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Qualitative, Quantitative, GCMS, and FTIR Phytochemical Screening of *Cassia occidentalis*

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Abstract

Cassia occidentalis Linn, a plant widely recognized in traditional medicine, was subjected to comprehensive phytochemical analysis to elucidate its bioactive constituents. Both qualitative and quantitative assessments confirmed the presence of key secondary metabolites, including alkaloids, flavonoids, phenolic acids, saponins, steroids, and terpenoids. Gas Chromatography-Mass Spectrometry (GC-MS) analysis of the methanolic extract identified 30 distinct compounds, notably hexadecanoic acid methyl ester, *cis*-9-hexadecenal, oleic acid, 9-octadecenoic acid methyl ester, and 9,17-octadecadienal, all of which are associated with antimicrobial, antioxidant, and anti-inflammatory properties. Fourier Transform Infrared Spectroscopy (FTIR) further confirmed the presence of characteristic functional groups such as hydroxyl, carboxyl, and alkene groups, supporting the structural integrity of the compounds identified via GC-MS. These findings provide a detailed phytochemical profile of *Cassia occidentalis*, offering a scientific foundation for its traditional therapeutic applications and supporting its potential for further pharmacological investigation.

Keywords: *Cassia occidentalis*; Phytochemicals; Methanol Extract; GC-MS; FTIR Analysis; Medicinal Plants

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INTRODUCTION

Cassia occidentalis Linn, a member of the *Caesalpiniaceae* (Leguminosae) family, is known by several synonyms, including *Senna occidentalis*, *Cassia caroliniana*, *Cassia ciliata*, *Cassia foetida*, *Cassia frutescens*, *Cassia geminiflora*, and *Cassia linearis* (Akbar, 2020; H. Singh et al., 2020). It is commonly referred to as Coffee *Senna* in English (Dikwa *et al.*, 2025; Mananga *et al.*, 2025) and locally called *Akidi agbara (Igbo,) Abo rere (Yoruba), and Rai Dore/Sanga sanga (Hausa)* (Egharevba *et al.*, 2010). Cassia occidentalis (C. occidentalis) is extensively employed in herbal and folk medicine as an antidote to poisons, a blood purifier, an expectorant, an anti-inflammatory agent, and a remedy for liver conditions (Arya *et al.*, 2024). The leaves, seeds, flowers, and roots of Cassia occidentalis are widely used in global herbal medicine for various purposes, such as serving as a laxative, expectorant, and analgesic (V. V. Singh *et al.*, 2016), anti-malarial (Maaji *et al.*, 2025), hepatoprotective (Abdullahi et al., 2025), anti-inflammatory (Ogochukwu *et al.*, 2025), antibacterial (M. P. Singh *et al.*, 2025) and wound healing (M. P. Singh *et al.*, 2025). The roots of *Cassia occidentalis* are considered a diuretic and a tonic for addressing dysmenorrhea (menstrual problems), tuberculosis, anemia, liver conditions, and fever (Kalombo *et al.*, 2022).

In this paper, qualitative and quantitative phytochemical screening of *Cassia occidentalis* leaf extract will be done to ensure the presence or absence of Phytochemicals, which are biologically active. The naturally occurring chemical compounds in the cassia occidentalis leaves that would provide health benefits to humans would be determined. This would help in drug discovery for certain ailments and the side effects it possess.

MATERIAL AND METHODS

The Plant Material

Fresh leaves of Senna occidentalis (L.) were gathered from the Panisau forest in Ungogo Local Government, Kano State, Nigeria. The specimens were identified and authenticated at the Biological Department of Bayero University, Kano. The leaves were cut into small pieces with a knife, air-dried under shade for 10 days, ground into a fine mesh, and stored in non-absorbent nylon for later use. For extract preparation, the dried and milled leaf material was sequentially extracted using a Soxhlet extractor at 80 °C. The milled plant material was soaked in methanol for 12 hours, and the resulting extracts were concentrated to dryness using a rotary evaporator.

Reagents and Chemicals used

Table 1: Inventory of Chemicals Utilized in the Study

Reagents/Chemicals	Grade	% Purity	Source
Molisch's reagent	Aldrich	98%	Aldrich chemical Company
Ninhydrin reagent	Aldrich	99%	Aldrich chemical Company
Baljents reagent	Aldrich	98%	Aldrich chemical Company
Dragendroff reagent	Aldrich	99%	Aldrich chemical Company
Hydrochloric Acid	Aldrich	98%	Aldrich chemical Company
Lead Acetate	GPR	99%	BDH Laboratory supplies Poole BH51TD England
Chloroform	Aldrich	99%	Sigma Aldrich
H_2SO_4	A.R	98%	Fison plc.
Ammonia	Aldrich	97%	Aldrich chemical Company
Ferric Chloride	M and B	99%	BDH Laboratory Supply England
Olive oil	SAMBROSO	98%	Olive pomase oil
Benzene	JHD	99.5%	Gunsgdong Guandgua Chemical Factory LTD
Sodium hydroxide	JHD	99%	Gunsgdong Guandgua Chemical Factory LTD
Acetic acid	JHD	99%	Gunsgdong Guandgua Chemical Factory LTD
Aluminum Chloride	GPR	99%	BDH Laboratory Supply England
Ethanol	AnalaR	99.7%	BDH Laboratory Supply England
Ammonium hydroxide	Aldrich	99%	Aldrich chemical company
Potassium ferrocyanide	M and B	99%	BDH Laboratory supplies Poole BH51TD England
Diethyl ether	JHD	98%	Gunsgdong Guandgua Chemical Factory LTD
n-butanol	AR	99.5%	Fison plc.
Sodium chloride	AnalaR	99.5%	BDH Laboratory Supply England
Trichloroacetic acid	JHD	99%	Gunsgdong Guandgua Chemical Factory LTD
Ether	JHD	98%	Gunsgdong Guandgua Chemical Factory LTD
Magnesium Acetate	AnalaR	98%	BDH Laboratory Supply England
Methanol	JHD	99%	Gunsgdong Guandgua Chemical Factory LTD

Equipment

Table 2: List of equipment used for the study.

Equipment	Model number	Manufacture
Ultraviolet Spectrophotometer	CE7200	Aquarius
Water Bath	HH.W21.Cr42II	Electronic thermostat water tank for Three usage
Mechanical Shaker	Innova 4000	NEW BRUNSWICK SCIENTIFIC
Centrifuge Machine	800D	GULFEX MEDICAL & SCIENTIFIC
Drier		Gallenkamp
Weighing Balance	26512132-9	Mettler Toledo

Phytochemicals Screening

Determination of cardiac glycoside

A set of experiments was carried out to identify the presence or absence of particular chemical constituents in the plant. Initial phytochemical screening was conducted using standardized methods, as described in the referenced methodology (Deokate *et al.*, 2020; Harborne, 1973; Usman and Osuji, 2007).

Qualitative Analysis of Primary Metabolites

Test for Carbohydrate

Molisch's test for Carbohydrates: The crude extract was combined with 2 ml of Molisch's reagent and thoroughly mixed using a vortex machine. Subsequently, 2 ml of concentrated H_2SO_4 was carefully added along the side of the test tube. The formation of a violet ring at the interface confirms the presence of carbohydrates in the sample (GUPTA et al., 2023).

Test for Amino Acids

To test for amino acids, 1 ml of the extract was mixed with a few drops of Ninhydrin reagent. The development of a purple color in the sample indicates the presence of amino acids. (Ranaweera *et al.*, 2024).

Qualitative Analysis of Secondary Metabolite

Test for Alkaloids

To test for alkaloids, 5 ml of the sample extract was combined with 2 ml of HCl. Subsequently, 1 ml of Dragendorff's reagent was added to the acidic mixture. The immediate formation of an orange or red precipitate signifies the presence of alkaloids (Ranaweera *et al.*, 2024).

Test for polyphenols

The addition of three drops of 5% lead acetate solution resulted in yellow precipitates, confirming the presence of phenolic compounds (Tailor and Lawal, 2021).

Test for Flavonoids

A few drops of 1% aluminum chloride solution were added to a portion of each filtrate, and the appearance of a yellow coloration confirmed the presence of flavonoids. (Aparna and Hema, 2022).

Test for Terpenoids (salkowski test)

To test for terpenoids, 5 ml of each extract was combined with 2 ml of chloroform, followed by the careful addition of 3 ml of concentrated H_2SO_4 to form a layer. The appearance of a reddish-brown coloration at the interface indicated a positive result for the presence of terpenoids. (Sharma *et al.*, 2012).

Test for Anthocyanin's

Two milliliters of the aqueous sample extract were combined with 2 ml of 2N HCl and ammonia. The shift from pink-red to blue-violet coloration signifies the presence of anthocyanins (Vishwakarma *et al.*, 2022).

Test for Tannins

Approximately 0.5 g of the dried, powdered samples were boiled in 20 ml of water in a test tube and then filtered. A few drops of 0.1% ferric chloride were added, and the solution was observed for the presence of a brownish-green or blue-black coloration. (KUMAR *et al.*, 2023).

Test for Saponin

Two grams of the powdered sample were boiled in 20 ml of distilled water in a water bath and then filtered. Ten milliliters of the filtrate were combined with 5 ml of

distilled water and vigorously shaken to produce a stable, persistent froth. Three drops of olive oil were added to the froth, and the mixture was shaken vigorously again, after which the formation of an emulsion was observed. (J. P. Yadav *et al.*, 2010).

Test for anthraquinones

Five milliliters of the extract solution were hydrolyzed with diluted concentrated H2SO4 and then extracted with benzene. One milliliter of dilute ammonia was added to the solution, and the appearance of a rose-pink coloration indicated a positive result for the presence of anthraquinones. (Ranaweera *et al.*, 2024).

Test for glycoside

Approximately 0.5 mg of the extract was dissolved in 1 ml of water, followed by the addition of aqueous NaOH solution. The appearance of a yellow color confirmed the presence of glycosides. (Faizy *et al.*, 2021).

Test for Steroids

0.5 g of sample was weighed and 2 ml of Acetic acid and allowed the mixture to cool in ice. Then concentrated H_2SO_4 was added. The color changed from violet to black or bluish-green (Tailor and Lawal, 2021).

QUANTITATIVE ANALYSIS

Estimation of flavonoids

Total flavonoid contents were measured using the aluminum chloride colorimetric assay (Kumar *et al.*, 2008). Aqueous and ethanol extracts that have been adjusted to come under the linearity range of (400µg/ml) or Aliquots of extract solutions were taken and made up the volume 3ml with methanol and different dilutions of a standard solution of Quercetin (10-100µglml) were added to 10ml volumetric flask. To the above mixture, 0.3 ml of 10% $AlCl_3$ was added. After 6 min, 2 ml of 1 M NaOH was added and the total volume was made up of 10 ml by adding distilled water to it. Then the solution was mixed well and the absorbance was measured against a freshly prepared reagent blank at 520nm. The total flavonoid content of the extracts was expressed as parentage of Quercetin equivalent per 100 g dry weight of the sample.

Determination of Alkaloid

Alkaloids are determined by the method described by (Harborne, 1973). Five grams of the sample were weighed into a 250 ml beaker, and 200 ml of 10% acetic acid in ethanol was added. The mixture was covered and left to stand for 4 hours. The solution was then filtered, and the extract was concentrated on a water bath to one-quarter of its original volume. Concentrated ammonium hydroxide was added drop wise to the extract until precipitation was complete. The solution was allowed to settle, and the precipitate was collected, washed with dilute ammonium hydroxide, and filtered. The resulting residue, identified as the alkaloid, was dried and weighed.

Tannin determination

Tannin's determination method is described by (Van Buren and Robinson, 1969). A 500 mg sample was weighed and placed into a 50 ml plastic bottle. Fifty milliliters of distilled water were added, and the mixture was shaken for 1 hour using a mechanical shaker. The resulting solution was filtered into a 50 ml volumetric flask and brought up to the mark with distilled water. Five milliliters of the filtrate were then pipetted into a test tube and combined with 2 ml of 0.1 M FeCl3 in 0.1 N HCl and 0.008 M potassium ferrocyanide. The absorbance of the solution was measured at a wavelength of 120 nm within 10 minutes.

Determination of Saponin

The method described by (Obadoni and Ochuko, 2002) was used. Twenty grams of each ground sample were placed in a conical flask, and 100 cm^3 of 20% aqueous ethanol was added. The samples were heated in a hot water bath at approximately 55°C for 4 hours with continuous stirring. The mixture was filtered, and the residue was re-extracted with an additional 200 ml of 20% ethanol. The combined extracts were concentrated to 40 ml in a water bath at about 90°C. The concentrated solution was transferred to a 250 ml separatory funnel, where 20 ml of diethyl ether was added and vigorously shaken. The aqueous layer was discarded, and the purification process was repeated. Subsequently, 60 ml of n-butanol was added, and the combined n-butanol extracts were washed twice with 10 ml of 5% aqueous sodium chloride. The remaining solution was heated in a water bath, evaporated, and the samples were dried in an oven to a constant weight.

Ten milliliters of the purified filtrate were transferred to a clean, dry, stoppered Erlenmeyer flask, and 10 ml of Baljet's reagent was added. A blank was prepared

simultaneously using 10 ml of distilled water instead of the purified filtrate, combined with 10 ml of Baljet's reagent. The solutions were allowed to stand for 1 hour to allow maximum color development. Then, 20 ml of distilled water was added to both the experimental and blank solutions, mixed, and their absorbance was measured at 495 nm (Bakir Çilesizoğlu *et al.*, 2022).

Spectrophotometric method of determination of total phenols

The fat-free sample was boiled with 50 ml of ether for 15 minutes to extract the phenolic components. Five milliliters of the extract were pipetted into a 50 ml volumetric flask, followed by the addition of 10 ml of distilled water. Then, 2 ml of ammonium hydroxide solution and 5 ml of concentrated amyl alcohol were incorporated, and the volume was brought up to the mark. The mixture was allowed to react for 30 minutes, after which color development was measured at 505 nm(Ladipo *et al.*, 2010).

Determination of Total Anthocyanin

The total anthocyanin content (TAC) of freeze-dried extract was determined using the method described by (Obouayeba *et al.*, 2015). Ten milligrams of freeze-dried extract were dissolved in 5 mL of methanol acidified with 0.1% (v/v) trifluoroacetic acid (TFA). Aliquots of the extracts were placed in a 10 mL glass tube, adjusted to a volume of 3 mL with methanol acidified with TFA, and the absorbance was measured at 530 nm. Alternatively, trichloroacetic acid can be used in place of trifluoroacetic acid

Determination of Total Anthraquinone

The crude extract was dissolved in 30 ml of methanol, weighed, and refluxed for 15 minutes. The aqueous mixture was cooled, reweighed, and adjusted to its original weight with water, then centrifuged at 4000 rpm for 10 minutes. To 10 ml of the supernatant, 20 ml of 10.5% FeCl3·6H2O was added, followed by refluxing for 20 minutes. Subsequently, 1 ml of concentrated HCl was added, and the mixture was refluxed for an additional 20 minutes. The solution was then extracted with 25 ml of ether three times. The combined ether layers were washed twice with 15 ml of water and adjusted to a total volume of 100 ml with ether. A 25 ml portion of the ether layer was evaporated to dryness, and the resulting residue was dissolved in 10 ml of 0.5% magnesium acetate in methanol. The absorbance of the solution was measured at 515 nm (Ahmed *et al.*, 2011).

RESULTS AND DISCUSSION

Results of qualitative phytochemical screening of the *Cassia occidentalis* leave extract.

Table 3: Results for qualitative screening of leave extract

S/N	Phytochemicals	Result
1	**Alkaloids**	**+**
2	**Saponin**	**+**
3	**Terpenoids**	**+**
4	**Tannin**	**+**
5	**Carbohydrate**	**-**
6	**Amino acid**	**-**
7	**Anthraquinone**	**+**
8	**Polyphenols**	**+**
9	**Steroid**	**+**
10	**Anthocyanin**	**+**
11	**Glycoside**	**+**
12	**Flavonoid**	**+**
Present = +		**Absent = -**

Results of quantitative phytochemical screening of *Cassia occidentalis* leaf extract.

Table 4. List of quantitative phytochemical results

S/N	Phytochemicals	Amount
1	Alkaloid(g)	0.055
2	Tannins(µg/ml)	26.93
3	Flavonoid (µg/ml)	120.45
4	Total phenolic(µg/ml)	550
5	Cardiac Glycoside (µg/ml)	12.89
6	Saponin(g)	0.08

S/N	Phytochemicals	Amount
7	Anthocyanin(μg/ml)	1.129
8	Anthraquinones(mean ± SD)	0.606 ±0.149

Result of GC-MS

Table 5: List of peaks of the leaf extract.

Peak#	Rate	Area	Library/ID	Ref #	Quality
1	26.341	0.12	Cyclopentadecanone, 2-hydroxy-	102369	96
2	26.637	3.47	Hexadecanoicacid, methyl ester	130822	99
3	27.755	-0.09	cis-9-Hexadecenal	100560	97
4	28.119	0.00	Oleic Acid	142070	93
5	29.212	13.48	9-Octadecenoicacid, methyl ester	155758	99
6	29.312	2.26	9,17-Octadecadienal,	125003	97
7	29.421	1.21	cis-9-Hexadecenal	100560	95
8	29.535	3.58	Methyl stearate	157879	93
9	29.925	8.41	cis-9-Hexadecenal	100560	96
10	30.086	2.29	Cyclopentadecanone, 2-hydroxy-	102369	96
11	30.213	2.25	Cyclopentadecanone, 2-hydroxy-	102369	95
12	30.399	2.81	Cyclopentadecanone, 2-hydroxy-	102369	95
13	30.683	6.25	13-Octadecenal,	126830	90
14	31.245	9.245	9-Octadecenoic acid,	142089	89
15	31.610	1.14	Oleic Acid	142071	89
16	31.839	6.11	Glycidyl palmitate	171251	91
17	32.020	1.18	6-Octadecenoic acid	142084	60
18	32.185	0.31	Oleic Acid	142071	74
19	32.847	0.35	i-Propyl 9-octadecenoate	182556	89
20	33.503	1.05	9-Octadecenal,	126829	83

Peak#	Rate	Area	Library/ID	Ref #	Quality
21	33.64	0.19	Oleic Acid	142071	64
22	33.782	0.16	n-Propyl 9-octadecenoate	182557	64
23	34.085	16.09	9-Octadecenal	126829	95
24	34.346	7.01	Elaidic acid, isopropyl ester	182563	56
25	34.627	3.84	16-Octadecenoic acid, methyl ester	155734	72
26	34.704	1.57	I-Propyl 9-octadecenoate	182556	72
27	34.900	3.02	11-Octadecenoic acid, methyl ester	155736	84
28	35.108	6.65	I-Propyl 9-octadecenoate	182556	59
29	35.528	0.32	1-Tricosene	180802	91
30	35.675	2.48	4-Trifluoromethylbenzoic acid, pentadactyl ester	142085	41

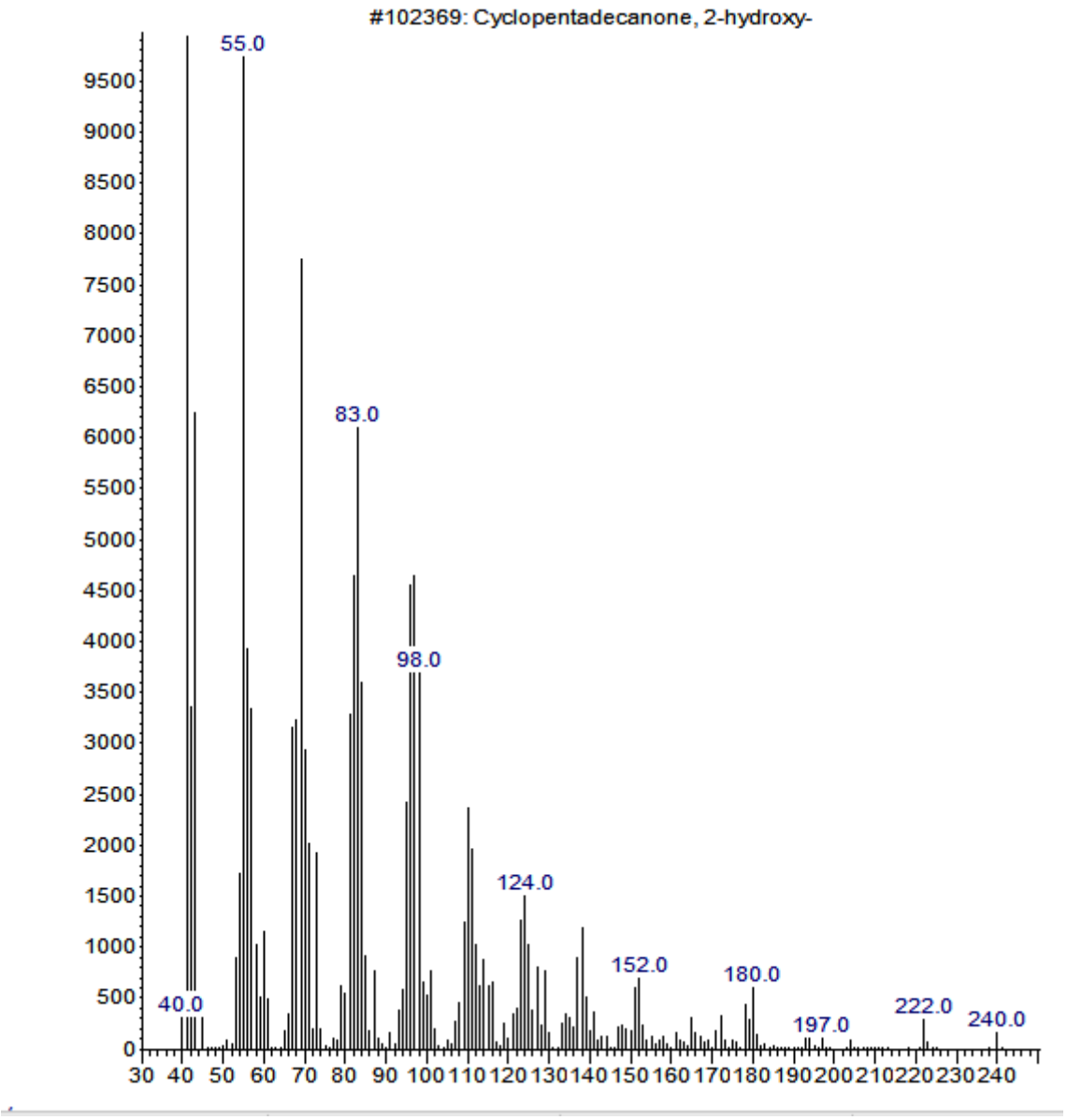

Figure 1. Peaks of GC-MS

3.4. Result of FTIR analysis

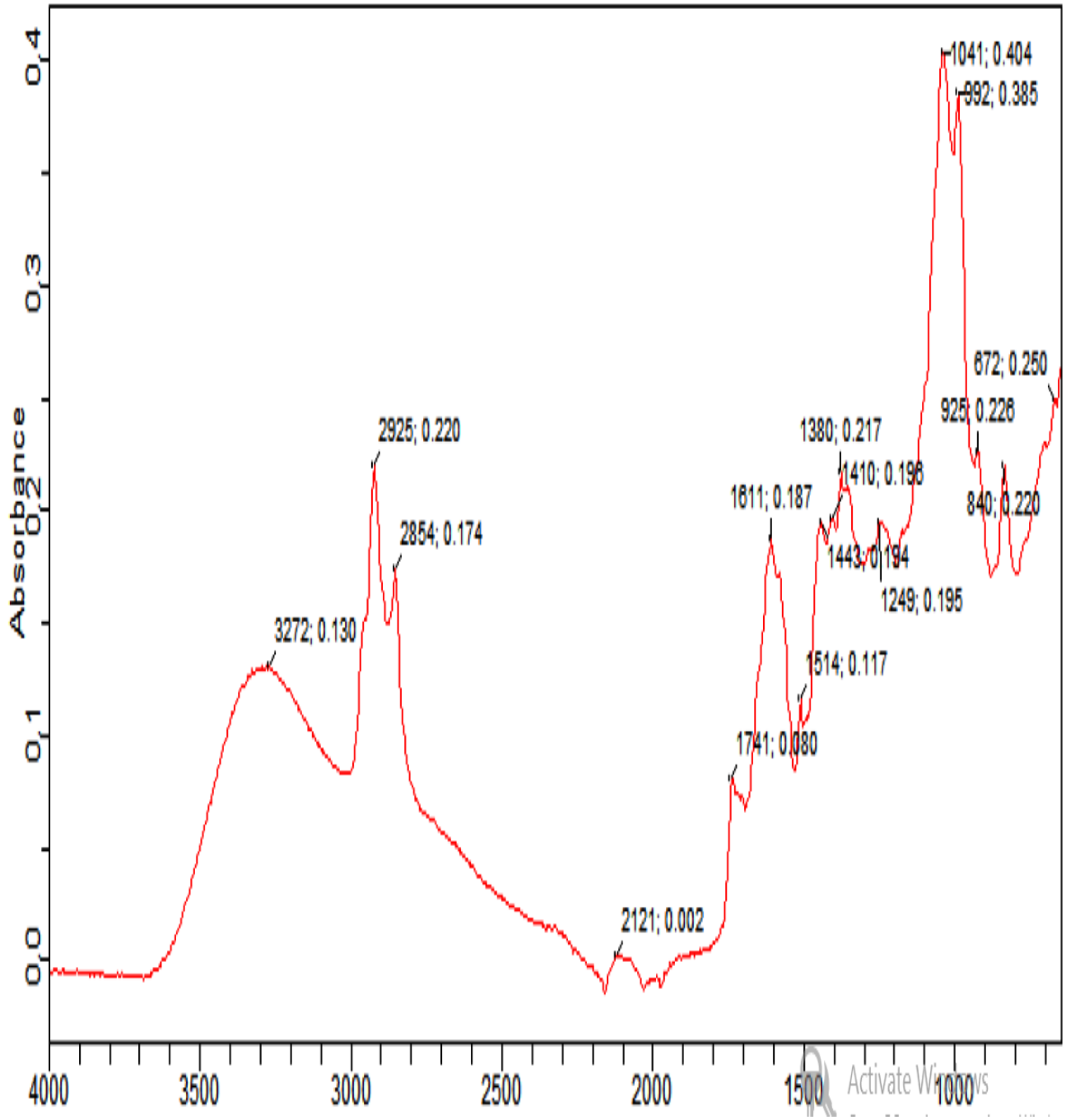

Figure 2: FTIR of the leave extract.

Table 6: List of functional groups of the leave extract

Pick Number	Functional Group Name and example compounds	Type of Vibration

Pick Number	Functional Group Name and example compounds	Type of Vibration
3272:0.130	Carboxylic Acid Example: Formic Acid	Hydrogen-bonded O-H Stretch
2925:0.220	Aromatic Ring Example: Benzene	C=C-H Asymmetric Stretch
2854:0.174	Aldehydes Example: Ethanal	C-H Stretch off C=O
2121:0.002	Alkynes Example: Propyne	C≡C Stretch
1741:0.0080	Ketones Example: Acetone	C=O Stretch
1611:0.187	Amide Example: Methanamide	N-H bond
1514:0.117	Amines-Secondary Example: N-Methyethylamine	N-H Bond
1443:0.194	Alkanes Example: Methane	H-C-H Bond
1410:0.198	Nitro Group Example: Nitromethane	N=O Stretch

DISCUSSION

Medicinal plants contain organic compounds such as tannins, alkaloids, terpenoids, steroids, and flavonoids, which exert specific physiological effects on the human body (Stéphane *et al.*, 2021). These compounds are synthesized by the primary or rather secondary metabolism of living organisms. Secondary metabolites are chemically and taxonomically extremely diverse compounds with obscure functions. They are widely used in human therapy, veterinary, agriculture, and scientific analysis (Nenni and Karahuseyin, 2024).

The qualitative phytochemical analysis of *Cassia occidentalis* leaves extract showed the presence of major phytochemicals: steroids, cardiac glycosides, terpenoids, alkaloids,

saponin, polyphenols, anthocyanin, anthraquinones, and flavonoids. The quantitative phytochemical analysis showed the quantity of phytochemicals in appreciable amounts.

The therapeutic properties of plant leaves may be attributed to their constituent phytochemicals. Steroids, in particular, are recognized for their role as cardio-tonic agents and are utilized in herbal medicines and cosmetics. (Chukwube *et al.*, 2021; Egbuna *et al.*, 2018). Steroids have been documented to possess antibacterial properties (Wen *et al.*, 2024) and are significant for their proliferative effects, particularly due to their association with sex hormones (Yang *et al.*, 2024). Cardiac glycosides significantly influence heart muscle function by inhibiting Na^+/K^+ pumps, which enhances the availability of sodium and calcium ions to the heart muscles, thereby improving cardiac output and reducing heart distension. This accounts for their application in treating congestive heart failure and cardiac arrhythmia. (Nagalingam *et al.*, 2012).

Phenolic compounds represent one of the most abundant and widely distributed groups of plant metabolites (Cheynier, 2012). Phenolic compounds exhibit a range of biological properties, including anti-apoptotic, anti-aging, anti-carcinogenic, anti-inflammatory, and anti-atherosclerotic effects, as well as cardiovascular protection, enhancement of endothelial function, and inhibition of angiogenesis and cell proliferation. (Evanjelene and Velu, 2022; Sharmila *et al.*, 2021). Numerous phenolic compounds, such as tannins found in plant cells, act as potent inhibitors of various hydrolytic enzymes, including proteolytic enzymes utilized by plant pathogens (Davidova *et al.*, 2024). Tannins interact with proline-rich proteins, disrupting protein synthesis (Mora *et al.*, 2022; A. Yadav and Kumar, 2022; J. P. Yadav *et al.*, 2010). In this study, the total flavonoid content in *Cassia occidentalis* leaves was measured at 120.4 μg/ml. The variation in polyphenolic constituents and their differential distribution in plants may account for the varying ranges observed in the total phenolic and flavonoid contents analyzed (Shen *et al.*, 2022; Yu *et al.*, 2021). Flavonoids, which are hydroxylated phenolic compounds, are produced by plants as a defense mechanism against microbial infections and exhibit antimicrobial activity against a broad range of microorganisms in vitro (Chagas *et al.*, 2022; Donadio *et al.*, 2021).

The existence of the various compounds using Gas chromatography and mass spectroscopy analysis such as Cyclopentadecanone, 2-hydroxy-, Hexadecanoic acid, methyl ester, cis-9-Hexadecenal, Oleic Acid, 9-Octadecenoic acid, methyl ester, 9,17-Octadecadienal, Methyl stearate, Cyclopentadecanone, 2-hydroxy-, 2-hydroxy-, 2-hydroxy-

,13-Octadecenal, Oleic Acid, Glycidyl palmitate, 6-Octadecenoic acid, i-Propyl 9-octadecenoate, 9-Octadecenal, Oleic Acid, n-Propyl 9-octadecenoate, Elaidic acid, isopropyl ester, 16-Octadecenoic acid, methyl ester, 11-Octadecenoic acid, methyl ester, 1-Tricosene, 4-Trifluoromethylbenzoic acid and pentadecyl ester proves that *Cassia occidentalis* leave extract consist of many compounds.

Hexadecanoic acid has been reported to function as an anticancer agent (Bharath *et al*., 2021), and (Ganesan *et al*., 2024) reported the antioxidant and anti-microbial properties of hexadecanoic acid. Similarly, (Momodu *et al*., 2022; and Pawar *et al*., 2023) reported that n-hexadecanoic acid serves as an antioxidant, hypocholesterolemic nematicide, pesticide, and anti-androgenic flavor hemolytic.

Fourier transform infrared spectroscopy analysis showed the presence of various functional groups with different types of vibrations such as carboxylic acid, aromatic ring, aldehydes, alkynes, ketones, amide, amine-secondary, alkane, and nitro groups.

However, a further detailed study on *Cassia occidentalis* leaf extract is necessary for antioxidant, inflammatory, anticancer, and so on.

CONCLUSION

The study revealed the presence of phytochemicals including alkaloids, tannins, flavonoids, steroids, terpenoids, anthocyanins, anthraquinones, polyphenols, and saponins in the leaf extract of *Cassia occidentalis*. FTIR analysis identified potential functional groups within the extract, while GC-MS analysis was employed to characterize the chemical compounds present. These findings suggest that *Cassia occidentalis* leaves possess medicinal properties, indicating their potential for therapeutic applications, pending further analysis to validate their efficacy.

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