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Characterisation and comparative quality assessment of edible oils from *Adansonia digitata* L. and *Carthamus tinctorius* L. seeds found in Kogi state, Nigeria

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Abstract

Background This study investigates the quality of *Adansonia digitata* L. and *Carthamus tinctorius* L. edible oils from Kogi state, Nigeria. Percentage oil yield, physicochemical properties, mineral content, antioxidant activity and chemical composition were analysed using standard analytical methods and GC-MS. Significant differences ($P \leq 0.05$) were found between samples.

Results *Adansonia digitata* L. seed oil had the highest percentage of oil yield (38.12%). *Adansonia digitata* L. seed oil had the least analysed physicochemical properties including, specific gravity (0.79 ± 0.01), peroxide value (1.14 ± 0.05 mEqO₂/kg), iodine value (86.72 ± 0.80 g/100 g), saponification value (198.24 ± 1.10 mgKOH/g), acid value (0.82 ± 0.02 mgKOH/g), free fatty acid ($0.46 \pm 0.01\%$), refractive index (1.46 ± 0.03) and viscosity index ($35.05 \pm 0.53\%$). *Adansonia digitata* L. seed oil had the highest potassium, sodium and magnesium, while phosphorus, calcium, iron and zinc were highest in *Carthamus tinctorius* L. seed oil. Both samples showed good antioxidant activity, with *Adansonia digitata* L. seed oil being more effective. GC-MS showed that palmitic acid (18.35%) was most abundant in *Adansonia digitata* L. seed oil, while linoleic acid (25.69%) was in *Carthamus tinctorius* L. seed oil.

Conclusion The findings from this study revealed that these edible oils are rich sources of nutritional and pharmaceutical properties.

Research Highlight

This study evaluates the nutritional and chemical quality of *Adansonia digitata* L. (baobab) and *Carthamus tinctorius* L. (safflower) seed oils sourced from Kogi State, Nigeria, with a focus on their oil yield, physicochemical properties, mineral content, antioxidant activity and chemical composition. Notably, *Adansonia digitata* oil yielded the highest oil content (38.12%) and exhibited superior antioxidant activity. It also had lower physicochemical indices such as peroxide, iodine and acid values, indicating greater oxidative stability. Mineral analysis revealed that

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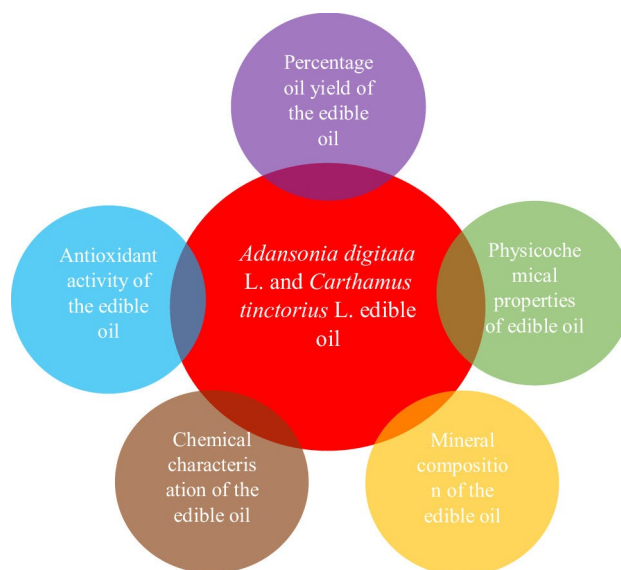
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Adansonia digitata oil was richer in potassium, sodium, and magnesium, whereas *Carthamus tinctorius* had higher levels of calcium, phosphorus, iron, and zinc. GC-MS profiling identified palmitic acid as the dominant fatty acid in *Adansonia digitata* L. and linoleic acid in *Carthamus tinctorius* L. These findings highlight the nutritional and therapeutic potential of both oils for use in functional foods and nutraceutical applications.

Keywords Percentage oil yield, Physicochemical properties, Mineral content, Antioxidant activity, Chemical composition

Graphical Abstract



Background

Edible oilseeds are a crucial component of the human diet, providing essential fatty acids, vitamins, minerals, phytosterols, polyphenols, and amino acids that are vital for maintaining good health (Li et al. 2020). It provides consumers with oils and fats that satisfy their industrial, medicinal, and nutritional needs (Lamani et al. 2021). In our daily lives, edible oils are essential. The quality of oilseeds determines the quality of edible oils. These oilseeds, which are utilised as components in traditional cuisines as well as for oil extraction, include sunflower, peanut, safflower, baobab, sesame, melon seeds, palm kernel, and African oil bean seeds, among others.

One of the oldest oil crops in the world, safflower (*Carthamus tinctorius* L.) is a member of the Compositae family. It is found in many parts of the world, including Europe, Argentina, the United States, Canada, Australia, Bangladesh, Pakistan, India, Afghanistan, the Middle East, Thailand, China, Japan, Ethiopia, Sudan, Tanzania, Kenya, and Tunisia (Chakradhari et al. 2020). It is primarily cultivated for its oil-rich seeds, which find extensive use in industries like pharmaceuticals, cosmetics, food, and feed. There are numerous medical applications for *Carthamus tinctorius* L. oil in various nations. The oil is used in India to cure rheumatism and sores and in Iran to treat liver and cardiac conditions. Depending on the

safflower type, soil quality, climate and other factors, the seed oil content can range from 24 to 36% (Ergönül and Özbek 2020). The largest market for safflower oil, which is used to make margarine and as cooking and salad oil, has been established in developed nations. Its high ratio of polyunsaturated/saturated fatty acids makes it non-allergenic and one of the healthiest oils for human consumption (Ergönül and Özbek 2020).

In India and Africa, traditional medicine views the *Adansonia digitata* L. tree as both symbolic and vital. It is thought to have existed for more than 4,000 years. According to Silva et al. (2023), eight species of the genus *Adansonia*, which is a member of the Malvaceae family, have been found in numerous African nations. The savannas of sub-Saharan Africa are home to the species *Adansonia digitata* L., which is indigenous to the African continent. Baobab is the common name for it (Silva et al. 2023). The essential oil product baobab seed oil has experienced a notable upsurge in global markets. Its remarkable ability to enhance attractiveness has led to its considerable attention in ethnobotany and ethnopharmacology. Baobab seed oil is a useful functional ingredient in creating cosmetic formulations since it has occlusive, moisturising, and nourishing qualities when applied (Komane et al. 2023). Approximately 33% of baobab seed oil consists of oleic and linoleic acids. Research has

shown that diets rich in these acids can enhance the suppleness, hydration, and renewal of the skin's outermost layer. Furthermore, it has been shown that baobab seed oil promotes the development and renewal of epithelial tissues. Baobab seed oil is also used in the production of toothpaste, soaps and lubricants. It has also been used to treat wounds, varicose veins, and muscle spasms (Ofori et al. 2023).

The novelty of this research lies in its focus on the quality assessment of edible oils from *Adansonia digitata* and *Carthamus tinctorius*, specifically grown in Kogi State, Nigeria, a region where the unique agro-ecological conditions have not been extensively studied regarding these edible oils. Additionally, the research provides a comparative analysis of these two edible oils within the same geographic framework, which has not been previously explored.

Although safflower and baobab are both recognised for their excellent oil content, little research has been done to assess the oilseeds' nutritional value, fatty acid composition, and oil yield in this specific area. This study closes a large gap in the literature by providing fresh perspectives on how regional environmental factors could affect the biochemical characteristics of these edible oils. A major knowledge gap about Kogi State's potential as a supplier of premium edible oils is created by the lack of localised data. This research aims to comparatively evaluate the quality of *Adansonia digitata* and *Carthamus tinctorius* edible oils found in Kogi State, Nigeria.

Materials and methods

Materials

All chemical compounds, reagents and solvents used in the experiment were acquired from Sigma-Aldrich (St. Louis, MO, U.S.A.). These included hydrochloric acid, sodium thiosulphate, potassium hydroxide, potassium iodide, glacial acetic acid, chloroform, carbon tetrachloride, ethanol, nitric acid, perchloric acid, n-hexane and DPPH (2,2-diphenyl-1-picrylhydrazyl). All of the reagents were of analytical reagent grade.

Instruments

A Shimadzu UV-1900 UV-VIS Spectrophotometer was used to analyse the samples' vitamin content. This instrument's double-beam optical technology improves baseline stability and measurement accuracy by compensating for variations in light intensity and wavelength. A high-sensitivity photomultiplier tube (PMT) detector is also included. Both the visible and ultraviolet portions of the spectrum are covered by the UV-1900, which measures wavelengths between 190 and 1100 nm. The device ensures accurate readings with its excellent wavelength precision, often within ± 0.3 nm or greater. While the photometric range is normally between -4.0 and 4.0

Absorbance Units (AU), the spectral bandwidth spans from 0.1 nm to 5 nm. For the UV-1900, Shimadzu also offers a range of alternatives and accessories, such as multiple cuvette types, sample holders, temperature control accessories, and more.

A Scitek Atomic Absorption Spectrometer, Model SP-AA3618, was used to analyse the samples for mineral content. This instrument features a double beam, eight lamp supports, and an air/acetylene burner. Additionally, it has a Czerny-Turner type monochromator with a focal length of 350 mm. The wavelength range of this spectrometer is 185–900 nm, and its precision is 0.15 nm, with a repeatability of ≤ 0.05 nm. Spectral bandwidth variation is ± 0.02 nm, and the external dimensions are $830 \times 650 \times 60$ (W x D x H). To ensure accuracy, the instrument uses deuterium background correction. Additionally, the photometer's optics are protected from dust and corrosive gases.

The GC-MS Agilent Technologies, Model-7890 A, the Gallenkamp oven (Model: 800-NE1V.32E-00), the Brookfield DV2T viscometer, and the water bath (Mettler model WTB24), were additional instruments utilised.

Methods

Sample collection

Matured accessions of Safflower (*Carthamus tinctorius* L.) and Baobab (*Adansonia digitata* L.) oilseeds were randomly collected from local Farms in Lokoja, Kogi State, specifically the communities of Adankolo and Felele, were sampled from May 18th to 24th, 2023. These samples were cleaned by brushing off soil particles and transported to the laboratory for analysis at a tropical ambient temperature.

Sample preparation

Baobab (*Adansonia digitata* L.) and safflower (*Carthamus tinctorius* L.) grains were separated,

and decaying grains and undesired items were removed. Following a three-day air-drying period, the grains were manually separated from their shells. A pestle and mortar were then used to crush the dried safflower and baobab oilseeds into a powder, which was then sieved through a 250 μ m sieve to create fine flour.

Oil extraction

Following the procedure outlined by AOAC (2005), n-hexane was used to extract the oils from safflower and baobab. Inside the Soxhlet extractor, 100 g of the ground seeds were wrapped in muslin cloth. Eight hours were spent using n-hexane as the extraction solvent. After the time was up, the solvent was extracted using a rotary evaporator, and any leftover oil was oven-dried for an hour at 75 °C. After that, the extracted oil was placed in a desiccator to cool to ambient temperature before being

analysed. Using the following formula, the percentage of oil yield in the examined samples was determined:

$$\% \text{ Oil yield} = \frac{W_1 - W_2}{W_1} \times 100 \quad (1)$$

Where W_1 and W_2 are the weights of samples before and after extraction, respectively.

Physicochemical analysis

The specific gravity, peroxide value, iodine value, saponification value, acid value, free fatty acid and viscosity index were determined using standard analytical methods as outlined by Onwuka (2005).

Determination of mineral concentration

The mineral analysis protocol of the AOAC (2005) was followed when digesting the samples. 1.00 g of the sample was placed in a 250 mL beaker following its pulverisation and weighing. A combination of 15.00 mL of nitric acid (HNO_3) and 5.00 mL of perchloric acid was added to a beaker. After ensuring the mixture was properly blended, it was heated on a hot plate until a clear digest formed. After cooling, the digest was quantitatively filtered into a 100 mL volumetric flask. To prepare for trace metal analysis, the filtrate was brought up to the 100 mL mark to be aspirated into the AAS device (Scitek Atomic Absorption Spectrometer, Model SP-AA3618).

Characterisation of the chemical composition of the samples using gas chromatography-mass spectrometry (GC-MS) analysis

Using the methodology described by Okpala et al. (2022), the chemical composition of baobab (*Adansonia digitata* L.) and safflower (*Carthamus tinctorius* L.) was analysed. For this investigation, an Agilent Technologies 5975 C mass spectrometer and a GC-MS Agilent Technologies Model 7890 A gas chromatograph were used. An HP-5MS capillary column for gas chromatography was employed; it was 30 m long, with an internal diameter of 0.320 mm and a film thickness of 0.25 μm . The carrier gas was helium, which had an average velocity of 43.311 cm/sec when the pressure was set at 1.5 PSI and the flow rate was kept at 1.4123 mL/min. After two minutes at 80 degrees Celsius, the temperature was set to rise to 240 $^{\circ}\text{C}$ at a rate of 10 $^{\circ}\text{C}/\text{min}$. A split ratio of 50:1 and a split flow rate of 70.615 mL/min were established. One

microliter of the sample was injected. After the full chromatogram was automatically integrated, the contents were determined by comparing the GC-MS data with the public mass spectrum database (NIST 11.L) and available literature.

Antioxidant activity

DPPH-radical scavenging (DPPH-RS) activity

The DPPH-RS activity of the samples was assessed using the procedure outlined by Behbahani and Fooladi (2018). 0.1 cm^3 of the sample and 3.9 cm^3 of a methanolic DPPH solution (0.12 mM) were mixed in a test tube. After giving the mixture a good shake, it was left in a dark place for half an hour. Lastly, a Shimadzu UV-1900 UV-VIS Spectrophotometer was used to measure the absorbance at 517 nm to evaluate the radical-scavenging activity.

$$\text{DPPH} - \text{radical scavenging activity (\%)} = \frac{\text{Absorbance of control} - \text{Absorbance of sample}}{\text{Absorbance of control}} \times 100 \% \quad (2)$$

Statistical analysis

Results were statistically analysed using Duncan's multiple range test, mean, standard deviation, and analysis of variance (ANOVA) to determine the significance level between different samples. Significance was established at $p < 0.05$.

Results

Percentage oil yield of baobab (*Adansonia digitata* L.) and safflower (*Carthamus tinctorius* L.) seed oils

The oil yield percentages for *Adansonia digitata* L. and *Carthamus tinctorius* L. seed oils are shown in Table 1. The seeds of *Adansonia digitata* L. demonstrated a significantly higher oil yield of 38.12% compared to the 35.45% yield from *Carthamus tinctorius* L. seeds. These values indicate that both seeds allow for efficient oil recovery.

Physicochemical properties of baobab (*Adansonia digitata* L.) and safflower (*Carthamus tinctorius* L.) seed oils

The physicochemical properties of *Adansonia digitata* L. (baobab) and *Carthamus tinctorius* L. (safflower) oils, as shown in Table 2, revealed significant differences across all assessed parameters ($p < 0.05$). The specific gravity of *A. digitata* oil was notably lower (0.79 ± 0.01) than that of *C. tinctorius* oil (0.92 ± 0.03). The peroxide value was significantly lower in *A. digitata* oil (1.14 ± 0.05 mEq O_2/kg) compared to *C. tinctorius* oil (4.40 ± 0.05 mEq O_2/kg). Conversely, the iodine value was considerably higher in *C. tinctorius* oil (116.25 ± 0.43 g $\text{I}_2/100$ g) than in *A. digitata* oil (86.72 ± 0.80 g $\text{I}_2/100$ g). Similarly, the saponification value of *C. tinctorius* oil (208.12 ± 0.54 mg KOH/g) surpassed that of *A. digitata* oil (198.24 ± 1.10 mg KOH/g). In terms of acidity, *C. tinctorius* oil exhibited a

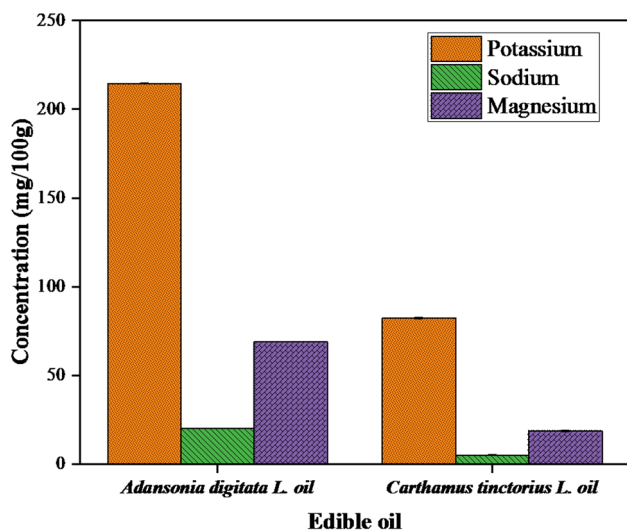
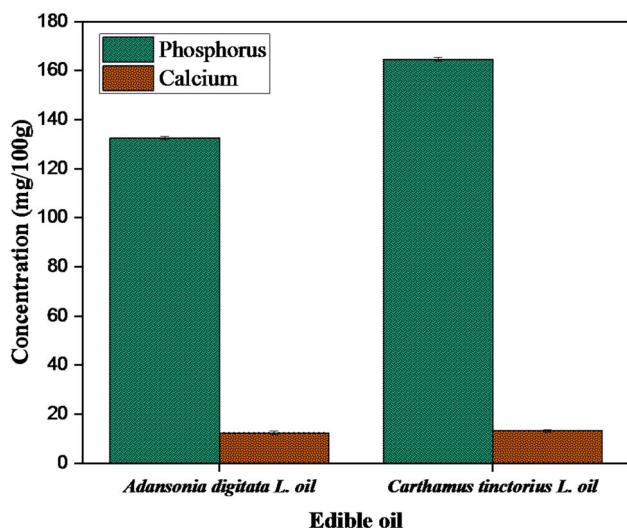
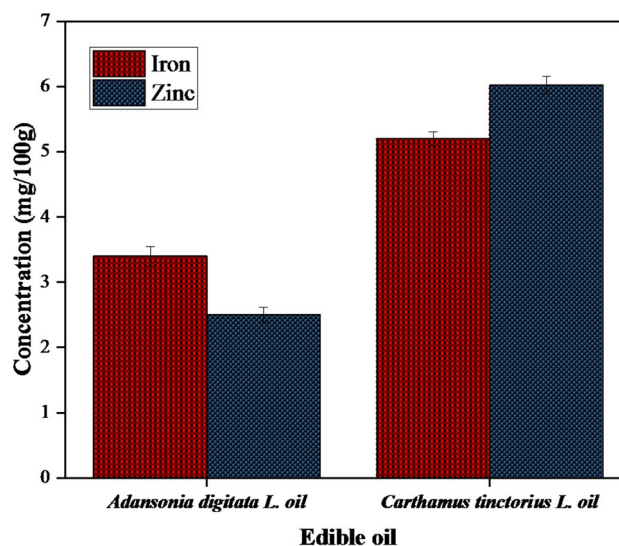
Table 1 Percentage oil yield of baobab (*Adansonia digitata* L.) and safflower seeds (*Carthamus tinctorius* L.) oilseeds

Samples	Weight of samples	% Oil yield	Colour of oil
<i>Adansonia digitata</i> L.	100 g	38.12	Golden-yellow
<i>Carthamus tinctorius</i> L.	100 g	35.45	Pale yellow

Table 2 Physicochemical properties of baobab (*Adansonia digitata* L.) and safflower oil (*Carthamus tinctorius* L.)

Parameters	<i>Adansonia digitata</i> L.	<i>Carthamus tinctorius</i> L.
Specific gravity	0.79 ± 0.01	0.92 ± 0.03
Peroxide value (mEqO ₂ /Kg)	1.14 ± 0.05	4.40 ± 0.05
Iodine value (g/100 g)	86.72 ± 0.80	116.25 ± 0.43
Saponification value (mg KOH/g)	198.24 ± 1.10	208.12 ± 0.54
Acid value (mg KOH/g)	0.82 ± 0.02	1.22 ± 0.04
Free fatty acid (%)	0.46 ± 0.01	0.66 ± 0.01
Refractive index	1.46 ± 0.03	1.48 ± 0.02
Viscosity index (cP)	35.05 ± 0.53	43.8 ± 0.45

Value: mean ± standard deviation

**Fig. 1** The potassium, sodium and magnesium content of *Adansonia digitata* L. and *Carthamus tinctorius* L. oil seeds**Fig. 2** The phosphorus and calcium content of *Adansonia digitata* L. and *Carthamus tinctorius* L. oil seeds**Fig. 3** The iron and zinc content of *Adansonia digitata* L. and *Carthamus tinctorius* L. oil seeds

slightly higher acid value (1.22 ± 0.04 mg KOH/g) and free fatty acid content ($0.66 \pm 0.01\%$) compared to *A. digitata* oil (0.82 ± 0.02 mg KOH/g and $0.46 \pm 0.01\%$, respectively). The refractive index of *C. tinctorius* oil (1.48 ± 0.02) was higher than that of *A. digitata* oil (1.46 ± 0.03), while its viscosity (43.8 ± 0.45 cP) was also greater than that of *A. digitata* oil (35.05 ± 0.53 cP).

Mineral content of baobab (*Adansonia digitata* L.) and safflower (*Carthamus tinctorius* L.) seed oils

The mineral profiles of *Adansonia digitata* L. (baobab) and *Carthamus tinctorius* L. (safflower) oilseeds, as illustrated in Figs. 1, 2 and 3, showed statistically significant differences ($p < 0.05$) for all measured elements. *A. digitata* oil displayed notably higher concentrations of potassium (214.60 ± 0.20 mg/100 g), sodium (20.16 ± 0.19 mg/100 g) and magnesium (68.95 ± 0.25 mg/100 g) compared to *C. tinctorius* oil, which contained 82.38 ± 0.54 mg/100 g, 5.25 ± 0.16 mg/100 g and 18.84 ± 0.55 mg/100 g of these minerals, respectively. On the other hand, *C. tinctorius* oil had significantly higher levels of phosphorus (164.64 ± 0.85 mg/100 g), calcium (13.20 ± 0.50 mg/100 g), iron (5.20 ± 0.11 mg/100 g) and zinc (6.02 ± 0.13 mg/100 g) compared to *A. digitata* oil, which contained 132.50 ± 0.66 mg/100 g, 12.37 ± 0.80 mg/100 g, 3.40 ± 0.15 mg/100 g and 2.50 ± 0.12 mg/100 g, respectively. These findings emphasise the distinct mineral compositions of the two oils, each offering specific nutritional benefits.

Table 3 Characterisation of the chemical composition of baobab (*Adansonia digitata* L.) seed oil using gas chromatography-mass spectrometry (GC-MS)

S/N	Compound	RT	% Composition	Formula	Class of compound
1	N-Methylpyrrolidinone	3.923	0.19	C ₅ H ₉ NO	Cyclic amide
2	Methyl palmitate	13.215	10.91	C ₁₇ H ₃₄ O ₂	Fatty acid methyl ester
3	Elaidic acid	13.558	0.23	C ₁₈ H ₃₄ O ₂	trans-monounsaturated fatty acid.
4	Ethyl palmitate	13.782	15.01	C ₁₈ H ₃₆ O ₂	Fatty acid ethyl ester
5	Palmitic acid	13.948	18.35	C ₁₆ H ₃₂ O ₂	saturated fatty acids
6	Cetylic acid	14.051	5.94	C ₁₆ H ₃₂ O ₂	saturated fatty acids
7	Myristic acid	14.274	1.15	C ₁₄ H ₂₈ O ₂	saturated fatty acids
8	Methyl 9,12-octadecadienoate	14.600	12.04	C ₁₉ H ₃₄ O ₂	Fatty acid methyl ester
9	Methyl oleate	14.651	7.54	C ₁₉ H ₃₆ O ₂	Fatty acid methyl ester
10	Methyl stearate	14.789	1.43	C ₁₉ H ₃₈ O ₂	Fatty acid methyl ester
11	Hexadecanoic acid	14.852	0.32	C ₁₆ H ₃₂ O ₂	saturated fatty acids
12	Ethyl linoleate	15.109	12.85	C ₂₀ H ₃₆ O ₂	Fatty acid ethyl ester
13	Ethyl Oleate	15.161	8.58	C ₂₀ H ₃₈ O ₂	Fatty acid ethyl ester
14	Ethyl stearate	15.298	1.89	C ₂₀ H ₄₀ O ₂	Fatty acid ethyl ester
15	Telfairic acid	15.973	0.22	C ₁₈ H ₃₂ O ₂	unsaturated fatty acid
16	cis-11-Hexadecenal	16.105	0.21	C ₁₆ H ₃₀ O	unsaturated aldehydes
17	1-Methyltetralin	17.987	0.57	C ₁₁ H ₁₄	aromatic hydrocarbons
18	Glycerol β-palmitate	18.439	0.75	C ₁₉ H ₃₈ O ₄	Fatty acid ethyl ester
19	Cyclamal	20.070	0.51	C ₁₃ H ₁₈ O	aromatic aldehydes
20	4-(3,4-Dihydroxy-2-oxobutyl amino)-benzotriazole	20.808	0.21	C ₁₁ H ₁₂ N ₂ O ₃	aromatic amines
21	Z-6-Pentadecen-1-ol acetate	21.157	0.45	C ₁₇ H ₃₂ O ₂	acetate esters

Characterisation of the chemical composition of baobab (*Adansonia digitata* L.) seed oil and safflower (*Carthamus tinctorius* L.) seed oil using gas chromatography-mass spectrometry (GC-MS)

The chemical composition of *Adansonia digitata* L. (baobab) and *Carthamus tinctorius* L. (safflower) seed oils, as shown in Tables 3 and 5, and summarised in Tables 4 and 6, was analysed using gas chromatography-mass spectrometry (GC-MS). This analysis revealed distinct profiles for each oil. *Adansonia digitata* L. oil contained 21 identified compounds, which made up 98.27% of its total composition. The predominant constituents of *A. digitata* L. oil included palmitic acid (18.35%), ethyl palmitate (15.01%), ethyl linoleate (12.85%), methyl 9,12-octadecadienoate (12.04%), methyl palmitate (10.91%), and ethyl oleate (8.58%). In contrast, *Carthamus tinctorius* L. oil comprised 16 compounds, accounting for 99.51% of its total composition. The major components of *C. tinctorius* L. oil were linoleic acid (25.69%), stearic acid (21.13%), linolenic acid (19.09%) and elaidic acid (18.78%). Fatty acids and their esters comprised the majority of both oils' compositions, accounting for 97.21% in *A. digitata* L. and 97.43% in *C. tinctorius*. These findings highlight the compositional diversity and potential functional applications of these two seed oils.

Discussions

Percentage oil yield of baobab (*Adansonia digitata* L.) and safflower (*Carthamus tinctorius* L.) seed oils

Table 1 shows the percentage oil yield of the oilseeds. Compared to *Carthamus tinctorius* L. (safflower), which had a percentage oil yield of 35.45%, *Adansonia digitata* L. (baobab) had the highest oil yield percentage (38.12%). These outcomes surpass the oil yield of 33.88% reported by Idris et al. (2020) for *Adansonia digitata* L. The carotenoid and pigment content, which influences oil quality and application, may also be the cause of the colour difference between safflower oil (pale yellow) and baobab oil (golden yellow) (Dodoo et al. 2022).

Physicochemical properties of baobab (*Adansonia digitata* L.) and safflower (*Carthamus tinctorius* L.) seed oils

The physicochemical properties of *Adansonia digitata* L. (baobab) and *Carthamus tinctorius* L.

(safflower) oils, as presented in Table 2, indicate a significant difference ($p < 0.05$) that influences their industrial and nutritional applications.

The specific gravity of *Adansonia digitata* L. (baobab) edible oils (0.79 ± 0.01) is considerably lower than that of *Carthamus tinctorius* L. (safflower) edible oils (0.92 ± 0.03). The outcome is similar to the baobab oil's 0.874 that Idris et al. (2020) found. According to Halilu and Muhammad (2024), this suggests a reduced density, which is advantageous for the food sector.

Table 4 Summary of the chemical composition of baobab (*Adansonia digitata* L.) seeds oil

S/N	Class of compound	% Composition
1	Amines	0.40
2	Fatty acids and fatty acid esters	97.21
3	Esters	0.45
4	Aldehydes	0.21
	Total	98.27

Peroxide value, a major indicator of oxidative stability, is much lower in *Adansonia digitata* L. edible oils (1.14 ± 0.05 mEqO₂/Kg) compared to *Carthamus tinctorius* L. edible oils (4.40 ± 0.05 mEqO₂/Kg). The result is similar to the 1.15 ± 0.46 mEqO₂/Kg that Ndiaye et al. (2022) found for *Adansonia digitata* L. at 30 °C. According to Ofori et al. (2023), this suggests that *Adansonia digitata* L. has a longer shelf life and superior oxidative stability.

The iodine value, which indicates the level of unsaturation, appears to be much higher in *Carthamus tinctorius* L. oil (116.25 ± 0.43 g/100 g) compared to *Adansonia digitata* L. oil (86.72 ± 0.80 g/100 g). This outcome is similar to the 128.51 ± 0.85 mg KOH/g of Wei safflower seed oil that Song et al. (2023) obtained using n-hexane extraction. According to Tulashie et al. (2022), this suggests that *Carthamus tinctorius* L. oil contains a greater number of unsaturated fatty acids, which makes it more oxidation-prone but beneficial for cardiovascular health.

The saponification value, which is a measure of the molecular weight of fatty acids, is higher in the *Carthamus tinctorius* L. oil (208.12 ± 0.54 mg KOH/g) than in *Adansonia digitata* L. oil (198.24 ± 1.10 mg KOH/g). This outcome is similar to the 184.67 ± 3.43 mg KOH/g of cold-pressed extracted Wei safflower seed oil that Song et al. (2023) obtained. This suggests that oil from *Carthamus tinctorius* L. contains fatty acids with shorter chains, which makes it suitable for use in soap and cosmetics (Mirghani and Elmoghtaba 2024).

The acid value of *Carthamus tinctorius* L. oil (1.22 ± 0.04 mg KOH/g) is slightly higher compared to *Adansonia digitata* L. oil (0.82 ± 0.02 mg KOH/g). The outcome is similar to the 0.90 mg KOH/g of safflower seed oil from an Ethiopian cultivar that Al Surmi et al. (2015) obtained, implying that the oil of *Adansonia digitata* L. might last longer than that of *Carthamus tinctorius* L. (Rahnama et al. 2024).

Free fatty acid, an indicator of oil freshness and quality, is slightly lower in *Adansonia digitata* L. ($0.46 \pm 0.01\%$) compared to *Carthamus tinctorius* L. oil ($0.66 \pm 0.01\%$). The outcome is similar to the $0.45 \pm 0.08\%$ baobab seed oil that Nkafamiya et al. (2007) obtained. According to Msalilwa et al. (2020), this implies that *Adansonia digitata* L. is safer, more stable, and of higher quality than the other oils.

Refractive index, an important parameter for determining purity, composition and quality of oil samples, was higher in *Carthamus tinctorius* L. oil (1.48 ± 0.02) compared to *Adansonia digitata* L. (1.46 ± 0.03). The outcome was similar to Ergönül and Özbek (2020) findings of 1.473–1.476 of cold-pressed safflower oil. This refractive index indicates a normal saturation level because it is within the permissible range for safflower, baobab, and other vegetable oils. Compared to *Carthamus tinctorius* L. oil, *Adansonia digitata* L. oil is comparatively more stable due to its lower RI, which suggests a better-balanced mix of monounsaturated and polyunsaturated fatty acids (Ghareeb et al. 2020).

The viscosity index of the *Carthamus tinctorius* L. oil (43.8 ± 0.45 cP) was higher than that of *Adansonia digitata* L. oil (35.05 ± 0.53 cP). The outcome is similar to the 46.6 ± 1.393 cP that Iskakov et al. (2023) found for the physical properties of safflower oil before filtering. This suggests that compared to the other examined oils, *Carthamus tinctorius* L. oil has a more consistent mouthfeel and texture, better cooking performance, and higher storage stability (César and Maia Campos 2020).

Mineral content of baobab (*Adansonia digitata* L.) and safflower (*Carthamus tinctorius* L.) seed oils

Figures 1, 2 and 3 show the mineral concentration of baobab (*Adansonia digitata* L.) and safflower (*Carthamus tinctorius* L.) oilseeds. This analysis revealed significant differences ($p < 0.05$) in nutritional profiles.

The *Adansonia digitata* L. seeds oil (214.60 ± 0.20 mg/100 g) showed a higher potassium concentration than the *Carthamus tinctorius* L. oilseeds (82.38 ± 0.54 mg/100 g). However, the outcome is less than the 506.20 ± 0.15 mg/100 g of oil from *Adansonia digitata* seeds that Oyeleke et al. (2012) reported. According to research, oils derived from *Adansonia digitata* L. are superior to the other oils examined in terms of preserving osmotic balance, promoting neuronal function, and stimulating enzymes in the human body (D'Elia 2024). The World Health Organisation (2004) recommends that adults have 2000 mg of potassium per day, while children should get 1000 mg.

The *Adansonia digitata* L. seeds oil (20.16 ± 0.19 mg/100 g) showed a higher sodium concentration than the *Carthamus tinctorius* L. oilseeds (5.25 ± 0.16 mg/100 g). The outcome is similar to the 22.56 ± 0.12 mg/100g *Adansonia digitata* L. oilseeds that Erwa et al. (2019) reported. According to Tremblay et al. (2024), this implies that the oil extracted from *Adansonia digitata* L. seeds is superior to the other oil samples examined in terms of encouraging muscle contraction, controlling blood pressure, facilitating nutritional absorption and bolstering neuron function. The

World Health Organisation (WHO 2004) recommends consuming fewer than 2 g of salt per day.

The *Adansonia digitata* L. seeds oil (68.95 ± 0.25 mg/100 g) showed a higher magnesium concentration than the *Carthamus tinctorius* L. oilseeds (18.84 ± 0.55 mg/100 g). Compared to the 51.67 ± 2.89 mg/100g *Adansonia digitata* L. oilseeds published by Babalola et al. (2021), this finding is higher. According to the results, compared to the other oil samples examined, the oil from *Adansonia digitata* L. seeds may be more advantageous for bone formation, blood glucose control, cardiovascular health, and muscle performance (Nielsen 2024). The World Health Organisation (WHO 2004) states that 80–320 mg of magnesium should be consumed daily.

The seed oil of *Carthamus tinctorius* L. demonstrated a higher phosphorus content (164.64 ± 0.85 mg/100 g) than that of *Adansonia digitata* L. (132.50 ± 0.66 mg/100 g). This outcome surpasses that of safflower oil that was solvent extracted (52.1 ± 0.72 mg/kg) and expeller pressed (24.1 ± 0.08 mg/kg) as reported by Mihaela et al. (2013). This implies that, in comparison to the other examined oil samples, *Carthamus tinctorius* L. is more advantageous for the growth of strong bones and teeth, energy production, cell repair and DNA creation (Idiyevna 2024). It also helps with nerve function and metabolism. The World Health Organisation (WHO) advises adults and children to consume 800 mg of magnesium per day (WHO 2004).

The seed oil of *Carthamus tinctorius* L. demonstrated a higher calcium content (13.20 ± 0.50 mg/100 g) than that of *Adansonia digitata* L. (12.37 ± 0.80 mg/100 g). This outcome is similar to the 110 ± 0.1 ppm *Carthamus tinctorius* L. oilseeds that Mariod et al. (2012) reported. This suggests that, in comparison to the other oil sample examined, *Carthamus tinctorius* L. may be advantageous for the formation of strong bones and teeth, as well as for muscular function, nerve signalling, blood coagulation, and heart health (Wawrzyniak and Suliburska 2021). Calcium intake should be between 500 and 800 mg per day for children and 1,000 mg per day for adults (WHO 2004).

The seed oil of *Carthamus tinctorius* L. demonstrated a higher iron content (5.2 ± 0.11 mg/100 g) than that of *Adansonia digitata* L. (3.4 ± 0.15 mg/100 g). This outcome is similar to the 6.3 mg/100 g oilseeds of *Carthamus tinctorius* L. that Barashovets and Popova (2016) reported. Compared to the other oil sample that was examined, *Carthamus tinctorius* L. is probably more effective at boosting the immune system, facilitating oxygen transport, avoiding anaemia, and promoting brain function (Dixit et al. 2021). According to the World Health Organisation (WHO), children should strive for

13.7 to 15.1 mg of iron per day, while adults should eat 17.0 to 18.9 mg (WHO 2004).

The seed oil of *Carthamus tinctorius* L. demonstrated a higher zinc content (6.02 ± 0.13 mg/100 g) than that of *Adansonia digitata* L. (2.50 ± 0.12 mg/100 g). This outcome is similar to the 6.17 ± 0.3 mg/100 g cold-pressed oil from *Carthamus tinctorius* L. seeds that Ergönül and Özbek (2020) reported. According to Totten et al. (2023), this suggests that *Carthamus tinctorius* L. may be more advantageous than the other oil samples examined in terms of immunological function, growth, wound healing, brain health, reproductive health, skin maintenance, and metabolism. According to the World Health Organisation (WHO, 2004), children should consume between 3 and 8 mg of zinc daily, while adults should consume 8 to 11 mg.

Characterisation of the chemical composition of baobab (*Adansonia digitata* L.) seed oil and safflower (*Carthamus tinctorius* L.) seed oil using gas chromatography-mass spectrometry (GC-MS)

The chemical compositions of *Adansonia digitata* L. seed oil and *Carthamus tinctorius* L. seed oil were analysed using Gas Chromatography-Mass Spectrometry (GC-MS), with the resulting spectra depicted in Figs. 4 and 5. The findings from this analysis are summarised in Tables 3 and 5. The *Adansonia digitata* L. seed oil contained twenty-one compounds, which accounted for 98.27% of the total composition. In contrast, the *Carthamus tinctorius* L. seed oil consisted of sixteen compounds, which represented 99.51% of its overall composition, as shown in Tables 4 and 6. The *Adansonia digitata* L. seed oil contained a high concentration of palmitic acid (18.35%), ethyl palmitate (15.01%), ethyl linoleate (12.85%), methyl 9,12-octadecadienoate (12.04%), methyl palmitate (10.91%) and ethyl oleate (8.58%) making them the most prevalent compounds in the edible oil. The primary constituents of the *Carthamus tinctorius* L. seed oil was linoleic acid, accounting for 25.69% of the total compounds, stearic acid (21.13%), linolic acid (19.09%) and linoelaidic acid (18.78%). *Adansonia digitata* L. seed oil and *Carthamus tinctorius* L. seed oil belonged to distinct groups of compounds. The *Adansonia digitata* L. seed oil was primarily composed of fatty acids and fatty acid esters (97.21%), with smaller amounts of amines and amides (0.40%), esters (0.45%) and aldehydes (0.21%). On the other hand, the *Carthamus tinctorius* L. seed oil was mainly composed of fatty acids and fatty acid esters (97.43%), with small amounts of amines (0.32%), terpenoids (0.43%) and alkanes (1.33%). Upon comparing the composition of *Adansonia digitata* L. seed oil and *Carthamus tinctorius* L. seed oil, it was found that palmitic acid and linolic acid are the predominant constituents in both samples, with a higher content

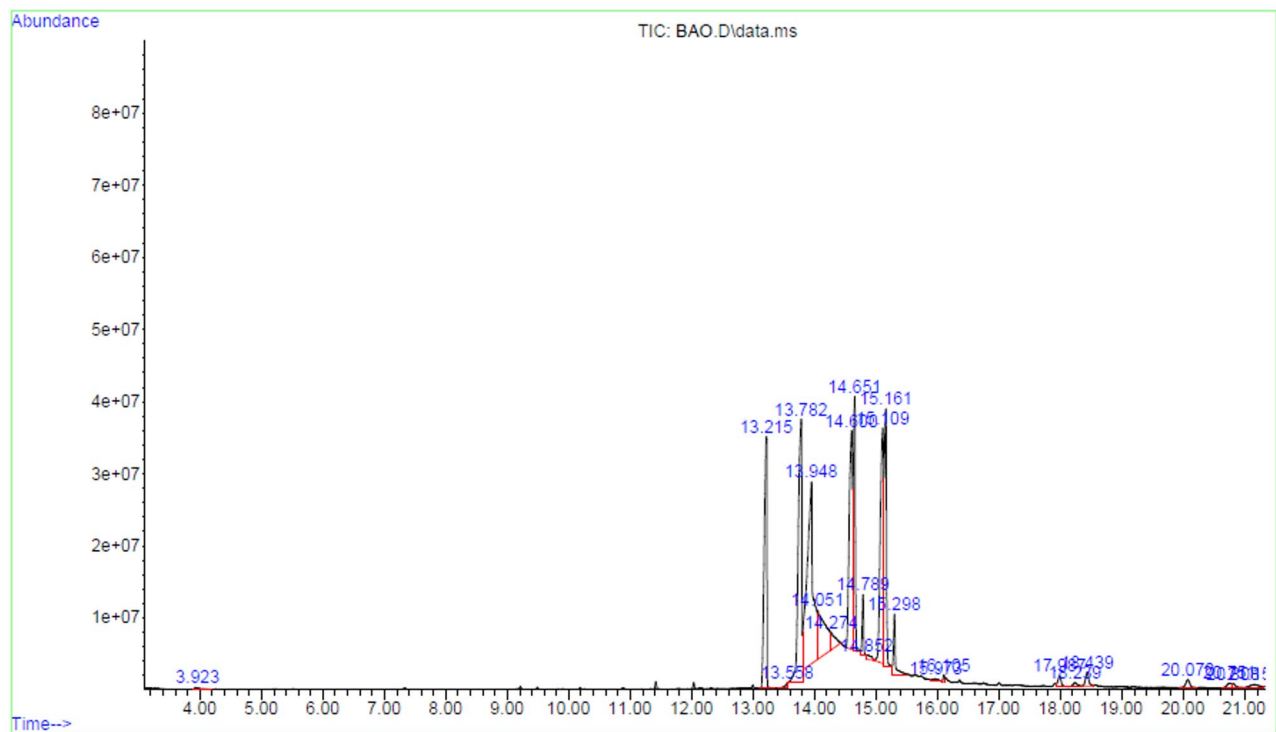


Fig. 4 Spectra of the characterisation of the Chemical Composition of Baobab (*Adansonia digitata* L.) seed oil using Gas chromatography-Mass spectrometry (GC-MS)

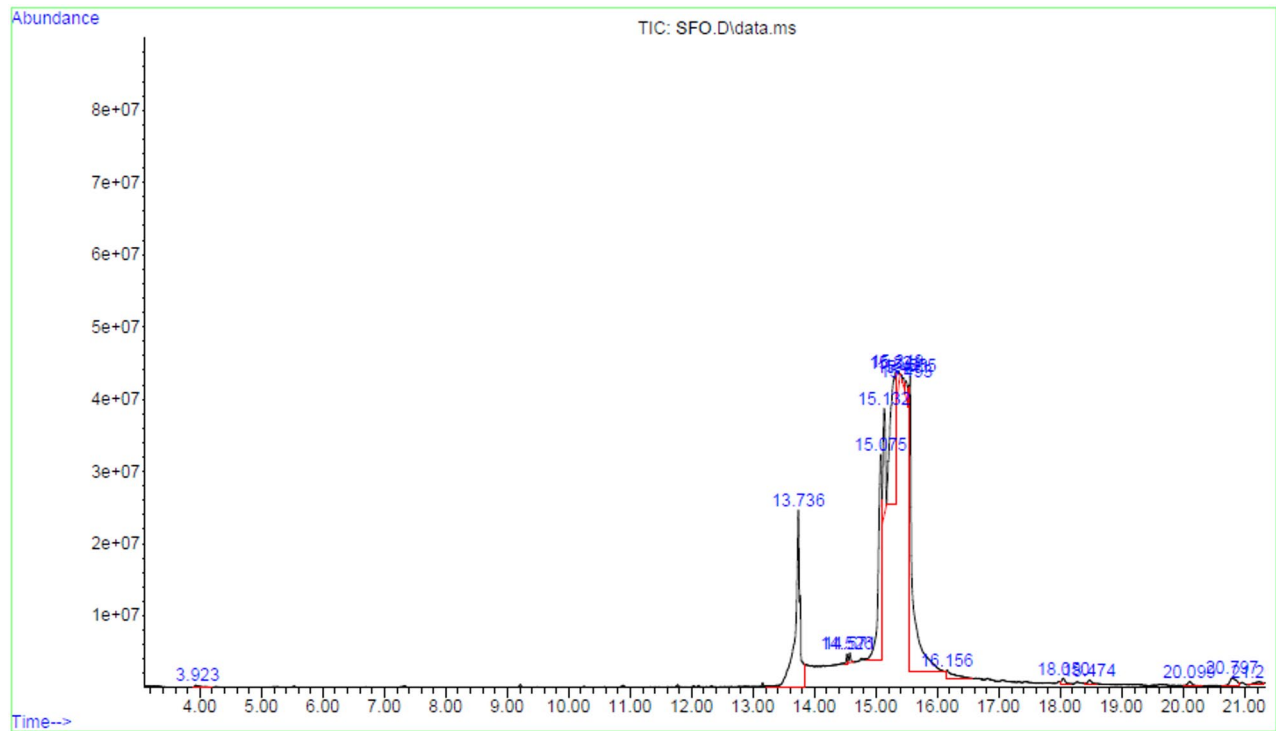


Fig. 5 Spectra of the characterisation of the Chemical Composition of safflower (*Carthamus tinctorius* L.) seed oil using Gas chromatography-Mass spectrometry (GC-MS)

Table 5 Characterisation of the chemical composition safflower (*Carthamus tinctorius* L.) seed oil using gas chromatography-mass spectrometry (GC-MS)

S/N	Compound	RT	% Composition	Formula	Class of compound
1	N-methyl-2-pyrrolidone	3.923	0.32	C ₅ H ₉ NO	aromatic amines
2	Stearic acid	13.736	21.13	C ₁₈ H ₃₆ O ₂	Saturated fatty acid
3	10,13-Octadecadienoic acid, methyl ester	14.526	0.40	C ₁₉ H ₃₄ O ₂	Fatty acid methyl ester
4	Pentadecylic acid	14.571	0.39	C ₁₅ H ₃₀ O ₂	Saturated fatty acid
5	Linoelaidic acid	15.075	18.78	C ₁₈ H ₃₂ O ₂	Unsaturated fatty acid
6	Grape seed oil	15.132	6.35	C ₁₈ H ₃₂ O ₂	Unsaturated fatty acids
7	Linolic acid	15.321	19.09	C ₁₈ H ₃₂ O ₂	Unsaturated fatty acids
8	Telfairic acid	15.349	1.48	C ₁₈ H ₃₂ O ₂	Unsaturated fatty acids
9	Acide linoleique	15.441	0.43	C ₁₈ H ₃₂ O ₂	Unsaturated fatty acids
10	cis-9,cis-12-Octadecadienoic acid	15.493	0.98	C ₁₈ H ₃₂ O ₂	Unsaturated fatty acids
11	Linoleic acid	15.555	25.69	C ₁₈ H ₃₂ O ₂	Unsaturated fatty acids
12	Emersol 310	16.156	1.69	C ₁₈ H ₃₂ O ₂	Unsaturated fatty acids
13	Oleic acid	18.474	0.36	C ₁₈ H ₃₄ O ₂	Saturated fatty acid
14	β-Methylionone	20.099	0.43	C ₁₄ H ₂₂ O	cyclic terpenoids
15	2-bromo-1-methyl-1-phenylcycloprop ane	20.797	1.33	C ₁₀ H ₁₁ Br	Halogenated cyclopropanes
16	Glycerol β-palmitate	21.209	0.66	C ₁₉ H ₃₈ O ₄	Fatty acid glycerol esters

Table 6 Summary of the chemical composition of safflower (*Carthamus tinctorius* L.) seed oil

S/N	Class of compound	% Composition
1	Amines	0.32
2	Fatty acid and fatty acid esters	97.43
3	Terpenoids	0.43
4	Alkanes	1.33
	Total	99.51

of 18.35% and 25.69%, respectively. The analysis of the composition pattern of *Adansonia digitata* L. seed oil and *Carthamus tinctorius* L. seed oil revealed significant qualitative and quantitative distinctions. The seed oil from *Adansonia digitata* L. is rich in vitamins and nourishing fatty acids, offering several benefits for the skin, such as deep hydration, improved elasticity, and potential anti-ageing effects. This makes it a valuable ingredient in skincare products (Vijayasree et al. 2024). On the other hand, *Carthamus tinctorius* L. seed oil is known to support heart health by potentially lowering cholesterol levels and aiding in blood sugar control. Additionally, it possesses anti-inflammatory and antioxidant properties (Jaradat et al. 2024). Palmitic acid, the primary chemical component of *Adansonia digitata* L. seed oil, may play a role in energy metabolism, cellular function, immune response, and infant development. However, excessive intake can lead to increased levels of LDL cholesterol, heightened inflammation, and a greater risk of cardiovascular disorders (Murru et al. 2022). This saturated fatty acid is commonly found in various foods, including dairy products, edible oils and animal fats. On the other hand, linoleic acid, the most prevalent chemical component in *Carthamus tinctorius* L. seed oil, is an essential omega-6 polyunsaturated fatty acid often found in edible oils. It is vital for cardiovascular health, skin integrity, cellular function and lowering of LDL cholesterol levels. However, excessive consumption of linoleic acid may disrupt the inflammatory balance and contribute to oxidative stress (Marangoni et al. 2020).

Antioxidant activity of baobab (*Adansonia digitata* L.) and safflower (*Carthamus tinctorius* L.) seed oils

It is common practice to assess the antioxidant potential of naturally occurring foods and plants by measuring their ability to scavenge DPPH free radicals. The DPPH scavenging abilities of various edible seed oils are compared to reference standards, ascorbic acid and gallic acid, as shown in Fig. 6. All the edible oils shown in this figure are capable of suppressing DPPH free radicals. The methanolic extracts of *Adansonia digitata* L. oil demonstrated percentage inhibitions ranging from 22.21 ± 0.20% to 54.74 ± 0.11%. In contrast, the percentage inhibitions for *Carthamus tinctorius* L. oil ranged from 17.24 ± 0.25% to 29.11 ± 0.22%. Among the oils examined, *Adansonia digitata* L. seed oil exhibited the strongest and most significant inhibitory potential ($p < 0.05$) compared to the other edible oils at various dosages. Furthermore, the DPPH scavenging properties of the tested food oils were found to be dose-dependent, with higher concentrations of each edible oil leading to greater scavenging activity. To determine the concentration needed to block 50% of radicals, the IC₅₀ value was employed. A lower IC₅₀ value indicates a higher antioxidant activity in the edible oil,

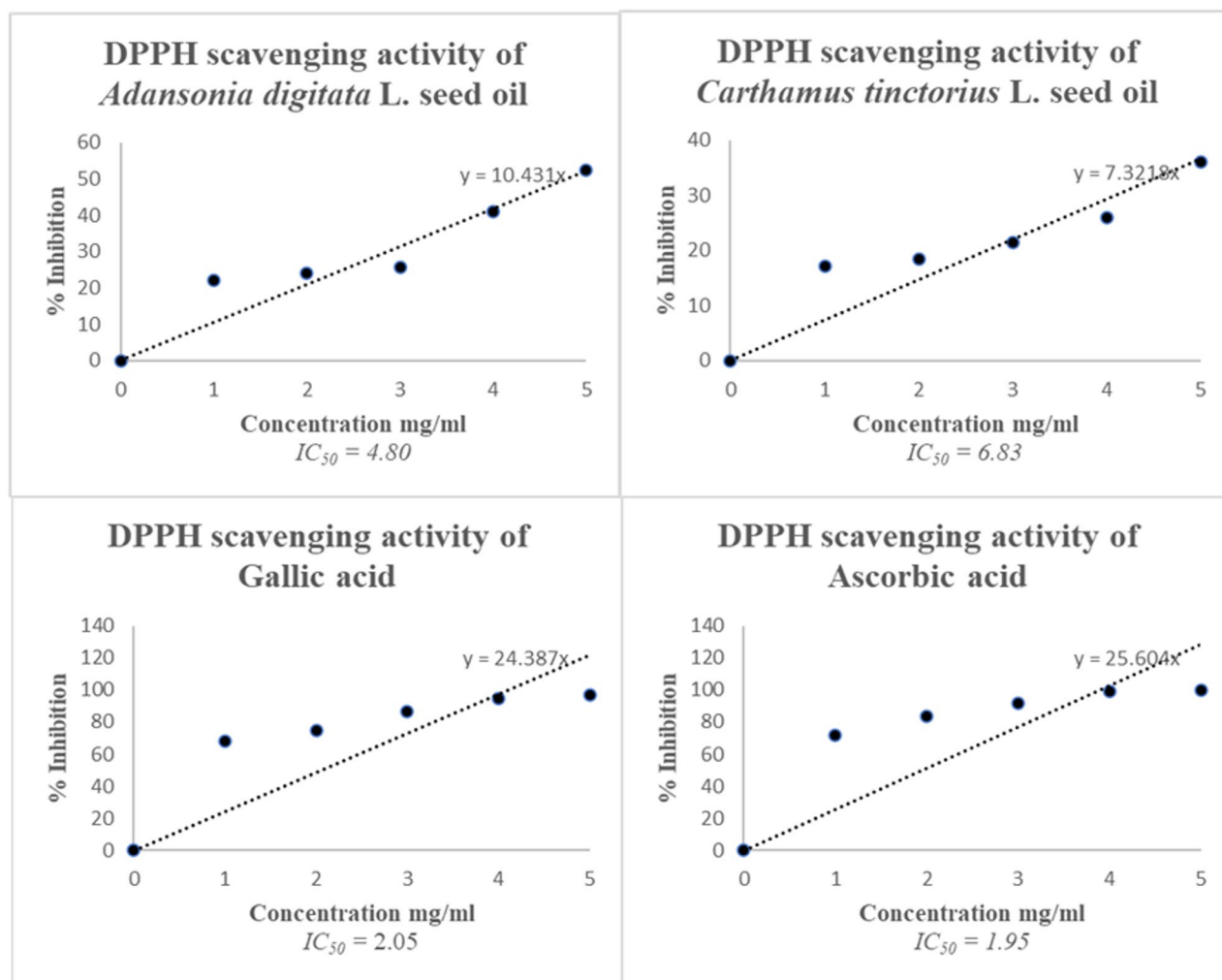


Fig. 6 DPPH radical scavenging activities of baobab (*Adansonia digitata* L.) and safflower (*Carthamus tinctorius* L.) seed oils

while a higher IC_{50} value reflects lower antioxidant activity (Martinez-Morales 2020). The findings are comparable to those reported by Hagr et al. (2021) and Alrasheid et al. (2019). However, the scavenging activities of the edible oil samples studied were different from those of the reference standards, gallic acid ($96.59 \pm 0.50\%$) and ascorbic acid ($99.35 \pm 0.65\%$). Antioxidants play a crucial role in the body by neutralizing harmful molecules known as free radicals (Godfrey et al. 2024). They contribute to heart health, cancer prevention, anti-ageing, and cellular protection (Alkadi 2020).

Conclusions

This study investigated the nutritional and chemical composition of two types of edible oils: *Adansonia digitata* L. seed oil and *Carthamus tinctorius* L. seed oil. A substantial amount of oil was extracted from both sources, with *Adansonia digitata* L. seed oil showing the highest yield. The results indicated that *Adansonia digitata* L. seed oil exhibited the least favourable physicochemical properties

among the oils analysed. Understanding these properties is essential for evaluating their quality, nutritional value, safety, and overall suitability for consumption. In terms of mineral content, *Adansonia digitata* L. seed oil contained the highest concentrations of potassium, sodium, and magnesium, while *Carthamus tinctorius* L. seed oil was more abundant in phosphorus, calcium, iron, and zinc. These differences in mineral composition provide valuable insights into the diverse nutritional benefits that each oil offers and highlight their important roles in various physiological functions within the human body. Gas chromatography-mass spectrometry (GC-MS) analysis highlighted the chemical diversity of the analysed samples, underscoring their potential as valuable sources of bioactive compounds for the food, pharmaceutical, and nutraceutical industries. The study identified 21 compounds in *Adansonia digitata* L. seed oil, with palmitic acid being the most abundant. In contrast, 16 compounds were identified in *Carthamus tinctorius* L. seed oil, with linoleic acid as the predominant compound. The findings

of this research could provide important insights into the potential applications of these edible oils in developing functional foods and nutraceuticals.

Abbreviations

ANOVA	Analysis of variance
RT	Retention time
IC ₅₀	Half-maximal inhibitory concentration
DPPH-RS	DPPH (2,2-diphenyl-1-picrylhydrazyl) radical scavenging
GC-MS	Gas chromatography-mass spectroscopy

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Author contributions

GOE conceptualised, designed, coordinated the entire research, drafted manuscripts and handled correspondence of the publication. EOO participated in designing the research, interpretation of results and drafting the manuscript. WOA contributed to the data collection and statistical analysis. FO contributed to the sample collection and preparation. EI managed the data entry and preliminary research. EAA and PCO provided important feedback on the experimental design and methodology. BIA oversaw the experimental protocol. GM and BCA ensured adherence to safety guidelines. IKF participated in data analysis and the discussion of results. The final manuscript was read, corrected and approved by all authors.

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Data availability

All generated data are available in this manuscript.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

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Competing interests

The authors declare no competing interests.

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