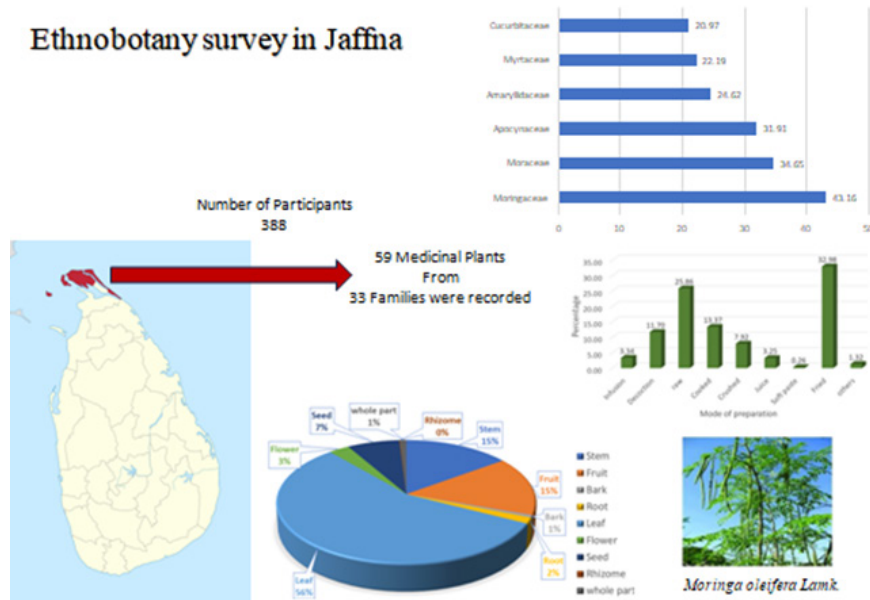**RESEARCH ARTICLE**

An Ethnobotanical Survey of Medicinal Plants Used by Diabetes Patients Attending the Teaching Hospital, Jaffna, Sri Lanka

N. Niluka, S. Sathya and S. Sivasinthujah*

Highlights

- A total of 59 species belonging to 33 families were reported to be used by 329 diabetic patients.
- Among them *Moringa oleifera* Lamk. (142) was stated as the most commonly used species followed by *Gymnema sylvestre* (105), *Momordica charantia* Linn. (104).
- Moringaceae was the dominant family with FIV 43.16.
- *Moringa oleifera* Lamk. showed the highest RFC value (0.432).
- Antidiabetic properties of *Achyranthus polygonoides*, *Argyreia pomacea* Wall. ex Choisy and *Cassia tomentosa* are yet to be investigated.

RESEARCH ARTICLE

An Ethnobotanical Survey of Medicinal Plants Used by Diabetes Patients Attending the Teaching Hospital, Jaffna, Sri Lanka

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Abstract: The scope of this study is to describe the ethnobotany of medicinal plants used in the management of diabetes mellitus (DM) among diabetic patients attending the Teaching Hospital, Jaffna. A cross-sectional descriptive study was conducted among 388 patients attending the medical clinic of Teaching Hospital, Jaffna, using systematic sampling technique. Data were collected using a validated structured interviewer-administered questionnaire and were analysed to generate the summary of the percentages using descriptive statistics. Family Important Value (FIV) and Related Frequency Citation (RFC) were calculated to quantitatively determine the common consent between the informants on the use of endemic medicinal plants in the division. A total of 59 species belonging to 33 families were reported by 329 diabetic patients with the response rate of 100%. Among them *Moringa oleifera* Lamk. (142) was stated as the species with the highest RFC value, followed by *Gymnema sylvestre* (105), *Momordica charantia* Linn. (104). Moringaceae was the most dominant family with FIV 43.16. The value of RFC of the plants mentioned in this survey varied from 0.003 to 0.432. *Moringa oleifera* Lamk. showed the highest RFC value (0.432). In this study, 29 plant species used for DM management were reported for the first time in Sri Lanka. Further, antidiabetic property of *Achyranthus polygonoides, Argyreia pomacea* Wall. ex Choisy and *Cassia tomentosa* are yet to be investigated. These findings facilitate the documentation and the conservation of medicinal plants used for DM by the patients in Teaching Hospital, Jaffna, Sri Lanka. Moreover this study open doors for phytochemical screening and identification of new antidiabetic active compounds.

Keywords: Diabetes mellitus; Ethnobotany; Medicinal plants; Patients; Jaffna; Diabetic patients

INTRODUCTION

Diabetes mellitus (DM) is a non-communicable metabolic disease, caused by the inappropriate elevation of blood glucose levels due to the impairment of insulin synthesis or utilization. About 422 million people worldwide have DM, of which the majority live in low and middle-income countries. According to the WHO, 1.5 million deaths occur because of DM each year (WHO, 2023). According to estimations from 2019, the prevalence rate of DM among adults in Sri Lanka was 8.7%, and the rate in Jaffna district was 16.4%. This rate corresponds to 19.6% of the male and 13.9% of the female population (Wasana et al., 2022).

DM is managed through diet, exercise, herbal formulations, oral hypoglycemic drugs, and insulin therapy. The interest in herbal formulations derived from the medicinal flora used by traditional medicine practitioners to treat diabetic patients in the local population has increased due to their effectiveness, lack of adverse effects, and low cost (Wasana et al., 2022). The usage of medicinal plants for the management of DM differs according to culture and geographical area. Ethnobotany is the study of the interrelationship between people and plants in which the medicinal flora used for the treatment of diseases among different populations is documented. It is important to preserve the traditional knowledge of plants, provide effective methods of identifying new medicinal plants, and discover new chemical entities for the treatment of diseases (Thirumalai et al., 2012).

Many surveys have been conducted on medicinal plants used for the treatment of DM in different countries and regions. Furthermore, within those countries, studies have been conducted among traditional healers, medicinal herb dealers, the local population, and patients attending the clinic using semi-structured questionnaires and structured interviews (Assmaa et al., 2020; Hamza et al., 2020; Skalli et al., 2019; Jayakumar et al., 2010). Experienced adults are the main source of information about the local names, part(s) of plants, and methods of preparation of the plants used in the management of DM.

Sri Lanka is an island in the Indian ocean rich in its biodiversity with flourishing flora and fauna and a rich authentic heritage of culture and traditional indigenous medicine. Only a small number of ethnobotanical studies have been conducted to record the details of medicinal plants used in Sri Lanka for different ailments, or specially for DM. Ethnobotanical studies of traditional treatments for DM have been conducted among the Siddha healers in Eastern Province, Sri Lanka, and among registered traditional medicine and Ayurveda practitioners in the Galle district of Sri Lanka (Sathasivampillai et al., 2017; Wasana et al., 2022). However, no studies have been conducted in the Jaffna district of Northern province, Sri Lanka. Therefore, this ethnobotanical survey is focused on the medicinal plants that have been widely used in the management of DM among the diabetic patients attending the medical clinic at Teaching Hospital, Jaffna with an aim of making an inventory of plant species.

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MATERIALS AND METHODS

Survey

The survey was conducted as a cross-sectional descriptive study among diabetic patients attending the Teaching Hospital, Jaffna from 1st of April to 30th April, 2023.This study was conducted in the Jaffna district, Sri Lanka. It is situated in the far north of Sri Lanka in the Northern province with a total land area including inland waters of 1,012.01 km². The district's geographical location is 9.6615° N latitude and 80.0255° E longitude with an altitude of 2 m. The population is 618,209, and the majority earn from livelihood of agriculture (Department of Census and Statistics, 2023). Teaching Hospital is the top most level of the health care system in Sri Lanka. Teaching Hospital, Jaffna which is situated in the Jaffna region provides advanced health care facilities in the Northern Province of Sri Lanka.

Questionnaire

A structured, interviewer-administered questionnaire was used to collect the data from the diabetic patients regarding socio-demographic and plant information. The questionnaire was adapted from previous studies with suitable modification that could be adapted for the local populations and was validated. The questionnaire was designed as section A and B, where section A included socio-demographic factors such as age, sex, religion and educational level and section B included plant information such as type of plant, plant part, harvesting time, harvesting method, and method of preparation for consumption.

Sample size and Sampling technique

The sample size of 388 was calculated based on the Cochran formula. A systematic sampling technique was used to collect the data from diabetic patients (388) attending the medical clinic of the Teaching Hospital, Jaffna. Informed written consent was obtained from the patients before data collection. Data were collected by interviewing patients individually. The average number of diabetic patients attending the medical clinic was around 1500 per week. The sampling interval was 15 (6000/388=15). Thus, the patient was selected randomly from first 15 patients and from there onwards every 15th patient was chosen to be included in the study.

Data analysis

The collected data were consolidated, classified, stored in Excel data sheets, and analytical tools were used for the data analysis following the approaches of Martin (Martin, 1995) and Cotton (Cotton, 1996). The percentage frequency method was used to analyze and summarize descriptive statistics of the ethnobotanical data obtained from interviews. Preference ranking was performed to analyse the most popular and preferred medicinal plants. Direct matrix ranking was used to rank medicinal plants reported frequently with various ethnobotanical roles. The relative importance of the medicinal plants which are used in antidiabetic remedies was calculated via a number of indices including Relative Frequency Citation (RFC) and Family Importance Value (FIV).

$$FIV = FC (family)/N * 100 \text{ (Orch et al., 2020)}$$

where;

FC family is the number of informants reporting the use of a particular family.

N is the total number of informants participated in the study.

$$RFC = FC species/N$$

Where;

FC species is the number of informants reporting the use of a particular species.

N is the total number of informants.

Ethical considerations

The study was approved by the Ethical Review Committee of Faculty of Medicine, University of Jaffna. Permission for data collection for this study was obtained from the Director of the Teaching Hospital, Jaffna, and the consultant of the medical clinic of the Teaching Hospital, Jaffna. The purpose of this study was explained in detail to the participants and they were assured that there would be no risks in this study. Written consent was obtained from the participants before data collection.

RESULTS AND DISCUSSION

During the study period, 388 diabetic patients were interviewed out of which 85.01% (329) used medicinal plants to manage DM. The response rate was 100%. Table 1 shows the distribution of socio-demographic factors of diabetic patients.

Diabetic patients were categorized into three groups according to their age as follows: 20-40 years (20 patients), 41-60 years (115 patients) and above 60 (194 patients): Amongst them 58.97% of the diabetic patients were above the age of 60 years. They stated the knowledge of which plants to use was gained from their own experience, family members, neighbors, or traditional practitioners.

Regarding the education level of the patients, 59.88% of the patients reported grade 10 as their highest completed education, while 23.10% reported primary education (1-5 grades). The remainder reported either secondary (grade 6-13) or tertiary (diploma and degree) education. In this study, the majority of the diabetic patients were Hindus (275 patients), followed by Christian (51 patients), Islam (2 patients) and Buddhist (1 patient).

Ethnobotanical survey data

Diabetic patients used medicinal plants along with allopathic medicine to manage their DM. The number of plants used by the patients ranged from one to seven and most people (31%) used at least three plants for managing DM. Further 10.03% of the patients used only one plant where as 89.97% of patients used multiple plants at the same time to manage DM (Figure 1).

In this study, a total of 59 species belonging to 32 families have been reported by 329 diabetic patients. Among them *Moringa oleifera* Lamk. (142) was the most commonly used

Table 1: Frequency and percentage of socio-demographic factors (sex, age, level of study and religion) of the diabetic patients attended the medical clinic at Teaching Hospital Jaffna, Sri Lanka.

Socio-demographic factor	Category	Frequency	Percentage (%)
Sex	Male	121	36.78
	Female	207	62.92
	Other	1	0.30
Age	20-40	20	6.08
	41-60	115	34.95
	>60 years	194	58.97
Level of study	Illiterate	4	1.22
	Grade 1-5	76	23.10
	Grade 5-10	197	59.88
	Grade 11-13	42	12.77
	Diploma	0	0.00
	Degree	10	3.04
Religion	Buddhist	1	0.30
	Hindu	275	83.59
	Christian	51	15.50
	Islam	2	0.61
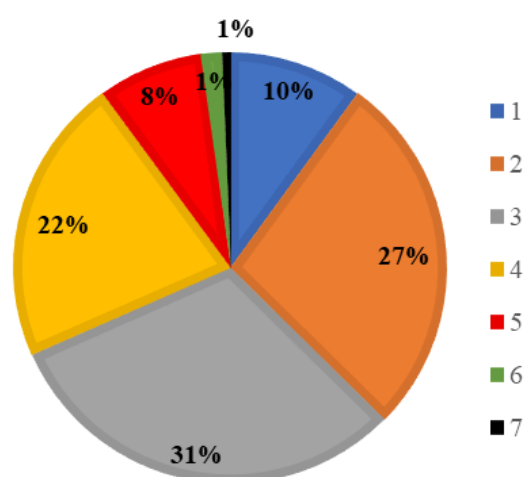
Figure 1: The pie chart indicates that percentage of the diabetic patients attended at medical clinic, Teaching Hospital, Jaffna based on the number of the medicinal plants used to manage the DM. The colors blue, orange, grey, yellow, red, green, and black represent the percentage of patients using one, two, three, four, five, six, and seven plants, respectively, to manage their DM.

species, followed by *Gymnema sylvestre* (105), *Momordica charantia* Linn. (104), *Allium sativum* Linn (81), *Psidium guajava* Linn. (66) and *Coccinia grandis* (64). Among these plants 38.56% were vines, 34.74% were trees and 26.7% were shrubs. Based on this survey, 74.87% of the plants grow spontaneously and 25.03% are cultivated, out of which 99.90% were cultivated throughout the year and are harvested using manual harvesting techniques. 69.77% of the diabetic patients obtained these plants from a home garden and 30.23% purchased them from the market.

The value of RFC for the plants mentioned in this survey varied from 0.003 to 0.432. *Moringa oleifera* Lamk. showed the highest RFC value (0.432), followed by *Gymnema sylvestre* (0.319) and *Momordica charantia* Linn. (0.316) (Table 2). RFC indicates the predominant usage of plants by the local people. This facilitates the identification of pharmacologically active compounds and sustainable usage of antidiabetic medicinal plants.

In this study, Moringaceae was the dominant family with a FIV of 43.16%. The second FIV for Moraceae was 34.65%, followed by Apocynaceae (31.91%), Amaryllidaceae (24.62%), Myrtaceae (22.19%) and Cucurbitaceae (20.67%) (Table 3).

Among the reported families, Cucurbitaceae and Fabaceae contained the higher number of plant species (6 plants) used for the management of DM. Cucurbitaceae includes *Benincasa hispida* Thumb., *Coccinia grandis.*, *Cucurbita maxima* Duch., *Momordica charantia* Linn., *Mukia maderaspatana* Linn., *Luffa acutangula* Roxb.Hort.Beng. Fabaceae includes *Cassia tomentosa, Senna auriculata*

Table 2: List of medicinal plants, their family, local name, part used, drug preparation, preparation mode, frequency of citation (FC) and relative frequency of citation (RFC) of the plant species used for diabetes mellitus (DM) management by diabetic patients in the Teaching Hospital, Jaffna

No	Scientific name	Family	Local name	Plant Part used	Drug preparation (Alone/combine) Quote combined plants	Preparation mode	FC	RFC N-329
01	*Abelmoschus esculentus*	Malvaceae	Vendi	Fruit	Alone	Cooked, Infusion	7	0.021
02	*Achyranthus polygonoides*	Amaranthaceae	Thoiyel keerai	Leaf	Alone	Porridge	1	0.003
03	*Aerva lanata* Juss	Amaranthaceae	Thengkaaip pook keerai	Leaf	Alone	Decoction, Fried	3	0.009
04	*Allium sativum* Linn	Amaryllidaceae	Venthayam	Seed	**Alone & in combination** *Nigella sativa* Linn., *Allium sativum* Linn., *Piper nigrum* Linn., *Carum copticum* Benth.	Infusion, Decoction, Raw, Soft Paste	81	0.246
05	*Aloe vera*	Liliaceae	Katralai	Leaf	Alone	Juice, Raw	4	0.012
06	*Alternanthera sessilis* R.Br.	Amaranthaceae	Ponnaam kaani	Leaf, Stem	**Alone & in combination** *Pisonia grandis* R.Br., *Moringa oleifera* Lamk., *Gymnema sylvestre.*, *Sesbania grandiflora* Linn.	Fried, Cooked	59	0.179
07	*Amaranthus viridis* Linn.	Amaranthaceae	Araikkirai	Leaf	Alone	Cooked	1	0.003
08	*Argyreia pomacea* Wall. ex Choisy	Convolvulaceae	Manpaanshan	Leaf	Alone	Raw, Porridge	1	0.003
09	*Artocarpus heterophyllus* Lam.	Moraceae	Palaa	Leaf	**Alone & in combination** *Psidium guajava* Linn., *Azadirachta indica* Juss., *Ocimum sanctum* Linn.	Decoction	9	0.027
10	*Averrhoea bilimbi* Linn.	Euphorbiaceae	vilimbik kaai	Fruit	Alone	Raw, Cooked	1	0.003
11	*Azadirachta indica* Juss	Meliaceae	Vembu	Leaf	**Alone & Combination** *Psidium guajava* Linn., *Artocarpus heterophyllus* Lam., *Allium sativum* Linn,, *Zingiber officinale* Robx.	Raw, Crushed, Decoction, Juice	13	0.040
12	*Benincasa hispida* Thumb.	Cucurbitaceae	Neettrup poosani	Fruit	Alone	Cooked, Juice	1	0.003
13	*Berberis aristata* D.C	Berberidaceae	Mara manjal	Root	Alone	Decoction	1	0.003
14	*Boerhavia diffusa*	Nyctaginaceae	Mukkaraichchi	Leaf	**Combination** *Allium sativum* Linn.	Cooked	1	0.003

15	*Borassus flabelifer* Linn.	Palmaceae	Panni	Tuber	**Combination** *Cicer arietinum* Linn., *Vigna unguiculata (L.)* Walp., *Oryza sativa* Linn., *Curcuma domestica*	Porridge (Koozh)	1	0.003
16	*Brassica oleraceae*	Curciferae	Kovaa	Leaf	**Alone & Combination** *Moringa oleifera* Lamk., *Gymnema sylvestre*	Cooked, Fried	2	0.006
17	*Cardispermum helicacabum* Linn	Sapindaceae	Mudakkoththaan	Leaf	**Combination** *Azadirachta indica* Juss., *Allium sativum* Linn,, *Zingiber officinale* Robx.	Decoction	1	0.003
18	*Carica papaya* Linn.	Caricaceae	Pappaasi	Leaf	Alone	Decoction	1	0.003
19	*Cassia sophera* Linn.	Leguminosae	Ponnaavarasu	Leaf, Flower	**Combination** *Pisonia grandis* R.Br.	Fried	1	0.003
20	*Cassia tomentosa*	Fabaceae	Kardavarri	Flower	Alone	Decoction	1	0.003
21	*Centella asiatica* Linn.	Umbelliferae	Vallaarai	Leaf, Stem	**Alone & Combination** *Murraya koenigii* Spreng.	Raw, Porridge	51	0.155
22	*Coccinia grandis*	Cucurbitaceae	Kovvai	Fruit, Leaf	**Alone & Combination** *Moringa oleifera* Lamk., *Musa rubra* Sieb., *Delonix elata* Gamble., *Pisonia grandis* R.Br., *Rivea ornate* Chois, *Alternanthera sessilis* R.Br., *Mukia maderaspatana* Linn., *Gymnema sylvestre, Piper longum* Linn., *Artocarpus heterophyllus* Lam., *Sesbania grandiflora* L., *Solanum trilobatum* Linn.	Raw, Cooked, Juice, Fried, Infusion	64	0.195
23	*Coriandrum sativum* Linn.	Umbelliferae	Koththa malli	Fruit	**Alone & Combination** *Zingiber officinale* Robx., *Allium sativum* Linn.	Decoction	2	0.006
24	*Costus speciosus* (koen) smith in trans. Linn	Zingeberaceae	Koddam	Leaf	**Alone & Combination** *Pisonia grandis* R.Br., *Gymnema sylvestre, Piper longum* Linn.	Fried, Raw, Crushed	29	0.088
25	*Cucurbita maxima* Duch.	Cucurbitaceae	Poosani	Fruit	Alone	Cooked	1	0.003
26	*Cynodon dactylon* (Linn) Pers.Syn.	Gramineae	Arugampillu	Whole part	**Alone & Combination** *Piper nigrum* Linn.	Decoction, Juice	9	0.027
27	*Delonix elata* Gamble.	Leguminosae	Vaatha naaraayani	Leaf	**Alone & Combination** *Moringa oleifera* Lamk., *Pisonia grandis* R.Br., *Cephalandra indica* Naud.	Fried	7	0.021

28	*Feronia elephantum* Correa.	Rutaceae	Vilaaththi	Fruit	Alone	Raw, Crushed	1	0.003
29	*Ficus racemosa* Linn.	Moraceae	Aththi	Fruit	Alone	Crushed, Raw	1	0.003
30	*Gymnema sylvestre*	Apocynaceae	Shirukurinjan	Leaf	**Alone & Combination** *Moringa oleifera* Lamk.*, Barringtonia acutangular* Linn.*, Alternanthera sessilis* R.Br.*, Pisonia grandis* R.Br.*, Delonix elata* Gamble.*, Coccinia grandis, Senna auriculata* Linn.*, Centella asiattica* Linn.*, Justicia tranquebariensis, Passiflora edulis*	Raw, Crushed, Juice, Fried, Decoction	105	0.319
31	*Gymnema sylvestre* (Retz.) R.Br. ex Schult.Syst	Asclepiadaceae	Sirukurinjaa	Tuber	Alone	Cooked	13	0.040
32	*Hemidesmus indicus* R.Br	Asclepiadaceae	Nannaari	Root	**Alone & Combination** *Nigella sativa* Linn.*, Carum copticum* Benth.*, Coriandrum sativum* Linn.	Decoction	1	0.003
33	*Hibiscus rosasinensis* Linn.	Malvaceae	Sevvaraththai	Flower	Alone	Decoction	1	0.003
34	*Justicia tranquebariensis*	Acanthaceae	Thavasi murunkai	Leaf	**Alone & Combination** *Pisonia grandis* R.Br.*, Moringa oleifera* Lamk.*, Passiflora edulis.*	Fried	7	0.021
35	*Luffa acutangula* Roxb.Hort.Beng.	cucurbitaceous	Pekankai	Fruit	Alone	Juice, Cooked	1	0.003
36	*Lycopersicum esculentum* Mill.	Solanaceae	Thakkaali	Leaf	Alone	Raw	1	0.003
37	*Macrotyloma uniflorum/ Dolichos biflorus* Linn	Fabaceae	Kollu	Seed	Alone	Infusion	1	0.003
38	*Malus domestica*	Rosaceae	Green Apple	Fruit	Alone	Juice, Raw, Crushed	1	0.003
39	*Momordica charantia* Linn.	Cucurbitaceae	Paakal	Fruit, Leaf	Alone	Cooked, Juice, Raw, Fried, Crushed	104	0.316

40	*Moringa oleifera* Lamk.	Moringaceae	Murungai	Leaf	**Alone & Combination** *Gymnema sylvestre, Pisonia grandis* R.Br.*, Solanum trilobatum* Linn.*, Alternanthera sessilis* R.Br.*, Delonix elata* Gamble.*, Musa rubra* Sieb, *Daucus carota* Linn.*, Brassica oleraceae* Linn.*, Justicia tranquebariensis, Moringa oleifera* Lamk.*, Costus speciosus* (koen) smith in trans. Linn.*, Piper longum* Linn.*, Passiflora edulis, Cephalandra indica Naud.*	Fried, Cooked, Soup	142	0.432
41	*Mukia maderaspatana* Linn.	Cucurbitaceae	Mochumochukkai	Leaf	Alone	Raw, Cooked	2	0.006
42	*Murraya koenigii* Spreng	Rutaceae	Kariveppilai	Leaf	**Alone & Combination** *Allium sativum* Linn.*, Piper nigrum* Linn.	Raw, Crushed, Juice, Decoction, Porridge	8	0.024
43	*Musa sapientum* Linn.	Musaceae	Vaazhai	Flower, Stem, Fruit	Alone & Combination *Moringa oleifera* Lamk.	Fried, Cooked, Raw, Crushed	21	0.064
44	*Nigella sativa* Linn.	Ranunculaceae	Seerakam	Fruit	**Alone & Combination** *Curcuma domestica, Piper nigrum* Linn.*, Allium sativum* Linn,*, Zingiber officinale* Robx.*, Trigonella foenum-graecum* Linn.	Raw, Infusion, Decoction	6	0.018
45	*Passiflora edulis*	Passifloraceae	Passion fruit	Leaf	**Alone & Combination** *Pisonia grandis* R.Br.*, Justicia tranquebariensis, Moringa oleifera* Lamk.*, Gymnema sylvestre, Psidium guajava* Linn.*, Sesbania grandiflora* L, *Spondias dulcis* Parkinson.	Raw, Fried, Crushed	29	0.088
46	*Phyllanthus emblica* Linn/ *distichus Muell*	Euphorbiaceae	Muzhu nelli/Arai nelli	Fruit	Alone	Juice, Raw, crushed, cooked	9	0.027
47	*Piper betle*	Piperaceae	Vettrilai	Leaf	**Combination** *Piper nigrum* Linn.*, Coriandrum sativum* Linn. *igrum* Linn.*, Syzygium aromaticum* Linn.*, Coriandrum sativum* Linn.*, Cuminum cyminum* Linn.	Decoction	1	0.003
48	*Piper nigrum* Linn	Piperacea	Milaku	Fruit	**Combination** *Cuminum cyminum* Linn.*, Nigella sativa* Linn.	Infusion, Decoction	2	0.006
49	*Pisonia grandis* R.Br.	Nyctaginaceae	Chandi	Leaf	**Alone & Combination** *Moringa oleifera* Lamk.*, Cucurbita maxima* Duch.*, Passiflora edulis, Justicia tranquebariensis, Gymnema sylvestre, Delonix elata* Gamble.	Fried, Raw	25	0.076

50	*Psidium guajava* Linn.	Myrtaceae	Koiyaa	Leaf	**Alone & Combination** *Artocarpus heterophyllus* Lam*., Ocimum sanctum* Linn*., Azadirachta indica* Juss*., Dregea volubilis* Benth.ex.Hook*., Mangifera indica* Linn*., Carica papaya* Linn*., Syzygium cumini* Linn*. Coleus amboinicus, Piper betle.*	Raw, Crushed, Decoction	66	0.201
51	*Raphanus sativus* Linn.	Cruciferae	Mullangi	Root, Leaf	**Alone & Combination** *Daucus carota* Linn*., Allium porrum* Linn*., Moringa oleifera* Lamk.	Cooked, Fried, Raw	20	0.061
52	*Rivea ornate* Chois	Convolvulaceae	Musuttai	Leaf, whole part	**Alone & Combination** *Moringa oleifera* Lamk.	Fried, Decoction	4	0.012
53	*Senna auriculata* Linn.	Fabaceae	Aavaarai	Flower, Root	**Alone & Combination** *Musa rubra* Sieb*., Cephalandra indica* Naud.	Decoction, Fried, Infusion, Raw	9	0.027
54	*Sesbania grandiflora* L	Leguminosae	Agaththi	Leaf, Flower	Alone & Combination *Moringa oleifera* Lamk*., Pisonia grandis* R.Br*., Musa rubra* Sieb*., Alternanthera sessilis* R.Br*., Brassica oleraceae* Linn.	Fried, Cooked	25	0.076
55	*Solanum torvum*	Solanaceae	Sundamkathri	Fruit		Cooked	2	0.006
56	*Spondias dulcis* Parkinson	Anacardiaceae	Ampallai	Leaf	**Alone & Combination** *Passiflora edulis*	Raw, Crushed	4	0.012
57	*Syzygium cumini* Linn	Myrtaceae	Naaval	Seed, Fruit	Alone	Decoction, Infusion, Raw, Crushed	7	0.021
58	*Withania somnifera* (Linn.) Dunal	Solanaceae	Asvaganthi		Alone	Raw	1	0.003
59	*Zingiber officinale* Robx.	Zingiberaceae	Inji	Rhizome	Alone	Juice	1	0.00

Linn*., Macrotyloma uniflorum/ Dolichos biflorus* Linn*, Cassia Sophera* Linn*., Delonix elata* Gamble*.* and *Sesbania grandiflora* L. Amaranthaceae included 4 species and Solanaceae included 3 species. Diabetic patients used different parts of the plants for DM management. Leaves (56.14%) were the most commonly used part, followed by fruits (15.47%), stems (14.92%) and seeds (7.37%) (Figure 2).

Fresh or dried (sun exposure/shade drying) plant parts were used by the patients. The majority of the patients consumed fresh plant parts (98.15%). Dried parts were mainly used in powdered form.

This survey reported that both fresh and dried plant parts were prepared in different modes including infusion, decoction, raw, cooked, crushed, juiced, fried and soft paste methods for consumption. Among these, the most common mode of preparation was fried (32.98%), followed by raw (25.86%), cooked (13.37%), and decoction (11.7%) (Figure 3). Further, the plants were consumed alone or in combination with other plants (Table 2).

The leaf was mentioned as the most used part to treat DM. This may be due to the presence of a high number of pharmacologically active compounds compared to other parts of the plant. Fresh plant parts were consumed by the majority of the patients as raw or fried to prevent the loss of bioactive compounds and their biological properties (Fillion & Henry, 1998). In addition, patients used the plant alone or in combination with other plants so as

Table 3: List of the plant families used by the diabetic patients with frequency of citation (FC) of families and Family Importance Value (FIV).

Family	FC	FIV	Family	FC	FIV
Acanthaceae	7	2.13	Meliaceae	13	3.95
Amaranthaceae	64	19.45	Moraceae	114	34.65
Amaryllidaceae	81	24.62	Moringaceae	142	43.16
Anacardiaceae	4	1.22	Musaceae	21	6.38
Apocynaceae	105	31.91	Myrtaceae	73	22.19
Asclepiadaceae	14	4.26	Nyctaginaceae	26	7.90
Berberidaceae	1	0.30	Palmaceae	1	0.30
Caricaceae	1	0.30	Passifloraceae	29	8.81
Convolvulaceae	5	1.52	Piperaceae	3	0.91
Cruciferae	22	6.69	Ranunculaceae	6	1.82
Cucurbitaceae	69	20.97	Rosaceae	1	0.30
Euphorbiaceae	10	3.04	Rutaceae	9	2.74
Fabaceae/ Leguminosae	44	13.37	Sapindaceae	1	0.30
Gramineae	9	2.74	Solanaceae	4	1.22
Liliaceae	4	1.22	Umbelliferae	53	16.11
Malvaceae	8	2.43	Zingiberaceae	30	9.12
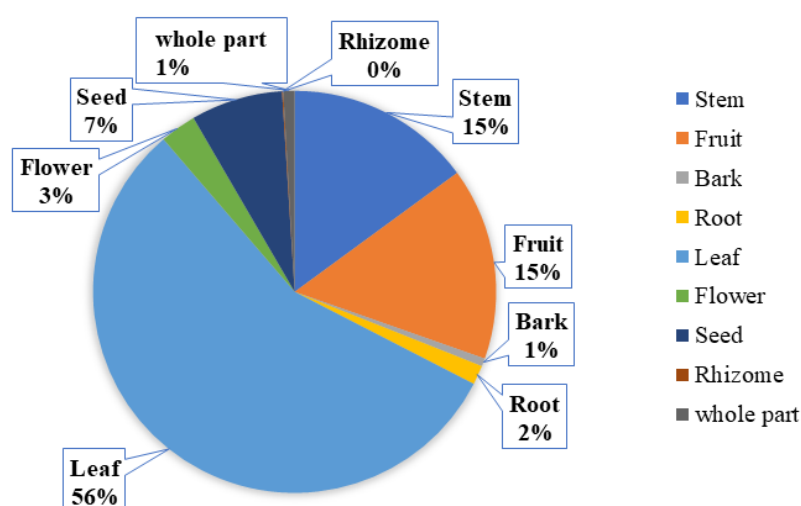
Figure 2: Percentage of different parts of plants (mentioned in Table 2) such as stem, fruit, bark, root, leaf, flower, seed, rhizome used by diabetic patients attended at medical clinic, Teaching Hospital, Jaffna for the mangement of diabetes mellitus.
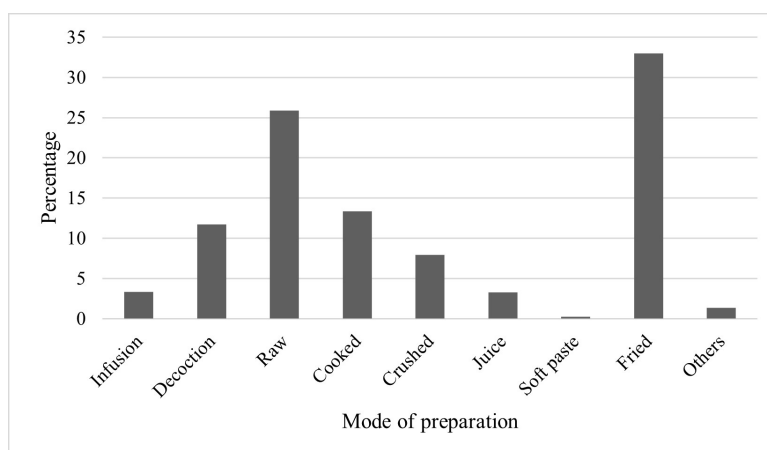
Figure 3: The mode of preparation (as a percentage) including infusion, decoction, raw, cooked, crushed, juice, soft paste, fried and other methods of the plants which were consumed by the diabetic patients who visited the Teaching Hospital, Jaffna, Sri Lanka.

to enhance the antidiabetic properties of the plant due to synergistic effects.

During this study, 59 plant species were mentioned by the patients in the Teaching Hospital, Jaffna, to manage DM. Ethnobotanical studies have been conducted among traditional practitioners in Sri Lanka to document the plant species used to manage the DM (Napagoda et al., 2019). However, the following plants mentioned in this study: *Malus Domestica, Spondias dulcis* Parkinson.*, Aloe vera, Cassia tomentosa, Gymnema sylvestre, Psidium guajava* Linn.*, Macrotyloma uniflorum, Brassica oleraceae, Cucurbita maxima* Duch.*, Pisonia grandis* R.Br.*, Solanum torvum, Hibiscus rosasinensis* Linn.*, Lycopersicum esculentum* Mill.*, Justicia tranquebariensis, Achyranthus polygonoides, Benincasa hispida* Thumb.*, Luffa acutangula* Roxb.Hort.Beng.*, Cassia Sophera* Linn.*, Argyreia pomacea* Wall. ex Choisy.*, Rivea ornate* Chois.*, Moringa oleifera* Lamk.*, Amaranthus viridis* Linn.*, Raphanus sativus* Linn.*, Centella asiatica* Linn.*, Delonix elata* Gamble.*, Musa Sapientum* Linn.*, Averrhoea bilimbi* Linn.*, Abelmoschus esculentus., and Piper betle* were reported for the first time in Sri Lanka. Further, the antidiabetic properties of *Achyranthus polygonoids, Argyreia pomacea* Wall. Ex Choisy and *Cassia tomentosa* have not been reported to date.

CONCLUSION

Among the ethnobotanical studies conducted in Sri Lanka this is the first study that was conducted on patients. This study revealed important information about the antidiabetic plants, mode of preparation and combinations of plants used for DM management. Further, 29 plant species mentioned in this study to manage DM were reported for the first time in Sri Lanka. Moreover, the antidiabetic properties of *Achyranthus polygonoides, Argyreia pomacea* Wall. ex Choisy and *Cassia tomentosa* have not been investigated to date. These findings facilitate the documentation of medicinal plants used for the treatment of DM by the patients attending the Teaching Hospital, Jaffna, Sri Lanka and the identification of new antidiabetic compounds.

ACKNOWLEDGEMENT

DECLARATION OF CONFLICT OF INTEREST

Authors declare that they do not have any conflict of interest.

REFERENCES

Assmaa, A., Said Laaribya, I., & Sezgin, A. (2020). Ethnobotanical survey of medicinal plants used for treating diabetes in Agadir Ida Outanane region, Southwestern Morocco. *Arabian Journal of Medicinal and Aromatic Plants*, **6**(2), 72–86. doi: 10.1155/2021/5515634.

Cotton, C.M. (1996). Ethnobotany: Principles and Applications. *John Wiley and Sons, Ltd.*, 1–426.

Department of Census and Statistics. (2023). *Jaffna District*. Retrieved August 28, 2023, from http://www.statistics.gov.lk/

Fillion, L., & Henry, C. J. K. (1998). Nutrient losses and gains during frying: a review. In *International Journal of Food Sciences and Nutrition*. **49**(2), 157-68. doi: 10.3109/09637489809089395.

Hamza, M., Imane, E., Fatima, Z. J., Amina, B., Andriy, G., & Dalila, B. (2020). Ethnobotanical survey about the management of diabetes with medicinal plants used by diabetic patients in Region of Fez-Meknes, Morocco. *Ethnobotany Research and Applications*, **29**(July), 35–45. doi:10.32859/era.19.12.1-28

Jayakumar, G., Ajithabai, M. D., Sreedevi, S., Viswanathan, P. K., & Remeshkumar, B. (2010). Ethnobotanical survey of the plants used in the treatment of diabetes. *Indian Journal of Traditional Knowledge*, **9**(1), 100–104.

Martin GJ. (1995). A methods manual. *Chapaman and Hill, London*, 1–251.

Napagoda, M. T., Sundarapperuma, T., Fonseka, D., Amarasiri, S., & Gunaratna, P. (2019). Traditional Uses of Medicinal Plants in Polonnaruwa District in North Central Province of Sri Lanka. *Scientifica*, **2019**, 1-11. doi:10.1155/2019/9737302

Orch, H., Zidane, L., & Douira, A. (2020). Ethnobotanical study of plants used in the treatment of respiratory diseases in a population bordering the forest of Izarène. *Journal of Pharmacy and Pharmacognosy Research*, **8**(5), 392–409. doi:10.56499/jppres20.819_8.5.392

Sathasivampillai, S. V., Rajamanoharan, P. R. S., Munday, M., & Heinrich, M. (2017). Plants used to treat diabetes in Sri Lankan Siddha Medicine – An ethnopharmacological review of historical and modern sources. *Journal of Ethnopharmacology*, **198,** 531–599. https://doi.org/10.1016/j.jep.2016.07.053

Skalli, S., Hassikou, R., & Arahou, M. (2019). An ethnobotanical survey of medicinal plants used for diabetes treatment in Rabat, Morocco. *Heliyon*, **5**(3), e01421. https://doi.org/10.1016/j.heliyon.2019.e01421

Thirumalai, T., Beverly, C. D., Sathiyaraj, K., Senthilkumar, B., & David, E. (2012). Ethnobotanical Study of Anti-diabetic medicinal plants used by the local people in Javadhu hills Tamilnadu, India. *Asian Pacific Journal of Tropical Biomedicine*, **2**(2), S910-S913 . https://doi.org/10.1016/S2221-1691(12)60335-9

Wasana, K. G. P., Attanayake, A. P., & Arawwawala, L. D. A. M. (2022). Ethnobotanical survey on medicinal plants used for the treatment of diabetes mellitus by Ayurveda and traditional medicine practitioners in Galle district of Sri Lanka. *European Journal of Integrative Medicine*, **55**(2), 102177. https://doi.org/10.1016/j.eujim.2022.102177

World Health Organization. (2023). *Diabetes*. Retrieved August 17, 2023 from https://www.who.int/health-topics/diabetes#tab=tab_1