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NUTRITIONAL EVALUATION OF SOME UNEXPLORED WILD LEAFY VEGETABLES (WLVS) OF MANIPUR, AN INDO-BURMA BIODIVERSITY HOTSPOT (NORTHEAST INDIA)

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Manipur falls under the Indo-Burma biodiversity hotspot region. The ethnic communities have comprehensible knowledge on the use of Wild Leafy Vegetables (WLVs) and highly dependent on them as regular food supplements and for their livelihood. WLVs are considered food-medicine and quality-food because of their nutritional and therapeutics values. They constitute an essential component in bringing household food security of local population. This study is conducted to evaluate the nutritional potential of fifteen unexplored WLVs of Manipur. The values of carbohydrate, lipids, protein, crude fibre, ash and calorific content of these vegetables ranged between 6.32% to 17.84%, 0.71% to 4.86%, 6.35% to 18.00%, 9.68% to 24.85%, 5.40% to 14.80% and 86.23 Kcal/100 g to 156.81 Kcal/100 g respectively. Minerals like sodium, potassium, magnesium, calcium, phosphorous, copper, zinc, iron, and manganese were also evaluated. WLVs contain mineral elements in varying concentration with potassium having the highest concentration and copper the least; while others show moderate to good amount. WLVs are good sources of nutrients and can fulfil multiple mineral requirements. Hence, attempts should be taken to conserve and promote these non-conventional vegetables for their sustainable utilization and to achieve food and nutritional security of local communities.

Keywords: Manipur, Wild leafy vegetables, Nutrient, Mineral, Nutritional security

INTRODUCTION

The use of wild plants as food is an integral part of the culture and tradition of many indigenous communities around the world. A large section of the rural population meets their nutritional requirement through unconventional means, by consuming various wild plants and animal resources [1]. Millions of people, mostly in developing countries, derive a substantial part of their subsistence and income from wild plant products [2]. Wild edibles constitute an essential component in the variation of diet and bring household food security of many ethnic communities. Wild Edible Plants (WEPs) provide staple food for indigenous people and serve as complementary food for non-indigenous people and offer an alternative source of income [3, 4]. They are important sources of nutrient, vitamins, minerals and hence, reduce the vulnerability of local communities to food insecurity thereby acting as a buffer for food shortage during the emergency [5].

Wild species are recognized for their characteristic colour, flavour, unique taste and therapeutic values and are sources of dietary supplements or functional foods. Several researchers also demonstrated that many WEPs have nutritional or therapeutic value due to the presence of biologically active compounds, and therefore can be considered as food-medicine and quality food [6, 7]. Nutritionally, many wild food plants are comparable or even

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superior to commonly cultivated plants [8]. WLVs also play important role in well-balanced diet. In addition to meeting nutrient intake levels, greater consumption of fruits and vegetables is associated with reduced risk of cardiovascular and several other diseases [9, 10]. Since WLVs are known to be rich in micronutrient, they should be included in the diet to eliminate micronutrient malnutrition and prevention of degenerative diseases. Therefore, the incorporation of wild and semi-wild species could be beneficial to nutritionally marginal population, especially in developing countries. The use of wild food plants as supplementary nutrients will not only partly replaced commercial vegetables but also increased the socio-economic community health, food security and conservation practices for sustainable utilization [11].

Even in the present times, WEPs continue to sustain lives of many rural communities across the globe. In Malaysia, Thailand and India about 150 wild-plant species have been identified as sources of emergency food [12]. Similarly, in South Africa, about 1400 edible plants are used [13]. Studies on the consumptions of wild greens in complementing staple food have also been reported in many European countries [14-16]. WEPs have significant contribution to the development of rural population. In the Indian subcontinent, 9500 wild plants are used for food, medicine, fodder, fibre, fuel, essence, cultural and other purposes by over a 53 million tribes belonging to 550 different communities [17]. Studies on agropastoral societies in Africa also indicate that wild plant resources play a significant role in nutrition, food security and income generation [8].

In spite of its manifold uses and important source of valuable food, wild edibles remain largely ignored. Consumption of such vegetables is confined to the people living in areas where they grow, due to non- existence of market chain and social stigma associated with them. Knowledge about their chemical composition is regarded as an important issue in nutritional and phytotherapy research [18, 19]. Nutritive values of commercial vegetables have been studied extensively. Nutritive values of some of the commonly consumed leafy vegetables such as spinach, amaranth, cauliflower, cabbage, lettuce etc., have been reported in the Food Composition table [20]. However, there are several lesser-known vegetables which are available seasonally, but practically no information is available about their nutritional content. Identification of such wild vegetables, which are believed to be nutritious, may help in achieving nutritional (micronutrient) security. Data about the nutritional composition of many WLVs consumed by the people of Manipur is scarce. No records are also available on nutritional potential and future prospects of such plants.

Hence, this study was undertaken to explore the lesser-known WLVs of Manipur and to evaluate their nutritional potential for ascertaining their contribution in food and nutritional security of local communities. The highly nutritive species could be integrated into the agricultural system for sustainable utilization and can be studied for their agro-industrial potential as well.

Study Area

Manipur is one of the seven states of Northeast India that forms an integral part of the Indo-Burma Biodiversity hotspot and has a rich heritage of biodiversity and traditional knowledge. The state lies between 23°27' to 25°41' N latitude and between 93°61' to 94°48' E longitude on the north-eastern part of India and comprises of an area of 22, 327 Km^2. The state is rich in both cultural and biological diversity, having populated by diverse ethnic, linguistic and religious groups including 33 sub-ethnic indigenous tribes. Forests account for 67% of the total land area and agriculture is the single largest occupation and the mainstay of the state’s economy. The tribal communities collect a large variety of wild edible and other useful plants from the forests and surrounding areas. They also sell them at the local market as a means of livelihood. The use of wild vegetables is an integral part of the local cuisine in every household. Knowledge associated with the utilization of WLVs is a part of the Traditional Knowledge (TK) of the ethnic communities.

MATERIALS

According to the previous ethnobotanical review of Konsam *et al.* [21] on WLVs traditionally consumed in Manipur, fifteen of the high-quality and most popular vegetables were selected for the present study. They are as follows - *Antidesma diandrum* (Roxb.) Heyne.ex.Roth, *Gnaphalium indicum* L., *Amomum* sp., *Zanthoxylum rhetsa* DC, *Cycas pectinata* Buch.-Ham, *Viola pilosa* Blume, *Cissus adnata* Roxb, *Ficus bengalensis* L., *Wendlandia glabrata* DC., *Zanthoxylum budranga* DC, *Elatostema lineolatum* Wight, *Aralia armata* Seem, *Piper pedicellatum* DC, *Exbucklandia populnea* Griff and *Clerodendrum colebrookianum* Walp.

METHODS

Sample Preparation

The fresh samples were washed under running water and blotted dry. They were dried under shade for a week or until completely dried, finely powdered and stored in airtight container until analysis.

Analysis of Macronutrient

The moisture content of the wild vegetables was determined in an automated moisture analyser (Sartorius MA 35). The official methods recommended by the Association of Official Analytical Chemists (AOAC) [22] were used to determine ash (#942.05), crude lipid (#920.39), crude fibre (#930.10) and crude protein (#978.04). Total ash content was determined by dry ashing in muffle furnace at 630 °C for 3-4 hrs. Crude lipid was estimated by soxhlet-extraction method using petroleum ether (bp 40-60 C). Crude fibre was determined by acid-base digestion method with 1.25% H_2SO4 and 1.25% NaOH solutions. Crude protein was estimated by the micro-Kjeldahl's nitrogen method, by multiplying the value obtained for percentage nitrogen content by a factor of 6.25. Total carbohydrate content was determined by Anthrone method [23]. Quantification of carbohydrate is done from the calibration curve of the Glucose standard. And Energy values (calorific values) were calculated in Kilocalories (Kcal) by multiplying the values for carbohydrate, fat, and protein by 4, 9 and 4 respectively and adding up the values [24]. Energy, E = [(9×fat) + (4×carbohydrates) + (4×protein)] Kcal/100 g**.**

Analysis of Mineral Profile

For mineral analysis, the samples were digested in tri-acid mixtures (nitric acid, sulphuric acid, and perchloric acid) and diluted to known volume. Magnesium (Mg), calcium (Ca), copper (Cu), iron (Fe), zinc (Zn) and manganese (Mn) were analyzed in Atomic Absorption Spectroscopy, AAS [25]. Sodium (Na) and potassium (K) were analyzed using Flame photometer. The total phosphorus content was determined by Vanadomolybdo phosphoric acid colorimetric method [26]. Quantification of samples is done from the calibration curve of the standard solution of respective elements. All the analyses were carried out in triplicate samples and the data are presented as mean ± SD.

RESULTS AND DISCUSSION

WLVs have numerous dietary and health benefits. They are inexpensive, easy to cook and are rich sources of macro and micronutrients. The ethnic communities of Manipur have a long history of domestication and developed a rich dietary habit of utilizing WLVs. Wild vegetables can be promoted into diets as the most practical and sustainable way to prevent common diseases and ensure nutritive food and health security of the local population. The nutritive values of leafy vegetables consumed by various tribal communities in India were found to be rich in various macro and micronutrients [27].

The nutritional compositions of the WLVs studied are presented in Table 1. The carbohydrate content ranged from 6.32% in *Ficus bengalensis* to 17.84% in *Elatostema lineolatum.* These values are comparable with other leafy vegetables such as *Oenanthe linearis* (6.41%), *Potentilla lineata* (11.05%) but lower than *Houttuynia cordata* (23.45%) as reported by Tapan Seal [28]. WLVs were found to be a poor source of total lipid which ranged from 0.71% in *Piper pedicellatum* to 4.86% in *Cycas pectinata.* But, they are potential source of dietary fibre having found highest in *Ficus bengalensis* (24.85%), followed by *Amomum* sp. (23.71%) and *Elatostema lineolatum* (22.61%), etc., which show good amount. The low lipid and high fibre content of WLVs could particularly be useful in the modern day contexts in preventing lifestyle diseases. Crude protein ranged from 6.35% in *Viola pilosa* to 18.00% in *Amomum* sp. According to the Food and Nutrition Board [29], food plants that provide more than 12% of their calorific value of protein are a good source of protein. In that context, half of WLVs in the present study are good source of protein. Ash content of the WLVs varied from 5.40% in *Cycas pectinata* to 14.80% in *Elatostema lineolatum* indicating that these non-conventional vegetables are good source of minerals. The calorific value ranged from 86.23 Kcal/100 g to 156.81 Kcal/100 g, the highest in *Clerodendrum colebrookianum*, followed by *Gnaphalium indicum (*138.33 Kcal/100 g*)*, *Cycas pectinata* (135.61 Kcal/100 g), etc. Higher calorific value is due to the overall presence of high values of carbohydrate, lipid and protein. The findings of the present study bear similarity with the nutritive values of wild edible plants of Northeastern states of India as reported by Kalitha *et al.* [11] and Tapan seal [28]. However, these results showed slightly higher nutritive content from local vegetables of Nigeria as reported by Agbaire and Emoyan [30] and underutilized GLVs of north India by Gupta and Yadav [31].

WLVs contain macro-minerals like sodium, potassium, calcium, magnesium, phosphorous and micro-minerals

Table 1: Nutritional Composition of Selected Wild Leafy Vegetables (WLVs) of Manipur

S. No.	Species	Edible Part	Total Carbohydrate (%) ±SD	Total Lipids % ± SD	Total Protein % ± SD	Crude Fibre % ± SD	Total Ash % ± SD	Moisture Content (Dry Weight) % ± SD	Energy kCal/100 g
1	*Antidesma diandrum* (Roxb.) Heyne.ex.Roth	leaf	10.026±0.145	1.896±0.824	16.05±0.458	**9.684±1.006**	7.40± 0.00	12.23 ±0.376	121.368
2	*Gnaphalium indicum* L	Whole part	11.576±0.009	3.296±0.776	15.668±0.611	18.55±0.282	10.518± 0.00	14.35± 1.20	138.336
3	*Amomum* sp.	Inflorescence	12.59 ±0.039	1.048±0.100	**18.006±2.413**	23.714±1.835	11.454± 0.00	14.20±0.41	131.816
4	*Zanthozylum rhetsa* DC.	Leaf	13.57 ±0.010	1.765±0.235	11.812±0.494	19.626±0.609	7.252± 0.00	11.81± 0.63	117.413
5	*Cycas pectinata* Buch.-Ham	Leaf	9.098 ±0.022	**4.86±0.28**	13.875±2.650	20.44± 0.42	**5.40± 0.00**	10.81±0.33	135.612
6	*Viola pilosa* Blume	Leaf	17.634±0.139	2.198±0.100	**6.352±1.985**	17.624±1.401	11.488± 0.00	11.91± 0.82	115.726
7	*Cissus adnata* Roxb	Leaf	9.278 ± 0.006	3.448±0.277	9.858±2.396	18.757±2.971	8.101±0.00	14.73± 0.42	107.576
8	*Ficus bengalensis* L.	Inflorescence	**6.327 ± 0.017**	3.08±0.275	13.912±2.511	**24.858±1.180**	6.384± 0.00	12.79± 0.86	108.676
9	*Wendlandia glabrata* DC.	Inflorescence	7.30 ± 0.016	1.982±0.104	11.2±0.854	11.843±0.613	6.968± 0.00	12.06±1.78	91.838
10	*Zanthoxylum budranga* DC	Leaf	11.538±0.068	1.615±0.116	6.387±1.915	14.792±1.360	7.638± 0.00	11.79± 0.71	**86.235**
11	*Elatostema lineolatum* Wight	Leaf	**17.84 ±0.041**	1.665±0.403	9.625±1.802	22.616±0.856	**14.807± 0.00**	13.24±0.291	124.845
12	*Aralia armata* Seem	Inflorescence	15.16 ±0.033	1.798±0.638	10.15±2.211	15.686±0.727	8.769± 0.00	13.47± 1.08	119.182
13	*Piper pedicellatum* DC	Leaf	9.86 ±0.049	**0.716±0.407**	15.163±2.254	18.783±0.256	10.484± 0.00	13.94± 0.26	106.536
14	*Exbucklandia populnea* Griff	Leaf	8.95 ±0.037	3.829±0.422	7.00± 1.442	16.452±0.620	7.781± 0.00	11.80± 1.16	98.261
15	*Clerodendrum colebrookianum* Walp.	Leaf	16.10 ±0.069	2.815±0.321	16.77± 2.351	13.112±0.414	5.677± 0.00	11.35± 0.21	**156.815**

copper, iron, zinc, manganese, etc., in varying concentration with potassium having the highest concentration and copper the least, as shown in Table 2. The values of sodium, potassium, magnesium, calcium and phosphorous are in the range of 41.95-1362 mg/100 g, 1118-3325 mg/100 g, 173.25-1767 mg/100 g, 114-1734 mg/100 g and 74.62-1351.5 mg/100 g respectively. And values for copper, zinc, iron, and manganese are in the range of 0.53-6.76 mg/100 g, 2.40-18.50 mg/100 g, 2.25-31.85 mg/100 g, and 2.0-87.15 mg/100 g respectively. The species with the highest mineral contents are shown in Figure 1a and 1b. Table 3 shows comparative values of the mineral content in WLVs and the Recommended Dietary Allowance (RDA) for Indians, ICMR [32]. The results indicate that these non-conventional leafy vegetables are good source of magnesium, calcium, manganese, copper and moderate source of phosphorous, iron, zinc. Species such as *Antidesma diandrum*, *Gnaphalium indicum*, *Amomum* sp., *Zanthoxylum rhetsa*, *Piper pedicellatum*, *Viola pilosa*, *Cissus adnata,* can meet the needs of multiple mineral requirements in the diet (Tables 2 and 3). WLVs can be promoted as mineral-rich foods and should be included in the diet to overcome micronutrient malnutrition. Including them in the diet on regular basis will play a significant role in combating nutritional disorder and ensuring nutritional security of local population. Domestication and development of cultivation practices for the selected wild vegetables

Table 2: Mineral Composition of Wild Leafy Vegetables (WLVs) of Manipur

S. No.	Species Name	Edible Part	Macrominerals (mg/100 g of DW)					Microminerals (mg/100 g of DW)			
			Na ± SD	K ± SD	Mg ± SD	Ca ± SD	P ± SD	Cu ± SD	Fe ± SD	Zn ± SD	Mn ± SD
1	*Antidesma diandrum* (Roxb.) Heyne.ex.Roth	Leaf	608.5±0.21	1547.6±3.76	1019±0.02	427.1±0.01	851.50±0.00	5.79±0.00	7.79±0.02	6.20±0.00	87.15±0.02
2	*Gnaphalium indicum* Linn	Whole part	631 ±0.27	2381±1.99	1169±0 .09	297.5±0.00	691.25±0.00	5.73±0.05	13.14±0.27	18.50±0.01	12.75±0.15
3	*Amomum* sp.	Inflorescence	476 ±0.19	3325±3.25	642 ±0.01	397.1±0.05	1351.5±0.00	6.76 ±0.10	8.9 ±0.12	18.33±0.01	26.90±0.01
4	*Zanthozylum rhetsa* DC.	Leaf	1362±0.09	2598±0.35	1224±0.01	728±0.00	406.75±0.00	5.60±0.05	8.45±0.03	5.30±0.00	67.55±0.06
5	*Cycas pectinata* Grift	Leaf	135.45±0.23	1433.3±4.30	173.25±0.00	114±0.07	520.90±0.02	0.53±0.00	11.25±0.05	6.51±0.05	2.71±0.05
6	*Viola pilosa* Blume	Whole part	378.45±0.15	1339.6±1.47	938.25±0.02	1032±0.01	282.90±0.00	0.53±0.04	31.85±0.54	15.5±0.02	11.21±0.00
7	*Cissus adnata* Roxb	Leaf	301.45±0.14	2400.6±1.77	862±0.01	782±0.01	266.20±0.00	0.60±0.05	23.65±0.05	6.15±0.01	60.19±0.03
8	*Ficus bengalensis* Linn	Inflorescence	70.45±0.04	1338.66±3.68	283.25±0.00	269.50±0.00	412.10±0.00	1.21±0.00	6.85±0.01	4.78±0.05	2.00±0.00
9	*Wendlandia glabrata* DC	Inflorescence	42.45±0.00	1347.00±7.23	794.50±0.03	994.50±0.09	267.45±0.00	0.77±0.00	2.25±0.02	3.68±0.02	8.54±0.05
10	*Zanthoxylum budranga* DC	Leaf	231.95±0.03	2389±2.74	809.5±0.00	179±0.00	249±0.00	0.61±0.07	4.60±0.00	2.40±0.00	50.89±0.04
11	*Elatostema lineolatum* Wight	Leaf	214.45±0	2045±3.90	1767±0.01	469±0.42	187.50±0.00	0.59±0.02	24.45±0.01	8.77±0.02	25.84±0.01
12	*Aralia armata* Seem	Inflorescence	346.44±0.09	3159.6±5.52	924±0.00	1594±0.07	355.40±0.00	1.06±0.02	4.40±0.03	5.54±0.08	5.32±0.00
13	*Piper pedicellatum* DC	Leaf	239.85±0.12	1324.3±1.71	1384±0.05	1734±0.23	474±0.00	6.31±0.20	8.33 ±0.21	14.20±0.01	9.41±0.00
14	*Exbucklandia populnea* Grift	Leaf	97.95±0.00	2225.3±4.72	573.25±0.02	1294.50±0.05	307.65±0.00	0.78±0.03	6.15±0.05	4.18±0.05	4.75±0.05
15	*Clerodendrum colebrookian* Walp	Leaf	41.95±0.02	1118.6±5.15	413.25±0.01	819±0.28	74.62±5.77	1.96±0.02	4.05±0.04	3.38±0.08	31.49±0.09

Note: Na = Sodium, K= Potassium, Mg = Magnesium, Ca = Calcium, P = Phosphorous, Cu = Copper, Fe = Iron, Zn = Zinc, Mn = Manganese.

Figure 1: Wild Leafy Vegetables (WLVs) with highest a) Macromineral, and b) Micromineral Content

(a)

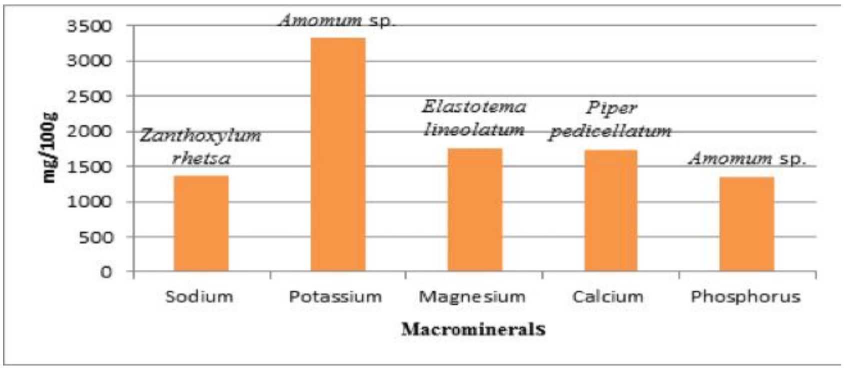

Figure 1 (Cont.)

(b)

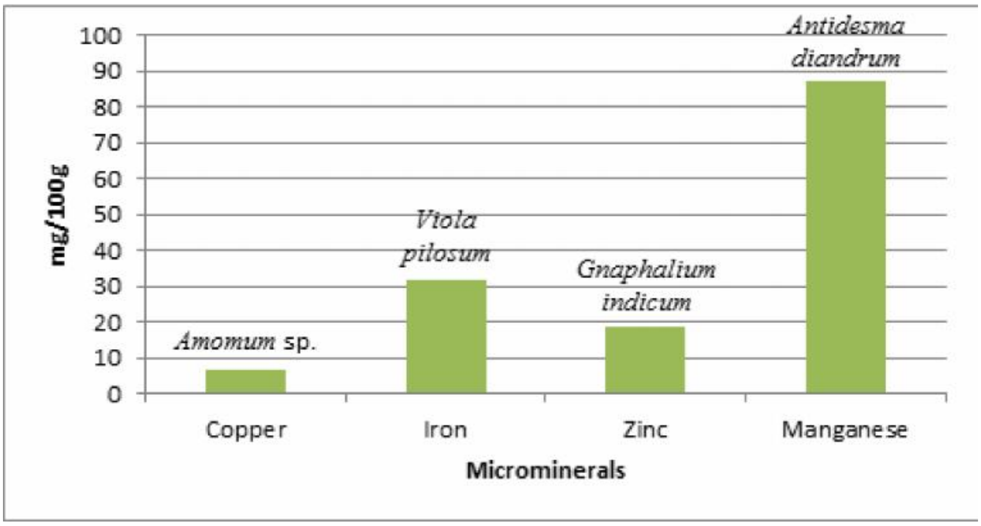

Table 3: Comparison of Minerals Content of WLVs with the RDA of Indians (RDA, ICMR, 2010)

Minerals	Range of Minerals Available in WLVs in mg/100 g	Recommended Dietary Allowance for Indians (mg/day)			Remarks
		Adult Men	Adult Women	Pregnant Woman	
Calcium	114 - 1734	600	600	1200	
Magnesium	173.25 - 1767	340	310	310	
Sodium	41.95 - 1362	2092	1902	-	Minimum requirement for adults is 500 mg and for children 58 mg/day
Potassium	1118.6 - 3325	3750	3225	-	
Phosphorous	74.62 - 1351.5	600	600	1200	
Iron	2.25 - 31.85	17	21	35	
Zinc	2.40 - 18.50	12	10	12	
Copper	0.53 - 6.76	2	2	-	
Manganese	2.00 - 87.15	2-5	2-5	-	

which are nutrient-rich will benefit the local communities by widening their nutrition base.

CONCLUSION

Based on these findings, WLVs can be recommended as a good source of dietary supplement to staple food. Since they are valuable to the human diet and are rich sources of nutrients, it is important to identify and promote the use of wild vegetables to improve nutrition and health status of the local people. They are likely to be neglected in future due to loss of traditional knowledge, growing urbanization and influence of western culture in food habits. Nutritional information can guide the people in decisions regarding the selection of important wild vegetables. Nutritionally potent WLVs should be integrated into the agricultural system for sustainable utilization, achieving nutritional security and further exploitation. Also, keeping in view the recent interests on pharmafoods and neutraceuticals, the study of wild-food plants assumes significance. Therefore, it is of utmost importance that nutritional, anti-nutritional, medicinal databases of wild species should be established to gain more information on these unique species. Many of them may possess superior genetic resource for the development of novel food products; therefore, studies about their nutritional and chemical characteristics are of great interest to understand their agro-industrial potential and to stimulate commercial exploitation from the wild to industries.

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