Use of Medicinal Plants for the Treatment of Diabetes Mellitus by the Brazilian Amazon Population

Uso de plantas medicinais para o tratamento do Diabetes mellitus pela população amazônica brasileira

Uso de plantas medicinales para el tratamiento de la Diabetes mellitus por la población amazónica brasileña

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Abstract

This study aimed to investigate the use of medicinal plants for the treatment of diabetes mellitus among residents of the Brazilian Amazon. An observational study was conducted using data from the Amazon Population Primary Care Health Study (SAPPA), comprising 691 participants. Data

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were exported to Microsoft Excel and analyzed using descriptive statistics and the chi-square test, with a significance level set at p ≤ 0.05. Overall, 58.76% of the sample reported using medicinal plants for diabetes management. Among the participants with diabetes who reported using medicinal plants, the majority were older women, illiterate, married or in a stable union, and residents of Manacapuru. A total of 108 plant species were cited, most of them exotic. The most frequently reported species were Cymbopogon citratus (13.79%) and Bauhinia forficata L. (9.85%). Leaves were the most commonly used plant part (57.85%), followed by bark (19%), and infusion was the predominant method of preparation (75%). The findings indicate that the use of medicinal plants is widespread among individuals with diabetes in the Brazilian Amazon and involves considerable botanical diversity. These results highlight the importance of further pharmacological and clinical research to confirm the antidiabetic properties of these species and to establish evidence-based guidelines for their safe and effective use.

Keywords: diabetes, alternative treatment, medicinal herbs, hypoglycemic agents

Resumo

Este estudo teve como objetivo investigar o uso de plantas medicinais no tratamento do diabetes mellitus entre residentes da Amazônia brasileira. Foi realizado um estudo observacional com base em dados do Estudo na Atenção Primária da População Amazônica (SAPPA), com 691 participantes. Os dados foram exportados para o Microsoft Excel e analisados por meio de estatística descritiva e teste do qui-quadrado, adotando-se o nível de significância de p ≤ 0,05. No total, 58,76% da amostra relatou utilizar plantas medicinais no manejo do diabetes. Entre os participantes com diabetes que relataram o uso de plantas medicinais, a maioria era composta por mulheres idosas, analfabetas, casadas ou em união estável e residentes de Manacapuru. Foram citadas 108 espécies vegetais, sendo a maioria exótica. As espécies mais frequentemente mencionadas foram Cymbopogon citratus (13,79%) e Bauhinia forficata L. (9,85%). As folhas foram a parte da planta mais utilizada (57,85%), seguidas da casca (19%), e a infusão foi o método de preparo predominante (75%). Os achados indicam que o uso de plantas medicinais é amplamente disseminado entre pessoas com diabetes na Amazônia brasileira, envolvendo uma considerável diversidade botânica. Esses resultados destacam a importância de pesquisas farmacológicas e clínicas adicionais para confirmar as propriedades antidiabéticas dessas espécies e estabelecer diretrizes baseadas em evidências para seu uso seguro e eficaz.

Palavras-chave: diabetes, tratamento alternativo, ervas medicinais, agentes hipoglicêmicos

Resumen

Este estudio tuvo como objetivo investigar el uso de plantas medicinales para el tratamiento de la diabetes mellitus entre los residentes de la Amazonía brasileña. Se realizó un estudio observacional utilizando datos del Amazon Population Primary Care Health Study (SAPPA), que incluyó a 691 participantes. Los datos fueron exportados a Microsoft Excel y analizados mediante estadística descriptiva y la prueba de chi-cuadrado, con un nivel de significancia p ≤ 0.05. En total, el 58.76 % de la muestra reportó el uso de plantas medicinales para el manejo de la diabetes. Entre los participantes con diabetes que informaron el uso de plantas medicinales, la mayoría eran mujeres de mayor edad, analfabetas, casadas o en unión estable y residentes de Manacapuru. Se citaron un total de 108 especies vegetales, la mayoría de ellas exóticas. Las especies más frecuentemente mencionadas fueron Cymbopogon citratus (13.79 %) y Bauhinia forficata L. (9.85%). Las hojas fueron la parte de la planta más utilizada (57.85 %), seguidas de la corteza (19 %), y la infusión fue el método de preparación predominante (75 %). Los hallazgos indican que el uso de plantas medicinales está ampliamente difundido entre las personas con diabetes en la Amazonía brasileña e involucra una diversidad botánica considerable. Estos resultados resaltan la importancia de realizar estudios farmacológicos y clínicos adicionales para confirmar las propiedades antidiabéticas de estas especies y establecer directrices basadas en evidencia para su uso seguro y eficaz.

Palabras clave: diabetes, tratamiento alternativo, plantas medicinales, agentes hipoglucemiantes

Introduction

Diabetes mellitus (DM) is a public health problem, with a growing increase in the number of cases worldwide. It is a metabolic disorder with a diverse etiology characterized by hyperglycemia (de Carvalho *et al.*, 2021). This disease can be generally classified into two main categories: type 1 and type 2 diabetes. Type 2 diabetes mellitus (T2DM), which accounts for 90-95% of all diabetes cases worldwide, arises from peripheral insulin resistance and a progressive loss of adequate insulin secretion by pancreatic beta cells. In this case, the etiology is related to overweight and obesity, advanced age, physical inactivity, and family history (Association, 2021).

A growing concern about the increasing prevalence of T2DM among indigenous populations in the Amazon has arisen, especially those transitioning to urban environments. This epidemiological shift has been strongly associated with dietary changes, particularly the increased consumption of carbohydrate-rich, highly processed foods that diverge from traditional diets and contribute to the risk of metabolic disorders (Welch, 2020).

Diabetes treatment is based mainly on diet, exercise, and pharmacological agents (Belmouhoub *et al.*, 2022). However, due to the high cost and adverse effects of medications, people have increasingly used medicinal plants as an alternative to prevent and treat diabetes (Belmouhoub *et al.*, 2022). In this context, it should be noted that Brazil is the country with the largest plant biodiversity on the planet, with a collection of about 46 000 species, including a large number of medicinal plants (Pinto, 2021).

It has been shown that the use of medicinal plants by patients with T2DM is frequent, especially among the elderly population, females, and individuals with low education levels (de Albuquerque *et al.*, 2018, UNA-SUS, 2020). Among the most widely used medicinal plants is Bauhinia forficata L., whose chemical constituents have shown promising results regarding hypoglycemic action (Neres de Pontes *et al.*, 2017). Phytotherapeutics can act as an additional form of therapy, considering their low cost and Brazil's great plant diversity (Brito *et al.*, 2020).

As a chronic disease, T2DM has been at the forefront of efforts to develop new treatment methods. In the literature, several plant species have been cited as adjuvants in the treatment of this disease. Considering the large number of individuals with T2DM in Brazil, their widespread use of medicinal plants, and the growing interest in research aimed at identifying hypoglycemic plants, this study sought to investigate the use of medicinal plants for DM treatment by the Amazonian population, who inhabit one of the most biodiverse biomes in the country.

Materials and methods

Geographic location

Amazonas is located in the northern region of Brazil and borders the state of Roraima, Venezuela, and Colombia to the north; the state of Pará to the east; the state of Mato Grosso to the southeast; the state of Rondônia to the south; and the state of Acre and Peru to the southwest (Viverde, 2023). The total area of Amazonas is 1 559 167.878 km^2 (IBGE, 2010). It is the largest state in Brazil, with an estimated population of 4 269 995 inhabitants (IBGE, 2021).

This study was conducted in the state of Amazonas, in the cities of Alvarães (532 km by boat from the capital), Coari (363 km by boat from the capital), Iranduba (38.1 km by car from the capital), Itacoatiara (270 km by car from the capital), Manacapuru (98.8 km by car from the capital), Novo Ayrão (194.8 km by car from the capital), Presidente Figueiredo (125.5 km by car from the capital), and Rio Preto da Eva (80.2 km by car from the capital) (Figure 1).

Figure 1. Map of Amazonas, highlighting the cities where this study was conducted.
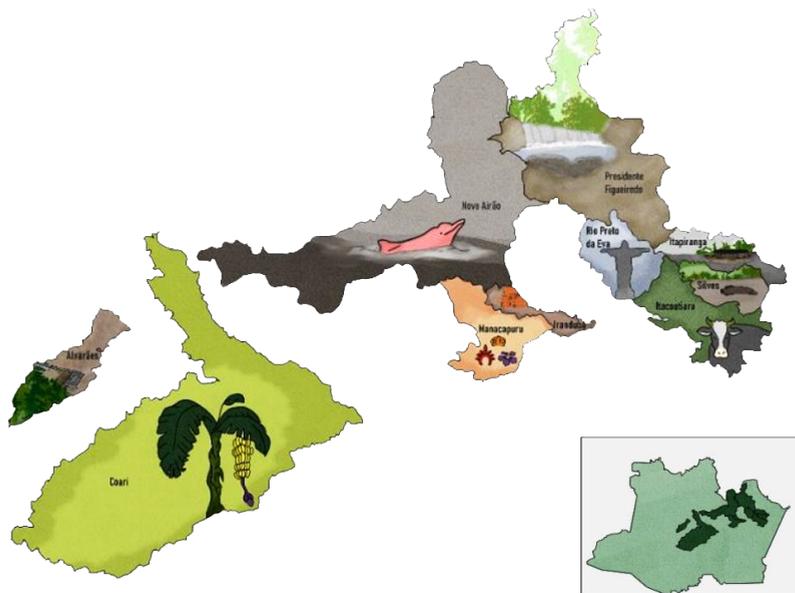
Data collection

An observational, cross-sectional study was conducted using data from the Amazon Population Primary Care Health Study (SAPPA) (de Leon *et al.*, 2022). Data collection occurred from August 2020 to April 2023. All participants with T2DM who had been monitored by the primary healthcare service for at least

six months were included. Individuals with severe cognitive impairment who were unable to participate in data collection were excluded. All participants signed an informed consent. Home visits were conducted in the presence of community health agents by interviewers who received prior training on offline Open Data Kit (ODK) forms and the instruments used. The collected variables included gender, age, marital status, education, city, occupation, use of diabetes medications, consumption of teas and/or special foods for diabetes control, and frequency of use of teas and/or special foods. A total of 691 patients were interviewed.

Identification of medicinal plants

The interviewees mentioned the vernacular names of the plants, and their family, scientific names, and origins were assigned based on various bibliographic sources.

Statistical analysis

The collected data were exported and tabulated in Microsoft Excel spreadsheets. Frequency analysis using a chi-square test ($p \leq 0.05$). The relevance of each plant employed in T2DM treatment was evaluated through the relative frequency of citation (RFC), which was calculated using the following formula (Tardío and Pardo-De-Santayana, 2008): $RFC = FC/N$, with FC meaning the number of people with diabetes who mention the use of the species and N being the total number of diabetes patients who use plants ($0 < RFC < 1$).

Results

A total of 691 males and females aged 23 to 116 years were interviewed at the primary care facilities in Alvarães, Coari, Iranduba, Itacoatiara, Manacapuru, Presidente Figueiredo, and Rio Preto da Eva. Among the participants interviewed, 554 (80.17%) were using pharmacological treatments for diabetes. Out of these, 242 (43.68%) used only pharmacological medicines, 406 (58.76%) used medicinal plants.

Sociodemographic characteristics of the participants

Table 1 presents the sociodemographic characteristics of the study subjects. Of the 406 participants using medicinal plants, 287 were female (70.69%), and the most frequent age group was 61-80, with 205 patients (50.49%). The mean age was 61.8 years, 57.64% of participants were married or living in a stable union, and 38.35% reported no formal education. The city with the lowest reported use of medicinal plants was Iranduba, with 20 (4.93%) participants, and Manacapuru exhibited the highest values.

Table 1 Sociodemographic characteristics of the study participants (n = 691)

Characteristics	N	%	Use of plants				P
			Yes (n = 406)		No (n = 285)		
Sex			n	%	n	%	0.50
Men	210	30.39%	119	29.31%	91	31.93%	
Women	481	69.61%	287	70.69%	194	68.07%	
Age							0.49
20-40 years	44	6.37%	21	5.17%	23	8.07%	
41-60 years	248	35.89%	148	36.45%	100	35.09%	
61-80 years	344	49.78%	205	50.49%	139	48.77%	
> 80 years	55	7.96%	32	7.88%	23	8.07%	
Color/ethnicity							0.24
White	98	18.18%	54	13.30%	44	15.44%	
Browm	521	75.40%	304	74.88%	217	76.14%	
Indigenous	9	1.30%	4	0.98%	5	1.75%	
Yellow	9	1.30%	5	1.23%	4	1.40%	
Black	54	7.81%	39	9.60%	15	5.26%	
Years of Study							0.20
0	265	38.35%	165	40.64%	100	35.09%	
1 until 4	119	17.22%	74	18.23%	45	15.79%	
5 until 8	114	16.50%	64	15.76%	50	17.54%	
≥ 9	193	27.93%	103	25.37%	90	31.58%	
Marital status							0.79
Married/stable union	391	56.58%	234	57.64%	157	55.09%	
Divorced	36	5.21%	20	4.93%	16	5.61%	
Single	125	18.09%	69	17%	56	19.65%	
Widower	139	20.12%	83	20.44%	56	19.65%	

Municipalities							< **0.0001**
Alvarães	34	4.92%	23	5.67%	11	3.86%	
Coari	146	21.13%	86	21.18%	60	21.05%	
Iranduba	28	4.05%	20	4.93%	8	2.81%	
Itacoatiara	166	24.02%	81	19.95%	85	29.82%	
Manacapuru	177	25.62%	131	32.27%	46	16.14%	
Presidente Figueiredo	79	11.43%	43	10.59%	36	12.63%	
Rio Preto da Eva	61	8.83%	22	5.42%	39	13.68%	

Medicinal plants most used by participants

108 plants from 54 families were mentioned by the participants, with Lamiaceae predominating with eight representatives (14.81%), followed by Asteraceae with seven (12.96%), Fabaceae with six (11.11%), and Myrtaceae with five (9.25%). The species most used by the interviewees were Cymbopogon citratus (13.79%), Bauhinia forficata L. (9.85%), Melissa officinalis (9.61%), Carica papaya L. (9.61%), Rubus brasiliensis Mart. (8.13%), Cissus sicyoides L. (7.88%), and Annona muricata (7.39%). As for the origin, 57 (52.77%) out of the 108 plants mentioned are considered exotic, while the rest are native species (47.22%). The parts of the plants most used by the patients are the leaves (57.85%), followed by the bark (19%). As for the preparation methods, the most widely employed were infusion and decoction, with 75 and 21.42%, respectively. Another method of note was juicing (3.57%) (Table 2).

Table 2 List of medicinal plants used for the treatment of diabetes in the interior of Amazonas

Family plant species	Local name	Origin	Part used	Local name	Method of preparation	RFC
Acanthaceae						
Justicia acuminatissima	Sara Tudo	native	bark	infusion	12	0.0295567
Alismataceae						
Echinodorus grandiflorus	Chapéu-de-couro	native	leaves	infusion	1	0.0024631
Alliaceae						
Allium sativum	Alho	exotic	stem	decoction	4	0.0098522
Amaranthaceae						
Beta vulgaris L.	Beterraba	exotic	roots	juice	1	0.0024631

Celosia cristata	Crista-de-galo	exotic	flowers	infusion	1	0.0024631
Pfaffia paniculata	Erva corrente	native	roots	decoction	1	0.0024631
Dysphania ambrosioides	Mastruz	exotic	flowers	infusion	2	0.0049261
Anacardiaceae						
Schinus terebinthifolius	Aroeira	native	leaves, bark	infusion	2	0.0049261
Spondias dulcis	Cajarana	exotic	leaves	infusion	2	0.0049261
Anacardium occidentale L.	Caju	native	bark	decoction	3	0.0073892
Mangifera indica L.	Manga	exotic	leaves	infusion	15	0.0369458
Annonaceae						
Annona montana	Araticum	native	leaves	infusion	1	0.0024631
Annona muricata	Graviola	exotic	leaves	infusion	30	0.0738916
Apiaceae						
Pimpinella anisum	Erva-doce	exotic	seed	infusion	16	0.0394089
Petroselinum crispum	Salsinha	exotic	leaves	infusion	2	0.0049261
Apocynaceae						
Aspidosperma nitidum	Carapanaúba	native	bark	decoction	9	0.0221675
Himatanthus sucuuba	Sucuba	native	bark	decoction	3	0.0073892
Aquifoliaceae						
Ilex paraguariensis	Erva-mate	native	leaves	infusion	3	0.0073892
Arecaceae						
Euterpe oleracea	Açaí	native	roots	infusion	2	0.0049261
Asteraceae						
Lactuca sativa	Alface	exotic	leaves	infusion	1	0.0024631
Matricaria chamomilla	Camomila	exotic	flowers	infusion	11	0.0270936
Baccharis trimera	Carqueja	native	stem	infusion	4	0.0098522
Cichorium intybus	Chicória	exotic	roots	infusion	1	0.0024631
Acmella oleracea	Jambu	native	leaves	infusion	12	0.0295567
Achyrocline satureioides	Marcela	native	flowers	infusion	4	0.0098522
Farfugium japonicum	Pata-de-cavalo	exotic	leaves	infusion	1	0.0024631
Bignoniaceae						
Arrabidaea chica	Crajiru	native	leaves	infusion	6	0.0147783

Bixaceae

Bixa orellana	Urucum	native	leaves, seed	infusion	4	0.0098522

Brassicaceae

Sisymbrium officinale Scopoli	Rinchão	exotic	leaves	infusion	1	0.0024631

Burseraceae

Protium heptaphyllum	Breu branco	native	bark	decoction	1	0.0024631

Cactaceae

Cereus jamacaru	Mandacaru	native	roots	infusion	2	0.0049261

Caesalpiniaceae

Bauhinia forficata L.	Pata-de-vaca	exotic	leaves	infusion	40	0.0985222

Caricaceae

Carica papaya L.	Mamão	exotic	flowers, leaves	infusion	39	0.0960591

Celastraceae

Maytenus ilicifolia	Espinheira-santa	native	leaves	infusion	1	0.0024631
Salacia Impressifolia	Miraruíra	native	bark	decoction	1	0.0024631

Combretaceae

Terminalia catappa L.	Castanhola	exótica	leaves	infusion	1	0.0024631

Convolvulaceae

Bonamia ferruginea (Choisy) Hallier f.	Cipó-tuira	native	leaves	infusion	3	0.0073892

Costaceae

Costus spicatus Jacq.	Cana-do-brejo	native	leaves	infusion	2	0.0049261
Costus spicatus (Jacq.) Sw	Pobre-velho	native	leaves	infusion	10	0.0246305

Crassulaceae

Kalanchoe brasiliensis Cambess	Corama	exotic	leaves	infusion	3	0.0073892

Cucurbitaceae

Cucurbita moschata	Jerimum	exotic	leaves	infusion	2	0.0049261
Cucumis anguria	Maxixe	exotic	leaves	infusion	6	0.0147783
Momordica charantia L.	Melão-de-são-caetano	exotic	leaves	infusion	7	0.0172414
Cucumis sativus L.	Pepino	exotic	fruit	juice	2	0.0049261

Euphorbiaceae

Croton cajucara Benth	Sacaca	native	leaves, bark	infusion	2	0.0049261

Fabaceae

Dinizia excelsa Ducke	Angelim	native	bark/ leaves	decoction/ infusion	2	0.0049261
Copaifera langsdorfii	Copaíba	native	bark	decoction	2	0.0049261
Hymenaea courbaril	Jatobá	native	bark	decoction	7	0.0172414
Libidibia ferrea	Jucá	native	leaves	infusion	10	0.0246305
Tamarindus indica	Tamarindo	exotic	leaves	infusion	7	0.0172414

Humiriaceae

Endopleura uchi	Uxi amarelo	native	bark	decoction	2	0.0049261

Hypericaceae

Hypericum perforatum	Erva-de- são-joão	exotic	leaves, flowers	infusion	1	0.0024631

Lamiaceae

Salvia rosmarinus	Alecrim	exotic	leaves	infusion	8	0.0197044
Ocimum gratissimum L.	Alfavaca	exotic	leaves	infusion	7	0.0172414
Lavandula latifolia	Alfazema	exotic	flowers	infusion	1	0.0024631
Plectranthus barbatus	Boldo- brasileiro	exotic	leaves	infusion	15	0.0369458
Melissa officinalis	Erva-cidreira	native	leaves	infusion	39	0.0960591
Mentha spicata	Hortelã	exotic	leaves	infusion	5	0.0123153
Hyptis crenata	Salva-de- marajó	native	leaves	infusion	1	0.0024631
Origanum vulgare	Orégano	exotic	leaves	infusion	3	0.0073892

Lauraceae

Persea americana	Abacate	exotic	leaves/ seed	infusion/ decoction	15	0.0369458
Cinnamomum verum	Canela	exotic	bark	decoction	17	0.0418719
Aniba canelilla	Casca-preciosa	native	bark	infusion	3	0.0073892
Laurus nobilis	Louro	exotic	leaves	infusion	2	0.0049261

Lecythidaceae

Bertholletia excelsa	Castanha- do-pará	native	bark	decoction	7	0.0172414

Malpighiaceae

Malpighia emarginata	Acerola	exotic	leaves	infusion	2	0.0049261

Malvaceae

Theobroma cacao	Cacau	native	leaves	infusion	4	0.0098522
Hibiscus sabdariffa	Hibisco	exotic	flowers	infusion	1	0.0024631
Malvaviscus arboreus	Malvarisco	exotic	leaves	infusion	1	0.0024631
Abelmoschus esculentus	Quiabo	exotic	fruit	infusion	4	0.0098522

Meliaceae

Carapa guianensis	Andiroba	native	bark	decoction	2	0.0049261
Cedrela fissilis	Cedro-rosa	native	bark	decoction	2	0.0049261

Moraceae

Artocarpus altilis	Fruta-pão	exotic	leaves	infusion	5	0.0123153
Artocarpus heterophyllus	Jaca	exotic	leaves	infusion	1	0.0024631
Morus nigra L.	Amora	exotic	leaves	infusion	33	0.0812808

Moringaceae

Moringa oleifera	Moringa	exotic	leaves	infusion	1	0.0024631

Myrtaceae

Syzygium cumini	Azeitona-roxa	exotic	leaves	infusion	1	0.0024631
Syzygium aromaticum	Cravinho/ Cravo-da-índia	exotic	flower buds	infusion	4	0.0098522
Psidium guajava	Goiaba	exotic	leaves	infusion	19	0.046798
Syzygium jambos	Jambo	exotic	leaves	infusion	4	0.0098522
Eugenia uniflora	Pitanga	native	leaves	infusion	4	0.0098522

Oleaceae

Olea europaea	Azeitona	exotic	bark/ leaves	decoction/ infusion	14	0.0344828

Oxalidaceae

Averrhoa carambola L.	Carambola	exotic	leaves	infusion	4	0.0098522

Passifloraceae

Passiflora edulis	Maracujá	native	fruit	decoction	1	0.0024631

Phyllanthaceae

Phyllanthus niruri	Quebra-pedra	native	leaves, flowers	infusion	7	0.0172414

Picrodendraceae

Piranhea trifoliata	Piranheira	native	bark	decoction	11	0.0270936

Piperaceae

Piper umbellatum	Capeba	native	leaves	infusion	4	0.0098522

Peperomia pellucida	Erva de jabuti	native	leaves	infusion	1	0.0024631
Plantaginaceae						
Scoparia dulcis	Vassourinha	native	leaves	infusion	1	0.0024631
Poaceae						
Saccharum officinarum	Cana-de-açúcar	exotic	leaves	infusion	2	0.0049261
Cymbopogon citratus	Capim-santo	exotic	leaves	infusion	56	0.137931
Portulacaceae						
Portulaca pilosa L.	Amor-crescido	native	leaves	infusion	2	0.0049261
Rhamnaceae						
Ampelozizyphus amazonicus Ducke	Saracura-mirá	native	bark	decoction	7	0.0172414
Rubiaceae						
Coffea arabica	Café	exotic	leaves	infusion	2	0.0049261
Morinda citrifolia	Noni	exotic	leaves	infusion	1	0.0024631
Cinchona spp.	Quina-quina	native	bark	decoction	1	0.0024631
Uncaria tomentosa	Unha-de-gato	native	bark, roots, leaves	infusion	6	0.0147783
Rutaceae						
Citrus sinensis (L.) Osbeck	Laranja	exotic	bark	decoction	13	0.0320197
Citrus limonum	Limão	exotic	leaves/ fruit	infusion/ juice	4	0.0098522
Simaroubaceae						
Quassia amara L.	Pau-tenente	native	leaves	infusion	10	0.0246305
Solanaceae						
Solanum melongena L.	Berinjela	exotic	fruit	decoction	1	0.0024631
Physalis angulata	Canapum	native	leaves, roots	infusion	3	0.0073892
Solanum sessiliflorum	Cubiu	native	fruit	juice	1	0.0024631
Theaceae						
Camellia sinensis	Chá-da-índia	exotic	leaves	infusion	1	0.0024631
Urticaceae						
Cecropia pachystachya	Embaúba	native	leaves	infusion	2	0.0049261
Vitaceae						
Cissus sicyoides L.	Insulina vegetal	native	leaves	infusion	32	0.0788177

Zingiberaceae						
Zingiber officinale	Gengibre	exotic	roots	decoction	1	0.0024631
Alpinia zerumbet	Vindicá	exotic	leaves	infusion	1	0.0024631

FC: Frequency of citation; RFC: Relative frequency of citation.

Discussion

Most participants use pharmacological treatments for diabetes, which is relevant given that they are monitored in primary care settings. Similar data were found by Defani and Oliveira (2015), where 85% of the interviewees showed adherence to medication. Kasole *et al.* (2019) noted that most participants preferred using a combination of conventional and traditional medicines to treat diabetes, a result also observed in this study, since a large portion of the patient's using medication reported associations with medicinal plants.

Moreover, this study allowed identifying numerous plants. The diversity of plants reported by patients evidences the search for complementary treatments. The type of plant used by the population to cure their ailments exhibits notable geographical and ethnic differences (Defani and Oliveira, 2015). However, several plant species and botanical families cited in this study were also reported in similar works from other regions of Brazil and the world. The Lamiaceae family, which was the most represented in this study, was also shown to be the predominant family for DM treatment in other studies conducted in North African countries (Belmouhoub *et al.*, 2022; Hinad *et al.*, 2022).

The highest RFC values were reported for *Cymbopogon citratus* (lemongrass), followed by *Bauhinia forficata L.* (pata-de-vaca), *Carica papaya* L. (papaya), and *Melissa officinalis* (Lemon balm). The plants with the highest RFC correspond to those predominantly used by the studied population. The following plants are listed below, along with some scientific studies demonstrating their therapeutic effects.

- *Cymbopogon citratus* (lemongrass). Also known as *capim-santo, capim-cheiroso*, or *capim-cidró*, it is a medicinal plant native to India, widely cultivated in countries with tropical and subtropical climates, that grows well in most of Brazil (eCycle, 2022). It was also the most cited plant in this research. Although other studies have already proven it to be a relaxant, recent works conducted with Wistar rats have evidenced that *C. citratus* has an antidiabetic effect, improving the glycemic profile and the functionality of pancreatic β-cells, in addition to decreasing insulin resistance (Garba *et al.*, 2020).

- *Bauhinia forficata L.* (pata-de-vaca). Many studies have been conducted to evaluate the antihyperglycemic activity of this plant, as it has long been used in folk medicine for the treatment of DM (Vieira, 2017). Its use for diabetes control largely occurs by exploiting the aqueous extract of its leaves and roots (de Carvalho *et al.*, 2021). A study using this aqueous extract, which was administered orally for seven days at doses of 200 and 400 mg/kg 48 hours after the experimental induction of diabetes, found a reduction in blood glucose, plasma triglyceride concentrations, and total and HDL cholesterol, especially in patients with DMT2 (de Lino *et al.*, 2004).

- *Carica papaya* L. (Papaya). Native to the eastern plains of Central America, this plant can be found from Mexico to Panama, although it is cultivated in all tropical and subtropical regions of the world (Juárez-Rojop *et al.*, 2012). Regarding its hypoglycemic properties, a study conducted by Ogundele *et al.* (2017) confirmed that the methanolic extract of C. *papaya* leaves has significant antidiabetic activity *in vitro*, demonstrating its potential for drug development. The study by Juárez-Rojop *et al.* (2012), conducted on rats with induced diabetes, showed that the aqueous extract of C. *papaya* (0.75 and 1.5 g/100 ml) significantly decreased blood glucose levels ($p < 0.05$), in addition to reducing cholesterol, triacylglycerol, and aminotransferase levels.

- *Melissa officinalis* (Melissa). In addition to being mentioned in diabetes treatments by this study's participants, other works have highlighted the anxiolytic properties of *M. officinalis* (da Silva *et al.*, 2018; Soltanpour *et al.*, 2019). This is a plant known for its calming action, influencing blood pressure control in the face of situations of emotional stress (Peres Junior *et al.*, 2022). The literature lacks studies that investigate its potential as an antidiabetic plant.

As for the parts of the plants that were preferentially used by the patients in this study, leaves were cited more often than bark, flowers, stems, roots, seeds, and fruit. This result resembles those of previous studies (Dalar, 2018; Defani and Oliveira, 2015; Hinad *et al.*, 2022). The main preparation methods were infusion and decoction, which are also consistent with previous studies (Belmouhoub *et al.*, 2022; Dalar, 2018; Defani and Oliveira, 2015). It should be emphasized that each part of the plant requires a specific method of preparation if one is to benefit from its phytotherapeutic properties, as some constituents of the plants need specific conditions for their extraction and use (Brandelli and Monteiro, 2017).

The plant species presented in this study could be important in evaluating research aimed at future drug discovery and the sustainable use of medicinal plants for diabetes treatment. There are plants that lack studies regarding their antidiabetic properties, as is the case of *Melissa officinalis*. Moreover, the

population's habit of combining the use of medicines with teas or medicinal plants ratifies the necessity and importance of studies on possible drug interactions resulting from this practice, which often takes place without medical or pharmaceutical guidance (Hahn and da Silva, 2011). This type of guidance is also necessary regarding proper preparation to obtain the expected benefits from the plant.

Conclusion

This research revealed that the use of medicinal plants for the treatment of DM is a common practice in the Brazilian Amazon, with participants using a considerable number of plant species. However, research confirming the hypoglycemic effects of these plants in humans and elucidating their mechanisms of action remains limited, so it is necessary to demonstrate their benefits scientifically before they can be properly introduced as a complementary therapy.

Declaration of competing interest

The authors declare that they have no conflicts of interest related to the publication of this study.

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Ethical approval

Ethical approval was obtained from the Human Research Ethics Committee of the Federal University of Amazonas (registration:3,937,812) in October 2020.

References

Association, A. D. (2021). 2. Classification and diagnosis of diabetes: Standards of medical care in diabetes—2021. *Diabetes Care*, *44*(Supplement 1), S15-S33. https://doi.org/10.2337/DC21-S002

Belmouhoub, M., Tacherfiout, M., Boukhalfa, F., Khodja, Y. K., and Bachir-Bey, M. (2022). Traditional medicinal plants used in the treatment of diabetes: Ethnobotanical and ethnopharmacological studies and mechanisms of action. *International Journal of Plant Based Pharmaceuticals, 2*(2), 145-154. https://doi.org/10.62313/ijpbp.2022.25

Brandelli, C. L. C., and Monteiro, S. da C. (2017). *Farmacobotânica: Aspectos teóricos e aplicação.* Artmed.

Brito, V. P. de, Freitas, M. C. de, Gomes, D. C., and Oliveira, S. V. de. (2020). A fitoterapia como uma alternativa terapêutica complementar para pacientes com Diabetes Mellitus no Brasil. *Saúde e Meio Ambiente: Revista Interdisciplinar, 9,* 189-204. https://doi.org/10.24302/SMA.V9I0.2847

Dalar, A. (2018). Plant taxa used in the treatment of diabetes in Van Province, Turkey. *International Journal of Secondary Metabolite, 5*(3), 171-185. https://doi.org/10.21448/ijsm.430703

Da Silva, T. G. L., Juvino, E. O. R. S., Marcelino, E. M., Da Silva, M. A., and Mariz, S. R. (2018, June 13). Propriedades terapêuticas da *Melissa officinalis*: uma revisão integrativa | Plataforma Espaço Digital. *III Conbracis.* https://www.editorarealize.com.br/index.php/artigo/visualizar/41341

de Albuquerque, A. V., Gomes, C. B. da S., Santos, E. de A., and Leite, S. G. (2018, June 13). O uso de plantas medicinais por pacientes com diabetes mellitus | Plataforma Espaço Digital. *III Conbracis.* https://www.editorarealize.com.br/artigo/visualizar/41225

de Carvalho, A. C., Oliveira, A. A. da S., and Siqueira, L. da P. (2021). Plantas medicinais utilizadas no tratamento do Diabetes Mellitus: Uma revisão / Medicinal plants used in the treatment of Diabetes Mellitus: A review. *Brazilian Journal of Health Review, 4*(3), 12873-12894. https://doi.org/10.34119/bjhrv4n3-247

Defani, M. A., and Oliveira, L. E. N. de. (2015). Utilização das plantas medicinais por diabéticos do município de Colorado - PR. *Saúde e Pesquisa, 8*(3), 413-421. https://doi.org/10.17765/1983-1870.2015V8N3.413-421

de León, E. B., Campos, H. L. M., Brito, F. A., and Almeida, F. A. (2022). Study of health in primary care of the Amazonas population: Protocol for an observational study on diabetes management in Brazil. *JMIR Research Protocols, 11*(9), e37572. https://doi.org/10.2196/37572

de Lino, C. S., Diógenes, J. P. L., Pereira, B. A., Faria, R. A. P. G., Andrade Neto, M., Alves, R. S., de Queiroz, M. G. R., De Sousa, F. C. F., and Viana, G. S. B. (2004). Antidiabetic activity of Bauhinia forficata extracts in alloxan-diabetic rats. *Biological and Pharmaceutical Bulletin, 27*(1), 125-127. https://doi.org/10.1248/BPB.27.125

eCycle (2022). *Capim-santo: benefícios e propriedades medicinais.* https://www.ecycle.com.br/capim-santo/

Garba, H. A., Mohammed, A., Ibrahim, M. A., and Shuaibu, M. N. (2020). Effect of lemongrass (*Cymbopogon citratus* Stapf) tea in a type 2 diabetes rat model. *Clinical Phytoscience, 6*(1), 1-10. https://doi.org/10.1186/S40816-020-00167-Y

HAHN, S. R., AND DA SILVA, B. Q. (2011). Use of medicinal plants by individuals with hypertension, diabetes mellitus or dyslipidemia. *Revista Brasileira de Farmácia Hospitalar e Serviços de Saúde*, *2*(3), 1. https://www.rbfhss.org.br/sbrafh/article/view/78

HINAD, I., S'HIH, Y., ELHESSNI, A., MESFIOUI, A., AND OUAHIDI, M. L. (2022). Medicinal plants used in the traditional treatment of diabetes in Ksar Elkebir Region (North-Western Morocco). *The Pan African Medical Journal*, *42*, 319. https://doi.org/10.11604/PAMJ.2022.42.319.32572

IBGE (2010). *Amazonas | Cidades e Estados | IBGE*. https://www.ibge.gov.br/cidades-e-estados/am.html

IBGE (2021). *Amazonas | Cidades e Estados | IBGE*. https://www.ibge.gov.br/cidades-e-estados/am.html

IZZO, A. A., AND ERNST, E. (2009). Interactions between herbal medicines and prescribed drugs: An updated systematic review. *Drugs, 69*(13), 1777-1798. https://doi.org/10.2165/11317010-000000000-00000

JUÁREZ-ROJOP, I. E., DÍAZ-ZAGOYA, J. C., BLE-CASTILLO, J. L., MIRANDA-OSORIO, P. H., CASTELL-RODRÍGUEZ, A. E., TOVILLA-ZÁRATE, C. A., RODRÍGUEZ-HERNÁNDEZ, A., AGUILAR-MARISCAL, H., RAMÓN-FRÍAS, T., AND BERMÚDEZ-OCAÑA, D. Y. (2012). Hypoglycemic effect of Carica papaya leaves in streptozotocin-induced diabetic rats. *BMC Complementary and Alternative Medicine, 12*(1), 236. https://doi.org/10.1186/1472-6882-12-236

KASOLE, R., MARTIN, H. D., AND KIMIYWE, J. (2019). Traditional medicine and its role in the management of diabetes mellitus: "Patients'' and herbalists' perspectives"." *Evidence-Based Complementary and Alternative Medicine, 2019*, 2835691. https://doi.org/10.1155/2019/2835691

MUZY, J., CAMPOS, M. R., EMMERICK, I., DA SILVA, R. S., AND DE ANDRADE SCHRAMM, J. M. (2021). Prevalência de diabetes mellitus e suas complicações e caracterização das lacunas na atenção à saúde a partir da triangulação de pesquisas. *Cadernos de Saúde Pública, 37*(5), e00076120. https://doi.org/10.1590/0102-311X00076120

NERES DE PONTES, M. A., SANTOS DE LIMA, D., MARA, H., FERNANDES DE OLIVEIRA, B., ALVES, A., AND FILHO, O. (2017). *Bauhinia forficata* L. e sua a ação hipoglicemiante. *Archives of Health Investigation, 6*(11), 2244. https://doi.org/10.21270/ARCHI.V6I11.2244

OGUNDELE, A. V., OTUN, K. O., AJIBOYE, A., OLANIPEKUN, B. E., AND IBRAHIM, R. B. (2017). Anti-diabetic efficacy and phytochemical screening of methanolic leaf extract of pawpaw (Carica papaya) grown in North Central Nigeria. *Journal of the Turkish Chemical Society Section A: Chemistry*, *4*(1), 99-114. https://doi.org/10.18596/JOTCSA.52813

Peres Junior, O. V., Ceolin, T., Timm Bonow, C., Polino Gomes, M., Araújo Fonseca, R., and Fraga Mercali, L. M. (2022). Plantas medicinais utilizadas por hipertensos e diabéticos em um município da Região Sul do Brasil. *Journal of Nursing and Health*, *12*(1), 2241. https://doi.org/10.15210/JONAH.V12I1.2241

Petermann, X. B., Machado, I. S., Pimentel, B. N., Miolo, S. B., Martins, L. R., and Fedosse, E. (2015). Epidemiologia e cuidado à diabetes mellitus praticado na atenção primária à saúde: uma revisão narrativa. *Saúde (Santa Maria)*, *41*(1), 49-56. https://doi.org/10.5902/2236583414905

Pinto, F. (2021). *Encontro virtual marca os 15 anos da Política Nacional de Plantas Medicinais e Fitoterápicos – Fiocruz Brasília*. https://www.fiocruzbrasilia.fiocruz.br/encontro-virtual-marca-os-15-anos-da-politica-nacional-de-plantas-medicinais-e-fitoterapicos/

Rocha Vázquez, M., and San Juan Bosch, M. A. (2009). The home visit as form of teaching in primary health care in Cuba. *Atencion Primaria*, *41*(9), 521-522. https://doi.org/10.1016/J.APRIM.2009.01.007

Soltanpour, A., Alijaniha, F., Naseri, M., Kazemnejad, A., and Heidari, M. R. (2019). Effects of Melissa officinalis on anxiety and sleep quality in patients undergoing coronary artery bypass surgery: A double-blind randomized placebo-controlled trial. *European Journal of Integrative Medicine*, *28*, 27-32. https://doi.org/10.1016/J.EUJIM.2019.01.010

Souza, Y. R. S. de, Silva, J. A. da, Silva, I. T. S. da, Souza, T. A. de, and Medeiros, M. R. de S. (2021). A influência da família na autonomia e participação do cuidado do sujeito diagnosticado com diabetes mellitus. *Research, Society and Development*, *10*(4), e56710414113. https://doi.org/10.33448/RSD-V10I4.14113

Tardío, J., and Pardo-De-Santayana, M. (2008). Cultural importance indices: A comparative analysis based on the useful wild plants of southern Cantabria (northern Spain). *Economic Botany*, *62*(1), 24–-9. https://doi.org/10.1007/S12231-007-9004-5

UNA-SUS (2020, April 27). *Diabetes, hipertensão e obesidade avançam entre os brasileiros - Notícia - UNA-SUS*. https://www.unasus.gov.br/noticia/diabetes-hipertensao-e-obesidade-avancam-entre-os-brasileiros

Vieira, L. G. (2017). *O uso de fitoterápicos e plantas medicinais por pacientes diabéticos*. https://bdm.unb.br/handle/10483/17579

Viverde (2023). *Informações geográfica e turásticas do Amazonas Manaus by Viverde*. https://www.viverde.tur.br/informacoes_turisticas.html

Welch, J. R., Ferreira, A. A., Souza, M. C. D., and Coimbra, C. E. A. (2020). Food profiles of indigenous households in Brazil: Results of the first national survey of indigenous peoples' health and nutrition. *Ecology of Food and Nutrition*, 60(1), 4-24. https://doi.org/10.1080/03670244.2020.1781105