Quantitative ethno-medicinal study of therapeutic flora found in Bunkure, Kano State Nigeria

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Research

Abstract

Background: Obtaining medicines from the plant is an ancient tradition worldwide. This study aimed to collect the ethnomedicinal understanding of therapeutic plants from the indigenous communities of Bunkure, a Kano State, Nigeria region.

Methods: A semi-structured interview using a validated questionnaire was applied to assess the valuable information from 200 participants (133 male and 67 female). Quantitative analysis of data was performed using Relative Frequency of Citation (RFC), Informant Consensus Factor (ICF), Use Value (UV), Jaccard Index, Direct Matrix Ranking, and Preference Ranking Exercise.

Results: 74 plant species belonging to 38 families and 63 genera were recorded in this region and used here for ethnomedicinal purposes. Leaves (42.5%) are the most favourable portion of the plant used for ethnomedicine followed by the stem (33%), roots (11.5%), seeds (11%), and fruits (2%). High levels of relative frequency of citation (RFC) were found for *Senna tora* (0.06), *Tamarindus indica* (0.03), *Ziziphus tripartite* (0.03), *Psidium guajava* (0.01), *Parkia biglobosa* (0.01), *Eucalyptus tereticornis* (0.02), *Anogeissus leiocarpus* (0.02), and *Allium sativum* (0.03). *Azadirachta indica* (Neem) and *Anogeissus leiocarpus* stood out for their cultural and medicinal significance. *Anogeissus leiocarpus* is highly valued in Hausa culture for treating malaria, high fever, and boosting immunity. Neem, known for its antibacterial and antifungal properties, is a cornerstone in traditional medicine, commonly used for skin conditions, infections, stomach disorders, and malaria fever.

Conclusion: The study underscores the threat to plant biodiversity and traditional medical knowledge due to the decline of therapeutic plants, largely driven by human activities. It highlights the vital role of herbal remedies, especially in underdeveloped regions with limited access to modern medicine. The research shows that a wide range of healing herbs is used to treat ailments, with traditional knowledge deeply embedded in daily life. However, this knowledge varies by demographics such as age, rural versus urban residence, and informant type. The study calls for more research into the antibacterial properties and toxicity of these plants to build community trust and protect natural habitats. Despite their ongoing use, these medicinal plants are increasingly at risk from deforestation and overharvesting. The study concludes that protecting and sustainably managing therapeutic plant species and preserving indigenous herbal knowledge are essential.

Keywords: Ethnomedicine, Ailments, Plants, Administration route, Bunkure.

Background

People have believed in the healing power of plants for ages, throughout continents. Their use greatly increases primary healthcare's accessibility and is considered a precious supply of medications, including herbal cures. Because they have minimal to no negative effects when taken correctly. Many people in the West use herbal medicines (Ekor 2014). Finding phytochemical or pharmacological justifications for traditional uses of plants could lead to the creation of novel medications. In addition to aiding in institutionalizing traditional medicine (Newman & Cragg 2007). Ethnobotany aims to preserve health by utilizing the information indigenous people have accumulated about plant and animal products (Afolayan and Olajuyigbe, 2012). At the same time, medicinal plants are becoming more valuable commercially, and the number of biological species is rapidly decreasing globally. By recording ethnobotanical knowledge, we can better understand how various plant species are utilized to treat various illnesses and create strategies to protect these natural resources. Much more to be discovered on the numerous traditional applications of medicinal herbs. Even though previous work reported using several plants to treat diarrhoea in South Africa (Appidi *et al.* 2008).

In Nigeria, more than 6000 vascular plants dwell, providing great scope for traditional medicinal practitioners residing here [National Biodiversity Strategy and Action Plan 2006, Plant of the World Online (POWO, 2021)]. Bunkure is one of the cities in Nigeria where practising traditional medicine is going on a large scale. The healthcare facility of the district is also not decent which forces the majority of the population to use medicinal plants for their primary healthcare needs. Still, there is no database available on the use of medicinal plants. The objective of this study is to prepare the inventory of medicinal plants used by people to treat various ailments. Most of the traditional medicinal practitioners are elderly, so it is necessary to conserve traditional knowledge of plants so that future generations can also benefit from this knowledge.

Materials and Methods

Geographical Location

With a total area of 9911.22 km^2, Bunkure Local Government Area (LGA) is located between 11.700°N latitude and 8.550°E longitude. To the north, it is bordered by the Local Governments of Kura and Dawakin Kudu, to the east by the Wudil and Garko LGAs, and to the southwest by the Kibiya LGAs (see Figure 1). The three different seasons define the region's climate: summer, rainy and winter. Summer starts in March and extends up to June. The rainy season starts in July and extends to October; the last winter falls in November and lasts till February. Bunkure LGA is estimated to be home to 177,845 people, the vast majority of whom are members of the Hausa and Fulani ethnic groups (Maryam *et al.* 2014).

Bunkure, (480 metres above sea level), has a climate classified as subtropical steppe (BSh, *Köppen classification*). The district experiences an annual temperature of 32.19ºC (89.94ºF), which is 2.73% higher than the average for Nigeria. Bunkure experiences 65.93 wet days (18.06% of the total) and 52.12 millimetres (2.05 inches) of precipitation annually (Olofin 2008). Although no specific forest kinds are identified, Bunkure LGA probably features a variety of natural plants. The area might have grasslands typical of the Sahel, Scrub forests, and Savannah Woodlands. *acacias, baobabs, neem* trees, and Shea butter are prevalent in this region of Nigeria. The seasons have a big impact on people's socio-economic activities as well. Thus, NEDECO (1974) the Netherlands Development Corporation discovered the following geological formations: a low terrace rising steeply from the canal; a storm channel, commonly known as a "flood plain"; and a plain highland, sharply divided from the high terrace by a wall (Olofin 2008). Hydromorphic soils with a basic complex and low nutrient content predominate in the area (Ahmed *et al.* 2016). With the population growing from 122,856 in 1991 to 170,891 in 2006, Bunkure LGA's population density climbed from 241 points in 1991 to 336 points in 2006 (National Population Commission 2006). Farmers make up the bulk of the population in the region.

Informant Selection Technique

In this study, 172 (One hundred and Seventy-Two) general informants and 28 (twenty-eight) traditional medicine practitioners were interviewed. Methods of systematic and purposeful random sampling, as outlined by Martin (1995), were applied. The informants' ages range from 15 to 70 years old. The selection of traditional medicine practitioners was based on information gathered from local experts and the elderly. General informants, however, were selected using the questionnaire that was distributed. Semi-structured questionnaires and in-person interviews with herbalists, farmers, tribal hunters, and practitioners of traditional medicine were used to gather data from the study area. Samples were taken using the snowball method to get responses from 200 respondents in total. They were explained the study's goal in *Hausa*, the native tongue. To gather information on the plant species, plant components, ways of preparation, and administering strategies employed, questionnaires were created.

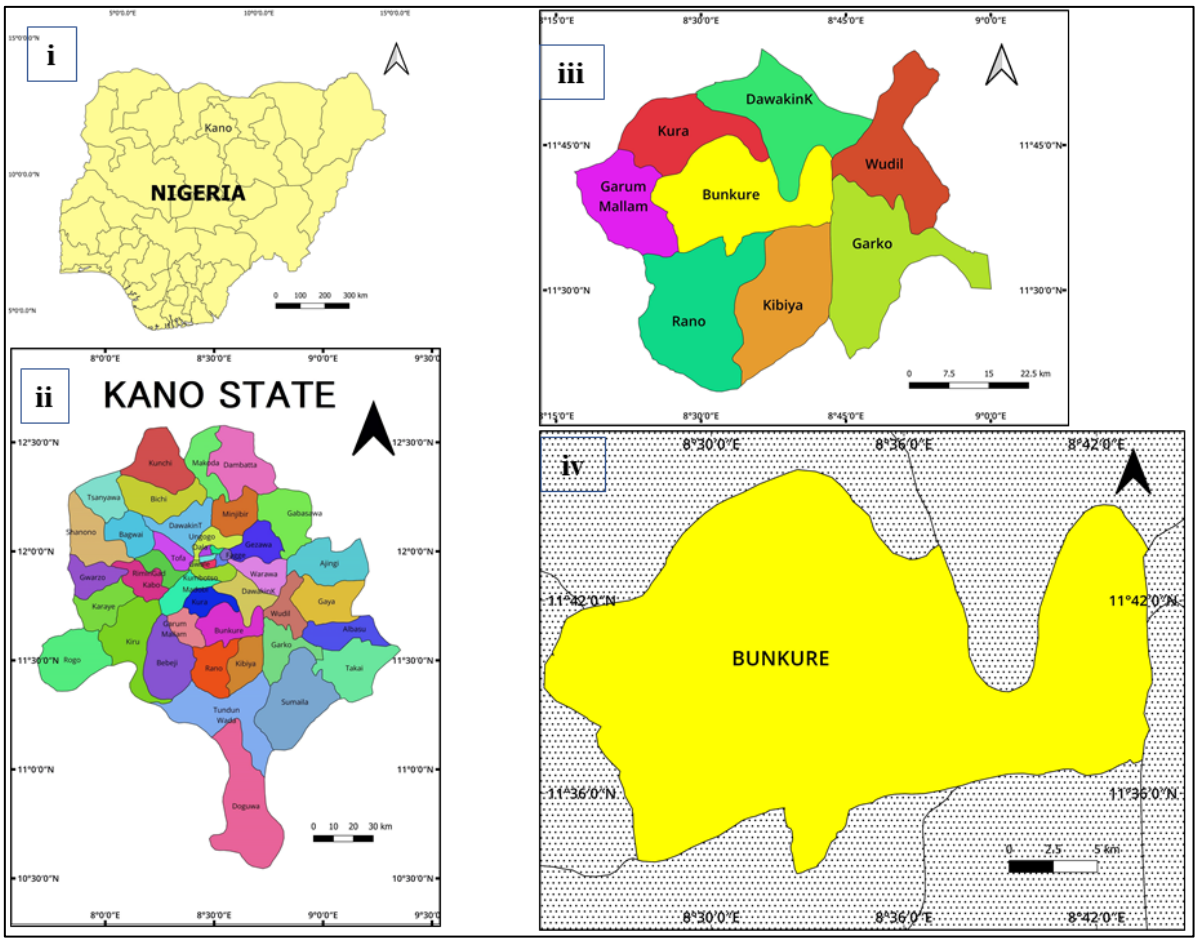

Figure 1: Map of the study area (I) Map of Country Nigeria (II) Map of Kano State (III) Map of Bunkure and Surrounding LGAs (IV) Map of Bunkure.

Sampling Method

Out of the 200 individuals surveyed, 148 were male and 52 were female, making them the test subjects of this study. We conducted oral interviews with herbalists, traditional medicine practitioners, village heads, local elders, and herb vendors regarding the medicinal use of plants in Bunkure. The interviews considered participants across different age groups: 15-34 years (Youth), 35-55 years (Adults), and 56 years and above (Elders). The study aims to develop a comprehensive database of the most frequently used medicinal plants (and their parts) for treating specific ailments.

Plant name identification and documentation were done in Hausa, the local language. If two or more informants independently identified a plant or plant part used for a particular treatment, the information was considered reliable and documented. The family names and scientific names of the plants were also recorded. Additionally, during the interviews, herbalists and traditional healers were asked about the methods of preparation and administration of the medicinal plants.

Quantitative Ethnobotany

Informant consensus factor (ICF)

Using the formula,

$$ICF = \frac{Nur - Nt}{Nur - 1}$$

Where "Nur" represents uses reported in each category and "nu" represents species reported in each category, the "informant consensus factor" (ICF) for various ailment categories was calculated to test agreements of the informants on medicinal plant knowledge of each category. (Heinrich 2000, Vitalini *et al.* 2013).

Relative frequency of citation (RFC)

The proportionate citation frequency and the relative value of the plant species mentioned by respondents or informants were assessed using RFC. Its greater value indicates that a specific medicinal plant is accepted locally. Computed using the following method along with the formula utilized by earlier researchers (Pradhan *et al.* 2020).

$$RFC = \frac{Fc}{N}$$

Where N is the overall number of participants involved in the study and FC is presenting how many informers were reporting the ethnomedical usage of a specific plant.

Use Value (UV)

The utility value of the plant revealed how specific treatments are applied in that specific area. A higher use value also reflects a community's familiarity with a plant's medical properties. (Rokaya *et al.* 2010) for precise plant species use the following formula to determine the relative value of each unique plant species.

$$UV = \frac{\Sigma U}{N}$$

Where V is the number of use reports, which list the number of therapeutic qualities associated with a specific plant.

Preference Ranking Exercise

Following Martin's (1995) advice, ten (10) key informants conducted a preference ranking exercise on ten medicinal plants used to treat malaria fever and stomach ache in the study area. Following the key informants' shortlisting of the plants for this exercise, how important they are in controlling stomachache and malaria fever was discussed. The respondents were given the plants, and on a scale of 1 to 5, they were graded according to their effectiveness. Ranking 5 was assigned to the medicinal plant thought to possess the greatest success in curing the ailments while ranking 1 was assigned to the plant thought to be the least effective. The total score for each species was used to calculate the rank. The overall preference exercise was calculated by adding the informant count.

Direct matrix ranking exercise

Using the direct matrix ranking exercise, the usage diversity of a particular plant species was compared using the method proposed by Martin (1995) and Cotton (1996). Species with the greatest variety of applications were chosen from among all the medicinal plants described. Key informants assigned a number to each species based on applications; 5 represents the best, 4 represents excellent, 3 represents good, 2 represents less common use, 1 represents seldom use, and 0 represents never. All of the medicinal plant species' average values, or scores, were then tallied and ranked. In addition, the 10 primary informants participated in a prioritization task centered on the assessed risks to species of medicinal plants.

Jaccard Index

This index is used to compare study data with findings from other ethnobotanical studies conducted in various parts of Nigeria and other countries, as well as among indigenous communities in the study areas. The formula for calculating the JI index (González-Tejero *et al.* 2008) is:

$$JI = \frac{\text{c x } 100}{(a + b - c)}$$

Here, "a" represents the number of species recorded in the study area "A," "b" refers to the number of species documented in area "B," and "c" is the number of species common to both areas "A" and "B." In the case of indigenous communities, "a" is the number of species reported by community "A," "b" is the number of species cited by community "B," and "c" is the number of species shared by both communities "A" and "B."

Statistical Analysis

MS-Excel 2013 and IBM SPSS (Ver. 27) were used to analyze the descriptive and comparative analyses, which were conducted using SPSS. Utilizing the software, the data on the participants' demographic characteristics, the variety of medicinal plants utilized, and the preparation and administration techniques of formulations were arranged and displayed as tables and graphs.

Results and Discussions

Demographic information of the participants

There were 200 participants in this study (Table 1). The participants' ages ranged from 15 to 70 years old. Regarding literacy level, 189 were found to be literate and 11 were illiterate. Most of the people had elementary knowledge. The majority of participant learned this ethnomedicinal knowledge from their forefather.

Table 1. Demographic features of the participants

Demographic features	Categories	No. of Person	Percentage
Gender	Male	148	74.00
	Female	52	26.00
Age-group	15-34	120	60.00
	35-55	56	28.00
	Above 55	24	12.00
Education	Post-graduation	8	4.00
	Graduate	28	14.00
	Secondary	75	37.50
	Elementary Knowledge	78	39.00
	Illiterate	11	5.50
Source of Knowledge	Self-Experiment	41	20.5
	Parents	159	79.50

Participants' Indigenous Knowledge

According to statistical analysis, there were statistically significant differences ($p < 0.05$) between age groups regarding the many medicinal plants. The significant *p*-value would indicate that these differences in preferences between the age groups are not due to random chance but likely reflect actual differences in how these age groups value or use medicinal plants. This could suggest that age is important in determining which medicinal plants are preferred, which might be influenced by different cultural, health-related, and experiential factors. Included in both gender groups (men and women). The majority of men, both elderly and adult, showed expertise in using therapeutic plants. There was also a statistically significant difference between key and general informants. Both literate and illiterate traditional medicine practitioners listed the greatest number of medicinal plants, while literate general participants listed the least number of medicinal plants.

Diversity of Medicinal Plants

The current study documented 74 medicinal plants belonging to 52 genera and 38 families, which are used to treat 28 human ailments. Acanthaceae and Amaranthaceae were the most abundant medicinal plant families in the study area.

Parts of Medicinal Plants Used for the Herbal Medicine Preparation

Results of the present study show that various parts of the medicinal plants were employed in the research area to treat a range of illnesses. The analyzed data shows that Leaves (42.5%) were most frequently utilized in the production of herbal medication followed by Stems (33%), Roots (11.5%), Seeds (11%), and then Fruits (2.0%) (Figure 2).

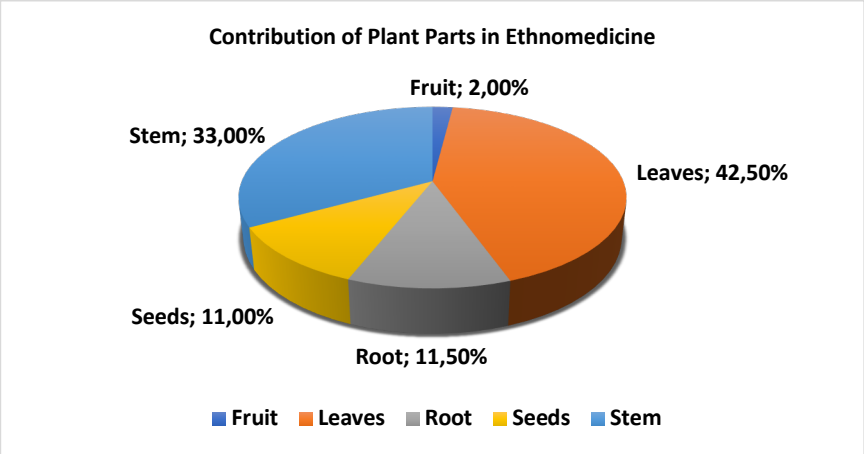

Figure 2: Parts of Medicinal Plants Used for the Herbal Medicine Preparation

Methods of Herbal medicine preparation in the research site

Various methods of medicine preparation were studied and analyzed. The most prevalent methods employed in the research site are boiling the plant part and drinking the portion or bathing with the boiled plant part, based on the nature of the illness. (Figure 3).

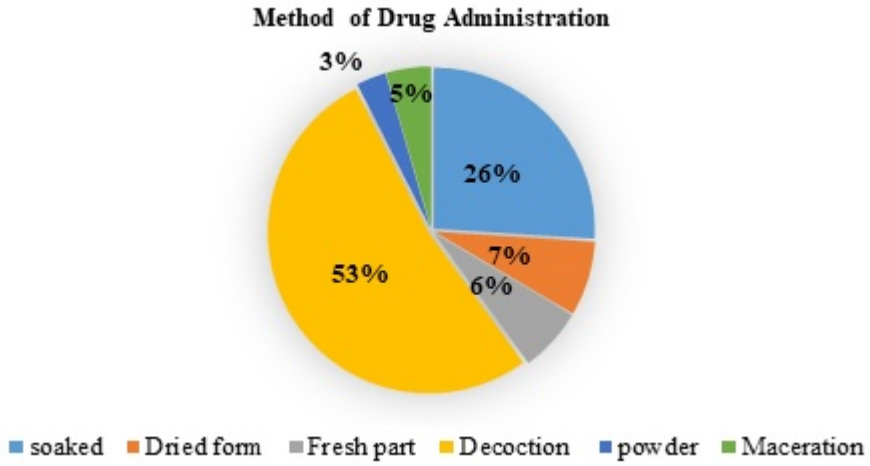

Figure 3: Methods used in the research area for preparing and administering of herbal medicine

Administration Route

The administration route refers to the method by which the medicine gets into the body of the patient. The current research shows that taking medicine through the oral method is the most popular method of drug administration followed by the topical route (application) among the people within the study area (Figure 4).

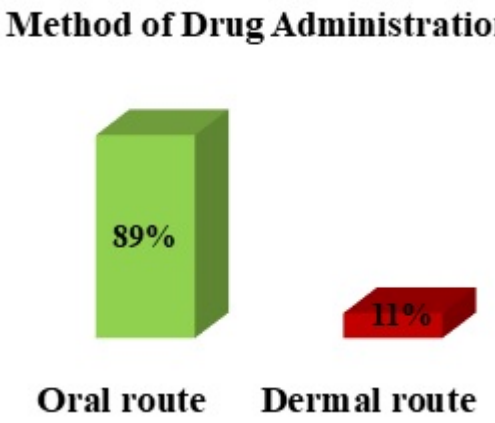

Figure 4. Methods of Drug Administration in the Study Area

Informant consensus factor (ICF)

The "informant consensus factor" (ICF) values showed that frequent diseases in the research area had higher ICF values than less common diseases. Lower ICF values indicated that traditional healers were not keen to share their indigenous knowledge, likely because they believed divulging their secrets would render their therapeutic efforts futile (Zerabruk &Yirga 2012, Tuasha *et al.* 2018). Additionally, traditional healers may use different types of medicinal plants to treat the same ailments in other environments. The ICF values also demonstrated that the community's knowledge about the most significant species of medicinal plants used to treat common ailments was similar. (Table 2)

Table 2. Informant Consensus Factor (ICF) analyzed according to ailment categories within the current study.

Category of Ailment	Number of Use Reports (Nur)	Number of Species (Nt)	ICF Value
Digestive system disorder (stomach ache, Indigestion, fatty liver, stomach cramps, Jaundice, Hemorrhoids, ulcer)	76	15	0.81
Microbial and Parasitic Infection (dysentery, fungal infection, ringworm, diarrhoea, Stomach worm)	105	49	0.54
Fever and Cough (Fever, cold and cough)	157	59	0.63
Pain & Inflammation (Headache)	126	23	0.82
Respiratory disorders (Asthma)	57	16	0.73
Rheumatism and Skeleto-muscular problems (Joint pain, Bone fracture, Arthritis, Sciatica pain, back pain, strain)	93	13	0.87
Dental Disorder (cleaning of Gums and teeth, Mouth Sore)	10	3	0.78
Circulatory and Cardiovascular disorders (Diabetes, blood circulation, blood purifiers, Anaemia)	32	13	0.61
Dermatological Disorder (Boils, abscesses, Swellings, cuts and wounds, Pustules, burning sensation, eczema, blisters, itching, psoriasis, leprosy)	12	9	0.27
Sexual and related problems (involuntary ejaculation, erectile dysfunction, irregular menstruation, infertility)	39	17	0.58

Relative frequency of citation

High levels of relative frequency of citation (RFC) were found for *Senna tora* (0.06)*, Tamarindus indica* (0.03)*, Ziziphus tripartite* (0.03)*, Psidium guajava* (0.01)*, Parkia biglobosa* (0.01)*, Eucalyptus tereticornis* (0.02)*, Anogeissus leiocarpus* (0.02)*,* and *Allium sativum* (0.03). According to Friedman *et al.* (1986), the faithfulness level is a gauge of a medicinal plant's healing capacity. The preference-ranking task also assisted in identifying the most commonly utilized species of medicinal plants for treating cellulitis (contact dermatitis), and malaria. The findings indicated that the best therapies for malaria were *Azadirachta indica, Carica papaya, and Tamarindus indica.* These species received the highest ratings, suggesting that future studies on the bioactive components of these species to prevent malaria may provide additional valuable information beyond the scope of the current study.

Use Value

Use Value (UV) was higher in *Citrus aurantifolia,* with a use value of 2.0 according to the study. The participants frequently mentioned these plants to cure various ailments in the study sites. *Psidium guajava* was found to be second in the highest use value in the study area with a 1.50 Use Value. Other medicinal plants reported in the study area have their use value calculated and documented, plants with low use values found in the study area are *Adansonia digitate (*0.33*), Cochlospermum planchonii* (0.15)*, Cyperus esculentus* (0.33*), Englerina gabonensis* (0.25) and *Senna tora* (0.17) This result is similar with findings of Gill who found *Morinda lucida* (Brimstone tree) as commonly used for treating fever, particularly in malaria cases. *Garcinia kola* (bitter kola) is another highly used plant known for its efficacy in treating coughs, colds, and bronchitis (Gill 1992). These plants are often more accessible and affordable than pharmaceutical drugs, making them vital for healthcare in economically disadvantaged areas.

Beyond their therapeutic importance, medicinal plants contribute to the local economy. Many communities cultivate, harvest, and sell these plants, providing a source of income. This is particularly true for plants like *Zanthoxylum zanthoxyloides* (prickly ash) and *Allium sativum* (garlic), which are also exported to other countries for their medicinal value (Okoegwale & Omefezi 2001).

Preference Ranking Analysis

An analysis was conducted on ten selected medicinal plants, identified by key informants as treatments for malaria, a common ailment in the district. Five key informants ranked these medicinal plants based on their effectiveness in treating stomachaches. The results showed that *Azadirachta indica*, *Carica papaya*, *Citrus sinensis, Tamarindus indica, Anacardium occidantale, Boutyrospermum paradoxum, Nauclea didderrichii, Boschia senegalensis* and *Blighia sapida* were ranked first to last respectively, for their efficacy in treating stomach aches. (Table 3). *Azadirachta indica* was particularly notable for its wide availability in the study area, making it a common choice for residents (Tutin *et al.* 1993).

Table 3. Preference Ranking Analysis of Highest Reported Plants against Most Common Ailment in the Study Area

Disease	Plant used for medication	Efficacy (on a scale of 1 to 5)Where: 1 is Low and 5 is the Highest						
		R1	R2	R3	R4	R5	TOTAL	RANK
Malaria	*Boutyrospermum paradoxum*	3	4	5	5	3	20	4
	Nauclea diderrichii	4	5	3	5	5	22	2
	Tamarindus indica	5	5	3	4	4	21	3
	Carica papaya	2	1	2	5	4	14	5
	Azadirachta indica	5	5	5	3	5	23	1
Stomachache	*Moringa olifera*	5	5	5	5	4	24	1
	Vernonia amygdalina	4	5	3	4	5	21	2
	Fiscus poliata	2	3	5	5	4	19	3
	Balanites aegyptica	5	2	3	2	5	17	5
	Acacia senegal	3	4	3	4	4	18	4

Direct matrix ranking (DMR) analysis

The Direct matrix ranking exercise conducted in Bunkure district, Kano State, aimed to assess the community's preferences for different medicinal plants (Table 4). The activity involved 200 participants from various backgrounds, including elders, traditional healers, and younger community members. The DMR exercise highlighted a clear preference for specific plant species. The top five plants identified by the participants were ranked accordingly which are: *Azadirachta indica, Moringa olifera*, *Adansonia digitate*, *Eucalyptus cameldalensis*, *Carica papaya and Anogeissus leiocarpus.* The high ranking of *Azadirachta indica* and *Anogeissus leiocarpus* highlights their strong cultural and medicinal importance. *Anogeissus leiocarpus* valued in Hausa culture, is widely valued for its medicinal properties, particularly in treating Malaria and high fever ailments and boosting immunity. Neem, renowned for its antibacterial and antifungal qualities, is a cornerstone of traditional medicine, commonly used to treat skin conditions and infections, fever, Stomachache and disorders, and Malaria fever. This result is concise with the result found by Adelanwa et al., (2013). Similar results were also discovered by the studies of Okoegwale & Omefezi (2001), Gill *et al.* (1993), and Gill (1992) which demonstrated that the use of certain plants, including their parts and purposes, crosses cultural boundaries. This practice extends beyond Nigeria to other regions with similar cultural and socio-economic contexts (Ayitey-Smith, 1989).

Jaccard Index

The ethnomedicinal plant applications documented in this study were compared with data from 30 previous ethnobotanical studies conducted in various countries, including Nigeria, using the Jaccard Index (JI). The JI values ranged from 0.63 to 17.35, indicating varying degrees of similarity. Notably, the highest similarity was observed with a study by Sulaiman *et al.* (2022) in Nigeria, which reported a JI of 18.89. This was followed by studies by Kankara *et al.* (2015) with a JI of 13.17 and Evbuomwan *et al.* (2023) with a JI of 10.57.

Table 4. Direct matrix ranking of six plant species by six informants on seven uses

Use diversity	*Azadirachta indica* R1	*Anogeissus leiocarpus* R6	*Adansonia digitate* R3	*Eucalyptus cameldalensis* R4	*Carica papaya* R5	*Moringa olifera* R2
Medication	5	5	4	4	5	5
Firewood	5	4	5	4	2	3

Furniture	4	5	4	3	0	0
Fencing	5	5	3	5	2	2
construction	5	5	5	4	0	0
decoration	2	1	0	2	5	3
Food	0	0	3	0	5	5
Total	**26**	**25**	**24**	**22**	**19**	**18**
Rank	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**

Table 5. List of Medicinal Plants Used to Treat Various Human Diseases in the Study Area: Botanical/Scientific Name, Vernacular/Local Name, Family, Plant Part, Relative Frequency Citation, Use Value, and Method of Drug Administration.

Botanical Name, Habit, IUCN Status, Voucher No.	**Vernacular Name**	**Family**	**Plant Part**	**RFC**	**UV**	**Method of Drug Administration**
Acacia linearifolia J.Forbes Shrub Least Concern BKKU01	**Bagaruwa**	Fabaceae	Root	0.005	1.00	Roots are collected, dried under shade, crushed into pieces, soaked in water, and then taken orally 2-3 times a day to treat high fever, sore throat, and cough.
Acacia sieberiana Scheele Tree Least Concern BKKU02	**Farar Kaya**	Fabaceae	Seed	0.005	1.00	After collecting the sample, it is allowed to dry in the sun, crushed to powder, mixed with warm water, and taken orally once or twice a day to treat diseases or infections such as diarrhoea, gonorrhoea, and rheumatism.
Acanthospermum hispidum DC. Shrub Least Concern BKKU03	**Imi-Esu**	Asteraceae	Seed	0.005	1.00	The seeds are soaked in water for 24 hours after that they are filtered and the filtrate is administered or taken orally three times a day this is to treat malaria, constipation, and stomachache
Achyranthes aspera. Pandiaka Moq. Herb Least concern BKKU04	**Hakorin maciji**	Amaranthaceae	Leaves	0.005	1.00	Leaves are collected and boiled. The water collected will be served as normal drinking water throughout the medication period to treat dysentery and malaria.
Adansonia digitata Leandro ex Baill. Tree Least Concern BKKU05	**Kuka**	Malvaceae	Leaves	0.015	0.33	A sufficient amount of leaves are collected and allowed to air dried and then crushed to powder, mixed with water, and then filtered. The filtrate is taken orally for treating high fever and malaria
Albizia odoratissima (L.f.) Benth. Tree, Least Concern BKKU06	**Katsari**	Fabaceae	Stem, Bark	0.01	0.50	The bark/stem is collected, crushed to powder, and used as a food supplement or mixed with water and taken orally as food or with water to cure diabetes or applied as a paste for the treatment of skin infections

Allium cepa David Stang Herb Least Concern BKKU07	**Albasa**	Amaryllidaceae	Bulb	0.01	0.50	*Allium cepa* bulb is collected and air dried then crushed to powder and then soaked in water to extract the secondary metabolites which are then filtered and used as drinking water for the treatment of Rheumatism. The bulb is eaten raw as a cure for high blood pressure
Allium paniculatum subsp. Paniculatum, Herbs, Least Concern BKKU08	**Albasa mai kara**	Amaryllidaceae	Leaves	0.005	1.00	Crushing the air-dried leaves to powder and soak in water for 1 hour and use in Bathing at least once in a day as a cure for rheumatism
Allium sativum B. Hammel Hebs, Least Concern, BKKU09	**Tafarnuwa**	Amaryllidaceae	Bulb	0.025	0.80	The bulbs are taken orally unprocessed to cure malaria. The Bulb could also collected and air dried, crushed to a fine powder mixed with salt and butter, and applied as a smear to treat scabies.
Alstonia boonei De Wild. Tree, Least concern, BKKU10	**Tumfafiya**	Apocynaceae	Seed	0.015	1.33	Seeds are collected and a sufficient amount is taken and Macerated. The macerated seeds are then mixed with either water or liquid and taken orally as a cure for gastrointestinal infections.
Anacardium occidentale B. Hammel, Tree, Least concern BKKU11	**Kashu**	Anacardiaceae	Leaves	0.01	1.00	Leaves are collected macerated and mix the water, the solution will be served as normal drinking water throughout the medication period to cure malaria
Ananas comosus (L.) Merr. Tree, Least concern BKKU12	**Mooda**	Bromeliaceae	Leaves	0.02	0.50	The leaves are collected and allowed to air dry, leaves are then crushed and mixed with water and allowed to stand for 6 hours in water the filtered water is taken orally three times a day for treating constipation and indigestion problems
Annona senegalensis Pers. Tree, Least concern, BKKU13	**Gwandar daji, Ararrabi,**	Annonaceae	Seeds	0.15	1.50	Seeds of *Annona senegalensis* are collected and taken orally unprocessed to treat insect bites or prevent snake bites. Seeds of *Annona senegalensis* are taken orally with seven seeds of *Aframomum melegueta* are taken orally as a cure for insect bites, especially snake bite

Anogeissus leiocarpus (DC.) Guill. & Perr. Tree, Least concern, BKKU14	**Marke**	Combretaceae	Root	0.02	0.75	Roots are boiled with water and allowed to cool. The water is taken orally to treat fever. Leaves of *Anogeissus leiocarpus* are macerated and crushed to a powder which is soaked in water and applied as a paste for curing skin infections.
Anthocleista djalonensis A.Chev. Shrub, Least concern BKKU15	**Kwari**	Gentianaceae	Stem/ Bark	0.005	1.00	Crushing the dried bark/stem under shade soaking in water and applying as paste as a cure for skin infection and eczema
Artemisia annua Pall. Shrub, Least concern, BKKU16	**Doddoya**	Asteraceae	Leaves	0.005	1.00	Leaves of *Artemisia annua* are macerated and soaked in water for 2-3 days and taken orally as a cure for malaria
Asclepias curassavica Griseb. Shrub, Least concern BKKU17	**Jar Fulawa**	Apocynaceae	Stem	0.005	1.00	Stem of *Asclepias curassavica* is allowed to dry and Eat unprocessed to stop bleeding. The stem can also be crushed to powder mixed with water and applied as a paste for treating skin infections and ringworm.
Asimina triloba Dunal Tree, Least concern, BKKU18	**Gwanda**	Annonaceae	Bark	0.01	1.00	About 50g of the sample is collected and soaked in 1000ml of water and taken orally to cure fever and malaria.
Atriplex cinerea adscendens H.Eichler Shrub, Least concern BKKU19	**Aki**	Amaranthaceae	Root	0.005	1.00	Boil at least 10 pieces of the root of equal length and drink the mixture for the treatment of stomach ache. For the fever treatment, three to four roots are soaked in water for 30-40 minutes, and then take the water orally 2 times a day.
Azadirachta indica A.Juss. Tree, Least concern BKKU20	**Darbejiya**	Meliaceae	Root	0.025	0.60	The leaves are collected together with leaves of *Magnifera indica* soaked in water and taken orally to treat malaria and jaundice.
Beaucarnea recurvata (K.Koch & Fintelm.) Lem. Herb, Least concern, BKKU21	**Dabino**	Asparagaceae	Fruit	0.005	1.00	The fruit is taken raw or dried for the treatment of diarrhea and constipation.
Blighia sapida K.D.Koenig Tree, Least concern, BKKU22	**Diginya**	Sapindaceae	Stem	0.01	0.50	10-15 leaves of *Blighia sapida* are soaked in water and boiled. The water is taken orally after being cooled to treat malaria.

Boscia senegalensis Hochst. Shrub, Least concern BKKU23	**Hanza**	Capparaceae	Leaves	0.005	1.00	Leaves are collected macerated and mixed in the water, the solution will be served as normal drinking water throughout the medication period as a cure for typhoid fever.
Calotropis procera (Aiton) Dryand. Shrub, Least Concern, BKKU24	**Tumfafiya**	Apocynaceae	Stem, Leaves, Bark	0.025	1.07	The bark/stem is collected, crushed to powder, and used as a food supplement or mixed with water and taken orally as food or with water for the treatment of Leprosy or Elephantiasis. Powder the leaves using four to five leaves, brew a decoction to cure malaria fever
Carica papaya B. Hammel Tree Least concern BKKU25	**Gwanda**	Caricaceae	Leaves	0.03	0.83	Stem is collected and boiled with water, allowed to cool, and filtered. The collected water is taken orally as drinking water to cure malaria
Ceiba pentandra (L.) Gaertn. Tree, Least concern BKKU26	**Rimi**	Malvaceae	Leaves	0.005	1.00	A handful of leaves are taken and boiled for 1 hour and then bathed to treat skin infections. Filtered the leaves and use the filtered water as drinking water 3 times a day to cure Malaria
Cistanche aethiopica Beck Herb, Least concern BKKU27	**Cistanshe**	Orobanchaceae	Leaves	0.01	1.00	Crushed the leaves and turned to powder and used as a food supplement to treat erectile dysfunction
Citrullus lanatus (Thunb.) Matsum. & Nakai Creeping Herb least concern, BKKU28	**Kankana**	Cucurbitaceae	fruit	0.005	1.00	Make a decoction of the fruit and take the mixture orally for the treatment of constipation and gastrointestinal disorders.
Citrus aurantifolia M.Hiroe Tree, Least concern BBKKU29	**Lemo**	Rutaceae	Fruit	0.005	2.00	The fruit is eaten sufficiently. It treats or cures constipation. The leaves are soaked in water which will be taken orally to cure malaria
Citrus sinensis Osbeck Tree, Lest concern BKKU30	**Lemun zaki**	Rutaceae	Leaves	0.01	0.50	The leaves of *Citrus sinensis* are boiled and allowed to cool at normal temperature, the mixture is taken orally 3 times per day to cure Typhoid fever
Cochlospermum planchonii Hook.f. ex Planch. Tree Least concern BKKU31	**Rawaya**	Bixaceae	Leaves	0.01	0.15	The leaves of *Cochlospermum planchonii* are boiled and allowed to cool at normal temperature, the mixture is taken orally 3 times per day to treat Malaria. The boiled leaves are taken orally when cooled at room temperature during the period of the stomach ache.

Cucurbita pepo David Stang Herb, Near threatened BKKU32	**Kabewa**	Cucurbitaceae	Leaves	0.005	1.00	4—5 leaves are Crushed and dried under shade, and mixed with water. The mixture is taken orally for the treatment of stomach ache
Cyperus esculentus (Boeckeler) P.Fourn. Sedge Least concern BKKU33	**Aya**	Cyperaceae	Stem	0.015	0.33	Stem decoction is conducted to dissolve the chemicals, the portion is taken orally in fever treatment
Detarium microcarpum Guill. & Perr. Tree Least concern BKKU34	**Taura**	Fabaceae	Fruit, Stem	0.015	1.50	About 50g of the stem sample is taken and air-dried, powdered, and soaked in water. The mixture is taken orally for treating malaria. The fruit of *Detarium microcarpum is* taken orally unprocessed to treat pile.
Diospyros mespiliformis Hochst. ex A.DC. Tree, Least concern BKKU35	**Kanya**	Ebenaceae	Leaves	0.005	1.00	Leaves are collected macerated and mix the water, the solution will be served as normal drinking water throughout the medication period to cure Malaria
Englerina gabonensis (Engl.) Balle Ephiphyte Least concern BKKU36	**Kauci**	Loranthaceae	Stem	0.02	0.25	40g of the stem is collected and boiled with water, allowed to cool, and filtered. The collected water is taken orally as drinking water 2-3 times per day to treat fever and Malaria
Eschenbachia aegyptica Brouillet Herb, Least concern, BKKU37	**Tufar biri**	Asteraceae	Seed	0.015	0.67	Pick a sufficient amount of the seed and boil, allow it the cool, and filter the mixture, the filtered water will be taken 3-4 times a day to treat Malaria and high fever
Eucalyptus tereticornis subsp. tereticornis Tree Least concern BKKU38	**Durumi**	Myrtaceae	Leaves	0.02	0.75	Collect at least 5-10 leaves, Crushed, dried under shade, and mixed with water. The mixture is taken orally for the treatment of stomach ache
Ficus platyphylla Delile Tree Least concern BKKU39	**Gamji**	Moraceae	Root	0.015	0.67	10 - 15 pieces of the root of *Ficus platyphylla* of equal length are boiled and allowed the water to cool to normal temperature. The water is then taken orally to cure stomach disorders.
Fuscus thoningii Ephiphyte Least concern BKKU40	**Mugumo**	Lamiaceae	Root	0.005	1.00	Collect a sufficient amount of the roots, pick at least 7 pieces and soak them in water for 24 hours, filter the root mixture and administer the water orally for the treatment of pile and Malaria

Grewia mollis morifolia (Fiori) Cufod. Shrub Least concern BKKU41	**Dargaza**	Malvaceae	fruit	0.005	1.00	For treating malaria, fruits are collected and a sufficient amount is taken and Macerated. The macerated seeds are then mixed with either water or liquid and taken orally.
Guiera senegalensis J.F.Gmel Shrub Least concern BKKU42	**Sabara**	Combretaceae	leaves	0.015	0.67	For treating malaria, leaves of *Guiera senegalensis* are collected and a sufficient amount is taken and Macerated. The macerated leaves are then mixed with water and administered orally.
Hyphaene thebaica Mart. Tree Least concern BKKU43	**Goruba**	Arecaceae	Root	0.01	1.00	For the malaria fever treatment, 3-4 roots are soaked in water for 30-40 minutes, and then the water orally 2 times a day. 20g of the stem is collected and boiled with water, allowed to cool, and filtered. The collected water is taken orally as drinking water 2-3 times per day this serves as a cure for pile and stomach disorders
Hypoestes verticillaris (L.f.) Sol. Ex Roem. & Schult. Herb, Least concern BKKU44	**Ganyen Kuka**	Acanthaceae	Leaves	0.005	1.00	Leaves are collected macerated and mixed with the water, the solution will be served as normal drinking water throughout the medication period. This helps in curing headaches, malaria, and cough.
Jungermannia polita H. Buch Shrub Least concern BKKU45	**Salak**	Scapaniaceae	Root	0.01	0.50	A concoction of dried roots is orally taken daily for the treatment of the pile.
Khaya senegalensis A.Juss. Tree Least concern BKKU46	**Madachi**	Meliaceae	Stem	0.015	1.00	The stem is taken and allowed to dry under shade after which the stem is orally taken unprocessed as a food supplement as a cure to typhoid fever.
Magnifera indica L. Tree, Least concern BKKU47	**Mangwaro**	Anacardiaceae	Stem	0.005	1.00	The stem was collected and dried which is crushed into powder and taken orally 3-4 times a day for the treatment of asthma. Unprocessed fruit is taken orally to treat dysentery and piles. The seeds are crushed and make a paste. The paste is then applied to treat various skin infections.
Mariscus alternifolius Vahl, Herb, Least concern BKKU48	**Aya**	Cyperaceae	Leaves	0.01	0.50	5 leaves are Crushed and dried under shade, and mixed with water. The mixture is taken orally 4 times daily for the treatment of malaria fever Malaria and Typhoid.

Melaleuca quinquenervia (Cav.) S.T.Blake Shrub, Least concern BKKU49	**Garahuni**	Myrtaceae	Leaves	0.01	1.00	Leaves are collected macerated and mix the water, the solution will be served as normal drinking water throughout the medication period for the treatment against
Mondia whitei (Hook.f.) Skeels Climber Least concern BKKU50	**Tafashiya**	Apocynaceae	Root	0.01	1.25	The concoction of dried roots is orally taken daily for the treatment of piles or taken unprocessed as a food supplement to treat Headaches and High fever. The boiled leaves are taken orally when cooled at room temperature 3-5 times a day during the period of the tuberculosis. The leaves are also collected and dried under shade which is crushed to powder and served as a food supplement to treat sexual weakness and erectile dysfunction.
Moringa oleifera Lam. Tree, Least concern BKKU51	**Zogale**	Moringaceae	Stem	0.03	0.83	A sufficient amount of the stem is taken and soaked in water for 3 days and taken orally 3 times a day for the treatment of stomachache, liver problems, and Typhoid fever. For the treatment of skin problems, grind 15-20 grams of leaves into a thick paste. Apply the paste to the affected regions, let it sit for a few hours, and then wash it with regular water.
Mormodica balsamina Herb, Least concern BKKU52	**Garahuni**	Rosaceae	Seed	0.005	1.00	For the treatment of skin problems, grind a sufficient amount of seeds into a thick paste. Apply the paste to the affected regions, let it sit for a few hours, and then wash it with regular water.
Nauclea diderrichii (De Wild.) Merr. Tree, Least concern BKKU53	**Aloma**	Rubiaceae	Bark	0.015	1.00	Soak the bark in water to extract secondary metabolite, the water is then used in bathing and washing the infected area. This helps in curing skin-related problems e.g. Eczema
Nymphaea lotus Schumach. & Thonn Herb, Least concern BKKU54	**Bado**	Nymphaeaceae	Bark	0.015	0.67	Soak and boil the bark in water to extract secondary metabolite and allow it to cool. The water is then administered orally to treat Malaria fever

Parkia biglobosa Benth. Tree, Least concern BKKU55	**Kalwa**	Fabaceae	Root	0.01	0.50	A concoction of dried roots is orally taken daily for the treatment of Malaria. Unprocessed stem powder of *Parkia biglobosa* as a food supplement for the treatment of Hypertension.
Pennisetum purpureum Schumach. Herb, Least concern BKKU56	**Dawar kada**	Poaceae	Leaves	0.01	0.50	Grind the leaves and soaked in water for 24 hours after that, administer them orally 2-3 times daily to treat diabetes and in treating polio-infected children.
Piper nigrum Herbs, Least concern BKKU57	**Barkono**	Piperaceae	Leaves	0.005	1.00	Collect and macerate the leaves, then mix them with water. Serve this solution as regular drinking water during the entire medication period. It can help alleviate symptoms of cold, asthma, and fever.
Pistia stratiotes Herb, Least concern BKKU58	**Kainuwa**	Araceae	Leaves	0.005	1.00	To extract the secondary metabolite, soak and boil ten pieces of leaf samples in water. Allow the mixture to cool. Then, use the resulting water to wash the infected skin surface, effectively treating skin conditions such as eczema. If administered orally, this water can also help cure infections related to piles, fever, and ulcers.
Pseudogalium paradoxum subsp. *paradoxum* shrub Not threatened BKKU59	**Ciyawar ruwa**	Rubiaceae	Stem	0.025	0.40	Stem is collected and boiled with water, allowed to cool, and filtered. The collected water is taken orally as drinking water 2-3 times per day to treat malaria and typhoid fever
Psidium guajava David Stang Tree, BKKU60	**Goba**	Myrtaceae	Stem	0.01	1.50	Soak and boil 5g of stems in water, then allow to cool to extract the secondary metabolite. The water is then taken orally to treat Typhoid and Malaria fever
Sclerocarya birrea Hochst. Tree, Least concern BKKU61	**Danya**	Anacardiaceae	Root	0.01	0.50	A concoction of dried root is orally taken 2-4 times daily for the treatment of Gonorrhea.
Senegalia senegal (L.) Britton Shrub, Least concern BKKU62	**Dakwara**	Fabaceae	Leaves	0.015	0.67	The leaves are collected and a sufficient amount is taken and Macerated. The leaves are mixed with either water or liquid and taken orally as a cure for Dysentery and Diarrhea

Senna occidentalis Link Herb, Least concern BKKU63	**Rai dore**	Fabaceae	Leaves	0.015	0.67	Leaves are collected, a decoction procedure is employed and the water solution will be served as normal drinking water throughout the medication period for the treatment of Typhoid, Headache, and Fever
Senna tora (L.) Roxb. Herb, Least concern BKKU64	**Bajamfari**	Fabaceae	leaves	0.06	0.17	Gather 5-10 leaves and let them dry in the shade to make a natural treatment for skin infections like ringworm. After they are dry, soak the leaves in water and leave them for 2-3 days. Then, use the water to wash the infected skin area.
Syzygium aromaticum (L.) Merr. & L.M.Perry Tree, Least concern BKKU65	**Malmo**	Myrtaceae	Root	0.005	1.00	Sufficient roots will be collected, allowed to dry under shade, and soaked in water for 3-5 days while taking the water orally 2-3 times a day for a cure to a tooth infection and toothache
Tamarindus indica Tree, Least concern BKKU66	**Tsamiya**	Fabaceae	Stem	0.03	0.50	The stem of *Tamarindus indica* will be collected and made a decoction. The decoction is taken orally for treating Malaria and jaundice, in rare cases as a Blood tonic.
Terminalia macroptera Mart. Tree, Least concern BKKU67	**Kwandari**	Combretaceae	Stem	0.005	1.00	Collect the sufficient stem of *Terminalia macroptera*, Allow to air dry and soak in water for 48 hours. The water is administered orally 3-5 times a day for treating cough and stomach disorders
Vachellia nilotica (L.) P.J.H.Hurter & Mabb. Tree, Least concern BKKU68	**Bagaruwa**	Fabaceae	Stem	0.035	0.57	The stem of *Vachellia nilotica* is collected, allowed to air dry, and chewed Unprocessed for treatment of Hypertension and worm infestations.
Vernonia amygdalina Delile Shrub Least concern BKKU69	**Fatefate**	Asteraceae	Stem	0.025	0.60	The stem of *Vernonia amygdalina* is collected, macerated, and soaked in water. The water is taken orally 3 times a day to treat stomach disorders and vaginal itch in females.
Vernonia glaberrima Welw. ex O.Hoffm. Herb Least concern BKKU70	**Shuwaka**	Asteraceae	Leaves	0.005	1.00	10 leaves are collected and boiled in water. The boiled water is filtered into a clean container and serves as drinking water at least 2 times a day to treat malaria and diabetes.

Viscum album lutescens (Makino) Kitag. Herb, Least concern BKKU71	**Zakami**	Santalaceae	Root	0.01	0.50	Roots of *Viscum album* are collected and macerated to powder form. The powder is soaked in water for 3 days and administered orally for the treatment of helminthes invasion and in treating high blood pressure
Vitex chrysocarpa Planch. Herb, Least concern BKKU72	**Dinyar rafi**	Lamiaceae	Stem	0.005	1.00	10-15 leaves are Crushed and dried under shade, mixed with water, and allowed to stay for 48 hours. The mixture is taken orally 4 times daily for the treatment of malaria fever Malaria and Typhoid.
Vitex doniana Sweet Tree, Least concern BKKU73	**Dinya**	Lamiaceae	Leaves	0.01	0.50	Leaves are collected and made an infusion to treat cold. The root of the plant is collected, macerated, and soaked in water, the solution is taken orally to treat malaria and Asthma.
Ziziphus tripartita Roem. & Schult. Shrub Least concern BKKU74	**Kanda**	Rhamnaceae	stem	0.03	0.67	The stem of *Ziziphus tripartita* is collected and allowed to be dried under shade. The dried sample is then crushed to powder and soaked in warm water to treat Headache, Malaria and Cold.

Table 6. Jaccard Index analysis

Previous Study Area	**References**	**Total Documented Species**	**Total documented species in the Present Study**	**Similar use of plant**	**Dissimilar use of plant**	**Plants common to both areas**	**Jaccard index (Percentage)**
Pauri District, India	Khajuria *et al.* 2021	236	74	1	2	3	0.98
Kano state Nigeria	Sulaiman *et al.* 2022	33	74	3	14	17	18.89
Edo State, Nigeria	Gbolade, 2012	70	74	0	13	13	9.92
Katsina State, Nigeria	Kankara *et al.* 2014	115	74	4	18	22	13.17
Purus province, Peruvian Amazon	Horackova *et al.* 2023	79	74	3	2	1	0.66
Bandarban district, Bangladesh	Faruque *et al.* 2018	159	74	7	2	3	1.30
Kwara State, Nigeria	Evbuomwan *et al.* 2023	62	74	7	6	13	10.57
Oyo State Nigeria	Odebunmi *et al.* 2022	86	74	02	04	6	3.90
Naya Raipur, Chhattisgarh India	Pandey 2022	104	74	01	03	04	2.30
Bargarh District, Odisha India	Pandey *et al.* 2024	70	74	02	08	10	7.46
Khatling Valley of Western Himalaya	Hussain *et al.* 2023	68	74	0	1	1	0.71

Chagunnarayan Municipality Bhakpatur Nepal	Dulal *et al.* 2022	96	74	2	2	4	2.41
Palamalai Region of Eastern Ghats, India	Silambarasan & Ayyanar 2015	118	74	0	7	7	3.78
Ramechhap District Nepal	Pradhan *et al.* 2020	139	74	0	4	4	1.91
Pauri Garhwal and Rudraprayag District Uttarakhand, India	Kumar et al.2021	88	74	5	6	8	5.19
Allada, Benin	Yetein *et al.* 2012	82	74	5	9	14	9.86
N'Djamena, Republic of Chad	Mahamat *et al.* 2024	22	74	0	3	3	3.16
Ouaddaï Province Chad	Chahad *et al.* 2015	38	74	04	09	13	12.87

Our study identified 82 medicinal plants belonging to 52 genera and 38 families used in the study area to treat various ailments. The surveyed species are listed in Table 5. For each taxon, we provide information on the scientific name, family, local name, and part of the plant used, medicinal applications, and the number of citations. Additionally, we indicate whether the species is wild or cultivated.

Residents of Bunkure district collect and prepare medicinal plants from various habitats. Most of the medicinal plants in the district inhabit the wild (65.35%), with 29.65% found in home gardens, and 5.00% found in both the wild and home gardens. The evidence suggests that residents primarily rely on wild medicinal plants to prepare remedies in the study area. Furthermore, the local people generally have limited potential and ability to cultivate plants in their home gardens. According to Mesfin *et al.* (2013) explanations, it is evident that the majority of medicinal plants are naturally found in the wild. This investigation also revealed a great diversity of therapeutic plants. Different agro-ecologies and climates likely encourage the growth of various plant species, contributing to the abundance of therapeutic plants in Bunkure. This wealth of plant species may be the primary source of the valuable indigenous medical knowledge used in the area. Additionally, cultural perspectives on the value and accessibility of medicinal herbs may play a role (Igoli *et al.* 2005, Gidey *et al.* 2012, Lulekal *et al.* 2013).

The habit of medicinal plants in the study area varies significantly. Among the recorded plant species, trees at 41%, making them the most common growth form, followed by shrubs at 32%, and herbs accounted for 27%. (Figure 5). These results indicate that the most frequently utilized growth habit of medicinal plants in the study area is herbs, followed by shrubs. This preference likely stems from the accessibility and abundance of herb species in the local environment (Kirtsoglou & Teodossopoulos 2001).

The society utilizes various parts of plants for medicinal purposes. Local communities predominantly use leaves, accounting for (42.5%) were most frequently employed in the production of herbal medication followed by Stems (33%), Roots (11.5%), Seeds 11%), and then Fruits (2.0%) (Figure 2). This result highlights that leaves are the most commonly used plant in remedy preparation. This preference is due to the ease of collection and preparation. However, harvesting roots often leads to the loss of the entire plant since it halts physiological activities (Kirtsoglou and Teodossopoulos 2001). Conversely, research by Collins *et al.* (2006) indicates that roots are widely used in medicinal preparations.

Leaves were commonly used to manufacture herbal treatments due to their greater accessibility and because harvesting leaves does not deplete the plant entirely (Getnet *et al.* 2016, Moges & Moges, 2019). Fresh portions of medicinal plant species are recommended for remedy manufacturing as they are easily accessible in the area, preserving the safety and effectiveness of traditional treatments for prompt use. Leaves are a good source of strong secondary metabolites that are bioactive, making leaf preparations a significant and predominant source of herbal medicine according to several scientific studies (Datta *et al.* 2014, Faruque *et al.* 2018, Worku 2018, Swargiary *et al.* 2019, Mandal *et al.* 2020). Moreover, most

studies suggest using leaves instead of roots because harvesting roots can lead to the permanent extinction of therapeutic plant species (Chowdhury *et al.* 2015, Chekole 2015).

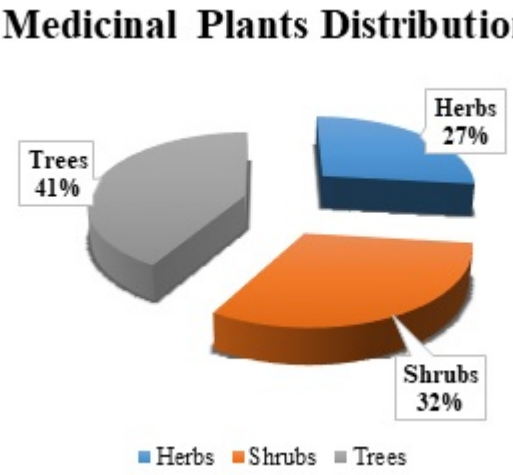

Figure 5. Distribution of Medicinal Plants Habit in the study area

The current study discovered that men had more knowledge than women about the application of therapeutic herbs. This could be due to the long-standing tradition of traditional healers passing their valuable indigenous knowledge of medicinal plants to their sons rather than their daughters. According to Chekole (2015), traditional healers prefer to teach their sons this information because they believe men are better equipped to travel great distances in search of therapeutic plants. Additionally, Ethiopia has a culture that divides labour by gender, providing men with greater opportunities to learn about important plant species. Several Ethiopian studies (Lulekal *et al.* 2013, Kidane *et al.* 2014, Chekole 2015 have found that men are more knowledgeable about medicinal plants than women. According to Voeks (2007), this valuable traditional wisdom is passed down orally and covertly among family members and close associates across several generations. Interestingly, similar ethnobotanical investigations concerning therapeutic plants and related native wisdom have revealed a comparable pattern of covert verbal transmission of knowledge within families (Lulekal *et al.* 2013, Kidane *et al.* 2014, Sodipo & Wannang 2015, Shehu *et al.* 2017), potentially leading to misinformation.

In the current study, two categories of respondents participated: general informants and traditional medicine practitioners. When tallying the number of medicinal plants, a notable indigenous knowledge gap was found between general respondents and traditional medicine practitioners. Traditional medicine practitioners (both literate and illiterate) mentioned additional medicinal plants, supporting the theory that they may conceal indigenous medical information about the application of medicinal herbs (Zerabruk & Yirga, 2012, Lulekal *et al.* 2013, Masango 2020). There were discernible knowledge gaps between different age groups. The youth and adult participants were either unwilling to carry on their parents' long-standing tradition or too young to have extensive experience using medicinal plants. This notable disparity in knowledge between the youth, adults, and elders (Wassie *et al.* 2015) could worsen the decline of indigenous medical expertise in the application of therapeutic herbs.

Regarding the preparation and administration of traditional medicine, local people employ various methods depending on the type of ailment and its location (Figure 3). The study found that the majority of ethnomedicinal plant preparations involve Decoction (53%), powdering (26.00%), dried (7.00%), maceration (5.0%) unprocessed (6.0%), and soaked (3.0%). Society primarily uses powdering and mixing with water for some time to quickly extract bioactive elements from plant parts for immediate responses to diseases and recovery from illnesses. Most remedies are prepared using a single plant part from the same plant, while some involve mixtures of different parts of the same plant or combinations of parts from different plants in the study area. These results are consistent with findings from Singh *et al.* (2012), and Albuquerque (2010), which indicate that crushing is the predominant method for preparing remedies.

Regarding route of administration, oral administration was the most common, accounting for 89.00%, followed by topical administration at 11.00% (Figure 4). This preference can be attributed to the effectiveness of oral administration, which allows medicines to quickly interact with pathogens, thereby enhancing their curative efficacy. Another factor contributing

to this preference could be the high prevalence of internal diseases in the study area. These findings align with previous reports by Weckerle (2018), which also identified oral administration as the predominant route for medicinal use. In the research region, herbal medicines are commonly administered orally, likely due to the high incidence of malaria. Oral administration was the primary method observed for administering herbal medications, followed by bathing (Lulekal *et al.* 2013, Fenetahun *et al.* 2017, Tuasha *et al.* 2018), consistent with earlier findings. This pattern is in line with research by Kontogiorgi (1998), who similarly found drinking to be the most prevalent method for applying prepared remedies. Internal ailments are typically treated by having patients consume medicinal preparations. For instance, tooth infections may be addressed by crushing and directly applying the medicinal plant to the affected tooth. In contrast, skin infections like ringworms are treated by applying herbal preparations directly to the infected skin. Moreover, swollen body parts may be treated with herbal remedies to reduce inflammation. Different plants exhibit diverse applications for treating various diseases, demonstrating the versatility of these preparations in managing different health conditions.

The threats to medicinal plants in the study area can be categorized into natural and human-induced factors. According to local informants, anthropogenic factors such as agricultural expansion, firewood collection, fencing, construction, and medicinal plant harvesting are the primary threats. Natural factors like drought and wildfires also pose significant risks.

Conservation practices are crucial for safeguarding natural resources, including medicinal plants. Both in-situ and ex-situ conservation efforts have been implemented. Wild medicinal plants, which constitute 59.55% of the source in the district, are particularly vulnerable due to insufficient conservation measures. Despite these challenges, various wise use practices are observed, such as establishing nursery sites to propagate and distribute plant species, and protecting areas like mountains and sacred groves around churches and mosques, where cutting plants is culturally prohibited. This cultural practice not only preserves medicinal plants but also indigenous knowledge associated with them. Overall, conservation efforts in home gardens are considered strategic and ideal (Sankaranarayanan & Jolly 1993).

Conclusion

The disappearance of therapeutic plants, primarily due to human activities, threatens plant biodiversity and traditional medical knowledge. Recognizing the importance of herbal remedies in managing and alleviating diseases, especially for individuals in underdeveloped nations with limited access to modern medical treatment, could help maintain and preserve medicinal plant environments and promote their continued use.

This study has demonstrated that a diverse selection of healing herbs is used in the study region to treat human ailments and that traditional knowledge about using herbal remedies is an essential aspect of daily life. However, this indigenous knowledge varies by the type of informants, age groups, and rural vs. urban residents. To foster greater community trust and begin protecting natural habitats, more research on the antibacterial activity and toxicity of these therapeutic plants is essential. These medicinal plant species may also serve as excellent sources for developing new pharmaceuticals.

Although the research area still frequently uses medicinal plants for traditional purposes, the described plant species are increasingly at risk from deforestation for fuelwood, fences, farm equipment, home construction, and overexploitation for medical purposes. This implies that it is critical to protect and preserve therapeutic plant species and indigenous medical knowledge of herbal medicine through sustainable use.

Declarations

List of abbreviations: ENT: Ear nose and threat, IFC: Informant consensus factor, UV: Use value, RFC: Relative frequency of Citation, IUCN: International Union for Conservation of Nature Ethics approval and consent to participate. All the informants were given oral consent for publishing their information.

Consent for publication: Not applicable

Competing interest: Authors have no conflict of interest between them.

Availability of data and materials: The voucher specimen and ethnobotanical questionnaire form were submitted to the Department of Biology, Kano State College of Education and Preliminary Studies, Kano Nigeria. The corresponding author can provide the data upon a specific request.

Authors' contribution: AKP designed the research**. TYU, MAY, and SAG** collected the data from the field, semi-structured interviews, and preparation of voucher specimens done by MAY. Analysis of data and writing of the manuscript were performed by AKP. **FB** performed a critical analysis and revised the manuscript.

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