Sustainable Health Practices: Ethnobotanical Insights into Seasonal Plants of Kalahandi, Western Odisha, India for Food and Medicine

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Research

Abstract

Background: Indigenous communities rely on different plant resources available during specific seasons. The development and utilization of resources inherited from one generation to another play a crucial role in shaping a community's identity and way of life. The study aimed to conduct ethnobotanical research across multiple regions in Kalahandi, Western Odisha, to identify the significant utility of various seasonal plants, trees, and other natural resources.

Methods: Ethnomedicinal data were gathered from 87 local informants through semi-structured questionnaires and face-to-face interviews between August 2022 and June 2023. These data were analyzed using quantitative indices Frequency citation (FC) and Relative frequency citation (RFC) for food and medicine preparation.

Results: The above experiment shows that the Kalahandi indigenous people use 32 seasonal plant types for food and medicine. According to the survey, RFC ranked first with *Bambusa vulgaris* (1), *Azadirachta indica* (0.96), and *Citrus acida (0.94),* respectively. *Bambusa vulgaris* is widely accessible during the rainy season and is commonly used to treat various conditions, including menstrual disorders, constipation, epilepsy, and arthritis. The indigenous communities typically boil the bamboo shoots and prepare numerous dishes with them. Among many, "Kardi Pitha" has the highest RFC_{food} value of 1, gaining popularity.

Conclusions: The study examines the Kalahandi tribes' utilization of seasonal herbs for sustenance and medicinal purposes. It also delves into the culinary traditions of bamboo cuisine. It emphasizes preserving plant diversity and cultural history, discovering therapeutic capabilities, expanding food options, and sustaining climate resilience for future relevance.

Keywords: Bamboo shoots, *Bambusa vulgaris*, Ethnobotanical survey, Kalahandi, Medicinal plant

Background:

The indigenous communities of Kalahandi, Odisha, utilize seasonal plants for ethnobotanical purposes, a significant and captivating facet of their customary wisdom and cultural legacy. These communities profoundly comprehend the regional vegetation and have established a complex interdependence with the botanical species that thrive in varying climatic conditions (Ndhlovu *et al.* 2023). Kalahandi, situated in the eastern part of Odisha, is renowned for its diverse ecological systems, including forests, hills, and plains. Indigenous communities in the region, like the Kondh, Saora, and Bonda tribes, have traditionally depended on locally grown seasonal flora for sustenance, medicinal purposes, cultural practices, and everyday needs (Bag 2022). The Indigenous communities exhibit varying plant preferences and corresponding traditional practices specific to different seasons. During the monsoon season, individuals may collect various wild edible flora, including but not limited to ferns, mushrooms, and bamboo shoots. The botanical specimens in question function as a means of sustenance and offer a wide array of gustatory experiences through their varying tastes and consistencies (Faraji &Karimi 2022). During the summer season, when water resources are limited, the indigenous population of Kalahandi has devised innovative methods of utilizing certain flora to combat the difficulties of dehydration and high temperatures. Individuals may opt to ingest plant-based foods with high water content, such as specific fruits and vegetables, or employ botanical remedies from plants recognized for their cooling attributes (Lalmuanpuii *et al.* 2020).

The utilization of traditional medicine constitutes a noteworthy aspect of the ethnobotanical customs observed by the indigenous population of Kalahandi. The individuals have amassed information regarding the therapeutic attributes of diverse botanical species and employ them to address a broad spectrum of medical conditions. Various plant components such as leaves, roots, bark, and flowers are gathered, subjected to specific procedures, and utilized in particular manners to tackle distinct health concerns (Dhal *et al.* 2015). The intimate relationship between indigenous communities and the natural world is reflected in their customary rituals and cultural traditions (Cheng *et al.* 2022; Kosimov *et al.* 2023). Several seasonal plants bear significant religious significance and are utilized in rituals to appease divinities or invoke blessings for favorable harvests, fecundity, and warding off evil entities. It is imperative to acknowledge that the ethnobotanical knowledge and practices of the indigenous population residing in Kalahandi are transmitted orally across generations, with minimal recorded data. The user's comprehension of the indigenous plant life and its customary applications embodies a sustainable and concordant methodology toward coexisting with the environment (Alam *et al.* 2022; Singh *et al.* 2023). It is imperative to recognize that the contemporary world's encroachment onto indigenous communities' territories has resulted in many challenges for their traditional knowledge and practices (Jessen *et al.* 2022; Mohammadi *et al.* 2023).

The ethnobotanical survey conducted in the Kalahandi district aimed to document the traditional knowledge and usage of medicinal plants within local communities. In 2007, Panda *et al.* extensively recorded 124 plant species, belonging to 112 genera and 63 families. These plants treat various ailments such as fever, cough, and digestive disorders. The study emphasized the heavy dependence on these medicinal plants due to limited access to modern healthcare facilities. Building on this foundation, Sahu *et al.*'s (2020) study broadened the scope to include treating serious conditions like diabetes, cancer, and hypertension, highlighting the importance of preserving traditional medicine in regions with restricted access to modern healthcare. In 2022, Das *et al.* reinforced the importance of sustainable plant use for both nutritional and medicinal purposes in addressing food security and healthcare challenges in Kalahandi. The study stressed the need for sustainable harvesting and utilization practices to guarantee the continued availability of medicinal plants for future generations and to fulfill healthcare requirements. However, a significant gap persists in improperly utilizing seasonal plants and a lack of knowledge about their medicinal properties within the indigenous community (Acharya *et al.*, 2023). Despite an in-depth understanding of local flora and its medicinal attributes, this valuable knowledge among the indigenous community in Kalahandi remains insufficiently shared and documented. Consequently, this gap hampers the broader integration of these plants into contemporary healthcare practices. Additionally, there is a pressing need for further research to delve into the efficacy and safety of traditional remedies while simultaneously developing sustainable methods for cultivating and preserving these medicinal plants (Mohapatra *et al.* 2020)

The accelerated process of urbanization, deforestation, and displacement from ancestral lands are jeopardizing the indigenous communities' cultural heritage, particularly their ethnobotanical knowledge and practices (Dewi *et al.* 2023). Researchers, conservationists, and local organizations are undertaking initiatives to record and safeguard this invaluable traditional knowledge for posterity. The utilization of seasonal plants by the indigenous population of Kalahandi, Odisha for ethnobotanical purposes indicates their profound affinity with the environment, dependence on ancestral wisdom, and eco-friendly methodologies (Kumar *et al.* 2017). Ultimately, these factors contribute to their sustainable way of life. The knowledge individuals possess regarding the indigenous plant life in their vicinity and its multifarious applications not only enhances their body health but also bears great cultural importance. The preservation and reverence of ethnobotanical

practices are imperative in upholding the cultural legacy of indigenous communities and fostering sustainable relationships with the environment (Swain & Mahapatra, 2013).

This study explores the intricate utilization of seasonal natural resources, focusing on their nutritional and medicinal properties, within the broader context of various environmental and cultural concerns. The primary objective is to conduct a quantitative analysis that centers on the usability and nutritional value of plants actively utilized by indigenous communities in the Kalahandi district. Integral to this investigation is the application of the relative frequency citation parameter, which assists in identifying and prioritizing plants based on their citation frequency. The research emphasizes plants with the highest relative frequency, subjecting them to a meticulous and critical analysis. This examination extends to exploring the various types of these plants and understanding the traditional methods indigenous communities employ in the Kalahandi district for their culinary preparation. In addition to these aspects, the study underscores the importance of sustainability in indigenous communities' customary utilization of diverse seasonal plants in the Kalahandi region. The overarching goal is to comprehensively investigate and understand these traditional practices and promote sustainable approaches that respect the delicate balance between cultural practices and environmental conservation.

Material and Methods

The study area

Kalahandi (pronounced Kalahani) is a major district of Odisha in India (Fig. 1). In ancient times, the region had a magnificent past and a renowned civilization. Kalahandi is located in the southwestern part of Odisha, between 19.3 N and 21.5 N latitudes and 82.20 E and 83.47 E longitudes. The district headquarters is located in Bhawanipatna, which is almost in the district's center (Singh *et al.* 2010). Kalahandi is divided into two sub-divisions: Bhawanipatna and Dharamgarh. Other important towns in Kalahandi include Kesinga, Junagarh, Lanjigarh, Jaipatna, and Mukhiguda. Kalahandi's major river is “Tel”. Among notable rivers, are Indravati, Hati, Utei, Udanti, Sagada, Nagabali, Rahul, Mudra, and others**.** Plain terrain, hills, and mountains make up Kalahandi's topography. In the pre-independence period, Kalahandi was largely inspired by Saivaism, Vaishanivism, and Shakti puja. Shakti Puja is largely accepted among tribal, perhaps due to which Kalahandi was well known for celebrating Shati Puja.

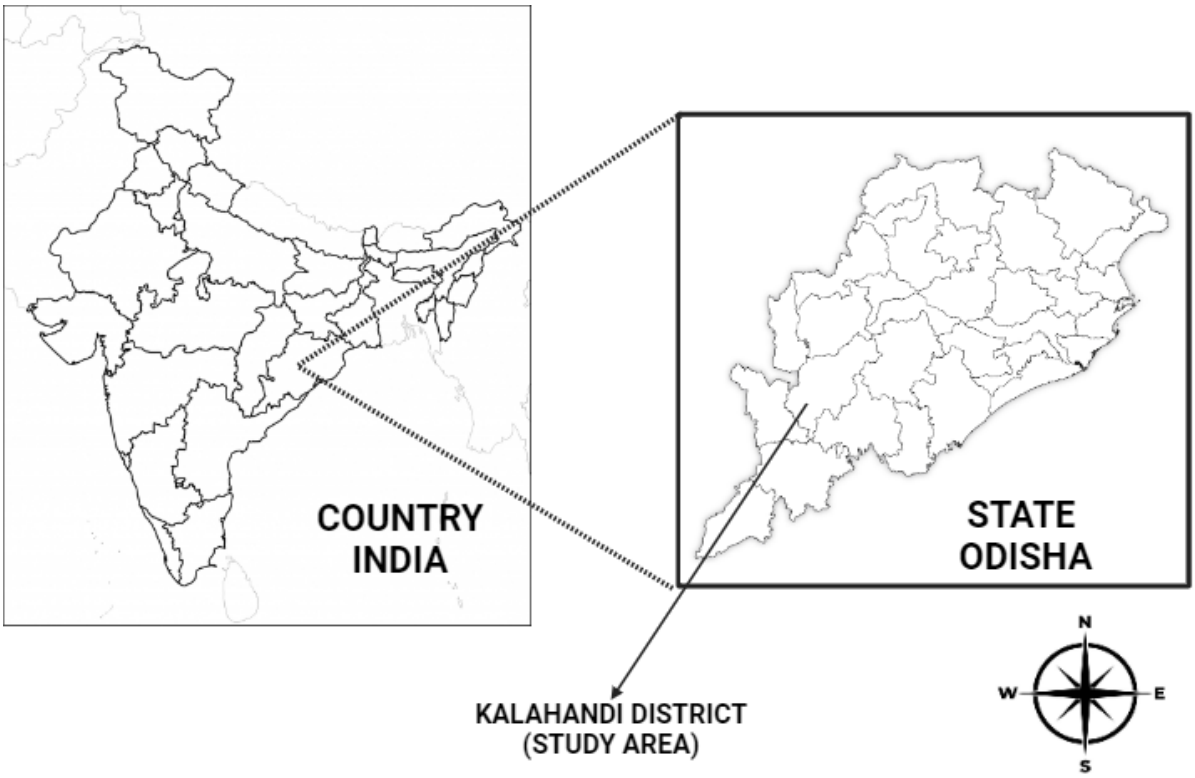

Figure 1. Map of the study area

Tribal Profile of Kalahandi District

The district's total population is 1335494, with a population density of 169 people per square kilometer. The number of people from scheduled tribes (ST) is 38,273 (28.14%), and the number of people from scheduled castes (SC) is 2,6019 (17.67%). The SC/ST population makes up 46.51 % of the district's total population (Goitsemang *et al.* 2020). The district has a literacy rate of 62.45 %. There are 2236 villages in the district, which is organized into 13 Community Development Blocks. In the district, there are 46 different tribes. Banjara, Bhottada, Harijan, Bhujia, Mali, Bhulia, Binjhal, Teli, Dal, Gond, Sundhi, Kutia Kandha, Kandha, Mirdha, Kulthia, Munda, Paroja, Saora, and Shabar are 12 statistically significant tribes among the 46. These 12 tribes account for 97% of the district's tribal population. The three largest tribes, however, are Kandha, Gond, and Shabar (Mallik *et al.* 2012).

Field Study

Between August 2022 and January 2023, a project-based research initiative was conducted in the Kalahandi district, focusing on four key blocks: Bhawanitana, Lanjigarh, Madanpur-Rampur, and Jaipatna. The selection of these blocks adhered to specific criteria, emphasizing geographical representation to capture diverse ecological features, climates, and plant distributions. Tribal diversity played a crucial role, ensuring representation from a spectrum of tribal groups and incorporating varied cultural perspectives and traditional plant knowledge. Accessibility considerations guided block selection, streamlining the research team's movement and data collection. Blocks were chosen based on potential ecological variation to foster a diverse dataset, enabling exploration of how environmental factors influence ethnobotanical knowledge. Thoughtful consideration of population density guaranteed a sufficient number of knowledgeable participants, accommodating variations in ethnobotanical practices and lastly, selecting blocks with rich cultural heritage aimed to reveal a nuanced understanding of the interplay between culture and ethnobotanical knowledge. This comprehensive strategy aimed to construct a well-rounded and diverse dataset, enhancing the depth and applicability of the study's findings.

The study encompassed 87 individuals possessing extensive knowledge and residing in diverse locations within the study area, representing seven distinct tribal groups: Gond, Teli, Mali, Kandha, Harijan, Kutia-Kandha, and Shabar. The selection process meticulously employed specific criteria to ensure a balanced representation of each tribal group. This approach aimed to acknowledge and capture the richness of the traditional knowledge held by these communities, recognizing the importance of their insights in the context of ethnobotanical research. Geographical variations in climate, ecology, and plant diversity were carefully considered, with participants selected from various locations to account for these nuances. Participants were individually interviewed in the local (Kalahandia) language using a set of questionnaires (Appendix A) while maintaining a high level of confidentiality. They were assured that their responses would remain anonymous and be used solely for research.

The researchers prioritized individuals who were willing to participate actively, considering language proficiency to facilitate effective communication for accurate documentation. Ethical standards were rigorously upheld throughout the research, including informed consent, respect for privacy, and cultural sensitivities. This comprehensive selection strategy was implemented to create a well-rounded and representative sample, thereby enhancing the reliability and depth of the ethnobotanical data collected.

In the study context, these specific tribal groups are integral due to their unique traditional knowledge, which plays a crucial role in understanding the local ecosystem, climate, and plant diversity. Traditional healthcare practitioners, experienced farmers, craftspeople, elderly individuals, carpenters, fishermen, forest residents, and non-timber forest produce collectors within these tribal communities constitute a diverse group of experts. Their participation ensures a holistic understanding of the local flora and its significance in various aspects of their daily lives, contributing significantly to the overall richness of the research findings.

Taxonomic identification of plant specimens

Plant specimens were collected for the development of herbaria, and photographs of each species were taken. The specimens were identified using relevant flora, such as the Flora of Odisha (Saxena & Brahman, 1996). The names of the plant list were updated using the link (https://powo.science.kew.org/) and the international plant index (www.ipni.org). The voucher specimen was deposited in the herbarium of the Department of Applied Botany, Centurion University of Technology and Management, Odisha, India.

Data Analysis

The data were analyzed using a Microsoft Office Excel sheet. The information, such as the scientific name of the plant, family name, voucher specimen number, local name, and the parts used in the herbal formulations, were attributed to each species. Ethnobotanical quantitative techniques such as Frequency citation and Relative frequency citation were also employed in analyzing data.

Relative frequency of citation (RFC)

Relative Frequency Citation (RFC) is a metric in ethnobotanical studies that gauges the importance of plant species within a community. Calculated as the ratio of informants citing a plant's use to the total number of informants, a higher RFC suggests greater cultural or practical significance. On the other hand, Frequency Citation (FC) represents the count of informants mentioning the use of a specific plant, indicating the prevalence of its use in the community. RFC and FC contribute valuable insights into plant species' cultural and practical relevance in ethnobotanical surveys (Bibi *et al.* 2022; Mondal 2023).
RFC index shows the local importance of each species.

$$RFC_{Plant\ species} = FC_{Plant\ species}/N$$

$FC_{Plant\ species}$ Informants mentioning the use of plant species, N= Total informants.
RFC index 1 shows that there is usefulness of plant species, and when it is 0, it indicates no usefulness of plant species.
Whereas,
The formula for the RFC index for the importance of different varieties of food from selected plants is calculated as follows (Tardío, J.& Pardo, 2008),
RFC index shows the local importance of each species.

$$RFC_{Food} = FC_{Food}/N$$

FC_{Food}= Informants mentioning different methods of preparation dishes/food using plant species, N= Total informants.
RFC index 1 shows the demand for particular cuisines amongst other cuisines, and when it is 0, it indicates no demand for that cuisine.

Results

Demographic information, encompassing names, gender, age, caste, village names, and educational qualifications of the informants, was collected through formal interviews and is presented in Table 1.

Table 1. Demographical information of the participant

Socio-Demographic Variables	Parameters	Sample number	Percentage (%)
Locality	Ichhapur	17	19.54
	Jagganathpur	08	9.19
	Medinipur	14	16.09
	Balarampur	08	9.19
	Basumatipur	08	9.19
	Bijepur	09	10.34
	Deypure	10	11.49
	Laxmipur	06	6.89
	Sripur	07	8.04
Gender	Male	47	54.02
	Female	40	45.97
Occupation	Herbalist	18	20.68
	Ordinary inhabitant (farmers, fishermen, daily wage laborers, artisans, craftsmen, cattle herders, small-scale traders, and some health workers)	31	35.63
	Plant merchants (sellers of fresh herbs)	15	17.24

	Attars (sellers of dried plants and plant-based items)	23	26.43
Age	<40	22	25.28
	40-60	20	22.98
	60-80	35	40.22
	>80	10	11.49
Study level	No study	20	22.98
	Primary	31	35.63
	High school	17	19.54
	University	18	20.68

Concerning locality, individuals from Ichhapur comprised 19.54% of the participants. Within age groups, 40.22% fell into the 60-80 age range, offering extensive knowledge about plant species. Educational data revealed that the majority (35.63%) had completed only primary education. Regarding occupation, 35.63% were ordinary inhabitants, including farmers, fishermen, daily wage laborers, artisans, craftsmen, cattle herders, small-scale traders, and health workers. Regarding herbal practice experience, participants provided concise and essential information with their consent. The ethnobotanical study documented 32 seasonal plant species from 24 families, detailed in Table 2 with botanical names, families, voucher specimen numbers, prevalent seasons, and various uses of these tree species. The name of the tribal community of the study area, who provided valuable information about individual species is also mentioned in Table 2.

The non-medicinal uses of these species include house construction, agricultural implements, gum, fuel wood, insect and pest repellant, edible fruit for culinary purposes, fish poison, bio-fencing, country liquor, etc. The medicinal values are potentially applicable for several diseases like diarrhea, dysentery, fever, cold, and cough, cut wounds, skin diseases, syncope, headache, etc. The families Rutaceae (*Citrus acida* & *Limonia acidissima*), Sapotaceae (*Manilkara zapota* & *Madhuca longifolia*), Arecaceae (*Phoenix dactylifera* & *Borassus flabellifer*), Myrtaceae (*Psidium guajava* & *Syzygium cumini*), Combretaceae (*Terminalia bellirica* & *Terminalia chebula*), Anacardiaceae (*Semecarpus anacardium* & *Mangifera indica*), Moraceae (*Ficus hispida* & *Artocarpus heterophyllus*), and Lecythidaceae (*Barringtonia acutangula* & *Careya arborea*) are prominent families that exhibit a high number of species utilized for various purposes by indigenous communities. Each of these families contributes two species to the overall diversity used by these communities. A graphical representation of the obtained plant family representing a distinct number of species is reported in Fig. 2. All 32 species have more or less ethnomedicinal value. According to the survey, RFC ranked first with *Bambusa vulgaris* (1), *Azadirachta indica* (0.94), and *Citrus acida* (0.88) respectively. A pictorial representation of ethnobotanical surveys and species with the highest RFC food and medicine value has been documented in Fig. 3. Similarly, The photocopies of species with RFC values more than 0.9 have been mentioned in Fig. 4. Their utility values by indigenous people are high as compared to other plant species. The overall information on the plant species by different tribals, habitat of species, the form of consumption, nature of species, part used, the process of food preparation, etc. has been provided in Table 3.

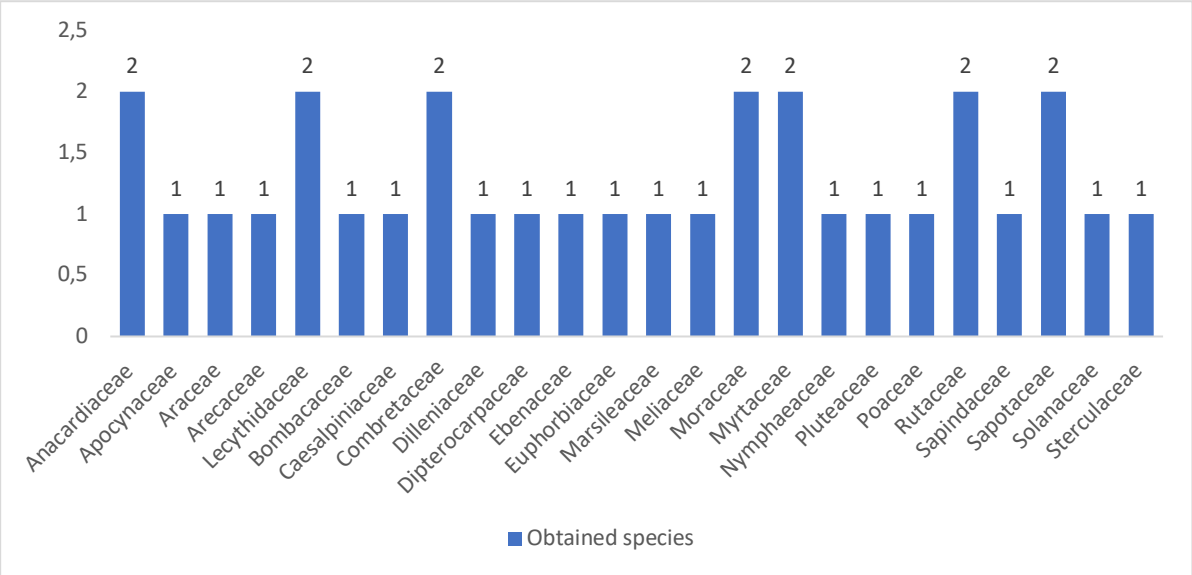

Figure 2. Distinct family from individual species

Table-2. Information about the reported specimen's botanical information, general characteristics, collecting and consumption techniques, and most-used tribal groupings

Botanical name of species	Family	Local names	Season in which it is widely available	Voucher Specimen number	Habitat	Part used	Mostly consumable form	Collection method	Nature	Name of the tribal community who used mostly this species
Mangifera indica L.	Anacardiaceae	Amba	Summer	CUTM/18/0012	T	Fr	Fresh	Picking	W	Gonds,Teli, Gouda, and Khandayats
Semecarpus anacardium L.f.	Anacardiaceae	Bhalia	Summer	CUTM/18/0019	T	Fr	Fresh, Dried	Picking	W	Gonds, Mali, Harijan,Kulta, and Bhandari
Nerium oleander L.	Apocynaceae	Karabira	Spring	CUTM/18/0023	T	F	Fresh	Plucking	W	Bhulia, Kondhas, and Brahmins
Colocasia esculenta (L.) Schott	Araceae	Saru	Rainy	CUTM/18/0025	S	Fr	Fresh	Digging	C	Bhulia, Mali, Gouda, and Khandayats
Borassus flabellifer L.	Arecaceae	Tal	Summer	CUTM/18/0029	T	Fr	Ripe	Picking	W	Bhulia, Teli Kondhas, and Khandayats
Phoenix dactylifer L.	Arecaceae	Khajuri	Summer	CUTM/18/0028	T	Fr	Ripe	Picking	W	Bhulia, Teli, Harijan, and Kulta
Bombax ceiba L.	Bombacaceae	Semel	Spring	CUTM/18/0006	T	F	Fresh	Plucking	W	Bhulia,Kutia, and Kondhas
Tamarindus indica L.	Caesalpiniaceae	Tentel	Summer	CUTM/18/0026	T	Fr	Ripe	Picking	W	Kutia, Teli, Gouda, and Harijan
Terminalia bellirica (Gaertn.) Roxb.	Combretaceae	Bahada	Summer	CUTM/18/0021	T	Fr	Dried	Picking	W	Kondhas, Harijan, and Brahmins
Terminalia chebula Retz.	Combretaceae	Harida	Summer	CUTM/18/0022	T	Fr	Dried	Picking	W	Kutia, Gonds, Harijan,Kulta, and Bhandari
Dillenia indica L.	Dilleniaceae	Ouu	Rainy	CUTM/18/0010	T	Fr	Fresh	Plucking	W	Bhulia, Gonds, Gouda, and Bhandari
Shorea robusta Roth	Dipterocarpaceae	Shala	Summer	CUTM/18/0020	T	G	Dried	Picking	W	Khandayats hulia, Mali, Gouda, and Bhandari
Diospyros melanoxylon Roxb.	Ebenaceae	Kendu	Summer	CUTM/18/0008	T	Fr	Fresh	Picking	W	Bhulia, Mali, Brahmins,Kulta, and Bhandari
Mallotus philippensis (Lam.) Müll.Arg.	Euphorbiaceae	Sindura	Winter	CUTM/18/0016	T	F	Fresh	Plucking	W	Bhulia, Kondhas, Brahmins, and Bhandari
Barringtonia acutangula (L.) Gaertn.	Lecythidaceae	Hinjala	Autumn	CUTM/18/0005	T	F	Fresh	Plucking	W	Bhulia,Teli, Gouda,Kulta, and Bhandari
Careya arborea Roxb.	Lecythidaceae	Kumbhi	Pre-Winter	CUTM/18/0013	T	Fr	Fresh	Picking	W	Kutia, Gonds, and Mali
Marsilea quadrifolia L.	Marsileaceae	Sunsunia saga	Rainy	CUTM/18/0003	R	L	Fresh	Picking	W	Teli, Kutia, Gouda, and Brahmins

Azadirachta indica A.Juss.	Meliaceae	Limba	Spring	CUTM/18/0002	T	L	Fresh	Plucking	W	Kutia, Kondhas, and Brahmins
Artocarpus heterophyllus Lam.	Moraceae	Panasa	Summer	CUTM/18/0001	T	Fr	Fresh or Ripe	Picking	W	Bhulia, Teli, Gouda, and Khandayats
Ficus hispida L.f.	Moraceae	Dumer	Summer	CUTM/18/0009	T	Fr	Fresh	Plucking	W	Kutia,Teli, Brahmins,Kulta, and Bhandari
Psidium guajava L.	Myrtaceae	Jammu	Summer	CUTM/18/0027	T	Fr	Fresh, Ripe	Picking	W	Kutia, Gonds, Harijan
Syzygium cumini (L.) Skeels	Myrtaceae	Jamurala	Winter	CUTM/18/0024	T	Fr	Fresh	Picking	W	Bhulia, Gonds, and Kondhas
Nelumbo nucifera Gaertn.	Nymphaeaceae	Padma nada	Autumn	CUTM/18/0014	S	S	Fresh	Digging	W	Bhulia, Kutia, Gouda, and Kulta
Volvariella volvacea (Bul.) Singer	Pluteaceae	Pual chhati	Rainy	CUTM/18/0007	F	B	Fresh	Digging	C	Teli, Mali, Gouda, Brahmins, and Bhandari
Bambusa vulgaris Schrad. ex J.C. Wendl.	Poaceae	Kardi	Rainy	CUTM/18/0004	T	S	Fresh, boiled	Picking	W	Bhulia,Kutia, Kondhas, and Gouda
Citrus acida Pers.	Rutaceae	Kagzi lembu	Winter	CUTM/18/0032	P	Fr	Fresh, Ripe	Picking	W	Kutia, Kondhas, and Khandayats
Limonia acidissima L.	Rutaceae	Kaitha	Spring	CUTM/18/0031	T	Fr	Ripe	Picking	W	Bhulia, Kondhas, Kulta, and Bhandari
Schleichera oleosa (Lour.) Oken	Sapindaceae	Kusuma	Rainy	CUTM/18/0017	T	Fr	Fresh, Dried	Plucking	W	Bhulia,Kutia, Gonds, and Khandayats
Madhuca longifolia (L.) J.F.Macbr.	Sapotaceae	Mahula	Winter	CUTM/18/0011	T	Fr	Fresh	Plucking	W	Kutia, Kondhas, and Mali
Manilkara zapota (L.) P.Royen	Sapotaceae	Sapeta	Rainy	CUTM/18/0030	T	Fr	Ripe	Picking	W	Kutia, Gonds Kondhas, and Bhandari
Solanum virginianum L.	Solanaceae	Bhejra	Winter	CUTM/18/0018	P	Fr	Fresh	Plucking	W	Kutia, Gonds, and Harijan
Helicteres isora L.	Sterculaceae	Baranga	summer	CUTM/18/0015	P	Fr	Fresh	Plucking	W	Mali Kondhas, and Brahmins

Figure 3. Ethnobotanical study with the most usable plant by people in the study area *Bambusa vulgaris* with RFC value 0.99.

Figure 4. Photographs of Plant species with RFC≥0.9. [A] *Borassus flabellifer*, [B] *Azadirachta indica*,[C] *Citrus acida*,[D] *Mangifera indica*,[E] *Bombax ceiba*, and [F] *Shorea robusta*

Table-3. Botanical descriptions of plant species along with their utility reports concerning their quantitative indices

Botanical name	**Medicinal uses**	**The most commonly used dosage form**	**Name of dosage form in local language**	**$FC_{Medicine}$**	**$RFC_{Medicine}$**	**Name of common traditional dishes**	**Type of cuisine**	**FC_{Food}**	**RFC_{Food}**
Artocarpus heterophyllus Lam.	Headache, stomachache, scabies, syncope, and acne.	Powder	Apasnarika	77	0.88	Panasa ambila and panasa bhaja	Raw, Curry, and Chips	71	0.82
Azadirachta indica A.Juss.	Jaundice, earache, scabies, itches, and stomach ache	Decoction	Harithaki	84	0.96	Limba fula bhaja and limba pana	Stir fry and juice	83	0.95

Marsilea quadrifolia L.	insomnia, diarrhea, alopecia, Itching, and anxiety	Powder	Minjiminjika	75	0.86	Saga bhaja and sag checha bhaja	Curry	70	0.80
Bambusa vulgaris Schrad. ex J. C.Wendl.	Menstrual disorder, constipation, epilepsy, and arthritis	Paste	Kardirani	86	0.99	Karadi ambila and karadi rai	Soup, raw, stir fry, and curry	86	0.99
Barringtonia acutangula (L.) Gaertn.	Dysentery, cut wounds, dog bite, lice, and alopecia	Powder	Mukalika	65	0.75	Hinjala cheka bhaja and hinjala chutney	Juice	75	0.86
Bombax ceiba L.	Bile, acne, conjunctivitis, and hair tonic	Decoction	Anushka	71	0.82	Simili bhaja and Simili ambila	Juice	79	0.91
Volvariella volvacea (Bul.) Singer	Constipation, wound, and epilepsy	Paste	Chhatrika	65	0.75	Chhati bhaja and chhatu bhaja	Normal fry and curry	74	0.85
Diospyros melanoxylon Roxb.	Diarrhea, allergies, insomnia, and constipation	Decoction	Anusandhika	52	0.60	Kendu pana and kendu khata	Raw and dried	63	0.72
Ficus hispida L.f.	Cuts, diarrhea, gonorrhea, fever, and dysentery	Decoction	Biswapita	67	0.77	Dumer achar and dumer khata, dumer saag	Juice	54	0.62
Dillenia indica L.	Appetizer, used to control bleeding	Decoction	Manduka pani	62	0.71	Ouu Khata and ouu achara	Curry	75	0.86
Madhuca longifolia (L.) J.F.Macbr.	Chest pain, pain during delivery, and Insomnia	Decoction	Nabaratrika	71	0.82	Mahula pana and mahula ambila	Fermented Juice	72	0.83
Mangifera indica L.	Diarrhea, allergies, erythema, and itching	Powder	Bambadika	79	0.91	Amba achara and amba khata	Raw, Pickle, and curry	79	0.91
Careya arborea Roxb.	Swelling due to injury, stomach ache, and skin allergy	Paste	Sucharita	72	0.83	Kumbhi cheka bhaja and kumbhi tarkari	Raw	65	0.75
Nelumbo nucifera Gaertn.	Constipation, bloating, and belching effects	Decoction	Swagatika	68	0.78	Padma nada khadkhada and padma nada chhana	Stir fry and curry	67	0.77
Helicteres isora L.	Cuts and wounds, and gripping	Paste	Ahoratrika	68	0.78	Barnga ambila and baranga saga	Raw and curry	59	0.68
Mallotus philippensis (Lam.) Müll.Arg.	Menstrual disorder	Powder	Rashmirekha	72	0.83	Sindura khata and sindura achara	Raw	71	0.82

Schleichera oleosa (Lour.) Oken	Body pain, migraine, and anxiety	Decoction	Barsharani	60	0.69	Kusuma khata and kusuma achara	Roasted	69	0.79
Solanum virginianum L.	Used in toothache, and allergies	Paste	Kadambini	55	0.63	Bhejra ambila and bhejra saaga	Curry	60	0.69
Semecarpus anacardium L.f.	Piles, rheumatism, anal fissure, and Fistula	Powder	Kalpita brahma	69	0.79	Bhalia pana and bhalia khata	Roasted and raw	70	0.80
Shorea robusta Roth	Wound, chicken pox, stomachache, and chest pain	Paste	Kamalatmika	70	0.80	Shala jhuna and sala bhaja	Roasted and smoked	80	0.92
Terminalia bellirica (Gaertn.) Roxb.	Headache, cold and cough stomach disorder, and constipation	Powder	Pushkarini padma	68	0.78	Bahada suntha and bahada saja	Roasted	65	0.75
Terminalia chebula Retz.	Diarrhea, Skin diseases, and constipation	Decoction	Param brahma	76	0.87	Harida khandi and harida gundi	Roasted	66	0.76
Nerium oleander L.	Hemorrhoids and piles	Paste	Karavira	74	0.85	Karabira chhecha and karabira santula	Juice	74	0.85
Syzygium cumini (L.) Skeels	Burn injury, tonsil, mouth ulcer, diabetes, stomach disorder, and diarrhea,	Powder	Ambubala	78	0.90	Jamurala khata and Jamurala ambila	Raw	77	0.88
Colocasia esculenta (L.) Schott	Cure boils, allergies, and rhinitis	Decoction	Binapani	66	0.76	Saru bhaja and saru santula	Curry and Stirr fry	64	0.73
Tamarindus indica L.	Bone fracture, dysentery, and leucorrhea boils	Decoction	Ardhangini	65	0.75	Tentel chutney and tentel achar	Raw, curry	50	0.57
Psidium guajava L.	Used to control lice and dandruff	Paste	Trushna rani	59	0.68	Jammukoli achar and jammukoli khata	Raw and juice	64	0.73
Phoenix dactylifera L.	Swelling due to injury, and toothache	Decoction	Ambimata	58	0.67	Khajuri khata and khajuraa	Raw and stir fry	57	0.65
Borassus flabellifer L.	Used for dehydration, and constipation	Paste	Arundhatika	54	0.62	Tala saja and tala santula	Raw and curry	80	0.92
Manilkara zapota (L.) P.Royen	Used to control seizures, and anxiety	Powder	Vaijayanti mala	70	0.80	Sapeta rai and saoeta pana	Raw and chutney	49	0.56

Limonia acidissima L.	Dog bite, diarrhea, and rabies	Decoction	Subhrantika	66	0.76	Kaitha khata and kaitha santula	Curry and stir fry	52	0.60
Citrus acida Pers.	Used to cure acne and dandruff	Powder	Suchismeeta	81	0.93	Lembu pani and lembu achara	Pickle and raw	81	0.93

Amongst all users and consumers, A total number of 12 indigenous communities were found in this survey. Though Kalahandi district is abundant in many indigenous communities, the study area contains only 12 major indigenous communities. Amongst all of them, the Bhulia community is the major consumer of forest products, followed by kutias and kandhas. Amongst all forms of food preparation methods, most indigenous communities consume the plant species products in raw form by making curry of them. Overall, a maximum number of species are available in trees by their habitat (Fig. 5). From the surveys, it also observed that most of the species are collected in the form of picking, followed by plucking and digging (Fig. 6). The summer season is the most suitable method for growing a total number of 13 identified species amongst all species out of 32. However, the Rainy season also contributes to the growth numbers of many species (Fig. 7). Among all obtained species, a total 30 number of species are wild, and only 2 species are cultivated in the study area(Fig. 8). From the study, it was found that out of all the parts fruit was the most usable part amongst all followed by flower with several 20 out of 32 (Fig. 9). The natives of Kalahandi mostly prepared decoctions for medicinal applications. However, Pastes and powders are also prepared by them for treating many ailments after decoctions (Fig. 10). Bamboo shoots are mostly used as food in Odisha's Western regions, where they are consumed fresh during the harvesting season or dried, fermented, or pickled during the off-season. In the local indigenous area of Kalahandi, bamboo is locally known as 'Kardi'. It is used to make several delicious dishes. According to the collected report few traditional cuisines 'Kardi santula', 'Kardi chingudi Bhaja', 'Kardi amil', 'Kardi bhaja', 'Kardi achar', 'Kardi-jhuri', 'Hendua', 'Kardi bara', 'Hendua-tomatoes' are much popular in several corners of Kalahandi region. The RFC report indicated that the cuisine 'Kardi-hendua pitha' is more popular than other Kardi-related cuisine with an RFC value of 1. The indigenous community of Kalahandi usually makes hendua by drying the powder of tender bamboo shoots under sunlight. The dry powder (Hendua) can be stored for many years without any preservatives. Later, they added several ingredients like tomatoes, dry fish, and ladyfinger with Hendua to make several delicious dishes throughout the year. Apart from Hendua, Other Kardi-related cuisines like Hendua-Bhendi and Kardi ambil have greater importance with RFC values of 0.94 and 0.88 respectively. For preparing all ingredients, uniformly and precisely chopped bamboo shoots have been used with excellent spice content, such as dry/roasted powder of clove, cardamom, coriander, nutmeg, anise, cumin, and cinnamon. Other dishes such as Kardi-hendua bhaja, Kardi-chingudi khata, and Kardi achar also have equally important with satisfactory RFC values, and the results have been depicted in Table 4 with their preparation methods and major ingredients used. Fig. 11 represents the photographs of bamboo plants and collected raw bamboo and several traditional cuisines (RFC≥0.9) of bamboo shoots, prepared and consumed by the peoples of Kalahandi districts.

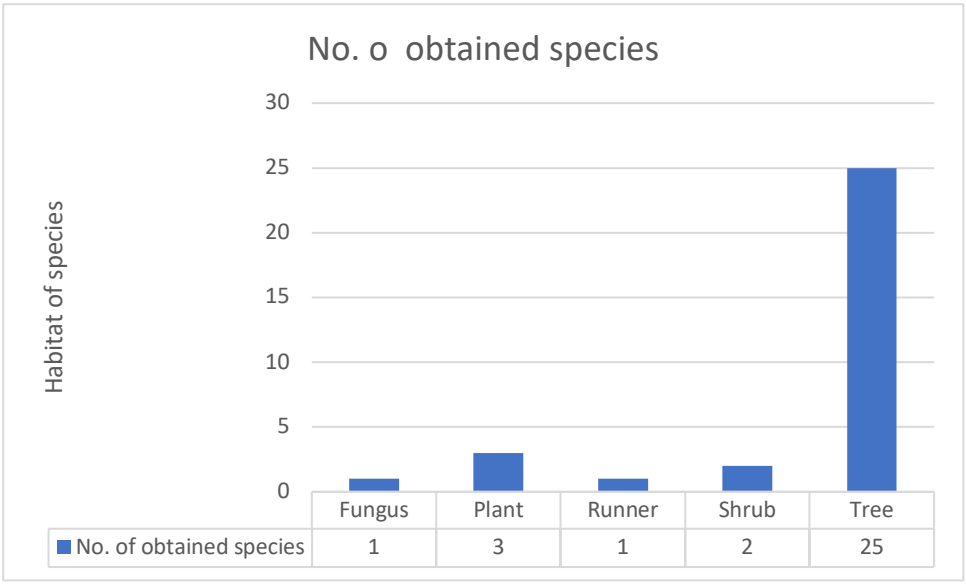

Figure 5. Habitat of the species along with number of species

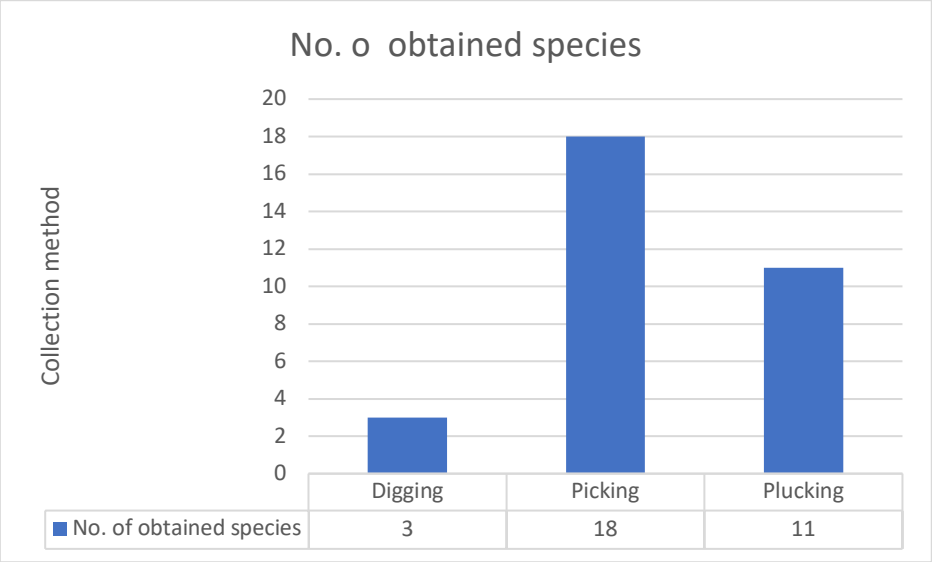

Figure 6. Different collection methods of plant species

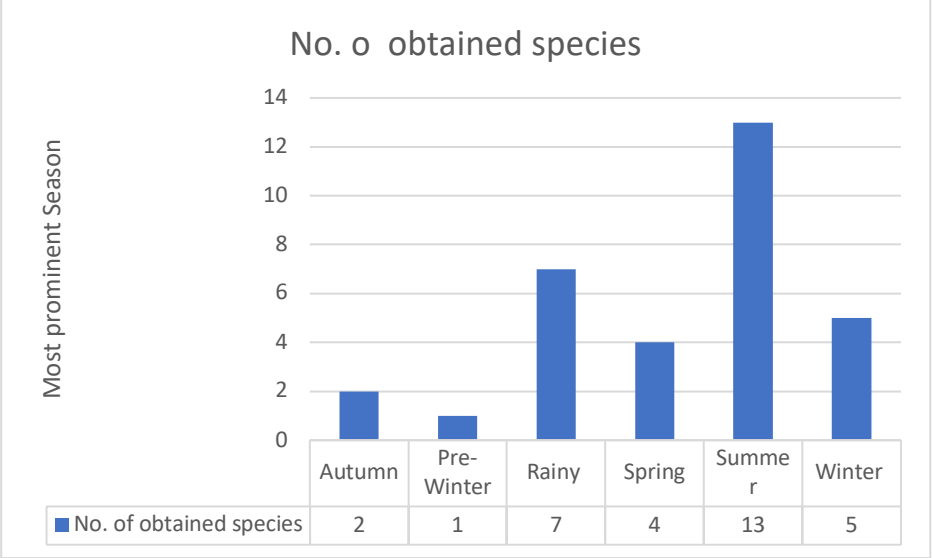

Figure 7. Species obtained concerning different season

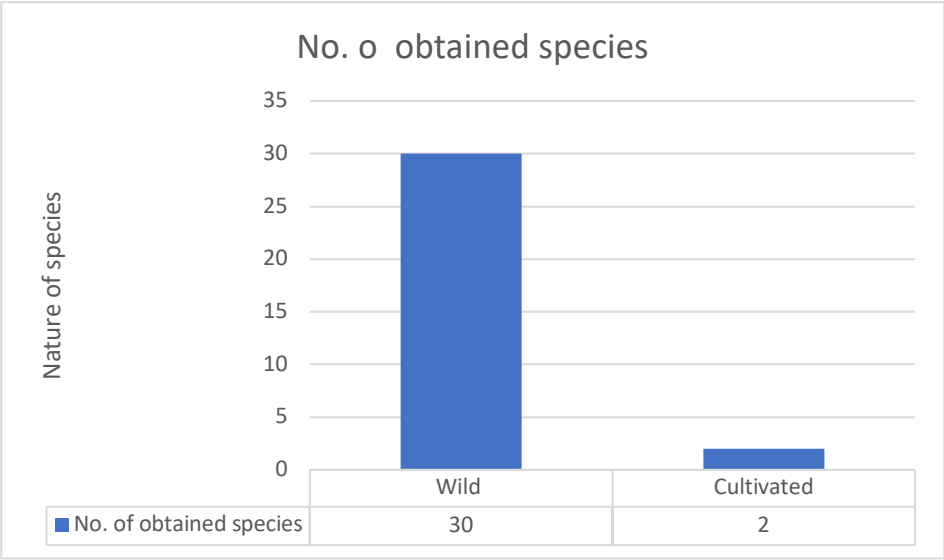

Figure 8. Nature of the obtained species with individual number

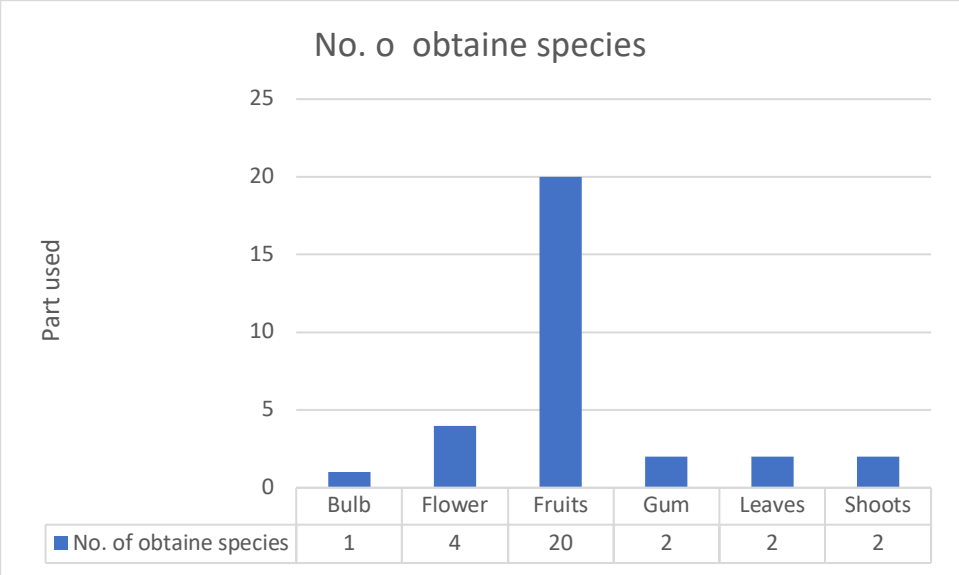

Figure 9. The most common part used by the informants from different species

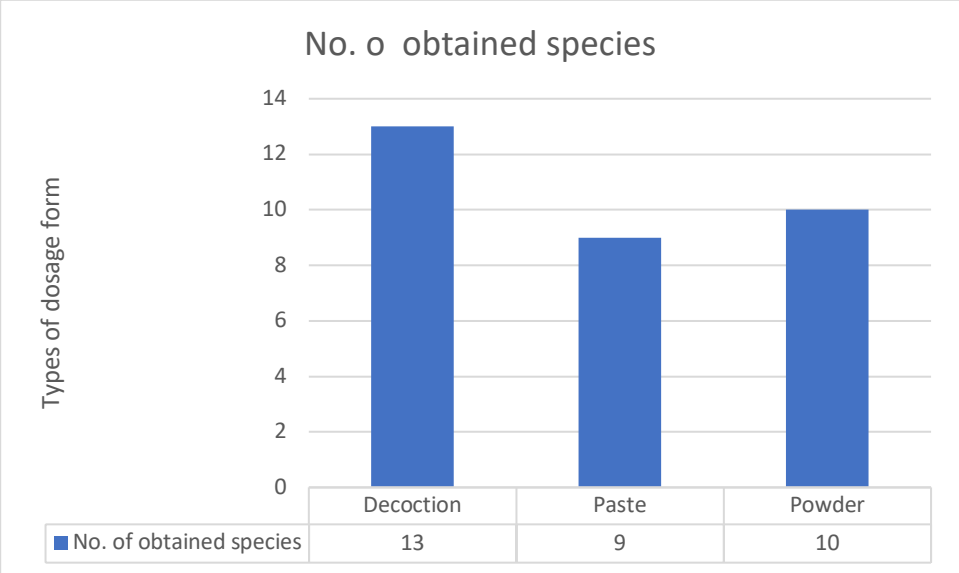

Figure 10. Types of dosage forms prepared by natives of Kalahandi

Table 4. Name, nature, major ingredients and method of preparation of different traditional Bamboo shoot dishes along with their quantitative indices values.

Names of the dishes	**Nature of Dishes**	**Major ingredients**	**Method of Preparation**	**FC**	**RFC**
Kardi chicken Bhaat	Steamed	Half-cooked rice, small pieces of chicken, ginger-garlic paste, turmeric, and chili powder, different types of spices, chopped bamboo shoots, chili sauce, and tomato sauce.	Oil, mustard, and chopped onions are placed in a bowl. Fry the onions until they turn red before adding the paste and other ingredients. Simmer for 5 minutes after adding the chicken. Next, add the half-cooked rice. Cover and cook for 15 minutes with tomato sauce and chili powder.	75	0.86
Kardi achar	Fermented	Red chilies, small slices of bamboo, spices, and oil.	The pickles were ready after cleaning and placing the slices in the jar, adding oil, spices, and marinating.	71	0.82

Kardi desi mouns	Chilies	Chicken, spices, garlic paste, chopped bamboo, onion, and garlic.	Fry the onion with oil, then transfer it to another bowl before frying the bamboo with cumin. Cook the chicken until half-cooked. Simmer the onion paste, fried bamboo, and chicken for 15 minutes on low heat.	80	0.92
Kardi patar puda	Dried	Banana leaf, thread, bamboo shoots, salt, chilies, turmeric powder, spices, gram flour, and chicken.	Stir the chicken with powder, spices, masala, and water along with the washed bamboo in a bowl. Mix gram flour and water. Cover the bamboo with a banana leaf, apply the mixture of spices, and put it over the flame to grill.	73	0.84
Kardi bara	Crispy	Well-chopped bamboo, green gram, rice, sugar, salt, water, and oil.	Add boiled bamboo shoots to rice and grind them separately from the green gram. Add salt and sugar, then shape them into circles to fry in the pan with oil.	67	0.77
Kardi pitha	Cake	Gram flour, water, chopped bamboo, oil, turmeric, and red chili powder.	Combine bamboo and spices in a basin. After that, mix it with gram flour, shape a circle, and bake it for 2 hours over a red flame.	86	0.99
Kardi chingudi khata	Gravy	Bamboo shoot, prawn, tomato, red chilies, mustard, spices, and salt.	In a bowl, coarsely chop all the tomatoes with bamboo and simmer them for five minutes until liquid. Add the required spices. Boil the prawn for five minutes. Then add red chilies to the tomato juice.	73	0.84
Hendua tomato	Gravy	Tomato, hendua, oil, garlic, mustard, green chilies, curry leaves, turmeric powder, and salt as per taste.	Oil a bowl properly. When hot, add curry leaves, mustard, garlic, green chilies, and hendua. Fry it until red. Again, heat oil, add tomato pieces and salt to taste, and fry. After the tomatoes melt, add turmeric powder, fried hendua, and water, and cook for one to two minutes.	69	0.79
Hendua Badi	Dried	Tomatoes, hendua, oil, garlic, green chilies, curry leaves, turmeric powder, salt as per taste, and badi.	Oil a bowl. When hot, add curry leaves, mustard, garlic, green chilies, and hendua. Fry it until red. Fry the badi slowly. Again, heat oil, add tomato pieces, salt to taste, and fry. After adding turmeric powder, add fried hendua and badi and simmer for 1-2 minutes. The Hendua Badi can now be served.	81	0.93
Hendua bhendi	Gravy	Tomato, hendua, oil, garlic, mustard, green chili, curry leaves, turmeric powder, salt as per taste, and bhendi.	Heat oil in a bowl. Once the oil is hot, add mustard, garlic, green chilies, and curry leaves. Place the hendua and fry until it turns red. Low-heat-fry slices of bhendi. In another bowl, heat oil, add tomato pieces, and salt to taste, then fry. As the tomatoes melt, add turmeric powder, fried hendua, and fried bhendi. Add water and cook for 1-2 minutes. Thus, Hendua-Bhendi is ready to be served.	83	0.95
Kardi rai	Gravy	Bamboo shoot, onion, red chili, garlic, ginger, red chili paste, coriander, curry leaves, turmeric powder, mustard, oil, salt, and spices.	Heat oil in a bowl. Add mustard, coriander, curry leaves, and red chilies to the hot oil. Introduce chopped onions, then incorporate the paste of onion, ginger, garlic, and red chilies. Followed by fried bamboo shoots, serve the dish with additional spices after cooking.	83	0.95

Kardi pakoda	Dried	Boil kardi, onions, green chilies, ginger-garlic paste, Chinese salt, food color, red chili powder, turmeric powder, salt, pea powder, and oil.	In a bowl, combine the following ingredients: boiled kardi, green chilies, salt, red chili powder, turmeric powder, food coloring, Chinese salt, ginger-garlic paste, 4 portions of sliced onions, and pea powder. Shape the mixture into small, flattened tikkis and fry in oil until they turn golden brown.	67	0.77
Kardi munga curry	Gravy	Mustard oil, drumstick, salt, bamboo shoot, chopped onion, 1-2 tsp cumin seeds, 2-3 curry leaves, 2 tomatoes, spices, and dry chilies.	Heat 2 teaspoons of oil, cumin seeds, and bay leaf in another pan. Then add the drumsticks. Cook the bamboo shoot with 1 teaspoon of salt and 1 teaspoon of turmeric for 2 minutes over medium heat. Add 2 cups of water, cover, and simmer for 4-5 minutes on medium heat. Add the curry leaf and dried chilies, then cook for an additional 2 minutes with chopped onions. Next, add pieces of tomato and 3–4 tablespoons of water. Cover and let it simmer for 3–4 minutes on low to medium heat. Adjust the flavor and salt. Finally, add 2 cups of water, the cooked drumstick, and the bamboo stalk. Cover the pan and let it cook for an additional 5–6 minutes on medium heat.	75	0.86
Kardi baigana santula	Gravy	Bamboo shoot, brinjal, coriander, chilies, and salt.	In a pan, add 3–4 cups of water and bring it to a boil. Boil bamboo shoots in hot water for 2–3 minutes, then add 2-3 tablespoons of chilies. Finally, add brinjal and cook until golden. Garnish with coriander and simmer for 2-3 minutes.	71	0.82
Kardi ambil	Gravy	Bamboo shoots, okra, eggplant, pumpkin, radish, tomato, dry mango pieces, turmeric, salt, curry leaves, garlic, dry chilies, rice paste, pancha futan, mustard oil, and mustard seeds.	Heat a kadai on the burner and add some oil. Fry the okra for 3–4 minutes. Then fry tomato, eggplant, pumpkin, radish, and dried chilies for 2–3 minutes in the kadai. Add dried mango for seasoning. Mix turmeric powder with garlic, dried chilies, and curry paste. Cook for two to three minutes, then add 3 to 4 cups of water or more as needed. After 10 minutes, add the rice paste and simmer covered over medium heat.	82	0.94
Kardi henua bhaja	Dried	Kardi, hendua, mustard seeds, oil, turmeric powder, chilies, salt, and garlic.	Heat oil in a pan. Once the oil is hot, add mustard seeds, dried chilies, and garlic. After adding turmeric powder, kardi, and hendua, cook for 5–6 minutes.	68	0.78

The biological source of the following ingredients used along with bamboo for preparation of traditional dishes are as follows, Bamboo: *Bambusa vulgaris*, Chilies: *Capsicum frutescens, Tomatoes: Solanum lycopersicum, Okra: Abelmoschus esculentus, Coriander: Coriandrum sativum, Turmeric: Curcuma longa, Curry leaf: Murraya koenigii, Brinjal/eggplant: Solanum melongena, mustard: Brassica nigra, Garlic: Allium sativum, Ginger: Zingiber officinale, drumstick: Moringa oleifera, Pea: Pisum sativum, Panchafutan: Combination* of the seeds of *Cuminum cyminum, Trigonella foenum, Brassica nigra, Foeniculum vulgare, Coriandrum sativum*

Figure 11. Collected photographs of traditional cuisine made from Bamboo shoots with RFC≥0.9 [A]Kardi Rai,[B] Hendua Bhendi,[C] Hendua Badi,[D]Kardi Ambil,[E]Kardi-hendua Pitha,and [F] Kardi Desi Mouns [G]Raw Bamboo Shoots

Discussion

Emphasizing seasonal food is vital for ensuring food safety and promoting healthier choices. Seasonal produce minimizes the use of pesticides and preservatives, contributing to overall well-being (Wallnoefer *et al.* 2021). Rich in essential nutrients, antioxidants, and vitamins, seasonal foods fortify the immune system, playing a crucial role in disease prevention (Kota *et al.* 2023). The recent focus on local, seasonal consumption provides fresher and more nutritious options, supporting farmers and businesses during challenging times (Shrivastava *et al.* 2023). This trend also enhances food security by strengthening local food supply chains and reducing import dependence. The culinary tradition of selecting seasonal ingredients and celebrating the unique flavors and textures each season brings has been practiced for centuries. Summer highlights the peak flavor of plants like tomatoes, strawberries, and corn, allowing chefs to craft vibrant dishes while supporting local farmers and reducing environmental impact (Abbas *et al.* 2019). Rainy seasons offer leafy greens and root vegetables for hearty dishes, enhancing flavor and nutrition in wetter weather (Haq *et al.* 2023). Winter, characterized by cold temperatures, inspires the use of seasonal produce like citrus fruits and cruciferous vegetables, contributing to cozy and nourishing meals that boost the immune system (Majeed *et al.* 2021). Choosing seasonal foods adds variety to menus and ensures freshness and sustainability while supporting local economies.

Kalahandi District's economy relies significantly on agriculture, with critical resources such as Kendu leaf, Mahua, bamboo, wood, and lumber playing pivotal roles (Vandana and Bhattacharya 2023). Cultural festivals, particularly the Nuakhai ceremony after harvest, hold immense significance, involving offerings of the first grains to the gods. The local cuisine, reflecting native ingredients and agricultural practices, features traditional dishes like Pakhala, Santula, Dalma, and various fish preparations (Pradhan & Goswami 2024). The socio-cultural fabric enveloping the utilization of seasonal plants in Kalahandi District is a rich tapestry woven with traditions, beliefs, and community practices. Across generations, ancestral wisdom has been passed down, detailing the diverse roles of seasonal plants in medicinal, culinary, and cultural domains. Trusted local healers, known as vaidyas or traditional medicine practitioners, rely on these botanical resources for healing, emphasizing a deep faith in indigenous therapeutic methods (Mir *et al*. 2023; Panda & Mund, 2019). Furthermore, seasonal plants infuse distinct flavors and nutritional profiles into traditional cuisines, shaping culinary identities and preferences. Ceremonial harvests and festive gatherings centered around seasonal plant collection reinforce communal ties and respect for the land, often accompanied by spiritual significance and collective rituals (Mishra *et al*. 2011). Environmental

consciousness prevails as communities prioritize sustainable harvesting practices to safeguard botanical resources for future generations. Gathering seasonal plants fosters bonds among residents, facilitating knowledge exchange and strengthening social cohesion. Moreover, the economic significance of seasonal plants is evident, with their trade in local markets and contribution to household livelihoods bolstering the local economy (Mohanty and Patra 2022). Residents of Kalahandi maintain a profound connection to their ancestral land, integrating an array of herbs into daily routines for health remedies. Traditional healers, or 'Vaidyas,' transmit ethnobotanical wisdom through oral traditions and folklore. The data indicates the importance of older age groups and educational levels in ethnobotanical studies, as the elderly contribute valuable insights into local customs. At the same time, education influences the community's sharing and comprehension of ethnobotanical knowledge. Male participants share extensive botanical knowledge more than their female counterparts, emphasizing their crucial contribution to ethnobotanical understanding in Kalahandi (Panda and Nayak 2009).

Ethnobotanical surveys identify plants with significant value due to their unique attributes and applications, particularly those specific to distinct seasons. Indigenous societies in Kalahandi showcase a profound understanding of the natural world and the therapeutic properties of flora, with examples like *Azadirachta indica*, *Terminalia bellirica*, and *Terminalia chebula* exhibiting substantial medicinal potential, particularly in terms of antibacterial and anti-inflammatory properties (Jan *et al.* 2021). The study reveals the diverse utilization of plant species in addressing various illnesses and cultural practices in the surveyed area (Jan *et al.* 2022a). Plants, such as Phoenix dactylifera and *Citrus acida*, are integral to medicinal uses for common ailments and play crucial roles in religious rituals, harvest festivals, and customary celebrations associated with specific seasons. These botanical species are also key ingredients in traditional dishes in Kalahandi, emphasizing their cultural significance. Moreover, certain seasonal plants contribute to the economy by generating income and possessing commercial value while enhancing the nutritional status of communities with essential vitamins and minerals (Mir *et al.* 2021). Examining Relative RFC values underscores the extraordinary importance of *Bambusa vulgaris*, *Azadirachta indica,* and Citrus acida. *Bambusa vulgaris*, with the highest RFC, holds paramount utility in medicinal and culinary domains, reflecting its integral role in traditional medicine and local culinary practices. The elevated RFC values emphasize the sustained recognition and reliance on these plants, portraying them as fundamental elements for fostering health and well-being within the community. Notably, *Bambusa vulgaris* emerges as a culturally significant "superfood" in Western Odisha, deeply embedded in customs and religious practices, showcasing its profound ethnobotanical importance for indigenous communities globally (Pradhan *et al.* 2011).

Bamboo holds a central role in the culinary traditions of communities like Bhulia, Kutia, Kondhas, and Gouda, particularly in dishes such as Kardi desi mouns, Kardi pitha, Hendua Badi, Hendua bhendi, and Kardi rai. These culinary customs are deeply rooted and collectively acknowledged through RFC. The geographical unity among these communities, characterized by similar climates and agricultural conditions, facilitates the use of shared indigenous ingredients, showcasing a culinary cohesion grounded in ancestral practices and cultural exchange (Hossain and Mishra, 2002). The interplay of climate, soil, and agriculture contributes to the distinctive flavor profiles of bamboo-infused dishes, emphasizing reliance on seasonal produce and locally sourced ingredients. Historical influences and trade routes have introduced standardized cooking techniques, creating a vibrant and interconnected culinary panorama (Satya *et al.* 2010). Globally, bamboo shoots are celebrated in various cuisines, from Chinese soups and stir-fries to Southeast Asian specialties like nimonos and salads (Gogoi *et al.* 2022; Chaudhary *et al.* 2023; Acharya *et al.* 2023a). In Korean cuisine, bamboo shoots are prominent in dishes such as Jukkumi-bokkeum, showcasing the culinary versatility spanning soups, salads, stir-fries, and curries across East and Southeast Asian cuisines. Ethnobotanically, *Bambusa vulgaris* extends its influence to traditional medicine, with various plant parts, including leaves, shoots, and roots, harnessed for therapeutic properties (Nirala *et al.* 2017). Bamboo leaves, transformed into herbal infusions, are believed to offer health benefits, while bamboo shoots, nutritionally rich, serve as dietary staples in specific indigenous communities, reflecting the plant's role in sustaining local diets and nutritional traditions. Pickled bamboo shoots and bamboo shoot salads contribute to the gastronomic diversity of bamboo-based culinary options (Satya *et al.* 2012; Singhal *et al.* 2013).

Bamboo, as explored by Kumar *et al.* (2017), holds nutritional prowess, boasting essential vitamins (B6, thiamin, riboflavin, niacin, and vitamin E) and a rich mineral profile (potassium, magnesium, calcium, iron, and zinc). Its low-calorie, low-fat content, highlighted by Chaudhary *et al.* (2023), makes it an ideal choice for health-conscious individuals. Additionally, bamboo is a natural source of silica, promoting healthy hair, skin, and nails, and contributing to holistic well-being. Beyond culinary and nutritional roles, bamboo's versatility extends to industries producing biofuels, papers, textiles, and more, supported by the presence of "Hemicelluloses" (Basumatary *et al.* 2017). Flavonoids, recognized for antioxidant properties (Tamang *et al.* 2022), position bamboo as a potential remedy for hypertension and arteriosclerosis. Phenolic acids in bamboo offer anti-inflammatory characteristics, hinting at its potential as a natural remedy for rheumatoid and gout arthritis.

Bamboo's influence also reaches massage therapy, with heated bamboo sticks relieving muscle tension and enhancing relaxation (Pandey *et al.* 2013). However, caution is warranted, as Baruah et al. (2022) noted, due to the presence of hydrogen cyanide (HCN) in bamboo shoots. While bamboo offers respiratory health benefits, boosts the immune system, and aids in detoxification, careful cooking to reduce HCN concentrations is essential for safe consumption (Santosh *et al.* 2022; Sang *et al.* 2011).

Culturally, *Bambusa vulgaris* is integral to daily life, crafted into tools and artifacts by indigenous communities, showcasing its diverse applications, including baskets, fishing traps, and musical instruments (Nirala *et al.* 2017). Bamboo's inner bark in Southeast Asia and the Pacific Islands contributes to strong yet lightweight cloth, enriching textile traditions (Mulatu *et al.* 2019). This cultural integration emphasizes the multifaceted role of bamboo in shaping indigenous material culture and artistic expression. In essence, the deep integration of *Bambusa vulgaris* into the lives of indigenous peoples reflects its adaptability, durability, and cultural, practical, and nutritional significance. This resilient plant exemplifies the symbiotic relationship between indigenous communities and their environment, highlighting the intricate interplay between nature, culture, and tradition throughout history (Bahru *et al.* 2021).

Azadirachta indica holds profound ethnobotanical significance among indigenous communities, showcasing a rich tapestry of traditional knowledge. Recognized for its medicinal prowess, various parts of the neem tree, including leaves, bark, and seeds, are adeptly employed in indigenous traditional medicine, addressing skin disorders and gastrointestinal issues (Sikuku *et al.* 2023). Beyond its medicinal role, neem assumes cultural and ritual importance, featuring in religious ceremonies and revered for its healing properties. In agricultural practices, indigenous communities embrace neem as a natural pesticide, promoting sustainable and eco-friendly pest management in their cultivation methods (Munir *et al.* 2022). Culinary traditions also intertwine with neem, with some communities incorporating young neem leaves into their diet after careful processing to mitigate bitterness. Additionally, neem twigs are natural toothbrushes, contributing to dental care practices by strengthening gums and preventing cavities (Mwingira *et al.* 2023).

Similarly, *Citrus acida* takes on multifaceted roles within indigenous communities. Its medicinal significance is highlighted by its high vitamin C content, which contributes to immune system support and is featured in traditional remedies for colds and respiratory issues (Rahmatullah *et al.* 2009). In culinary and cultural practices, *Citrus acida* becomes an integral part of indigenous cuisines, enhancing both flavor and nutritional value in various dishes. The fruit often holds cultural importance in ceremonies and celebrations. Key lime's Culinary applications extend to sweet and savory recipes, with its juice and zest lending a distinctive taste (Sofiyanti *et al.* 2022). Traditional beverages, including limeades and herbal infusions, are prepared, reflecting cultural practices and offering hydrating and nutritional options. Furthermore, Citrus acida plays a role in indigenous food preservation techniques, leveraging its acidic properties (Jain *et al.* 2021). The ethnobotanical significance, culinary practices, and traditional uses of *Bambusa vulgaris*, *Azadirachta indica*, and *Citrus acida* underscore the profound connection between indigenous people and their natural environment, weaving a narrative of sustainable practices, cultural richness, and holistic well-being.

The sustainability of socio-cultural practices and the preservation of 32 species, including 30 wild species, face challenges that require careful consideration to ensure their conservation and continued utilization. Habitat loss and degradation, stemming from deforestation, urbanization, and agricultural expansion, pose significant threats to the availability of wild plants and disrupt traditional gathering practices (Reid et al., 2019). Additionally, overharvesting and unsustainable collection methods for medicinal, culinary, or cultural purposes can lead to population declines and local extinctions, exacerbating the issue further. Climate change presents another formidable challenge, altering plant distributions and availability through shifts in temperature and precipitation patterns, thus impacting traditional harvesting calendars and practices. Introducing invasive species further compounds these threats, as they out-compete native plants for resources and disrupt traditional plant communities (Sarkar et al., 2006). Conflicts over land use, including competing interests between conservation efforts and socio-economic needs, can compromise conservation efforts and traditional practices. Moreover, the lack of legal protection and enforcement for many wild plant species leaves them vulnerable to exploitation. The erosion of traditional knowledge and cultural practices related to wild plant use further diminishes the value of these species, leading to decreased conservation efforts (Casas et al., 2016). A holistic approach is imperative, integrating conservation, sustainable management, and community engagement to address these challenges. Strategies such as habitat protection and restoration, sustainable harvesting guidelines, community involvement and empowerment, education and awareness, research and monitoring, policy and legal frameworks, and collaboration and partnerships are essential to promote these species' conservation and sustainable use. Through collective action and commitment, we can work towards safeguarding the rich biodiversity and cultural heritage associated with wild plant species in the region (Khan et al., 2013).

Conclusions

In conclusion, our ethnobotanical study sheds light on the crucial role of seasonal plants, particularly *Bambusa vulgaris*, *Azadirachta indica*, and *Citrus acida*, in the daily lives of indigenous communities. By documenting age-old production methods used by these groups to craft essential goods for sustenance, clothing, tools, and medicines, our research highlights their cultural heritage. It emphasizes the need for safeguarding these traditions. The income generated from the handmade goods sustains their livelihoods and serves as a custodian of cultural practices. However, these invaluable customs face threats from modernity and globalization. To address this, integrating traditional wisdom with modern scientific studies is crucial for developing safe nutraceuticals and pharmaceuticals, thereby ensuring the holistic well-being of these communities. Our research underscores the significance of simplifying technology, promoting rural industrialization, and empowering indigenous communities to navigate global changes successfully. Bamboo, renowned for its longevity and adaptability, plays a vital role, as highlighted in our study. Encouraging the use of bamboo and other renewable resources helps communities meet their daily needs and actively contributes to preserving their rich cultural heritage. The documentation provided by our study serves as a valuable resource for future research, offering insights into ethnobotanical significances that can guide sustainable practices and contribute to the well-being of local communities. In future studies, researchers can build upon our findings to further explore and understand the intricate connections between indigenous people and their environment. This documentation enriches academic knowledge and has practical implications for the communities involved. By recognizing and appreciating the ethnobotanical significance of these plants, future initiatives can be designed to support local economies, promote sustainable practices, and ensure the continued flourishing of cultural heritage for generations to come.

Declarations

List of abbreviations: FC – Frequency Citation; RFC – Relative frequency citation; HCN – Hydrogen Cyanide; SDG – Sustainability Development Goals

Ethics approval and consent to participate: Verbal prior informal information consent was obtained before the survey

Consent for publication: People who participated in this study gave their prior informed consent for the publication of the article. People shown in images gave their consent to have their images published.

Availability of data and material: All the supporting data available in the article

Competing interests: The author declared no competing of interest

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Author's Contribution: B.A. designed and analyzed the data, conducted the survey, and framed the final manuscript. A.B. and B.A. prepared and proofread the manuscript. P.K.S, B.C, and S.B. conducted the survey and collected the data. All authors read and approved the final manuscript.

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APPENDIX A

1. **Participant Demographic Information:**

- Gender:

i. Male
ii. Female
iii. Other (please specify): _____

- Age:

i. 18-30
ii. 31-40
iii. 41-50
iv. 51-60
v. 61-70
vi. 71-80

- Caste/Ethnicity: _____
- Educational Information:
  i. No study
  ii. Primary standard
  iii. Less than high school
  iv. High school graduate
  v. Bachelor's degree
- Location (From which they are belonging to)

2. **Survey on Traditional Seasonal Plants:**

i. Are you familiar with traditional seasonal plants in your region?
- Yes
- No

ii. If yes, please list any traditional seasonal plants you are familiar with: _____
iii. Can you describe the habitat or natural environment where these traditional seasonal plants are typically found?
iv. What are the primary sources or methods of obtaining these traditional seasonal plants?
v. Which part of the traditional seasonal plants is typically used in medicinal applications?
vi. What are some of the medicinal uses attributed to these traditional seasonal plants?
vii. Are there any culinary uses for these traditional seasonal plants?
- Yes
- No

If yes, please specify the culinary uses: _____

3. **Survey on Bamboo Shoots and Traditional Dishes:**

i. Are you familiar with bamboo shoots as a culinary ingredient?
- Yes
- No

ii. Can you describe the natural habitat or environment where bamboo shoots are typically found?
iii. What are the primary sources or methods of obtaining bamboo shoots?
iv. Which part of the bamboo plant is typically used in culinary applications?
v. Are there any traditional dishes in your culture incorporating bamboo shoots?
- Yes
- No

vi. If yes, please list some traditional dishes and describe how bamboo shoots are used in them: _____
vii. Can you provide the names of traditional dishes made using bamboo shoots?
viii. How are these traditional dishes typically prepared? Please describe the method of preparation.