BMC Chemistry

RESEARCH

Open Access

Evaluation of phytochemical compounds and proximate analysis of doum palm fruit (*Hyphaene thebaica*) blend with turmeric powder (*Curcuma longa*)

Temiloluwa O. Amusan[1], Oluwagbenga J. Ogunbiyi[2*], Mansurat O. Shoge[1], Maurice Jemkur[1] and Peter S. Joseph[2]

Abstract

Doum palm and turmeric are traditional medicinal plants with a rich history of use. This study investigated the phytochemical composition, proximate analysis, and GC-MS characterization of doum palm and turmeric blends at different ratios (100%, 80:20%, 60:40%, and 50:50%) using ethanol and warm-water extracts. Phytochemical screening revealed the presence of various bioactive compounds, including alkaloids, anthraquinones, flavonoids, glycosides, saponins, tannins, terpenoids, and phenols, in the blends at ratios of 80:20%, 60:40%, and 50:50%. Alkaloids were absent in the 100% doum palm sample. Proximate analysis showed significant variations in moisture, ash, fat, and protein content among the samples. GC-MS characterization identified at most 30 phytochemical compounds in sample A and more additional 9 bioactive compounds in samples B, C and D, including two new compounds, eucalyptol and carotol, found in the doum palm-turmeric blends. These compounds have been known to possess various antioxidant and therapeutic potential. The findings suggest that doum palm and turmeric blends have improved potential health benefits due to their high content of phytochemical compounds and balanced proximate composition. Further research is warranted to determine the most effective doum palm to turmeric ratio (Optimal Blending Ratios) for specific health applications. This includes identifying the blend ratios that maximize the therapeutic benefits for particular conditions or diseases.

Keywords GC-MS, Extract, Bioactive, Therapeutic, Composition

Introduction

The study of phytochemicals and mineral content in medicinal plants has grown in popularity in the fields of nutritional science and pharmaceutical industries due to its implications in the production of drugs and food supplements for human wellness and health. The synergistic potential of combining various natural compounds has emerged as a focus of scientific research, with the goal of determining the unique chemical constituents and potential health benefits derived from such mixtures.

One such exciting discovery is the scientific study of phytochemicals and mineral composition in a mixture of

*Correspondence:
Oluwagbenga J. Ogunbiyi
2rayacoa@gmail.com
[1]Department of Chemistry, Air Force Institute of Technology, PMB 2104, Kaduna, Nigeria
[2]Biology Unit, Air Force Institute of Technology, PMB 2104, Kaduna, Nigeria

Fig. 1 Sample preparation of doum palm fruit

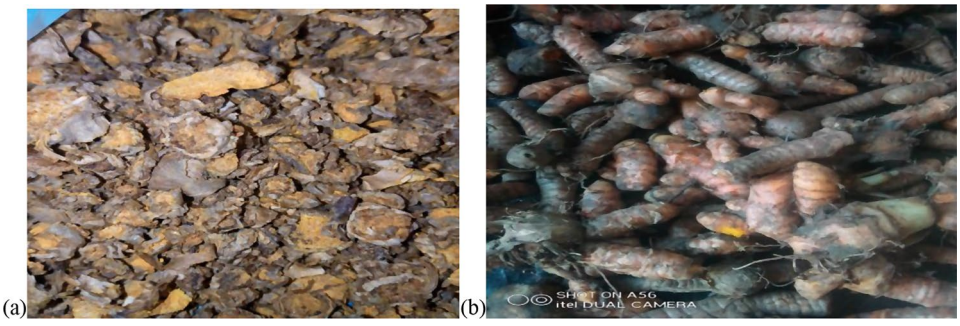

Fig. 2 Sample preparation of turmeric rhizomes (**a**) Turmeric sample dried using an oven. (**b**) Fresh turmeric rhizomes

doum palm fruit and turmeric powder. Doum palm fruit (*Hyphaene thebaica*) and turmeric (*Curcuma longa*) have each been recognized for their high phytochemical content and nutritional value [1, 2]. Combining these diverse botanicals opens up a new path of investigation, allowing researchers to discover the synergies that may result from their combined phytochemical and mineral contents.

Doum palm fruit is a staple in many parts of the world. It has long been consumed for its potential health advantages [3]. The scientific study of doum palm fruit goes beyond its nutritional worth and investigates its phytochemical content and mineral composition. Understanding the complex chemical composition of doum palm fruit lays the framework for understanding its potential benefits to human nutrition and health.

Turmeric, a golden spice originating from the rhizomes of *Curcuma longa*, has long been valued for its medicinal ingredient, curcumin [4]. Due to its anti-inflammatory and antioxidant actions [5], turmeric's therapeutic qualities have prompted substantial research. However, its interaction with other botanicals, particularly doum palm fruit, remains a mystery in the scientific community. The rationale for combining doum palm fruit and turmeric powder is to develop a health-promoting dietary supplement.

This scientific study aims to thoroughly assess the phytochemical components and proximate composition of a doum palm fruit and turmeric powder blend. The study intends to assess potential synergies and determine how the combination will affect the nutritional landscape of these botanicals. The findings of this study show promise not just for furthering our understanding of the chemistry of doum palm fruit and turmeric, but also for providing insights into the possible health advantages of their combined intake.

Materials and methods

Sample Collection

Doum palm fruits and turmeric rhizomes were collected in Kawo Market, Kaduna North Local Government Area of Kaduna State, Nigeria. Kawo is located at longitude $7^{0}4333''$ and latitude $10^{0}5167''$ in Kaduna State, Nigeria. The plant was authenticated by a Botanist in the Biology Department, Air Force Institute of Technology, Kaduna, with the authentication reference numbers AFITBIO/DP-001-0001 and AFITBIO/TU-001-0001.

Sample Preparation

The epicarp of the doum palm fruit was removed with a mortar and pestle (Fig. 1). The doum palm sample was then shade-dried at room temperature for 7 days before being pulverized into a fine powder with an electric blender until a fine powder was achieved. The samples were then kept in a glass container for further use.

The turmeric rhizomes were rinsed, chopped into smaller bits, and oven-dried for 8 h at 60 °C (Fig. 2). Thereafter, the dried rhizomes were pulverized using an

electric blender until a fine powder was achieved, and the samples were kept in a glass container for further use.

The powdered doum palm sample was combined with the powdered turmeric sample in four ratios: 100%, 80:20%, 60.40%, and 50:50%. For the phytochemical screening, aqueous extracts and organic (ethanol) extracts were synthesized.

The two samples were homogenized using different blending proportion ratios. Table 1 shows the blending ratio of the homogenized samples.

Extraction procedures

The aqueous extract was prepared utilizing the infusion method of extraction. For 30 min, 20 g of the sample blend were dissolved and stirred in 200 ml. of hot distilled water. The resultant solution was filtered using a muslin cloth, concentrated and stored for later use [6].

The ethanol extract was prepared using the cold maceration method. Accurately measured 20 g of the sample blend was macerated in 200 mL of ethanol for 48 h. The resultant ethanol and distilled water extract were filtered using a muslin cloth, concentrated and stored for later use [6].

Phytochemical screening

The principal chemical groups contained in the extracts (tannins, saponins, flavonoids, alkaloids, phenols, anthraquinone, glycosides, and terpenoids) were determined by confirmatory qualitative phytochemical screening of plant extracts using standard methods.

Test for alkaloids

Using a modified process of the Mayer-Wanger test, 3 drops of 1% HCl were added to 2 ml of sample extract. Likewise, 2 mL of the Mayer-Wagner reagent was added. The appearance of a reddish-brown precipitate indicated the presence of alkaloids [7].

Test for tannins

The ferric chloride test was adopted to determine tannins. 2 ml of 0.1% ferric chloride was added to 2 ml of the sample extract, which was then observed for Reddish-brown colouration, indicating the presence of tannins [8].

Table 1 Percentage composition of Doum Palm and Turmeric Blend

Samples	% Composition of Doum Palm	% Composition of Turmeric
Sample A	100%	0%
Sample B	80%	20%
Sample C	60%	40%
Sample D	50%	50%

Test for saponins

0.1 ml of the sample extract was dissolved in a test tube with 10 ml of distilled water, then 2 ml of distilled water was added, and it was agitated for 60 s. The presence of saponin indicated the production of a persistent 1-cm layer of foam [9].

Test for flavonoids and glycosides

The alkaline reagent test was used during the alkaloids test. 2 ml of the sample extract was treated with 2–3 drops of a 10% sodium hydroxide solution. The formation of an intense yellow colour, which becomes colourless with the addition of a few drops of dilute sulphuric acid, indicates the presence of flavonoids [10].

Test for Anthraquinone

Using a modified version of Bontrager's test, 5 ml of plant extract was added to chloroform and agitated for 5 min. The mixture was then filtered, and 2 ml of a 10% ammonia solution was added afterwards. A pink or red colouration will indicate the presence of anthraquinone [11].

Test for terpenoids

The presence of terpenoids was determined by using the Salkowski test. 0.5 mL of a crude extract with 2 mL of chloroform and 2 mL of concentrated sulfuric acid was added. An appearance of reddish-brown in the interface indicated the presence of terpenoids [11].

Test for glycosides

When 1 mL of distilled water and NaOH were added to 0.5 mL of crude extract, a yellowish color formed, which indicated the presence of glycosides [12].

Test for Phenols

1 mL of the extract was combined with three drops of 0.1% $FeCl_3$. The presence of a greenish-brown color indicated the presence of phenol [13].

Proximate Analysis of Doum Palm Fruit Blend Turmeric Powder

The proximate compositions of doum palm fruit blend with turmeric powder were determined using standard analytical methods. All measurements were done in triplicates, and values were presented in percentages [14, 15].

Determination of moisture content

A platinum plate was weighed and dried in an oven for 1 h at 105° C before being cooled at room temperature in a desiccator for 30 min and weighed. In the platinum dish, 2 g of the sample blend was inserted. The dish containing the sample blend was dried for 2 h at 105 degrees Celsius, cooled in a desiccator, and weighed [16]. The

moisture content will then be determined using the following formula:

$$\text{Moisture}\% = \frac{W_1 - W_2}{W_2} \times 100\%$$

Where W_1 = Weight of the sample before drying.
W_2 = Weight of the sample after drying.

Determination of Ash Content

The ash content was determined by igniting 2 g of the sample blend in a muffle furnace at 550 °C for 2 h until a black colour developed. The residue was weighed after cooling in desiccators [17]. Using a conventional calculation, the difference in weight before and after the burning operation yields the per cent ash content:

$$\text{Total ash}\ (\%) = \frac{\text{Ash weight}}{\text{Sample weight}} \times 100\%$$

Determination of protein content

The protein content was determined as follows: 1 g of sample blend transferred into the Kjeldal flask (500 mL) with 25 ml of concentrated sulfuric acid, 25 ml of H_2SO_4, and 0.1 g of copper sulfate. The mixture was then heated gently so that it would cease to be a loose pear-shaped stopper in the top of the flask, and then it was heated more strongly so that the liquid would boil at a moderate temperature. The flask was then shaken from time to time, and the heating was continued for 3 h at 400 °C until the liquid became clear. 200 ml of the digest was transferred to the distillation flask, followed by 85 mL of 50% sodium hydroxide. So, the dilute digest will mix up; rinse with 50 ml of dilution H_2O. The distillation apparatus was connected to the delivery tube, which was dipped in 50 ml of 2% boric acid and placed into the receiving flask. The ammonia liberated was distilled into the boric acid solution; after reaching 250 mL, it was opened, and the condenser was washed down into the delivery tube and then received. The distillate was then titrated with 0.02 M hydrochloric acid. The blank did not exceed 0.5 ml. The nitrogen in the sample was then calculated (1 ml, 0.02 M hydrochloric acid) [18]. The percentage of crude protein content was calculated using the following formula:

$$\text{Nitrogen}\ \% = \frac{\text{Titre value} \times 0.0014}{\text{Sample weight}} \times 100\%$$

$$\text{Protein}\ \% = \text{Nitrogen}\% \times 6.25\ (\text{protein conversion factor})$$

Determination of Fat Content

The fat content was determined using the Gerber method.: 2 g of sample blend was weighed into a clean, dry test tube. Then, 10 ml of distilled water and 10 ml of conc. HCl were added and placed in a boiling water bath for 30 min for hydrolysis. The hydrolyzed sample was cooled and transferred to the separating funnel. The test tube was rinsed with 10 ml of ethanol and added to the experimental separating funnel. Then, 30 ml of diethyl ether was added and shaken, which was allowed to settle for separation to occur. A clean, dry, empty conical flask was weighed as W_1. The ether layer was collected in a pre-weighed flask, and the combined ether extract was evaporated over a boiling water bath. After evaporation, the evaporated conical flask was placed in an oven maintained at 105 °C for 2 h, after which it was cooled at the desiccator and weighed again as W_2 [18].

$$\text{Fat content}\% = \frac{W_2 - W_1}{\text{Weight of the sample}}$$

Determination of the total carbohydrate content

To test for carbohydrates in the sample, 2 ml of Fehling's solutions A and B were mixed with 2 ml of sample blend extract. After that, the solution was placed in a boiling water bath for 10 min. The formation of a crimson precipitate indicated the presence of carbohydrates.

The carbohydrate content of the test sample was determined by estimation using the arithmetic difference method [19, 20].

Total carbohydrates = 100 − (% Moisture + % crude fat + % crude protein +% ash content).

Gas Chromatography-Mass Spectrometry Analysis of Doum Palm Fruit Blend with Turmeric Powder

Utilizing a combined 7890 A gas chromatograph and mass spectrophotometer, GC-MS analysis was performed. The apparatus was equipped with an HP-5 MS fused silica column (5% phenyl methyl siloxane, 30.0 m × 250 µm, film thickness 0.25 µm), which was interfaced with a 5675 C Inert MSD featuring a triple-axis detector. As a carrier gas, helium gas was employed, and its column velocity flow was set at 1.0 milliliters per minute. Additional GC-MS parameters include a 250 °C ion-source temperature, a 300 °C interface temperature, a 16.2 psi pressure, a 1.8 mm out time, and a 1 µl split mode injector with a 1:50 split ratio and a 300 °C injection temperature. After five minutes at 36 °C, the temperature in the column increased to 150 volts at a rate of 4 °C per minute. The temperature was raised to 250 degrees Celsius at a rate of 20 degrees Celsius per minute and kept for 5 min. The entire time for elution was 47.5 min [21].

Table 2 Phytochemical screening of ethanolic extract of samples A-D

Phytochemical components	Test	Observations	Inferences			
			A	B	C	D
Alkaloids	Mayer- Wanger's test	Reddish-brown precipitate	-	+	+	+
Anthraquinone	Borntrager's test	Red coloration	+	+	+	+
Flavonoids/Glycoside	Alkaline reagent test	Yellow coloration	+	+	+	+
Saponin	Froth test	Presence of foam precipitate	+	+	+	+
Tannin	Ferric-chloride test	Reddish-brown coloration	+	+	+	+
Terpenoids	Salkowski test	Reddish-brown	+	+	+	+
Phenol	Ferric chloride test	Greenish- brown	+	+	+	+

Note + = Phytochemical detected (present); - = Phytochemical was not detected (absent)

Table 3 Phytochemical screening of hot water extract of samples A-D

Phytochemical components	Test	Observations	Inferences			
			A	B	C	D
Alkaloids	Mayer-Wanger'stest	Reddish-brown precipitate	-	+	+	+
Anthraquinone	Bontrager's test	Red coloration	+	+	+	+
Flavonoids/Glycoside	Alkaline reagent test	Yellow coloration	+	+	+	+
Saponin	Froth test	Presence of foam precipitate	+	+	+	+
Tannin	Ferric-chloride test	Reddish-brown coloration	+	+	+	+
Terpenoids	Salkowski test	Reddish-brown	++	++	++	++
Phenol	Ferric chloride test	Greenish- brown	++	++	++	++

Note + = Phytochemical detected (present); - = Phytochemical was not detected (absent)

Statistical analysis

Descriptive analysis was done using bar graphs and tables. Data were analysed using the Microsoft Excel 2019 version.

Results and discussion

Phytochemical screening

Tables 2 and 3 show the phytochemical composition of the ethanol and aqueous extracts of samples A—D of doum palm blended with turmeric powder. The results revealed the presence of alkaloids, anthraquinone, glycoside, saponins, tannins, terpenoids, and phenol in the ethanol extracts of samples B, C, and D, with the absence of alkaloids in sample A alone, which is 100% doum palm.

The result also revealed the presence of alkaloids, saponins, terpenoids, and flavonoids in the aqueous extract, with the absence of alkaloids in sample A, which is also 100% doum palm.

The results showed that these phytochemical compounds, phenols, tannin, flavonoids, anthraquinone, terpenoids, saponin, and glycosides are present in samples B, C, and D. The previous study [22] on the phytochemical composition of crude mesocarp extract of *H. thebaica* revealed the presence of tannins, saponins, steroids, glycosides, flavonoids, and terpenoids. Also, another study conducted by Ahamefula and Dahiru with Nadro [23, 24] shows the presence of phenols, tannin, flavonoids, anthraquinone, terpenoids, saponin, and glycosides in turmeric powder and doum palm fruit, respectively. Sample A, which contains 100% doum palm content, shows the absence of alkaloids. This study agrees with a study previously reported [25], which recorded the absence of alkaloids in the aqueous and organic extract of *H. thebaica*, doum palm fruit.

Other samples, which are a mixture of doum palm and turmeric at different ratios, show the presence of alkaloids, phenols, tannin, flavonoids, anthraquinone, terpenoids, saponin, and glycosides. In a similar study [26], alkaloids, flavonoids, terpenoids, and saponin in doum palm (*H. thebaica)* were reported previously. However, glycosides were not detected, which was detected in this study. Different phytochemicals have been reported to have various medicinal and antioxidant activities. These include peptides, alkaloids, glycopeptides, triterpenoids, amino acids, steroids, xanthone, flavonoids, lipids, phenolics, coumarins, iridoids, alkyl disulfides, inorganic ions, and guanidines, which are extracted from different parts of the various plants (root, stem, leaf, flower, fruit, and other) [27, 28].

The present study indicates that the doum palm and turmeric blend would have improved synergistic, therapeutic, and medicinal potential [29].

Proximate Analysis of Doum palm fruit blend with turmeric powder

The proximate composition of the doum palm fruit blend with turmeric powder is presented in Table 4.

Table 4 shows the moisture content of each sample 1–4. Sample A, with the highest moisture content of 15.11, comprises doum palm fruit only (100%), while other

Table 4 Proximate composition of doum palm fruit blend with turmeric powder

Content (%)	Sample A	Sample B	Sample C	Sample D
Moisture	15.11	2.66	13.91	14.51
Ash	2.62	8.80	11.76	10.78
Fat	2.37	4.75	3.40	1.47
Protein	1.54	0.87	0.99	0.80

samples B, C and D have moisture content of 2.66, 13.91 and 14.51. Sample B contains 80% doum palm fruit blend in 20% turmeric; sample C contains 60% doum palm fruit and 40% turmeric; and sample D contains 50% doum palm fruit and 50% turmeric. As seen from the above table, there is not much difference between samples A, C, and D. However, sample 2 seems to have a much lower moisture content than the others, which may be because of operational or instrumentational errors. Sample A, which is 100% doum palm have the highest moisture content; this is higher than some previous studies found in the literature; Hussein reported a moisture content of 11.50% in doum palm fruit [30], Reda reported a moisture content of 10.15% of doum palm fruit [31], FAO reported 4.00%, [32], Abdel-Rahman reported 5.47% [33] and Aboshora reported 5.50% moisture content of doum palm fruit [34]. However, Aremu and Fadele have also recorded a higher moisture content of 24.05% of doum palm fruit [35]. Moisture content measures the water content in a sample, which reflects the sample's degree of hydration or dehydration. The variation in the moisture content of the fruit could be due to the extent of dying before analysis.

The percentage ash content of samples A-D are 2.62, 8.80, 11.76, and 10.78. The results show that sample A, 100% doum palm, has the lowest ash content. This is lower than the previous result [17, 31] in which ash content of 6.24% and 9.57% of doum palm fruit were recorded. In addition, it can be observed that the different ratios of doum palm fruit to turmeric affect the overall ash content of the samples; the increase in the percentage of turmeric has a greater impact on the ash content than the increase in the percentage of doum palm fruit.

Table 5 Total Carbohydrate and Total Energy content

Sample	Total Carbohydrate content (%)	Total Energy content (kcal/g)
Sample 1	78.43	341.46
Sample 2	81.58	372.5
Sample 3	69.63	313.5
Sample 4	74.23	313.4

The fat contents for sample A-D are 2.37%, 4.75%, 3.40%, and 1.47%. Sample B, with a fat content of 4.75%, has the highest value, followed by sample C, which has 3.40%; sample A, which has 2.37%; and sample D, which has a 1.47% yield.

The percentage protein content for sample A-D includes the following1.54, 0.87, 0.99, and 0.80. in comparison to the previous work reported in the literature, Reda presented 2.87% of crude protein in doum palm fruit [31], Datti presented 2.86% of crude protein in doum palm [17], and Ahamefula presented 9.40% of protein content in Turmeric [23]. From the present results, there seems to be not much difference in the values, which means that the protein content of the samples is not affected by the amount of turmeric or doum palm fruit in the samples. However, the protein content can be influenced by other factors, such as the source of the raw materials and the processing methods. Figure 3 shows the bar chart representation of the proximate analysis of sample A-D.

Total carbohydrate and energy content

The result of the percentage of total carbohydrate and energy content of doum palm blend with turmeric powder is shown in Table 5.

From the result, the total carbohydrate and total energy content of each sample A-D are 78.43%/341.46 kcal/g, 81.58%/372.5 kcal/g, 69.63%/313 kcal/g and 74.23%/313.4 kcal/g respectively (Fig. 4). The previous

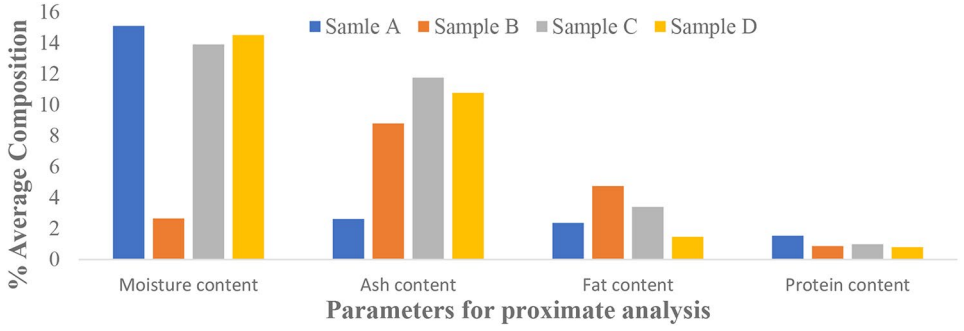

Fig. 3 Bar chart representation of the proximate analysis of doum palm fruit blend with Turmeric powder

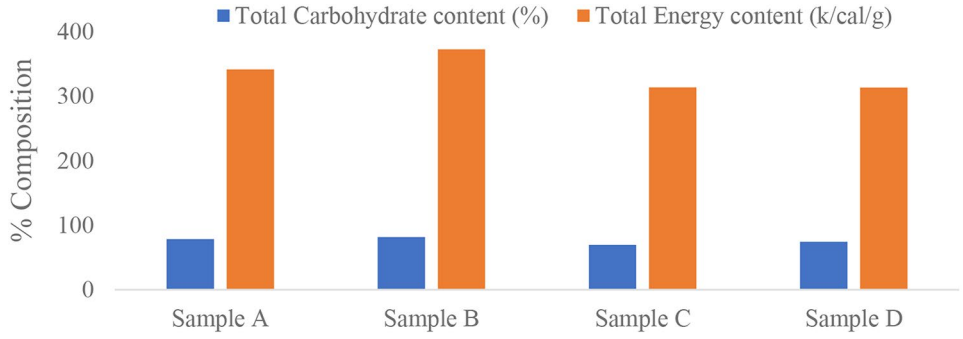

Fig. 4 Bar chart representation of the total carbohydrate content (%) and the total energy content (kcal/g)

Table 6 GC-MS analysis of Sample A (100% doum palm fruit) – bioactive compounds

S/N	Compound Name	Molecular Formula	Molecular Weight	*R*/T	Area%
1	Cis-1,2-Cyclohexanediol	$C_6H_{12}O_2$	116	3.588	0.37
2	1,3-Cyclopentanedione	$C_5H_6O_2$	98	3.650	2.66
3	Glycerin	$C_3H_8O_3$	92	4.275	1.79
4	Cyclopentanol	$C_5H_{10}O$	86	4.506	9.46
5	2-ethyl-4-methyl-1-Pentanol	$C_8H_{18}O$	130	4.894	1.53
6	2,3-Hexanedione	$C_4H_6O_3$	102	5.145	3.91
7	Propanoic acid	$C_6H_8O_3$	128	5.180	1.28
8	Furaneol	$C_3H_6N_6$	126	5.370	3.39
9	1,3,5-Triazine	$C_7H_8O_2$	124	5.673	6.73
10	2-methoxyphenol	C_4H_8O	72	5.765	1.09
11	Cyclopropylcarbonyl	$C_{10}H_{18}0_3$	186	5.906	3.08
12	2-methylbutanoic anhydride	$C_6H_8O_4$	144	6.292	0.61
13	4 H-Pyran-4-one	$C_6H_{10}O_3$	130	6.634	0.89
14	Ethylacetoacetate	$C_6H_6O_3$	126	7.387	0.82
15	5-Hydroxymethyl-1-furfural	$C_{15}H_{30}$	210	7.771	4.83
16	1-Pentadecene	$C_8H_{16}O_2$	144	10.031	1.09
17	Acetic acid	$C_{19}H_{38}$	266	11.856	0.89
18	1-Nonadecene	$C_7H_{24}O_6$	194	12.560	0.99
19	Alpha-D-Glucopyranoside	$C_{19}H_{38}$	226	13.337	3.20
20	1-Nonadecene	$C_{16}H_{32}O_2$	256	14.909	0.97
21	n-Hexadecanoic acid	$C_{18}H_{36}O_2$	284	17.364	7.03
22	Ethyl ester	$C_{21}H_{44}$	296	17.771	2.54
23	Heneicosane	$C_{18}H_{32}O_2$	280	17.882	0.71
24	9,12-Octadecadienoic acid	$C_{18}H_{34}O_2$	282	19.525	3.90
25	Oleic acid	$C_{20}H_{36}O_2$	308	19.592	3.78
26	Linoleic acid	$C_{20}H_{38}O_2$	310	19.820	1.45
27	Ethyl oleate	$C_{20}H_{38}O_2$	310	19.893	1.53
28	Tetrapentacontane	$C_{19}H_{38}O_4$	330	22.518	1.18
29	Hexadecanoic acid	$C_{24}H_{38}O_4$	390	23.245	0.87
30	Bis(2-ethylhexyl) phthalate	$C_{35}H_{62}O_3$	530	23.413	2.62

research on doum palm fruit [17] showed a total carbohydrate content of 68.49%, and another research on turmeric powder [23] showed a total carbohydrate content of 67.38%. This present study shows that sample B has the highest carbohydrate content of 81.58%, and sample C has the lowest carbohydrate content of 69.63%. Sample B has the highest outcome for the energy content with 372.5 kcal/g, followed by sample A with 341.46 kcal/g. Likewise, sample C had 313.5 kcal/g, and sample D had a value of 313.4 kcal/g.

Table 7 GC-MS analysis of sample B (80:20% doum palm fruit: turmeric powder) – bioactive compounds

S/N	Compound Name	Molecular Formula	Molecular Weight	*R*/T	Peak Area %
1	Eucalyptol	$C_{10}H_{18}O_2$	170	4.995	0.39
2	4-Hydroxy-2-methylacetophenone	$C_9H_{10}O_2$	150	9.004	5.14
3	Alpha-Curcumene	$C_{15}H_{22}$	202	11.253	1.03
4	2,4-Bis(1,1-dimethyl)-phenol	$C_{14}H_{22}O$	206	11.549	0.37
5	Alpha- Bisabolol	$C_{15}H_{26}O$	222	11.809	1.06
6	Carotol	$C_{15}H_{22}O$	218	12.904	0.80
7	Turmerone	$C_{12}H_{18}O$	178	13.542	39.22

Gas Chromatography-Mass Spectrometry (GC-MS) analysis

The GC-MS result of the analysis conducted on sample A, which contains 100% doum palm, identifies the presence of 30 phytochemical compounds, which have been known to have various therapeutic properties and more antioxidants [36]. The retention time and the peak area with the various molecular weights of these bioactive compounds are shown in Table 6.

The GC- MS result of the analysis conducted on sample B, which contains 80% doum palm and 20% turmeric, identifies the presence of 7 additional phytochemical compounds which are not present in sample A; these are Eucalyptol, 4-Hydroxy-2-methylacetophenone, Alpha-curcumene, 2,4-Bis (1,1-dimethyl)-phenol, Alpha-Bisabolol, Carotol and Turmerone which are alkaloids and terpenoids which are known for their antioxidants activity and therapeutic potentials. The retention time, along with the peak area with the various molecular weights of these bioactive compounds, is shown in Table 7.

The GC-MS result of the analysis conducted on samples C and D identifies the same additional phytochemical compounds as present in sample B, which are Eucalyptol,

Table 8 Medicinal Application of Phytochemicals Present in Doum Palm Fruit Blend with Turmeric Powder

S/*N*	Compound Name	*R*/T	Peak Area%	Medicinal application
1. 21	n-Hexadecanoic acid	17.364	7.03	Cancer prevention agent, hypocholesterolemic nematicide, pesticide, hostile to androgenic flavor, hemolytic, 5-Alpha reductase inhibitor [36].
2. 1	Cis-1,2-Cyclohexanediol	3.588	0.37	Anti-cancer, anti-infective drugs - useful in the production of dihydroaetemisinin, and dihydroartemisitene drugs
3. 2	1,3-Cyclopentanedione	3.650	2.66	Used as insecticide and for acaricidal purposes
4. 3	Glycerin	4.275	1.79	Food, cosmetics and pharmaceuticals
5. 22	Ethyl ester	17.771	2.54	Cancer prevention agent, hypocholesterolemic nematicide, pesticide, hostile to androgenic flavor, hemolytic, 5-Alpha reductase inhibitor [39].
6. 23	Heneicosane	17.882	0.71	Used as insecticide and for acaricidal purposes
7. 24	9,12-Octadecadienoic acid	19.525	3.90	hepatoprotective, nematicide, insectifuge, antihistaminicantieczemic, antiacne, antiandrogenic, antiarthritic, anticoronary, and insectifuge [36].
8. 25	Oleic acid	19.592	3.78	Antiinflammatory, Cancer-Preventive, Choleretic, Dermatitigenic Flavor, Hypocholesterolemic, Insectifuge, Irritant [40].
9. 27	Ethyl oleate	19.893	1.53	Flavoring and fragrance agents, drug preparation, lubricants and plasticizers
10.	Eucalyptol	4. 995	0.39	Anti-inflammatory and antioxidant effects are present in various diseases, including respiratory diseases, pancreatitis, colon damage, and cardiovascular diseases.
11.	Alpha-Curcumene			Anti-inflammatory, Cancer-Preventive, Choleretic, Dermatitigenic Flavor [41]

4-Hydroxy-2-methylacetophenone, Alpha-curcumene, 2,4-Bis (1,1-dimethyl)-phenol, Alpha-Bisabolol, Carotol and Turmerone, totally different from those identified in sample A; these phytochemical compounds fall to the class of alkaloids and terpenoids which are known for their antioxidants activity and therapeutic potentials. Previous research on the GC-MS analysis conducted by Abdallah [37] and Arivoli [38] also confirms the presence of these bioactive compounds in doum palm fruits and turmeric powder, respectively. The present research (samples B, C, and D) identified two compounds, Eucalyptol and Carotol, that have not been identified before. Table 8 shows some medicinal and pharmaceutical applications of some selected phytochemicals in doum palm fruit blended with turmeric powder.

Conclusion

As the pharmaceutical industry shifts its focus toward natural products and botanicals for drug discovery and health promotion, this study's findings provide valuable insights. The synergies in phytochemical and mineral composition between doum palm fruit and turmeric powder highlight the possibility of developing innovative medicinal formulations. The antioxidant and anti-inflammatory capabilities make this mix an appealing candidate for formulations addressing oxidative stress and inflammation-related illnesses or as a complementing element in nutraceutical therapies.

With its intrinsic therapeutic properties, the doum palm fruit and turmeric blend appears promising for future pharmacological research and formulation development.

Acknowledgements
The authors would like to show appreciation to the Department of Chemistry, Air Force Institute of Technology, Kaduna, for unwavering cooperation in supporting research that provided the facilities necessary to accomplish the desired aim of this research. The authors also acknowledge Miss Abasiediuem Eddion's technical efforts in making the research a success.

Author contributions
ATO conceived the idea for this research and proposed the research design. ATO, OOJ and SM supervised the research and were major contributors to writing the original manuscript. ATO, JM, and JPS conducted the experiment, analyzed, and interpreted the research data. OOJ carried out a critical review of the revised manuscript and was a major contributor to editing it. All authors read and approved the final manuscript.

Funding
This research did not receive any funding.

Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Received: 30 May 2024 / Accepted: 23 July 2024
Published online: 29 July 2024

References

1. Niranjan A, Prakash D. Chemical constituents and biological activities of turmeric (*Curcuma longa L.*) - a review. J Food Sci Technol. 2008;45(2):109–16.
2. Omayma AE, Nahla AA, Abdel-Nasser BS, Mohamed MA. Potential antioxidant phenolic metabolites from doum palm leaves. Afr J Pharm Pharmacol. 2009;3(4):158–64. http://www.academicjournals.org/ajpp.

3. Hossam SE, Heba IM, Hany NY, Eman MF. Biological Activities of the Doum Palm (*Hyphaene thebaica L.*) Extract and Its Bioactive Components. Intechopen Journal of Antioxidant in Food and its Application, Chapt. 3. https://doi.org/10.5772/intechopen.74772.
4. Zhang Y, McClain SA, Lee HM, Elburki MS, Yu H, Gu Y, et al. A novel chemically modified curcumin normalizes wound-healing in rats with experimentally induced type I diabetes: initial studies. J Diabetes Res. 2016;216:5782904. https://doi.org/10.1155/2016/5782904.
5. El-Saadony MT, Yang T, Korma SA, Sitohy M, Abd El-Mageed TA, Selim S, Al Jaouni SK, Salem HM, Mahmmod Y, Soliman SM, Mo'men SA, Mosa WF, El-Wafai NA, Abou- Aly, Sitohy HE, El-Hack BA, El-Tarabily ME, K. A., Saad AM. Impacts of turmeric and its principal bioactive curcumin on human health: Pharmaceutical, medicinal, and food applications: A comprehensive review. *Front. Nutr* 2023;9:1040259. https://doi.org/10.3389/fnut.2022.1040259.
6. Senhaji S, Lamchouri F, Bouabid K, Assem N, El Haouari M, Bargach K, Toufik H. Phenolic contents and antioxidant properties of Aqueous and Organic extracts of a Moroccan Ajugaiva Subsp. Pseudoiva. J Herbs Spices Med Plants. 2020;26(3):248–66. https://doi.org/10.1080/10496475.2019.1709249.
7. Dubale S, Kebebe D, Zeynudin A, Abdissa N, Suleman S. Phytochemical screening and antimicrobial activity evaluation of selected Medicinal plants in Ethiopia. J Experimental Pharmacol. 2023;15:51–62. https://doi.org/10.2147/jep.s379805.
8. Seow LJ, Hooi K, Amirin S, Mohd ZA. Preliminary phytochemical and physicochemical characterization of Gynura Segetum (Lour) Merr (Compositae) Leaf. Trop J Pharm Res. 2013;12(5):777–ISSN782. https://doi.org/10.4314/tjpr.v12i5.18.
9. Kumari P, Kumari C, Singh PS. Phytochemical screening of selected Medicinal plants for secondary metabolites. Int J Life-Sciences Sci Res. 2017;3(4):1151–7. https://doi.org/10.21276/ijlssr.2017.3.4.9.
10. Yadav R, Khare RK, Singhal A. Qualitative phytochemical screening of some selected Medicinal plants of Shivpuri District (M.P). Int J Life-Sciences Sci Res. 2017;3(1). https://doi.org/10.21276/ijlssr.2017.3.1.16.
11. Evans WC. Trease and Evans Pharmacognosy. 15th ed. London: Saunders; 2002. pp. 42–4.
12. Kancherla N, Dhakshinamoothi A, Chitra K, Komaram RB. Preliminary Analysis of Phytoconstituents and Evaluation of Anthelminthic Property of Cayratia auriculata (in Vitro). J Clin Med. 2019. https://doi.org/10.26574/maedica.2019.14.4.350.
13. Anoma GS, Kumari A. Alcoholic extraction and phyto-chemical evaluation of chakramarda seeds (cassia toralinn). Int J Res Ayurveda Pharm. 2017;8(3):157–61. https://doi.org/10.7897/2277-4343.083190.
14. Shumaila G, Mahpara S. Proximate composition and mineral analysis of cinnamon. Pakistan J Nutr. 2009;8:1456–60.
15. Oluduro AO. Evaluation of antimicrobial properties and nutritional potentials of Moringa oleifera Lam. Leaf in South Western Nigeria. Malaysian J Microbiol. 2012;8(2):59–67.
16. Association of Official Analytical Chemists (AOAC). Official method of analysis. (15th Edition), Washington D.C. Journal of Medicinal Plants Research. 2003;4(4): 212.
17. Datti Y, Ibrahim MI, Salihu MI, Abdulhad MM, Muhammad SM, Abubakar SA, Halima S, Ahmad UU, Nura T. Mineral Content, Proximate Composition and the antioxidant properties of the ethanol extract of Hyphaene the baicaL. From Gezawa Town, Kano State, Nigeria. Asian J Appl Chem Res. 2020;6(2):33–40. https://doi.org/10.9734/AJACR/2020/v6i230157.
18. Siddeeg A, Salih ZA, Al-Farga A, Ata-Elfadeel EMA, Ali AO. Physiochemical, nutritional and functional properties of doum (Hyphenethebaica) powder and its application in some processed food products. J Nutri Food Sci Forecast. 2019;2(1):1009.
19. De Conto LC, Gragnani MAL, Maus D, Ambiel HCI, Chiu MC, Grimaldi R, Goncalves L. A. G. characterization of crude 62 watermelon seed oil by two different extraction methods. J Am Oil Chemists' Soc. 2011;88:1709–14.
20. James CS. Analytical chemistry of food. London: Champman and Hall; 1995. pp. 64–5.
21. Olivia NU, Goodness UC, Obinna OM. Phytochemical profiling and GC-MS analysis of aqueous methanol fraction of Hibiscus asper leaves. Future J Pharm Sci. 2021;7(1). https://doi.org/10.1186/s43094-021-00208-4.
22. Auwal MS, Sanda KA, Mairiga IA, Lawan FA, Mutah AA, Tijjani AN, et al. The Phytochemical, Elemental and hematologic evaluation of crude Mesocarp Extract of Hyphaene thebaica (doumpalm) in Wistar albino rats. Asian J Biochem. 2013;8(1):14–23. https://doi.org/10.3923/ajb.2013.14.23.
23. Ahamefula I, Onwuka GI, Nwankwo C. Nutritional Composition of Tumeric (*Curcuma longa*) and its Antimicrobial properties. Int J Sci Eng Res. 2014;5:10.
24. Dahiru MM, Nadro MS. Phytochemical composition and antioxidant potential of Hyphaene thebaica Fruit. Borneo J Pharm. 2022;5(4):325–33. https://doi.org/10.33084/bjop.v5i4.3632.
25. Sani I, Abdulhamid A, Bello F, Fakai IM, Nassir SA. Phytochemical compositions and in Vitro antioxidant potentials of some wild Edible fruits found in Northern Part of Nigeria. Acta Velit. 2015;1(4):100–7.
26. Abubakar S, Etim VA, Usman AB, Isyaku A, Sabo BB. Nutraceutical potential of two wild edible fruits growing in Sub-sahara Region of Nigeria. Am J Environ Sci Eng. 2017;1(2):52–8. https://doi.org/10.11648/j.ajese.20170102.14.
27. Yatoo MI, Saxena A, Gopalakrishnan A, Alagawany M, Dhama K. Promising antidiabetic drugs, Medicinal Plants and herbs: an update. Int J Pharmcol. 2017;13(7):732–45. https://doi.org/10.3923/ijp.2017.732.745.
28. Manivannan V, Johnson M. Total accepted phenolic, tannin, triterpenoid, flavonoid and sterol contents, anti-diabetic, anti-inflammatory and cytotoxic activities of Tectariaparadoxa (Fee.) Sledge. Toxicol Rep. 2020;7:1465–8. https://doi.org/10.1016/j.toxrep.2020.10.013.
29. Rani R, Sharma D, Chaturvedi M, Yadav JP. Phytochemical Analysis, antibacterial and antioxidant activity of Calotropis procera and Calotropis gigantea. Nat Prod J. 2019;9(1):47–60. https://doi.org/10.2174/2210315508666180608081407.
30. Hussein AM, Salah ZA, Hegazy NA. Physicochemical, sensory and functional properties of wheat-doum fruit flour composite cakes. Pol J Food Nutr Sci. 2010;60(3):239–44.
31. Reda AA. Physicohemical properties of Doum (*Hyphaene thebaica*) fruits and utilization of its flour in formulating some functional foods. Alexandria J Food Sci Technol. 2015;12(2):29–33.
32. FAO. Composition and characteristics of selected palm products. FAO Corporate Document Repository. Forestry Department. Tropical Palm. FAO. Rome. Italy; 2006.
33. Abdel-Rahman N, Awad I, Elshafe'a B. Characterization of some Sudanese edible forest fruits. J Agri-Food Appl Sci. 2014;2:39–44.
34. Aboshora W, Lianfu Z, Dahir M, Gasmalla MA, Musa A, Omer E, Thapa M. Physicochemical, nutritional and functional properties of the Epicarp, flesh and pitted sample of Doum fruit (*Hyphaene thebaica*). J Food Nutr Res. 2014;2(4):180–6.
35. Aremu AK, Fadele OK. Study of some properties of doum palm fruit (HyphaenethebaicaMart.) In relation tomoisture content. Afr J Agric Res. 2011;6(15):3597–602. https://doi.org/10.5897/AJAR11.247. Available online at. http://www.academicjournals.org/AJARDOI.
36. Azhagu MS, Vijayakumar S, Sripriya R, Rajalakshmi S. Phytochemical screening and GC–MS analysis of Bioactive compounds Present in Ethanolic Leaf Extract Murraya koenigii. Bull. Env Pharmacol Life Sci. 2021;10(4):158–64.
37. Abdallah EM, Mujawah AAH, Al-Mijalli SH. GC-MS and antibacterial potential of Methanolic Extract of *Hyphaene thebaica L*. Fruit Pulp against antibioatics-resistant pathogens. J Pure Appl Microbiol. 2021;15(3):1655–64. https://doi.org/10.22207/JPAM.15.3.62.
38. Arivoli S, Tennyson S, Divya S, Rani S, Marin G. GC-MS analysis of bioactive compounds of *Curcuma longa* Linnaeus (Zingiberaceae) rhizome extract. J Pharmacognosy Phytochemistry. 2019;8(6):49–52. Available online at phytojournal.com.
39. Priyanka G, Rohit C, Lavanya V, Ethnobotany, Phytochemical. Pharmacological potentials of *Murraya koenigii*, and its health benefits – A review. Curr J Appl Sci Technol. 2020;39(26):29–38. Article no. CJAST.60532; ISSN: 2457 – 1024.
40. Laxman S, Vijapur N, Jayadev, Hiremath N, Nikhil B, Bonageri, Anitha R, Desai. *Murraya Koenigii*: Biogenic Synthesis of Silver nanoparticles and their cytotoxic effects against Mda-Mb-231, human breast Cancer cell lines. World J Pharm Med Res. 2019;5(6):206–11.
41. El-Saadony MT, Yang T, Korma SA, Sitohy M, Abd El-Mageed TA, Selim S, Al Jaouni SK, Salem HM, Mahmmod Y, Soliman SM, Mo'men SAA, Mosa WFA, El-Wafai NA, Abou-Aly HE, Sitohy B, Abdel-Hack ME, El-Tarabily KA, Saad AM. Impacts of turmeric and its principal bioactive curcumin on human health: Pharmaceutical, medicinal, and food applications: a comprehensive review. Front Nutr. 2023;9:1040259. https://doi.org/10.3389/fnut.2022.1040259.

Publisher's Note