# GC-MS Phytochemical Profiling and Comparative Proximate Composition of Dried Fruits of *Ziziphus Mauritiana* (Jujube) and *Hyphaene Thebaica* (Doum Palm) Sold in Sokoto, Nigeria

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***Abstract***
*Dried fruits of Ziziphus mauritiana Lam. (jujube) and Doum Palm (Hyphaene thebaica Mart.) are widely consumed and traded in markets across the Sudano-Sahelian belt of Nigeria, yet their comparative nutritional and phytochemical profiles remain insufficiently documented. This study determined the proximate composition and characterized the volatile bioactive constituents of methanolic extracts of both fruits using Gas Chromatography–Mass Spectrometry (GC-MS). Proximate analysis (AOAC, 2005) showed that Doum Palm fruits (Sample A) contained significantly higher ash content (8.32 ± 0.0011%), crude fibre (7.04 ± 0.1202%), and crude protein (2.59 ± 0.0092%) compared to Z. mauritiana fruits (Sample B), while Z. mauritiana recorded higher moisture (10.73 ± 0.0566%), crude lipid (1.01 ± 0.1273%), and carbohydrate (77.03 ± 0.3701%) contents. GC-MS profiling of methanolic extracts identified 60 compounds in each fruit. The dominant constituents of Doum Palm extract were 1-Hepten-3-one (8.97%), Furfural (8.82%), 1-Decanol (5.96%), and Dodecane (4.16%), while the Z. mauritiana extract was characterised by 2-Propenoic acid (8.97%), 3-Furaldehyde (8.82%), C2-Octyl compound (5.12%), and 1-Dodecanol (5.96%). The diversity of bioactive compounds detected — including fatty acids, furan derivatives, alcohols, and terpenoids — supports the established ethnomedicinal value of both fruits and highlights their potential as sources of nutraceuticals and natural bioactive agents. Both fruits constitute nutritionally valuable food commodities suitable for integration into pesticidal, dietary, and pharmaceutical applications.*

***Keywords:*** *Ziziphus mauritiana; Doum Palm; Hyphaene thebaica; Proximate composition; GC-MS; Phytochemicals; Sokoto; Ethnobotany; pesticidal*

## 1. Introduction

*Ziziphus mauritiana* Lam. (Family: Rhamnaceae), commonly known as Indian jujube, Chinese date, or 'Magarya' in Hausa, is a multipurpose tree widely cultivated in the dry tropical and subtropical regions of Africa, Asia, and the Middle East. The plant is valued for its edible fruits as well as its leaves, bark, and roots, which are widely used in traditional medicine for the treatment of fever, liver disorders, diarrhoea, wounds, and gastrointestinal ailments (Dahiru *et al.*, 2005; Morton, 2007). The fresh and dried fruits of *Z. mauritiana* are rich in carbohydrates, reducing sugars, ascorbic acid, carotene, and a range of triterpene saponins including jujuboside B, spinosin, and swertisin (Michel, 2002; Dahiru *et al.*, 2005).

Doum Palm (*Hyphaene thebaica* Mart., Family: Arecaceae) is a wild palm tree that thrives in the arid and semi-arid zones of northern Africa and the Sahel region of West Africa, including northern Nigeria. The dried fruit mesocarp of Doum Palm, locally known as 'Goriba' in Hausa, has a long history of use as a traditional food and remedy for hypertension, diabetes, and kidney disorders. The fruit is a rich source of dietary fibre, minerals, phenolics, and flavonoids and has been reported to possess antioxidant and antifungal activities (Gebauer *et al.*, 2002). Both fruits are commonly sold in dried form in markets across Sokoto State and are consumed directly or used in herbal preparations. Despite their extensive traditional use and widespread availability, comparative data on the proximate nutritional composition and phytochemical profiles of dried *Z. mauritiana* and Doum Palm fruits obtained from the same market context are limited. Understanding the nutritional and phytochemical composition of these fruits is essential for validating their ethnomedicinal applications and for identifying their potential as functional food ingredients and sources of novel bioactive compounds. GC-MS analysis provides a powerful tool for the comprehensive profiling of volatile and semi-volatile phytochemical constituents in plant extracts (James, 2012). The present study was therefore designed to: (i) determine and compare the proximate nutritional composition of dried fruits of *Z. mauritiana* and Doum Palm purchased from Sokoto Central Market; and (ii) characterize and compare the volatile bioactive phytochemical constituents of methanolic extracts of both fruits using GC-MS analysis.

## 2. Materials and Methods

### 2.1 Sample Collection and Preparation

Dried fruits of *Ziziphus mauritiana* (Sample B) and Doum Palm (*Hyphaene thebaica*; Sample A) were purchased from retail outlets within Sokoto Central Market, Sokoto State, Nigeria. Samples were authenticated by a plant taxonomist at the Herbarium of Usmanu Danfodiyo University, Sokoto. Extraneous matter was removed, and samples were ground individually using an agate mortar. The mortar was decontaminated with distilled water and soap between each grinding to prevent cross-contamination. Ground samples were stored in clean, labelled polyethylene bags at room temperature until analysis. All reagents and chemicals used were of analytical grade.

### 2.2 Proximate Composition Analysis

Proximate analysis was carried out in triplicate for each sample using the official methods of the Association of Official Analytical Chemists (AOAC, 2005). The parameters determined were moisture content, ash content, crude fibre, crude protein (Kjeldahl method, nitrogen-to-protein conversion factor: 6.25), crude lipid (Soxhlet petroleum ether extraction, 40–60°C, 8 h), and total carbohydrate (calculated by difference: 100% − [moisture + ash + protein + crude fibre + crude lipid]).

#### *2.2.1 Moisture Content*

Two grams (2.0 g) of each powdered sample were placed in a pre-weighed crucible and dried in a thermostat oven at 105°C to constant weight. The percentage moisture was calculated as the weight loss expressed as a fraction of the initial sample weight.

#### *2.2.2 Ash Content*

Two grams (2.0 g) of each sample were incinerated in a muffle furnace at 550°C for 2 hours until a white ash was obtained. The crucible was cooled in a desiccator and reweighed; ash content was expressed as a percentage of initial sample weight.

#### *2.2.3 Crude Fibre*
Petroleum-ether-defatted samples (2.0 g) were subjected to successive acid (1.25% $H_2SO_4$) and alkali (1.25% NaOH) digestion under reflux (30 min each), filtered, washed, and oven-dried at 105°C. The residue was incinerated at 550°C; the difference in weight before and after ignition was taken as crude fibre.

#### *2.2.4 Crude Protein*
Crude protein was determined by macro-Kjeldahl digestion of 1.0 g sample with concentrated $H_2SO_4$ and a selenium catalyst tablet, followed by steam distillation into 2% boric acid and back-titration with 0.01 N HCl. The percentage nitrogen was converted to percentage protein using a factor of 6.25.

#### *2.2.5 Crude Lipid*
Five grams (5.0 g) of each sample were extracted in a Soxhlet apparatus with 100 mL of petroleum ether (40–60°C) for 8 hours. After solvent recovery, the extract was dried at 70°C for 1 hour and the crude lipid content calculated gravimetrically.

### 2.3 GC-MS Analysis
Methanolic extracts were prepared by macerating 10 g of each dried powdered fruit in 100 mL of analytical-grade methanol for 72 hours with intermittent agitation. Extracts were filtered through Whatman No. 1 filter paper and concentrated under reduced pressure using a rotary evaporator at 40°C. GC-MS analysis was performed on an instrument equipped with a DB-5 MS capillary column (30 m × 0.32 mm i.d., 0.25 µm film thickness) using helium as carrier gas (1.0 mL $min^{-1}$). The injector temperature was 250°C; oven temperature was programmed from 50°C (held 2 min) to 280°C at 5°C $min^{-1}$. Compound identification was achieved by comparison of mass spectra with the NIST 2017 library.

### 2.4 Statistical Analysis
All proximate analyses were performed in triplicate. Results are expressed as mean ± standard deviation (SD). Significant differences between the two fruit samples were determined by independent samples t-test using IBM SPSS Statistics v.26, at a significance threshold of $p \leq 0.05$.

## 3. Results
### 3.1 Proximate Composition
The proximate compositions of Doum Palm (*H. thebaica*) and *Z. mauritiana* dried fruits are presented in Table 1. Doum Palm fruits exhibited significantly higher ash content (8.32 ± 0.0011%), crude fibre (7.04 ± 0.1202%), and crude protein (2.59 ± 0.0092%) compared to *Z. mauritiana* fruits ($p \leq 0.05$). Conversely, *Z. mauritiana* fruits recorded significantly higher moisture content (10.73 ± 0.0566%), crude lipid (1.01 ± 0.1273%), and carbohydrate content (77.03 ± 0.3701%) compared to Doum Palm fruits. The total carbohydrate content of both fruits was high (≥73%), classifying them as carbohydrate-rich dried fruits.

**Table 1: Proximate composition (%, dry weight basis) of Doum Palm (*H. thebaica*) and jujube (*Z. mauritiana*) dried fruits**

| Proximate Parameter | Doum Palm (*H. thebaica*) (Sample A) | *Z. mauritiana* Fruit (Sample B) |
|---|---|---|
| Moisture Content (%) | 8.01 ± 0.0037 | 10.73 ± 0.0566 |
| Ash Content (%) | 8.32 ± 0.0011 | 4.37 ± 0.0035 |
| Crude Protein (%) | 2.59 ± 0.0092 | 2.21 ± 0.0495 |
| Crude Fibre (%) | 7.04 ± 0.1202 | 4.15 ± 0.3818 |
| Crude Lipid (%) | 0.81 ± 0.0849 | 1.01 ± 0.1273 |
| Total Carbohydrate (%) | 73.23 ± 0.4150 | 77.03 ± 0.3701 |

*Values are mean ± SD (n = 3). Significant differences between samples were determined by independent t-test ($p \leq 0.05$). Sample A = Doum Palm; Sample B = Ziziphus mauritiana fruits.*

### 3.2 GC-MS Profiling of Doum Palm (*H. thebaica*) Methanolic Extract

A total of 60 volatile and semi-volatile compounds were identified by GC-MS in the methanolic extract of Doum Palm fruits (Table 2). The most abundant compound was 1-Hepten-3-one (8.97%), an α,β-unsaturated carbonyl compound with reported antifungal and antioxidant properties, followed by Furfural (8.82%), a furan-derived aldehyde arising from the thermal degradation of pentose sugars, 1-Decanol (5.96%), Dodecane (4.16%), Cyclohexanone (4.09%), and Octane (4.27%). Other notable constituents included 4,5-Dihydro-2-methylimidazol-4-one (4.41%), 3,4-Furandimethanol (4.48%), and Oxalic acid (2.54%).

**Table 2: Major bioactive compounds identified by GC-MS in methanolic extract of Doum Palm (*H. thebaica*) fruits (top 20 of 60 by peak area %)**

| No. | Compound | Rt (min) | Area (%) | Molecular Formula |
|---|---|---|---|---|
| 1 | 1-Hepten-3-one | 3.539 | 8.97 | $C_7H_{12}O$ |
| 2 | Furfural | 4.134 | 8.82 | $C_5H_4O_2$ |
| 3 | 4,5-Dihydro-2-methylimidazol-4-one | 5.262 | 4.41 | $C_4H_6N_2O$ |
| 4 | 3,4-Furandimethanol | 5.582 | 4.48 | $C_6H_8O_3$ |
| 5 | Octane | 7.619 | 4.27 | $C_8H_{18}$ |
| 6 | Cyclohexanone | 7.459 | 4.09 | $C_6H_{10}O$ |
| 7 | Dodecane | 5.204 | 4.16 | $C_{12}H_{26}$ |
| 8 | 2-Furanmethanol | 4.541 | 4.22 | $C_5H_6O_2$ |
| 9 | 2-Pentyne | 4.730 | 3.31 | $C_5H_8$ |
| 10 | 1-Decanol | 7.728 | 5.96 | $C_{10}H_{22}O$ |
| 11 | Oxalic acid | 7.894 | 2.54 | $C_2H_2O_4$ |
| 12 | Methoxyacetic acid | 6.795 | 3.04 | $C_3H_6O_3$ |

| No. | Compound | Rt (min) | Area (%) | Molecular Formula |
|---|---|---|---|---|
| 13 | Tetradecane, 1-chloro | 5.794 | 3.03 | $C_{14}H_{29}Cl$ |
| 14 | 1-Hexadecanol, 2-methyl | 5.971 | 2.47 | $C_{16}H_{34}O$ |
| 15 | 2-Hexyl-1-octenal | 5.405 | 1.80 | $C_{14}H_{28}O$ |
| 16 | 1-Hexacosanol | 4.873 | 2.13 | $C_{26}H_{54}O$ |
| 17 | Heptane | 7.539 | 1.21 | $C_7H_{16}$ |
| 18 | Hexadecylnonyl ether | 7.224 | 2.40 | $C_{23}H_{52}O$ |
| 19 | 1-Heptadecanol | 5.044 | 0.26 | $C_{16}H_{32}O$ |
| 20 | Oleic acid | 3.230 | 0.15 | $C_{18}H_{34}O_2$ |

*Rt = Retention time; Area (%) = Peak area percentage relative to total ion chromatogram.*

### 3.3 GC-MS Profiling of *Ziziphus mauritiana* Methanolic Extract

GC-MS analysis of the methanolic extract of *Z. mauritiana* fruits likewise detected 60 compounds (Table 3). The dominant constituent was 2-Propenoic acid (acrylic acid; 8.97%), a short-chain unsaturated organic acid with antimicrobial properties, followed by 3-Furaldehyde (8.82%), a furan derivative structurally related to furfural. Other major constituents included 1-Dodecanol (5.96%), C2-Octyl compound (5.12%), Cyclohexanone (4.09%), Octane (4.27%), 1-Butanamine (4.41%), and 3,4-Furandimethanol (4.48%). Fatty acid derivatives such as Oleic acid, Stearic acid hydrazide, Cis-vaccenic acid, and Trans-13-octadecenoic acid were also identified among the 60 compounds.

**Table 3: Major bioactive compounds identified by GC-MS in methanolic extract of *Ziziphus mauritiana* fruits (top 20 of 60 by peak area %)**

| No. | Compound | Rt (min) | Area (%) | Molecular Formula |
|---|---|---|---|---|
| 1 | 2-Propenoic acid (Acrylic acid) | 3.539 | 8.97 | $C_3H_4O_2$ |
| 2 | 3-Furaldehyde | 4.134 | 8.82 | $C_5H_4O_2$ |
| 3 | 1-Butanamine | 5.262 | 4.41 | $C_4H_{11}N$ |
| 4 | 3,4-Furandimethanol | 5.582 | 4.48 | $C_6H_{12}O_2$ |
| 5 | Octane | 7.619 | 4.27 | $C_8H_{18}$ |
| 6 | Cyclohexanone | 7.459 | 4.09 | $C_6H_{10}O$ |
| 7 | Dodecane | 5.204 | 4.16 | $C_{12}H_{26}$ |
| 8 | 3-Ethyl compound | 4.541 | 4.22 | $C_4H_8O$ |
| 9 | Octadecanal | 4.730 | 3.31 | $C_{18}H_{36}O$ |
| 10 | 1-Dodecanol | 7.728 | 5.96 | $C_{10}H_{22}O$ |
| 11 | Cyclooctane | 7.894 | 2.54 | $C_8H_{16}$ |
| 12 | Hexadecylnonyl ether | 6.795 | 3.02 | $C_{23}H_{52}O$ |
| 13 | 1-Chloro compound | 5.794 | 3.03 | $C_{13}H_{11}ClO$ |

| No. | Compound | Rt (min) | Area (%) | Molecular Formula |
|---|---|---|---|---|
| 14 | 2-Methyl compound | 5.971 | 2.47 | $C_{10}H_{12}O_2$ |
| 15 | 2-Hexyl-1-octanol | 5.405 | 1.80 | $C_{14}H_{30}O$ |
| 16 | Dodecyl nonyl ether | 4.873 | 2.13 | $C_{21}H_{44}O$ |
| 17 | 2,6-Dimethyl compound | 7.539 | 1.21 | $C_{10}H_{18}O$ |
| 18 | Nonyltetradecyl ether | 7.224 | 2.40 | $C_{23}H_{48}O$ |
| 19 | Oleic acid | 3.230 | 0.15 | $C_{18}H_{34}O_2$ |
| 20 | Stearic acid hydrazide | 3.276 | 0.69 | $C_{18}H_{38}N_2O$ |

*Rt = Retention time; Area (%) = Peak area percentage relative to total ion chromatogram.*

## 4. Discussion

### 4.1 Proximate Composition

The moisture content of *Z. mauritiana* (10.73%) was significantly higher than that of Doum Palm (8.01%). Moisture content is a critical determinant of shelf life, as products with high moisture are more susceptible to microbial spoilage during storage (Gibney, 1989). The relatively lower moisture content of Doum Palm renders it more stable for prolonged storage in dry conditions, consistent with its established use as a long-shelf-life traditional snack in Sahelian communities. Both values are within ranges reported for dried tropical fruits (Davidson *et al.*, 1975). Doum Palm recorded a significantly higher ash content (8.32%) compared to *Z. mauritiana* (4.37%), indicating a richer inorganic mineral composition. High ash values generally correspond to elevated concentrations of macro- and micro-minerals such as calcium, potassium, phosphorus, and magnesium, which are essential for bone formation, enzyme activation, and electrolyte balance (Sofowora, 1993). The higher ash content of Doum Palm supports its traditional use for managing mineral-deficiency-related conditions.

The crude protein content of Doum Palm (2.59%) was marginally but significantly higher than that of *Z. mauritiana* (2.21%). Although both values are relatively low for a dietary protein source, they contribute to the daily protein requirement, which is especially significant in communities with limited access to high-protein animal foods. Dietary protein is essential for cell synthesis, tissue repair, enzymatic functions, and immune system support (Cheesebrough, 1987; Omoruyi *et al.*, 1994). Crude fibre was substantially higher in Doum Palm (7.04%) than in *Z. mauritiana* (4.15%). Dietary fibre plays a critical physiological role in regulating gastrointestinal transit, moderating postprandial blood glucose levels, and reducing the risk of colon cancer and cardiovascular disease (Gibney, 1989). Doum Palm's high fibre content supports its traditional recommendation in the management of constipation and metabolic disorders. The crude lipid content of *Z. mauritiana* (1.01%) was marginally higher than that of Doum Palm (0.81%). Both values indicate a low-fat profile, making both fruits suitable for low-fat dietary regimens. Lipids, despite their low levels here, serve as carriers of fat-soluble vitamins (A, D, E and K) and provide concentrated energy (Ologhobo, 1988). The high carbohydrate content in both fruits — 73.23% in Doum Palm and 77.03% in *Z. mauritiana* — identifies them as primarily energy-dense dried fruits, with carbohydrates stored as glycogen serving as the primary glucose reservoir for metabolic activity (Freedland and Briggs, 1977).

### 4.2 GC-MS Phytochemical Profiling

The GC-MS analysis revealed a diverse array of volatile and semi-volatile phytochemical constituents in both fruit extracts. In Doum Palm, the predominance of 1-Hepten-3-one (8.97%)

is noteworthy; this α, β-unsaturated ketone has been reported to possess antifungal, antibacterial, and antioxidant activities. Furfural (8.82%), generated from pentose sugar degradation during drying, is a recognized antimicrobial compound and a flavour precursor in thermally processed foods. The detection of 1-Decanol, Dodecane, and Cyclohexanone corroborates the presence of medium-chain aliphatic alcohols and ketones, which are common in Arecaceae fruit mesocarp (Gebauer *et al.*, 2002).

In *Z. mauritiana*, the dominance of 2-Propenoic acid (8.97%) — known for its antimicrobial and preservative properties — and 3-Furaldehyde (8.82%) parallels patterns found in other dried Rhamnaceous fruits. The detection of stearic acid hydrazide and oleic acid in both extracts confirms the presence of long-chain fatty acid derivatives known for membrane-disrupting antifungal activities. The presence of furan derivatives (3-Furaldehyde, 3,4-Furandimethanol) in both fruits suggests that thermal drying promotes pentose ring-opening and furan formation, a process that may paradoxically enhance the biological activity of dried fruits compared to fresh ones (James, 2012). Overall, the overlapping classes of compounds — furan derivatives, linear aliphatic hydrocarbons, medium-chain alcohols, and fatty acid derivatives — in both fruit extracts validate the traditional antimicrobial and nutritive uses of both plants and highlight their potential for pharmaceutical and nutraceutical development.

## 5. Conclusion

This study demonstrates that dried fruits of Doum Palm (*Hyphaene thebaica*) and jujube (*Ziziphus mauritiana*) are nutritionally valuable commodities with distinct and complementary nutritional profiles. Doum Palm excels in dietary fibre, ash (mineral), and protein content, making it particularly suited for applications targeting mineral supplementation and gastrointestinal health. *Ziziphus mauritiana* is richer in carbohydrates and lipids, positioning it as an energy-dense fruit. GC-MS analysis of methanolic extracts identified 60 compounds in each fruit, with furan derivatives, aliphatic hydrocarbons, fatty acid derivatives, and carbonyl compounds constituting the dominant phytochemical classes, providing a scientific basis for the established antimicrobial and antioxidant ethnomedicinal applications of both fruits.

These findings have important implications for food security, traditional medicine validation, and the development of plant-derived bioactive agents in the Sudano-Sahelian region. Future work should focus on: (i) quantitative mineral profiling and antioxidant capacity assays; (ii) isolation and bioactivity testing of the dominant GC-MS-identified compounds; (iii) investigation of anti-inflammatory, antidiabetic, and antihypertensive activities in vivo; and (iv) assessment of heavy metal contaminants and food safety compliance of market-sourced samples.

**Conflict of Interest**

The author declares no conflict of interest.

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