

# Ethnobotanical survey of genus Garcinia L. (Clusiaceae) in Bodoland Territorial Region, Assam, India

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**Ethnobotany Research and Applications 30:70 (2025)** - http://dx.doi.org/10.32859/era.30.70.1-14 Manuscript received: 20/03/2025 – Revised manuscript received: 15/05/2025 - Published: 18/05/2025

## Research

## Abstract

*Background:* The Bodoland Territorial Region, Assam, India, lies on the north bank of the Brahmaputra River, below the foothills of the Himalayan range as a biodiversity hotspot. Many underutilized species used by tribal communities needs documentation due to health beneficial properties. The study aims to explore one such underutilized genus, *Garcinia*, and investigate three species, namely, *Garcinia pedunculata*, *Garcinia morella*, and *Garcinia xanthochymus*, for their uses in medicinal, culinary, and others.

*Methods:* The ethnobotanical study was conducted in the four districts of BTR-Kokrajhar, Chirang, Baksa, and Udalguri with the help of questionnaire for data collection and 100 key informants per district interviews with plant parts used, method of use, status, history, and propagation of the plant in the villages and market areas between 2020 and 2023.

*Results: Garcinia* species were identified as *G. pedunculata*, *G. xanthochymus*, and *G. morella*. Current study revealed that the awareness in major population, consumption in either fresh or preserved by sun-drying, pickle making, juice, candy, and use in traditional medicine to cure mild body ailments like dysentery, stomach ache, and headache. *G. morella* was absent in Kokrajhar and Chirang districts, but *G. pedunculata* and *G. xanthochymus* were found in all four districts. With an RFC and UV value of 1 and 0.89, *G. pedunculata* is found to be the most significant species used for multiple applications.

*Conclusions: G. pedunculata* is found to be the most recognized variety, followed by *G. xanthochymus*, and *G. morella* within the local community.

Keywords: Ethnobotany, Underutilized fruit, Traditional medicine, Garcinia

## Background

Bodoland, officially designated as the Bodoland Territorial Region (BTR), is an autonomous region situated in Assam, Northeast India (BTR 2025). The region is characterized by a rich diversity of indigenous flora and fauna, including numerous endemic and unexplored species. A floristic survey conducted in the Kokrajhar and Chirang districts of the BTR recorded 728 plant taxa, representing 492 genera across 138 families, several of which are categorized as endemic and endangered (Basumatary 2023). Many of these plants remain underutilized and insufficiently studied.

Underutilized plant species, often indigenous but neglected, are typically confined to limited ecological niches, independent of national boundaries. These species frequently remain underexplored due to their occurrence in environmentally threatened or geographically remote habitats. Despite their remarkable genetic resilience, traditional cultural significance, and substantial nutritional and medicinal value, they have been largely overlooked by mainstream agricultural and industrial sectors (Thakur 2014). In Assam, a range of underutilized fruit species remains scientifically underexplored. Some examples of unused fruits found in Assam include **thekera** (*Garcinia* spp.), **kordoi** (*Averrhoa carambola*), **leteku** (*Baccureasapida*), etc. (Hazarika *et al.* 2020). A study conducted in Kokrajhar district, Assam, documented 76 underutilized edible plant species with ethno-medicinal value traditionally used by tribal communities, particularly the Bodo community. These wild plants, commonly consumed as vegetables and herbal medicines, are vital for both nutrition and health. Notable fruit species include *Garcinia* spp., *Moringa oleifera,Dilleniaindica* L., *Piper longum*, etc. (Brahma S *et al.* 2022).

Traditionally, the fruits of *Garcinia* species like *G. pedunculata*, *G. morella*, and *G. xanthochymus are* often eaten fresh when ripe. Fresh fruit juice is used to cure stomach disorders. The raw fruit is used for making pickles and chutneys. Ripe fruit of *G. pdecundulata*, *G. morella*, etc., are also known to be used in culinary preparation. Raw fruit is used to make pickles, and preserved fruit pericarp is used to make soft drinks, which are famous in the Assamese community. Locals preserve the fruit by slicing the pericarp and sun-drying it. The dried fruit pericarp is used to make refreshing drinks, which helps combat summer heat (Baruah *et al.* 2021, Brahma J *et al.* 2022).

A recent study aimed at preserving traditional knowledge documented the ethnobotanical significance of the genus *Garcinia* in Assam and revealed various ethnobotanical uses; for example, *G. morella* fruit juice is used to treat fever, diabetes, and jaundice. Dried pericarps of *G. pedunculata* are used to treat dysentery and digestive ailments (Baruah *et al.* 2021). A similar study on *G. pedunculata* exhibits potent antioxidant properties and is effective in mitigating hyperlipidemia and oxidative stress (Sarmaet al. 2016). Another survey in Kokrajhar district has reported 77 indigenous wild edible plant species, including *G. pedunculata*, traditionally used for treating dysentery, gastrointestinal disorders, and as refreshing beverages prepared from dried fruit pericarps (Brahma S *et al.* 2022). A similar study from Kokrajhar district documented the use of plant *G. pedunculata* to heal stomachache, diarrhea, and dysentery (Basumatary*et al.* 2024). Additionally, ethnomedicinal studies in the Baksa district recorded 129 medicinal plant species utilized by the Bodo community, with *G. pedunculata* among those used to treat diverse ailments (Boro*et al.* 2023).

Recent pharmacological investigations have provided scientific validation for the therapeutic potential of *Garcinia* spp. from the region, highlighting their bioactive compounds and possible health benefits. *Garcinia* spp. are known to have antilipidemic and anti-diabetic properties. Its fruits contain hydroxy citric acid (HCA), a known anti-obesity agent that aids in weight management by regulating serotonin levels, glucose uptake, and fat oxidation (Dutta *et al.* 2023). Comparative studies have shown that several *Garcinia* spp. such as *G.cambogia, G.indica, G. atroviridies, G. pedunculata, G. lanceaefolia, G.cuspida, G.morella, G.cowa* etc.are rich source of HCA (Jena *et al.* 2002, Dutta *et al.* 2023). The fruit extract of *G. pedunculata* showed significant efficacy in a streptozotocin-induced diabetic rat model by lowering blood glucose and HbA1c levels, enhancing insulin secretion, improving lipid profiles, and restoring antioxidant enzyme activity in key tissues. These findings highlight the therapeutic potential of *G. pedunculata* in the management of diabetes and related oxidative stress complications(Ali *et al.* 2017). Scientific studies have also reported the anti-inflammatory properties of *G. pedunculata* (Fan *et al.* 2025) and its potential anti-tumor effects (Zou *et al.* 2025, Sharma *et al.* 2020), further supporting its pharmacological relevance. Recent studies have provided scientific evidence on the anticancer activity of *G. xanthochymus* (Jin*et al.* 2019) and *G. morella* (Choudhury *et al.* 2016), which offers pharmacological validation and identification of compounds for the treatment of the diseases.

As scant literature is available on the *Garcinia* genus found in BTR districts, hence, it is crucial to scientifically explore the significance of this genus. According to FAO's voluntary guidelines for the conservation and sustainable use of crop wild relatives and wild food plants, many neglected and underutilized species (NUS) are gradually disappearing from nature due to habitat destruction for agriculture expansion, climate change, and neglect. These guidelines emphasize the need for national strategies to conserve these species both in situ (in their natural habitats) and ex situ (in gene banks) (FAO 2017). The conservation status of *G. pedunculata* was most recently evaluated for the IUCN Red List of threatened species in 2023 and was classified as Least Concern (IUCN 2025). *G. xanthochymus* and *G. morella* have most recently been assessed for the IUCN Red List of threatened species in 2020 and are listed as Least Concern as well (Deepu&Geethakumary 2020a, Deepu&Geethakumary 2020b).

A critical review reveals a dearth of comprehensive studies on *Garcinia* from the BTR. Although over 17 *Garcinia* species have been recorded in Assam (Brahma J *et al.* 2022), detailed documentation from the BTR remains insufficient. Therefore, the present study focuses on the genus *Garcinia* in the four districts of the BTR.

The present study seeks to document traditional knowledge related to the uses of various *Garcinia* species among the Bodo community and to identify the natural habitats where these species are found within the Bodoland Territorial Region (BTR) of Assam, and collect plant specimens like fruits, leaves, flowers, and stems from natural habitats, and to identify the collected species through taxonomic verification, using herbarium techniques. This study will identify *Garcinia* species in BTR districts and promote awareness among the locals by engaging with them and sharing knowledge regarding the significance of these plants, thereby encouraging active participation in their conservation through cultivation or preserving the knowledge of their uses. This study will also analyze the ethnobotanical data using statistical tools such as frequency distribution, Relative frequency of citation (RFC), and use value (UV), to evaluate the cultural importance, usage diversity, and prominence of each *Garcinia* species in the study area. Literature surveys affirm that *Garcinia* species are rich in bioactive compounds and exhibit notable biofunctionalproperties like antioxidant activity, antimicrobial activity, antilipidemic activity, etc. (Brahma J *et al.* 2022). Nevertheless, large-scale commercial cultivation remains largely absent, and local communities have limited knowledge regarding their market potential. The study aimed to explore the underutilized genus *Garcinia* from the four districts of BTR. These are Kokrajhar, Chirang, Baksa and Udalguri.

## **Materials and Methods**

### Study area

Bodoland Territorial Region (BTR) is an autonomous administrative region located in Assam, Northeast India, extending geographically between 26° 7'12" N to 26° 47' 50" N latitude and 89° 47' 40" E to 92° 18' 30" E longitude (Fig. 1). It occupies the northern bank of the Brahmaputra river, lying just below the foothills of Bhutan and Arunachal Pradesh. The region, named after the indigenous Bodo community, covers an area of more than 9,000 square kilometers and is predominantly inhabited by the Bodo people, along with several other indigenous and ethnic groups (BTR 2025). For the present ethnobotanical investigation, four districts within BTR, namely Kokrajhar, Chirang, Baksa, and Udalguri, were deliberately selected for the collection of plant samples and associated traditional knowledge.



Figure 1. Map of the study area, BTR districts, Assam, India

#### Ethnobotanical documentation and natural habitat assessment

An ethnobotanical and field survey was carried out to document indigenous knowledge and collect *Garcinia* specimens from local habitats. During the flowering and fruiting seasons, specimens of *Garcinia* species were gathered from local market areas to trace the origin of the samples by interacting with vendors and local gatherers to ensure their natural habitat relevance to the study area, and this helped to sample the specimens including fruits, leaves, and flowers though field explorations. These market specimens can provide valuable insights into species distribution, local uses, vernacular identification, and ethnobotanical significance. Required for our study. Collections of data were undertaken from major local markets such as Gossaigaon Bazaar, Kokrajhar Bazaar, Chappaguri Bazaar, Kalpani Bazaar, Udalguri Bazaar, and Tangla Bazaar. Additionally, specimens were gathered directly from trees located in residential backyards and peripheral areas adjacent to the forest fringe villages.

The present study included interaction with locals regularly during the flowering and fruiting season from the year 2020-2023. The primary tool used for data collection was a structured questionnaire. Data were gathered personally through face-to-face interviews with the individuals who were familiar with the *Garcinia* members, and the purpose and objectives of the study were mentioned. A total of 400 informants were selected using non-probability and snowball sampling methods, with 100 informants from each of the four districts. The informants, aged between 18 and 75 years, were local residents who were familiar with *Garcinia* species.

#### Specimen collection and taxonomic identification

After locating the trees of *Garcinia* from their natural habitat, documentation of important physical characteristics of the tree was noted, like its habitat, flower, fruit size, color, seeds, etc., during the field collection. The specimens, like fruits, leaves, flowers, and stems, were provisionally identified by the locals and compared with the descriptions available in the authentic literature (Jan *et al.* 2020). A standard procedure was adopted in the specimens' collection, only healthy, mature individuals during the flowering stage, along with undamaged leaves and stems showing normal morphology, were selected. Both ripe and raw healthy fruits were selected. Specimens were preserved following standard herbarium techniques (Jain & Rao 1977) and submitted to the Department of Botany, Gauhati University, Assam, India, for identification, and accession numbers were obtained. The map of the four districts of BTR has been prepared by using QGIS Software 3.42.0.

#### **Data Analysis**

The collected data were systematically tabulated and subjected to analysis according to the objectives of the study. Statistical techniques, including frequency distribution analysis, the Relative frequency of citation (RFC), and use value (UV), were utilized to interpret the data and derive conclusions.

#### Determination of frequency distribution

Frequency distribution is used for any set of data for comparison (Gogoi*et al.* 2016). Frequency percentage is determined by dividing a part of the sum of frequencies by the sum of frequencies and multiplying by hundred (100) as shown below:

Percentage (%) = X/N x 100 Equation 1

Where, X = A part of the sum of Frequencies N = Sum of Frequencies

#### Determination of the relative frequency of citation (RFC)

RFC is useful in determining the local importance of each species in the particular study area. This index ranges from 0 to 1 theoretically (0 < RFC < 1) (Tardío& Pardo-De-Santayana 2008). It was calculated by using the following formula:

RFC=FC/N (0<RFC>1 Equation 2

Where,

FC: Number of informants who cited the use of plant species N: Total number of informants in the survey, without considering the use categories

#### Determination of use value (UV)

UV determines the relative importance of the medicinal value of the plant. Higher UV scores usually imply the importance of the species. A low score approaching zero indicates few reports on its usage (Jan *et al.* 2020). It was calculated by using the following formula:

 $UV = \Sigma U / Equation 3$ 

Where,

U: Number of use reports mentioned by each informant for the given plant species n: Number of informant interviews for the given plant species

#### Generation of PCA biplot and heatmap

Principal Component Analysis (PCA) is a statistical technique used to reduce the dimensionality of large datasets while retaining as much variance (information) as possible. In ethnobotany, PCA can be used to analyze and identify patterns in the use of plants by different communities across various regions. Reducing complex data (such as multiple plant species or ethnobotanical attributes) into principal components helps identify the most significant variables affecting plant use, distribution, and cultural importance. In ethnobotany studies, PCA often reveals how plant use correlates with cultural practices, ecological factors, or geographic locations.

A Heatmap is a data visualization technique that uses color to represent values in a matrix. In ethnobotany, a heatmap can be used to visually represent the frequency and intensity of plant use across various attributes, such as medicinal, culinary, or ritual uses. It provides an immediate and intuitive way to identify trends and outliers within ethnobotanical data. For example, a heatmap might show which plants are more commonly used in certain geographic areas or how frequently particular plant parts (leaves, fruit, seeds) are used for specific purposes. The PCA biplot and heatmap were generated at https://biit.cs.ut.ee/clustvis/.

## **Results and Discussion**

#### Species description and overview of indigenous practices

Three *Garcinia* species were collected from the BTR districts: *G. pedunculata, G. morella,* and *G. xanthochymus.* Table 1 represents the list of species and their key morphological characteristics. All three species were identified authentically, and their accession numbers were obtained. Fig. 2 illustrates photographs of *Garcinia* specimens collected from the region. The survey indicated that *Garcinia* is a known plant by the locals, and they were known for their folk medicinal uses and culinary practices. *G. pedunculata* and *G. morella* are known as **thaika**, and *G. xanthochymus* is known as **tempwr**in the Bodo language. Baruah *et al.* (2021) identified 12 species and one variety of *Garcinia* species in the state, including BTR districts. The findings confirm the widespread use of these species in the region.

*G. morella* was found only in the Baksa and Udalguri districts of BTR. It is a dioecious, medium-sized fruit tree with many branches. The bark is dark brown and secretes latex. The leaves are simple and obovate, measuring about 9-13 x 4-9 cm. The flower is polygamous. The fruit is fleshy, pulpy, and yellow when ripe, weighing around  $64.33 \pm 49.11$  g. The fruit is globose to kidney-shaped. It has 2-8 dark brown seeds.

Scientific name: Garcinia morella (Gaertn.) Desr.

Family: Clusiaceae

Phenology: - Flowering: March-April; Fruiting: May-September

Indigenous practices: The Bodo community eats fruits when they are ripe. Acidic raw fruit is used for pickle making and has culinary uses. Sun-dried fruit pericarp is used to heal stomach ailments and to make summer drinks to combat the hot sun. The wood is occasionally used for making furniture but is primarily utilized as firewood.

*G. pedunculata* was found in all four districts. It is commonly available and sold in the market. It is a large dioecious evergreen tree. The bark is brown and secretes latex. The leaves are elliptical or oblong with a prominent marginal vein measuring 12-26 x 14-21 cm. The flowers are polygamous. The fruits are large ( $495 \pm 170.55$  g). They have 2-8 seeds with fleshy and waxy pericarp.

Scientific name: Garcinia pedunculata Roxb. ex Buch. Ham

Family: Clusiaceae

Phenology: - Flowering: April-September; Fruiting: October-March

Indigenous practices: The Bodo community uses it as a table fruit. Raw fruit is used for making chutneys and pickles, and in cooking to prepare tangy dishes with fish and pork. Fruit pericarp is sliced and sun-dried to preserve and later used occasionally to treat stomach ailments, dysentery, headache, and high pressure. Wood is used to make houses as it is hard and strong. It is also used to make furniture. They believe that acidic tree wood generally deters termites from eating it.

*G. xanthochymus* was found in all four districts of BTR. It is a dioecious medium-height tree with many branches and dark brown bark that releases latex when cut. The flowers are polygamous. The fruits are globular in shape and smaller than *G. pedunculata*. The fruit turns yellow when ripe and weighs around 67.57 ± 82.42 g. They have 2-6 seeds. The leaves are large and elliptical (23-34×3-8 cm).

Scientific name: *Garcinia xanthochymus Hook*.f ex T Anderson Family: Clusiaceae

Phenology: - Flowering: March-May; Fruiting: June-October

Indigenous practices: Fruit, when consumed raw, can cause an upset stomach due to latex release, so it is mostly eaten ripe by the Bodo community. Raw fruit is used to make pickles. The ripe fruit is eaten as chutney and cooked with fish. Seldom is the sun-dried pericarp used for the treatment of stomach ailments and dysentery. Yellow wax obtained from the fruit is sometimes used as a natural dye to color thread to make yellow fabric. Wood is mostly used as firewood.

#### Relative frequency citation and use value

RFC is a measure used in ethnobotanical and scientific studies to determine the relative importance of a species based on how frequently it is mentioned or cited in a study. With RFC value 1, *G. pedunculata* and *G. xanthochymus are* the most cited species among the three species. Both species were cited in all four districts. They are morecommon, usedfor medicinal, cultural, and economic use, followed by *G. morella* with an RFC value of 0.5, which is cited in two districts, Baksa and Udalguri. Recent studies have also cited *G. pedunculata* in the Baksadistrict (Boro*et al.* 2023) and Kokrajhar district (Brahma S *et al.* 2022). Baruah *et al.* (2021) also cited the presence of *G. pedunculata, G. morella*, and *G. xanthochymus* in their study on the ethnobotany survey of the *Garcinia* genus in Assam. The Use Value (UV) is an ethnobotanical index that quantifies the medicinal importance of a species based on how frequently informants use it. Here, *G. pedunculata*, with a UV value of 0.89, is the most significant medicinally, suggesting it is used for multiple treatments and trusted by many. This aligns with its known role in local communities as a common remedy for digestive ailments and its frequent use in traditional cooking, especially among the Bodo community. *G. morella*, with a moderate UV of 0.45, appears to have fewer medicinal roles, possibly because it is not familiar with the locals. Meanwhile, *G. xanthochymus*, with a UV of 0.40, is important as a medicinal plant, but it is not used often due to unfamiliarity. The alignment of RFC and UV values with traditional uses reflects how deeply these species are embedded in the cultural and medicinal landscapes of the region (Table 1).

Species	Accession	Vornacular namo	Key Morphological	DEC	UV
	Number	vernacular name	Characteristics	NFC	(medicinal)
G. morella	GUBH20642	thaika	The tree is medium-		0.45
			sized, leaves are small		
			and obovate, and fruits	0.5	
			are small and sweet-		
			sour when ripe.		
G. pedunculata	GUBH20643	thaika	The tree is large and		0.89
			tall, leaves are large		
			and have marginal	1	
			veins, the fruit is large	1	
			and sweet-sour when		
			ripe		
G. xanthochymus	GUBH20644	tempwr	Medium height tree		0.40
			with many branches,		
			fruits are small and	1	
			acidic, leaves are large		
			and elliptical		

Table 1. List of Garcinia species sourced from BTR districts, Assam, India



E) Dehydrated fruit pericarp of

G. xanthochymus

F) Dehydrated fruit pericarp of *G. pedunculata* 

Figure 2. Garcinia specimens collected from BTR districts, Assam, India

D) Dehydrated fruit pericarp

of G. morella

#### Analysis of Garcinia usage across BTR districts

Fig. 3 shows the principal component analysisof various Garcinia parts used in BTR districts. Together, PC1 and PC2 capture 98.2% of the total variance, meaning that these two components summarize most of the information from the original dataset. The x-axis represents Principal Component 1 (PC1), which captures the most variance in the data. The y-axis represents Principal Component 2 (PC2), which captures the second-highest variance. Each point represents a district (Kokrajhar, Chirang, Baksa, and Udalguri). Their positions indicate how similar or different they are in terms of the percentage of fruits, seeds, leaves, and bark across different species. Closer points like Baksa and Udalguri indicate more similarity, while farther points like Kokrajhar and Chirang suggest distinct differences. Although the survey was conducted following a standardized protocol to ensure uniformity and comparability of data, like systematic sampling methods, consistent interview procedures, and identical data collection formats across all districts. The relatively distinct clustering in the PCA plot suggests that, despite a uniform survey design, local variations in species distribution, ecological conditions, or ethnobotanical practices (use of fruit, seeds, leaves, and bark) may have influenced the observed patterns. Thus, while the methodology was consistent across sites, natural or cultural heterogeneity among districts likely contributed to the spatial separation observed in the PCA analysis. From Fig. 4 showing the heatmap of the frequency, it is clear that only fruit is used 100 %, and bark is seldom used by some percent. Seeds and Leaves are not used in all the districts. The reason may be due to the unfamiliarity of the locals with the leaves. As per studies conducted previously, the leaves and bark of G. xanthochymus have been recorded for their medicinal uses. For instance, the stems and leaves are traditionally employed to treat worm and leech infections, while the bark and fruit are also utilized for various other medicinal purposes (Lin et al. 2021).



Figure 3. PCA biplot of the plant parts used by the respondents

Table 2 shows the frequency % of respondents on account of the method of use and frequency of use of the plants. As no *G. morella* was known by the locals of Kokrajhar and Chirang districts, we couldn't record the responses. However, we have observed that 100 % *G. morella* was used as folk medicine in the Baksa district. *G. pedunculata* and *G. xanthochymus* also showed medicinal uses by locals of all four districts. It is used as a medicine for stomach pain, headaches, often after a hangover from consuming alcoholic substances, and dysentery. *G. pedunculata* was used 100 % in culinary practices in all four districts, followed by *G. xanthochymus*. The raw fruit was often used for preservation through the sun-drying process. The ripe fruit is acidic, so it is used to make chutney by roasting the fruit, and also cooked with fish or pork meat. Matured raw fruit is used to make pickles by mixing with spices and mustard oil, which is relished throughout the year. Matured fruit after the removal of seeds is sun-dried and preserved for future use. In summer, locals use it to make soft drinks by soaking the dried fruit overnight and mixing it with sugar, salt, and ginger to make refreshing summer drinks. *G. pedunculata*, being

the tallest plant, is often used as timber by the locals. It is found that acidic plants are used because it is resistant to pests and insects and can last longer. Similarly, *G. pedunculata* is primarily valued for its fruits, which are commonly used as food and are known for their digestive properties (Chaudhury *et al.* 2021).Similarly, *G. pedunculata* is a traditional home remedy for stomach ailments in Northeast India and Bangladesh (Paul & Zaman 2022).Studies on the biodiversity and traditional uses of*G. lanceifolia* in Nagaland and Meghalaya highlight the significance of *the* plant. Its fruits and leaves are commonly used to treat stomach disorders, including dysentery and diarrhea, while the bark is traditionally used for dysentery, dyspepsia, and biliousness. The fruits are consumed fresh, made into pickles, or used in refreshing drinks, whereas the leaves are cooked as vegetables. The bark is either chewed, macerated, or powdered for medicinal purposes, showcasing its diverse applications in local healthcare and cuisine (Sarkar*et al.* 2023).



Figure 4. Heatmap of the frequency of plant parts used by the respondents

Several previous studies also showed the culinary and medicinal uses of various*Garcinia* species (Gogoi*et al.* 2016, Dutta*et al.* 2017, Gogoi*et al.* 2012, Sarma*et al.* 2016, Sarma*et al.* 2015, Baruah&Borthakur 2012). Dutta*et al.*(2017) observed leaves of *G. nervosa* used as a laxative for cattle. *G. mangostana* is widely used for bothfood and medicinal purposes. Its fruits and leaves are consumed as food, while it also serves as an analgesic. Lin *et al.* (2021) documented the use of Garcinia plants in China fromancient times to the present, which have various usesas food, ethnomedicine, ornamentaltrees, construction and technology, cultural and spiritual applications, and other miscellaneous uses. Karthik*et al.* (2024) studied ethnobotanical uses of *G. gummi-gutta*, noting that the fruit rind is used in curries and pickles, and seed butter for frying, lighting, and skincare; although 85.71% of respondents were familiar with butter extraction, none engaged in commercial production. Promoting its commercializationcouldstrengthen rural livelihoods and introduce the product to widermarkets.

Districts	Medicine (%)			Culinary (%)			Wood (%)		
	G. morella	G. peduncul ata	G. xanthoch ymus	G. morella	G. peduncul ata	G. xanthoch ymus	G. morella	G. peduncul ata	G. xanthoc hymus
Kokrajhar	0	92	21	0	100	85	0	75	22
Chirang	0	86	35	0	100	100	0	93	15
Baksa	100	87	49	100	100	92	57	85	20
Udalguri	80	91	56	100	100	88	21	76	36

Table 2. Frequency percentage of various uses of the *Garcinia* species by the respondents

Fig. 5 depicts a heatmap visualization of different methods of use: Table Purpose/Fresh (eaten as raw fruit when ripe), Preserved (pickle making and sundried fruit pericarp), and Processed (juice, syrup, and dry powder) across districts. Preservation and processing are two related but distinct concepts in food science, each focusing on different aspects of food treatment. Preservation primarily refers to methods used to extend the shelf life of food and prevent spoilage due to microbial growth, oxidation, or other factors, like drying, pickling, fermentation, etc. In contrast, processing refers to transforming raw ingredients into a final product through various techniques that may include physical, chemical, or biological methods. Processing may or may not involve preservation, but it often serves to modify the food's texture, taste, appearance, or nutritional profile. For example, juicing, canning, grinding to make powders, etc. (Amit et al. 2017). In the figure, darker colors (higher values) indicate districts with more usage for that category. Lighter colors (lower values) show less usage. Locals consumed the ripe, fresh fruit as it became sweet and sour, often enhancing its flavor by adding salt and chili. Most of the population abstains from eating raw fruit as it is waxy and can cause stomach indigestion, according to the informants. G. pedunculata is commonly preserved (100 %) in all districts, meaning all districts prioritize preservation then processing. Baksa and Udalguri also prefer preservation of G. morella through sun-drying and making of pickle. Processing of G. pedunculata is highest in the Baksa (51%) district. When the fruit is ripe, most locals preserve it by sun-drying and later process it into dry powder and use it for making tangy curries, refreshing juice during summer, etc. We can see locals selling the preserved sun-dried Garcinia in the local markets. Although the fruit is consumed and has medicinal properties, it is not cultivated on large land, one can find them only in the backyards of houses, among other fruit trees like mangoes and jackfruit. Previous studies have recorded that Garcinia species from Assam, India, are known to be rich in flavonoids, organic acids, and essential nutrients. It also has hydroxycitric acid (HCA), a known anti-obesity compound in several Garcinia species like G. pedunculata, which has the highest HCA content (445.85 ± 99.49) compared to G. xanthochymus (83.30 ± 20.31) and G. morella (394.65 ± 82.75) (Dutta et al. 2023). Hazarika et al. (2023) revealed that the juice extract from six selected wild edible fruits, including G. lanceifolia of Northeast India, contains a range of rich phytochemicals, including quercetin, gallic acid, caffeic acid, ferulic acid, and rutin. These extracts exhibit strong ethnomedicinal potential, as they are rich in bioactive components. Their diverse therapeutic properties suggest they could be beneficial for treating various ailments and serve as a valuable resource for developing novel natural therapeutic drugs. Traditional knowledge associated with Garcinia encompasses its utilization in food, traditional medicine, timber, and oil extraction. The integration of this indigenous knowledge with molecular science, coupled with a systematic evaluation of its distribution, usage patterns, and resource management strategies, holds significant potential to inform sustainable development and foster innovative entrepreneurial ventures(Bora & Joshi 2024).



Figure 5. Heatmapvisualizationusing different methods by the respondents

#### Propagation practices and indigenous status of Garcinia in the BTR region

Table 3 shows the frequency percentage of respondents on account of the propagation method and history of the plant. The survey observed that 100 % propagation of all the species is through seeds, and they were indigenously present in the region and not cultivated by bringing them from other places. Gogoi*et al.* (2016) reported that the use and propagation techniques of *Garcinia* species, namely *G. pedunculata*, *G. cowa*, *G. lanceaefolia*, and *G. xanthochymus*, have been practiced traditionally since the 19th century, suggesting that these species are likely indigenous to Assam.

Species	Location (%)		Origin (%)		Propagation (%)	
	Natural					
	habitat	Cultivation	Indigenous	Introduced	Seed	Vegetative
G. morella	50	0	50	0	50	0
G. pedunculata	100	0	100	0	100	0
G. xanthochymus	100	0	100	0	100	0

Table 3. Frequency percentage of the propagation method and distribution of the plant

#### Significance of the study

The study highlights the rich traditional knowledge associated with the genus *Garcinia* in the Bodoland Territorial Region (BTR), Assam. It documents the indigenous practices of *Garcinia* use among the Bodo community. Limited data on their local uses addresses a gap in ethnobotanical research from this region, pointing to a critical need for interdisciplinary research that bridges ethnobotany, value-addition, and sustainable utilization. The findings reveal that while the fruit is widely consumed and occasionally used for medicinal purposes, cultivation and commercialization remain limited. This study underscores the need for scientific intervention to enhance the plant's utilization, promote value-added products, and support conservation efforts. The research paves the way for further studies on its nutritional and pharmacological properties by recognizing *Garcinia*'s potential health benefits and economic value.

#### Limitations of the study

The data is based on personal interviews, which may be subject to recall bias or variations in individual knowledge, potentially affecting the accuracy of reported plant uses. However, the study included focus group discussions, observations, and standardized questionnaires to improve accuracy. Future studies could include more comprehensive in situ surveys across a broader geographic range to gather data from a wider variety of habitats. Additionally, integrating molecular identification techniques alongside traditional ethnobotanical methods could provide more precise species identification and help mitigate any misidentification. While the study identifies *Garcinia* as underutilized, it does not explore economic feasibility, market demand, or potential barriers to commercialization in depth. Furthermore, although the lack of cultivation is noted, this study does not explore *Garcinia* species' ecological status, conservation threats, or sustainable propagation methods. Addressing these gaps through ecological field surveys and collaboration with conservation experts will be essential for informing both sustainable use and potential domestication strategies.

## Conclusion

The study indicates that while the people of the Bodoland Territorial Region (BTR), Assam, have long been familiar with *Garcinia* fruit, their knowledge about the plant's full potential remains limited. *Garcinia* is a perennial tree with varying fruiting seasons across its different species. The fruit is primarily used in traditional medicine to treat mild ailments such as dysentery, indigestion, and headaches, and it is also incorporated into local culinary practices. Due to its sour taste, the fruit is commonly used for making pickles and soft drinks, particularly during the summer. Among the locals, *G. pedunculata* is the most recognized variety, followed by *G. xanthochymus*, while *G. morella* is the least known. Despite the fruit's prevalence, it is not actively cultivated, and value-added products made from the fruit are consumed within the community but are not commercialized. As a result, *Garcinia* remains an underutilized fruit. Scientific intervention, community involvement, harvesting practices, and the promotion of value-added products are necessary to fully explore the plant's properties and maximize its uses, which could also aid in the conservation of the species.

## Declarations

List of abbreviations: BTR- Bodoland Territorial Region,HCA-Hydroxycitric acid,PC-Principal Component,QGIS-Quantum geographic information system,RFC- Relative Frequency of Citation,UV- Use value, NUS-Neglected and Underutilized Species Ethics approval and consent to participate: All participants provided oral prior informed consent before the interview Consent for publication: All authors agreed to the submission.

Availability of data and materials: All data are available within the article and will be available from the corresponding author upon request.

Competing interest: The authors declare no conflict of interest

Funding: This research did not receive any specific grant from any funding agencies

Author contributions: Jonali Brahma: Study design, ethnobotanical surveys, methodology, manuscript writing, data analysis, interpretation of results, review editing, and approved the final version of the manuscript.

Subhajit Ray: Study design, methodology, supervision, manuscript improvement, review editing, and approved the final version of the manuscript.

AnuckIslary: Study design, methodology, supervision, manuscript improvement, review editing, and approved the final version of the manuscript.

## Acknowledgments

The authors would like to acknowledge the informants who have participated in this survey and shared their traditional knowledge. The authors are thankful to the Central Institute of Technology, Kokrajhar, Assam, India, for giving the facility.

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