



Medicinal plants of Teesta Valley, Darjeeling district, West Bengal, India: A quantitative ethnomedicinal study

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ABSTRACT

The present paper offers considerable information on therapeutic plants used traditionally by the residents of Teesta Valley in Darjeeling district, West Bengal. For the acquisition of ethnomedicinal information, semi-structured interviews were conducted with 28 knowledgeable people. The Free, Prior Informed Consent was taken from each participant prior to the collection of field data. A total of 74 species belonging to 68 genera and 44 families were documented to treat 42 types of health conditions. Leaf (30.77%) was mostly used in the preparation of traditional herbal medicines. Collected ethnobotanical data have been evaluated using suitable statistical tools like fidelity level (FL%), informant consensus factor (F_{ic}) and importance value index (IVs). Highest F_{ic} were reported from digestive system disorders. In FL%, highest score (92.8%) was observed in the plants *Drymaria cordata* (L.) Roemer & Schultes and *Zingiber officinale* Roscoe. The highest score for IVs was noticed in cases of *Centella asiatica* (L.) Urb., *Artemisia nilagirica* (C.B. Clarke) Pamp., and *Terminalia chebula* Retz. This documentation will enhance the database on ethnomedicine of the district as well as the country, but scientific validation of the documented ethnomedicinal claim is required.

INTRODUCTION

Natural products have been shown to have a crucial role in the creation of novel medications. The medicinal species of plants enjoy huge popularity in traditional as well as folk medicine system. It has drawn considerable attention of researchers worldwide to such various systems of ethnomedicine (Umair *et al.*, 2017). The knowledge of ethnobotany and ethnobotanical traditions has been crucial in the invention of various contemporary medications. In developing countries, the major portion of rural populations relies on medicinal plants for illness treatment because of limited health care facility (Moktan and Rai, 2019; Payyappallimana, 2010). This health-care approach is founded on ethnic people's beliefs and experiences, which are part of their tradition and culture.

Out of the 422,000 flowering plant species recorded, 50,000 flowering plants are used medicinally (Moktan and Rai,

2019; Umair *et al.*, 2017). Herbal medications are becoming increasingly popular in international business since they are less expensive, ease to access, and potent, and are said to have no negative impacts on health. For its fundamental knowledge on medicinal plants, their diverse traditional applications, methods of formulation, dose, and mode of application of crude pharmaceuticals, this area of ethnobotany is currently procuring increasing relevance in the field of pharmacognosy and natural product discovery. Documentation, preservation, and the informative database of medicinal plants and associated ancestral knowledge, as well as their cultivation, are currently the top precedence on our national program. Through rigorous ethnobotanical research, the number of therapeutic plants in our country's traditional pharmacopoeia is gradually enhancing (Rahaman and Karmakar, 2015).

Ethnomedicinal data is mostly passed on from capable peers to the next generation orally (Karmakar and Rahaman, 2022). But due to modernization of the ethnic people loss of wisdom integrated with ethnic health care practices is very common in almost all ethnic societies globally. Scientific documentation of such knowledge has proved it as a skillful tool in protection and conservation of those verbal traditions of herbal medicine.

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As the Himalayan region of Darjeeling is gifted with the richest depository of medicinal plants (Das, 2004), the people of many isolated and rural regions continue to favor traditional treatment methods. These people's lives are inextricably tied to the abundant plant resources that sustain them and serve as an invaluable source of ethnomedicine. Numerous investigations on ethnobotanical knowledge and resources have been conducted in this region of eastern Himalaya (Moktan and Das, 2013; Pradhan and Ghosh, 2021; Shankar *et al.*, 2016; Yonzon *et al.*, 2011). The Lepchas, Bhutias, Sherpa, Tamang, Limboo, Rai, Kagate, Mangar, Gurung, and Newar are among the ethnic groups in this Himalayan region, and each community has its own particular system of herbal remedies practiced traditionally or through the spiritual healers locally known as Baidang, Bijuwaa, Pompa, Phedangma, Mata, Bomba, Pongba, Pijyu, Bungthing, Khepre, Dhavaju, Gyabring, and Jhyankri. They all reside and continue the herbal practice in remote villages and tea garden areas (Moktan and Rai, 2019; Rai and Bhujel, 1999).

The experts of traditional medicine make use of a variety of plant resources available locally to create medicines to combat different ailments. Although basic medical and health care facilities have been afforded in the Darjeeling Hills urban areas, people from remote and peripheral areas, which account for approximately 78% of the total population, have become accustomed and reliant on their own system of traditional medication, which they have believed in and practiced for generation (Moktan and Rai, 2019).

Till now, no ethnobotanical study including the quantitative analysis has been done from the region of Teesta Valley in Darjeeling. In this context, the current research study has been executed to document the traditional herbal knowledge of tribal people living in Teesta valley region of the state West Bengal.

MATERIALS AND METHODS

Study area

Teesta Valley is located in Rangli Rangliot block of Darjeeling district. It is approximately 43 km away from Darjeeling main town by road. Geographically, this region spans from 27° 01' 57" N to 88° 22' 47.87" E with a height of 844.91 m above mean sea level. Teesta Valley covers an area of 10.52 km². The river Teesta flows through this geographical area. The utmost temperature in this area is 28°C, and the annual rainfall is 2,637.55 mm, with an overall humidity of 74%.

There are two types of forest cover in this study area. The subtropical mixed forests of broadleaf trees grow at an altitude of 1,000 to 1,600 m and dry deciduous forests grow at an altitude of up to 900 m.

This study area is inhabited by various ethnic communities like Limboo, Tamang, Chettri, Rai, and others. The total population of this area is 6,064 (Census of India, 2011).

Data collection

The ethnomedicinal data were collected through regular field visits between February 2020 and December 2020 following the standard methods (Jain, 1987; Jain and Mudgal, 1999) from five villages (Lower Kamjet, Upper Kamjet, Dharen goan, Rai goan, and Tamang goan) of Teesta valley, Darjeeling district (Fig. 1). The visits were made once a month and a total of 10 visits were made within 10 months in each of the villages during the

surveyed period. The villages were visited in all the seasons, i.e., summer, rainy, and winter seasons in order to collect the majority of plant resources in their blossoming state.

The ethnomedicinal information were obtained from 28 informants of different ethnic groups in the area. In the present study, 22 key medicine men and 6 knowledgeable persons were finally selected as informants using the purposive sampling method (Tongco MDC, 2007). The purposive sampling technique is a type of non-probability sampling that is very effective in choosing the participants based on the purpose of the study. Free, prior informed consent was obtained from each informant prior to the interview in written form. The data were gathered using semi-structured and open-ended conversations in the local Nepali language. The plants vernacular name, plant part used, the formulation of the crude drug, administration of the crude medication, the diseases healed, and so forth were noted (Rahaman and Karmakar, 2015).

Identification of plant species

Various books and journals were consulted to establish the taxonomic identity of the plant species recorded (Das, 1995; Ghosh and Mallick, 2014; Hara, 2008; Noltie, 1994; Ranjan *et al.*, 2016). The valid names of the collected plant species were updated using the website Plants of the World Online (<https://powo.sciencekew.org>). The voucher specimens were prepared from the collected plants following standard protocol (Jain and Rao, 1977). The specimens were then kept in the departmental Herbarium, Department of Botany, Visva-Bharati, Santiniketan, India for future references.

Quantitative ethnobotanical data analysis

In present investigation, selective quantitative tools, namely, Informant Consensus Factor (F_{ic}) (Trotter and Logan, 1986), Fidelity level (FL%) (Friedman *et al.*, 1986), and Importance value (IVs) (Byg and Balsev, 2001) were used for statistical analysis of the recorded ethnobotanical data.

Informant consensus factor

One of the extensively used indices is the F_{ic} . It is based on the equation of Informant Agreement Ratio which was first introduced by Trotter and Logan (1986). F_{ic} value quantifies the most potential medicinal plants species used by knowledgeable persons in the study area. The F_{ic} value varies between 0 and 1. High F_{ic} value denotes the higher informant's consent and more information exchange among informants within a community. The low F_{ic} score, on the other hand, indicates that there is less consent among informants and there is less exchange of information about the usage of plant species among the informants. The F_{ic} value was calculated by using the following formula:

$$F_{ic} = \frac{N_{ur} - N_t}{N_{ur} - 1}$$

where N_{ur} is the number of use reports from informants for a particular disease category, N_t is the number of taxa that are used for that disease category.

Fidelity level

FL% is used to measure the reliability of the information provided by the informants in a study area. It is used to estimate

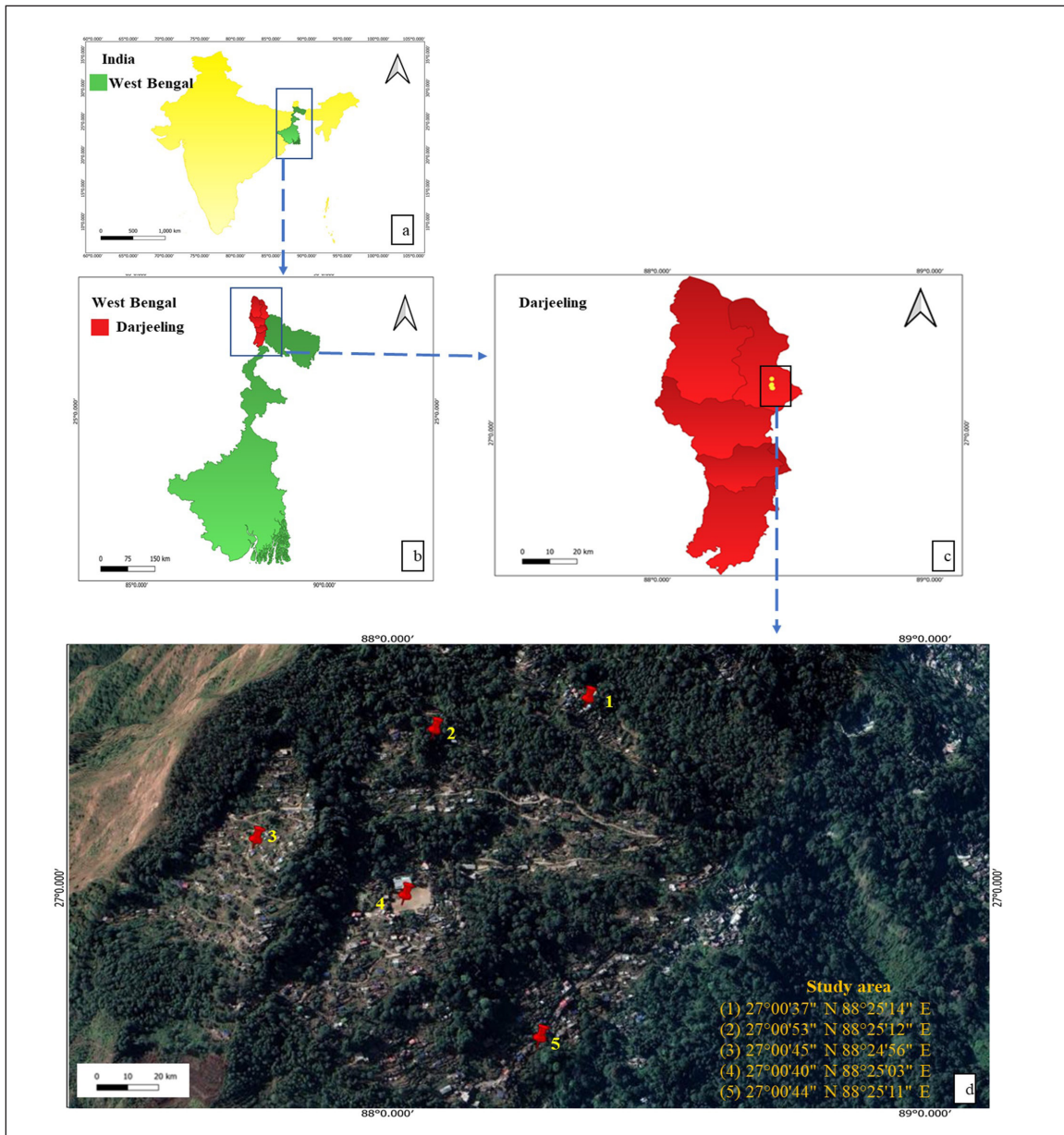


Figure 1. Map (a–d). a) The map showing the geographical location of West Bengal in India. b) Geographical location of Dajeeling district in West Bengal. c) The map of surveyed area. d) Map depicting the various villages visited during the present study in Teeta valley, Dajeeling district, West Bengal. (The map is created using Qgis software and Google earth pro.)

the percentage of informants who claim the use of a specific plant species for treating the particular disease, and it is calculated by the following formula:

$$FL(\%) = \frac{N_p}{N} \times 100$$

where N_p denotes the number of respondents who claim to employ a species for curing a specific disease and N indicates the number of respondents who utilize the plant as a remedy to heal any given diseases. The greatest FL% implies that the plant species is used very often and extensively by the informants in the study region to cure a certain disease.

Importance value

IVs is the proportion of informants who consider a species (s) as most important to the sum of number of respondents and was calculated as follows:

The IVs is the proportion of informants (s) as most important and was calculated as follows:

$$IV_s = \frac{n_{is}}{n}$$

where n_{is} = number of informants (i) who regard the species (s) as the most important; n = total number of informants.

RESULTS

Socio-demographic profile of the informants

Altogether 28 persons have been selected as informants from the study area and information on traditional phytotherapy knowledge were collected by interrogating the informants. Out of total number of informants interviewed, 22 individuals were medicine men who acted as key-informants and rest 6 are knowledgeable persons who served merely as informants. A list of total informants along with their name, address, age, marital status, ethnicity, educational status, and their category has been prepared and presented in tabular form (Tables 1 and 2). Sociodemographic profiles of the informants show that all the informants are tribal and majority of them (about 57.14%) belong to the Limbu community, followed by Rai and Tamang communities (about 21.43% each). The percentage of the males is 75% (21 persons), and only seven informants were found to be female (25%) who regularly practice ethnomedicine. Among the informants, 12 persons belong to the age group of 40–60 years (42.81%), 16 informants are above 60 years of age (57.14%), but no younger informants (belonging to the age group of 20–39 years) are found familiar with plants used as medicine. In respect of their educational status, out of 28 informants, 13 individuals are illiterate (46.42%), and the rest 15 are literate (53.57%). Narendra Subba, a graduate who teaches in a government primary school, has the highest educational qualification among the informants. However, the education standard among the informants is not high due to their poor economic conditions.

Ethnomedicinal knowledge and phytoresources

The plant species were arranged and presented in alphabetical order along with their family name, followed by voucher number, vernacular name, plant part(s) used, diseases cured, mode of administration, scores of IV_s and FL% (Table 4).

Reported medicinal plants, dominant plant families, and plant habit

A total of 74 ethnomedicinal plants have been collected from the study sites of Teesta Valley. These 74 recorded taxa spread over 44 families, 68 genera, and 74 species (Table 3). The dicot family Rosaceae was represented by the greatest number of plant species (five species, 11.36%) followed by Asteraceae and Zingiberaceae (four species each, 9.09%), Anacardiaceae, Lauraceae, Poaceae, Solanaceae, Moraceae and Lamiaceae (three species each, 6.81%), Fabaceae, Malvaceae, Amaranthaceae, Saxifragaceae, Phyllanthaceae, Apiaceae, Urticaceae, Rubiaceae and Combretaceae (two species each, 4.54%). The remaining 26 families had single species representation (2.27% each) (Fig. 2).

According to the habit of the plants, the reported taxa fall under four groups namely trees, shrubs, herbs, and climbers (Fig. 3). The herbaceous flora exhibit the highest contribution of 30 species (40.54% of total plant species), then trees of 23 plant species (31.08%), shrubs 16 (21.62%), and climbers 5 (6.75%).

Plant part(s) used

In the present study, it was observed that the leaf was the maximally utilized plant part accounting for 30.77% of medicinal recipes followed by the underground part (23.08%),

bark (16.49%), fruit (13.19%), stem (5.49%), flower (4.4%), seed (3.29%), whole plant (2.19%), and resin (1.1%) (Fig. 4).

Disease categories

Based on the diseases classification of Cook (1995) the recorded 42 diseases have been grouped into 11 disease categories (Table 5) like digestive system disorders, genitourinary system disorders, respiratory system disorders, musculo-skeletal system disorders, etc. It has been observed that maximum number of medicinal plant species (27 species) were used in the case of digestive system disorders. For respiratory system disorders 22 species were prescribed, followed by 10 numbers of species used in the musculo-skeletal system disorders, 8 plant species were used in circulatory system disorders and endocrine, nutritional or metabolic disorders, etc.

Use of drugs in various forms

In present study, knowledgeable persons collected fresh plant ingredients from various sources (wild and commercial). Among the 74 documented species of plants, 41 plant species have been collected from wild sources which show the richness of medicinal flora in the wild and highlights the dependency of local people on wild plant sources. Apart from it, 24 plants are cultivated locally in the area and ingredients of nine plant species are bought from commercial establishments and markets in the locality.

A total of 81 remedies are applied for treating 42 types of diseases. Majority (85%) of the remedies were prepared from fresh materials. Some remedies were prepared from dried materials (10%) only and few were prepared from dried or fresh plant materials depending upon their accessibility in the area (5%).

The informants gave data about 81 monoherbal preparations of plant species for treating 42 different types of diseases. It was observed that informants in the surveyed region follow various ways of remedy preparation which depend on type of disease treated. The major modes of remedy preparations were juice (37.92%) followed by decoction (32.75%), paste (24.14%), and smoulder (5.17%) (Fig. 5).

Method of administration and doses

Approximately 72.60% of drugs were administered in oral form. Remedies are applied in form of paste, juice, decoction, powder, etc. About 21.92% folk remedies followed topical route as massage, paste, etc., followed by 4.11% nasal inhalation and 1.37% by tooth brushing. The medicinal plant species used as sniffing are burnt to inhale fumes. The leaf and bark of some plant species are boiled and decoction is taken against body pain, fever, cough, diarrhea, and dysentery etc.

The informants used common measuring units like teaspoons, cups, pinch, and fingers, etc., unlike scientific measuring units like, millimeter (mm), milliliter (ml), gram (gm), etc. This traditional method of measuring helps ethnic herbalists greatly in calculating the quantity of plant materials needed for remedy manufacturing and determining the correct dosage of medication to give to a patient for efficient treatment (Cunningham, 2001). There was agreement among informants in terms of measurement or units but doses varied from diseases to diseases, health condition, and physical state of the patient.

Table 1. List of the informants and their sociodemographic information ($n = 28$).

Sl. no.	Name	Age	Sex	Ethnicity	Marital status	Educational qualification	Category of informant
1.	Ashbahadur Limbu Vill.-upper Kamjet	66 years	Male	Limbu	Married	Illiterate	Key informant
2.	Bhudaram Limbu Vill.-upper Kamjet	65 years	Male	Limbu	Married	Illiterate	Key informant
3.	Bina Subba Vill.-upper Kamjet	60 years	Female	Limbu	Married	5th standard	Key informant
4.	C.K. Limbu Vill.-upper Kamjet	80 years	Male	Limbu	Widower	Illiterate	Key informant
5.	Dawa Tamang Vill.-Tamang goan	70 years	Male	Tamang	Married	Illiterate	Knowledgeable person
6.	Dipendra Rai Vill.-Rai goan	51 years	Male	Rai	Married	8th standard	Key informant
7.	Jasmati Subba Vill.-upper Kamjet	68 years	Female	Limbu	Married	Illiterate	Knowledgeable person
8.	Jiwan Rai Vill.-Dharen gaon	64 years	Male	Rai	Married	Illiterate	Key informant
9.	Kalyan Tamang Vill.-Tamang goan	65 years	Male	Tamang	Married	Illiterate	Key informant
10.	Kamala Tamang Vill.-Tamang goan	61 years	Female	Tamang	Widow	Illiterate	Key informant
11.	Karbir Subba Vill.-upper Kamjet	72 years	Male	Limbu	Married	4th standard	Key informant
12.	Kiran Subba Vill.-upper Kamjet	51 years	Male	Limbu	Married	5th standard	Key informant
13.	Lakpa Tamang Vill.-Dharen gaon	64 years	Male	Tamang	Married	10th standard	Key informant
14.	Mahabir Subba Vill.-upper Kamjet	67 years	Male	Limbu	Married	5th standard	Key informant
15.	Mahendra Rai Vill.-Rai goan	54 years	Male	Rai	Married	Illiterate	Knowledgeable person
16.	Manbahadur Subba Vill.-upper Kamjet	68 years	Male	Limbu	Married	Illiterate	Knowledgeable person
17.	Manlachi Rai Vill.-Dharen gaon	61 years	Female	Rai	Married	8th standard	Key informant
18.	Menuka Subba Vill.-Tamang goan	45 years	Female	Limbu	Married	12th standard	Knowledgeable person
19.	Narendra Subba Vill.-upper Kamjet	58 years	Male	Limbu	Married	Graduate	Key informant
20.	Naresh Subba Vill.-lower Kamjet	64 years	Male	Limbu	Married	Illiterate	Key informant
21.	Naresh Tamang Vill.-lower Kamjet	55 years	Male	Rai	Married	10th standard	Key informant
22.	Prasan Tamang Vill.-Tamang goan	47 years	Male	Tamang	Married	12th standard	Key informant
23.	Randul Limbu Vill.-lower Kamjet	68 years	Male	Limbu	Married	10th standard	Key informant
24.	Sabita Subba Vill.-upper Kamjet	47 years	Female	Limbu	Married	8th standard	Key informant
25.	Santi Limbu Vill.-upper Kamjet	64 years	Female	Limbu	Married	Illiterate	Key informant
26.	Suren Rai Vill.- Rai goan	55 years	Male	Rai	Married	12th standard	Knowledgeable person
27.	Suren Subba Vill.-lower Kamjet	55 years	Male	Limbu	Married	12th standard	Key informant
28.	Tshering Tamang Vill.-Tamang goan	56 years	Male	Tamang	Married	Illiterate	Key informant

Address common to each village: Teesta Valley Tea Garden, P.O-Rangli Rangliot, Dist-Darjeeling, Pin-734226.

Table 2. Summary of the sociodemographic profile of the informants ($n = 28$).

Demographic features	Number of people	Percentage (%)
Gender		
Male	21	75
Female	07	25
Age group		
40–50 years	3	10.71
51–60 years	9	32.10
61–70 years	14	50
71–80 years	02	7.14
Community		
Limbu	16	57.14
Rai	6	21.42
Tamang	6	21.42
Literacy		
Literate	13	46.42
Illiterate	15	53.57

Table 3. Number of families, genera, and species recorded.

	No. of families	No. of genera	No. of species
Dicotyledons	38	57	62
Monocotyledons	4	9	10
Pteridophytes	2	2	2
Total	44	68	74

Statistical analysis

The data were analyzed by employing the three quantitative indices like F_{ic} , FL%, and IVs to get more objectivity in the present investigation.

Informant consensus factor

F_{ic} is a very preferred index employed in ethnobotany research to highlight the extensively used plants for a specific disease category. The F_{ic} values of 11 disease categories ranged between 0.7 and 0.83. Among the categories of disorders, the digestive system disorders secured the highest F_{ic} value (0.83) which means there is a greater consensus among informants regarding the use of the 27 prescribed plants for this disease category. The least F_{ic} value was calculated in case of certain infectious or parasitic disorders (0.7). Here, respiratory system disorders obtained F_{ic} value of 0.81, followed by 0.8 value obtained in the two disease categories [injury/infestations and ear, nose, eyes, and mouth (ENEM) disorders], and endocrine and nutritional or metabolic disorders (0.79), etc. (Table 5).

Fidelity level

FL% values of the recorded 74 plant species ranged from 36% to 92.8%. Highest FL% value (92.8%) was recorded for two plant species *Drymaria cordata* (L.) Roemer & Schultes (throat pain, sinuses) and *Zingiber officinale* Roscoe (throat pain, cold

and cough). The lowest FL% was observed in *Acmella paniculata* (Wall. ex DC.) R.K. Jansen, used to treat toothache (Table 4).

Importance value

After analyzing the data, it was found that IV of the plants ranged from 0.28 to 1 (Table 4). The highest IVs i.e., 1 was recorded for three species, namely, *Artemisia nilagirica* (C.B. Clarke) Pamp. (nose bleeding and mouth ulcer), *Centella asiatica* (L.) Urb. (tonsillitis), and *Terminalia chebula* Retz. (hypersensitivity and throat pain). Other three plants species secured the IVs of 0.96, such as *D. cordata* (L.) Willd. ex Schult. (throat pain, sinuses, tonsillitis), *Curcuma longa* L. (for curing cough, cold), and *Terminalia bellirica* (Gaertn.) Roxb. (cough, cold, and bronchitis). The lowest IVs, i.e., 0.28 was calculated for two species of medicinal plants namely *Aeschynanthus parviflorus* (D.Don) Spreng. (used for fever) and *Baccaurea ramiflora* Lour. (for constipation).

DISCUSSION

The current investigation embodies the information on 74 medicinal plants distributed in 44 families of angiosperms and pteridophytes which are utilized by the informants in the study region. According to the findings, people in the area have been using plant resources to treat a variety of diseases. Through personal experience, ancestral prescription, and long history of utility, the locals are familiar with valuable plants and recipe preparation. A total 81 monoherbal formulations are prepared by the informants. It clearly indicates the richness of ethnomedicinal plants and wider knowledge domain on folk herbal knowledge among the local people in the study area.

Among the recorded 44 families, highest number of species was recorded from Rosaceae family. The five species recorded in this family fall in three types of growth forms, namely, tree (two species), shrub (two species), and herb (one species). The dominance in the number of used plant species in the family Rosaceae may be because of their medicinal or therapeutic properties and also their wide distribution in this region of Teesta Valley.

The present study elucidates that the herbs (40.54%) are dominantly used in the region for curing various diseases followed by trees (31.08%). The possible reason for using the herbaceous form in highest number is that herbs are abundantly grown and easily available in the locality (Mandal and Rahaman, 2022). In addition, herbs are more easily gathered than tree species as it is shorter in height and smaller in size. It is the reality that people tend to look for food and therapeutic plants that are plentiful, simple to acquire, and accessible all year round (Albuquerque *et al.*, 2005).

Folk medical practices are mostly based on wild-growing plants, and the use of local wild plants is still practiced in all ethnic cultures. The majority of the therapeutic plant species were obtained by local people from natural sources, demonstrating the local people's reliance on plants growing in the wild.

In the present study, informants mostly prefer leaf (30.77%) for the preparation of their herbal drug that is followed by root (23.08%). Leaves are frequently used as it is readily accessible than other parts of the plant. In addition, leaves are the main sites for the production of many bioactive secondary

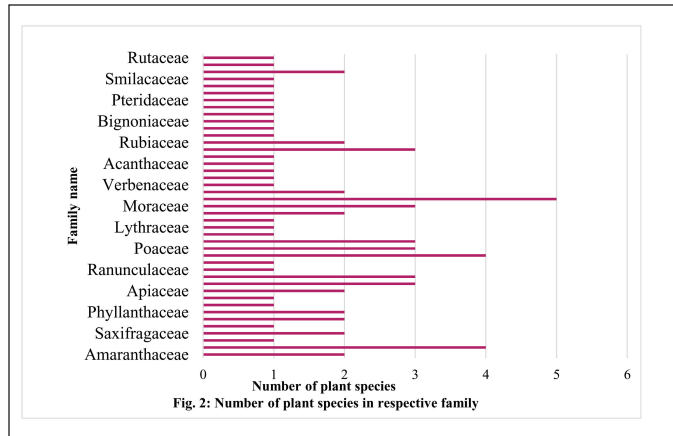


Figure 2. Number of plant species in respective family.

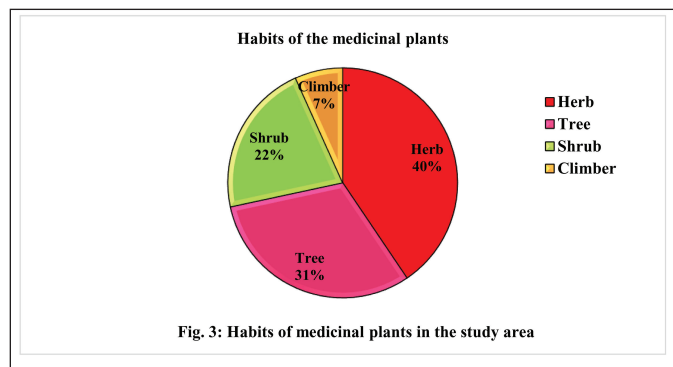


Figure 3. Habits of medicinal plants in the study area.

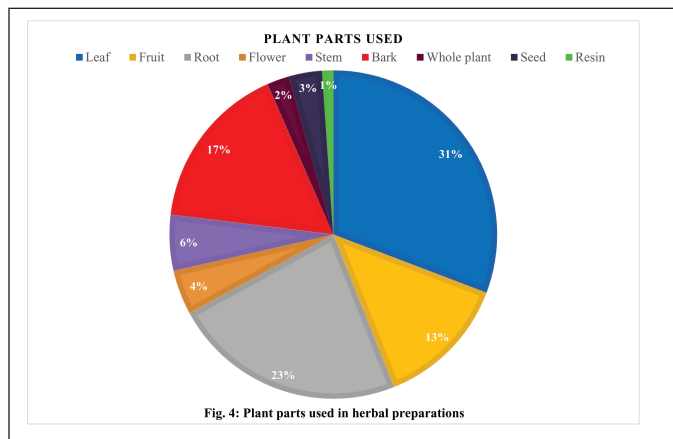


Figure 4. Plants parts used in herbal preparations.

metabolites (Gonçalves and Martins, 1998; Rahaman and Karmakar, 2015). In previous studies, it has been reported that leaves were the mostly used plant part (Rahaman and Karmakar, 2015; Swargiary *et al.*, 2020) in India. Therapeutically active various phytochemicals belonging to the classes of alkaloids, tannins, phenolics, terpenoids, vitamins, minerals, and others are stored in the foliage of medicinal plants which explains the basis for ethnic herbalists' dependence on leaves (Yineger *et al.*, 2008).

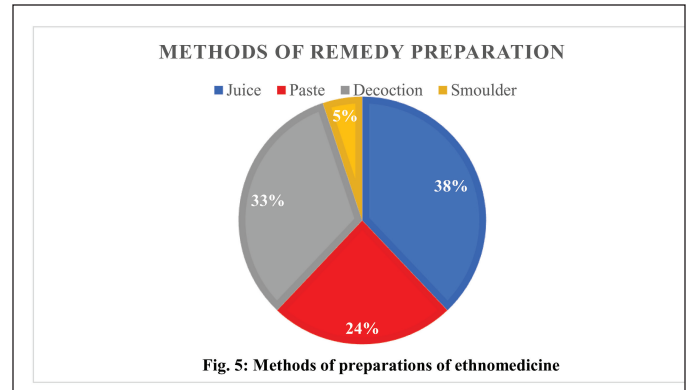


Figure 5. Methods of preparations of ethnomedicine.

In several earlier works, it was illustrated that leaves are the most used part for the preparation of traditional recipes for treating various diseases (Biswakarma *et al.*, 2017; Mussarat *et al.*, 2014; Tangjitman *et al.*, 2015; Umair *et al.*, 2017).

From this study, it is noticed that digestive system disorders are most prevalent in this surveyed area. There are various kinds of digestive system disorders recorded like stomach pain, constipation, diarrhea, indigestion, etc. Stomach disorders such as stomach ache, indigestion, constipation, dyspepsia, and flatulence have been documented in both rural and urban areas across the globe (Anh *et al.*, 2011; Bhandari *et al.*, 2009; Biswakarma *et al.*, 2017).

From the above result, it is found that the major method of remedy preparation is juice (37.92%) followed by decoction (32.75%). Juice may be preferred because of its simple way of preparation and efficacy (Singh *et al.*, 2017). It also might possibly be because juice has a greater concentration of active components than other dose forms like decoction, paste and powder (Yaseen *et al.*, 2015).

When required, the majority of the dosage forms were made fresh. The informants believe that while using fresh components in remedy formulation, the effectiveness potential of the substances is more, which they believe it would be reduced if the items were dried. The fact that both fresh and dried forms are employed in the manufacture of remedies gives the informants a higher chance of having access to the materials used in medicinal formulations throughout the year.

In statistical analysis, the highest F_{ic} value was found in the case of digestive system disorders. The plant species with the highest F_{ic} score can be recognized as valuable in the development of evidence-based phytomedicine (Rahaman and Karmakar, 2015). Also, many researchers have determined that high consensus species are very suitable for phytochemistry and pharmacology research (Heinrich, 2000; Trotter and Logan, 1986).

The highest FL% is recorded in the case of *D. cordata* and *Z. officinale*. The plants with high FL% might be considered the most potential candidates for the treatment of particular diseases. Plants with the highest FL% rating might be studied further phytochemically to find out what bioactive chemicals are responsible for their great healing capacity (Tariq *et al.*, 2015).

The highest IVs is found in *C. asiatica* (L.) Urb., *A. nilagirica* (C.B. Clarke) Pamp., and *T. chebula* Retz. The plants

Table 4. List of medicinal plants used by the ethnic people of Teesta valley.

Sl. no.	Family name /scientific name of the plant (s)/voucher number	Habit	Local name	Part (s) used	Health condition/disease cured	Method of preparation and mode of administration	IV	FL%
Family-Acanthaceae (one species recorded)								
1	<i>Justicia adhatoda</i> L./VBYS74	Shrub	Asuru	Young leaf and shoot	Headache, body ache	Young leaves and shoots are taken orally against fever, headache and body ache.	0.53	86.3
Family-Amaranthaceae (two species recorded)								
2	<i>Achyranthes bidentata</i> Blume// VBYS25	Herb	Ankhlay jhar	Root	Rheumatism	Root juice with salt is massaged for 30 days.	0.71	40
3	<i>Pupalia lappacea</i> (L.) Juss.// VBYS290	Herb	Ultra-kuro	Leaf	Dysentery	Leaf juice is consumed in the case of dysentery.	0.35	41.2
Family-Anacardiaceae (3 species recorded)								
4	<i>Choerospondias axillaris</i> (Roxb.) B.L.Burtt and A.W.Hill/ VBYS44	Tree	Lapsi	Fruit, bark	Burns	Bark paste is applied topically in burns two times a day.	0.67	72.5
5	<i>Rhus chinensis</i> Mill./VBYS240	Tree	Bhakimlo	Resin	Diarrhoea, dysentery	Resin is taken orally in empty stomach in the morning.	0.92	85.7
6	<i>Spondias pinnata</i> (L. f.) Kurz VBYS78	Tree	Amaro	Fruit and bark	Cough, cold and throat pain	Dried fruits are taken during cough and cold. During throat pain, raw bark is consumed.	0.7	82.3
Family-Apiaceae (two species recorded)								
7	<i>Centella asiatica</i> (L.) Urb. /VBYS103	Herb	Golpatta, paisa jhar, athane jhar	Leaf, young shoot	Tonsillitis	Leaf and young shoot juice are taken orally 10–20 ml twice a day.	1	90.1
8	<i>Eryngium foetidum</i> L./ VBYS109	Herb	Bhote dhaniya	Leaf	Gastritis and stomach troubles	Juice is extracted from leaves and mixed with pinch of rock salt powder and taken for gastritis and stomach troubles in the morning before food.	0.64	87.5
Family-Arecaceae (one species recorded)								
9	<i>Calamus erectus</i> Roxb./VBYS41	Shrub	Betgera, phakrey	Fruit, young shoot	Diabetes	Raw fruits are directly consumed once in a day in case of diabetes.	0.89	86.5
Family-Asteraceae (four species recorded)								
10	<i>Acmella paniculata</i> (Wall. ex DC.) R.K. Jansen /VBYS 102	Herb	Latoos ghas	Flower	Toothache	5–6 flowers are chewed in toothache.	0.53	36
11	<i>Ageratina adenophora</i> (Spreng.) R.M.King & H.Rob./VBYS15	Herb	Banmara	Young leaf and shoot	Wounds	Paste of leaf and shoot is applied externally till the wound is healed.	0.96	41
12	<i>Ageratum conyzoides</i> (L.) L./ VBYS11	Herb	Ilamay	Leaf and twig	Fever	Decoction of leaves and tender twigs are taken after the breakfast in case of fever.	0.57	62.5

Sl. no.	Family name /scientific name of the plant (s)/voucher number	Habit	Local name	Part (s) used	Health condition/disease cured	Method of preparation and mode of administration	IV	FL%
13	<i>Artemisia nilagirica</i> (C.B. Clarke) Pamp./VBYS56	Herb	Tetipati	Shoot, leaf	Mouth ulcer, nose bleeding, headache	Fresh shoot parts are consumed directly to cure mouth ulcer. Leaves are crushed and juice is applied externally on forehead during dizziness and headache. The tender shoots are taken and put in nostrils till the nose bleeding is stopped.	1	71.4
	Family-Betulaceae (one species recorded)							
14	<i>Betula alnoides</i> Buch-Ham. ex D. Don/VBYS71	Tree	Saur	Stem bark	Snakebites	Stem bark paste is applied in case of snakebites.	0.82	40.9
	Family-Bignoniaceae (one species recorded)							
15	<i>Oroxylum indicum</i> (L.) Kurz/VBYS142	Tree	Totola	Root	Antidiabetic, diarrhoea and dysentery	Root decoction is taken two times a day in diabetes, diarrhoea and dysentery.	0.78	75.6
	Family -Brassicaceae (one species recorded)							
16	<i>Nasturtium officinale</i> W.T. Aiton/VBYS70	Herb	Simrayo	Whole plant	Cough	Soup prepared from entire plant is taken orally during cough twice a day.	0.39	58.2
	Family-Caricaceae (one species recorded)							
17	<i>Carica papaya</i> L./VBYS223	Tree	Mewa	Seed	Anthelmintic	Seeds are taken orally in empty stomach.	0.45	78.2
	Family-Caryophyllaceae (one species recorded)							
18	<i>Drymaria cordata</i> (L.) Willd. ex Schult./VBYS80	Herb	Abijal	Whole plant	Throat pain, sinuses, and tonsillitis.	Whole plants are crushed and wrapped in leaves of other plants and it is roasted in fire for few minutes. The burnt plant produces a pungent smell which is inhaled in case of sinuses. Same preparation is given in case of tonsillitis and throat pain.	0.96	92.8
	Family-Combretaceae (two species recorded)							
19	<i>Terminalia bellirica</i> (Gaertn.) Roxb/VBYS171	Tree	Barra	Fruit and bark	Cough, cold and bronchitis	The mature fruits are dried and ground and taken orally in case of cough and cold. Bark paste is taken orally in bronchitis.	0.96	86.5

Continued

Sl. no.	Family name /scientific name of the plant (s)/voucher number	Habit	Local name	Part (s) used	Health condition/disease cured	Method of preparation and mode of administration	IV	FL%
20	<i>Terminalia chebula</i> Retz. /VBYS189 Family-Convulvaceae (one species recorded)	Tree	Harro	Fruit	Blood pressure and throat pain	Raw fruit is taken orally in throat pain and to lower blood pressure.	1	87.9
21	<i>Ipomoea batatas</i> (L.) Lam. /VBYS60 Family-Costaceae (one species recorded)	Climber	Sakarkhanda	Leaf	Antidiabetic	Leaf juice is extracted and taken orally for 3–4 weeks.	0.75	82.1
22	<i>Cheilocostus speciosus</i> (J.Koenig) C.D.Specht/ VBYS210 Family-Ericaceae (one species recorded)	Herb	Betlauri	Stem	Diabetes and urinary tract infection	Juice of stem is taken in empty stomach in case of diabetes and urinary tract infection.	0.78	81.45
23	<i>Rhododendron arboretum</i> Sm./VBYS521 Family-Euphorbiaceae (one species recorded)	Tree	Lali guras	Flower	Dysentery and diarrhoea	Juice of fresh flower petals is taken orally in dysentery and diarrhoea.	0.67	85.2
24	<i>Mallotus philippensis</i> (Lam.) Müll.Arg./VBYS8 Family-Fabaceae (two species recorded)	Tree	Sindure	Bark	Body pain	Bark decoction is taken for body pain twice a day after food.	0.35	83.3
25	<i>Entada gigas</i> (L.) Fawc. and Rendle/VBYS87	Woody climber	Pangra	Seed	Dandruff	Seed paste is applied on scalp for 20 minutes and then it is washed to remove dandruff.	0.39	55.6
26	<i>Mimosa pudica</i> L. /VBYS50 Family- Gesneriaceae (1 species recorded)	Herb	Buharai jhar	Root	Toothache	Decoction of roots with water is gargled to reduce toothache.	0.35	65.2
27	<i>Aeschynanthus parviflorus</i> (D.Don) Spreng./VBYS95 Family-Lamiaceae (three species recorded)	Herb	Thirjo	Root	Fever	Decoction of root is taken 2–3 times daily.	0.28	55
28	<i>Mentha suaveolens</i> Ehrh./VBYS22	Herb	Pudina	Leaf	Stomach trouble	Juice of leaves is taken orally during stomach trouble.	0.93	90.9
29	<i>Ocimum tenuiflorum</i> L. /VBYS114	Shrub	Tulsi	Leaf	Cough and throat pain	Fresh leaves are chewed two times a day for cough and throat pain.	0.89	83.3
30	<i>Perilla frutescens</i> (L.) Britton/ VBYS10 Family-Lauraceae (three species recorded)	Herb	Silam	Seed	Cough and cold	Mature seeds are chewed in cough and cold.	0.71	62.5

Continued

Sl. no.	Family name /scientific name of the plant (s)/voucher number	Habit	Local name	Part (s) used	Health condition/disease cured	Method of preparation and mode of administration	IV	FL%
31	<i>Cinnamomum tamala</i> (Buch-Ham.) T.Nees and C.H.Eberm./VBYS115	Tree	Tejpatta	Leaf	Piles	Decoction of leaf is taken during piles.	0.85	83.3
32	<i>Litsea cubeba</i> (Lour.) Pers./VBYS125	Tree	Siltimbur	Fruit	Gastric troubles	Juice is extracted from fruits and mixed with salt taken orally two times a day after food.	0.89	89.5
33	<i>Litsea monopetala</i> (Roxb.) Pers./VBYS18 Family-Lythraceae (one species recorded)	Tree	Patmero	Bark	Throat pain	Decoction of bark is taken twice a day.	0.60	80
34	<i>Duabanga grandiflora</i> (Roxb.exDC.)Walp./VBYS250 Family-Malvaceae (two species recorded)	Tree	Lampatay	Bark	Stomach pain	Bark is boiled and decoction is taken orally in stomach pain twice a day after food.	0.32	72.9
35	<i>Hibiscus rosa-sinensis</i> L./VBYS52	Shrub	Jawa kusum	Flower, leaf	Tonsilitis, dandruff and hair problems.	Young unopened flowers are chewed for tonsillitis. Leaves and flowers are crushed and extract is applied on the hair scalp to get rid of dandruff and hair problems.	0.53	75
36	<i>Sida acuta</i> Burm.f./VBYS99 Family-Menispermaceae (one species recorded)	Herb	Khareto	Stem	Bone fracture	Paste is prepared and applied and bandaged in case of bone fractures.	0.71	80
37	<i>Tinospora sinensis</i> (Lour.) Merr./VBYS178 Family-Moraceae (three species recorded)	Shrub	Giloy	Stem	Used for treating piles, liver complaints	Decoction of stem is taken orally twice a day in piles and liver complaints.	0.93	87.8
38	<i>Ficus auriculata</i> Lour./VBYS91	Tree	Nebhara	Fruit	Diabetes	Fruits are taken in a raw form twice a day.	0.71	66.6
39	<i>Ficus lacor</i> Buch.-Ham./VBYS12	Tree	Kabra	Bark	Diabetes and stomach related problems	Decoction of bark is taken in diabetes and stomach problems.	0.53	82.3
40	<i>Morus alba</i> L./VBYS48 Family-Nephrolepidaceae (one species recorded)	Shrub	Kimbu	Fruit	Laxative	5–7 fruits are chewed twice a day.	0.67	45
41	<i>Nephrolepis cordifolia</i> (L.) C. Presl/VBYS100 Family-Oxalidaceae (one species recorded)	Herb	Pani amala	Tuber	Indigestion, cough, and body pain	Tuber juice is extracted and taken orally two times a day for curing these ailments.	0.71	62.3
42	<i>Oxalis corniculata</i> L./VBYS130 Family-Phyllanthaceae (two species recorded)	Herb	Chare amilo	Leaf	Indigestion	Leaf juice is taken out and consumed orally twice a day after food for indigestion.	0.53	60

Continued

Sl. no.	Family name /scientific name of the plant (s)/voucher number	Habit	Local name	Part (s) used	Health condition/disease cured	Method of preparation and mode of administration	IV	FL%
43	<i>Baccaurea ramiflora</i> Lour./ VBYS181	Tree	Kusum	Fresh bark	Constipation	Fresh bark of the plant is chewed in empty stomach in case of constipation.	0.28	81.9
44	<i>Phyllanthus emblica</i> L./ VBYS145 Family-Poaceae (three species recorded)	Tree	Amala	Fruit	Indigestion	Raw fruits are chewed twice a day.	0.85	87.4
45	<i>Cynodon dactylon</i> (L.) Pers./ VBYS89	Herb	Dubo	Root	Liver cirrhosis	Juice is prepared from the freshly collected root and consumed in the morning in empty stomach.	0.71	45
46	<i>Imperata cylindrica</i> (L.) P.Beauv./VBYS107	Herb	Siru	Root	Fever and jaundice	Freshly collected root juice is orally taken in case of fever and jaundice.	0.35	78
47	<i>Thysanolaena latifolia</i> (Roxb.ex Hornem.) Honda /VBYS444 Family-Polygonaceae (one species recorded)	Herb	Amliso	Root	Boils	Root paste is made and applied externally to boils.	0.78	70.5
48	<i>Koenigia mollis</i> (D. Don) T.M.Schust.and Reveal/ VBYS164 Family- Pteridaceae (one species recorded)	Herb	Thotne	Young leaf and stem	Diarrhoea	Young shoot is taken in raw form for diarrhoea.	0.53	45.2
49	<i>Pteris biaurita</i> L./VBYS122 Family-Ranunculaceae (one species recorded)	Herb	Oonew	Fronde	Dysentery	One teaspoonful of frond juice is consumed twice a day for 2 weeks	0.46	55.2
50	<i>Clematis buchananiana</i> DC./ VBYS76 Family-Rosaceae (five species recorded)	Climber	Pinase lahara	Leaf, root	Sinusitis	Leaves are burnt and its smoke is inhaled 3–4 times daily for a week.	0.92	70
51	<i>Fragaria nubicola</i> (Lindl. ex Hook.f.) Lacaíta/VBYS17	Herb	Bhui aiselu	Aerial part	Cough and cold	Juice is extracted from the plant and taken orally two times a day.	0.32	55.2
52	<i>Prunus cerasoides</i> Buch-Ham. ex D.Don/VBYS156	Tree	Paiyun	Stem bark	Fever	Decoction of stem bark is taken orally 2–3 times daily for 1 week.	0.71	62.1
53	<i>Prunus persica</i> (L.) Batsch/ VBYS191	Tree	Aaru	Tender leaf	Bacterial infection	From the tender leaves, juice is extracted and applied on the wounds (affected by bacterial infection) once a day.	0.75	74.2
54	<i>Rubus ellipticus</i> Sm./VBYS19	Shrub	Aiselu	Root and fruit	Abortion, gastritis	Root is administered orally for abortion. Two teaspoons of fruit juice are consumed once a day for gastritis.	0.46	75
55	<i>Rubus paniculatus</i> Sm./ VBYS97 Family- Rubiaceae (three species recorded)	Shrub	Bhalu aiselu	Bark	Scabies	Paste of bark is used against scabies.	0.64	66.6

Continued

Sl. no.	Family name /scientific name of the plant (s)/voucher number	Habit	Local name	Part (s) used	Health condition/disease cured	Method of preparation and mode of administration	IV	FL%
56	<i>Mussaenda treutleri</i> Stapf/ VBYS66	Shrub	Sitalu	Root	Cold, cough and urinary tract infection.	Root decoction is taken in case of cold, cough and urine burning sensation.	0.60	78.9
57	<i>Rubia sikkimensis</i> Kurz /VBYS113	Climber	Magito	Root	Skin disease	Root paste is applied topically once a day for skin disease.	0.78	87.5
58	<i>Zanthoxylum acanthopodium</i> DC./VBYS184	Shrub	Boke timboor	Fruit	Indigestion.	In the case of dyspepsia, fruits (4-5) are consumed on an empty stomach in the morning for a month.	0.78	84
	Family-Sapotaceae (one species recorded)							
59	<i>Diploknema butyracea</i> (Roxb.) H.J.Lam /VBYS67	Tree	Chewri	Bark	Diabetes and stomach problem	Juice of bark is taken orally in diabetes and stomach troubles.	0.42	85.2
	Family-Saururaceae (one species recorded)							
60	<i>Houttuynia cordata</i> Thunb./ VBYS53	Herb	Gandey ghar	Leaf	Tuberculosis	Leaf decoction is taken once daily for 2 weeks.	0.32	60
	Family- Saxifragaceae (two species recorded)							
61	<i>Astilbe rivularis</i> Buch.-Ham. ex D.Don/VBYS46	Herb	Bansupari or budookhati	Root	Bone fracture, dislocation, cough, cold and body pain.	Paste is prepared from the roots and applied externally and bandaged for curing bone fracture and dislocation. Roots are dried and cut into small pieces and taken during cough, cold and body pain once a day.	0.75	50
62	<i>Bergenia ciliate</i> (Haw.) Sternb./VBYS65	Herb	Pakhanbed	Rhizome	Cough and cold	Fresh rhizome is chewed during cough and cold.	0.89	84.9
	Family-Smilacaceae (one species recorded)							
63	<i>Smilax aspericaulis</i> Wall. Ex A.DC./VBYS92	Climber	Kukurdine	Stem	Pyorrhoea and gingivitis	Stem is used as brush against yorrhoea and gingivitis.	0.78	78.9
	Family-Solanaceae (three species recorded)							
64	<i>Datura stramonium</i> L./ VBYS119	Shrub	Dhatura	Root	Nausea	Root paste is taken orally till the health condition is improved.	0.85	79.1
65	<i>Solanum betaceum</i> Cav. /VBYS221	Shrub	Rukhtamatar	Leaf	Sore throat	For a sore throat, the leaves are heated over a low flame and wrapped around the neck.	0.75	50
66	<i>Solanum torvum</i> Sw./VBYS144	Shrub	Ban-bihi	Leaf	Toothache	Leaves are rolled into cigars and smoked twice a day for toothache.	0.64	54.6
	Family-Theaceae (one species recorded)							

Continued

Sl. no.	Family name /scientific name of the plant (s)/voucher number	Habit	Local name	Part (s) used	Health condition/disease cured	Method of preparation and mode of administration	IV	FL%
67	<i>Schima wallichii</i> (DC.) Korth./VBYS86	Tree	Chilawne	Bark and leaf	Cut, wounds, diarrhoea, and dysentery	Leaf paste is applied on cuts and wounds for a cure. The decoction of root is taken for the treatment of diarrhoea and dysentery.	0.71	60.1
	Family-Urticaceae (two species recorded)							
68	<i>Urtica ardens</i> Link/VBYS197	Shrub	Sisnu	Root	Kidney stones.	One teaspoon of root juice is consumed after meal for 3 weeks.	0.85	71.4
69	<i>Girardinia diversifolia</i> (link) Friis /VBYS120	Shrub	Bhangra sisnu	Root, inflorescence	Bone fracture, high blood pressure	Root paste is applied in bone fracture once a day. Inflorescence is boiled in water and eaten in case of high blood pressure.	0.67	76.9
	Family-Verbenaceae (one species recorded)							
70	<i>Gmelina arborea</i> Roxb. ex Sm./VBYS150	Tree	Khamari	Bark	Body pain	Bark decoction is taken two times a day in the morning and evening after food.	0.42	71.4
	Family-Zingiberaceae (four species recorded)							
71	<i>Curcuma aromatica</i> Salisb./VBYS63	Herb	Ban hardi	Rhizome	Wounds and cuts	Grounded rhizome paste is applied to wounds for healing purpose.	0.89	89.2
72	<i>Curcuma longa</i> L./VBYS85	Herb	Hardi	Rhizome	Cough and cold	Rhizome paste is taken orally two times a day.	0.96	90.6
73	<i>Kaempferia rotunda</i> L./VBYS121	Herb	Bhui champa	Rhizome	Bone fracture	Rhizome paste are applied externally on bone fracture once a day.	0.78	85.2
74	<i>Zingiber officinale</i> Roscoe /VBYS122	Herb	Aduwa	Rhizome	Throat pain	Rhizomes are taken orally and decoction of rhizome is taken for 3–4 days.	0.96	92.8

Table 5. Informant consensus factor (F_{ic}) for each disease category.

Disease category	Number of taxa (N_t)	Number of use reports (N_{ur})	F_{ic}
Circulatory system disorders	8	30	0.75
Musculo-skeletal system disorders	10	42	0.78
Injury/infestations	5	21	0.8
Certain infectious or parasitic disorders	7	21	0.7
ENEM disorders	5	22	0.8
Respiratory system disorders	22	115	0.81
Digestive system disorders	27	155	0.83
Endocrine, nutritional or metabolic disorders	8	35	0.79
Genitourinary system disorders	3	10	0.78
Birth/puerperium disorders	2	5	0.75
Skin/subcutaneous cellular tissue disorders	4	12	0.73

having the highest IVs score indicate that they are therapeutically very significant and may be considered as a suitable candidate for natural product development program.

CONCLUSION

According to the current study, a total of 74 potential ethnomedicinal plants were recorded which cure 42 varieties of diseases. This highlights a very rich traditional knowledge base among the ethnic groups of Teesta Valley of Darjeeling district and will certainly enrich the ethnomedicinal database of this area as well the State of West Bengal. It has been found from the study that diseases of the digestive system are prevalent in this region and its remedial traditional knowledge depends upon 27 medicinal plant species. It indicates the rich alternative options of medicinal plants and the resilience strength of traditional knowledge for treating digestive system disorders. The plants which are maximally used in curing a particular disease category should be exploited further in order to develop a cost-effective supply of medicine for the benefit of mankind. This study will also be instrumental in documentation and preservation of knowledge of ethnomedicine prevalent in the study area which is passed from generation to generation only in the oral form.

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AUTHORS' CONTRIBUTIONS

Chowdhury Habibur Rahaman, Yasodha Subba, and Samik Hazra have conceptualised and designed the present research work. Yasodha Subba visited the study areas and collected all the information. Yasodha Subba and Samik Hazra interpreted and analyzed the data, prepared the figures, maps and drafted the manuscript after consulting with Chowdhury Habibur Rahaman. Chowdhury Habibur Rahaman has critically revised the manuscript and corresponded this. All the authors consented to submit their work to the present journal; approved the present version for publication and agree to be responsible for all facets of the work. All the authors are eligible to be an author as per the International Committee of Medical Journal Editors requirements/guidelines.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

ETHICAL APPROVALS

This study does not involve experiments on animals or human subjects.

DATA AVAILABILITY

All data generated and analyzed are included within this research article.

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GRAPICAL ABSTRACT

