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Phytochemical profiling and FTIR analysis of aqueous extracts from three selected ethnomedicinal plants of North East India

Seema Khakhalary[1,2], Silistina Narzari[1]*

[1]Department of Biotechnology, Bodoland University, Kokrajhar-783370, Assam, India, [2]Department of Botany, B.H. College, Howly-781316, Assam, India

ABSTRACT

Ethnomedicinal plants have played an important role in natural product research and drug discovery since antiquity. The current study used phytochemical screening and Fourier Transform Infrared Spectroscopy (FTIR) to analyze the leaves of three ethnomedicinal plants identified in Goalpara area of Assam. The investigation was carried out to characterize the crude extract and identify the functional groups in these plants. Phytochemical screening revealed the presence of many secondary plant metabolites in the examined plants, including alkaloids, glycosides, flavonoids, terpenoids, steroids, tannins and phenolic compounds. The FTIR spectroscopy study revealed the existence of several key functional groups. The presence of various functional groups such as C-I stretch, C=O stretch, C-H stretch, and C-N was confirmed by FT-IR analysis. As a result, the current study provides solid support and a foundation for using these plant species as herbal treatments for a variety of diseases. This study confirms that aqueous leaf extracts of *Zanthoxylum oxyphyllum* Edgew., *Rotheca serrata* (L.) Steane & Mabb., and *Blumea lanceolaria* (Roxb.) Druce contains numerous bioactive compounds, in addition to previously reported phytochemicals, which could be utilized in the development of plant-based drugs.

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***Corresponding author:**
Silistina Narzari
E-mail: nsilistina@gmail.com

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INTRODUCTION

The identification of the chemical composition of phytochemical in medicinal plants provides insight into the various functional groups responsible for their therapeutic effects. GCMS, FTIR, and other spectroscopic methods can be employed for both qualitative and quantitative analysis of plant leaf extracts. Among these, FTIR (Fourier Transform Infrared) spectroscopy has been particularly significant in medicinal plant analysis. It is regarded as one of the most effective methods for identifying the types of chemical bonds (functional groups) present in compounds (Ashokkumar & Ramaswamy, 2014). The FTIR method is helpful in identifying the many organic and inorganic substances found in plants. According to Eberhardt *et al.* (2007), it defines the molecule and establishes its structure. FTIR is a high-resolution analytical tool that clarifies the structural components of chemical constituents, aiding in their classification. This rapid and non-destructive method is particularly useful for fingerprinting powdered herbs or their extracts. As a physicochemical analytical technique, FTIR provides an estimate of a tissue's metabolic composition at a specific moment. According to Surewicz *et al.* (1983) and Griffiths and de Haseth (1986), FTIR monitors the vibrations of bonds within chemical functional groups, producing a spectrum that can be considered the sample's metabolic or biochemical fingerprint.

Ethnomedicinal plants are excellent sources of herbal medications. A vast range of medicinal plants are utilized as alternative medicine for human and animal problems because they have less adverse effects than synthetic medications. Several tribes in the Indian subcontinent use them not only as medicines to maintain their health but also as sustenance. As a result, there is a significant increase in interest among domestic manufacturers of herbal-based medicines.

Zanthoxylum oxyphyllum is a scrambling shrub belonging to family Rutaceae. In India, the genus *Zanthoxylum* is represented by around 11 species (Hooker, 1875). All these species are commonly used by local population for ethno-medicinal purposes. Phytochemical studies on *Z. oxyphyllum* revealed the occurrence of glycosides, coumarins, flavonoids, phenols,

tannins in crude ethanolic leaf and seeds extract as reported by Ayangla *et al.* (2016). The study by Munda and Kakoti (2017) is known for the anti-inflammatory and analgesic activities in the methanolic extract of *Z. oxyphyllum*.

Rotheca serrata earlier known as *Clerodendrum serratum (L)* Moon is one of the important medicinal plants of India belonging to the family Lamiaceae. Few important common names of this plant are Moon, Bharangi, Phelang Riho, Bamun Hatee, Baman hatee, Bhuijam, Bharangee etc. Literature revealed the pharmacological activity of the plant such as anti-inflammatory activity, antinociceptive activity, anti-carcinogenic activity, wound healing activity (Singh *et al.*, 2012) and hepatoprotective activity (Gupta *et al.*, 2008; Sinha & Sinha, 2013; Jain *et al.*, 2016). Phytochemical studies showed the presence of secondary metabolites such as glycosides, steroids, alkaloids and phenolic class of compounds.

Blumea lanceolaria (Roxb.) Druce (Asteraceae), often known as "Jwglaori," is a perennial herb found in several parts of India. *B. lanceolaria* is a unique folkloric medicinal plant used by the people of Goalpara. The plant *B. lanceolaria* which is traditionally utilized by Mizoram's indigenous people, has good analgesic, antipyretic, and anti-inflammatory properties (Victoria *et al.*, 2012). The genus Blumea contains approximately 70 compounds, which include flavonoids, sesquiterpenes, triterpenoids, acetylenic thiophenes, monoterpenes, xanthenes, diterpenes, and essential oils. Blumealactones A, B and C produced from *B. balsamifera* demonstrated antitumor activities against Yoshida sarcoma cells in tissue culture (Fujimoto *et al.*, 1988; Chen *et al.*, 2009).

A review of the literature revealed that FTIR analysis of functional groups had not been previously conducted on the medicinal plants used by the people of Goalpara District, Assam. Therefore, the present study aims to analyze the functional groups of phytoactive compounds present in the leaves of three ethnomedicinal plants - *Z. oxyphyllum*, *R. serrata* and *B. lanceolaria* using FTIR spectroscopic analysis.

MATERIALS AND METHODS

Collection of Plant Materials

Healthy and fresh leaves of *Zanthoxylum oxyphyllum* Edgew., *Rotheca serrata* (L.) Steane & Mabb., and *Blumea lanceolaria* (Roxb.) Druce were collected from Goalpara District, Assam, India during March to April 2022. The plant species were taxonomically identified with the help of taxonomical experts. Voucher specimens were deposited in the Gauhati University Botanical Herbarium, Gauhati University and Bodoland University Botanical Herbarium, Bodoland University (Voucher No: *Zanthoxylum oxyphyllum* Edgew-18924, *Rotheca serrata* (L.) Steane & Mabb-18926 and *Blumea lanceolaria* (Roxb.) Druce-BUBH0000868). The collected leaves were washed with water, surface sterilized with 10% sodium hypochlorite solution, rinsed with sterile distilled water, and shade dried at room temperature. The samples were then ground into a coarse powder.

Preparation of plant extracts

30 g of dried powder was taken for each sample and extracted using 300 mL of water. The extraction was performed using a Soxhlet extractor for three hours at 60 ºC. The solvent was then filtered using Whatman filter paper, and the filtrate was evaporated under vacuum using a rotary evaporator at 40 ºC. The extraction process was repeated three times. The crude viscous semi solid extract, was subjected to phytochemicals screening tests.

Qualitative Phytochemical Screening

The qualitative phytochemical screening of solvent extracts from the ethnomedicinal plants was conducted to detect the presence or absence of secondary metabolites. A total of ten qualitative phytochemical tests were performed on the solvent extracts of the three plant samples, following the standard protocols of Harborne (1998) and Evans (2009) as outlined below.

Test for alkaloids

Mayer's Test: To detect alkaloids, 2 mL of concentrated HCl was added to 2 mL of the extract. After forming an aqueous layer, a few drops of Mayer's reagent were added. The presence of alkaloids was indicated by the formation of a white precipitate.

Test for flavonoids

Alkaline reagent Test: To 2 mL of extract, a few drops of 20% NaOH was added. The appearance of an intense yellow color indicated the presence of flavonoids.

Test for phenols

Ferric chloride test: For the detection of phenols, 2 drops of 5% ferric chloride solution was added to 2 mL of extract. The formation of intense color signified the presence of phenols.

Test for saponins

Foam Test: 2 mL of extract was taken and 1 mL of distilled water was added to it. The solution was shaken vigorously in a graduated cylinder for 30 seconds. The development of a foamy layer in the solution indicated the presence of saponins.

Test for glycosides

Salkowski's test: A small amount of extract was taken in 2 mL of water in a test tube and a few drops of aqueous NaOH were added. The formation of yellow colour indicated the presence of glycosides.

Test for terpenoids

Liebermann's test: To screen for terpenoids, 2 mL of the extract was mixed with 2 mL of chloroform, and the mixture was evaporated to dryness. To the dried residue, 2 mL of

concentrated H_2SO_4 was added. The presence of terpenoids was indicated by the formation of a yellowish-green layer at the lower portion of the solution.

Test for steroids

Salkowski's test: For detection of steroids, 2 mL of chloroform was taken and added to 2 mL of extract followed by addition of 2 mL concentrated H_2SO_4. A layer of red color produced at the bottom of the test tube indicated the existence of steroids.

Test for tannins

Lead Acetate test: For tannins, 10% of lead acetate was prepared. 2mL of the extract was then treated with 1mL of 10 % lead acetate. The development of white precipitate showed the presence of tannins.

Test for phytosterols

Liebermann-Burchard's Test: To 2 mL of extract, a few drops of Chloroform, Acetic Anhydride and concentrated H_2SO_4 were added. Presence of phytosterol was indicated by the appearance of translucent green color.

FTIR Analysis of Plant Extracts

Fourier transform infrared spectroscopy (FTIR) was used to identify the functional groups of compounds in crude powder of the plants. The wavelength of light absorbed corresponds to features in the chemical bond, which can be observed in the annotated FTIR spectrum. The infrared absorption spectrum in FTIR is used to interpret the chemical bonds in the compound. For FTIR analysis, 10 mg dried powder of each sample was encapsulated in 100 mg of potassium bromide (KBr) pellet and translucent sample discs were prepared. FTIR analyses of the samples were performed in THERMO NICOLET IS10 FTIR Spectrometer (THERMOSCIENTIFIC). The samples were run at infrared region between 400-4000 cm^{-1} and standard DLATGS detector was used at 2.8 mm/sec mirror speed.

Table 1: Phytochemicals present in *Z. oxyphyllum, R. serrata* and *B. lanceolaria* aqueous extracts

Phytochemicals	*Z. oxyphyllum*	*R. serrata*	*B. lanceolaria*
Alkaloids	+	+	+
Phenols	+	+	+
Flavonoids	+	+	+
Saponins	+	-	+
Terpenoids	+	+	+
Steroids	+	+	+
Glycosides	-	+	+
Tannins	+	+	+
Phytosterols	+	+	+

Note: "+" indicates present, "-" indicates absent

RESULTS

The present study investigated the phytochemicals in the leaves of three selected ethnomedicinal plant species: *Z. oxyphyllum*, *R. serrata* and *B. lanceolaria*. Aqueous leaf extracts from each plant species were subjected to preliminary phytochemical screening to identify the presence of secondary metabolites such as alkaloids, tannins, phenolics, flavonoids, and steroids. The results are presented in the Table 1.

Identification of Functional Groups in Plant Extracts

In this study, the FTIR spectrum was used to identify the functional groups of the active components based on the peak values in the infrared region. The FTIR peak values and corresponding functional groups in the medicinal plants are presented in Tables 2 to 4, while the FTIR spectra of the plant materials are shown in Figure 1. All three samples studied exhibited nearly identical wave numbers, indicating the presence of similar functional groups. Seven different functional groups were observed within the peak range of 497.98–3342.17 cm^{-1} in the crude leaf powder of each sample.

Table 2 shows the functional groups, peak values and types of bonds present in *Z. oxyphyllum*. The FTIR spectrum for *Z. oxyphyllum* is presented in Figure 1a. The Infra-red spectroscopic (IR) analysis of *Z. oxyphyllum* reveals the presence of various functional group within the peak ranges of 3267 to 1012 cm^{-1}. The peak at 3267 cm^{1} is associated with the C-H bond for alkyne. The band at 2918.56 cm^{-1} and 2850.21 cm^{-1} correspond to C-H bonds, indicating the presence of aliphatic compounds, alkanes, and alkynes. The band at 1731.30 cm^{-1} is attributed to C=O, suggesting the presence of an aldehyde group. The peak at 1601.35 cm^{-1} represents C=C in the aldehyde compound, while the band at 1243.13 cm^{-1} is associated with C-N in aliphatic amines and proteins. Additionally, the band at 1012 cm^{-1} corresponds to C-N in amines.

In *R. serrata*, FTIR analysis identified seven distinct functional groups within the intensity range of 506.24 to 3274.42 cm^{-1}

Table 2: FTIR peak values and functional groups in *Zanthoxylum oxyphyllum* leaf

S. No.	Wave Number cm^{-1} (Test Sample)	Frequency range cm^{-1} (Reference number)	Chemical Bond	Functional Group
1	3267	3333-3267	C-H	Alkyne
2	2918.56	3000-2850	C-H	Aliphatic compound
3	2850.21	3000-2850	C-H	Aliphatic compound
4	1731.30	1740-1720	C=O	Aldehyde compound
5	1601.35	1680-1600	C=C	Aldehyde compound
6	1243.13	1250-1080	C-N	Aliphatic amines
7	1012	1400-1000	C-N Stretch	Amine

Table 3: FTIR peak values and functional groups in *Rotheca serrata* leaf

S. No.	Wave Number cm^{-1} (Test Sample)	Frequency range cm^{-1} (Reference number)	Chemical Bond	Functional Group
1	3274.42	3333-3267	C-H	Alkyne
2	2918.08	3000-2850	C-H	Aliphatic compound
3	2850.04	3000-2850	C-H	Aliphatic compound
4	1601.07	1680-1600	C=C	Aldehyde compound
5	1247.38	1250-1080	C-N	Aliphatic amines
6	1008.68	1400-1000	S=O	Sulfoxide
7	506.24	600-500	C-Br	Alkyl halide

Table 4: FTIR peak values and functional groups in *B. lanceolaria* leaf

S. No.	Wave Number cm^{-1} (Test Sample)	Frequency range cm^{-1} (Reference number)	Chemical Bond	Functional Group
1	3342.17	3650-3000	O-H	Aromatic compound
2	2923.28	3000-2850	C-H	Aliphatic compound
3	2852.51	3000-2850	C-H	Aliphatic compound
4	1737.31	1740-1720	C=O	Aldehyde compound
5	1455.76	1432-1621	C-H	Alkanes
6	1260.77	1270-1150	C-N	Aromatic Amine
7	497.98	500	C-I	Alkyl halide

(Table 3). The FTIR results indicated the presence of a C-H bond associated with an alkyne, evidenced by the peak at 3274.42 cm^{-1}. The peaks at 2918.08 and 2850.04 cm^{-1} correspond to the stretching of the C-H bond in aliphatic groups. An aldehyde compound, characterized by the C=C group, was observed at 1601.07 cm^{-1}. The frequency peak at 1247.38 cm^{-1} confirms the presence of aliphatic amines (C-N), while sulfoxides (S=O) were identified at 1008.68 cm^{-1}. The peak at 506.24 cm^{-1} indicates the presence of C-Br, suggesting the presence of alkyl halides (Figure 1b).

In the crude sample of *B. lanceolaria*, FTIR analysis revealed the presence of seven distinct functional groups. A major peak observed at 3342.17 cm^{-1} was assigned to the O-H group, indicating the presence of alcohol. The absorption peaks at 2923.28 cm^{-1} and 2852.51 cm^{-1} suggest the presence of a C-H aliphatic compound. An aldehyde compound (C=O) was detected at 1737.31 cm^{-1}. The presence of alkanes was indicated by the absorption peak at 1455.76 cm^{-1} (C-H), while aromatic amines (C-N) were observed at 1260.77 cm^{-1}. Additionally, alkyl halides (C-I) were identified at 497.98 cm^{-1} through FTIR analysis (Figure 1c).

DISCUSSION

Plants are a valuable source of various bioactive compounds that can be directly or indirectly used in the treatment of numerous human ailments (Kuldip *et al.*, 2005). The study of plants primarily focuses on discovering novel secondary metabolites with various pharmacological properties. Functional group analysis is a prerequisite in any phytochemical study, as it helps determine the chemical composition of lead compounds. Identifying functional groups is a crucial step in determining the chemical constituents, and this can be elucidated through FTIR analysis.

In the present study, qualitative phytochemical analysis revealed the presence of a wide range of phytochemicals in the leaf extracts of all the plant species examined. As shown in the tables, most of the tested phytochemicals, including alkaloids, glycosides, phytosterols, phenols, tannins, flavonoids, and steroids, were found in the extracts of the three plant species. The presence of these phytochemical groups suggests a potential for a broad spectrum of biological and pharmacological activities. However, saponin was absent in *R. serrata*. In contrast, saponin was detected only in *Z. oxyphyllum* and *B. lanceolaria*. This finding aligns with earlier reports by Kebede *et al.* (2021), where saponin was detected in aqueous extracts of *Discopodium penninervium* and *Polysphaeria aethiopica* leaves. Additionally, glycoside was absent in *Z. oxyphyllum*, consistent with the findings of Ramya *et al.* (2017), which reported the absence of glycosides in the aqueous leaf extracts of *S. cumina*, *Terminalia arjuna*, and *Naringi crenulata*.

In the present study, a significant source of phytochemicals was screened, confirming the assumption that ethnomedicinal plants are rich in secondary metabolites such as alkaloids, saponins, flavonoids, and tannins, all of which are known for their medicinal properties. The presence of these diverse secondary metabolites in the selected plant species justifies their traditional medicinal use, as these phytochemicals have immense therapeutic potential. According to Riaz *et al.* (2023), certain chemical constituents found in plant extracts exhibit various therapeutic properties. Batiha *et al.* (2020) also reported that plant-derived components such as flavonoids and terpenoids have biological functions that promote therapeutic activities, including anti-carcinogenic, anti-mutagenic, anti-inflammatory, and antioxidant capabilities. Phytochemicals such as flavonoids, tannins, saponins, alkaloids, and terpenoids exhibit a range of biological effects, including antioxidant, anti-inflammatory, anti-diarrheal, anti-ulcer, and anticancer activities, as noted by Starlin *et al.* (2019).

Phenols, the most abundant group of phytochemicals, account for the majority of antioxidant activity in plants or plant products (Sulaiman & Balachandran, 2012). They

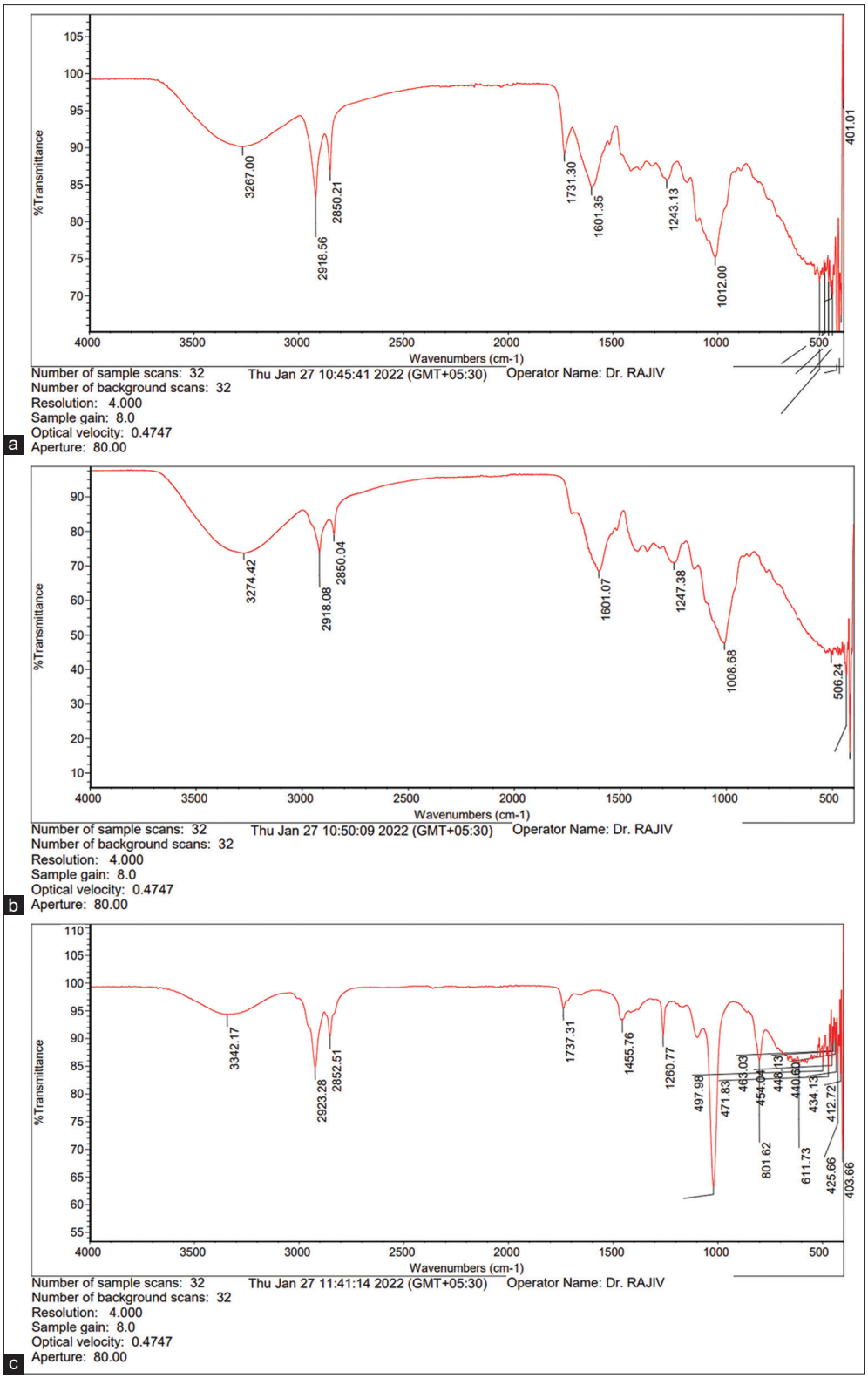

Figure 1: a) FTIR spectrum of *Z. oxyphyllum* leaf, b) FTIR spectrum of *R. serrata* leaf and c) FTIR spectrum of *B. lanceolaria* leaf

have also been shown to possess a wide range of biological activities, such as antimutagenicity, anti-carcinogenicity, and the ability to regulate gene expression (Marinova *et al.*, 2005). Glycosides are recognized for their strong physiological effects, with cardiac glycosides being a preferred treatment for congestive heart failure. Furthermore, Boyce and Christy (2004) mentioned that glycosides possess laxative, diuretic, and antiseptic properties.

Phytosterols are known to exert various biological activities, including anticarcinogenic effects (Atif & Carol, 2000), immunomodulatory and anti-inflammatory properties (Bouic, 2001; Navarro *et al.*, 2001), and antioxidant potential, as well as hypocholesterolemic and antidiabetogenic effects (Marineli *et al.*, 2012; Furlan *et al.*, 2013). The presence of phytosterols in all plant extracts suggests that these compounds may contribute to the use of *Z. oxyphyllum*, *R. serrata*, and *B. lanceolaria* as anticancer agents by traditional healers.

Similarly, the detection of steroids in the plant extracts suggests their contribution to antibacterial properties (Epand *et al.*, 2007). The presence of saponins, triterpenoids, tannins, flavonoids, glycosides, and steroids indicates that these compounds might be responsible for the observed anti-inflammatory activities in plant extracts. This aligns with the report of Ahmadiani *et al.* (2000), which stated that flavonoids and tannins possess anti-inflammatory effects.

In the present study, FTIR analysis was conducted on plant samples of *Z. oxyphyllum*, *R. serrata* and *B. lanceolaria*. The FTIR analysis of selected medicinal plants revealed absorption peak at various values, indicating the presence of different functional groups, such as like alcohol (O-H), alkyne, aliphatic compound (C-H), aldehyde compound (C=O), aliphatic amines (C-N), sulfoxide (S=O) and alkyl halide (C-Br).

The absorption peaks at 3267 and 3274.42 cm^{-1} in *Z. oxyphyllum* and *R. serrata* suggest the presence of alkyne (C-H) groups, which is consistent with findings by Shah *et al.* (2019) in *Thymus linearis* leaf extract. In *B. lanceolaria*, the infra-red spectrum showed a frequency range of 3650-3000 cm^{-1}, representing O-H stretching vibrations, confirming the presence of aromatic compounds (phenolics and alcohols). These results align with those of Noviany *et al.* (2023), who reported O-H functional groups in *Sesbania grandiflora*. Similar O-H alcohol groups were observed at a peak of 3354.08 cm^{-1} in the crude methanol extract of *Ceropegia juncea* by Visveshwari *et al.* (2017). Medium peaks at 2918.56 and 2850.21 cm^{-1} in *Z. oxyphyllum*, 2918.08 and 2850.04 cm^{-1} in *R. serrata*, and 2923.28 and 2852.51 cm^{-1} in *B. lanceolaria* indicate the presence of aliphatic compounds (C-H stretching). The detection of hydroxyl groups suggests the presence of flavonoids, alcohols, and phenolic compounds, as noted by Kumar and Pandey (2013). The aromatic nature of *B. lanceolaria* is further confirmed by the presence of aromatic functional groups. Flavonoids, which contain aromatic rings and hydroxyl groups, are known for their strong antioxidant activities (Peterson *et al.*, 2005). FTIR analysis revealed the presence of flavonoids due to O-H stretching, terpenes due to C-H groups consistent with the findings by Dhivya and Kalaichelvi (2017). Peaks at 1601.35 and 1601.07 cm^{-1} in *Z. oxyphyllum* and *R. serrata*, respectively, were assigned to aldehyde compounds (C=C), supporting results found in *Sesbania grandiflora* by Noviany *et al.* (2023). The band at 497.98 cm^{-1} corresponds to C-I at 500 cm^{-1}, revealing the presence of alkyl halide groups in *B. lanceolaria* leaf, similar to results by Theja and Kuber (2022) in *Ficus sagittifolia*.

An absorption band at 506.24 cm^{-1} in *R. serrata* exhibited a C-Br bond, indicating the presence of alkyl halides, consistent with findings by Kavipriya and Chandran (2018) in *Cassia alata* methanolic extract. Maitera and Chukkol (2016) also observed C-Br stretching at a peak frequency of 650 cm^{-1} in the stem bark of *Faidherbia albida*. The absorption peak at 1260.77 cm^{-1} in *B. lanceolaria* indicates the presence of C-N aromatic amines, supporting previous reports by Kamble and Gaikwad (2016) and Arunprasath and Indhumathi (2019). Shah *et al.* (2019) confirmed the presence of aromatic amines at an absorption peak of 1271.17 cm^{-1} in *Thymus linearis* leaf extract. Vanamane *et al.* (2021) identified S=O sulfoxide at an absorption peak of 1007.66 cm^{-1} in dried leaf and fruit peel extract of *Capparis divaricata lam*, supporting the presence of S=O sulfoxide in *R. serrata* leaf at 1008.68 cm^{-1}.

The frequency range of 1740-1720 cm^{-1} represents C=O stretching vibrations, confirming the presence of aldehyde groups at 1731.30 and 1737.31 cm^{-1} in *Z. oxyphyllum* and *B. lanceolaria*. The presence of C-H alkanes in *B. lanceolaria* at an absorption band of 1455.76 cm^{-1} supports the findings of Mugendhiran and Sheeja (2020). Chandra (2018) confirmed the presence of C-N stretching at 1240.23 cm^{-1}, indicating the presence of aliphatic amines, which corresponds to the results in *Z. oxyphyllum* and *R. serrata* at 1243.13 and 1247.38 cm^{-1}, respectively. Peaks in the range of 1400-1000 cm^{-1} denote C-N stretching vibrations for amine groups, detected at a peak value of 1012 cm^{-1} in *Z. oxyphyllum*. No peaks were observed between 2220-2260 cm^{-1}, indicating the absence of cyanide groups in all three plants, suggesting that these plants do not contain any toxic substances.

The FTIR analysis confirmed the presence of functional groups important for the synthesis of bioactive phytoconstituents. These functional groups belong to secondary plant metabolites, as explained by researchers such as Skoog *et al.* (2007) and Paul *et al.* (2011). FTIR spectrophotometry identified the presence of groups such as O-H, C-H, C-N, C=O, C=C, S=O, and C-Br, indicating the various medicinal properties of these plants.

Many researchers have analyzed plant parts using FTIR spectroscopy, revealing that medicinal plants have the potential to induce insecticidal, nematicidal, and antimicrobial activities due to the presence of functional groups and secondary metabolites (de Amorin, 1999; Anis *et al.*, 2000; Venkanna *et al.*, 2013; Radhakrishnan *et al.*, 2015; Koshy *et al.*, 2017). Alkanes, present in nearly all biological organisms, provide ecological and metabolic functions as sources of carbon and energy. Amines, essential components of amino acids, play crucial roles in both plants and animals. The present findings are in agreement with Venkanna *et al.* (2013), who reported antimicrobial properties in *Datura stramonium* due to the presence of alcohol, alkynes, esters, amines, and alkane functional groups. In *Eucalyptus globulus*, the presence of alcoholic (O-H), amide, carbonyl (C=O), and ether (C-O) functional groups was responsible for antimicrobial activity against various fungi and bacteria (Koshy *et al.*, 2017). FTIR spectral analysis of *Clitoria ternatea* leaf extract by Lakshmi *et al.* (2015) reported that functional groups such as alkanes, aromatic amines, phenols, and primary and secondary amines were responsible for various therapeutic applications. Functional groups in these plants can be utilized in

different pharmaceutical products, including anti-cancer, anti-ulcer, anti-inflammatory drugs, and treatments for jaundice, headaches, and stomach aches, or as sources of antimicrobial and antioxidant compounds (Baker, 1982; Skoog *et al.*, 2007; Maobe & Nyarango, 2013). This may explain why these plants are traditionally used by locals to treat stomach aches, as anti-inflammatory medicine, and more. Analysis of the data clearly shows that the selected plants in this study have similar functional groups, and the FTIR spectrum facilitates the determination of plant extract constituents for further analysis of their medicinal properties.

CONCLUSIONS

From the FTIR spectra, it is evident that each band corresponds to characteristic absorption peaks, indicating the presence of specific functional groups in the samples. The screening revealed the presence of phenolic groups, alkanes, aliphatic amines, alcohols, alkyl halides, and aromatic amines, which confirm the presence of secondary metabolites. The identification of these functional groups supports the medicinal properties of the analyzed samples, providing a scientific basis for the ethnomedicinal use of the selected plants by the people of Goalpara.

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REFERENCES

Ahmadiani, A., Hosseiny, J., Semnanian, S., Javan, M., Saeedi, F., Kamalinejad, M., & Saremi, S. (2000). Antinociceptive and anti-inflammatory effects of *Elaeagnus angustifolia* fruit extract. *Journal of Ethnopharmacology, 72*(1-2), 287-292. https://doi.org/10.1016/S0378-8741(00)00222-1

Anis, M., Sharma, M. P., & Iqbal, M. (2000). Herbal ethnomedicine of the gwalior forest division in madhya pradesh, India. *Pharmaceutical Biology, 38*(4), 241-253. https://doi.org/10.1076/1388-0209(200009)3841-AFT241

Arunprasath, A., & Indhumathi, M. (2019). Identification of functional groups in Corbichonia decumbens by Fourier-Transform Infrared Spectroscopy. *Journal of Drug Delivery & Therapeutics, 9*(3), 583-587. https://doi.org/10.22270/jddt.v9i3-s.3003

Ashokkumar, R., & Ramaswamy, M. (2014). Phytochemical screening by FTIR spectroscopic analysis of leaf extracts of selected Indian medicinal plants. *International Journal of Current Microbiology and Applied Sciences, 3*(1), 395-406.

Atif, B. A., & Carol, S. F. (2000). Phytosterols as anticancer dietary components: evidence and mechanism of action. *The Journal of Nutrition, 130*(9), 2127-2130. https://doi.org/10.1093/jn/130.9.2127

Ayangla, N. W., Singh, N., & Kumar, A. (2016). Phytochemical analysis of plant species of genus Zanthoxylum. *International Journal of Medicine and Pharmaceutical Science, 6*(1), 1-8.

Baker, E. A. (1982). Chemistry and Morphology of Plant Epicuticular Waxes. In D. F. Cutler, K. L. Alvin & C. E. Price (Eds.), *The Plant Cuticle* (pp. 139-166) London, UK: Academic Press.

Batiha, G. E., Beshbishy, A. M., Alkazmi, L., Adeyemi, O. S., Nadwa, E., Rashwan, E., El-Mleeh, A., & Igarashi, I. (2020). Gas chromatography-mass spectrometry analysis, phytochemical screening and anti-protozoal effects of the methanolic *Viola tricolor* and acetonic *Laurus nobilis* extracts. *BMC Complementary Medicine and Therapies, 20*, 87. https://doi.org/10.1186/s12906-020-2848-2

Bouic, P. J. D. (2001). The role of phytosterols and phytosterols in immune modulation: a review of the past 10 years. *Current Opinion Clinical Nutrition and Metabolic Care, 4*(6), 471-475. https://doi.org/10.1097/00075197-200111000-00001

Boyce, P. W., & Christy, L. P. (2004). *Applied pharmacology for veterinary technicians*. (2nd ed). St. Luis, USA: WB Saunders Co.

Chandra, S. (2018). Fourier transform infrared (FT-IR) spectroscopic analysis of *Nicotiana plumbaginifolia* (Solanaceae). *Journal of Medicinal Plants Studies, 7*(1), 82-85.

Chen, M., Jin, H.-Z., Zhang, W.-D., Yan, S.-K., & Shen, Y.-H. (2009). Chemical constituents of plants from the genus *Blumea*. *Chemistry and Biodiversity, 6*(6), 809-817. https://doi.org/10.1002/cbdv.200800113

de Amorin, A., Borba, H. R., Carauta, J. P. P., Lopes, D., & Kaplan, M. A. C. (1999). Anthelmintic activity of the latex of *Ficus* species. *Journal of Ethnopharmacology, 64*(3), 255-258. https://doi.org/10.1016/S0378-8741(98)00139-1

Dhivya, S. M., & Kalaichelvi, K. (2017). UV-Vis Spectroscopic and FTIR analysis of Sarcostemma brevistigma, Wight. And Arn. *International Journal of Current Pharmaceutical Research, 9*(3), 46-49. https://doi.org/10.22159/ijcpr.2017.v9i3.18890

Eberhardt, T. L., Li, X., Shupe, T. F., & Hse, C. Y. (2007). Chinese tallow tree (Sapium Sebiferum) utilization: Characterization of extractives and cell-wall chemistry. *Wood and Fiber Science, 39*(2), 319-324.

Epand, R. F., Savage, P. B., & Epand, R. M. (2007). Bacterial lipid composition and the antimicrobial efficacy of cationic steroid compounds (Ceragenins). *Biochimica et Biophysica Acta (BBA)-Biomembranes, 1768*(10), 2500-2509. https://doi.org/10.1016/j.bbamem.2007.05.023

Evans, W. C. (2009). *Trease and Evans Pharmacognosy*. London, UK: Saunders Limited.

Fujimoto, Y., Soemartono, A., & Sumatra, M. (1988). Sesquiterpene lactones from *Blumea balsamifera*. *Phytochemistry, 27*(4), 1109-1111. https://doi.org/10.1016/0031-9422(88)80284-X

Furlan, C. P. B., Marques, A. C., Marineli, R. da. S., & Junior, M. R. M. (2013). Conjugated linoleic acid and phytosterols counteract obesity induced by high-fat diet. *Food Research International,* 51(1), 429-435. https://doi.org/10.1016/j.foodres.2012.12.023

Griffiths, P. R., & de Haseth, J. A. (1986). *Fourier transform infrared spectroscopy*. New York, UK: Wiley.

Gupta, A. K., Tandon, N., & Sharma, M. (2008). *Review on Indian Medicinal Plants* (Vol. 7, pp. 110-111) New Delhi, India: Indian Council of Medical Research.

Harborne, A. J. (1998). *Phytochemical methods A guide to modern techniques of plant analysis*. (3rd ed.). Dordrecht, Netherlands: Springer.

Hooker, J. D. (1875). *The Flora of British India*. London, UK: L. Reeve & Co, London.

Jain, J. B., Kumane, S. C., & Bhattacharya, S. (2016). Medicinal flora of Madhya Pradesh and Chattishgarh-A Review. *Indian Journal of Traditional Knowledge, 5*(2), 237-242.

Kamble, V., & Gaikwad, N. (2016). Fourier Transform Infrared Spectroscopy Spectroscopic Studies in *Embelia ribes* Burm. F.: A Vulnerable Medicinal Plant. *Asian Journal of Pharmaceutical and Clinical Research,* 9(3), 41-47. https://doi.org/10.22159/ajpcr.2016.v9s3.13804

Kavipriya, K., & Chandran, M. (2018). FTIR and GCMS Analysis of bioactive Phytocompounds in methonalic leaf extract of *Cassia alata*. *Biomedical and Pharmalogy Journal, 11*(1), 141-147. https://doi.org/10.13005/bpj/1355

Kebede, T., Gadisa, E., & Tufa, A. (2021). Antimicrobial activities evaluation and phytochemical screening of some selected medicinal plants: A possible alternative in the treatment of multidrug-resistant microbes. *Plos One, 16*(3), e0249253. https://doi.org/10.1371/journal.pone.0249253

Koshy, O., Thomas, S., & Subramanian, L. (2017). Green Synthesis of Silver Nanoparticles using Aqueous Plant Extracts and its Application as Optical Sensor. *International Journal of Biosensors & Bioelectronics, 2*(3), 82-85. https://doi.org/10.15406/ijbsbe.2017.02.00022

Kumar, S., & Pandey, A. K. (2013). Chemistry and biological activities of flavonoids: an overview. *The Scientific World Journal, 2013*, 162750. https://doi.org/10.1155/2013/162750

Lakshmi, N. D. M., Mahitha, B., Madhavi, T., & Sushmaa, N. J. (2015). Phytochemical screening and FTIR analysis of *Clitoria ternatea* leaves. *International Journal of Scientific & Engineering Research, 6*(2), 287-290.

Maitera, O. N., & Chukkol, I. B. (2016). Phytochemical and Fourier Transform Infrared Spectroscopy analysis of *Faidherbia albida* (Del)

as a preservative agent. *World Journal of Research and Review, 3*(3), 25-29.

Maobe, M. A. G., & Nyarango, R. M. (2013). Fourier Transformer Infra-Red Spectrophotometer Analysis of *Warburgia ugandensis* Medicinal herb used for the Treatment of Diabetes, Malaria and Pneumonia in Kisii Region, Southwest Kenya. *Global Journal of Pharmacology, 7*(1), 61-68.

Marineli, R. da S., Furlan, C. P. B., Marques, A. C., Bicas, J., Pastore, G. M., & Marostica, M. R. (2012). Phytosterols: Biological effects and mechanisms of hypocholesterolemic action. In V. K. Gupta & M. G. Tuohy (Eds.), Biotechnology of Bioactive Compounds: Sources and Applications (pp. 565-581) New York, US: John Wiley & Sons, Ltd. https://doi.org/10.1002/9781118733103.ch23

Marinova, D., Ribarova, F., & Atanassova, M. (2005). Total phenolics and total flavonoids in Bulgarian fruits and vegetables. *Journal of University and Chemical Technology and Metallurgy, 40*(3), 255-260.

Mugendhiran, S., & Sheeja, B. D. (2020). Evaluation of phytoconstituents of *Erigeron canadensis* L. by FTIR and GC-MS analysis. *International Journal of Pharmaceutical Sciences and Research, 12*(5), 2823-2834. https://doi.org/10.13040/IJPSR.0975-8232.12(5).2823-34

Munda, S., & Kakoti, B. B. (2017). Pharmacological evaluation of methanolic extract of *Zanthoxylum oxyphyllum* Edgew with special reference to anti-Inflammatory and analgesic activity. *International Journal of Applied Biology and Pharmaceutical Technology, 8*(4), 5-10.

Navarro, A., Heras, B. D. L., & Villar, A. (2001). Anti-inflammatory and immunomodulating properties of a sterol fraction from *Sideritis foetens*. *Biological & Pharmaceutical Bulletin, 24*(5), 470-473. https://doi.org/10.1248/bpb.24.470

Noviany, N., Amrulloh, M. H., Mohamad, R., Irawan, B., Kusuma, W. A., Hadi, S., Supriyanto, R., Nofiani, R., Hussin, M. H., & Yuwono, S. W. (2023). FTIR-Based metabolomics for characterization of antioxidant activity of different parts of *Sesbania grandiflora* plant. *Sains Malaysiana, 52*(1), 165-174.

Paul, K. R., Irudayaraj, V., Johnson, M., & Patric, D. R. (2011). Phytochemical and anti-bacterial activity of epidermal glands extract of *Christella parasitica* (L.) H. Lev. *Asian Pacific Journal of Tropical Biomedicine, 1*(1), 8-11. https://doi.org/10.1016/S2221-1691(11)60059-2

Peterson, J., Dwyer, J., Bhagwat, S., Haylowitz, D., Hoiden, J., Eldridge, A. L., Beecher, G., & Aladesanmi, J. (2005). Major flavonoids in dry tea. *Journal of Food Composition and Analysis, 18*(6), 487-501. https://doi.org/10.1016/j.jfca.2004.05.006

Radhakrishnan, S., Alarfaj, A. A., & Annadurai, G. (2015). Estimation of phytochemical analysis and invitro antioxidant activity of calotropis gigantea extract: wound healing activity and its biomedical application. *International Journal of Pharmaceutical Sciences and Research, 6*(7), 3053-3060.

Ramya, B., Seetharaman, S., Indra, V., Sheela, D., Perinbam, K., & Augustain, G. (2017). Phytochemical profiling of aqueous extracts of selected medicinal plants. *Journal of Pharmaceutical and Scientific Innovation, 6*(1), 14-16.

Riaz, M., Khalid, R., Afzal, M., Anjum, F., Fatima, H., Zia, S., Rasool, G., Egbuna, C., Mtewa, A. G., Uche, C. Z., & Aslam, M. A. (2023). Phytobioactive compounds as therapeutic agents for human diseases: A review. *Food Science & Nutrition, 11*(6), 2500-2529. https://doi.org/10.1002/fsn3.3308

Shah, T. K., Kumar, A., Tandel, R., Bhat, R. A. H., & Sarma, D. (2019). Identification of functional groups in *Thymus linearis* ethanol leaf extract through fourier transform infrared spectroscopy (FTIR). *Journal of Pharmacognosy and Phytochemistry, 8*(4), 3013-3015.

Singh, M. K., Khare, G., Iyer, S. K., Sharwan, G., & Tripathi, D. K. (2012). *Clerodendrum serratum*: A Clinical approach. *Journal of Applied Pharmaceutical Science, 2*(2), 11-15.

Sinha, M. K., & Sinha, D. (2013). Herbal medicinal plants of Koria district (C.G.) India. *International Journal of Green and Herbal Chemistry, 2*(4), 1114-1120.

Skoog, D. A., Holler, F. J., & Crouch, S. R. (2007). *Principles of instrumental analysis*. (6th ed.). Belmont, California: Brooks Cole.

Starlin, T., Prabha, P. S., Thayakumar, B. A., & Gopalakrishnan, V. K. (2019). Screening and GC-MS profiling of ethanolic extract of *Tylophora pauciflora*. *Journal of Biomedical Informatics, 15*(6), 425-429. https://doi.org/10.6026/97320630015425

Sulaiman, C. T., & Balachandran, I. (2012). Total phenolics and total flavonoids in selected Indian medicinal plants. *Indian Journal of Pharmaceutical Sciences, 74*(3), 258-260.

Surewicz, W. K., Mantsch, H. H., & Chapman, D. (1993). Determination of Protein Secondary Structure by Fourier Transform Infrared Spectroscopy: A Critical Assessment. *Biochemistry, 32*(2), 389-393. https://doi.org/10.1021/bi00053a001

Theja, I., & Kuber, B. R. (2023). Phytochemical screening and Fourier Transform IR Analysis of *Ficus sagittifolia* (Warburg Ex Mildbread and Burret) stem bark. *International Journal of Pharmacy Research & Technology, 13*(1), 73-78.

Vanamane, R. S., Vhankade, A. M., Bhosale, P. A., Salgar, P. S., & Manjunath, G. (2021). FTIR (Fourier transform infrared spectroscopy) spectroscopic analysis of dried leaf and fruit peel extract of *Capparis divaricata* lam. *International Journal of Environment, Agriculture and Biotechnology, 6*(6), 141-145. https://doi.org/10.22161/ijeab.66.17

Venkanna, B., Uma, A., Suvarnalaxmi, Ch., Chandrasekharnath, N., Prakasham, R. S., & Jayalaxami, L. (2013). Antimicrobial property of Datura leaf extract against methicillin- resistant *Staphylococcus aureus* isolated from urethral and skin suppurative infection. *Current Trends in Biotechnology and Pharmacy, 7*(3), 782-792.

Victoria, S. H., Das, S., Lalhlenmawia, H., Phucho, L., & Shantabi, L. (2012). Study of analgesic, antipyretic and anti-inflammatory activities of the methanolic extract of *Blumea lanceolaria* (Roxb.) Druce. *International Journal of Life Sciences Biotechnology and Pharma Research, 1*(3), 2250-3137.

Visveshwari, M., Subbaiyan, B., & Thangapandian, V. (2017). Phytochemical analysis, antibacterial activity, FTIR and GCMS analysis of *Ceropegia juncea* Roxb. *International Journal of Pharmacognosy and Phytochemical Research, 9*(7), 914-920. https://doi.org/10.25258/phyto.v9i07.11155