

PHYTOCHEMICAL SCREENING OF INDIAN JUJUBE (*Ziziphus mauritiana*) AND JACKFRUIT (*Artocarpus heterophyllus* Lam.) LEAVES EXTRACTED BY ULTRASOUND-ASSISTED EXTRACTION (UAE)

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Abstract: Recently, scientists explored the potential of certain tropical plant species like *Ziziphus* sp. and *Artocarpus* sp. for antidiabetic, anti-inflammatory, and antigout properties due to their high-level bioactive compounds, polyphenols, flavonoids, and alkaloids. Despite the vast medicinal potential of these plants, a common practice in the agri-industry to collect and burn fallen *Ziziphus mauritiana* (Indian jujube) and *Artocarpus heterophyllus* Lam. (Jackfruit) leaves, which contribute to the greenhouse effect and global warming. Therefore, the utilisation of *Z. mauritiana* and *A. heterophyllus* Lam. leaves in therapeutic medicine may increase their economic value and improve the agri-industry in terms of sustainability, aligning with the United Nations' Sustainable Development Goals (SDG) 2030 agenda; SDG 3: Good health and wellbeing and SDG 13: Climate action. This research investigates the physicochemical properties of compounds extracted from *Z. mauritiana* and *A. heterophyllus* Lam. leaves using ultrasound-assisted extraction (UAE) technique at two amplitudes: 20 kHz and 40 kHz. Both plants leaves are found to have coumarins, saponins, quinones, phenols, glycosides, carbohydrates, and tannins. *Z. mauritiana* leaves extracted at 40 kHz showed the highest antioxidant capacity and phenolic content of 74.34% and 4.549 mg GAE/g, respectively. The amplitude of UAE plays a significant role in chemical extraction as a high UAE amplitude (40 kHz) has demonstrated the highest antioxidant capacity and phenolic content.

Keywords: Sustainability, *Ziziphus mauritiana*, *Artocarpus heterophyllus* Lam., ultrasound-assisted extraction, bioactive compounds, Gallic Acid Equivalence (GAE).

Introduction

Ultrasound-assisted extraction (UAE) is a recent and effective technique to extract bioactive compounds from heat-sensitive samples. It is fast, high-yield, cost-effective, environmentally safe, and easy to operate, as it requires little equipment and training (Zhang *et al.*, 2024). Besides, the UAE method preserves the quality of the extract because it does not use harsh chemicals or high temperatures that could alter or damage the target ingredients (Carreira-Casais *et al.*, 2021). Compared with traditional shaking water bath extraction, the UAE extraction is more effective at extracting total phenolics

and antioxidant compounds (Saifullah *et al.*, 2020). Therefore, the extraction of antioxidants, pigments, and phenolic compounds in *Z. mauritiana* and *A. heterophyllus* Lam. leaves can be elevated by using UAE and it may affect the physicochemical properties of *Z. mauritiana* and *A. heterophyllus* Lam. leaves.

Indian jujube tree (*Ziziphus mauritiana*), known as *Bidara* in Malaysia and *Magarya* in Nigeria, belongs to the *Rhamnaceae* family (Lawan *et al.*, 2024). *Ziziphus mauritiana* leaves normally measure between 2 cm to 9 cm

in length, are ovate or elliptical in shape with a pointed apex and a rounded or slightly tapering base with a smooth, leather-like, and glossy surface (Shoemaker *et al.*, 2019a). For thousands of years, *Z. mauritiana* leaves have been used in Traditional Chinese Medicine (TCM) to enhance sleep, nourish the heart, and calm the nerves (Shahrajabian *et al.*, 2020). *Z. mauritiana* leaves are abundant in bioactive substances such as phenolics, flavonoids, and triterpenoids, which have potent antioxidant activity and also demonstrated anti-inflammatory properties (Shahrajabian *et al.*, 2020; Wang *et al.*, 2020). These compounds are present in different parts, namely fruit, buds and leaves, and are among the most crucial functional nutrients (Xue *et al.*, 2021).

Jackfruit (*Artocarpus heterophyllus* Lam.) belongs to the *Moraceae* family, commonly known as *Nangka* in Malaysia. Jackfruit trees are endemic in Asia primarily, India, Sri Lanka, Bangladesh, Bhutan, Malaysia, Thailand, and Indonesia as well as several regions in Brazil, Africa, and Australia (Ranasinghe *et al.*, 2019; Gupta *et al.*, 2020; Khan *et al.*, 2021). Jackfruit has different names according to different regions such as *Kathar*, *Panos*, *Chakka* (India), *Paala* (Tamil), *Kapiak* (New Guinea), *Mit* (Vietnam), *Khanun* (Thailand), *Nanka* (Indonesia), and *Jaca* (Brazil) (Moke *et al.*, 2017). *A. heterophyllus* Lam. fruit is regarded as a “poor man’s meal” in Bangladesh and India, as it is consumed by rural people during periods of food scarcity. Jackfruit is a tropical, non-seasonal fruit, economical, and rich with nutrients. It is also used as a meat alternative due to its meaty and bland flavour, firm, fibrous, and stringy texture comparable to shredded beef and chicken (Beabout, 2022; Reinmann, 2022). *A. heterophyllus* Lam. leaves are oval or oblong in shape with slightly leathery-glossy texture, coriaceous, alternating, simple, pinnately veined, green all year long, and range in size from 4cm to 25 cm long by 2 cm to 12 cm wide, and their form varies depending on the tree’s environment and its maturity level (Crane *et al.*, 2019; Heuzé *et al.*, 2019). *A. heterophyllus* Lam. leaves consist of a petiole and a leaf blade and

are arranged alternately along the tree branches (Athapakala, 2022). Farmers feed cattle with jackfruit leaves as they are rich with minerals and vitamins (Khan *et al.*, 2021).

Numerous researchers have revealed the antidiabetic properties of *A. integer* leaves (Patel, 2023). Proanthocyanidin and flavonoids, two phytochemicals found in *Artocarpus* sp. leaves have been shown to suppress the development of lipid peroxidation and lower blood sugar levels (Rao *et al.*, 2021). Some animal tests have also demonstrated that extracts from the *Artocarpus* sp. leaves and stems can lower blood sugar levels (Shoemaker, 2019b). By delaying digestion and giving jackfruit a relatively low glycaemic index score, the substantial fibre content in the leaves can also help control blood sugar levels (Fatima, 2022). Its fibre and protein content also helps lessen the risk of post-meal blood sugar spikes.

Previous studies revealed that other *Artocarpus* sp., namely *Artocarpus artilis* (Breadfruit), contain numerous bioactive compounds, high antioxidant capacity, and antimicrobial properties (Soifofoini *et al.*, 2021). Hence, this study investigated the phytochemical screening of *Z. mauritiana* and *A. heterophyllus* Lam. leaves, including for coumarins, saponins, quinones, phenols, glycosides, carbohydrates, and tannins. Further, the leaves were extracted using ultrasound-assisted extraction (UAE) at different amplitudes (20 kHz and 40 kHz) and tested for total phenolic content, antioxidant capacity using 2,2-diphenyl-1-picrylhydrazyl (DPPH) assay, compounds identification using gas chromatography-mass spectrometry (GC-MS) analysis, and trace mineral determination using Inductively Coupled Argon Plasma Optical Emission Spectrometer (ICP-OES).

Materials and Methods

Collection and Preparation of Sample

About 5 kg of *Ziziphus mauritiana* (Indian jujube) leaves were collected from Rawang, Selangor and *Artocarpus heterophyllus* Lam. (Jackfruit) leaves were collected from UiTM Shah Alam near the Faculty of Applied Sciences.



Figure 1: (A) *Ziziphus mauritiana* and (B) *Artocarpus heterophyllus* Lam. leaves were subjected to a drying process using a cabinet dryer for 12 hours at 52°C

The jackfruit tree is 12 years old; however, the age of the Indian jujube tree is unknown. The leaves collected from both trees were from the top position and usually get sunshine. After collection, the leaf samples were washed to avoid contamination and then dried using a cabinet dryer for 12 hours at 52°C until the leaves looked dry and had a crispy texture (Figure 1). The moisture content was estimated at 10%.

Sample Extraction Using Ultrasound-assisted Extraction (UAE)

Both *Z. mauritiana* and *A. heterophyllus* Lam. leaves were extracted using ultrasound-assisted extraction (UAE) by following the protocol in Zhang *et al.* (2024) with a slight modification. 25 g of each sample were dissolved with 250 mL of 70% (v/v) methanol and mixed with a homogeniser at 4.0 rpm. The sample mixtures were put in an ultrasonicator for 30 minutes at 30°C with 750 W of power. The amplitude was varied at 20 kHz and 40 kHz for both samples. *Z. mauritiana* leaves extracted at 20 kHz and 40 kHz were labelled B20 and B40, respectively. *A. heterophyllus* Lam. leaves extracted at 20 kHz and 40 kHz were labelled N20 and N40, respectively. The extracts were filtered, evaporated, and kept below 20°C for further analysis after extraction.

Phytochemical Screening Test for Secondary Metabolites

Several qualitative screening tests, namely the Coumarin test, Lead acetate test, Saponin test, Gelatine test, Ferric chloride (Phenol) test, Quinones test, Fehling's test, and Phlobatannins test were conducted to detect the presence of certain chemical compounds in the *Z. mauritiana* and *A. heterophyllus* Lam. leaves. Solubility tests were also conducted using a variety of solvents such as chloroform, methanol, ethanol, acetone, acetonitrile, and distilled water to determine the solubility and stability of plant extracts, according to Abrar *et al.* (2023), Juwarat *et al.* (2023), and Khan *et al.* (2024) with slight modifications to the volume of reagents.

Phytochemical Quantification Analysis

Two phytochemical quantification tests, the Folin-Ciocalteu assay and DPPH radical-scavenging assay were conducted to determine the plant extracts' Total Phenolic Content (TPC) and antioxidant capacity, respectively. The method of these two analyses was based on Rosli *et al.* (2022), Marlita and Sujono (2024), and Zhang *et al.* (2024) with slight adjustments.

Determination of Compounds by GC-MS

The methanolic extracts of *Z. mauritiana* and *A. heterophyllum* Lam. leaves were analysed for the presence of volatile and semi-volatile chemical compounds using the GC-MS technique (Oni *et al.*, 2020) with some modifications. Chromatography analysis was performed with a column temperature of 50°C initially, raised to 230°C for 2 minutes by 5°C each minute, and then maintained at 290°C for 2 minutes. The chromatographic conditions were as follows: 1.0 mL per minute of split mode with high purity helium flowing as the carrier gas. Retention time and integral area of peaks were used to identify the chemicals in the spectra.

Determination of Minerals by ICP-OES

An Inductively Coupled Argon Plasma Optical Emission Spectrometer (ICP-OES, Optima 2100 DV, Perkin Elmer, Germany) was used to evaluate dried leaf samples for mineral content (Badarusham *et al.*, 2019). Dried samples were digested using nitric acid (HNO₃) and the dry ashing method. 3 g of dried samples were charred until no smoke appeared. Then, they were placed in a furnace at 550°C for 3 hours. The whitish or greyish ash was dissolved and filtered with 65% nitric acid. Then, it was diluted by taking 4.61 mL of stock solution into a 100 mL volumetric flask with deionised water to meet instrument conditions.

Statistical Analysis

One-way analysis of variance (ANOVA) and T-test analysis were used to identify significant differences in the quantitative analysis data. Means were compared at a 5% significance level and an independent T-test was applied when comparing solely jackfruit and jujube leaves without using two different amplitude leaf extracts. Statistical Package for the Social Sciences (SPSS) software version 29 was utilised for statistical analysis and the data acquired was reported as mean ± standard deviation (Syaril *et al.*, 2021).

Results and Discussion

Qualitative Phytochemical Screening

Phytochemical screening is a qualitative analysis that is capable of detecting the presence of bioactive compounds in plant extracts. Phytochemical screening was conducted due to its reliable, fast, easy, straightforward, and cost-effective technique to estimate the presence of specific bioactive compounds in the plant extracts before further quantitative analysis using instruments such as GC-MS and liquid chromatography-mass spectrometry (LC-MS).

Phytochemical screening has been frequently utilised to examine the presence of bioactive compounds in plant extracts such as alkaloids (Wagner's test, Mayer's test, Hager's test), saponins (Froth test, Lead acetate test), tannins (Ferric chloride test, Gelatin test, Lead acetate test), flavonoids (Alkali reagent test, Shinoda's test, Acid test), glycosides (Keller kilani Test), quinone (Sulphuric acid test), coumarins (NaOH test), triterpenes (Tschugajen test, Salkowski test), carbohydrates (Benedict's test, Fehling's test, Molisch's Test), proteins (Millon's test, Xanthoproteic test) (Abrar *et al.*, 2023; Juwarat *et al.*, 2023; Khan *et al.*, 2024).

Both plants leaves, *Ziziphus mauritiana* (Indian jujube) and *Artocarpus heterophyllum* Lam. (Jackfruit) demonstrated positive results for all bioactive compounds, including coumarins, saponins, tannins, phenols, glycosides, and carbohydrates except phlobatannins as shown in Table 1. Currently, researchers aim to find a new strategy to combat cancer with minimal side effects such as utilising herbal medicine rich in phytocompounds such as terpenoids and phenolics. Since many bioactive compounds are present in both plant extracts, *Z. mauritiana* and *A. heterophyllum* Lam. have vast potential as medicinal plants due to their high antioxidant properties. Scientists are also interested in combining two or more medicinal herbs to create a polyherbal formulation, which is believed to be more effective in combating diseases such as cancer, gout, and diabetes (Gnanaselvan *et al.*, 2022).

Table 1: Qualitative phytochemical analysis of *Z. mauritiana* and *A. heterophyllum* Lam.

Phytochemical Class	Phytochemical/Reagent Test	Indication	<i>Z. mauritiana</i> (Indian jujube)	<i>A. heterophyllum</i> Lam. (Jackfruit)
Coumarins	Sodium hydroxide (NaOH)	Yellow fluorescence under UV	+	+
Saponins	Lead acetate test	White precipitate	+	+
Saponins	Froth test	Persistent froth	+	+
Tannins	Gelatine test	Dark green colour	+	+
Phenols	Ferric chloride test	Blue-black or dark green colour	+	+
Glycoside	Quinone/sulfuric acid test	Red/brown ring	+	+
Carbohydrate	Fehling's test	Brick red precipitate	+	+
Phlobatannins	Phlobatannins test	Pink precipitate	-	-

Note: (+) means the test result is positive and the compound is present in the leaves; (-) means the test result is negative and the compound is absent in the leaves.

Solubility studies evaluated the extract's stability in various conditions and assisted in determining the suitable solvents for extracting and purifying components of interest. Bioactive substances could be extracted using solvents such as acetone, alcohol, and water.

Table 2 illustrates that *Z. mauritiana* leaves were not soluble in all test solvents; meanwhile, *A. heterophyllum* Lam. leaves were only soluble in distilled water and methanol. The solubility of samples was decided individually, where the absorbance value exceeding 1.5 was considered soluble (Zhang *et al.*, 2022). A solubility test on leaf extracts is vital because it may reveal

information about the extract's characteristics, stability, and possible uses by determining how soluble it is in different solvents. Water has proved useful for removing polar substances like phenolic compounds from plant materials (Dai & Mumper, 2010). It is well-recognised that alcohol, mainly ethanol and methanol could extract various polar and non-polar bioactive substances (Sasidharan *et al.*, 2024). Acetone's miscibility with water makes it a suitable solvent for various purposes and it is effective for extracting chemicals that are not readily soluble in water (Dahman *et al.*, 2019). Bioactive substances' polarity and

Table 2: Absorbance and solubility properties of *Z. mauritiana* and *A. heterophyllum* Lam. leaves in different solvents

Solvents	<i>Z. Mauritiana</i> (Indian jujube)	<i>A. heterophyllum</i> Lam. (Jackfruit)
Chloroform	0.595 (Insoluble)	1.107 (Insoluble)
Distilled water	0.582 (Insoluble)	2.274 (Soluble)
Methanol	0.846 (Insoluble)	1.510 (Soluble)
Ethanol	0.734 (Insoluble)	1.173 (Insoluble)
Acetone	0.781 (Insoluble)	1.055 (Insoluble)
Acetonitrile	0.586 (Insoluble)	1.039 (Insoluble)

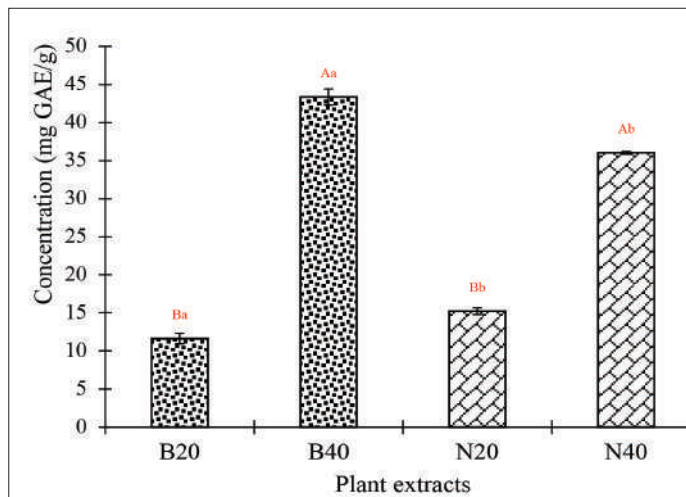
Note: The absorbance value exceeding 1.50 was considered soluble (Zhang *et al.*, 2022).

chemical structure determine their solubility in various solvents. While less polar flavonoids, including flavanones, flavanols, isoflavones, and methylated flavones may have been extracted using ethyl acetate, diethyl ether, chloroform, and dichloromethane. Flavonoid glycosides, for instance, are more water-soluble than aglycone (Mojzer *et al.*, 2016).

Total Phenolic Content (TPC)

The polyphenolic compound is one of the primary natural secondary metabolites abundant in different plant parts such as leaves, bark, and fruit. Due to its antimicrobial, anti-inflammatory, and antioxidant properties, it is associated with significant biological activities, physiological functions, and health-promoting qualities. Therefore, polyphenolic compounds are extensively utilised in various industries, namely the pharmaceutical industry (precursors), the food industry (natural food additives), and the cosmetic industry (active ingredient in cosmetic formulation on the skin products for anti-ageing) (Zhang *et al.*, 2024).

According to Figure 2, the Total Phenolic Content (TPC) in sample B40 was significantly higher than N40, although both samples were extracted at the same amplitude, 40 kHz. Sample B20 was significantly lower when compared to N20. However, as the UAE was set at amplitude 20 for both leaves, the total phenolic content was significantly lower compared to extraction at amplitude 40. Therefore, the amplitude of the ultrasonicator influenced the amount of phenolic extract for both samples. The maximum amount of total phenolic content was discovered in the leaves of the two species under study, *Z. lotus* (949.87 mg GAE/100 g DW) and *Z. mauritiana* (532.95 mg GAE/100 g DW), respectively (Yahia *et al.*, 2020). A previous study by Ojwang *et al.* (2017) found that the average phenolic content of the jackfruit leaves was 35.18 ± 2.33 mg/g using the maceration technique of extraction. Therefore, the UAE method was more efficient than the maceration extraction method as it could extract more phenolic content.



Note: Means values with different superscripts are significantly different at $p < 0.05$ based on Tukey's test of one-way ANOVA analysis and T-test analysis. Capital letters indicate the effect of ultrasound-assisted extraction amplitude (A-B). The small letter indicates the effect of different leaves at the specific amplitude (a-b). B20 (*Z. mauritiana* extracted by UAE at amplitude 20 kHz), B40 (*Z. mauritiana* extracted by UAE at amplitude 40 kHz), N20 (*A. heterophyllus* Lam. extracted by UAE at amplitude 20 kHz), and N40 (*A. heterophyllus* Lam. extracted by UAE at amplitude 40 kHz).

Figure 2: Total phenolic content of *Z. mauritiana* (Indian jujube) and *A. heterophyllus* Lam. (Jackfruit) leaves

Free Radical Scavenging Activity on DPPH

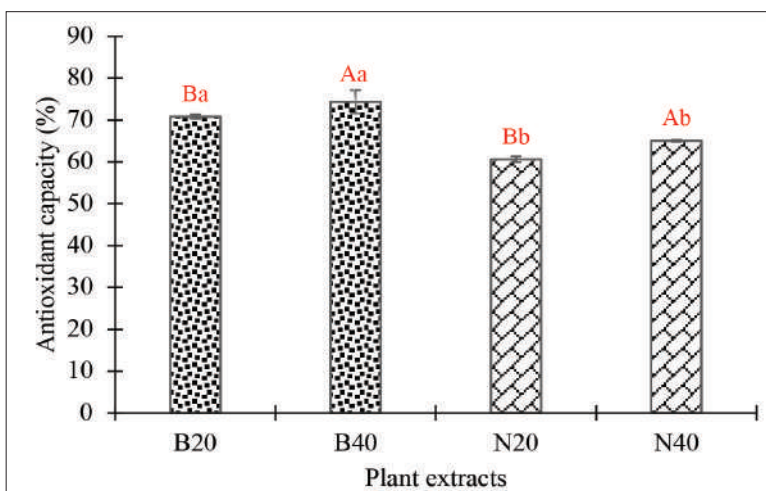
Antioxidants like flavonoids and phenolics abundant in *Z. mauritiana* and *A. heterophyllum* Lam. leaves, shield the body from oxidative stress (Bao *et al.*, 2021). According to Gulcin and Alwasel (2023), antioxidants neutralise harmful free radicals and avoid cellular damage, which might lower the risk of chronic disease development.

As illustrated in Figure 3, the antioxidant capacity in *Z. mauritiana* leaves (B20 and B40) was significantly higher than *A. heterophyllum* Lam. leaves (N20 and N40), respective to their amplitude of extraction. Thus, the ultrasonicator's amplitude greatly influenced the samples' antioxidant capacity. As the amplitude of the ultrasonicator increases, the amount of antioxidant capacity determined also increases. *Z. mauritiana* has components that contribute to its antioxidant qualities, including cyclopeptide alkaloids, lupane, and ceanothane triterpenes, according to phytochemical research (Jha *et al.*, 2023). Compared to other plant organs, *Ziziphus*

leaves, especially *Z. mauritiana* leaves had the highest total antioxidant capacity, showing the leaves' strong antioxidant potential (Yahia *et al.*, 2020). Thus, *Ziziphus mauritiana* leaves were expected to contain more antioxidants than *Artocarpus heterophyllum* Lam. leaves.

Identification of Chemical Compounds by GC-MS

Gas chromatography-mass spectrometry (GC-MS) greatly aided the identification and quantification of volatile and semi-volatile chemicals in food samples. GC-MS aided in characterising the intricate blend of natural ingredients, pollutants, additives, allergens, taste, and fragrance chemicals found in different food products. According to Oni *et al.* (2020), GC-MS has been firmly established as a critical platform for secondary metabolites profiling of plants and non-plant species in the last few years. Based on previous studies, certain tannins have antiviral and antibacterial properties. Some flavonoid compounds play vital roles in



Note: Means values with different superscripts are significantly different at $p < 0.05$ based on Tukey's test of one-way ANOVA analysis and T-test analysis. Capital letters indicate the effect of ultrasound-assisted extraction amplitude (A-B). The small letter indicates the effect of different leaves at the specific amplitude (a-b). B20 (*Z. mauritiana* extracted by UAE at amplitude 20 kHz), B40 (*Z. mauritiana* extracted by UAE at amplitude 40 kHz), N20 (*A. heterophyllum* Lam. extracted by UAE at amplitude 20 kHz), and N40 (*A. heterophyllum* Lam. extracted by UAE at amplitude 40 kHz).

Figure 3: Total antioxidant capacity of *Ziziphus mauritiana* (Indian jujube) and *Artocarpus heterophyllum* Lam. (Jackfruit) leaves

psoriasis, rheumatoid arthritis, antidiabetic, asthma, sclerosis, antimicrobial, and therapeutic activities against influenza virus and hepatitis virus (Wang *et al.*, 2020). Most aromatic compounds, mainly terpenoids and phenolics

have been associated with anticancer activity (Gnanaselvan *et al.*, 2022).

Based on Table 3, several bioactive compounds with various benefits were detected in *Ziziphus mauritiana*. For instance, 2,2-furan-

Table 3: Chemical compounds detected in both *Ziziphus Mauritiana* and *Artocarpus heterophyllus* Lam., at 20 kHz and 40 kHz

Sample	Retention Time	Compounds Detected	Molecular Weight (MW) (g/mol)	Peak Area	Similarity (% Probability)
B40	15.149	Methenamine, N- [3-methyl-2-butenylidene]	97.2	4.90	80
	25.598	Oxirane, decyl-	184.3	3.05	83
	30.321	1,2-Benzenedicarboxylic acid, butyl 2-ethylhexyl ester	334.4	0.50	83
B20	6.722	2-Furanmethanol	98.1	18.59	87
	15.043	2-Propyn-1-amine, N, N-dimethyl-	83.1	8.31	80
	17.839	1-(3,6,6-Trimethyl-1,6,7,7a-tetrahydrocyclo Penta-tetrahydrocyclo [c]pyran-1-y) ethone	206.3	0.32	85
	29.407	7,9-Di-tert-butyl-1-oxaspiro (4,5)deca-6,9-diene-2,8-dione	276.4	0.97	99
	30.294	Dibutyl phthalate	278.34	0.55	91
	32.221	9-hexadecenoic acid	254.4	0.41	83
N40	17.161	Isovaleraldehyde semicarbazone	143.2	2.21	82
	29.406	7,9-Di-tert-butyl-1-oxaspiro (4,5)deca-6,9-diene-2,8-dione	276.4	2.12	99
	32.777	<i>Cis, cis, cis</i> -7,10,13-hexadecatriena	234.4	0.24	91
	33.018	Eicosyl octyl ether	410.8	0.31	84
	41.000	2-(Acetoxymethyl)-3-(methoxycarbonyl)biphenylene	282.3	7.43	87
N20	6.073	2-propanamine, N-methyl-N-nitroso-	102.1	1.39	87
	29.399	7,9-Di-tert-butyl-1-oxaspiro (4,5)deca-6,9-diene-2,8-dione	276.4	2.03	99
	30.335	n-Hexadecanoic acid	256.4	1.23	97
	32.766	9,12,15-octadecatrienoic acid, methyl ester, (<i>Z,Z,Z</i>)-	292.5	7.25	99
	33.011	Phytol	296.5	6.24	99
	39.880	2,5-Dihydroxybenzoic acid, 3 TMS derivative	370.7	1.64	83

methanol is used in cosmetics as an aromatic ingredient in perfumes. Usually, compounds from the furans group are associated with roasting processes and do not naturally exist (Yuan *et al.*, 2023). Additionally, 7, 9-di-tert-butyl-1-oxaspiro(4, 5)deca-6,9-diene-2, 8-dione was used in traditional medicine to cure intestinal parasites, warts, gonorrhoea, and skin problems (Sharif *et al.*, 2015). Nevertheless, dibutyl phthalate was utilised in paper coatings, adhesives, nail polish, printing inks, lacquers, explosives, and resin solvents. 2,5-dihydroxybenzoic acid, a TMS derivative is a benzoic acid derivative easily oxidised and utilised as an antioxidant excipient in several pharmaceutical compositions and it is also derived from gentisic acid (Nugrahani *et al.*, 2022).

Chemical compounds present in *Artocarpus heterophyllus* Lam. leaves have many therapeutic benefits such as n-hexadecanoic acid, which might help increase the anti-inflammatory effect of 5-dodecanolide (Capo *et al.*, 2021). The methyl ester of 9,12,15-octadecatrienoic acid, (*Z,Z,Z*)- exhibited anti-inflammatory, antidiarrheal, antibacterial, antiplasmodial, anti-ulcer, estrogenic, and analgesic qualities (Chanemougame *et al.*, 2018). Additionally, phytol was discovered to inhibit joint swelling and hyperalgesia by preventing inflammation (Carvalho *et al.*, 2020). Isovaleraldehyde semicarbazone exhibits antiviral and anticancer properties, facilitated mainly by binding to iron or copper within cells (Mir *et al.*, 2024).

Determination of Minerals by ICP-OES

Based on Table 4, both plant leaves contain essential minerals. Magnesium helps to reduce uric acid levels and is involved in enzymatic reactions (Zhang & Qiu, 2018). While a sufficient calcium intake is necessary for good bone health, the source of calcium is significant for gout. Calcium supplementation (770 mg/d from dairy or calcium citrate) decreases serum urate concentrations, indicating that calcium's urate-lowering action might be at least partially responsible for the gout-protective benefits of low-fat dairy consumption (Cândido *et al.*, 2022). Potassium encourages the kidneys to excrete uric acid and assists in the body's acid-neutralisation process. Suction was necessary to maintain a balanced potassium-to-sodium ratio for gout patients (Li *et al.*, 2018).

Conclusions

Researchers worldwide have explored the phytochemical compounds in tropical plants in recent years, especially regarding phytochemical profiling, functionality, and health benefits. Tropical plants are rich in phytochemical compounds due to their geographical location that receives more sunlight exposure compared with plants from regions that receive less sunlight. The presence of alkaloids, flavonoids, terpenoids, tannins, phenols, and saponins contributed to the therapeutic benefits such as anti-inflammatory, antigout, antidiabetic, anti-obesity, anti-ageing, antimicrobial, anti-

Table 4: Minerals concentration in *Ziziphus mauritiana* and *Artocarpus heterophyllus* Lam.

Minerals (mg/100 g)	<i>Ziziphus mauritiana</i>	<i>Artocarpus heterophyllus</i> Lam.
Zinc (Zn)	0.17 ± 0.00 ^a	0.00 ± 0.00 ^b
Ferum (Fe)	1.20 ± 0.01 ^a	1.14 ± 0.01 ^b
Potassium (K)	79.12 ± 0.57 ^b	103.77 ± 1.96 ^a
Calcium (Ca)	176.54 ± 1.23 ^b	329.53 ± 0.74 ^a
Manganese (Mn)	0.61 ± 0.01 ^a	0.34 ± 0.00 ^b
Copper (Cu)	0.12 ± 0.00 ^a	0.03 ± 0.00 ^b
Magnesium (Mg)	17.67 ± 0.21 ^a	9.39 ± 0.09 ^b

Note: Means values with different superscripts significantly differ within the same row at $p < 0.05$ based on T-test analysis.

osteoporosis, and antihistamine properties. Based on the current phytochemical profiling findings, it can be inferred that both *Ziziphus mauritiana* and *Artocarpus heterophyllus* Lam. leaves have huge medicinal potential due to many pharmacologically active compounds. For instance, the presence of methyl ester of 9,12,15-octadecatrienoic acid, (Z,Z,Z)- in *Artocarpus heterophyllus* Lam., which was identified as an anti-inflammatory agent, might be beneficial in gout treatment. Certain minerals detected in *Ziziphus mauritiana* and *Artocarpus heterophyllus* Lam. are also involved in gout treatment such as magnesium, potassium, and calcium, as they reduce uric acid levels. Thus, further research such as isolation of bioactive compounds, in vitro and in vivo studies, and preclinical studies are required to validate these plant extracts' medicinal benefits and safety to the human body.

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Conflict of Interest Statement

The authors declare that they have no conflict of interest.

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