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Leafy vegetable diversity and their ethnomedicinal uses against gastrointestinal disorders in the Balasore district of Odisha, India

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ABSTRACT

With an ever-increasing demand for food due to the population explosion, leafy vegetables play a significant role in mitigating the starvation of the human population. The present study was undertaken to explore the diversity of leafy vegetables consumed by the inhabitants and to document their use for gastric disorders in the Balasore district of Odisha, India. A total of 126 leafy vegetables belonging to 93 genera under 43 families were recorded, which revealed that the local communities consume many wild leafy vegetables. Twenty-five species were reported for their ethnomedicinal claims against gastrointestinal complaints, implying their role in maintaining the good gut health of the local populace. *Oxalis corniculata* L. is the most cited ethnomedicinal leafy vegetable for gastrointestinal ailment and diarrhea, with a fidelity level of 93.83%. The Factor of informant consensus value was found to be maximum (Fic value 1) in the disease category of peptic ulcer. The findings of the present study reveal that leafy vegetables not only meet the nutritional requirements but also have the potential to fulfill the medicinal demands of humankind. It can be recommended that further investigation could throw light on their efficacy as a suitable nutraceutical.

1. INTRODUCTION

The accelerated growth of the population worldwide results in growing levels of food inadequacy. To overcome this issue, food production needs to be enhanced to satisfy the food requirements of the growing population. In view of this, exploration, identification, and utilization of less known leafy vegetables could play a prominent role in alleviating the hunger of the world's expanding population [1]. Further, traditional leafy vegetables, being highly nutritive, play a crucial role during times of famine and poor harvest in ensuring food security [2]. Many unexplored leafy vegetables with hidden nutritional and medicinal values exist in their natural habitat that needs commercialization to solve the menace of malnutrition. Leafy vegetables not only add variety and flavor to our diet, but also meet our daily nutrient requirements. Due to their ready accessibility and lower price, they are regarded as "poor man's vegetables," thereby being identified as the food bowl of tribal and rural people. They also earn their livelihood by selling those leafy vegetables in the local market, boosting their socioeconomic standard. Unfortunately, they are considered inferior foods despite being a rich source of nutritional and medicinal values.

Leafy vegetables are excellent sources of minerals such as iron, magnesium, calcium, and potassium, along with Vitamins B, C, E, and K. Besides, they are bestowed with phytonutrients such as beta-carotene, lutein, zeaxanthin, and Omega-3 fatty acids, which protect cells from injury and age-related problems [3]. They are enriched in compounds that possess antidiabetic [4], anti-histaminic [5], and anti-carcinogenic properties [6]. Being enriched in folic acid, leafy vegetables fight anemia. Antioxidants in leafy greens protect against various diseases by scavenging free radicals in our body [7]. Due to the nutritional and therapeutic benefits of leafy vegetables, it can be explored as future herbal drugs and superfoods [8].

Leafy vegetables promote the growth of beneficial gut bacteria, forming a healthy gut microbiome. According to the earlier findings, sulfoquinovose, a sulfonated monosaccharide, found in many green vegetables supplies, a selective but crucial substrate for a few but widely distributed bacteria in the human gut [9]. This particular sort of sugar, which is utilized as an energy source by good gut bacteria as an energy source, increases their dominance and inhibits harmful bacteria from multiplying in the stomach [10]. Furthermore, as a good source of magnesium, leafy vegetables can help relieve constipation by increasing muscle contractions in our gastrointestinal tract. Further, it facilitates bowel movements by increasing water content in the intestines. They are low in calories and fat while being high in dietary fiber; they aid in weight loss and digestion. Thus, leafy greens boost our gut health, protecting us from gastrointestinal disorders.

Although several floristic and ethnobotanical studies on wild edible plants have been conducted in the state of Odisha [11-16], very little attempt has been made to document the diversity and ethnomedicinal uses of leafy vegetables in this region [17,18]. Despite the wide

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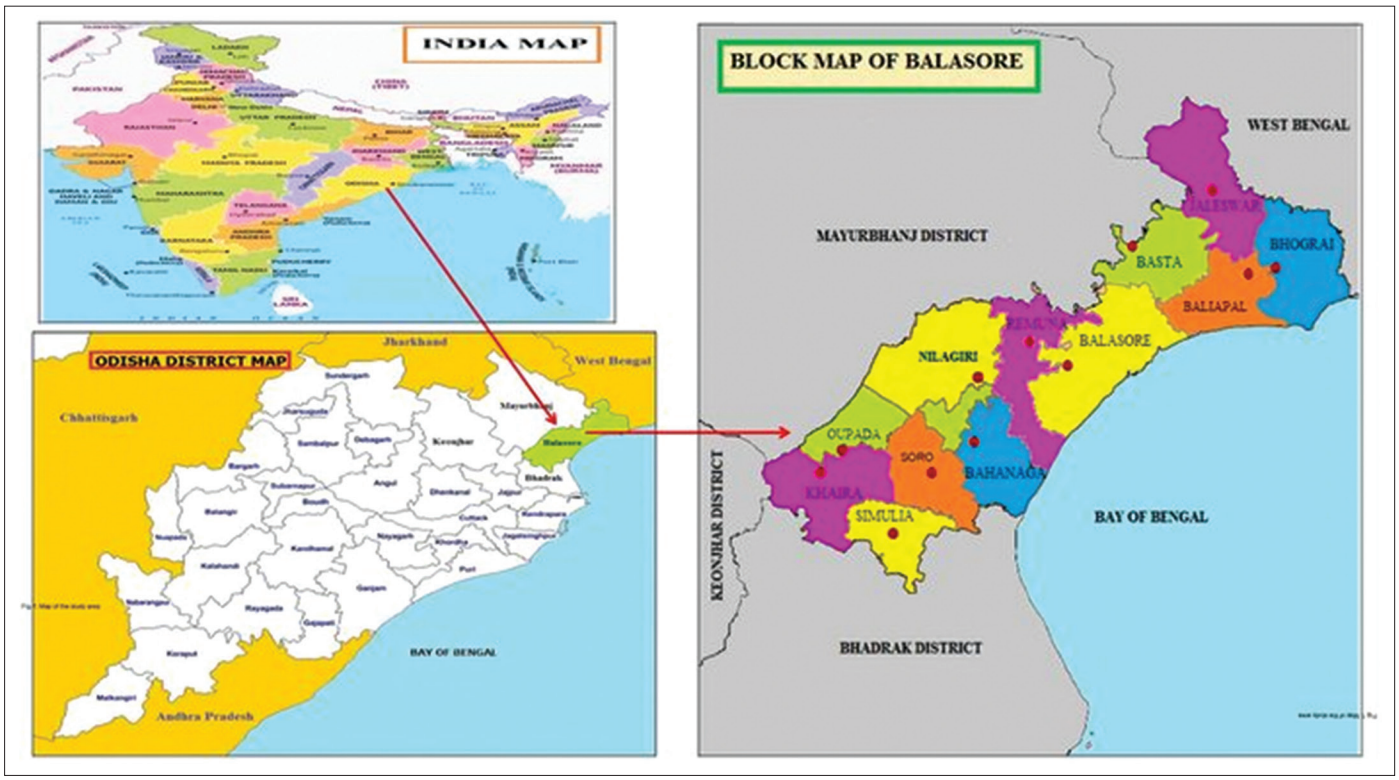

Figure 1: Map of the study area.

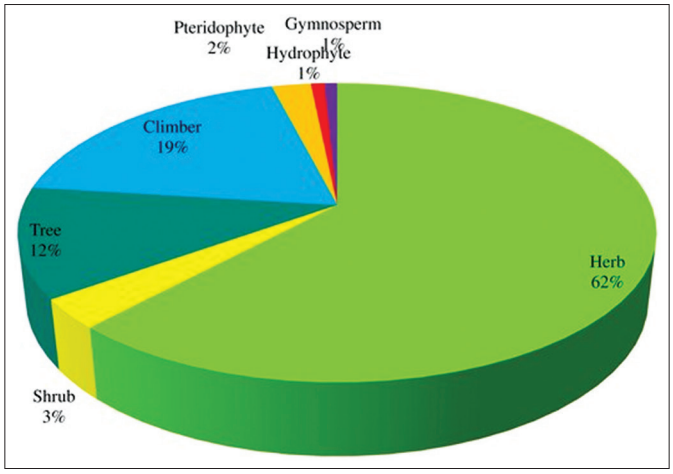

Figure 2: Habit-wise distribution (in %) of leafy vegetables in Balasore district.

diversity of leafy vegetables in the Balasore district of Odisha, it is still unexplored by scientific communities. Therefore, the present study aims to identify, document and create a scientific database on leafy vegetables found in different blocks of the Balasore district, along with the determination of the most cited ethnomedicinally potent leafy vegetable used against gastrointestinal disorders.

2. MATERIALS AND METHODS

2.1. Study Area

Balasore (latitude 21°3'–21°59' N, longitude 86°20'–87°29' E) is an administrative district which is located in the northern most coastal part of Odisha state, in Eastern India [Figure 1]. It is densely populated (92,320,529 people; 2011 census) and covers an area of 3806 km^2. It is bordered on the North by the Midnapore district of West Bengal, on the East by the Bay of Bengal, on the South by Bhadrak district, and the West by Mayurbhanj and Keonjhar districts. Balasore and Nilagiri are the two administrative subdivisions, with 12 C.D. blocks: Jaleswar, Bhograi, Basta, Baliapal, Balasore, Remuna, Nilagiri, Bahanaga, Oupada, Soro, Khaira, and Simulia. It is known for its special tone of the local dialect, "Baleswari bhasa." Besides, this district is inhabited by numerous ethnic, linguistic, religious groups, and indigenous tribes such as Santal, Bhumij, Oraon, etc. It is blessed with a good climate, alluvial soil, and perennial rivers that favor rich floral diversity in this region.

2.2. Data Collection

Intensive seasonal field tours were conducted in the inner pockets of 12 blocks in the Balasore district of Odisha from April 2019 to March 2022. Through semi-structured interviews and discussions, information about the variety of leafy vegetables consumed by the district's native and tribal people, along with their ethnomedicinal uses against gastrointestinal diseases, was gathered. During the survey, 216 local informants were interviewed, including 66% of men and 34% of women. The informants were between the ages of 28 and 80. Each plant's data includes its botanical name, vernacular name, voucher number, family, habit, flowering, and fruiting season. The data for ethnomedicinal leafy vegetables comprise the botanical name, vernacular name, parts used, diseases treated, and mode of utilization.

2.3. Plant Identification and Collection of Voucher Specimens

By referring to the regional floras, plant specimens obtained during field visits were thoroughly studied taxonomically and identified [19-21]. Plants were photographed digitally in their natural

Table 1: Diversity of leafy vegetables in Balasore district of Odisha, India.

S. No.	Botanical name	Vernacular name [O: Odia; B:Bengali]	Family	Voucher number	Habit	Flowering and Fruiting
1	*Abelmoschus moschatus* Medik.	Bano bhindi (O)	*Malvaceae*	NN–363	Herb	Aug–Jan
2	*Abutilon indicum* (L.) Sweet	Pedi–pedika (O)	*Malvaceae*	NN–395	Herb	Jul–Apr
3	*Achyranthes aspera* L.	Apamaranga (O)	*Amaranthaceae*	NN–298	Herb	Oct–Feb
4	*Aerva lanata* (L.) Juss. ex Schult.	Paunsia (O)	*Amaranthaceae*	NN–256	Herb	Aug–Jan
5	*Allium cepa* L.	Piaja (O)	*Amaryllidaceae*	NN–305	Herb	Feb–Apr
6	*Allium sativum* L.	Rasuna (O)	*Amaryllidaceae*	NN–277	Herb	Feb–Apr
7	*Allmania nodiflora* (L.) R.Br. ex Wight	Chadheimundia Saga (O)	*Amaranthaceae*	NN–380	Herb	Jul–Dec
8	*Alocasia fornicata* (Kunth) Schott.	Dudh maan Kochu (B)	*Araceae*	NN–251	Herb	Jun–Sep
9	*Alocasia macrorrhizos* (L.) G.Don	Mana Saru (O)	*Araceae*	NN–390	Herb	Jul–Nov
10	*Alternanthera philoxeroides* (Mart.) Griseb	Denga Madaranga (O)	*Amaranthaceae*	NN–243	Herb	Dec–Apr
11	*Alternanthera sessilis* (L.) R.Br. ex DC.	Chotta Madaranga (O)	*Amaranthaceae*	NN–227	Herb	Jul–Jan
12	*Amaranthus blitum* L.	Kosala (O)	*Amaranthaceae*	NN–232	Herb	Jan–Dec
13	*Amaranthus caudatus* L.	Khada Sago (O)	*Amaranthaceae*	NN–295	Herb	Jun–Oct
14	*Amaranthus graecizans* L. subsp. *thellungianus* (Nevski ex Vassilez.) Gusev	Champa neutiya (O)	*Amaranthaceae*	NN–318	Herb	Aug–Dec
15	*Amaranthus spinosus* L.	Kanta neutia (O)	*Amaranthaceae*	NN–240	Herb	Jan–Dec
16	*Amaranthus tricolor* L.	Lal Khada (O)	*Amaranthaceae*	NN–235	Herb	Jan–Dec
17	*Amaranthus viridis* L.	Leutiya (O)	*Amaranthaceae*	NN–233	Herb	Jan–Dec
18	*Amorphophallus bulbifer* (Roxb.) Blume	Dhala Oal (O)	*Araceae*	NN–353	Herb	Jul– Aug
19	*Amorphophallus paeoniifolius* (Dennst.) Nicolson	Olua (O)	*Araceae*	NN–388	Herb	Apr–Jun
20	*Andrographis paniculata* (Burm.f.) Nees	Bhuinimbo (O)	*Acanthaceae*	NN–396	Herb	Sep–May
21	*Antidesma acidum* Retz.	Matha Saag (O)	*Phyllanthaceae*	NN–225	Tree	May–Dec
22	*Antidesma ghaesembilla* Gaertn.	Kath marmuri (O)	*Phyllanthaceae*	NN–264	Tree	Apr–Oct
23	*Azadirachta indica* A.Juss.	Nimba (O)	*Meliaceae*	NN–261	Tree	Feb–Jul
24	*Bacopa monnieri* (L.) Pennell.	Brahmi (O)	*Plantaginaceae*	NN–211	Herb	Apr–Dec
25	*Basella alba* L.	Poi (O)	*Basellaceae*	NN–284	Climber	Dec–Feb
26	*Bauhinia purpurea* L.	Raajbiji (O)	*Fabaceae*	NN–239	Tree	Sep–Mar
27	*Bauhinia variegata* (L.) Benth.	Kanchano (O)	*Fabaceae*	NN–322	Tree	Feb–May
28	*Benincasa hispida* (Thunb.) Cogn.	Panikakharu (O)	*Cucurbitaceae*	NN–254	Climber	Oct–Jan
29	*Boerhavia diffusa* L. nom. cons.	Puruni (O)	*Nyctaginaceae*	NN–347	Herb	Jan–Dec
30	*Brassica napus* L.	Sorisa (O)	*Brassicaceae*	NN–372	Herb	Sep–Feb
31	*Brassica oleracea* L. var. *botrytis* L.	Phulkobi (O)	*Brassicaceae*	NN–356	Herb	Nov–Mar
32	*Brassica oleracea* L. var. *capitata* L.	Bandha kobi (O)	*Brassicaceae*	NN–374	Herb	Dec–Feb
33	*Brassica oleracea* L. var. *gongylodes* L.	Olkobi (O)	*Brassicaceae*	NN–368	Herb	Dec–Feb
34	*Capsicum annuum* L.	Lanka (O)	*Solanaceae*	NN–221	Herb	Jan–Dec
35	*Cayratia auriculata* (Roxb.) Gamble	Nadara dunka (O)	*Vitaceae*	NN–335	Climber	Jul–Dec
36	*Celosia argentea* L.	Nahanga Saga (O)	*Amaranthaceae*	NN–288	Herb	Aug–Jan
37	*Centella asiatica* (L.) Urban	Thalkuri (O)	*Apiaceae*	NN–270	Herb	May–Nov
38	*Chenopodium album* L.	Bathua Saga (O)	*Amaranthaceae*	NN–237	Herb	Nov –Apr
39	*Cheilocostus speciosus* (J.Konig) C. Specht	Gaigobra (O)	*Costaceae*	NN–392	Herb	July–Dec
40	*Cicer arietinum* L.	Chana (O)	*Fabaceae*	NN–378	Herb	Jan–Dec
41	*Cissampelos pareira* L.	Akanabindi (O)	*Menispermaceae*	NN–316	Climber	Jun–Jan
42	*Clerodendrum infortunatum* L.	Ghetu (B)	*Lamiaceae*	NN–383	Shrub	Jan–Jul
43	*Cleome viscosa* L.	Anasorisha (O)	*Cleomaceae*	NN–202	Herb	May–Oct
44	*Cleome rutidosperma* DC	Anasorisha (O)	*Cleomaceae*	NN–215	Herb	Dec–Feb
45	*Coccinia grandis* (L.) Voigt	Kundri (O)	*Cucurbitaceae*	NN–269	Climber	Jun–Sep
46	*Cocculus hirsutus* (L.) Diels	Musakani (O)	*Menispermaceae*	NN–331	Climber	Apr–May

(*Contd...*)

Table 1: (*Continued*).

S. No.	Botanical name	Vernacular name [O: Odia; B:Bengali]	Family	Voucher number	Habit	Flowering and Fruiting
47	*Coleus barbatus* (Andrews) Benth. ex G.Don	Rukunahata pochha (O)	*Lamiaceae*	NN–283	Herb	Oct–Dec
48	*Colocasia esculenta* (L.) Schott.	Saru (O)	*Araceae*	NN–394	Herb	Jun–Nov
49	*Commelina benghalensis* L.	Kaniseera (O)	*Commelinaceae*	NN–223	Herb	Jul–Jan
50	*Commelina erecta* L.	Konisir (O)	*Commelinaceae*	NN–253	Herb	Aug–Dec
51	*Corchorus aestuans* L.	Bana nalita (O)	*Malvaceae*	NN–245	Herb	Jul–Dec
52	*Corchorus capsularis* L.	Jhutto/Nalita (O)	*Malvaceae*	NN–302	Herb	May–Nov
53	*Corchorus olitorius* L.	Madhura nalita (O)	*Malvaceae*	NN–303	Herb	Jul–Nov
54	*Cordia dichotoma* G. Forst.	Sheluka (B)	*Boraginaceae*	NN–361	Tree	Mar–Sep
55	*Coriandrum sativum* L.	Dhaniya (O)	*Apiaceae*	NN–291	Herb	Nov–Mar
56	*Cucumis sativus* L.	Kakudi (O)	*Cucurbitaceae*	NN–255	Climber	Sep–Nov
57	*Cucurbita maxima* Duchesne	Boitalu (O)	*Cucurbitaceae*	NN–273	Climber	Mar–Aug
58	*Cucurbita pepo* L.	Kakharu (O)	*Cucurbitaceae*	NN–258	Climber	Jul–Oct
59	*Cyanotis axillaris* (L.) D.Don ex Sweet	Kanasari (O)	*Commelinaceae*	NN–262	Herb	Jul–Jan
60	*Cycas orixensis* (Haines) Singh & Khuraijam	Bheru (O)	*Cycadaceae*	NN–349	Tree	May–Oct
61	*Dicliptera bupleuroides* Nees.	Khaparakatia (O)	*Acanthaceae*	NN–262	Herb	Sep–Feb
62	*Diplazium esculentum* (Retz) Sw.	Dheki Saag (B)	*Athyriaceae*	NN–327	Pteridophyte	Jan–Dec
63	*Eclipta prostrata* (L.) L.	Bhrungaraj (O)	*Asteraceae*	NN–272	Herb	Aug–Apr
64	*Enydra fluctuans* Lour.	Hidimicha Sago (O)	*Asteraceae*	NN–311	Herb	Dec–Feb
65	*Eryngium foetidum* L.	Jangli dhania (O)	*Apiaceae*	NN–340	Herb	Apr–Aug
66	*Erythrina variegata* L.	Paladhua (O)	*Fabaceae*	NN–333	Tree	Mar–Jul
67	*Euphorbia hirta* L.	Chita–kutei (O)	*Euphorbiaceae*	NN–241	Herb	Jan–Dec
68	*Ficus religiosa* L.	Aswatta (O)	*Moraceae*	NN–385	Tree	Jun–Oct
69	*Foeniculum vulgare* Mill.	Pan mohari (O)	*Apiaceae*	NN–369	Herb	Oct–Mar
70	*Glinus oppositifolius* (L.) Aug. DC.	Pitagama (O)	*Molluginaceae*	NN–293	Herb	Mar–Oct
71	*Hibiscus sabdariffa* L.	Kaunria Saga (O)	*Malvaceae*	NN–355	Herb	Jul–Feb
72	*Hygrophila auriculata* Schumach.	Koelekha (O)	*Acanthaceae*	NN–308	Herb	Oct–Feb
73	*Ipomoea aquatica* Forssk.	Kalama Saga (O)	*Convolvulaceae*	NN–260	Herb	Nov–Mar
74	*Ipomoea batatas* (L.) Lam.	Kandumulo (O)	*Convolvulaceae*	NN–344	Herb	Dec–Jan
75	*Ipomoea sepiaria* Koenig ex Roxb.	Mushakani (O)	*Convolvulaceae*	NN–370	Climber	Oct–Apr
76	*Justicia adhatoda* L.	Basango (O)	*Acanthaceae*	NN–359	Shrub	Jun–Feb
77	*Lablab purpureus* (L.) Sweet	Simbo (O)	*Fabaceae*	NN–310	Climber	Oct–Feb
78	*Lagenaria siceraria* (Molina) Standl.	Lau (O)	*Cucurbitaceae*	NN–377	Climber	Jul–Feb
79	*Leucas aspera* (Willd.) Link	Gaiso (O)	*Lamiaceae*	NN–299	Herb	Jul–Jan
80	*Leucas cephalotes* (Roth) Spreng.	Goyoso (O)	*Lamiaceae*	NN–292	Herb	Aug–Dec
81	*Luffa acutangula* (L.) Roxb.	Janni (O)	*Cucurbitaceae*	NN–279	Climber	Aug–Nov
82	*Luffa aegyptica* Mill.	Tadari/Pitta Torai (O)	*Cucurbitaceae*	NN–266	Climber	Aug–Nov
83	*Marsilea minuta* L.	Sunsunia Saga (O)	*Marsileaceae*	NN–286	Pteridophyte	Nov–Mar
84	*Marsilea quadrifolia* L.	Sunsunia saga (O)	*Marsileaceae*	NN–325	Pteridophyte	Nov–Feb
85	*Mentha spicata* L.	Pudina (O)	*Lamiaceae*	NN–320	Herb	Jul–Sep
86	*Merremia quinquefolia* (L.) Hallier f.	Chadhei saga (O)	*Convolvulaceae*	NN–351	Climber	Apr–Sep
87	*Mollugo pentaphylla* L.	Pita saga (O)	*Molluginaceae*	NN–324	Herb	Jan–Dec
88	*Momordica charantia* L.	Kalara (O)	*Cucurbitaceae*	NN–265	Climber	Jun–Feb
89	*Momordica dioica* Roxb. ex. Willd	Kankada (O)	*Cucurbitaceae*	NN–280	Climber	Aug–Nov
90	*Moringa oleifera* Lam.	Sajana (O)	*Moringaceae*	NN–229	Tree	Jan–Jun
91	*Murraya koenigii* (L.) Spreng.	Bhursunga (O)	*Rutaceae*	NN–375	Tree	Feb–Sep
92	*Nyctanthes arbor–tristis* L.	Gangaseoli (O)	*Oleaceae*	NN–399	Tree	Sep–Jan
93	*Olax scandens* Roxb.	Bhadbhadia (O)	*Olacaceae*	NN–387	Shrub	Mar–Dec

(*Contd...*)

Table 1: (*Continued*).

S. No.	Botanical name	Vernacular name [O: Odia; B:Bengali]	Family	Voucher number	Habit	Flowering and Fruiting
94	*Oxalis corniculata* L.	Ambiliti (O)	*Oxalidaceae*	NN–315	Herb	Jan–Dec
95	*Paederia foetida* L.	Prasaruni (O)	*Rubiaceae*	NN–338	Climber	Aug–Oct
96	*Pisum sativum* L.	Matar (O)	*Fabaceae*	NN–352	Herb	May–Oct
97	*Polygonum plebeium* R.Br.	Muthi saga (O)	*Polygonaceae*	NN–294	Herb	Feb–Jun
98	*Portulaca quadrifida* L.	Balbalua (O)	*Portulacaceae*	NN–309	Herb	Jan–Dec
99	*Portulaca oleracea* L.	Badabalbalua (O)	*Portulacaceae*	NN–342	Herb	Jan–Dec
100	*Pontederia hastata* L.	Konsida (O)	*Pontederiaceae*	NN–391	Hydrophyte	Apr–Sep
101	*Raphanus sativus* L.	Mula saga (O)	*Brassicaceae*	NN–300	Herb	Jan–Feb
102	*Rungia pectinata* (L.) Nees	Sankh Sago (O)	*Acanthaceae*	NN–332	Herb	Nov–Feb
103	*Senna sophera* (L.) Roxb	Ghodachakunda (O)	*Fabaceae*	NN–217	Shrub	Aug–Feb
104	*Senna tora* (L.) Roxb.	Chakunda (O)	*Fabaceae*	NN–262	Herb	Sep–Dec
105	*Senna occidentalis* (L.) Link	Kola chakunda (O)	*Fabaceae*	NN–329	Herb	Sep–Feb
106	*Sesbania grandiflora* (L.) Poiret	Agasthi (O)	*Fabaceae*	NN–213	Tree	Nov–May
107	*Sesbania sesban* (L.) Merr.	Jayanti (O)	*Fabaceae*	NN–218	Shrub	Oct–Jan
108	*Solanum lycopersicum* L.	Bilati baigan (O)	*Solanaceae*	NN–337	Herb	Jan–Dec
109	*Solanum melongena* L.	Baigana (O)	*Solanaceae*	NN–341	Herb	Jan–Dec
110	*Solanum tuberosum* L.	Alu (O)	*Solanaceae*	NN–268	Herb	Jan–Dec
111	*Spermacoce articularis* L.f.	Solaganthi (O)	*Rubiaceae*	NN–360	Herb	July–Dec
112	*Spinacea oleracea* L.	Palanga (O)	*Amaranthaceae*	NN–257	Herb	Nov–Feb
113	*Spondias pinnata* (L.f.) Kurz.	Ambada (O)	*Anacardiaceae*	NN–210	Tree	Feb–Mar
114	*Streblus taxoides* (Roth) Kurz.	Phutkuli (O)	*Moraceae*	NN–366	Tree	Mar–Jun
115	*Talinum fruticosum* (L.) Juss.	Jangli Poi (O)	*Talinaceae*	NN–290	Herb	Oct–Jan
116	*Tamarindus indica* L.	Tentuli (O)	*Fabaceae*	NN–216	Tree	Jan–Jun
117	*Telosma pallida* (Roxb.) W.G. Craib	Tokeikundei (O)	*Apocynaceae*	NN–307	Climber	May–Jan
118	*Tinospora cordifolia* (Thunb.) Miers	Guluchi (O)	*Menispermaceae*	NN–365	Climber	Aug–May
119	*Trichosanthes cucumerina* L.	Chichendara (O)	*Cucurbitaceae*	NN–400	Climber	May –Aug
120	*Trichosanthes dioica* Roxb.	Potala (O)	*Cucurbitaceae*	NN–252	Climber	Apr– Sep
121	*Trianthema protulacastrum* L.	Khapara Sago (O)	*Aizoaceae*	NN–281	Herb	Jul–Dec
122	*Trigonella corniculata* (L.) L.	Piring Saga (O)	*Fabaceae*	NN–393	Herb	Nov–Mar
123	*Trigonella foenum–graecum* L.	Methi Saaga (O)	*Fabaceae*	NN–397	Herb	Dec–Mar
124	*Typhonium trilobatum* (L.) Schott	Ghet Kachhu (B)	*Araceae*	NN–350	Herb	Jan–Dec
125	*Vigna unguiculata* (L.) Walp.	Jhudango (O)	*Fabaceae*	NN–357	Climber	Jul–Oct
126	*Zanthoxylum asiaticum* (L.) Appelhans, Groppo & J.Wen	Tundpora (O)	*Rutaceae*	NN–345	Climber	Aug–Apr

habitat to facilitate their identification and nomenclature. The plant specimens were dried and kept as voucher specimens using herbarium techniques [22] and submitted as herbarium samples to the Department of Botany, School of Applied Sciences, Centurion University of Technology and Management, Odisha, India.

2.4. Statistical Analysis

With the help of biostatistical formulas, the factors of informant consensus (Fic) and fidelity level (Fl) of the most recorded (cited) leafy vegetables used against gastrointestinal diseases were calculated. The following equation calculated the Fic: Fic = Nur-Ntaxa/Nur-1, where Nur is the number of valuable reports in each category and Ntaxa is the number of species in each category [23,24]. The Fl was calculated for the most commonly reported medicinal leafy vegetables as: Fl (%) = (Np/N) × 100, where Np denotes the number of informants who claim to have used a plant species to treat a specific disease, and N denotes the number of informants who have used the plants as medicine to treat any given disease [25].

3. RESULTS AND DISCUSSION

The study area recorded a total of 126 (122 angiosperms, 3 pteridophytes, and 1 gymnosperm) leafy vegetables belonging to 93 genera under 43 families [Table 1]. Among the 122 angiosperms recorded, 109 were dicot species belonging to 81 genera under 35 families, and 13 were monocot species belonging to 9 genera under 5 families. The distribution of leafy vegetables by habit revealed that 78 (62%) were herbs, followed by 24 (19%) climbers, 15 (12%) trees, 4 (3%) shrubs, 3 (2%) pteridophytes, 1 (1%) hydrophyte, and

Table 2: Ethnomedicinal uses of leafy vegetables against gastrointestinal disorders.

Botanical name and family	Vernacular name	Tribe	Parts used and treatment mode
Achyranthes aspera L. [*Amaranthaceae*]	Buridataram	Santal	Leaves: 1–2 teaspoonful leaf juice is orally administered 3 times a day for 7 days on an empty stomach for curing peptic ulcer
Aerva lanata (L.) Juss. ex Schult. [*Amaranthaceae*]	Chindi	Oraon	Leaves: Leaf paste along with boiled rice is grinded and made into cake and consumed for treating dysentery
Antidesma acidum Retz. [*Phyllanthaceae*]	Matha arak	Santal	Leaves: Dried leaf powder along with water is given for curing dysentery
Basella alba L. [*Basellaceae*]	Purai	Santal	Leaves: ¼ th of the leaf along with two black pepper is grinded and is taken three times a day for treating diarrhoea
Cayratia auriculata (Roxb.) Gamble [*Vitaceae*]	Nadara dunka	Bhumija	Leaves: Dried leaves made into powder and taken for curing dysentery
Cicer arietinum L. [*Fabaceae*]	But arak	Santal	Seeds: 50 g of seeds soaked overnight in water is prescribed raw for treating constipation
Cocculus hirsutus (L.) Diels [*Menispermaceae*]	Musakani	Santal	Leaves: For treating stomach aches, leaf juice along with fresh curd is given twice a day for 3 days
Coleus barbatus (Andrews) Benth. ex G.Don [*Lamiaceae*]	Ban juani	Bhumija	Leaves: 10 ml leaf juice along with a pinch of rock salt is given once in every one hour for curing diarrhea
Cucurbita pepo L. [*Cucurbitaceae*]	Kahanda arak	Santal	Seeds: For expelling intestinal worms, a paste prepared by mixing 25 g seed kernel along with a little water and jaggery is given with 4 teaspoonful warm milk in the morning after breakfast
Eclipta prostrata (L.) L. [*Asteraceae*]	Kala kesadura	Oraon	Leaves: 10 ml of leaf juice added with 20 ml sheep's milk is taken 2 times a day for treating dysentery
Eryngium foetidum L. [*Apiaceae*]	Jangli dhania	Bhumija	Leaves: To stop vomiting caused due to indigestion, 10 ml leaf decoction is consumed 2 times a day on an empty stomach
Erythrina variegata L. [*Fabaceae*]	Paladhua	Oraon	Leaves: To expel intestinal worms in children, 1–2 teaspoonfuls of leaf juice are orally administered once a day for 3–4 days
Ficus religiosa L. [*Moraceae*]	Hesak arak	Santal	Bark: Ash obtained from burnt bark is blended with water and given 2–4 teaspoonful in every 1 h for curing vomiting
Foeniculum vulgare Mill. [*Apiaceae*]	Pan mohari	Oraon	Seeds: Mixture of 10 g seeds and 50 g sugar is boiled in100 ml water and the syrup (5 ml) obtained is given to children 3 times in a day for curing colic and stomach pain caused by gas
Hygrophila auriculata Schumach. [*Acanthaceae*]	Koelekha	Bhumija	Leaves: Equal amount of leaf juice and lemon juice is given once a day for 3 days against worm infestation
Lablab purpureus (L.) Sweet [*Fabaceae*]	Simbo	Bhumija	Fruit: For relieving constipation, stir–fried fruit is consumed
Mentha spicata L. [*Lamiaceae*]	Pudina sakaam	Santal	Leaves: For the cure of diarrhoea, a mixture of leaf juice (10 ml), sunthi powder (5 g dried ginger) and a little salt is given
Momordica charantia L. [*Cucurbitaceae*]	Kaalra sakaam	Santal	Leaves: For complete deworming in children, 20 ml of leaf juice is prescribed in the early morning on an empty stomach for 4–5 days
Murraya koenigii (L.) Spreng. [*Rutaceae*]	Kadhi patta	Bhumija	Leaves: About ½ cup of fresh leaf juice is given in the early morning on an empty stomach to treat hyperacidity
Oxalis corniculata L. [*Oxalidaceae*]	Chomorakoi arak	Santal	Leaves: 10 ml leaf juice along with a little sugar candy powder is given to children twice a day for 2 days for treating diarrhoea
Portulaca oleracea L. [*Portulacaceae*]	Bek saga	Oraon	Leaves: Leaves are boiled, stir–fried and eaten to get rid of intestinal worms
Raphanus sativus L. [*Brassicaceae*]	Mula arak	Santal	Fruit: 20 ml fruit juice added with 10 g sugar candy powder is orally administered twice (morning and evening) on an empty stomach to treat hyperacidity
Spinacea oleracea L. [*Amaranthaceae*]	Palanga	Santal	Leaves: 50 mL of leaf juice and 50 mL of tomato juice are boiled together with a pinch of black salt and black pepper powder and taken orally to treat indigestion and to regain taste
Tamarindus indica L. [*Fabaceae*]	Jojo	Santal	Leaves: For curing vomiting, leaves are boiled and the resulting filtered water is consumed
Trichosanthes dioica Roxb. [*Cucurbitaceae*]	Potala	Oraon	Leaves: To cure diarrhoea, leaf decoction mixed with black pepper powder is orally administered

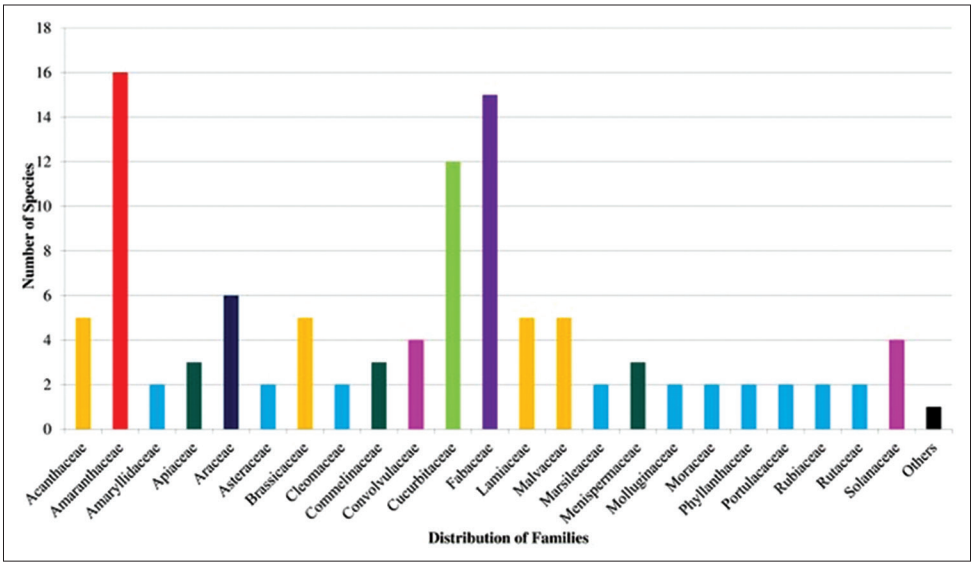

Figure 3: Family-wise distribution of leafy vegetables in Balasore district.

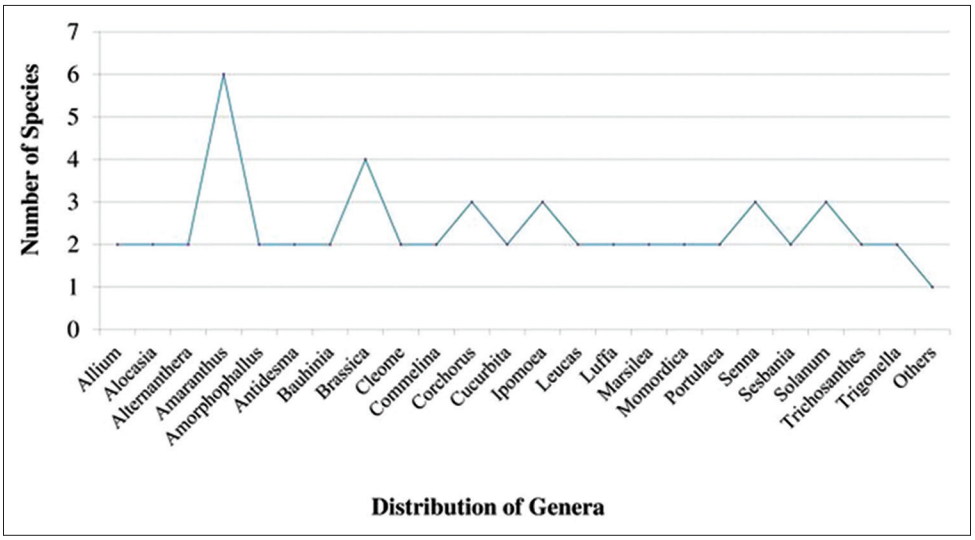

Figure 4: Genus-wise distribution of leafy vegetables in Balasore district.

1 (1%) gymnosperm [Figure 2]. Among the taxonomic families to which the documented leafy vegetables belong, *Amaranthaceae* with 16 species was observed to be dominant, followed by *Fabaceae* (15) and *Cucurbitaceae* with 12 species [Figure 3]. In contrast, Amaranthus with six species was reported to be the dominant genus [Figure 4]. A good number of less-known leafy vegetables, such as *Abelmoschus moschatus* Medik., *Abutilon indicum* (L.) Sweet, *Achyranthes aspera* L. *Aerva lanata* (L.) Juss. ex Schult., *Antidesma ghaesembilla* Gaertn., *Bauhinia purpurea* L., *Bauhinia variegata* (L) Benth., *Cayratia auriculata* (Roxb) Gamble, *Celosia argentea* L., *Cleome viscosa* L., *Dicliptera bupleuroides* Nees. and *Telosma pallida* (Roxb) W.G. Craib, etc. are consumed by the tribes of the Balasore district. Despite the fact that most of the species are grown as weeds, they are consumed as popular leafy vegetables by the tribal and rural belts of the Balasore district, revealing their hidden potential to combat malnutrition and hunger.

It is worth noting that 25 ethnomedicinally potent leafy vegetables belonging to 16 families under 25 genera were documented in the study area, which was used to treat gastrointestinal disorders [Table 2]. The most cited ethnomedicinal leafy vegetables are *Oxalis corniculata* L., *Eryngium foetidum* L., *A. aspera* L., *A. lanata* (L.) Juss. ex Schult., *Momordica charantia* L., and *Murraya koenigii* (L) Spreng. Among the most frequently cited indigenous medicinal leafy vegetables, four species displayed greater than a 75% Fl [Table 3]. *O. corniculata* L., with a Fl of 93.83%, was observed to be the most recommended species against diarrhea. Interestingly, the observations of the present study on *O. corniculata* in the treatment of diarrhea are supported by the studies of several researchers [26-28]. Orally, 10 ml of leaf juice of this plant mixed with a little sugar candy powder is administered twice a day for 2 days to treat diarrhea. Apart from their culinary uses, they have the potential to meet the primary health-care needs of the tribal and rural people, thereby preserving their endangered ethnomedicinal knowledge.

To determine tribal general agreement in the use of the recorded ethnomedicinal plants, the Fic values of total gastrointestinal disorders was categorized into nine groups. The average Fic value obtained for

Table 3: Fidelity level (Fl%) of most cited leafy vegetables against gastrointestinal disorders.

Species	Ailments	NP	N	Fl%
Oxalis corniculata L.	Diarrhoea	137	146	93.83
Eryngium foetidum L.	Vomiting	107	139	76.97
Achyranthes aspera L.	Peptic ulcer	62	81	76.54
Aerva lanata (L.) Juss. ex Schult.	Dysentery	84	111	75.67
Momordica charantia L.	Deworming	128	197	64.97
Murraya koenigii (L.) Spreng.	Hyperacidity	112	177	63.27

Table 4: Factor of informant consensus (Fic) value of each disease category.

Diseases categories	Number of taxa	Used report	Fic values
Diarrhoea	5	163	0.975
Deworming	5	141	0.971
Dysentery	4	97	0.968
Vomiting	3	144	0.986
Indigestion	3	87	0.976
Constipation	2	108	0.99
Hyperacidity	2	121	0.991
Peptic ulcer	1	62	1
Colic and Stomach ache	2	93	0.989

all gastrointestinal disorders categories was 0.982, indicating that most tribals in the Balasore district were well aware of ethnomedicinal plant knowledge. The gastrointestinal disorder category-"peptic ulcer" attained the highest Fic value of 1 [Table 4]. A Fic value of 1 indicated that a large number of respondents used fewer plant species to treat peptic ulcers, thereby indicating that specific plant remedies against peptic ulcers were well practiced among informants in the study area. *A.* aspera L. is used for treating peptic ulcers by the tribals of Balasore district. To treat a peptic ulcer, 1–2 teaspoons of its leaf juice are taken orally 3 times a day on an empty stomach for 7 days. Furthermore, a good number of studies have supported the gastroprotective effects of *A. aspera* against peptic ulcers [29-31].

The results of the present investigation revealed that many unexplored or lesser-known leafy vegetables are still consumed by the tribal and indigenous people, which need immediate documentation and preservation. Several leafy vegetables were used against gastrointestinal complaints, which indicated that they boost our gut health and provide a healthy gut environment. In addition, they are loaded with nutrients and antioxidants that help improve our immunity, thereby protecting us against different diseases. Further, ethnomedicinal leafy vegetables with high FL and Fic values that have not been investigated yet can be screened for phytochemical, nutritional, antioxidant, and pharmacological analysis to discover novel drugs to treat various diseases. However, due to a lack of awareness among people about their beneficial effects, they are underutilized. Therefore, it is recommended that immediate necessary measures should be taken for its exploration, documentation, and conservation for the future sustainable utilization.

4. CONCLUSION

The present study reveals that indigenous leafy vegetables can play a prominent role in addressing developing countries' food scarcity and malnutrition issues. Wild edible plants ensure food security and household income for tribal and rural communities. Documentation and exploration of indigenous leafy vegetables would open up new horizons for popularizing their wider consumption by the indigenous people in their diet, thereby promoting good health. Further research on a greater scale is required to reveal their potential as the future medicines. However, there is an urgent need for restoration and perpetuation of ethnomedicinal uses of indigenous leafy vegetables that face severe genetic loss. Mainstreaming the use of nutrient-rich underutilized leafy vegetables fulfills not only dietary requirements but also meets new market demands. Furthermore, an integrated conservation approach will be an effective measure for the sustainable utilization of undervalued leafy vegetables. Joint forest management, participatory rural appraisal, organic farming, *in situ* conservation strategies, bioprospection, biofortification, and commercialization are essential for effectively utilizing underutilized leafy vegetables.

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6. AUTHORS' CONTRIBUTIONS

KBS and NN conceived the idea. NN performed the experiments. KBS and NN analyzed the information. Both authors have made significant contributions in drafting the manuscript.

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8. CONFLICTS OF INTEREST

The authors report no financial or any other conflicts of interest in this work.

9. ETHICAL APPROVALS

This study does not involve experiments on animal and human subjects.

10. DATA AVAILABILITY

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

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