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Original Article

Comparison of Anti-Inflammatory and Antioxidant Effects of Leaves, Stem, and Seeds of *Ruta chalepensis* from South India

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ABSTRACT

Background/Objectives: *Ruta chalepensis* is a herb with many health benefits due to the abundance of secondary metabolite compounds, including both terpenoids and nonterpenoids. Comparative information on effects from individual plant parts is lacking, and we have tried to analyse the Antioxidant and anti-inflammatory effects of extracts from stem, leaves, and seeds. **Materials and Methods:** Fresh plants were collected from a village in Nilgris in Tamil Nadu, and leaves, stems, and seeds were segregated and shade-dried for extract preparation. FTIR analysis was done for the three. Anti-inflammatory effects were analysed by Bovine Serum Albumin denaturation assay (BSA assay), Egg albumin denaturation assay, and Membrane Stabilization Assay. Antioxidant assays were DPPH (2,2-diphenyl-1-picrylhydrazyl) Assay, FRAP (ferric reducing-antioxidant power) Assay, ABTS (2,2-azo-bis 3 ethylbenz -thiozoline -6-sulfonic acid) Assay, Hydrogen peroxide (H_2O_2) decomposition assay-ROS scavenging activity, and Nitric oxide scavenging activity - Griess reaction assay. Cytotoxicity was tested using the Brine shrimp Nauplii Mortality assay. **Results:** All three parts had good anti-inflammatory effects when compared with the standards. Seeds had the highest and stems the lowest. Antioxidant assay results were also comparable with the standards, but leaves had a slightly higher effect. Free hydroxyl groups in stems and more bound in leaves indicates as seen by FTIR analysis, indicate a faster antioxidant effect by stem extracts but a stable effect of leaves. Stems showed no cytotoxic effect, and with leaves and seeds, more than 80% of Nauplii were alive even on day 2 of the cytotoxic assay. **Conclusion:** All three parts studied showed good antioxidant and anti-inflammatory effects. The possibly faster antioxidant effect of the stem needs further exploration. The higher anti-inflammatory effect of seeds may be beneficial in the preparation of concentrated formulations.

Keywords: Anti-inflammatory, Antioxidant activity, Brine shrimp lethality analysis, FTIR, *Ruta chalepensis*.

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INTRODUCTION

Ruta chalepensis or Fringed Rue, also called as Aruda, Shazab, etc., (Aati *et al*., 2023) belongs to the family Rutaceae and genus Ruta. The extracts as well as fresh leaves infusions have been widely used traditionally as a medicinal plant as well as for spiritual purposes (Marami *et al*., 2021). Its medicinal values have been explored as early as the era of Hippocrates (Pollio *et al*., 2008). Some of the medicinal benefits of extracts of Ruta reported include gastrointestinal, neurological, immunological, haematological, and gynaecological ailments. Analysis of the composition of Ruta extracts has shown an abundance of compounds present in the plant parts, which are medically beneficial. Quercitin, Myrecitin, camphor, limonene, terpinene, and Rutin are some of the compounds belonging to compound classes of Flavinoids, monoterpenes, Ketones, Polyphenols, etc., (Althaher *et al*., 2024). Studies have reported that all parts of Ruta have anti-inflammatory and antioxidant properties, but there is not much information comparing the effects of isolated extracts of different parts of *Ruta chalepensis*. We have tried to analyse if there are any differences in the antioxidant and anti-inflammatory properties of Leaves, stem, and Seed extracts of *Ruta chalepensis*. An FTIR (Fourier Transform Infrared Spectrometer) analysis was also done to compare the compounds in the different parts. Extracts can be prepared from the most beneficial part so that

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the quantity (dosage) as well as toxic effects, if any, can also be minimised.

Essential oils of Ruta are dominated by two aliphatic ketones, 2-undecanone and 2-nonanone, but considerable variations in their amounts could be observed, which was primarily attributed by Nahar *et al.*, to the differences in climatic conditions, soil quality etc. (Nahar *et al.*, 2017) It has been reported by other studies also that there are variations in the properties of the plants based on geographical locations (Jaradat *et al.*, 2017). In this study the plants were obtained from Nilgris, a Hill station in South India well known for its forests and villages with medicinal plants.

MATERIALS AND METHODS

Collections and extract Preparation

Plants were cut fresh from a village in Nilgris, a hill station in Tamil Nadu, India. Identification of the plant and an authentication certificate as *Ruta chalepensis* L. was obtained from the Government Siddha Institute in Arumbakkam, Chennai. Leaves, stems, and fruits/seeds were segregated and dried in shade for 3 weeks. Dried parts were then ground to fine particles and stored in labelled, air-tight jars. To 1 g powder of each part, 50 mL of distilled water was added, and the mix was heated in a heating mantle at 50°C till the volume was halved. It was then filtered using a muslin cloth and again concentrated to 5 mL.

FTIR (Fourier Transform Infrared Spectrometer) analysis

The principle is that when molecules absorb Infrared rays of a particular frequency, they get excited to an increased vibrational state. Different bonds in the molecules correlate with the vibrational state. A spectrum is generated with wave number and transmittance values. The peak size in the spectrum indicates the quantity of the substance (Gurumurthy *et al.*, 2017 and Krishnaswamy *et al.*, 2024). FTIR was done using a Thermo Scientific Nicolet Summit FTIR spectrometer, and spectra for leaves, stem, and seeds/fruits (named as flower in this analysis) were obtained individually. Spectral analysis was done using the IR spectrum Table and Chart-Sigma Aldrich.

In vitro analysis of Anti-inflammatory activity

In this study, the Bovine serum albumin denaturation assay, the Egg albumin denaturation assay, and the Membrane stabilisation assay were used.

Principle

Protein denaturation plays a pivotal role in the inflammatory process, and inhibition of denaturation is the principle used in the Bovine serum albumin denaturation assay and the Egg albumin denaturation assay. Membrane stabilisation assay uses the concept that Red blood cell membrane is similar to lysosomal membrane, and prevention of rupture indicates anti-inflammatory property (Pérez-Salas *et al.*, 2023).

Bovine serum albumin denaturation assay (BSA assay)

Different concentrations of *Ruta chalepensis* extract (10 ul, 20 ul, 30 ul,40, and 50 µL were added to 0.45 mL (1% aqueous solution) of bovine serum albumin. 1N hydrochloric acid was used to adjust the pH of the mixture to 6.3. After incubation at room temperature for 20 min and heating for 30 min in a water bath at 55°C, the samples were then cooled and absorbance estimated spectrophotometrically at 660 nm. Diclofenac Sodium, a well-known anti-inflammatory, was used as the standard. Dimethyl sulphoxide (DMSO) was utilized as the control, as it makes BSA more stable at low concentrations (Shilajyan and Grigoryan, 2015; Shanmugam *et al.*, 2024).

The percentage of inhibition of protein denaturation was determined utilizing the following equation,

$$\% \text{ inhibition } = \frac{\text{Absorbance Control } - \text{ Absorbance } - \text{ sample}}{\text{Absorbance of control}} \times 100$$

The % inhibition of protein denaturation = % Anti-inflammatory Activity (Subramanian *et al.*, 2022).

Egg albumin denaturation assay

A 5 mL control solution was prepared with 2.8 mL of freshly prepared phosphate-buffered saline of pH 6.3, 0.2 mL of hen egg albumin, and 2 mL distilled water. Similar solutions of specific concentrations (10 µL, 20 µL, 30 µL, 40 µL, and 50 µL) of Ruta extracts instead of distilled water were also prepared. A 5 mL solution with diclofenac was also prepared as the standard. The percentage of inhibition of protein denaturation was determined similarly to the Bovine Serum Albumin assay.

Membrane Stabilization Assay

MSA is based on the concept that the RBC membrane can resemble a lysosomal membrane. Stabilizing Lysosomal membranes, preventing them from rupture and release of granules, is one of the mechanisms that prevent inflammation. If RBC membrane stability can be assessed, it will give an indication of the stability of lysosomal membranes, thereby indicating the anti-inflammatory effect

RBC SUSPENSION

Human Blood was collected in a tube containing an anticoagulant and centrifuged at 1000 g for 10 min for separation of RBCs at the bottom of the tube, with plasma and other constituents at the upper level. The supernatant plasma is discarded. The segregated RBCs are rinsed thrice with plasma-buffered saline and again reconstituted to form a 10% (v/v) suspension with Tris-HCl Buffer. Blood used for this assay was from a common pool. Separate ethical approval was not obtained.

Absorbance of Supernatant Hemoglobin By Spectrophotometry

1 mL of the RBC suspension was then taken in tubes to which 1 mL of different concentrations of extracts (10-50 µL) was added to make 2 mL in each tube. Diclofenac sodium in different concentrations was also tested as a standard. This was kept at 37°C in a controlled environment for half an hour to induce hemolysis. RBCs were then segregated by centrifugation at 3000 RPM for 10 min, and the absorbance of hemoglobin in the hemolysed supernatant was measured using a spectrophotometer at 540nm.

Calculation

The percentage inhibition of hemolysis was determined by the formula:

% inhibition = (OD control - OD sample)/OD control) × 100.

OD control is the absorbance of the supernatant above the Red Blood Cell (RBC) suspension in the tube without the extract.

OD sample refers to the absorbance of the supernatant in the tube with the extract or the standard.

If the extract has anti-inflammatory and therefore membrane-stabilizing properties, the haemoglobin released will be less in sample when compared to the control, which will show a higher percentage inhibition value when calculating (Harris *et al.*, 2023).

Antioxidant Assays

A dearth in antioxidants in the body or an excess of Reactive oxygen species (nascent oxygen, superoxide anion radicals, and Hydrogen peroxide (nonradical) beyond physiological limits can result in necrosis, apoptosis, DNA mutations, et, causing several diseases. Antioxidant activity depends on their chemical structure; specifically, it depends on their ability to donate a hydrogen electron, metal chelation, and their ability to delocalize the unpaired electron within the aromatic structure, and these activities are utilised in antioxidant assays.

In the Ferric Reducing-Antioxidant Power (FRAP) assay and ABTS (azino-bis(3-ethylbenzothiazoline-6-sulfonic acid) cation decolorization assay, the property of electron transfer is measured. In the DPPH assay, hydrogen transfer is measured. Lipid oxidation and ROS/RNS scavenging activity are used in H_2O_2 and NO assays (Kotha *et al.*, 2022 and Kedare and Singh, 2011).

DPPH (2,2-diphenyl-1-picrylhydrazyl) Assay

DPPH is considered a stable radical violet in colour and loses the colour when it is reduced by the hydrogen transferred from the sample if it has antioxidant properties. This can be measured as absorbance by spectrophotometry.

Extracts at different concentrations (10-50 µL) were added to 1 mL of 1 mM DPPH solution and incubated at 37°C in the dark. Absorbance is measured at 517 nm and is compared with the control and with the standard.

$$\text{Radical Scavenging activity (RSA)of the extract} = \frac{\text{Absorbance Control} - \text{Absorbance} - \text{sample (extract)}}{\text{Absorbance of control}} \times 100$$

FRAP (ferric reducing-antioxidant power) Assay

In this, electron transfer from the antioxidant sample reduces FeIII-TPTZ (ferric-tripyridyltriazine) to ferrous form, and the colour becomes green /blue from its original straw colour and is measured at 593 nm.

FRAP REAGENT-Acetate buffer, TPTZ, and Ferric chloride are the 3 Chemicals in FRAP Reagent

3.1 g sodium acetate trihydrate and glacial acetic acid 16 mL were mixed to form a 300 mM acetate buffer at a low pH of 3.6 and were diluted with 1 L of distilled water. 10 mM of TPTZ (2, 4, 6-tri (2-pyridyl)-s-triazine) was prepared using 0.031 g of TPTZ in 10 mL of 40 mM HCl. 20 mM Ferric chloride was also prepared with 0.054 g $FeCl_3$. $6H_2O$ and dissolves in 10 mL distilled water. A 10:1:1 ratio of the three chemicals was mixed just before the assay formed the straw coloured FRAP solution. A standard solution of $FeSO_4$. $7H_2O$: 0.1 to 1.5 mM in methanol was also prepared.

Procedure

After an initial incubation of 3.6 mL FRAP solution and 0.4 mL distilled water at 37°C for 5 min, the extract was added and again incubated for 10. Absorbance was measured at 593nm. 5 different concentrations of the standard $FeSO_4$ solution were used for the calibration curve.

ABTS 2,2-azo-bis(3ethylbenz-thiozoline-6-sulfonic acid) Assay

ABTS is a blue-green radical cation, which loses colour when it is reduced by the electron transfer from an antioxidant and is measured at 750 nm.

Potassium persulphate 2.4 mM and ABTS solution 7 mM were mixed to form a working solution and stored in a dark place for 12 hr at room temperature. 1 mL of different concentrations of the extract (10, 20, 30, 40, and 50 µg/mL) was mixed with 1 mL of the working solution, and absorbance was measured after 6 min at 734 nm. The ABTS scavenging or reducing activity by the extract was calculated as FRAP, DPPH assays (Manigandan *et al.*, 2024).

Hydrogen peroxide (H_2O_2) decomposition assay-ROS scavenging activity

H_2O_2 is a non-radical reactive oxygen species that gets decomposed or scavenged by antioxidants. 0.4 mL of different concentrations (10-50 µg/mL) of the extract was added to 0.6 mL

of a previously prepared hydrogen peroxide solution of 20 mM in 50 mM phosphate buffer (pH 7.4). The mix was incubated at room temperature for 10 min, and the absorbance was measured at 240 nm (Chellathurai *et al*., 2024; Janani *et al*., 2023; Richards and Chaurasia, 2022).

Nitric oxide scavenging activity-Griess reaction assay

Nitric oxide formed from sodium nitroprusside was mixed with sulphanilamide at low pH, waited for 10 min, and then mixed with NED (N-naphthyl-ethylenediamine), which produces a stable azo compound with intense purple colour measured at 596 nm. When an antioxidant is added, it causes scavenging of nitric oxide, which is indicated by the colour loss of the end product measured as absorbance.

$$\% \text{ Antioxidant activity} = (\text{Abs sample} - \text{Abs control} \times 100/\text{Abs control}$$

Where Abs is used for absorbance in a spectrophotometer (Petsantad *et al*., 2020; Sun *et al*, 2003).

Cytotoxic assay - Brine shrimp Nauplii Mortality assay

In a 2L funnel, Cysts of *Artemia salina* (Brine shrimp) were soaked in fresh water for 1 hr. Sea salt was then added, and hatching of cysts was facilitated for the next 48 hr by aeration and illumination of the funnel. Nauplii were collected in a small beaker with 0.9% NaCl. 10-20 nauplii from the beaker (in 5 mL of 0.9% NaCl with the nauplii) were added to wells of a 24-well plate, and different concentrations (10-50 µL) of the extracts and the standard were added. The plates were incubated at 25ºC for 24 hr. Stereoscopic examination was done, and nauplii were considered live if there was movement of the shrimp during a 10-sec observation, and the percentage of live larvae was calculated (Kamala *et al*., 2023; Banti and Hadjikakou, 2021).

For analysis of all the anti-inflammatory and anti-oxidant assays-scatter plot with trend line were created in Excel worksheet. Trendline equation for each was used to calculate IC_{50}.

RESULTS

FTIR analysis of decoction extracts of Leaves, stem, and seeds of *Ruta chalepensis* was done and the functional groups and compound class were listed from Sigma Aldrich IR spectrum table (Figure 1 and Table 1). Anti-inflammatory (Figure 2) and antioxidant effects (Figure 3) were compared with standard controls. IC_{50} levels (Table 2) were also compared. The cytotoxic effect of the extracts was also assessed

All three anti-inflammatory assays-BSA, EAA, and MSA showed that the seeds extract showed the highest effect, with around 96-98% as effective as the standard anti-inflammatory substance. Both Leaves and stems had anti-inflammatory effects of more than 80% to that of the standard used. Regarding anti-oxidant effect, overall percentage inhibition was more for leaves. But IC_{50} values indicate that seeds are more potent.

At all concentrations, the percentage of live Naupli was 100% for the stem extract on both day 1 and day 2. For leaves and seed extracts, there was no mortality on day 1. On day 2, for leaves, 10% mortality with 40 µg/mL and 20% with 80 µg/mL was observed.

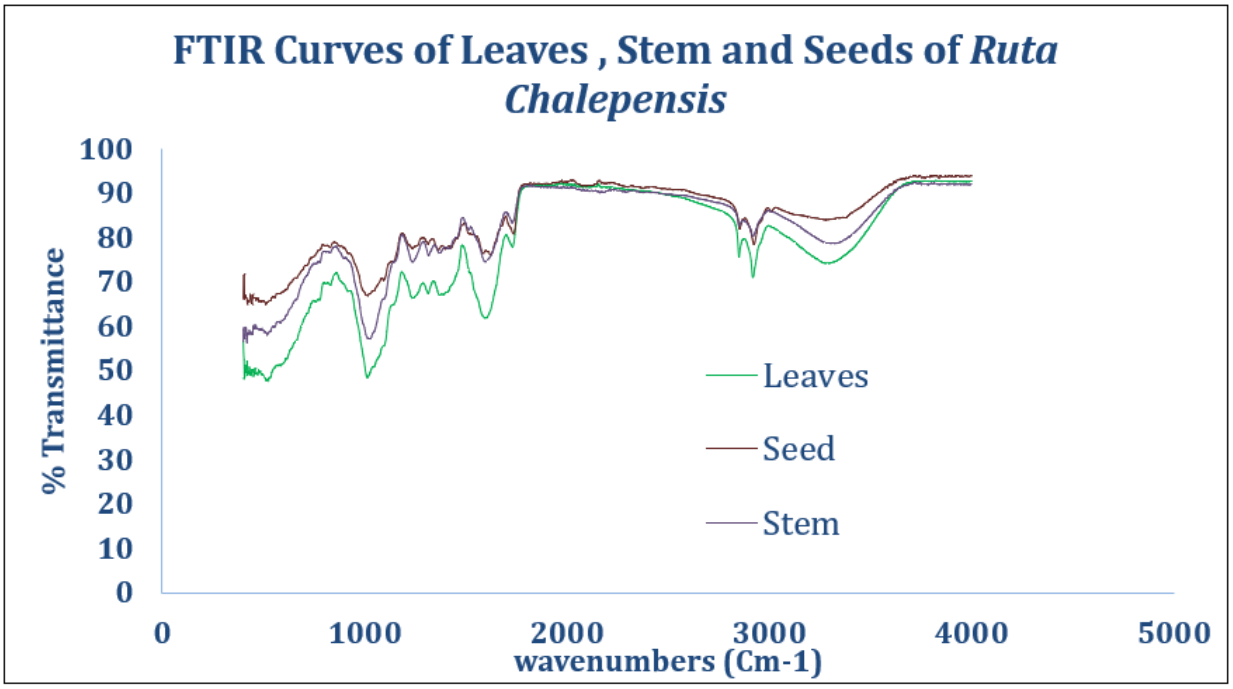

Figure 1: FTIR analysis of *Ruta chalepensis* stem, leaves and seeds.

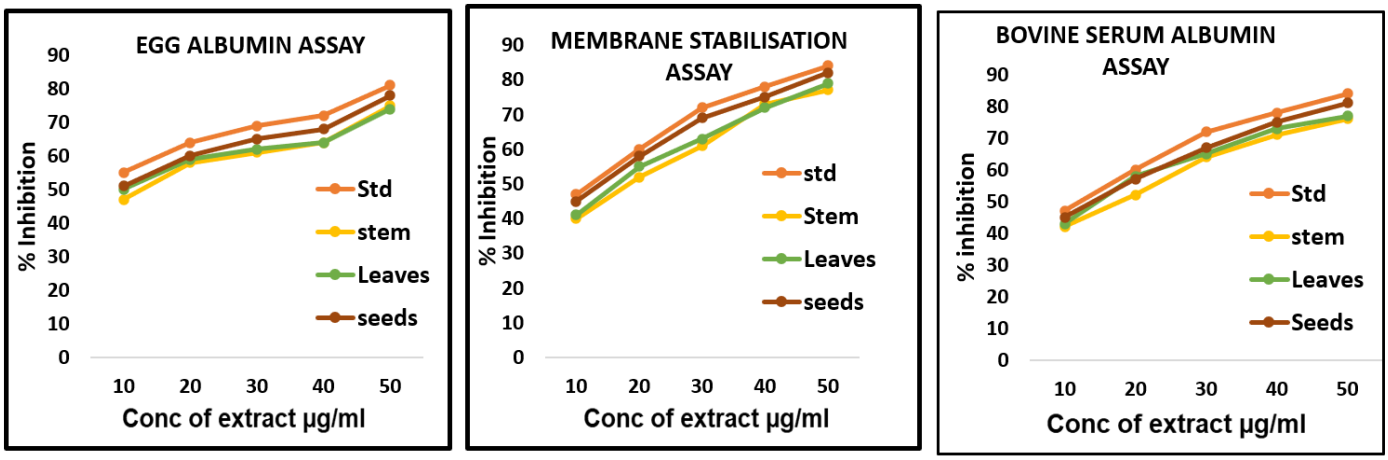

Figure 2: Anti-Inflammatory Assays. Percentage inhibition of protein denaturation (% Anti-inflammatory effect) in Bovine Serum Albumin (BSA) and Egg Albumin (EA) measured in a spectrophotometer at 660 nm. Percent inhibition of hemolysis in Membrane Stabilization Assay (MSA), for protein and 540 nm for haemolysis.

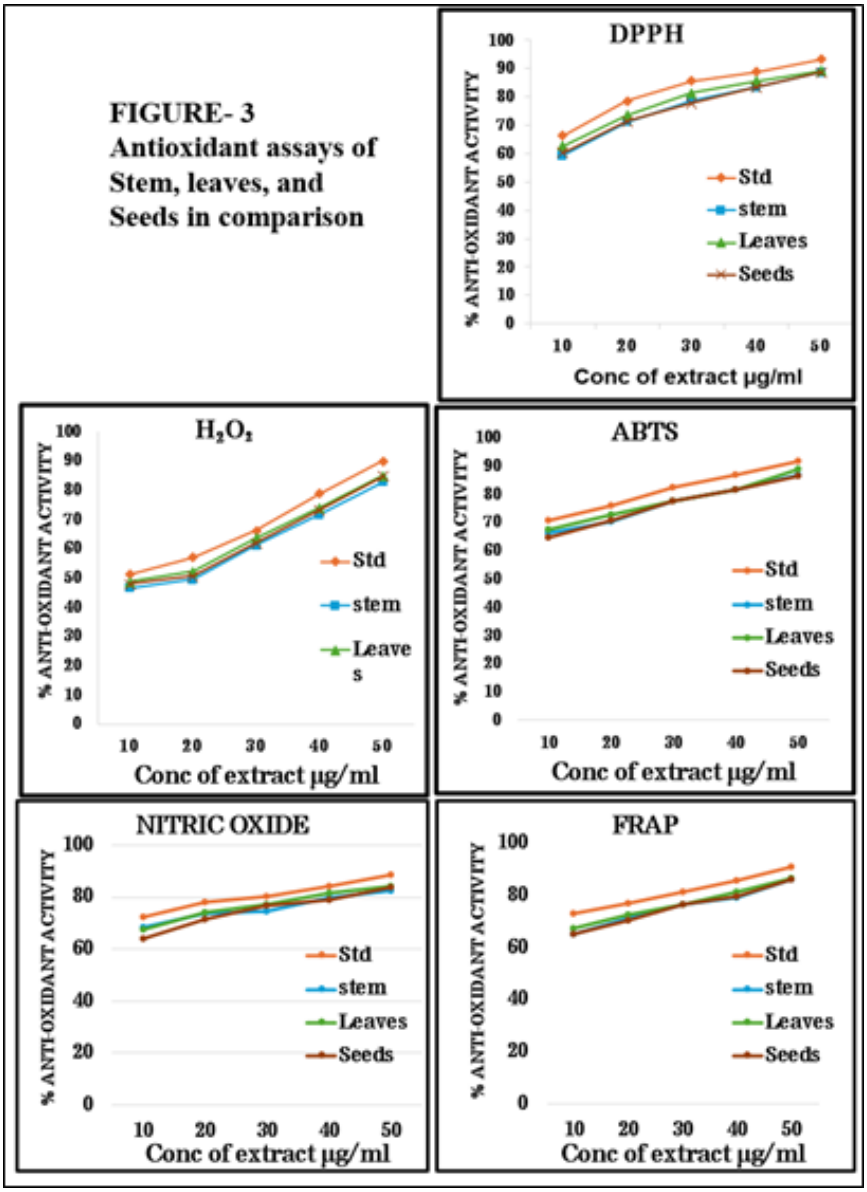

Figure 3: Antioxidant assays of stem, leaves, and seeds in comparison.

Table 1: Functional Groups and Compound Class-From Sigma Aldrich IR Spectrum Table.

Absorption (cm^{-1})				Group	Compound Class
range (cm^{-1})	RC Seeds	RC Leaves	RC Stem		
3274-3485	3274, 3485	3291	3319	O-H stretch (broad)	Alcohols, phenols (hydroxyl groups)
2923-2934	2923, 2853	2918, 2849	2918	C-H stretch (alkane)	Aliphatic (methylene, methyl) groups
2091	2091	-	-	C≡C or C≡N (stretch	Alkynes or nitriles
1735-1731	1735	1731	1729	C=O stretch (strong)	Ester /Ketone
1623-1597	1623, 1597	1697, 1597	1697, 1597	C=C stretch (aromatic), N-H bend	Aromatic rings, possible amides
1381-1236	1381, 1319, 1236	1389, 1318, 1236	1380, 1318, 1236	C-H bend, C-O stretch	Alkanes, alcohols, ethers, esters
1011-1023	1011	1012	1023	C-O stretch	Alcohols, ethers, esters
511-420	511, 425, 420, 488	514, 442, 420, 488	518, 442, 418, 484	C-Cl stretch, out-of-plane aromatic C-H	Aromatic rings, halogenated compounds

Table 2: IC_{50} (Half-Maximal Inhibitory Concentration).

IC_{50} values µg/mL	Standard	Stem	Leaves	Seeds
DPPH	15	16	18	17
NO	60	81	57	46
FRAP	43	40	44	36
ABTS	30	35	35	32
H_2O_2	12	19	17	17
BSA	14	23	22	18
EA	33	38	48	35
MSA	14	21	20	16

For seeds, 10% mortality with 10 µg/mL and 20% mortality were observed in 40 and 80 µg/mL.

DISCUSSION

In this study, we compared the anti-inflammatory and antioxidant effects of the stem, leaves, and seeds (berries) of *Ruta chalepensis* with those of commercially available standards. FTIR analysis was also done for the three extracts. The compound classes identified in FTIR were Alcohols, Ethers, esters, Ketone, phenols (hydroxyl groups), Aliphatic (methylene, methyl) groups, Alkynes or nitriles, Aromatic rings, possible amides, Alkanes, halogenated compounds (Khadhri *et al.*, 2017).

The health effects, like Anti-inflammatory, antioxidant, and other medicinal effects of plants, are mainly due to secondary metabolites, which are compounds produced by plants as a protective mechanism to survive in the environment. Of these, fat-soluble secondary metabolites like alcohols, aldehydes, and ketones are grouped as terpenes and terpenoids, which are compounds from isoprene, a 5-carbon molecule. Non-terpenoids are compounds not formed from isoprenes and include Flavonoids, Phenols, alkaloids, coumarins, Tannins, etc., (Zielińska-Błajet and Feder-Kubis 2020). Like this study, in a study in Jordan, Althaher *et al.*, have shown that RC extracts are rich in both Terpenoid and non-terpenoid compounds, which rationalises their several health benefits. In their review article on Ruta species, Ayda Khadhri *et al.*, also confirm, with Phytochemical screening, the presence of alkaloids, flavonoids, coumarins, tannins, volatile oil, glycosides, sterols, and triterpenes as possible active constituents (Khadhri *et al.*, 2017).

In a study on three different *Ruta* species-*chalepensis*, graveolens, and Corsica, *Ruta chalepensis* had the highest antioxidant effect. Hydroxyl groups can donate an electron to the hydroxy radicals and neutralize its oxidative effect. In phenolic acids, hydroxyl groups are linearly related to their antioxidant effect (Chen *et al.*, 2020). In our FTIR results, there is a slight shift to higher wave numbers in the hydroxyl stretch region of stem extract.

This may be due to free hydroxyl groups, which may indicate a quicker antioxidant effect due to the availability of free hydrogen/electrons which can neutralize free radicles. The IC_{50} value of stem extract in DPPH assay supports this viewpoint. In leaves, there is a strong, broad peak, which may be an indication of a more sustained antioxidant effect due to the bonding of the H group. Khadhri A *et al.*, have reported that stem extracts of certain other plants have higher phenols when compared to leaves (Khadhri *et al.*, 2024). In our study, though FTIR shows more free hydroxyl groups in the stem, the *in vitro* analysis results showed that extracts of all parts are 90-95% effective when compared to a standard, with leaves having the highest antioxidant effect.

Flavonoids, which are abundant in *Ruta chalepensis*, have been shown to inhibit inflammatory factors like cytokines, C-reactive proteins, Transcription factors, etc. (Serafini *et al.*, 2010). In their Gas chromatography analysis of essential oils of *Ruta chalepensis* L., Bagchi GD *et al.*, have shown the aliphatic ketones 2-undecanone and 2-nonanone as the two major compounds (Bagchi *et al.*, 2003). Others have also reported similarly on major compounds in aerial parts of *Ruta. c*. Anti-inflammatory effects 2 undecanone has several benefits, including protection against heart inflammation, improved effectiveness of anticancer therapy, asthma, etc. *In vitro* studies have shown that 2-undecanone inhibits inflammatory cytokines like TNF-alpha, IL-1beta, H_2O_2, nitric oxide, etc., (Chen *et al.*, 2014; Khade *et al.*, 2023). Our FTIR analysis also indicates the presence of aliphatic ketones. Comparison of anti-inflammatory effects of the three parts showed that all the parts had anti-inflammatory effects, but seeds had slightly higher effectiveness, with the stem having the least of the three. Regarding cytotoxicity using b. Stem extract showed no toxicity at all, but with leaves and seed extracts, 80% of the Brine shrimp nauplii were alive after day 2, even in the highest doses (Santhosh *et al.*, 2024).

CONCLUSION

We had compared the anti-inflammatory and antioxidant effects of leaves, stem, and Seeds of *Ruta chalepensis*. We also compared the difference in absorbance of Infrared rays by the compounds in the three parts. All the parts are effective as antioxidants and anti-inflammatory agents. According to the percentage of antioxidant effect, leaves have a better effect, but based on IC_{50}, seeds appear to have greater potency than leaves. Based on FTIR values, stem extracts may have quicker antioxidant action and leaves have a delayed but stable antioxidant effect. Of the three parts compared, seeds have a higher anti-inflammatory effect. Cytotoxicity of seeds was a little higher as shown by higher mortality of brine shrimp nauplii on day 2. Further studies are needed to confirm the effects, and the knowledge may be helpful in the preparation of concentrated formulations used for specific purposes.

ABBREVIATIONS

FTIR: Fourier Transform Infrared Spectrometer; **BSA:** Bovine Serum Albumin Denaturation Assay; **DPPH:** 2,2-Diphenyl-1-Picrylhydrazyl; **FRAP:** Ferric Reducing-Antioxidant Power; **ABTS:** 2,2-Azo-bis 3 Ethylbenz-Thiozoline-6-Sulfonic Acid/Azino-bi s(3-Ethylbenzothiazoline-6-Sulfonic Acid); **H_2O_2:** Hydrogen Peroxide; **ROS:** Reactive Oxygen Species; **NO:** Nitric Oxide; **DMSO:** Dimethyl Sulphoxide; **OD:** Absorbance (Optical Density); **RBC:** Red Blood Cell; **MSA:** Membrane Stabilization Assay; **EAA:** Egg Albumin Denaturation Assay; **TPTZ:** Tripyridyltriazine; **RSA:** Radical Scavenging Activity; **NED:** N-Naphthyl-Ethylenediamine; **RC:** Ruta chalepensis (used in Table 1); **IC_{50}:** Half-Maximal Inhibitory Concentration (IC_{50}).

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

AUTHORS' CONTRIBUTION

The authors confirm contribution to the paper as follows: Study design and conception was created by Rajeshkumar Shanmugam, Lingaraj Jayalakshmi and Sulochana Govindharaj, Data Collection was carried out by the Sulochana Govindharaj. Analysis and interpretation of results was performed by the Rajeshkumar Shanmugam, Lingaraj Jayalakshmi and Sulochana Govindharaj. Draft manuscript preparation was executed by Dr Rajeshkumar Shanmugam, Lingaraj Jayalakshmi and Sulochana Govindharaj All authors reviewed the results and approved the final version of the manuscript.

SUMMARY

In this study anti-inflammatory and antioxidant effects of leaves, stem and seeds of *Ruta chalepensis* were compared by *in vitro* analysis. Seeds have better anti-inflammatory effects and a potent antioxidant effect. But cytotoxic effects of seeds are higher in comparison with leaves and stem.

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