided by PC software photolab®, data spectral plus photolab®, colour, field case, checking tools for AQA.

2.5 Analysis of vitamin components in Kigelia africana powder

Analysis of fat and water soluble vitamins in *Kigelia africana* powder was carried out using high performance liquid chromatograph vitamin analyzer (HPLC, model – YL 9100+, Korea). 2 g of *K. africana* powder is passed through the plastic inlet of the machine, dilution and calibration are done by adhering strictly to the

manufacturers' recommendation.

The equipment has the following technical specifications; Maximum flow rate: 10 mL/min^{-1} per channel, Internal volume per channel: 925 µL per channel, Solvent contact materials: Teflon AF, PEEK and Glass-filled PTFE Quaternary Pump, Flow range: 0.001-10 ml/min, Flow rate accuracy: ≤ ± 1% at 1 mL/min^{-1}, Flow rate precision: < 0.1% RSD at 1 mL/min^{-1}, Number of eluent lines: 4, Pressure pulsation: ≤ ± 0.5 % at 1 mL/min^{-1}.

Wavelength accuracy: ± 1 nm, Wavelength precision: ± 0.1 nm, Linearity: > 99.5% at 2.5 AU (Acetone, 254 nm, Noise level: < ± 0.35 X 10-5 AU, 254 nm, dry cell, Drift: < 1 X 10-4 AU/hour, Temperature range: 4 °C (Cooling) - 90 °C, Temperature stability: ± 0.05 °C, Temperature accuracy: ± 0.5°C, with 2-point temp. calibration, Temperature programs : 40 Steps, Column capacity: three columns up to 300 mm length (max OD: up to 18mm).

2.6 Statistical analysis

The analysis was carried out in triplicates and the data obtained were expressed as standard error of the mean (mean ± SEM).

3. Results

As revealed in Table 1, proximate composition of *Kigelia africana* fruit powder contained moisture 10%, dry matter, crude protein, crude fibre, ether extract, ash and carbohydrate at 89%, 7%, 2%, 2%, 5% and 72% respectively.

Table 1. Proximate composition of *Kigelia africana* powder.

Index	**Composition (%)**
Moisture	10.33 ± 0.92
Dry matter	89.67 ± 0.28
Crude protein	7.98 ± 0.02
Crude fibre	2.71 ± 0.03
Ether extract	2.10 ± 0.01
Ash	5.49 ± 0.08
Carbohydrate	72.06 ± 0.34

Source: Authors, 2023.

The chemical composition for vitamins is presented in (Table 2) for *K. africana*. Significant contents of vitamins B1, B2, B3, B6, D, E and K are present in *K. africana*.

Table 2. Vitamin composition of *Kigelia africana* powder.

Index*	Scientific name	Unit	Composition
A	Retinol	iu /100g	4.24 ± 0.02
B1	Thiamine	mg/100 g	82.9 ± 0.01
B2	Riboflavin	µg/100g	25.1 ± 0.08
B3	Niacin	µg/100g	49.6 ± 0.01
B6	Pyridoxine	µg/100g	143.1 ± 0.34
B9	Folic acid	mg/100 g	6.70 ± 0.22
B12	Cobalamin	µg/100g	3.90 ± 0.12
C	Ascorbic acid	µg/100g	5.86 ± 0.04
D	Calciferol	iu/100g	124.4 ± 0.47
E	Tocopherol	mg/100 g	44.2 ± 0.21
K	Phytonadione	iu/100g	39.2 ± 0.02

Note: *Vitamins. Source: Authors, 2023.

Bioactive profiling of *K. africana* fruit powder Figure 1 and Table 3 revealed the presence of 19 compounds with their retention times. In particular, the following compounds presented an area greater than 5%: 2-Dimethylsilyloxytetradecane; 3,7-dimethyl-Pentaerythritol; 9-Octadecenoic acid and Cyclopropaneoctanal.

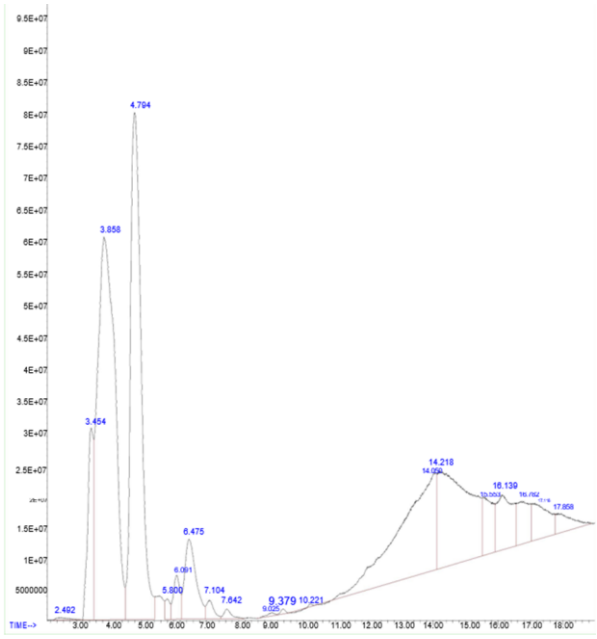

Figure 1. Analysis by gas chromatography with sequential mass spectrometry of volatile compounds in *Kigelia africana*. Source: Authors, 2023. Thanks to PhD. Emeka, A.

Table 3. Bioactive profiling of *Kigelia africana* powder

Peak	Compounds	R.T (sec)	Area %	Chemical formula	Nature of compound
1.00	2-Chloroethyl 1-propynyl sulfoxide	2.492	0.12	C_8H_9CIOS	Alcoholic
2.00	Allyl fluoride	3.454	4.50	C_3H_5	Triterpene
3.00	2-Dimethylsilyloxytetradecane	3.858	27.42	$C_{19}H_{44}OSi_2$	Alcoholic
4.00	3,7-dimethyl- Pentaerythritol	4.794	22.08	$C_5H_{12}O_4$	Alcoholic
5.00	1-Butanol, 3-methyl-, acetate	5.800	0.40	$C_7H_{14}O_2$	Oleic acid ester
6.00	Dimethyl Urethane	6.091	1.19	$C_3H_8N_{2O}$	Nitrogen
7.00	2-hydroxy- Propanenitrile	6.475	3.80	C_3H_5NO	Nitrogen
8.00	2,2-dimethyl- Cyclohexanol	7.104	0.57	$C_8H_{16}O$	Alcoholic
9.00	Hexanoic acid	7.642	0.30	$C_6H_{12}O_2$	Oleic acid ester
10.0	10-Azido-1-decanethiol Cyclopentaneundecanoic acid	9.025	0.10	$C_{10}H_{21}N_3S$	Alkaloid
11.0	Isopropylcyclobutane	9.379	0.10	C_7H_{14}	Triterpene
12.0	Cyclopentaneundecanoic acid	10.221	0.01	$C_{17}H_{32}O_2$	Oleic acid ester
13.0	9-Octadecenoic acid	14.050	14.84	$C_{18}H_{34}O_2$	Oleic acid ester
14.0	Cyclopropaneoctanal	14.218	12.60	$C_{19}H_{36}O$	Alcoholic
15.0	2- Chloropropionic acid	15.553	2.42	$C_3H_5CIO_2$	Chlorine
16.0	9-Octadecenoic acid	16.139	3.60	$C_{18}H_{34}O_2$	Amino
17.0	1-Tricosene	16.782	2.19	$C_{23}H_{46}$	Diterpene
18.0	2-octyl- 6-Octadecenoic acid	17.116	2.48	$C_{26}H_{52}O_2$	Palmitic
19.0	13-Octadecenal	17.858	1.28	$C_{18}H_{36}O$	Palmitic
Total		-	**99.98**	-	

Note: R. T = reaction time. Source: Authors, 2023

4. Discussion

The nutritional parameters obtained from fresh *K. africana* fruits proved to be a great option for the human diet in our study. The moisture content recorded in this study is low suggesting that the was sample kept for a relatively long time without deteriorating (Alagbe, 2022).

Comparing our results with other edible fruits, we found that the content of the moisture value recorded in this study was higher than those of *Sphaeranthus hirtus* 3.71%, *Fumaria officinalis* 9.42% and *Cuscuta reflexa* 7.72% reported by Javid et al. (2009). Crude protein (7.98 %) in *K. africana* fruit powder indicates that it is low in protein and cannot be used as a protein supplement in livestock feed (NRC, 1994) like *Jatropha kernel* meal (Ojediran; Emiola, 2012), *Sphenostylis stenocarpa* and *Cajanus cajan* seed meals (Abioye et al., 2017).

However, the value obtained is higher than those of *Melia azadiracta* 5.60%, *Vitis venifera* 4.85% and *Artesmisa vulgaris* 3.72% according by Pendey et al. (2006). Dietary fibre can hasten the digestion of feed in the gut and can also lower the risk of high cholesterol in the serum (Singh et al., 2022). Fibre recorded in Table 1 was lower than those of *F. officinalis* 30.43%, Polypodium vulgare 13.30% reported by Javid et al. (2009) and palm kernel meal (Ojediran et al, 2020). Ash is used to determine the mineral composition in a sample (Singh et al., 2022).

The values recorded for ash 5% and ether extract 2% was lower than 7.57% and 9.23 % reported by Oseni & William (2018) for *K. africana* fruit powder. This variation can be attributed to age of plant, specie, geographical location and processing methods (Alagbe et

al., 2023). *Kigelia africana* fruit powder is a good source of carbohydrate given a percentage composition of 72% in (Table 1). Carbohydrate provides energy for the proper functioning of cells in the body of animals (Alagbe, 2022). Earlier studies have reported 36.10 %, 35.88 % and 43.84 % carbohydrate composition for the fruits of *Kigelia africana* (Atawodi; Olowoniyi, 2015).

The result suggests that the sample is rich in vitamin A, vitamin B1, vitamin B2, vitamin B3, vitamin B6, vitamin B9, vitamin B12, vitamin C, vitamin D, vitamin E and vitamin K at 4.24 iu /100 g, 82.9 mg/100 g, 25.1 µg/100 g, 49.60 µg/100 g, 143.1 µg/100 g, 6.70 mg/100 g, 3.90 µg/100 g, 5.86 µg/100 g, 124.4 iu/100 g, 44.20 mg/100 g and 39.20 iu/100 g respectively. Vitamins are chemical compounds that carry out certain biological functions and maintain growth in animals (Alagbe, 2023).

They are taken in small amounts and are beneficial in many metabolic processes for instance, vitamin A are important for better eye sight, improves the immune system and healthy growth of reproductive tissues (Asensi-Fabado; Munne, 2010). Vitamin B complex (B1, vitamin B2, vitamin B3, vitamin B6, vitamin B9, vitamin B12) are important in maintaining nerve cell function, production of red blood cells, synthesis of fats and cholesterol as well as replication of deoxyribo nucleic acid (Shearer et al., 2012; Combs, 2007). Vitamin C is an antioxidant and are responsible for the formation of iron in the body (Muhammad et al., 2017). Vitamin D aids in the growth of bone tissues by absorbing calcium in the blood (Jolliffe et al., 2013).

The body also requires vitamin E to produce better defense against diseases. Insufficient dietary supply of this vitamin could result in neuropathy or breakdown in the red blood cell (Lanska, 2010; McDowell, 2000). Vitamin K is the main factor that aid in the coagulation of the blood (Kurosu; Begari, 2010). The result obtained in this study is in agreement with the findings of Neergheen et al. (2006).

These compounds have different therapeutic properties with 2-Dimethylsilyloxytetradecane 27% as a major compound followed by 3,7-dimethyl-Pentaerythritol 22%, 9-Octadecenoic acid 14%, Cyclopropaneoctanal 12%), Allyl fluoride 4%), 2-hydroxy- Propanenitrile 3, 9-Octadecenoic acid 3%, 2-octyl- 6-Octadecenoic acid 2%, 2- Chloropropionic acid 2%, 1-Tricosene 2%, 13-Octadecenal 1%, Dimethyl Urethane 1%, 2,2-dimethyl- Cyclohexanol 0.57%, 1-Butanol, 3-methyl-, acetate 0.40%, Hexanoic acid 0.30%, 2-Chloroethyl 1-propynyl sulfoxide 0.12%, 10-Azido-1-decanethiol Cyclopentaneundecanoic acid 0.10%, Isopropylcyclobutane 0.10% and Cyclopentaneundecanoic acid 0.01%. The presence of 2-dimethylsilyloxytetradecane, 3,7-dimethyl-pentaerythritol and 9-octadecenoic acid suggests that it possess antimicrobial, antioxidant and immune-stimulatory properties (Kala et al., 2011; Lalitharani et al., 2009).

Cyclopropaneoctanal, Allyl fluoride and 2-hydroxy-Propanenitrile and have been reported to have antimicrobial and antifungal effect (Mamza et al., 2012; Awa et al., 2012). 9-Octadecenoic acid and 2-Chloroethyl 1-propynyl sulfoxide found in Kigelia africana fruit possess antimicrobial, antioxidant, anti-inflammatory, and antidiarrheal properties (Usman; Usuji, 2007; Yang et al., 2013). Hexanoic acid and Isopropylcyclobutane is reported to have antimicrobial activity and has been found to be present in Sauropus bacciformis extracts (Arockia et al., 2012).

10-Azido-1-decanethiol Cyclopentaneundecanoic acid and 1-Tricosene also found in methanolic extract of *Cypraea arabica* whole fruit have been reported to suppress the activities of *Shigella flexneri*, *Salmonella typhi*, *Proteus mirabilis*, *Pseudomonas aeruginosa*, *Klebsiella pneumonia*, *Enterococcus faecalis* and *Bacillus cereus*, amongst others (Subavathy; Thilaga, 2015). It has also been found to have antioxidant effects and can prevent oxidative stress in animals (Edeoga et al., 2005; Klavina et al., 2015).

5. Conclusion

In conclusion, Kigelia africana fruit is rich in several phytochemicals with therapeutic properties such as: antimicrobial, antifungal, hepato-protective, immune-modulatory, anti-inflammatory, antiviral amongst others. The presence of vitamins suggests that the fruit can promote growth, maintain nerve cell function, aid in the replication of deoxyribonucleic acid and improve the immune system of animals.

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Ethics

No applicable.