ETHNOBOTANICAL DIVERSITY AND PHYTOCHEMICAL STUDIES OF SELECTED PLANTS SPECIES IN CHURACHANDPUR DISTRICT, MANIPUR

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

K. THANG LIAN KHUP

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BY

K.THANG LIAN KHUP

Department of Botany

Supervisor:

Dr. KHOMDRAM SANDHYARANI DEVI

Submitted

In partial fulfillment of the requirement of the Degree of Doctor of Philosophy in Botany of Mizoram University, Aizawl.

Dr. Khomdram Sandhyarani Devi
Assistant Professor
Department of Botany
Phone-Office: (0389) 2330733, 2330857
Mobile: + 91 9615586093
E-mail: sandhyakhomdram@gmail.com

MIZORAM UNIVERSITY
TANHRIL:AIZAWL-796004
MIZORAM, INDIA
Gram: mzu
Post Bag No: 190
Website: www.mzu.edu.in

CERTIFICATE

This is to certify that this study **"Ethnobotanical diversity and Phytochemical Studies of selected plants species in Churachandpur District, Manipur"**, submitted by **K. THANGLIANKHUP** (MZU/Ph.D/1027 of 26/05/2017) in partial fulfillment of the requirement of the degree of Doctor of Philosophy in Botany is a record of bonafide work carried out by him under my supervision and guidance.

Place: **Dr. KHOMDRAM SANDHYARANI DEVI**

Date: Supervisor

DECLARATION

MIZORAM UNIVERSITY
MARCH, 2025

I **K. THANGLIAN KHUP**, hereby declare that the subject matter of this thesis is the record of work done by me, that the contents of this thesis did not form basis of the award of any previous degree to me or to do the best of my knowledge to anybody else, and that the thesis has not been submitted by me for any research degree in any other University/Institute.

This is being submitted to the Mizoram University for the **Degree of Doctor of Philosophy in Botany.**

(K. THANG LIAN KHUP)

Candidate

(Prof. F.LALNUNMAWIA)	**(Dr. KHOMDRAM SANDHYARANI DEVI)**
Head of Department	**Supervisor**

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K.THANG LIAN KHUP

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Abbreviations

%	Percentage
<	Less than
>	Greater than
°C	Degree Celsius
µg	Microgram
ABTS	(2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid
ANF	Anti-nutritional factors
BHT	Butylated hydroxytoluene
BSI	Botanical survey of India
Ca	Calcium
Ccpur	Churachandpur
CE	Critically endangered
cm	Centimetre
CP	Cultivated processed
CR	Cultivated raw
Cu	Copper
DMRT	Duncan's multiple range comparison
DPPH	2,2-diphenyl-1-picrylhydrazyl
DW	Dry weight
Et al.	"*et alia*" and others
Etc	Et cetra: and other things
Fe	Iron
FTIR	Fourier Transform Infrared Spectroscopy
GAE	Gallic acid equivalent
Hb, Sb, Tr, Cl, Ep, Lv, St, Fr, Fl, Sd, Rh, Rt, Bk.	Herb, Shrub, Tree, Climber, Epiphytes, Leaves, Stem, Fruit, Flower, Seed, Rhizome, Root, Bark,
ICF	Informant Consensus factor
ICPC	International Classification of Primary Care
LC, VU, NE, DD	Least Concern, Vulnerable, Not Evaluated, Data Deficient

LCMS	Liquid chromatography-mass spectroscopy
Mg	Miligram
Ml	Mililiter
Mn	Manganese
MZUH	Mizoram University Herbarium
Ni	Nickel
P/T/H/G/V/S/H	Paite , Thadou, Hmar, Gangte, Vaiphei, Simte, Zou
Pb	Lead
PCA	Principle Component Analysis
QAE	Quercetin acid equivalent
Rh	Rhizome
Sq.km	Square kilometres
TFC	Total flavonoid content
TPC	Total phenol content
WEP	Wild edible plants
WHO	World Health Organisation
WP	Wild process
WR	Wild raw
Zn	Zinc

CHAPTER–1

Introduction

1.1. General introduction on ethnobotany

To comprehend the relationship between indigenous people and its associated phytoresources, ethnobotany was developed in late 19th century and spread through the 20th century with its multi-dimensional approaches. Harshberger (1895), who coined the the term “Ethnobotany” defined it as the study of plants used by primitive and aboriginal people. The term "ethnos" originates from the Greek word for "Nation," while "botany" refers to the study of plants. "Ethnos" is further linked to "ethnic," denoting a group sharing a common heritage, culture, or language. Schultes (1962) defined ethnobotany as the study of relationships between people of a primitive society and the environment. Jones (1941) defined ethnobotany as the study of the interrelations of primitive man and plant. He established the foundation for the future development of ethnobotany. Castetter (1944) defined ethnobotany, as ‘The Domain of Ethnobiology’ and advised researchers to keep certain "factors" in mind when conducting field studies including plant identification, relative abundance and availability of the plants. Faulks (1958) however, redefine ethnobotany as the relationship between man and plants, with a broader perspective beyond the scope of economic botany. Jain and De (1964) defined ethnobotany as “the relationship between the indigenous people and their plant surroundings”.

Ethnobotany is developing into an interdisciplinary science which can serve as gateway to many disciplines that encompasses the aspects of humanities and sciences that include ethnomedicine, ethonagriculture, ethnogastrology, ethnohorticulture, ethnomusicology, ethnotoxicology, ethnopharmacology, ethnogynaecology, ethnopediatrics, ethnonarcotics, ethnocosmetics, ethnolinguistics, ethnoorthopaedics (Jain,1986). Many of the ethnobotanical works highlight valuable information on the complex relationship between humans and plants along with the cultural and ecological significance of plants on human life. Recent ethnobotanical research work comprises of interactions with the local informants through different

types of interviews by taking prior informed consent, followed by survey and collection of the ethnobotanically important plants for their correct identification and further screening and phytochemical analysis of some selected significant plants (Alexiades, 1996; Yadav et al., 2014) . Ethnobotany has become a significant focus of research for documentation, preservation of historical traditional knowledge of the indigenous communities which also aims to develop resource management, biodiversity conservation at genus, species, ecosystem, forest type and regional level (Bussmann, 2002). Recently, indigenous traditional knowledge has been employed to describe information with reference to ethnobotanical importance of plants (Chauhan, 2020). In this context, the World Health Organization (WHO) has initiated funding for numerous research endeavours focused on Traditional Herbal Medicine across many developing countries worldwide (WHO, 2019). In India, institutions such as the Botanical Survey of India (BSI), Central Council of Research in Unani Medicine (CCRUM), Central Drug Research Institute (CDRI), National Botanical Research Institute (NBRI), Cental Institute of Medicinal and Aromatic Plants (CIMAP) along with several other institutions and Universities are actively participating in diverse aspects of ethnobotanical research, including bioprospecting from medicinal plants (Jain and Jain, 2016).

Another aspect of ethnobotany is the study of wild edible plants (WEPs) as a source of medicine and food. WEPs are found in various natural habitats, not subject to cultivation or domestication, and are harvested for consumption as food (Meragiaw et al., 2015). Food and Agricultural Organization (FAO) described WEPs as "plants that develop spontaneously in self-maintaining populations in natural or semi-natural habitats and can persist without direct human influence" (Heywood, 1999). WEPs protect the ethnic community against food insecurity during famine or conflict (Balemie and Kebebew, 2006). Many WEPs have medicinal properties with potential sources of natural antioxidant compounds (Matkowski, 2006; Uusiku et al., 2010) that provide protection from oxidizing agents and free radicals (Kaur et al., 2002). At times, wild edible species exhibit higher nutritional value compared to domesticated species as indicated by their distinctive characteristics such as colour and flavour (Msuya et al., 2010). While consuming WEPs as food sources, it is

essential to prioritize nutritional considerations. However, the nutritional value of these plants has been a subject of scrutiny among many researchers due to existence of chemicals affecting the nutrients known as the anti-nutritional factors. Anti-nutritional factors generally include phytic acid, lectins, oxalates, tannins, alkaloids, saponins etc. that can interfere with the absorption of nutrients in the body (Thakur and Kumar, 2017). So, knowledge about the nutritional composition as well as about the antinutritional factors of the WEPs is necessary to provide the complete nutritional values. After undergoing traditional culinary processes, these wild species can serve as supplements to address nutrient deficiencies and prevent degenerative diseases reducing the anti-nutritional factors (Sethi et al., 2021).

The eight Northeast (NE) states of India have a vast scope for ethnobotany as it is home to diverse ethnic tribal communities with rich indigenous knowledge of plant usage. Manipur state is a part of NE India and is home to several distinctive ethnic groups. The state is located under Indo-Burma biodiversity hotspot which is recognized globally as one of the most biodiverse region inhabited by many ethnic communities that offers immense scope for ethnobotanical studies (Sharma et al., 2013).

1.2. Brief description of Manipur

Manipur nestled amidst mountains and lush valleys, stands as one of the eight NE states of India. Situated on the arm of the Himalayas known as the Purvanchal (Eastern) mountain ranges, it spans from 92°58´E to 94°45´E longitudes and 23°50´N to 25°42´N latitudes, encompassing a total geographical area of 22,327 km squares. Encircled by nine hill ranges, the state boasts a captivating oval shaped valley at its centre. Manipur shared its international boundary with Myanmar to the east, while Cachar hills of Assam border to the west. Nagaland lies to its north, and the Chin Hills of Myanmar and Mizoram border it to the south (Pamei, 2014). The altitude within the state ranges from 790 metres to 3500 metres above mean sea level enjoying a subtropical to temperate climate. Manipur can be divided into two distinct regions viz. the hills and the dales. The hill region encompasses five districts: (i) Senapati, (ii) Tamenglong, (iii) Churachandpur, (iv) Chandel and (v) Ukhrul. In

contrast, the valley comprises of four districts viz. (i) Imphal East, (ii) Imphal West, (iii) Bishnupur and (iv) Thoubal (Zou, 2018). Notably, recent administrative changes have resulted in the addition of seven new districts: Kamjong, Kakching, Tengnoupal, Noney, Jiribam, Pherzawl and Kangpokpi (Meitei, 2019). The state is celebrated for its pictureaque landscapes, abundant natural resources and cultural heritage that show cases a diverse topography. The natural vegetation of the state covers about 17,418 square km which is about 78% of the total geographical area. The state experiences various climatic zones, ranging from tropical rainforest to sub-alpine forest (Anonymous, 2002).

1.2.1. Drainage

Manipur features several significant drainage systems contributing to its hydrological landscapes. The largest drainage system includes (a) The Barak River System, (b) The Manipur River System and (c) The Chindwin River System. (Kshetrimayum and Laishram, 2020)

The Barak River is a major river that flows through Manipur, providing a crucial drainage system. It drained through the fertile plains impacting the irrigation system of the region and water resources. The important tributaries include Jiri, Tipai, Maku, Irang, Leimatak and Maklang rivers (Salam, 2013).

The Manipur River system is recognized as one of the longest rivers in the region that exhibits a dendritic pattern. It originates from the borthern hills of the state and flos in a branching and tree like manner. Among the main tributaries are Iril, Thoubal, Khuga and Chakpi rivers where all these tributaries conversge into Loktak Lake which stands as the largest freaswater lake in Northeast India.

The Chindwin River System includes Akonglok, Chamu, Chingai, Yu and their associated tributaries sucgh as maklang, Tuyungbi, Taretlok, Lokchao, Limlok and Tuiyang Rivers (Laishram and Kshetrimayum, 2018).

1.2.2. Vegetation

The natural vegetation in the state is largely influenced by factors such as geological structure, relief, soil properties, and climatic conditions, including rainfall and temperature. According to Kingdom Ward (1952) the forests in Manipur encompass types found in the Himalaya to Malaya to Chinese region (Dikshit et al ., 2014). The total forest covers 15,154 sq. km, with tree forest comprises 50%, bamboo forest 22% and open forest 28% contributing significantly to forest products. Various forest types contribute to this extensive covering including Wet Temperate Forest, Pine Forest, Wet Hill Forest, Semi-evergreen Forest, Bamboo brakes, and Grass brakes (Meitei et al., 2019). The hilly region is well characterized by dense natural vegetation, encompassing a variety of trees, shrubs, herbs and bamboos. However, 'Jhum' cultivation has disrupted the habitats of many important plants, placing several plant species at the brink of extinction in different parts of the district (Sharma, 2001)

(a) Temperate forests

These forests types are found at elevations beyond 1600m in areas such as Ukhrul, Hingsaw and Maoching, closely bordering evergreen Noteworthy species in this category include *Quercus glauca, Q.griffithii, Q.lamillosa, Q.serrata, Castanopsis tribuloides, Lithocarpus dealbata, Mahonia* sp., *Magnolia* sp., *Machilus* sp., *Rubus ellipticus, Rhododendron arboretum.* Some of the herbaceaous species include *Hedychium* sp., *Impatiens* sp., and *Polygonum* sp.

(b) Pine forests.

These forest types are situated in the northeastern hilly tracts of the state, bordering Ukhrul and Chandel districts (Indo-Myanmar border), as well as in the western hilly tracts of the Tamenlong district. It extends up to an altitude of 900 to 1800m. Important species in this ecosystem include *Pinus kesiya, Quercus* sp., *Castanopsis* sp., *Rhododendron arboreum, Betula* sp., *Alnus napalensis, Lithocarpus dealbata, Ageratina adenophora, Lyonia aovalifolia, Dendrobium* sp., *Vanda* sp. and

various terrestrial and epiphytic ferns that form gregarious patches (Nandy et al., 2006

(c) Wet hill forests.

These forests, ranging from evergreen to semi-evergreen, thrive at altitudes between 1000 to 1800m, where the annual rainfall exceeds 200-450 cm. The vegetation in these forests is notably rich in shrubs and herbs. In the presence of trees, their height reaches up to 20m. Key plant species in this habitat include *Toona ciliata, Tectona grandis, Schima wallichii, Pinus* sp., *Quercus* sp., *Prunus cerasoides, Gaultheria* sp., *Rhus semialata, Artemisia* sp., *Urena lobata* etc. (Rawat, 2008)

(d) Semi-evergreen forests

These forests extends over Tamenglong and Churachandpur districts in the Western hills of Manipur, receiving an average rainfall of 300-500cm. Rich in species diversity, it is limited to an altitude of 1200m. Key species in this forest include *Quercus dealbata, Q.griffithii, Duabanga grandiflora, Alnus napalensis, Gmelina arborea, Phyllanthus emblica, Engelhardtia spicata, Entada pursaetha, Mangifera indica, Hedychium* sp, *Polygala arillata, Ageratina adenophorum* and *Polygonum* sp. (Saharia and Sharma, 2022).

(e) Bamboo Brakes

Key bamboo species in the region include are *Arundinaria callosa, Bambusa nana, Cephalostachyum latifolium* and *Dendrocalamus strictus* (Kharlyngdoh et al., 2023).

(f) Grass Brakes

The dominant grass species comprise *Imperata cylindrica, Cymbopogon* sp., *Commelina benghalensis, Asplenium* sp., *Astilbe rivularis* (Kharlyngdoh et al., 2023).

1.3. Brief Description of Churachandpur District

The undivided Churachandpur District is situated in the southern part of Manipur, covering an expanse of 4,570 square km (located between North latitudes 23^0 56' 20.4″ to 24^0 36 ' 46.8″ and East longitudes 92^0 58' 12″ & 93^0 52' 58.8″). The district is characterized by its hilly terrain and a limited percentage of the plain areas sharing its borders with Myanmar to the South, Mizoram state to the West and South West, Bishnupur district to the North, Tamenglong district to the West and Thoubal district in the East. The recorded population of the district based on 2011 census is 2, 71,274. Churachandpur District, headquartered in Churachandpur is administratively divided into five blocks i.e. Churachandpur, Thanlon, Henglep, Singhat and Parbung.

The hills within the district form part of the Eastern Himalayas, characterized by elevations ranging from 900 to 2500 meters above sea level. These hills are adorned with dense forest and grassland, creating habitat that sustains a diverse array of flora and fauna. Meanwhile, the valley in the district is fertile and primarily utilized for agriculture, with a focus on cultivating crops such as rice, maize, sugarcane and various vegetables. It is noteworthy that the district lacks primary forest but boasts secondary the secondary forests, including mixed bamboo forest, covering an extensive area of 1,18,092 hectares. Wasteland encompasses an area of 98, 424 hectares, and the total area of the water bodies' amounts to 2,144 hectares, comprising 2,072 hectares of rivers and streams with 72 hectares of lakes, tanks and ponds. The Barak River, a major river in the district flows through the fertile plains, serving as a vital water source for irrigation (Jain et al., 2007).

1.3.1. Geomorphology and Soil Types

Churachandpur exhibits both residual and transported types of soils. Residual soils predominate in the hilly regions, characterized by deficiency in nitrogen, but containing adequate amounts of phosphorous, potassium and other nutrients for plant growth (Ansari et al., 2015). The soils in both the valley and hill regions tend to be acidic. Additionally, sandy and clay loams are present in certain areas. Sandy loams are known for their lower water holding capacity and excessive internal drainage,

while clay loam soils have high excessive water- holding capacity but impede internal drainage (Singh, 2000).

1.3.2. Rainfall and Climate

In Churachandpur district, Tinsong holds the record for the highest rainfall at 3,080 mm, while Geljang has the lowest at 597 mm. Humidity levels range from a maximum of 100% to a minimum of 61%. The temperate and salubrious climate enhances the beauty of the landscape with a maximum temperature of 37^0 C and a minimum of 10^0 C. (Alam et al., 2022). The cold winter season spans from November to February especially in the hills, although the days remain bright and sunny. Monsoon months, from May to September, bring heavy showers. Despite the high humidity, the spring and summer months are pleasantly mild (Feroze et al., 2014)

1.3.3. Flora and Fauna

The flora and fauna contribute to the ecological significance of the region and offer opportunities for biodiversity conservation. The district is characterized by extensive, wild, and dense forests that provide habitat for a diverse range of wildlife including boars, deer, tigers and monkeys (Pandey et al., 2022). The evergreen forest in the district are home to commonly found trees such as *Pinus kesiya*, *Albizzia procera*, *Artocarpus hirsuta*, *Aquilaria agallocha*, *Bombax ceiba*, *Phoebe hainesiana* and others. Additionally, trees like *Tectona grandis* and *Quercus* sp. are also found on the hill slopes.

The Manipur Forest Department is responsible for safeguarding the forests in different parts of Manipur including Churachandpur district. In Churachandpur district, the protected areas include Kaihlam Wildlife Sanctuary and Cheklakphai Reserved Forest. This region is abundant with endemic species to the Eastern Himalayas, including *Betula cylindrostachya, Thottea tomentosa* and *Blumea lanceolaria*.

1.4. About the Tribe

A mythical cave holds significant importance in the origin narrative of the Kuki-Chin or Zo ethnic group. The tribes belonging to Chin-Kuki ethnic group have attributed various names to this cave, including Khul, Khur, Khurpui, Khurtu-bijur, Khor, Puk, Shinlung, and Chhinlung (Doungel, 2021). The term "Khul or Chhinlung origin people" can be employed to collectively denote the Chin-Kuki-Mizo ethnic group, as all these tribes their trace their origins back to this mythical cave, referred to as Khul or Chhinlung (Doungel and Lawngtlai, 2011).

The Chin-Kuki-Mizo tribe falls under the Tibeto-Burman group, a classification utilized by linguists to categorize linguistically and culturally related Central Asian tribes. The term "Tibeto-Burman" is employed by linguists to denote the closely linked languages and cultural practices shared by these tribes.

Undivided Churachandpur District situated in the south west part of Manipur is dominated by different tribes under Kuki-Chin Tribes that include *Paites, Zo, Hmar, Thadou, Vaiphei, Gangte* and *Simte*.

1.6. Resource utilization and need for the study

The tribes in Churachandpur district have been utilizing forest products for wide range of purposes such as food, fodder, medicine, fuel, gums, oils, charcoal, fishing, furniture making and construction of houses. The forest resources are vital for their daily needs and self-sustenance. However, much of this knowledge is passed down through oral traditions, making documentation and preservation essential. However, the rapid changes in the culture of the tribal in Churachandpur district due to modernization, urbanization, adoption of religious belief are contributing to the transformation of their traditional practices related to plant use. Ethnobotanical study can be an important tool for documenting and preserving the traditional knowledge and practices of the tribe, promoting the sustainable use and conservation of plant resources and maintaining cultural diversity in the region.

In this context, there is an urgent need for the documentation of ethnobotanical knowledge among different ethnic communities in Churachandpur district. Data on previous ethnobotanical studies on various tribal groups have not been quantified using the ethnobotanical indices and suitable statistical analysis. Therefore, the present study is an attempt to document ethnobotanical information from different tribal communities employing the dedicated ethnobotanical indices.

In this study, quantitative indices such as Use value (UV), Fidelity level (FL), Frequency of citation (FC) and Relative frequency of citation(RFC) have been applied to understand the important and popular phytoresources used by the diverse tribal group in the region. The critical objective is to investigate ethnobotanical resources and sustainable livelihoods while documenting the entire indigenous knowledge of this neglected ethnic group before it is lost completely.

In addition, selected wild edible plants (WEPs) and medicinal medicinal plants were subjected to phytochemical analysis. For the WEPs, nutritional content, nutritional and antinutrional factors, mineral composition, and antioxidant potential were assessed. In the case of medicinal plants, the study focused on phenolic, and flavonoid content, antioxidant properties and identification of bioactive compounds through LCMS analysis.

1.7. Objectives of the study

The Churachandpur district in Manipur, India is known for its rich biodiversity, yet prior to thesis study, there has been a noticeable absence of ethnobotanical research in the region. The current study titled, "Ethnobotanical diversity and phytochemical studies of selected plant species in Churachandpur district, Manipur," aims to address this gap by focussing on the following objectives:

1. Documentation of ethnobotanical diversity in Churachandpur district

2. Nutritional analysis of selected wild edible plants.

3. Phytochemical studies on selected medicinal plants

CHAPTER –2

Review of literature

2.1. Ethnobotany in the world

Contemporary ethnobotanical research has been carried out in different parts of the world that covers diverse topics such as paleo-ethnobotany, historical ecology, nutritional ethnobotany and food ways, medical ethnobotany, cognitive ethnobotany, symbolic ethnobotany etc. (Nolan and Turner, 2011). This interdisciplinary approach allowed the researcher to better understand the complex relationship between humans and plants (Prance et al., 1987). With the growth of the environmental movement in the late 1960s and early 1970s, ethnobotanists began exploring how the view of people on plants and their environments influenced conservation efforts. They also explored how the beliefs and values of indigenous cultures could impact their interactions with other species and the environment. The Brundtland Commission report published "Our Common Future" (United Nations Commission on Environment and Development, 1987) (Wced, 1987) with the focus area strengthened by endorsing the need to recognize the knowledge systems of the indigenous and local people in our global search for sustainability and biodiversity conservation (Burton, 1987). Eventually, Traditional Ecological Knowledge (TEK), that includes many traditional strategies for managing land and resources, has played a significant role in ethnobotanical studies (Nazarea, 2013). Thus, ethnobotany has evolved into a field of study with a more global and international focus.

Numerous ethnobotanists have published their works globally, highlighting their focus on particular ethnic communities, for instances from China on the Dong and Moana communities (Liu et al., 2016); on Ayata communities from Philippines (Tantengco et al., 2018) on Tamang and Sikles communities from Nepal (Rana et al., 2015; Manandhar, 1991) and on different Thai communities from Thailand (Phumthum and Balslev, 2018).

To quantify and assess the information gathered by the ethnobotanists, qualitative and quantitative methods are employed. Qualitative studies include

participant observation, field observations, group discussion, questionnaires, and market survey (Martin, 1995; Alexiades, 1996); their local songs, oral knowledge transmission, local names, and folk dances (Zemede, 1997). Quantitative ethnobotany introduced by Prance in 1987, represents a significant methodological advancement in ethnobotanical research. Prance and his colleagues (1987) used it as evidence in a remarkable ethnobotany paper. The last few decades have seen a worldwide appreciation of the use of quantitative tools for the analysis of ethnobotanical data. In 2007, Hoffman and Gallaher published a paper with a list of different indices like Use value (Phillips and Gentry, 1993 a, b; Prance et al., 1987), Cultural Significance Index (Medeiros et al., 2022), Fidelity Level (Friedman et al., 1986), Cultural practices and Economic Value (Reyes-Garcia et al., 2005), Overall use value (Gómez Beloz, 2002).

Worldwide, several publications in the field of quantitative ethnobotany have emerged; assessing levels of importance and consensus among informants regarding the ethnobotanical information (Faruque et al., 2018). Globally, ethnobotanical researchers are gaining increasing recognition, with India, in particular, standing out as a hub for ethnobotanists. The nation boasts a significant number of experts in this field, surpassing many other counties in terms of its contribution to ethnobotanical research (Shaheen et al., 2015).

2.2. Ethnobotany in India

With the arrival of the British botanist, ethnobotany in India began to take shape after surveying wild and cultivated plant for their floristic and botanical studies. *Tylophora asthmatica,* described by Roxburgh in 1932 was the earliest efforts of ethnobotanical research in India where the leaves were used in asthma and roots against dysentery (Shah and Kapoor, 1977). Comprehensive discussion on interdisciplinary aspects of ethnobotamy was made by Jain (1986, 1988, 1989, 2001). However, this interdisciplinary approach for ethnobotanical studies can be achieved through collaborative work involving specialists from different disciplines (Ramakrishna, 2022).

Ethnomedicinal research in India is directed towards investigating various diseases and disorders prevalent among tribal communities. The "Chenchus" tribe at the Nagarjunsagar Srisailam Tiger Reserve, Andhra Pradesh used medicinal plants to treat jaundice (Padmarao et al., 2007). Numerous rheumatic conditions and the associated ethnomedicines have been reported from Madhya Pradesh (Wagh and Jain 2020). and Diwanji, 1999). The ethnomedicinal plants utilized by the Indian Bhill and Bhat tribes for fertility and ethnogynecology have been documented by (Singh and Jadav, 2011).The tribal groups of Odisha have developed ethnomedical formulations for the treatment of skin conditions and dental care (Behera and Mishra, 2005; Sen and Behera, 2003; Singh et al., 2013). Various research articles focused on certain medicinal plant species, such as *Aegle marmelos* L. Corr., *Polygonum strigosum* R. Br. and *Saussurea obvallata* DC. Eolgew have been published by various ethnobotanist (Pawar and Patil 2006; Saikia 2008; Saklani and Rao 1996). The focus of many of these studies are based on the plant parts like flowers, roots, stem bark, leaves, etc. used as folk medicine for healing several diseases (Banerjee, 1996; Shukla and Verma, 1996). Several ethnobotanists published their research work to specify the plant groups such as Lichen, Fungi, Bryophytes, Pteridophytes and Gymnosperms (Das and Dutta, 2007; Pande et al., 2000; Upreti and Negi, 1996). Researchers from India focused on traditional herbal traditions like Unani and the Indian Traditional Medicine Systems (Bhogaonkar and Ahmad, 2007), Tibetan Medicine System (Jain and Goel, 2005), and Homeopathy (Hembrom and Goel, 2005).

Indian Ethnobotanists have published several paper from different parts of the country where 31 wild edibles reported from Jammu and Kashmir (Mir, 2014), 110 plants from Meghalaya consumed by the tribal (Kayang, 2007), edible bamboos from NE India (Laha, 2000), 41 wild edible species consumed by the tribals of Tripura in their traditional food recipes (Deb et al., 2013), 50 WEPs from Kolhapur district and 11 fruit species enlisted from Western Ghats regions of Maharashtra (Deshmukh and Waghmode, 2011). From Kerala, Tamil Nādu, Karnataka and Andhra Pradesh, numerous papers were published documenting the wild fruits and vegetables which are consumed by the tribal people of these states (Arinathan et al., 2007; Harisha and

Padmavathy, 2013) and from Manipur, paper published on wild edibles and their association with the sustainable livelihood of the local people (Hazarika and Singh, 2018). In case of ethnoveterinary medicines, fewer papers have been published from the districts like Uttar Dinajpur, Dakshin Dinajpur districts, Koch Bihar and Birbhum of West Bengal (Bandyopadhyay and Mukherjee, 2005; Mandal and Rahaman, 2014; Mitra and Mukherjee, 2007).

On the traditional wisdom of the tribal communities, papers were published from tribals like Bhil from Madhya Pradesh (Singh and Jadav, 2011), Bhoxa from Uttarakhand (Singh, 2003), Birhor from Jharkhand and West Bengal (Mairh et al., 2010), Gujjar and Bakerwals from Jammu and Kashmir (Shah et al., 2015), Gujjar from Western Himalaya (Rana et al., 2019), Irulas from Tamil Nadu (Sarvalingam et al., 2014), Kharias from Central India (Varghese, 1996), Korkus from Maharashtra (Bhogaonkar and Devarkar, 2002), Rabha and Mishing from Assam (Das and Teron, 2014; Das et al., 2008; Das and Hazarika, 2015), Munda from Jharkhand (Hembrom and Goel, 2005), Naga from North-East India (Jamir and Tsurho 2017), Oraon from Jharkhand (Marandi and Britto, 2014) etc.

An encouraging method observed among Indian ethnobotanists is that they started employing statistical methods for their ethnobotanical research analysis. Quantitative ethnobotanical researches published on *Kani* tribe of Kerala where their ethnomedicinal uses have been analyzed by employing four quantitative indices such as Fidelity Level (FL), Informant Consensus Factor (ICF), Use Value (UV) and Relative importance (RI) (Ayyanar and Ignacimuthu, 2011). In the coastal parts of Karnataka, ethnomedicinal plants were recorded for skin diseases using quantitative analysis using indices like, Use value (UV), Informants Consensus Factor (ICF) and Fidelity level (FL%) (Bhat et al., 2014). From the northern part of India, quantitative ethnobotanical researches have also been published by the researchers from Uttar Pradesh, employing statistical indices such as Informant Consensus Factor (Fic), Relative Frequency of Citation and Use Value (Kumar et al., 2012; Kumar and Bharati, 2013; Wagh and Jain, 2018).

In Manipur, Sinha (1996) pioneered the ethnobotanical study which reported 667 plant species used in various ways by the indigenous communities. Singh (2011) reported 523 ethnobotanically important plant species from Tengnoupal district, Manipur. Singh et al. (1998) published a paper on the indigenous biofolklore and practices; they also reported on the WEPs found in the markets of Manipur (Singh et al., 1988). Singh and Kushwaha (1992) reported 51 medicinal plants against various diseases and ailments. A large number of good papers on various aspects of ethnobotanical research were published in recent years (Imotomba and Devi, 2011; Hazarika et al., 2012; Lokendrajit et al., 2012; Lokho, 2012; Ningombam and Singh, 2013; Athokpam et al., 2014; Devi et al., 2014; Rajkumari et al., 2014; Devi et al., 2015; Yuhlung and Bhattacharyya, 2016; Panmei et al., 2019).

However, ethnobotanical works employing quantitative ethnobotanical from the NE India are limited based on the traditional knowledge of diverse tribal communities that include Limboo from Sikkim, Monpa from Arunachal, Reang from Tripura (Namasa et al., 2011). From Manipur, Panmei et al., (2019) described the ethnomedicinal plants used by the Zeliangrong tribal community. Various researchers have documented the different uses of WEPs including the native food plants of the North eastern tribals (Arora, 1981), Arunachal Pradesh (Murtem, 2000), in Sikkim (Sundriyal and Sundriyal, 2004) and Assam (Kar and Borthakur, 2008)

Quantitative ethnobotanical studies within Churachandpur district will give us new insight of the traditional medicinal plants used by the different tribal communities Churachandpur (Guite, 2011; Gangte et al., 2013; Thangliankhup et al., 2023). No research based on quantitative ethnobotanical approaches in Churachandpur district, Manipur is available except the recently published work by the researvher (Thangliankhup et al., 2023). Many researchers have documented the tribal knowledge of WEPs which are consumed as food and sold in market (Kar et al., 2007; Deb et al., 2013), Karbi Anglong (Borthakur, 1996); Assam (Borthakur, 1996), Mahur market of Dima Hasao district, Assam (Medhi and Borthakur, 2013); Wild edible plants from Imphal, Manipur, (Chakraborty, 2003) and fermented foods of Churachandpur (Singh et al., 2019), probiotics in fermented fish (Singh et al., 2018). To fulfil the food and nutritional security, meat-based foods are mostly

preferred along with processed (fermented) foods. Recently, the focus on indigenous food has grown significantly due to its potential to play a crucial role in ensuring food security, promoting nutrition, and enhancing overall health.

Local delicacies of Manipur like Iromba, Champhut, Kangsoi, Hawaijar, Soibum, Ngari, and Paknam (Devi and Kumar, 2012; Singh et al., 2018), traditional recipes of Tripura (Deb et al., 2013), Sikkim (Tamang and Thapa, 2014), Mizo food in Mizoram (Lalmuanpuii et al., 2015) and alcoholic and non-alcoholic beverage of Manipur tribal groups (Singh and Singh, 2006) have been documented. Traditional foods are mainly crafted by individuals to meet local demands and needs (Dutta et al., 2005), resulting in limted commercial availability at food stalls. The present study was designed to determine and document the WEPs and its market values in Churachandpur District, Manipur and traditional knowledge on associated processing technique. So, this research will help in conservation and bringing an economic impact creating identities in local culinary cultures.

2.7. **Nutritional Value**

The consumption of WEPs remains prevalent in various communities, particularly among the indigenous people, who incorporate them into their traditional food system (Powell et al., 2009). Food insecurity and malnutrition are common among indigenous peoples, but local knowledge can help mitigate this issue through hunting, and harvesting of wild plants (FAO, 2009, 2017). WEPs supplement our diets, and offer health benefits. Studies have revealed the importance of wild plants as sources of nutrients and minerals (Jones et al., 2011). Additionally, certain wild plants are essential component of diets, providing documented biological and pharmacological health benefits (Singh et al., 2018; Baliga et al., 2011). Thus, documenting the worth of WEPs can improve food and health security in traditional communities.

Wild edible plants are the sources of important dietary compositions and bioactive components. Among the important components proteins and amino acids play numerous role in human health that helps in cell growth, metabolism, and

differentiation (Vincentea et al., 2014). The recommended daily allowance (RDA) of protein is 56g and 46g per day for men and women respectively (Eicher-Miller, 2012). Carbohydrates are the structural framework of cells that serve as energy storage (Nelson et al., 2008). Carbohydrates and proteins provide (4 kcal/g of energy) fats yield 9 kcal/g of energy value and moisture, fibre, ash, energy content of plants are essential for maintaining good health (Vincentea et al., 2014). The moisture content in vegetables, fruits are an excellent source of water required by our body, and studies revealed that more intake of fresh wild plants can reduce the chance of developing diseases like cancer, heart attack, diabetes, etc. (Aregheore, 2012). So, it is important to know the nutritional composition of the important wild edible plants.

WEPs are reservoirs of natural antioxidant compounds like phenolic, flavonoid, tannin etc. (Matkowski, 2006; Uusiku et al., 2010), that provide protection from oxidative stress and free radicals (Kaur et al., 2002). Researchers have revealed that consuming wild vegetables that contain high phenol and flavonoid compounds lowers the risk of developing cardiovascular disease, cancer, diabetes, and neurodegenerative diseases (Adebooye et al., 2008).

The human body requires certain minerals in order to function properly, and these minerals are found in various parts of plants (Ajasa et al., 2004). WEPs do contain both essential and toxic elements in varying concentrations, with numerous toxicological properties on the human body. Thus, World Health Organization strongly advised heavy metal analysis in specific plants due to negative health effects (Orisakwe et al., 2012; Garg, 2014). Various factors contribute to heavy metal absorption by plants that include atmospheric deposition, soil composition, and plant species (Singh and Singh, 2014) which uptake them from the soil or from pesticides and fertilizers (Ramadan and Al-ashkar, 2007). Iron (Fe), manganese (Mn), zinc (Zn), copper (Cu) are essential micronutrients where their deficiency or excess can result into metabolic disorders (Narzary and Basumatary, 2017). Heavy metals such as lead, arsenic, cadmium are non-essential and highly toxic to plants as well as animals (Sahito et al., 2003). Regular intake of vegetables rich in elements such as

sodium, magnesium, potassium, calcium, manganese, copper, and zinc has been associated with reduced risk of cardiovascular disease (Jabeen et al., 2010). Many metals serve as enzyme activators as magnesium plays both as a structural component of the chloroplast and a cofactor in biomolecules synthesis (Karimi et al., 2008). Iron catalyzes the ferredoxin nitrate reeducates reaction which is involved in chlorophyll synthesis (Nookabkaew et al., 2006). Calcium plays pivotal role in photosynthesis, biomolecule metabolism, which is also an important component of bone and tooth. Zinc is a micronutrient that is linked to several enzymes, including those involved in RNA synthesis. Copper and zinc are important for normal plant growth and development.

2.4. Anti-nutritional Factors

Nutritional value is crucial when WEPs are consumed as a source of food, however, recently researchers has questioned the health benefits of plants due to the existence of compounds known as anti-nutrients or anti-nutritional factors. The anti-nutritional factors include lectins, oxalates, phytates, phytoestrogens, tannins, glycosides, alkaloids and hydrocyanic acid (Pandey et al., 2023). Anti-nutritional factors serve as a dual role by acting as defense mechanism and as well as supporting many biological processes however it reduces nutrients availability such as minerals, vitamins and even proteins thus affect the nutritional value. Anti-nutritional factors are also absorbed when a plant food is consumed as a food source. According to FAO statistics, approximately 1 billion individuals in developing countries depend on WEPs for both sustenance and medicinal purposes (Unuofin et al., 2017).

The primary storage form of phosphorous in leaves is phytic acid. In addition to reducing the bioavailability of metal ions like zinc and iron and interfering with protein and starch digestion, phytic acid has been observed to hinder the absorption of minerals. Iron absorption in humans is reduced by 4-5-fold when phytic acid intake is between 4-9 mg/100g. Excessive phytate-rich diet has been linked to nutritional disorders like rickets and osteomalacia in both children and adults (Unuofin et al., 2017).

Alkaloids are nitrogen-containing compounds formed as byproducts of metabolism and can have physiological effects. They are present in approximately 15-20% of vascular plants, found in different plant parts like seeds, leaves, roots, and bark. They can be classified into authentic alkaloids, exemplified by nicotine in tobacco, which are heterocyclic nitrogenous bases originating from amino acids and are harmful to both humans and animals; pseudo alkaloids, like purine alkaloids, which are heterocyclic nitrogenous bases but are generally less toxic than true alkaloids; protoalkaloids, which are basic amines without heterocyclic nitrogen, like capsaicin in hot peppers. Excessive intake of tropane alkaloids can lead to adverse effects such as rapid heartbeat, paralysis, and even death, as well as disruption of cell membranes in the gastrointestinal tract (Sinha and Khare, 2017). Leafy plant foods contain oxalic acid, in different forms, including soluble salts of potassium and sodium, insoluble salts of calcium and magnesium, or combinations of these salts that can chelate with calcium, that inhibit its absorption (Akwaowo et al., 2000). Oxalic acid can negatively impact human nutrition and health by diminishing calcium absorption and potentially leading to the formation of kidney stones.

Saponins, which occur naturally in plants, have several health effects. They have been linked to damaging red blood cells, inhibiting enzymes, and interfering with thyroid functions (Fan et al., 2013). These compounds possess a bitter flavour and can be harmful in elevated concentrations, impacting nutrient absorption by inhibiting enzymes and binding to minerals such as zinc. When saponins are present alongside cholesterol, they exhibit a potent cholesterol-lowering effect and may lead to lower blood sugar levels/hypoglycemia (Ikewuchi et al., 2012). Additionally, saponins can disrupt protein digestion, potentially resulting in the development of a condition known as a leaky gut (El Barky et al., 2017).

2.5. Reduction of anti-nutritional factors

Various processing techniques have been used to reduce the content of anti-nutritional components found in plant-based foods. These techniques include small-scale domestic (Emily and Aman 2013) to large-scale industrial process like soaking, roasting, fermenting, and boiling. These techniques can lower anti-nutritional

elements to varying degrees. Removing such compounds from plant based food is essential for improving their overall quality, and combining different methods to reduce anti-nutritional factors may be more efficient than doing so solely. Eventually, this may result in higher crop value and increased protein digestibility (Handa et al., 2017; Jaybhaye and Srivastav, 2015).

Roasting is a common and well-known food processing method that enhances sensory characteristics, causing various physicochemical changes in food. These changes include alterations in texture and colour, reduced moisture content, lipid modifications, under the influenced of Maillard reaction (Schlörmann et al., 2019). Recent research has shown that roasting treatments can improve protein digestibility (both *in vitro* and *in vivo*) and reduce anti-nutritional factors in Samh flour, alongside affecting its protein and carbohydrate contents (Alderaywsh et al., 2019). In Iran, roasting flax seed has been a traditional method that has been used to prevent digestive issues (Moknatjou et al., 2015). In another study, roasting of maize led to an increase in crude fat, carbohydrates, calcium (Ca), sodium (Na), magnesium (Mg), and zinc (Zn) content, while decreasing crude protein, crude fiber, iron (Fe), and potassium (K) content. Interestingly, it also reduced the phytate content (Oboh et al., 2010). Roasting of Samh seeds enhanced antioxidant activity and calcium content but reduced total phenolic content, total flavonoid content, and the levels of essential minerals such as phosphorus (P), magnesium (Mg), iron (Fe), and manganese (Mn) (Oboh et al., 2010). Another study found that roasting pumpkin seeds increased total phenolic compounds, total flavonoids content, and total antioxidant capacity as the roasting temperature increased at different temperatures (Peng et al., 2021). Roasting of yellow and white maize varieties in Nigeria revealed a significant increase in crude fat, carbohydrate, and mineral (Ca, Na, Mg, and Zn) contents while causing a significant decrease in crude protein, crude fibre, Fe, K content, and phytate content. Thus, roasting reduced protein content of maize however increases the energy and antioxidant capacity value (García-Herrera et al., 2020)

Culinary treatment of green vegetables in the Mediterranean basin, such as boiling and frying, improve their edible quality while removing undesirable

compounds such as oxalic acid and saponins that inactivate proteins in fruits and tubers through solubilization in cooking liquid or heat degradation (Hadad et al., 2005; Lin et al., 2006: Güçlü-Üstünda et al., 2007). It also shows Mg, Zn content losses after the boiling while Ca, Cu and Fe were more stable, in another study the boiling process can reduce anti-nutrient (oxalic acid) content of wild greens (Olanipekun et al., 2015). A study on the Mediterranean culinary process of WEPs shows Na, K, Mg, and Zn content losses after boiling, whereas Ca, Cu, and Fe were more stable as analysed from principal component analysis (García et al., 2020). In China, the cooking process of three different varieties of potatoes showed lower content of phenolic, and antioxidant activity, however such effects were dependent on the cooking methods that include frying, air drying, roasting microwave and steaming (Liu et al., 2021).

2.6. Antioxidant properties of Traditional Culinary Processed Foods

There are reports that roasting increased antioxidant activity, TPC, and TFC of Samh seeds (Dewanto et al., 2002). Roasting of Samh seeds also increases phenolic and flavonoid compounds (Ahmed et al ., 2020). In another study, varying temperature of roasting treatments have an impact in the increment or decrease of the antioxidant activity (Gallegos-Infante, 2010; Wani et al., 2016), total phenol content (Gallegos Infante et al., 2010; Wani et al., 2016), and total flavonoid content (Boateng et al., 2008).

In contrast to roasting, cooking process showed a reduction in the total phenolic and antioxidant activity. However, such effects depend on the cooking techniques (Fan et al., 2022). Yet in another study, the phenolic content of potatoes increased significantly after boiling, steaming, and microwave cooking (Faller and Fialho, 2009) and such variation may be attributed to different reasons such as the potato varieties, cooking conditions, the pre-treatment conditions along with the different processing methods (Tian et al., 2016).

In food matrices, FTIR has been successfully utilized to determine food composition, distinguish/differentiate foods, and authenticate foods (Karoui et al., 2010; Franca et al, 2011). They have also been used in dairy products, meat products,

fish, edible oils, cereals and cereal products etc. (Fang et al., 2023). A study of roasted and unroasted *Dioclea reflexa* seed flours revealed a consistent absorption pattern, suggesting the similarity of compounds present. However, a vibrational stretch was observed in the carbonyl group when compared to the control medium which could be due to the effect of roasting releasing the aldehydes, ketones group adding up the flavours and aromas in the seed (Farag et al., 2021). The roasting affects the alcohol-phenol group which however had no effect on carboxylic acid functional group. The application of heat causes a decrease in the absorption bands related to carbonyls and the peptide groups found in proteins. These alterations can be connected to the Maillard reaction, which is responsible for the release of aroma and flavour to the denaturation of proteins. The FTIR showed that roasting of foods could help in reducing food rancidity (Jan et al., 2019).

2.7. Medicinal plants and their phytochemicals

Plants provide essential nutrients of macronutrients and micronutrients required for life that contribute to health and prevention of diseases (Lee et al., 2011; González et al., 2013). Phytochemicals are classified as primary or secondary constituents on the basis of their metabolism with the secondary metabolites, a non-nutritive chemical compounds (Upadhyay et al., 2013: Probst et al., 2013). The secondary constituents like alkaloids, flavonoids, terpenes, phenolics, lignans, plant steroids, curcumins, saponins, glucosides have been used for treatment of various ailments (Okoegwale and Omefezi, 2001) as they possess antioxidant properties (Soobrattee et al., 2005). Such chemicals exhibit a wide range of medicinal values such as anti-cancer, anti-diabetic and anti-inflammatory properties (Nagavani et al., 2010). Flavonoids also have been reported to possess antioxidant properties and scavenge free radicals in the body and protect the body from various diseases like cancer, arthritis, diabetes mellitus, anti-inflammatory diseases, antiallergenic activities, antiviral activities etc. (Parajuli et al., 2012; Pereira et al., 2009). Setchell and Cassidy (1999) reported that tannin and saponin have pharmacological effects (Hamzah et al., 2014). Saponin has been reported to be a cough suppressant

and exhibit antioxidant, anti-inflammatory, diuretic, and antimicrobial properties (Okwu, 2004).

Recently, the use of medicinal plants as a supplementary and alternative treatment combining with other therapeutic approaches has gained popularity (Kawamura et al., 2018). Humans have been plagued by a variety of diseases, the majority of which are linked to the production of free radicals (Gbadegesin et al., 2018). Free radicals are essential for aerobic life and metabolism (Adesanoye et al., 2014). They are essential to any biochemical process and have been linked to the aetiology of many diseases, including cancer, Alzheimer, Parkinson, inflammatory disease, DNA damage, stroke (Bouzid et al., 2018), cardiovascular disease (Khan et al., 2013), protein oxidation (Yu et al., 2018) and diabetes. Antioxidants protect cells from the damage caused by free radicals (Goodarzi et al., 2018). Antioxidants can be obtained both internally and externally (Khaled et al., 2014). Internally produced antioxidants due to body enzymes activity include superoxide dismutase (SOD), catalase (Cat) (Cheng et al., 2017) while vitamins A, vitamin E (alpha tocopherol), (Lai et al., 2015), vitamin C (ascorbic acid), minerals and polyphenols (Bahadoran et al., 2013; Alin et al., 2013) are predominantly plant based antioxidants mainly supplied externally through food sources (Sen, 2021).

There are two methods to determine the antioxidant properties of plants, namely *in vitro* and *in vivo* methods (Khatoon et al., 2018). The *in vitro* methods involves all assays which are spectrophotometrically measure such as 2,2′-azino-bis-3-ethylbenzotiazolin-6-sulfonic acid ($ABTS^{+}$), 2,2′-diphenyl-1-picrylhydrazyl (DPPH) and (FRAP) (Park et al., 2019).

Medicinal plants are potential sources of natural antioxidant as it contains secondary metabolites (Matkowski, 2006; Uusiku et al., 2010) that provide protection against oxidative stress from oxidizing agents and free radicals (Kaur et al., 2002). Various studies have revealed that wild vegetables consumption is linked with lower chance of getting cardiovascular diseases like cancer, diabetes, and neurodegenerative diseases (Adebooye et al., 2008; Mensah et al., 2008). Understanding the antioxidant activity of significant WEPs is crucial in obtaining easily accessible and inexpensive antioxidants for the prevention of diseases

against oxidative stress (Sarikurkcu et al., 2009). Thus, more intakes of these wild vegetables can play a significant role in chemoprevention of diseases and pathophysiology against reactive oxygen species ROS (Odukoya et al., 2005).

No scientific validation has been carried out till date on the effects of traditional mode of preparation on their nutritional, anti-nutritional, mineral contents, antioxidant properties and FTIR analysis of the selected WEPs and medicinal plants. Thus, this study will help us understand how indigenous knowledge manages to provide daily dietary requirements to meet the food security along with the medicinal benefits using the locally available medicinal plants.

CHAPTER-3

MATERIALS AND METHODS

3.1. Study area

Churachandpur district lies in the south western part of Manipur with its district headquarter located at Churachandpur (Fig.1). The total geographical area of undivided Churachandpur district is 4, 570 sq. km which is located between 23º 55' N and 24º 30' N latitudes and between 92^0 59'E to 93º 50'E longitudes. The Churachandpur district is known for hilly terrain and diverse topography which include hills, valleys and rivers (Haokip and Ansari, 2018).

3.2. Demography of Study Area

Churachandpur district has a population of 274,143 of which 138, 820 are males and 135, 323 are females and occupy fifth rank in terms of population in the state (Census, 2011). The population density is 60 per sq km. The schedule tribe and schedule caste population represent (93.2 and 0.9 %) of the total population respectively showing the dominance of the previous one. The major religious groups in Churachandpur district reported with Christians 213, 186 (93.54%), Hindu 10, 538 (4.62%) and Muslim 2, 573 (1.13%) (Census of India 2011) (Table.7). The undivided district which is taken for the present study is resided by rich tapestry of tribes falling under the Kuki-Chin category that include the *Paite*, *Zo*, *Hmar*, *Thadou*, *Vaiphei* and *Simte* Communities (Das, 2021).

3.3. Field survey and data collection

Prior to systematic field work for ethnobotanical data collection, extensive survey were conducted between 2017-2020 in all the five sub-division and tribal development block focusing on villages associated with their respective tribal groups (Vogl et al., 2014) (Table 1).

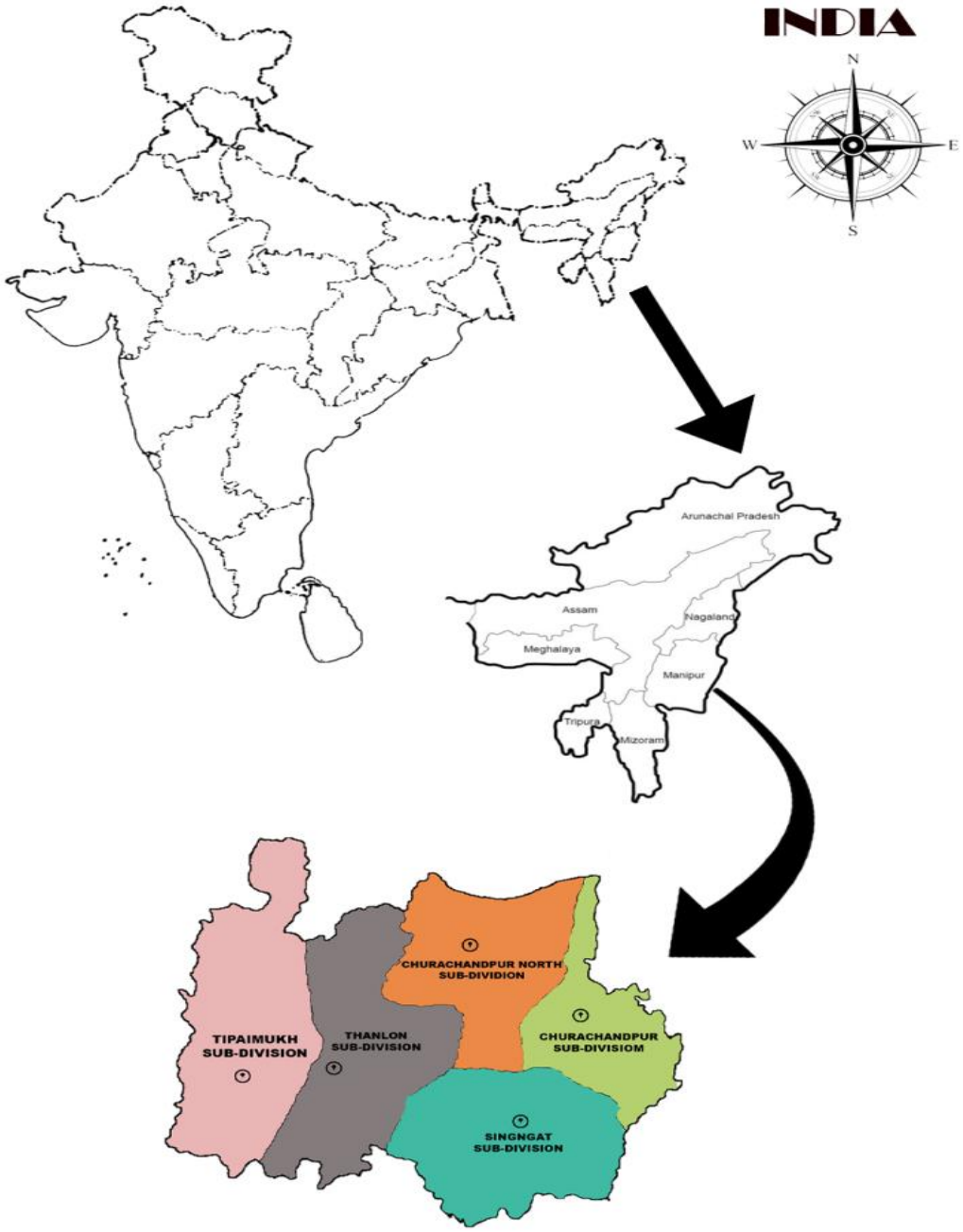

Fig.1. Location Map of Churachandpur District, Manipur.

Table 1. Subdivisions of undivided Churachandpur District

Sub division	**Headquarter**
Tipaimukh	Parbung
Thanlon	Thanlon
Churachandpur North	Henglep
Churachandpur	Churachandpur
Singngat	Singngat

Field survey has been undertaken throughout the year during 2017-2020 covering all seasons in the 5 sub-division. Survey sites consist of 57 villages in accordance with the most populated tribes of Churachandpur district, Manipur. From the study area, a total of 210 informants (132 men and 78 women) were selected representing different tribal communities for data collection by purposive sampling methodology (Tongco, 2007). Prior Informed Consent (PIC) was taken from all the informants including the knowledgeable person like healers, herbalist, philanthropic organisation leaders and village chiefs. The main objective of PIC is to protect the Intellectual Property Rights (IPR) of the knowledge holders (Manchikanti, 2021).

Two methods were adopted for field work as *in-situ* and *ex-situ* methods for documentation and data collection on the ethnobotanical studies (Holt, 2021). Although, both methods have positive and negative prospects, it provides the best results in the ethnobotanical research (Rodrigues and Barnes, 2007). In the *in-situ* method, walk in the wood approach where the first stage of field work provides an opportunity to work in the field with the local people and collected the information through discussion with the local informants in the field (Cunningham, 2001). This tool helps to gather better quality and reliable ethnobotanical data from the informants.

The *ex-situ* method was primarily designed for individual with limited mobility such as the elderly and women. It entails engaging a substantial number of informants in the process. In this method, herbarium specimens or photographs were shown to the informants for identification of the plants in their local languages. To get accurate information, cross verification of the data by asking same questions to more than one informant from the same as well as different areas has also been done throughout the study (Gerique, 2006).

A semi-structured interview with a series of questionnaires was prepared in local languages that include *Paite, Hmar, Thadou, Zou, Simte, Vaiphei* and *Gangte* to obtain maximum information (Cunningham, 2001; Martin, 2008).

3.4. Collection of plant specimen

All the plants reported to have the ethnobotanical uses have been collected during the flowering season especially for the flowering plants with the help of the informants or as suggested by the informants. Multiple photographs in their original habitats were captured and detailed notes were made for the plants. Healthy flowering plant parts were selected and collected in triplicates for their dissection for identification and making voucher specimens (Smith and Chinnapa 2015).

3.5. Identification and Voucher Specimens

The collected plants were dissected in detail for their correct identification and identification was done with the help of the available local floras that include all the volumes of Flora of British India (Hooker, 1872-1897), Flora of Assam (Kanjilal et al., 1934-1940), Flora of Tripura State (Deb, 1981-1983), Flora of Manipur (Singh et al., 2000), Flora of Mizoram (Pandey et al., 2015). Other available online literatures and Herbaria (ASSAM, CAL) including Virtual ones were consulted (JSTOR, GBIF, TROPICOS, POWO) for authentication of identified plants. The scientific names of all the recorded identified plant species have been updated following the standard websites (The Plant List- www.theplantlist.org and POWO). Voucher specimens of the collected plants specimens were prepared following standard herbarium procedures (Pandey et al., 2015). The voucher specimens were

deposited in Mizoram University Herbarium (MZUH), Department of Botany, Mizoram University. A number of Websites were also consulted for the information regarding each and every species as follows:

1. http://www.bsienvis.nic.in
2. http://indiabiodiversity.org
3. http://www.iucnredlist.org/details/19891902/
4. http://wfo.kew.org/taxon/urn:kew.org:wcs:taxon:9909
5. http://e-monocot.org/taxon/urn:kew.org:wcs:taxon:222283

3.6. Quantitative ethnobotany

The data collected from the informants were analysed to quantify the presence, use, or importance of the wild edible and medicinal plants within a given cultural or ecological context. The indices used in the present study include the following:

3.6.1. Frequency of citation and Relative frequency of citation (RFC)

The data was analysed using the formula) (Kumar and Bharati, 2013)

Frequency of citation $=\frac{number\ of\ informants\ who\ cited\ the\ plant}{\text{total number of informants interviewed}} x100$

Relative frequency of citation$=\frac{frequency\ of\ citation}{\text{total frequency of citation of all species}} x100$

3.6.2. Use value (UV)

The Use value signifies the importance of each plant species for a particular ethnic group (Martin, 2008)

$$UV= U/N$$

Where, U =number of uses mentioned in each event by the informant and N means the number of events for species (s) with informants.

3.6.3. Fidelity Level (FL)

Fidelity level identifies the species according to their relative effectiveness (Friedman et al., 1986). It is calculated as follow:

$$FL = I_P / I_U \times 100$$

I_p =no. of informants who suggested the use of a species for particular purpose.

I_U = total no of informants who mentioned the plant use for multiple usages.

3.6.4. Informant consensus factor (ICF)

The Informant Consensus Factor (ICF) was computed for every disease category or group to evaluate the level of consensus among traditional informants, as described below:

$$ICF = N_{ur} / (N_{ur} - 1)$$

Where N_{ur} = the number of reports for the use of each plant species within a specific disease category, N_t =the total number of plant species used in that category. The ICF value is a number between 0 and 1, where a greater value (close to 1) indicates stronger community agreement in the use of a given plant species for a given disease (Friedman et al., 1986). Data provided by informants was used in the ICF computation to evaluate the coherence of the data gathered for the study.

3.7. Phytochemical studies of selected WEPs and medicinal plants

3.7.1. Collection of wild edible plants

Three WEPs from the present study which have unique traditional values as a part of local cuisines were selected for their nutritional evaluations were collected from different parts of the study area. The details of the selected WEPs which were collected from different localities for their comparative studies were given in (Table 2). The available seasons of the three selected wild edible plant were identified through a thorough survey and the edible parts of the plants were collected from two different sites which represent the occurrence in wild and cultivated form with the

site of collection sites. Collection from two different representations was done to understand whether the occurrence in wild or cultivated form affects the phytochemical constituents (Chodar Moghadas and Rezaei 2017). García and Silver, 2002).

Table 2. Details of Wild Edible Plants (WEPs) selected for Phytochemical and nutritional analysis

Scientific name	Local name	Flowering Season	Edible Part/s	Local market value (Rs)	Traditional processing	Collection Site from Forest	Collection Site from Cultivation
Alocasia fornicata (Kunth) Schott	Baibing	Aug.-Sept.	Inflore-scence	50/-bundle (100/-bundle processed)	Boiled for 20 minutes and smoked dried	Thanlon (26016'24" N 93016'26" E)	Zoutung 24013'34" N 93018'09" E
Amorphophallus napalensis (Wall.) Bogner& Mayo	Telhawng	April-May	Tuber	100/ kg (Fresh) 200/ half kg (dried)	Cooked with traditional soda and pounded	Bukpui 24012'36" N 93013'50" E	Palkhuang 24009'11" N 93015'24" E
Oroxylum indicum (L).Kurz	Archangk-awm	May-Aug.	Pods	100/ two pods	Roasted over ember or fire.	Leijangphai 24024'16" N 93030'31" E	Sainoujang 24020'04" N 92021'36" E

3.7.2. Preparation of Plant Samples

(i) The freshly collected edible plant materials were shade dried, ground well using mechanical blender into fine powder and transferred into airtight containers with proper labelling for future use (Vorass, 2013).

(ii) For the processed plant samples of WEPs, samples were prepared in laboratory to replicate the traditional culinary methods, ground well into fine powder and stored in air-tight containers with proper labelling for future use(Duea, 2011).

3.7.3. Methods of replicating culinary process for WEPs

3.7.3.1. *Alocasia fornicata* (Kunth) Schott Local name (Local name: *Baibing*)

In the traditional preparation method, the *A. fornicata* inflorescences are typically subjected to a process involving soaking in water and gentle heating until it reaches a partially cooked state (Phopin et al., 2022). Following this, the water is drained and subsequently smoked over an open fire. This smoking process not only imparts a unique flavour but also facilitates extended storage of the fruit. This technique has been employed for generations to ensure the preservation of *A. fornicata* for future consumption.

In a laboratory setting, the same traditional method for *A. fornicata* inflorescence (300 g) was replicated with a systematic approach (Deb et al., 2013). Initially, the inflorescences were soaked for a brief period of 5 minutes. Subsequently, it undergoes blanching (partially cooked) in 500 ml of distilled water for duration of 20 minutes. After the blanching process, excess water was drained, and the fruit was then transferred to an oven. The fruit was subjected to a controlled drying process at a temperature of 70 degrees Celsius for a duration of 30 minutes which ensures that the distinctive aroma and flavour of the *A. fornicata* fruit effectively diffused out, allowing for preservation without compromising its sensory qualities. The dried inflorescences were finely pulverized and stored in airtight container for future analysis (Lee et al ., 2002).

3.7.3.2. *Amorphophallus napalensis* (Wall.) Bogner & Mayo (Local name:*Telhawng*)

Traditionally, the corm undergoes a specific preparation process, where the outermost layer was peeled before slicing it into small pieces. These pieces are then boiled in a solution containing traditional soda for duration of one hour to reduce the presence of any irritating substances. The cooked corm is meticulously crushed using a traditional wooden mortar and pestle, ensuring the preservation of its unique qualities and flavours. This age-old technique not only makes the corm safe for consumption but also highlights the importance of preserving cultural culinary practices.

The traditional process for preparing the corm of *A. napalensis* was replicated in the laboratory (Srivastava et al., 2022). Initially, the corm was meticulously peeled and thoroughly washed. Cleaned and sliced 450 grams of the corm cooked (1 liter of distilled water) for 1 hour-long and 100 ml traditional soda was added, excess water is drained away. The cooked corm was pounded using a wooden mortar and pestle, resulting in the formation of sticky chunks or lumps. Subsequently, the processed plant materials were dried in an oven and finely ground into a powder. The powder was carefully stored in an airtight container future use.

3.7.3.3. *Oroxylum indicum* (L). Kurz (Local name=*Archangkawm*)

In the traditional method, the immature pods of *O. indicum* undergo a thorough washing with water before being delicately roasted over an open fire until their distinct aroma and flavour are released. This roasting process is carried meticulous to avoid overcooking or burning the pods.

In the laboratory the immature pods (445g) was washed with distilled water and roasted in an oven for 1 hour at 70^0 C till the outer sheath of the pods are partially burnt or the aroma of the pods diffused out. The roasted pods were again cleansed and ground to fine powder and stored in air-tight container for future use (Mbah et al., 2012).

3.8. Collection of medicinal plants

The freshly collected medicinal plant parts (Table.3) were shade dried, ground well using mechanical blender into fine powder and transferred into airtight containers with proper labeling for future use (Patil., 2020).

3.9. Extraction of plant material

A beaker containing 200ml of methanol was filled with a 5g portion of finely powdered samples of medicinal and wild food plants that were collected in both raw and processed forms from the wild and from cultivation. A magnetic stirrer was used to agitate the mixture for 24 hours at 600 rpm. The extract was then passed through filter paper to create a filtrate, which was then used for phytochemical analysis. After

that, the dehydrated extracts were put in jars for further examination (Abubakar and Haque, 2020).

Table 3. Details of the three selected Ethnomedicinal Plants for Phytochemical Analysis

Scientific name	Local name	Flowering Season	Parts	Local medicinal usages	Reported bioactivity	Local use coherent with known Properties	Collection Site
Blumea lanceloria (Roxb.) Druce	Bualze	Feb.-April	Leaves	Diabetes, diabetic foot ulcer, dysentery, cuts and wounds	Antimicrobial, stomach ulcer, dysentry and wound – antidiabetic	Partial yes	Mata $24^0$17'46"N $93^0$40'38"E
Betula cylindrostachya Wall.	Hiangzau	April-June	Bark	Bark used as anti-diabetic,ulcer and stomachache	Anti-dandruff	No	Thanlon $24^0$22'05"N $93^0$16'55"E
Thottea tomentosa (Blume) Ding Hou	Nahkha	May-Aug.	Leaves	Leaves dysenetry, diarrhoea and antidiabtic	Skin diseases, dysentry, ulcer and cough	Partial yes	Bilpikot $24^0$11'59"N $93^0$11'52"E

3.10. Preliminary Phytochemical group testing for WEPs and medicinal plants

Preliminary phytochemical screening of methanol extracts of the three WEPs collected from (Table.4) Wild and Culltivated and medicinal plants and were performed following (Abubakar and Haque, 2020).

Table 4. Qualitative phytochemical screening of WEPs and medicinal plants

Compounds	Test used	Indications
Alkaloids	**Mayer's test:** 1 to 2 drops of Mayer's reagent were added in 2ml of extract of the plant samples with 2N HCl.	White ppt. or turbidity
Phenols	**Ferric chloride test:** Few drops of ferric chloride solution were added in 10mg of plant extracts.	Bluish color Formation
Saponin	**Foam test:** 1ml of extract solution was added to water and shaken vigorously and stands for 15 minutes.	Formation of foamy leather
Flavonoid	**H_2SO_4 test**: Extract was treated with few drops of sulphuric acid.few drops of sulphuric acid was added to the extract	Orange colour formation
Tannins	**Ferric chloride test**: 1ml of extract mixed with water and heated. The mixture was filtered, and few drops of ferric chloride wad added.	Formation of dark green colour
Carbohydrates	**Fehling's test**: 2ml of extract was mixed with Fehling solution A and B and heated.	Brick red precipitation
Protein	**Biuret test**: 2 drops of 1% CuSO4 and 1 millilitre of 40% NaOH were used to treat 1 ml of extract.	Formation of violet colour
Fats and oils	**Spot test:** The extract was applied between filter paper and pressed.	Oil staining or transparent appearance on the filter paper.

3.11. Evaluation of total phenol and total flavonoid content of WEPs and medicinal plants

The three selected ethnomedicinal plants and wild edible plants(WEPs) analysed for total phenol and total flavonoid content were determined using the following two methods.

3.11.1. Total phenol content

The total phenolic content was estimated following Folin ciocalteau method (Kujala et al., 2000) with slight modifications. Briefly, a stock solution of each

methanolic plant extract was prepared (1 mg/ml) alongside standard solution of gallic acid (100 µg/ml) as standard by dissolving 10 mg of gallic acid in 100 ml of water. Various concentrations of gallic acid ranging from (50 to 500 µg/ml) were prepared from this standard solution. Then 100 µl of each plant extract was mixed with 900µl water and 500 µl of 50% Folin ciocalteau (1N). After incubation for 5 minutes, 1.5ml of (7%) Na_2CO_3 was distilled water was added to make the final volume 10ml. It was then measured at 760 nm after 2 hours of incubation. The total phenolic content was determined from the standard curve and results expressed as mg Gallic acid equivalents/gram (mg GAE/g) of dry weight.

3.11.2. Total flavonoid content

The evaluation of total flavonoid content was determined by aluminum chloride method with slight modifications as outlined by (Chang et al., 2002). A range of Quercetin concentrations (10µg/ml-100µg/ml) served as the standard, prepared from a stock solution (1mg/ml). Methanol plant extracts (1mg/ml each) were also derived from the original extract. For the plant extracts, 500µl was combined with 1.5ml of methanol, 0.1ml aluminum chloride, 0.1 ml potassium acetate, and the final volume was adjusted to 5ml. The mixture was incubated at room temperature for 30 minutes and then measured at 415nm using a UV-VIS spectrophotometer. The total flavonoid content was determined from the Quercetin standard curve, and the results were expressed as mg of Quercetin equivalent per gram (mg QE/g) of dry weight.

3.12. Determination of antioxidants

For the three WEPs collected from wild and cultivated and medicinal plants, antioxidant properties were determined using the following two methods.

3.12.1. DPPH radical scavenging activity

The DPPH (2,2'-diphenyl-2-picrylhydrazyl) free radical scavenging activity in the methanolic plant extract was conducted in accordance with the methods outlined by (Braca et al., 2001) with slight modifications. Briefly, various concentrations of

the methanolic plant extract (ranging from 20 µg/ml to 120 µg/ml) were prepared. Subsequently, 1ml of each plant extract was combined with 2ml of DPPH solution (0.004% W/V) and incubated for 30 minutes in darkness, with absorbance measured at 517nm. A negative control was prepared using 1ml of methanol and 2ml of DPPH, while BHT served as a positive control. The percentage of scavenging activity for each sample was calculated using the formula provided below:

$$\text{DPPH Scavenging activity (\%)} = \frac{\text{Abs control} - \text{Abs sample}}{\text{Abs control}} X100$$

3.12.2. ABTS free radical scavenging activity

The evaluation of ABTS (2,2'-azinobis, 3-ethylbenzothiazoline-6-sulfonic acid) radical scavenging activity followed the method described by (Re et al., 1999). In summary, a (7mM) ABTS solution was prepared using methanol and incorporating a 2.45mM potassium persulfate solution. This mixture underwent 16-hour incubation in complete darkness. From this stock solution, 1ml of ABTS was extracted, diluted with 50% methanol to achieve an absorbance of 0.700±0.01 at 734nm. Different concentrations of the plant extract (ranging from 20µg/ml to 120µg/ml) were then prepared from a (1mg/ml) stock solution. The volume was adjusted to (100µl) with methanol, and (100µl) of the extract solution was combined with (100µl) of the ABTS solution, with absorbance measured at 734 nm against methanol. BHT served as a positive control. The percentage of radical scavenging activity was calculated using the equation provided below:

$$\text{ABTS Scavenging activity (\%)} = \frac{\text{Abs control} - \text{Abs sample}}{\text{Abs control}} X100$$

3.13. Nutritional analysis of WEPs

The nutritional contents of the three WEPs collected from WR and WPand CR and CPones were analysed using the following parameters.

3.13.1. Total moisture content:

Total moisture content was determined as per (AOAC, 1990). 2g of fresh sample was dried in an oven at 100°C for overnight and was then cooled and weight till until constant weight was obtained. The differences were expressed as the percentage of oven-dry weight.

$$\text{Moisture (\%)} = \frac{\text{fresh weight} - \text{dry weight}}{\text{fresh weight}}$$

3.13.2. Total ash content (AOAC, 1990)

From the dried samples, 1 gram each was placed in crucible in furnace and subjected to a temperature of 550°C for three hours. This cycle was repeated until a consistent weight was achieved. The total ash content was calculated as:

$$\text{Ash (\%)} = \frac{weight\ of\ ash}{weight\ of\ sample} X\ 100$$

3.13.3. Total Fat Determination (AOAC, 1990)

From the dried sample, 50 grams each were placed in a Soxhlet with 600 ml of petroleum ether for an 8-hour extraction process. The extracted fat was allowed to air-dry at room temperature, weighed, and then the percentage was calculated.

$$\text{Fat (\%)} = \frac{\text{Mass of extracted}}{\text{Sample weight}} X100$$

3.13.4. Total Protein Content

The quantification of total protein content was conducted through the Lowry assay as outlined by (Lowry et al., 1951). Initially, 0.1g of each dried powdered sample was crushed with 10ml of phosphate buffer (pH 7.4) and centrifuged at 10,000rpm for 10 minutes. The supernatant, collected after discarding the pellets, was then used. Subsequently, 0.1ml of each extract was diluted with 0.9ml of Milli-Q water to reach a total volume of 1ml. After the addition of the analytical reagent, the mixture was incubated for 10 minutes at room temperature. Following this, 0.2ml of Folin-Ciocalteau reagent (1N) was added, and the solution underwent incubation for

an additional 30 minutes at room temperature. The absorbance was measured at 660nm using a UV-Vis spectrophotometer. The protein content in each sample was determined using the standard curve prepared with BSA (1mg/ml), and the results were expressed in mg/g of dry weight sample.

3.13.4. Total carbohydrate content

The determination of total carbohydrate content was carried out using Anthrone reagent in accordance with (Hedge and Hofreiter 1962). In summary, 100mg of each sample was hydrolysed with 10ml of 80% ethanol, followed by centrifugation at 8000rpm for 5 minutes. The supernatant was collected, and 0.1ml of each extract volume was adjusted to 1ml. Subsequently, 4ml of Anthrone reagent was added to each extract, and the mixture was subjected to a water bath at 60ºC for 5 minutes before being cooled to room temperature. The samples were read at 630nm using a UV-Vis spectrophotometer. The amount of carbohydrates present in each sample was calculated from the standard curve prepared using glucose (1mg/ml) with concentrations ranging from 10 to 100µg/ml. The results were expressed in mg/g of dry weight sample.

3.13.5. Estimation of calorific value

The total energy content of WEPs was determined by values for protein, carbohydrates, and fats multiplied by 4.00, 4.00, and 9.00 respectively, (AOAC, 2000).

Energy Kcal/100g = amount of carbohydrate in gram x 4 + amount of protein in gram x 4 + amount of fat in gram x

3.14. Anti-nutritional contents (WEPs)

Plants and plant products are an important element of people's life because they are our source of nutrition. Nevertheless, researchers are raising concerns about the nutritional value of plant-based foods due to the existence of specific compounds referred to as 'anti-nutrients' or anti-nutritional factors Anti-nutritional factors (ANFs) are substances that impede the process of digestion of nutrients disturbing

the absorption of biomolecules and hamper the availability to human beings and can produce other adverse effects. The major anti-nutrients found in plant-based foods are phytates, tannins, alkaloids, lectins, oxalates, etc (Soni et al., 2020)

3.14.1. Phytate

The phytate content was determined following a procedure described by (Arjmand et al., 2023). From each dried sample, 2 grams each were soaked in 100 ml of 2% HCL for 3 hours and then filtered using Whatman no 1 paper. Subsequently, 5 ml of a 0.3% ammonium thiocyanate solution and 53.3 ml of distilled water were added to 25 ml of the filtrate in another conical flask. Then the solution was titrated against iron III chloride solution (0.00195 g iron per ml) until it developed a reddish-brown colour that remained stable for 5 minutes. The phytate content was then calculated.

$$\text{Phytate (\%)} = \text{Titer value} \times 0.001\,95 \times 1.19 \times 100.$$

3.14.2. Oxalate

Oxalate content were determined as described by (Ohikhena et al., 2017). Briefly, 1 gm of each samples were weighed in a beaker that contained 75 ml of 3M H_2SO_4, mixed properly and filtered. 5ml of the filtrate were heated to 90°C and titrated against 0.05M of $KMnO_4$ till colour change that persists for 30 seconds. The oxalate content was calculated taking 1ml of 0.05 M of $KMnO_4$ to 2.2 mg oxalate.

3.14.3. Saponin

The saponin content was determined using a method (Oyeyinka and Afolayan, 2019). Briefly, 0.5 grams of each sample were placed in a beaker with 50 ml of 20% ethanol followed by water bath at 55°C for 4 hours, then filtered, and the residue was re-extracted with another 50 ml of 20% ethanol. The resulting solutions were combined and concentrated to a final volume of 20 ml in a water bath at 90°C. This solution was then transferred to a separating funnel containing 20 ml of diethyl ether. The aqueous layer was collected, and 20 ml of n-butanol was added. This mixture was washed three times with 10 ml of 5% sodium chloride, and the ethyl

layer was discarded. The mixture was oven dried at 40 ^{0} C. Saponin percentages were calculated as below:

$$\text{Saponin (\%)} = \frac{\text{weight of the final filtrate}}{\text{weight of the sample}} \text{X100}$$

3.14.4. Alkaloid

Alkaloid content was determined according to methods described by (Oyeyinka and Afolayan, 2019). Briefly, 5 gm of each sample were mixed with 200 ml of 10% acetic acid in ethanol followed by incubation at room temperature for 4 hours, filtered and concentrated to quarter of its original volume in water bath. After that concentrated ammonium hydroxide was added drop wise till precipitation was obtained. The solution was filtered after washing with diluted ammonium hydroxide. It was oven dried at 40°C. The alkaloids content was calculated as:

$$\text{Alkaloid (\%)} = \frac{\text{final weight of the sample}}{\text{initial weight of the sample}} \text{X 100}$$

3.14.5. **Mineral digestion and AAS spectrophotometer**

For the anlysis of minerals in raw and processed sample (Pequerul et al., 1993) was followed with slight modification) .0.5 g of sample in a 250 mL dry flask and stirred. Then 4 mL of 33% H20 2 were carefully and was heated on a hot plate and a strong effervescence was produced. When the brown fumes were less dense (7-8 minutes), the solution was allowed to cool. A slightly yellow dissolution and a small white solid quantity in suspension still remained. The solution was filtered, washed with 5 mL of (1: 1) HCl (density 1.18 g mL - 1) and diluted up to 25 mL with distilled water which was then filtered in microsyringe 2mm and further analysed in AAS following (Ajatta et al., 2021)

3.15. Liquid chromatography-mass spectrometry (LC-MS) characterization of medicinal plants

LC-MS was used for the determination of bioactive compounds of the three medicinal plants which were carried out at Aakaar Biotech Research Institute (Table

5 & 6) Lucknow, using LC-ESI-MS (Liquid Chromatography-Electrospray Ionization-Mass Spectrometry). The methanol extracts were centrifuged at 12,000 rpm for 10 min before analysis. The HPLC system consisted of two pumps and an automated injector. Separation was achieved on a C-18 column (Agilent Eclipse, 5 µ, 15 cm, 4.6 mm id). Two mobile phases were used: A-0.1% formic acid in water and B- 90% of acetonitrile in water, at a flow rate of 500 µl min^{-1}. The LC conditions were 5% at 0^{-3} min in B, a linear increase from 5 to 20% between 3 and 25 min, 20 to 40% during 25–40 min, and from 40 to 50% between 40 and 55 min, finally, it reached 50 to 95% at 55–63 min followed by (Pai et al., 2015). The Water UPLC-TQD Mass spectrometer was used in positive ionization mode for the MS analysis using data-dependent automatic switching between MS and MS/MS acquisition modes.

A) Instrument Details

Table 5. LC Instrument: XEVO-TQD#QCA1232

Column: SUNFIRE C18, 250 X 2.1, 2.6um

A%	0.0 H_2O
B%	5.0 CAN
C%	0.0 MeOH
D%	95.0 0.1% Formic Acid in water
Flow (ml/min)	1.500
Stop Time (mins)	5.0
Column Temperature (°C)	30.0
Min Pressure (Bar)	0.0
Max Pressure (Bar)	300.0

B) Table 6. The Gradient

Time	A%	B%	C%	D%	Flow
0.00	0.0	5.0	0.0	95.0	1.500
1.00	0.0	5.0	0.0	95.0	1.500
6.00	0.0	30.0	0.0	70.0	1.500
12.00	0.0	60.0	0.0	40.0	1.500
16.00	0.0	60.0	0.0	40.0	1.500
20.00	0.0	80.0	0.0	20.0	1.500
26.00	0.0	5.0	0.0	95.0	1.500
30.00	0.0	5.0	0.0	95.0	1.500

3.16. Statistical analysis

All the experiments were replicated thrice for all the samples of the WEPs and medicinal plants and their values were reported as mean ± standard deviation. Obtained results were statistically analysed using SPSS software and graph pad prism (2017) and were subjected to one -way ANOVA ($p < 0.05\%$ significance level) followed by *post hoc* test using Duncan's multiple range for comparison of statistical significance. Points of FTIR were plotted using Origin Pro 2021 (version 9.8.0.200, Origin Lab Corporation, USA).

CHAPTER– 4

Results

4.0. Socio-demographic of the informants

Altogether 210 number of diverse tribal informants (*Paite, Thadou, Hmar, Gangte, Vaiphei, Simte* and *Zou*) from undivided Churachandpur district (20-61yrs and above) was interviewed during the field survey. Among them, 132 were male and 78 were female informants. The male informants represents 25 (*Paite* and *Thadou*), 20 Hmar, 16 (*Gangte* and *Vaiphei*) and 15 (*Simte* and *Zou*). It was observed that 15% respondent were of age group (above 61), 22% respondent (51-60), 30% respondent (41-50), 21% respondent (31-40) and 12% respondent (21-30) (Table.7). Despite the absence of ethnic base census enumeration it can be concluded that, the *Paite* and the *Thadou* constitute the largest population while the other tribal groups constitute the lowest from the study site based on the ethnic based educational level (Fig.1.2).

Among the total informant, 36% of the respondents were found to be illiterate (Fig.1.3). The graduates constitute only up to 9% among the informants and they primarily comprised the church leaders from various denominations who dispatched missionaries to villages to promote Christianity and establish open educational institutions. Overall, the informants show the educational qualification with secondary level and primary level constituting a percentage of 24 and 31 respectively. It is worth noting that government run primary schools and anganwadi centres often struggle to operate effectively and, in some cases, schools are conspicuously absent in certain villages.

The *Paite* and the *Thadou* respondents constitute the highest secondary education standard along with the graduates (Fig.1.4) while the highest illiterate informants come from *Zou, Simte* and *Gangte* tribes' respondents (Fig.1.5 and 1.7).

Table 7. Demographic profile of the informants from the study sites

Demographic features	**Variables**	***Paite***	***Thadou***	***Hmar***	***Gangte***	***Vaiphei***	***Simte***	***Zou***
Gender								
Male	142	29	26	23	18	15	17	14
Female	68	15	12	10	9	8	6	9
Occupation								
Male herbalist	27	5	5	3	4	5	3	2
Female herbalist	18	3	2	4	2	3	2	1
Agriculturist	70	16	15	8	9	7	7	8
Animal drover	30	5	3	4	5	4	5	4
Church leader	16	3	3	2	2	2	2	2
Village head men	49	7	7	7	7	7	7	7
Religion								
Christianity	151	36	30	20	21	22	20	20
Others	59	9	10	8	8	8	8	8
Educational								
Graduate	20	5	5	2	2	2	2	2
Secondary	50	12	10	8	5	5	6	4
Primary	65	15	15	10	7	5	8	5
Illiterate	75	16	17	10	9	8	9	6
Age group								
>20-30	65	10	10	10	10	10	8	7
31-40	45	7	7	7	7	7	5	5
41-50	38	6	6	6	5	5	5	5
51-60	37	5	6	6	5	5	5	5
>61	25	4	4	4	4	3	3	3

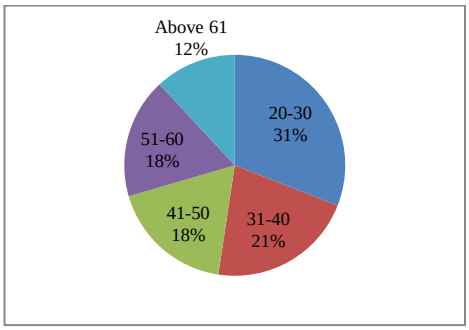

Fig.1.2. Age group.

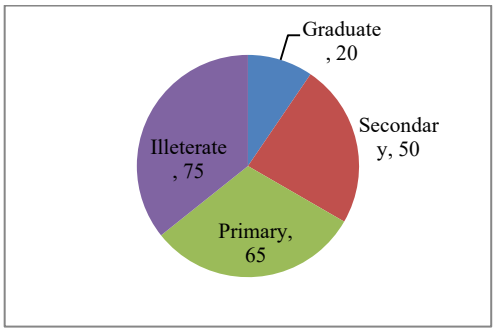

Fig.1.3. Education level as a whole

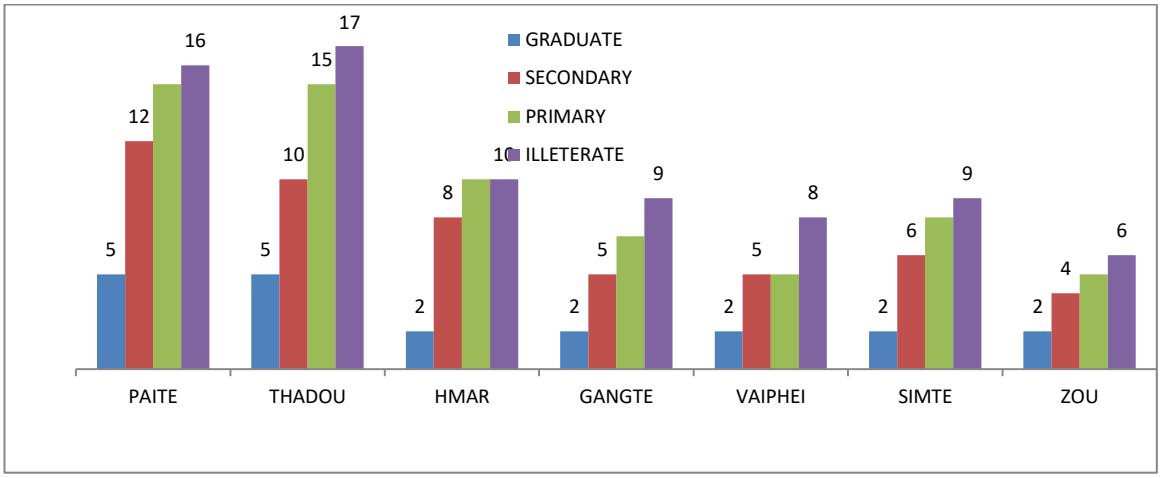

Fig.1.4. Ethnic base Education level as per the tribe or clan

(*Educational base only: no other data*)

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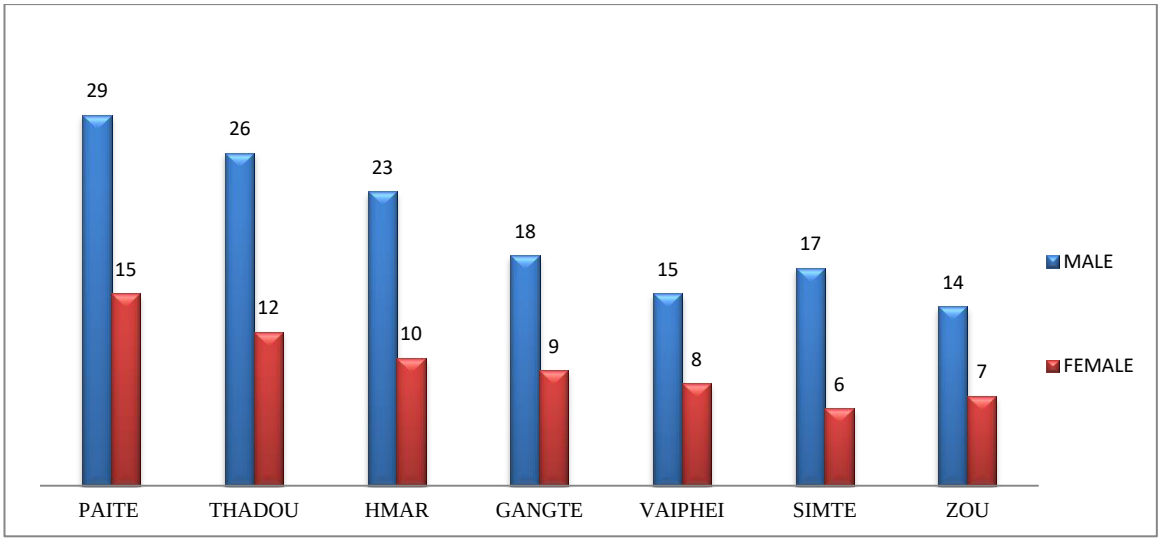
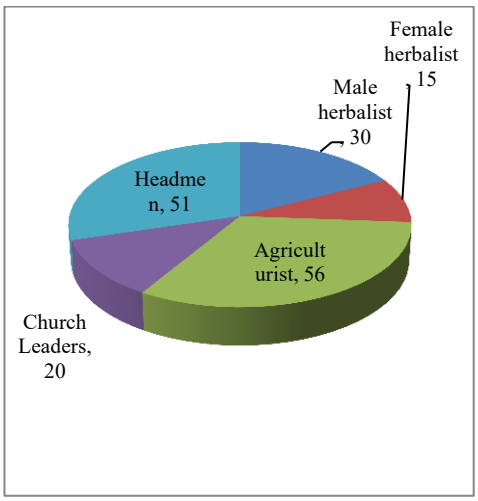


Fig.1.5. Gender representations of informants as per the tribe or clan



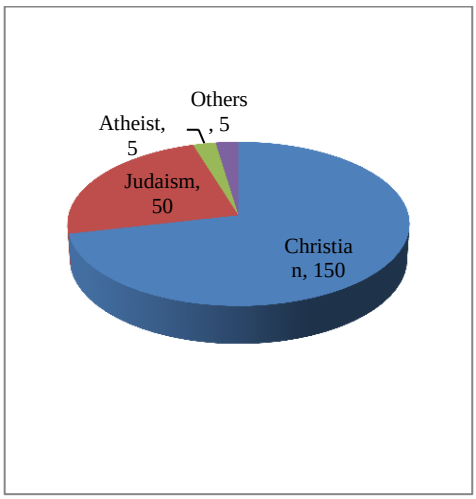


Fig.1.6. Occupation of the tribal informants. Fig.1.7. Religions of the tribal group.

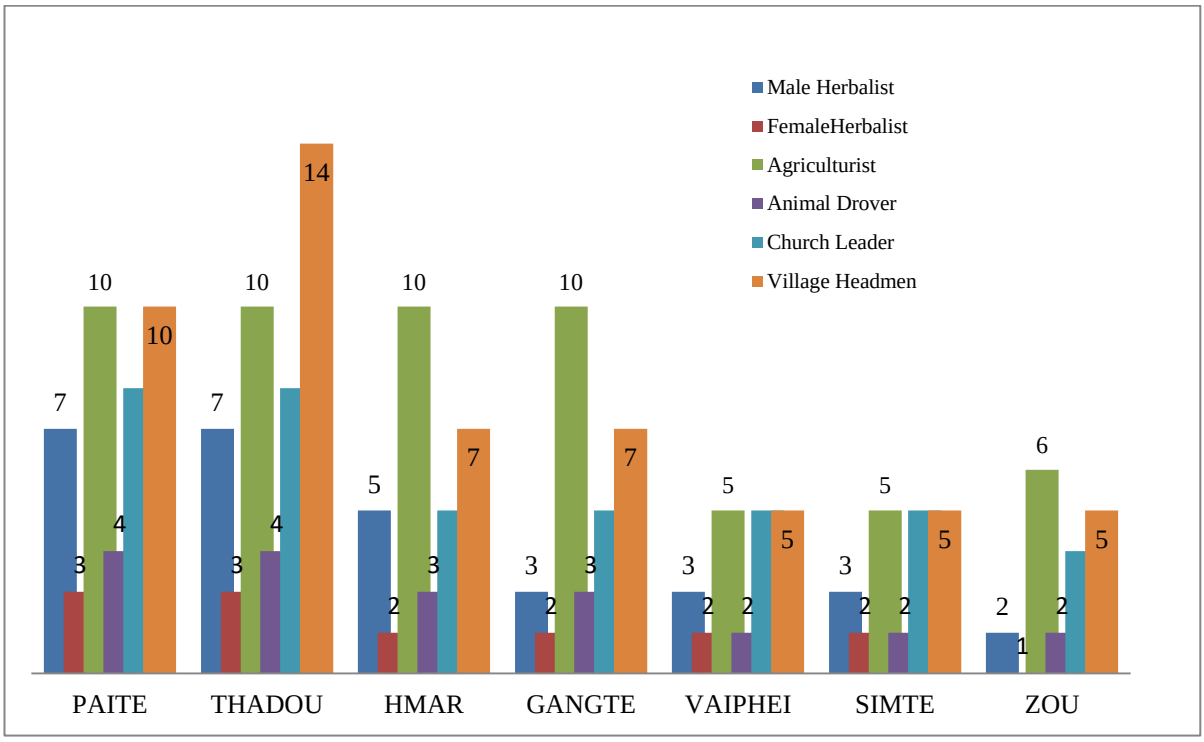


Fig.1.8. Occupations of the ethnic groups. *(only occupations and not as a whole)*

Despite religion playing big role in the society where Christianity (72%) is the dominant groups followed by believers in Judaism which constitute 24% (Fig.1.5). It is customary that each villager have to make small amount of surplus earnings to the village headmen as a form of courtesy. Thus, many tribal groups grab the opportunity to become headmen which is quite prominent in the case of the *Thadou* community (Fig.1.6). Village headmen have great privileges from many villagers and the government. Male herbalist was more dominant compare to their female counterpart.

4.1. Demographic details of the informants

The analysis revealed that the age of the informants does have an impact on their knowledge domain. Out of the total, 62 informants are of the middle age (41-50 yr) and were found to have the highest traditional knowledge followed by 46 informants representing the oldest age group (above 61yr), then 45 respondents of (31-40yr) age group. The least knowledgeable group of 26 informants were found to represent the youngest (20-30 yr). The traditional knowledge is transmitted from the older to the younger generation. However, it is quite evident that younger generation are no more interested in taking up such career and choose a better way of earning as obvious in their occupation (Fig.1.7 and 1.8).

4.2. Qualitative and Quantitative ethnobotanical studies

The present investigation has been carried out to record the information regarding the diversified traditional or folk uses of plants by the different tribes in Churachandpur district, Manipur.

4.2.1. Wild Edible Plants (WEPs)

A total of 78 WEPs have been documented from the study site belonging to 66 genera and 47 Families (Table 8).

Table 8. Details of WEPs with Scientific Name, Local Name, Habit, Mode of Consumption, Flowering/Fruiting, Market Value, UV and RFC

Sl. No.	**Scientific name and Family**	**Local name P/T/H/L/S/Z/V**	**Habit**	**Mode of consumption**	**Fruiting/ flowering**	**Market value (Rs)**	**UV**	**RFC**
1.	*Acmella paniculata* (Wall. ex DC.) R.K.Jansen (Asteraceae) MZUH-0106	Ansache T/Z/V/S	Hb	Cooked or eaten raw	May – Sept	30/bundle	0.16	0.06
2.	*Acmella uliginosa* (Sw.) Cass. (Asteraceae) MZUH-0120	Ansateh T/H/Z Anasa Ankasa T/H/Z	Hb	Fry and steam	Jun- Sept	30-50/ bundle	0.08	0.05
3.	*Aesculus hippocastanum* L. (Sapindaceae) MZUH-0115	Segah P/T/Z/V/S	Tr	Raw	April-June Aug-Oct	60/bundle	0.06	0.03
4.	*Allium hookeri* Thwaites (Amaryllidaceae) MZUH-0129	Phunlunzung T/H/Z	Hb	Processed traditionally	Aug-Sept.	40-60/bundle	0.5	0.02
5.	*Alocasia fornicata* (Kunth) Schott (Araceae) MZUH-0127	Baibing P/T/H/	Hb	Cooked and smoked	June- Aug	70 per bundle	0.19	0.09
6.	*Alpinia roxburghii* Sweet (Zingiberaceae) MZUH-0043	Aichal P/T/H/	Hb	Cooked	May-June	-0/bundle	0.12	0.05
7.	*Amaranthus spinosus* L. (Amaranthaceae) MZUH-0111	Bawngektehlian Lenhling- T/Z/V/S	Hb	Boil, fry and steam	April- June	40/bundle	0.03	0.03
8.	*Amomum maximum* Roxb. (Zingiberaceae) MZUH-0130	Aigechil Aidu P/T/H	Hb	Cooked, roasted fried	Mar- May	50/bundle	0.2	0.09

9.	*Amorphophallus bulbifera* (Schott) Blume(Araceae) MZUH-0209	Telhong nu P/T/H/	Hb	Processed	June–July	-	0.09	0.03
10.	*Amorphophallus napalensis* (Wall.) Bogner & Mayo (Araceae) MZUH-0121	Telhongpa P/T/H	Hb	Processed traditionally	June- July	50 per cup	0.20	0.32
11.	*Ananas comosus* (L.) Merr. (Bromeliaceae) MZUH-0107	Lengthei- T/Z/V/S	Hb	Raw	May-June	30/bundle	0.07	0.06
12.	*Artocarpus heterophyllus* Lam. (Moraceae) MZUH-0110	Lamkhuang T/Z/V/S	Tr	Raw	Feb-June	100/fruit	0.03	0.04
13.	*Artocarpus lacucha* Buch.-Ham. (Moraceae) MZUH-0103	Taat P/T/H/	Tr	Raw and process	Feb- April	70/ kg	0.04	0.04
14.	*Averrhoa carambola* L. (Oxalidaceae) MZUH-0128	Theihelhawt P/T/H/	Tr	Raw /pickle	July-Aug	10-30/ Bundle	0.16	0.07
15.	*Azadirachta indica* A.Juss. (Meliaceae) MZUH-0013	Neem T/Z/V/S	Tr	Raw leaves fried with egg yolk	April- May	-	0.18	0.06
16.	*Baccaurea ramiflora* Lour. (Phyllanthaceae) MZUH-0109	Pangkai T/Z/V/S	Tr	Ripen fruit	May- July	50 /bundle	0.04	0.08
17.	*Bambusa tulda* Roxb. (Poaceae) MZUH-0112	Gua - T/Z/V/S Rawthing –L	Sb	Cooked/fried and fermented	April- May	50 per pack.	0.05	0.02
18.	*Bauhinia variegata* L. (Fabaceae) MZUH-0014	Bible pak T/Z/V/S	Tr	Cooked	Feb-April	-	0.02	0.6
19.	*Begonia roxburghii* (Miq.) A.DC.(Begoniaceae)	Sekhupthur T/Z/V/S	Hb	Cooked	Jun-Sept	30/bundle	0.08	0.06

	MZUH-0104							
20.	*Blumea lanceolaria* (Roxb.) Druce (Asteraceae) MZUH-0036	Bualze T/Z/V/S	Hb	Fried and cooked	Feb-April	50/bundle	0.27	0.35
21.	*Bruinsmia polysperma* (C.B.Clarke) Steenis (Styracaceae) MZUH-0108	Theipalingkoh T/Z/V/S	Tr	Ripen fruit	April-July		0.05	0.12
22.	*Calamus erectus* Roxb. (Araceae) MZUH-0117	Chiingngek Thil-thek- T/Z/V/S	Cl	Fried, boiled and local cuisine	Oct-Dec	70/pith	0.25	0.11
23.	*Calamus tenuis* Roxb. (Araceae) MZUH-0125	Chiingngek- T/Z/V/S Hruizik -L	Cl	Fried,boiled and local cuisine	Oct –Dec	70/pith	0.22	0.09
24.	*Caryota mitis* Lour. (Arecaceae) MZUH-0126	Tuum - T/Z/V/S	Hb	Boiled, fried	All season	100/bundle	0.06	0.19
25.	*Centella asiatica* (L.) Urb. (Apiaceae) MZUH-0002	Tankuang- T/Z/V/S Lambak -–L	Hb	Boil steam and fry	July –Aug	50/bundle	0.22	0.23
26.	*Cinnamomum verum* J.Presl (Lauraceae) MZUH-0003	Singuithak- T/Z/V/S	Tr	Dried	All season	70-100/bundle	0.12	0.11
27.	*Cissus repanda* (Wight & Arn.) Vahl (Vitaceae) MZUH-0131	Lenpuang- T/Z/V/S Hruipawl-L	Cl	Boil,cooked and fried	Aug-Sept	40/bunble	0.09	0.10
28.	*Citrus* × *aurantium* f. *delicio sa* (Ten.) M.Hiroe (Rutaceae) MZUH-0123	SeMZUHhum- T/Z/V/S	Tr	Raw	Nov- Jan	100/bundle	0.05	0.07
29.	*Citrus* × *aurantium* L. (Rutaceae) MZUH-0119	Sekmam- T/Z/V/S	Tr	Raw or ripen	Nov-March	50/bundle	0.12	0.09
30.	*Clerodendrum colebrookeanum* Walp. (Lamiaceae) MZUH-0004	Anphui - T/Z/V/S Phuihnam	Tr	Boil steam and fried	Sept-Dec	50/bundle	0.09	0.21

31.	*Coix lacryma-jobi* L. (Poaceae) MZUH-0134	Miimtang- Z/V/S	Sb	Roasted	May- Oct.	-	0.03	0.04
32.	*Colocasia esculenta* (L.) Schott (Araceae) MZUH-0005	Baal- T/Z/V/S	Hb	Cooked	All season	80/bundle	0.13	0.06
33.	*Cucumis sativus* L. (Cucurbitaceae) MZUH-0007	Tangmai - Z/V/S	Cl	Raw and ripen fruit	Mar- April	100/bundle	0.13	0.09
34.	*Cucurbita maxima* Duchesne (Cucurbitaceae) MZUH-0142	Mai - Z/V/S	Cl	Cooked	All season	50/pieces	0.18	0.08
35.	*Cycas pectinata* Buch.-Ham. (Cycadaceae) MZUH-0097	Tanglu - T/Z/V/S	Sb	Cooked and fried	April-May	150/bundle	0.15	0.18
36.	*Daucus carota* L. (Apiaceae) MZUH-0022	Carrot Z/V/S	Hb	Cooked or raw	May –Sept	150/kg	0.09	0.91
37.	*Dendrocalamus latiflorus* Munro (Poaceae) MZUH-0140	Gomi Z/V/S	Hb	Cooked fried boiled with fermented fish meat	May-Oct	60-100/bundle	0.15	0.78
38.	*Dendrocalamus latiflorus* Munro (Poaceae) MZUH-0150	Gova Z/V/S	Hb	Cooked fried, boiled, fermented	May-Oct	60-100/bundle	0.14	0.63
39.	*Dendrocalamus manipureanus* H.B.Naithani & N.S.Bisht (Poaceae) MZUH-0149	Gopi Z/V/S	Hb	Cooked, fried,boiled, fermented	May-Oct	60-100/bundle	0.11	0.07
40.	*Dioscorea bulbifera* L. (Dioscoraceae) MZUH-0027	Bachhim Z/V/S	Cl	Boiled	Aug-Nov	40-80/bundle	0.03	0.08
41.	*Diplazium esculentum* (Retz.) Sw.(Aspleniaceae) MZUH-	Chakawk Z/V/S	Tr	Boiled ,cooked and fried	Feb- May	60/bundle	0.14	0.5

	0139							
42.	*Ensete superbum* (Roxb.) Cheesman (Musaceae) MZUH-0152	Saisuang Saisu-L Z/V/S	Hb	Boiled ,fried fermented	All season	60/bundle	0.04	0.7
43.	*Eurya acuminata* DC. (Pentaphylacaceae) MZUH-0137	Sihzo Z/V/S	Tr	Boiled and cooked	All season	30/bundle	0.08	0.4
44.	*Ficus rumphii* Blume (Moraceae) MZUH-0143	Mawnglawk	Tr	Boiled or fried	May- June	20/bundle	0.08	0.05
45.	*Ficus semicordata* Buch.-Ham. ex Sm. (Moraceae) MZUH-0032	Theipi P/T/H/Z	Tr	Ripen fruit	May- Oct	30/budnle	0.11	0.06
46.	*Glinus oppositifolius* (L.) Aug.DC. (Molluginaceae) MZUH-0147	Bahkhate P/T/H/Z	Hb	Fried	July-Aug	40/bundle	0.09	0.08
47.	*Gnetum gnemon* L. (Gnetaceae) MZUH-0146	Pelh P/T/H/Z	Hb	Leaves	June-Sep	10/bundle	0.06	0.4
48.	*Hibiscus sabdariffa* L. (Malvaceae) MZUH-0155	Anthuk P/T/H/Z	Sb	Cooked	All season	50/pack	0.09	0.5
49.	*Houttuynia cordata* Thunb. (Saururaceae) MZUH-0114	Aithanglou P/T/H/Z Uithinthang-L	Hb	Leaves and roots	April-May	20/ bundle	0.14	0.27
50.	*Ipomoea batatas* (L.) Lam. (Convolvulaceae) MZUH-0148	Kawkai Z/V/S	Hb	Cooked	All season	100/kg	0.09	0.07
51.	*Lepionurus sylvestris* Blume (Opiliaceae) MZUH-0089	Anpangthuam P/T/H/Z	Sb	Cooked, steam	Whole year	25/bundle	0.06	0.08
52.	*Manihot esculenta* Crantz (Euphorbiaceae) MZUH-0139	Singkawlkai Z/V/S	Hb	Cooked	All season	100/kg	0.05	0.06

53.	*Momordica charantia* L (Cucurbitaceae) MZUH-0092	Tangkhaneu P/T/H/Z Chankha neu	Cl	Fruit steamed, leaves	April- Oct	60/kilos 30/bunde leaves	0.18	0.31
54.	*Musa balbisiana* Colla (Musaceae) MZUH-0136	Nahtang lawk Tumbu-L P/T/H/Z	Hb	Cooked , roasted, fried	Aug-Nov	30/pieces	0.09	0.09
55.	*Musa. x paradisiaca* L. Musaceae MZUH-0135	Nahtang tang nei Lairawk –L P/T/H/Z	Hb	Cooked, roasted, fried	Aug- Nov	20/pieces	0.03	0.08
56.	*Oroxylum indicum* (L.) Kurz (Bignoniaceae) MZUH-0095	Baklawng P/T/H/Z Archangkawm P/T/H/Z	Tr	Roasted, cooked and fried	Aug-Nov	50-100/bundle	0.18	0.31
57.	*Phyllanthus emblica* L. (Phylllanthaceae) MZUH-0080	Suaklu Sunhlu	Tr	Raw or dried	All season	50-100/package	0.10	0.21
58.	*Plantago depressa* Willd. (Plantaginaceae) MZUH-0158	Vohpibilteh P/T/H/Z Vawknan-an	Hb	Cooked,fried	Mar- Sep	-	0.09	0.08
59.	*Prasoxylon excelsum* (Spreng.) Mabb.(Meliaceae) MZUH-00151	Singthupi Z/V/S	Tr	Boil steam and fry	All season	50/bundle	0.15	0.19
60.	*Psophocarpus tetragonolobus* (L.) DC (Fabaceae) MZUH-0160	Bepi gui lian P/T/H/Z	Cl	Cooked	Mar-June	50/pack	0.06	0.16
61.	*Punica grantum* L (Lythraceae) MZUH-0165	Theibuhfai P/T/H/Z	Tr	Ripen fruit	Sep-Feb	200/kg	0.02	0.08
62.	*Raphanus raphanistrum* subsp. *sativus* (L.) Domin(Brassicaceae)	Mulla P/T/H/Z	Hb	Raw or cooked	April-june	50/kg	0.05	0.16

	MZUH-0171							
63.	*Rhus chinensis* Mill. (Anacardiaceae) MZUH-0034	Khongma P/T/H/Z	Tr	Raw, cooked or processed	Sep-Oct	30-50/package	0.01	0.16
64.	*Rhynchotechum ellipticum* (Wall. ex D.Dietr.) A.DC. (Gesneriaceae) MZUH-0156	Chiaklep P/T/H/Z	Sb	Cooked	All season	30-50/bundle	0.02	0.06
65.	*Rubus alceifolius* Poir. (Rosaceae) MZUH-172	Siali-nu-chhu P/T/H/Z	Sb	Ripen fruit	March-April	-	0.02	0.09
66.	*Rubus ellipticus* Sm. (Rosaceae) MZUH-0055	Lingtheimin P/T/H/Z	Sb	Raw	Feb-April	-	0.08	0.09
67.	*Ruehssia macrophylla* (Humb. & Bonpl. ex Schult.) H.Karst. (Apocynaceae) MZUH-0153	Ankhapi P/T/H/Z Ankhapui P/T/H/Z	Cl	Cooked with fermented meat fats	All season	30/bundle	0.08	0.8
68.	*Senegalia pennata* (L.) Maslin (Fabaceae) MZUH-0203	Khangkhuh-P/T/H/Z/V Hanghuh-L	Sb	Boil, fry or steam	May- June	50-100/ bundle	0.2	0.071
69.	*Senna occidentalis* (L.) Link (Fabaceae) MZUH-0166	Lengan P/T/H/Z Rengan	Sb	Cooked with local rice	May-Jul	20-30/bundle	0.1	0.16
70.	*Solanum nigrum* L. (Solanaceae) MZUH-0099	Anzo P/T/H/Z Anhling	Sb	Cooked, fried	Feb- Oct	30-50/bundle	0.03	0.06
71.	*Solanum torvum* Sw. (Solanaceae) MZUH-0174	Tawkpi P/T/H/Z Samphawkpi P/T/H/Z	Sb	Cooked fried ,salad, side dish	May-July	30-40/bundle	0.16	0.24
72.	*Solanum violaceum* Ortega (Solanaceae) MZUH-1059	Samphokneu Tawlte P/T/H/Z	Sb	Cooked, boiled, fried, processed	April-July	30-40/bundle	0.12	0.20
73.	*Spondias pinnata* (L.f.) Kurz (Anacardiaceae) MZUH-	Tuaiteng P/T/H/Z	Tr	Raw	All season	Fruit-20-50/kg	0.08	0.19

	0056							
74.	*Syzygium cumini* (L.) Skeels (Myrtaceae) MZUH-0169	Jamun P/T/H/Z	Tr	Raw or ripen	All season	300/kg	0.05	0.06
75.	*Trevesia palmata* (Roxb. ex Lindl.) Vis./ (Araliaceae)MZUH-0069	Uilusiin P/T/H/Z Kawhtebel P/T/H/Z	Tr	Fried, cooked	Feb-April	50-90/bundle	0.02	0.09
76.	*Zanthoxylum rhetsa* (Roxb.) DC. (Rutaceae) MZUH-0070	Singjual P/T/H/Z Chingit Z	Tr	Raw, Boiled, cooked as bai	Aug-Dec	30-50/bundle	0.20	0.38
77.	*Zingiber kangleipakense* Kishor & Škorničk. (Zingiberaceae) MZUH-0161	Aipak ngek P/T/H/Z Namra	Hb	Cooked fried,raw	June–July	50/bundle	0.18	0.02
78.	*Ziziphus mauritiana* var. *mauritiana* (Rhamnaceae) MZUH-0050	Boroi P/T/H/Z	Tr	Raw or dried	All season	200/pack	0.18	0.20

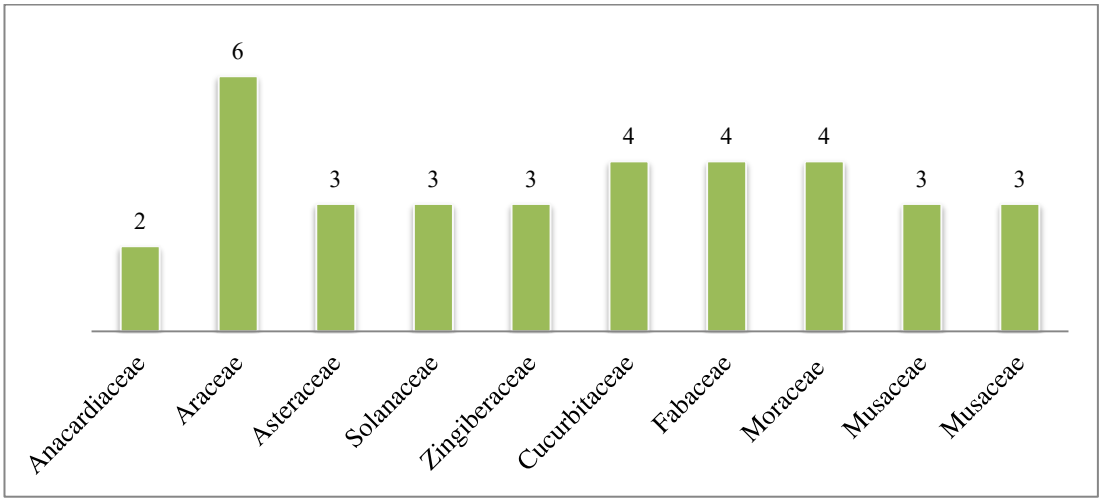


Fig.1.9. Top 10 Families of WEPs

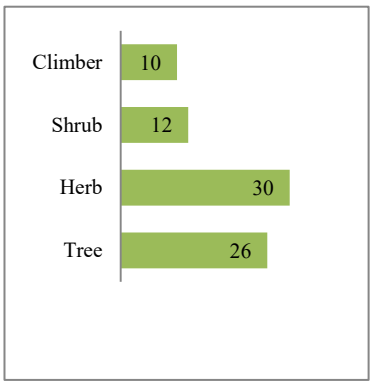


Fig.2. Habit of WEPs

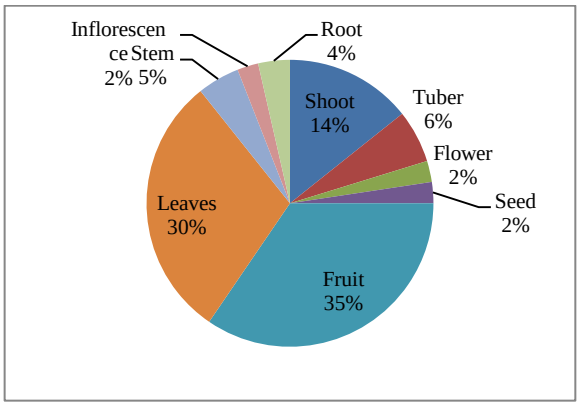


Fig.2.1.Edible parts of the WEPs

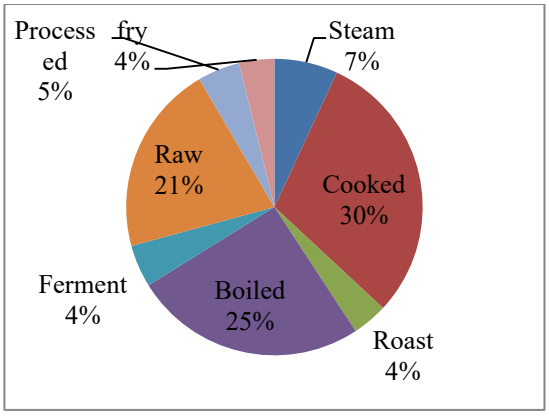


Fig.2.2. Mode of consumption of WEPs

4.2.2. Taxonomic diversity of WEPs

Out of the total reported WEPs**,** the taxa represented from the families include Araceae-6, Poaceae-5, Moraceae & Cucurbitaceae-4, Asteraceae, Fabaceae, Musaceae, Solanaceae-3 each, Apiaceae, Anacardiaceae, Rosaceae, and the rest 1 family each (Fig.1.9). The WEPs investigated in the study site exhibited a range of life forms, with trees (26 species) comprising the largest portion of the collected plant specimens from the study site. This was followed by herbs (30 species), shrubs (13 species) and climbers (10 species) (Fig.2). The plant parts (Fig.2.1) consumed as fruit is the highest among the WEPs representing 35% followed by leaves 30%, shoot 14%, tuber 6%, stem 5%, root 4%, flower 2%, seed 2%, and inflorescence 2%.

The different mode of consumptions of the WEPs are as cooked representing (30% with 35 species), raw (21% with 22 species), fried (4% with 5 species), and steam (7% with 9 species) (Fig.2.2). Out of the 7 mode of consumption the most unique and common form of enhanching the wild edible species is the traditionally processed form like roasting and fermentation. The roasting species includes *(Amomum dealbatum, Coix lacryma jobi*, *Musa x paradisiaca*, *Oroxylum indicum*) traditionally processed *Amophophallus napalensis*, *Amophophallus bulbifera, Allium hookerii* and fermentation (*Bambusa tulda*, *Dendrocalamus latiflorus*, *Dendrocalamus manipureanus*, *Ensete superbum* and *Marsdenia maculata*. The traditionally processed plant products are mixed with fermented fats of pig or cow's fat locally known as sathu, which are elaborated in the traditional dishes.

4.2.3. Ethnomedicinal uses of the WEPs

The WEPs were also found to have the ethnomedicinal properties. Out of the total of 78 numbers of plants which were used as good source of vegetables and fruits were found to be used as medicinal plants with selected 13 plants commonly used to treat 17 major disease/ailment (Table 10) categories like Anti-diabetic (*Phyllanthus emblica*, *Momordica charantia*, *Centella asiatica* and *Punica grantum*), Diarrhoea (*Musa balbisinia*), dysentery (*Dysoxyllum gobara*), Blood pressure (*Clerodendrum colebrookianum, Cucumis sativa*, *Solanum americanum*, *Solanum torvum*), Food poisoning (*Averrhoea carambola, Centella asiatic*a, *Zanthoxylum*

rhetsa, Intestinal worm (*Solanum americanum, Senna occidentalis, Solanum torvum*, Toothache (*Solanum torvum, Solanum violaceum*, Skin problem (*Centella asiatica*), Liver problem (*Cajanus cajan, Cuscuta reflexa*, *Saccharum officinarum*), Urinary problem (*Ananas comosus*, *Cycas pectinata*), Fever (*Cucumis sativa*, *Plantago depressa*) Insomnia (*Ziziphus jujuba*, *Amomum dealbatum*). These WEPs with ethnomedicinal properties were quantitatively analysed for the following indices with the results as shown in Table 9 and Table 10.

Table 9. ICF category of WEPs with medicinal properties

Ailments category ICPC 2	**Nur**	**Nt**	**ICF**
General and unspecified : Fever (A03) , Cancer (A26), Tonic (A98), Vitamin (B81)	55	5	0.92
Stomachache (D01): Indigestion (D07) , Diarrhoea(D11), Constipation(D12), Jaundice(D13), Piles (D16), Teeth complaint (D19), Indigestion (D07), Hepatitis (D72), Gastroenteritis (D73) , Ulcer (D87), Liver disease (NOS)	151	20	0.87
Cardiovascular:Hypertension (K25), Blood pressure (K85)	42	5	0.9
Neurological: Headache (N01), Convulsion (N07)	71	7	0.91
Psychological : Sleep disturbance (P06)	12	2	0.92
Skin : Insect bite /sting (S12), Burn (S14), Ring worm (S75), Chronic ulcer (S97), Cuts (S18)	246	22	0.91
Urological: Dieuretic (U08), Urinary calculus (U95)	105	9	0.92
Respiratory: Cough (R05), Sinusitis (R75), Tonsilitis (R76), Bronchitis (R78), Influenza (R80), Asthma (R96)	131	9	0.93
Endocrine/Metabolic and Nutritional: Diabetics insulin dependent (T89)	88	13	0.86

Table 10. Fidelity of WEPs with medicinal properties

Diseases category	Plant species	Np	N	FL%
Anti-diabetic	*Phyllanthus emblica, Momordica charantia, Centella asiatica, Punica granatum*	45	50	90
Diarrhoea	*Musa balbisiana*	17	20	85
Dysentery	*Dysoxyllum gobara*	12	18	66
Cancer	*Oroxylum indicum*	38	40	95
Blood pressure	*Clerodendrum colebrookianum, Cucumis sativa, Solanum violaceum, Solanum torvum*	43	46	93
Food poisoning	*Averrhoea carambola, Centella asiatica, Zanthoxylum rhetsa*	24	30	80
Intestinal worm	*Solanum americanum, Senna occidentalis Solanum torvum*	15	24	62
Tooth ache	*Solanum torvum, Solanum violaceum*	41	43	97
Liver problem	*Cajanus cajan, Phyllanthus emblica*	14	19	73
Urinary problem	*Ananas comosus, Cycas pectinata*	20	25	80
Fever	*Cucumis sativa, Plantago depressa*	15	19	78
Insomnia	*Ziziphus jujube, Amomum dealbatum*	25	27	92

4.3. Quantitative results of WEPs

The quantitative indices that include the Fidelity Level percentage, the Frequency of citations, informant consensus factor (ICF), Relative Frequency of citations, and the Use value were incorporated and given in Table 8.

4.3.1. Use Value (UV)

The Use Value (UV) of WEPs ranges from (0.09-0.5) with *Hibiscus sabdariffa* and *Allium hookerii* having minimum and maximum value respectively. The plant species with high UV index indicates that the plant has relative importance in respect of its use in various tribal communities of Churachandpur district.

The plants with the highest UV value for WEPs are *Amophophallus napalensis* (0.20), *Alocasia fornicata* (0.19), *Azadirachta indica* (0.18), *Blumea lanceolaria* (0.27), *Calamus erectus* (0.25), *Calamus tenuis* (0.22), *Centella asiatica* (0.22), *Cucurbita maxima* (0.18), *Momordica charantia* L. (0.18), *Oroxylum indicum*

(0.18), *Zanthoxylum rhetsa* (0.20), *Ziziphus jujuba* (0.18), *Zingiber kangleipakense* (0.18). These plants are highly consumed in different forms and play an important role in their diet.

While on the other hand the plants plant with low UV value include *Amaranthus spinosus* (0.03), *Ananas comosus* (0.07), *Bambusa tulda* (0.05), *Bauhinia variegata* (0.02), *Baccaurea ramiflora* (0.04), *Cissus repanda* (0.09), *Caryota mitis* (0.09), *Coix lacryma* jobi (0.03), *Daucus carota* (0.09), *Ipomoea batatas* (0.09), *Manihot esculenta* (0.05), *Dioscorea bulbifera* (0.04), *Ensete superbum* (0.04), *Eurya acuminata* (0.09), *Gnetum gnemon* (0.06), *Lepionurus sylvestris* (0.06), *Luffa acutangula* (0.03). These plants have relatively lower use value, indicating that they are less important in terms of traditional uses and medicinal significance in the study area. However, these plants were consumed in every season. They are highly priced in the market and considered a delicacy next to meat in every season.

4.3.2. Fidelity level (FL)

The most preferred WEPs with medicinal properties (Table 10) for treating ailments were determined with fidelity level. High FL value indicate that the healers used same plants to treat same ailments/diseases (Laloo and Hemalatha, 2011) while low fidelity indicates that same plants were used to treat same or other ailments/diseases.These are the specified plants that are most preferred by particular tribes.The fidelity level (FL) for WEPs with medicinal properties ranges from (62-95%). The highest fidelity level of WEPs is - *Solanum torvum* and *Solanum violaceum* (97%) for Toothache, *Oroxylum indicum* against Cancer (95%), *Ziziphus jujuba* and *Amomum dealbatum* (92%) against Insomnia, *Clerodendrum colebrookianum*, *Cucumis sativa*, *Solanum americanum* and *Solanum torvum* against High blood pressure (93%), and *Phyllanthus emblica*, *Momordica charantia*, *Centella asiatica* and *Punica grantum* and Antidiabetic (90%).

Thus, in our present study, the fidelity test have less significance to find/scale out plants with high healing properties because all the ethnobotanical uses showed

high fidelity percentage. However, this problem has been overcome by analyzing the data with another effective index *i.e.,* relative frequency of citation.

4.3.3. Relative frequency of citation (RFC)

The Relative frequency of citation (RFC) among the enlisted species varies. The RFC has been divided into three groups according to the values of Relative frequency of citation index.The first group contains the plant species with RFC value >0.21. The second group contains plant species with RFC value between (0.101 and 0.20) and the third group contains other less known uses with RFC value less than 0.20 (RFC <0.20).

The first group of WEPs includes 10 species *Amophophallus napalensis* (RFC=0.034), *Blumea lanceolaria, Centella asiatica* (RFC=0.23), *Clerodendrum colebrookianum* (0.21), *Houttuynia cordata* (RFC=0.27), *Solanum torvum* (RFC=0.24), *Momordica charantia* (RFC=0.031), *Oroxylum indicum* (RFC=0.31), *Solanum violaceum* (RFC=0.20), *Zanthoxylum rhetsa* (RFC=0.038).

The second group of WEPs 8 species includes species *Amomum dealbatum* (RFC=0.20), *Centella asiatica* (RFC=0.23), *Solanum violaceum* (RFC=0.20), *Phyllanthus emblica* (0.21), *Senna occidentalis* (RFC=0.16), *Cycas pectinata* (RFC=0.18), *Ziziphus jujuba* (RFC=0.20), *Luffa acutangula* (RFC=0.19).

The third group of WEPs includes the following species *Musa balbisiana* (RFC=0.09), *Plantago depressa* (RFC=0.08), *Punica granatum* (0.08), *Acmella paniculata* (RFC=0.06), *Solanum americanum* (RFC=0.06), *Acmella uliginosa* (RFC=0.05), *Cucumis sativa* (RFC=0.09), *Averrhoea carambola* (RFC=0.07), *Ananas comosus* (RFC=0.06), *Plantago depressa* (RFC=0.08) *Azadirachta indica* (RFC=0.06), *Senegalia pennata* ((RFC=0.07), *Acmella uliginosa* (RFC=0.05), *Solanum americanum* (RFC=0.06), *Ficus semicordata* (RFC=0.06) *Cissus repanda* (RFC=0.10).

4.3.4. Informant consensus factor (ICF)

The ICF value in the present study is categorized into 9 different ailments as per ICPC-2 with value that ranges from 0.91 to 0.99 which is given (Table 9). General and unspecified, Digestive, Cardiovascular, Neurological, Psychological, Skin, Urological, Respiratory, and Endocrine/Metabolic and Nutritional.

The elevated values of ICF observed in the study indicate a notable consensus among the informants from diverse tribes regarding the shared information. The high ICF value for respiratory ailments (0.93) was attributed to the tribal communities' closed societal living, coupled with their habitual consumption of tobacco and related products. Additionally, the nature of their work further contributed to the prevalence of such respiratory conditions. Following respiratory ailments, the ICF values for urological, psychological, and general/unspecified health issues were also substantial (0.92). The primary occupation of the communities played a role in determining their health challenges, with dermatological infections, ear, nose, and throat problems, and genitourinary ailments being linked to monsoon-dependent cultivation and the unpredictable changes in monsoon patterns, leading to water scarcity and associated health complications, causing psychological distress. It is noteworthy that these health issues are widespread in various parts of India due to poor hygiene and the consumption of unsafe water sources. However, the unique modes of traditional food preparation, described in traditional recipes, are distinct and share similarities with those in Mizoram.

4.4. Plants for Traditional dishes preparation

A total of 36 species, representing 31 genera across 22 families, used in the preparation of traditional dishes have been documented from the study site (Table 11).

4.4.1. Growth habit

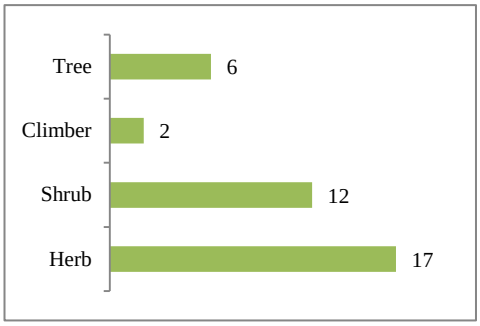
The traditional dishes analyzed in the study featured a variety plant from varied life forms, with herbs (20 species) making up the largest portion of the plant specimens collected from the study site, followed by shrubs (9 species), trees (6 species), and climbers (1 species) (Fig.2.3).

Table11. Plants used in traditional dishes with scientific name, family, local name, habit, plant part/s consumed and traditional mode of preparation

Sl. No.	Scientific name and Family	Local name P/T/H/S/Z/V	Habit	Plant part/s consumed	Traditional mode of preparation
1	*Acmella paniculata* (Wall. ex DC.) R.K.Jansen(Asteraceae) MZUH-0113	Ansache P/T/H/S	Hb	Young leaves	Cooked or mixed with green leaves as salad
2	*Allium hookeri* Thwaites (Amaryllidaceae) MZUH-0208	Phunlunzung S/Z/V	Hb	Roots and leaves	Roots cooked with chilly and animal fats sathu also add as salad
3	*Alocasia fornicata* Schott (Araceae) MZUH-132	Baibing - P/T/H/S	Hb	Inflorescence	Blanched and smoked stored, cooked with chilly as side dish
4	*Alpinia calcarata* (Andrews) Roscoe (Zingiberaceae) MZUH-0043	Aichal -S/Z/V	Hb	Young shoot	Cooked/steam with chilly or *soda as side dish
5	*Amaranthus spinosus* L. (Amaranthaceae) MZUH-0122	Bawngekteh Lenhling- S/Z/V	Hb	Tender leaves	Boil, fry and steam with chilies, fermented fish as side dish
6	*Amomum maximum* Roxb. (Zingiberaceae) MZUH-0124	Aigechil S/Z/V Aidu	Hb	Young shoot	Cooked/steam with chilly or *soda as side dish
7	*Amorphophallus napalensis* (Wall.) Bogner & Mayo (Araceae) MZUH-0170	Telhongpa - S/Z/V	Hb	Tuber	Tuber roasted –chopped and cooked with Traditional**soda –pounded to desired shape side dish or fried as main dish
8	*Bambusa tuldoides* Munro (Poaceae) MZUH-0113	Gua -S/Z/V Rawthing –T	Sb	Young shoots	Cooked/fried/ fermented prepared with *sathu and green chilies with dried meat as side dish
9	*Benincasa hispida* (Thunb.) Cogn. (Cucurbitaceae) MZUH-0179	Maipuang Maipawl -S/Z/V	Cl	Fruit	Boil, fried with samphok as soup side dish and main dish.
10	*Blumea lanceolaria* (Roxb.) Druce (Asteraceae) MZUH-0036	Bualze P/T/H/S	Hb	Leaves	Fried with local chicken meat= main dish
11	*Brassica juncea* (L.) Czern. (Brassicaceae) MZUH-0164	Ankam chii- P/T/H/S	Hb	Leaves	Fermented leaves with green chillies as side dish, main dish, salad

12	*Brassica rapa* L. (Brassicaceae) MZUH-0204	Ankam Antam-/H	Hb	Leaves, seed	Fermented leaves with green chilies as side dish, add as salad
13	*Cajanus cajan* (L.) Huth (Fabaceae) MZUH-0198	Behiang Behhliang-H	Sb	Pods	Prepared with *sathu and green chillies =side dish and as salad
14	*Calamus erectus* Roxb. (Arecaceae) MZUH-0168	Chiingngek Thil-thek -S/Z/V	Sb	Stem pith	Cooked with rice and smoked dried pork=main dish
15	*Calamus tenuis* Roxb. (Arecaceae) MZUH-0157	Chiingngek S/T Hruizik –z	Sb	Stem pith	Cooked with rice and smoked dried pork=main dish
16	*Capsicum frutescens* L. (Solanaceae) MZUH-0201	Malta-P Hmarcha-T/V	Sb	Fruit and seed	Prepared with *sathu=side dish
17	*Centella asiatica* (L.) Urb. (Apiaceae) MZUH-0002	Tankuang P/T/L/S/ Lambak –H	Hb	Leaves	Pounded with Roasted badam as side dish and *tauh
18	*Clerodendrum colebrookeanum* Walp. (Lamiaceae) MZUH-004	Anphui -P Phuihnam -T/H	Sb	Leaves	Leaves cooked with meat , blanched with green chillies as side dish
19	*Colocasia esculenta* (L.) Schott (Araceae) MZUH-0005	Baal -S/Z/V	Hb	Rhizome/tuber	Boiled ,cooked ,fried with green chillies and mixed with *Z.rhesta* and A.sativum roots as main and side dish
20	*Dendrocalamus hamiltonii* Nees & Arn. ex Munro (Poaceae) MZUH-0002	Gova -S/Z/V	Sb	Young shoots	Cooked/fried/ fermented prepared with *sathu and green chillies with dried meat=side dish
21	*Dendrocalamus latiflorus* Munro (Poaceae) MZUH-0139	Gomi P/T/H	Sb	Young shoots	Cooked/fried/ fermented prepared with *sathu and green chillies with dried meat=side dish
22	*Dendrocalamus manipureanus* H.B.Naithani & N.S.Bisht (Poaceae) MZUH-0163	Gopi P/T/H	Sb	Young shoots	Cooked/fried/ fermented prepared with *sathu and green chillies with dried meat=side dish
23	*Diplazium esculentum* (Retz.) Sw. (Aspleniaceae) MZUH-0182	Takok -S/Z/V	Hb	Leaves	Boiled, fried with green chillies as side dish and *tauh
24	*Eurya acuminata* DC. (Pentaphylacaceae) MZUH-0144	Sihzo P/T/H	Tr	Leaves	Main ingredients for festivals meat cooked with leaves and rice

25	*Glycine max* Merr. (Fabaceae) MZUH-0208	Bekan P/T/H	Hb	Seed	Fermented cooked with smoke pork,green chillies as side and main dish
26	*Houttuynia cordata* Thunb. (Saururaceae) MZUH-0114	Aithanglou -P Uithinthang-Z/H	Hb	Leaves and roots	Pounded with green chillies as side dish
27	*Lablab purpureus* (L.) Sweet (Fabaceae) MZUH-0154	Bepi P/T/H/S/	Cl	Fruit	Cooked with sathu as side dish
28	*Musa ×paradisiaca* L. (Musaceae) MZUH-0173	Nahtangtang-S/Z Lairawk –S	Hb	Inflorescence	Fried with pounded sii as main and side dish
29	*Musa balbisiana* Colla (Musaceae) MZUH-0206	Nahtang lawk P/T/H/	Hb	Inflorescence	Fried with pounded sii as main and side dish
30	*Oroxylum indicum* (L.) Benth. ex Kurz (Bignoniaceae) MZUH-0095	Baklawng P/T/H Archangkawm-H	Tr	Pods	Roasted, cooked and fried with green chilies
31	*Parkia timoriana* (DC.) Merr. (Fabaceae) MZUH-0167	Zawngtah – P/S/Z	Tr	Pods	Cooked with sathu as side dish
32	*Prasoxylon excelsum* (Spreng.) Mabb. (Meliaceae) MZUH-0105	Singthupi P/T/H/	Tr	Leaves	Blanched with chillies
33	*Ruehssia macrophylla* (Humb. & Bonpl. ex Schult.) H.Karst.(Apocynaceae) MZUH-0145	Ankhapi P/T Ankhapui-H	Sb	Leaves and shoots	Cooked with cooked with fermented meat fats as side dish
34	*Senegalia pennata* (L.) Maslin (Fabaceae) MZUH-0202	Khangkhuh-P/T Hanghuh-H	Sb	Tender shoots	Boil, fry or steam with sathu as side dish
35	*Solanum melongena* L. (Solanaceae) MZUH-0207	Manta P/T/H	Sb	Fruit	Roasted with green chillies
36.	*Zanthoxylum rhetsa* (Roxb.) DC. (Rutaceae) MZUH-0070	Singjual P/T Chingit –H	Tr	Leaves	Cooked with baal/potato as bai



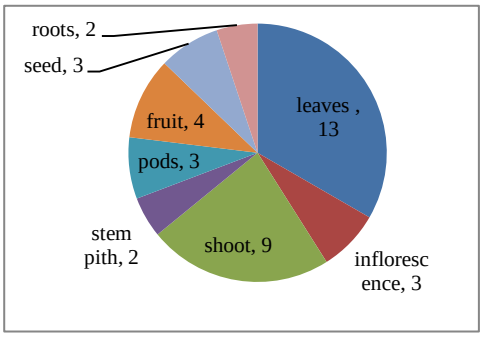


Fig.2.3. Growth habit of traditional dish

Fig.2.4. Parts consumed

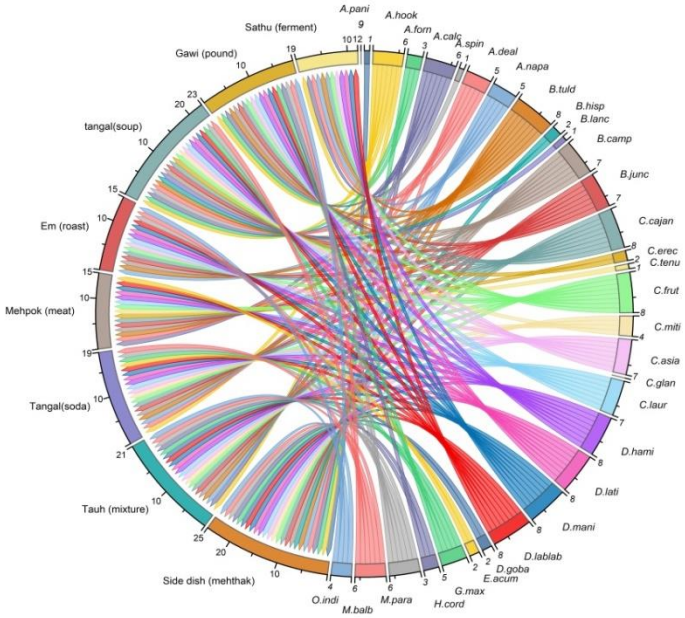


Fig.2.5 Traditional dishes with different mode of preparation

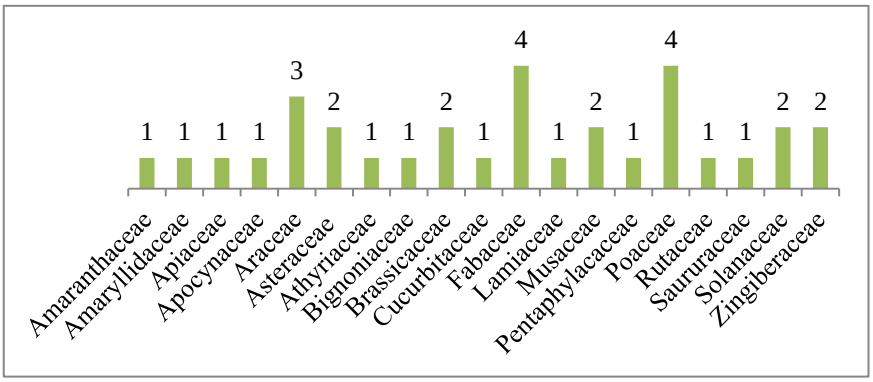


Fig.2.6. Families of plants used in traditional dish preparation

4.4.2. Plant parts used in Traditional dishes

In the plant parts consumed, leaves constitute (12 sp.) the highest number followed by shoot (9 sp.) fruit (4 sp.), Inflorescence, seed and pods (3 sp.) each and roots (2 sp.) (Fig.2.4).

4.4.3. Mode of consumption

The mode of consumption are as followed side dish (13 species), fermented (11 species) and with Traditional cheese (sathu)- (8 species). Of the 36 plant species, 20 species were cultivated and 16 grown in the wild. Nine mode of traditional preparation existed within the study site, side dish (13) constitute the highest number, followed by fermented-11,*sathu- 8, fried and salad-5 each, blanched-3 and roasting-2 (Fig. 2.5).

4.4.4. Taxonomic diversity

Plants especially used in making traditional dishes were recorded from the respective families of Poaceae constituting 4 species followed by Araceae-3 sp., Asteraceae, Zingiberaceae, Brassicaceae, Solanaceae Musaceae constitute 2 sp. each and the rest 1 family each (Fig.2.6).

4.4.5. Recipes of Traditional Dishes

The following are the types of traditional recipe of the different tribal group from the study site (Fig. 2.5).

4.4.5.1. Mehpok

The most common form of traditional recipe during Christmas and other traditional events is mehpok.This recipe is common to all the tribes within the study sites but differs in the mode of meat used and the religious denomination. The fresh leaves (200 g) of *Eurya acuminata* mixed with locally grown rice (2 cups) is boiled in hot and mixed with (approx. 1kg) smoked pork/ fresh red meat/ roasted wild meat. The contents are contoniouly stirred towards the end of cooking till it

become porridge. Two spoonful of traditional soda is added for seasoning along with salt. Another important porridge very common to the tribal is (*Calamus erectus, Calamus tenuis*) where the stempith are sliced cooked with rice and smoke pork/beef/chicken. The other ingredients include ginger, garlic and traditional sodas also known as Chingngek pok.

4.4.5.2. Sialnek/ salad

Salad or sialnek is one common features of the tribal in the study site. The raw leaves and roots of the plants are mixed together with other vegetables, green chillies and consumed. *Acmella paniculata*, *Allium hookeri, Centella asiatica, Houttuynia cordata, Parkia timoriana, Senegalia pennata*, *Zanthoxylum rhetsa* is the species with other vegetables. During the off-season however, sun/smoked dried, packed vegetables replaced the fresh vegetables. For instances, cold packaged of seed of *Parkia timoriana*, sundried of roots of *Allium hookeri* and *Houttuynia cordata*.

4.4.5.3. Mehthak/chilly

Chillies or mehthak is mainly side dish where the main seasoning is chillies (green/dried/powdered) with salt. There are different forms of traditional recipe chillies cooked/blanched/pounded/roasted with green vegetables. The mehthak side dish is a must for any occasion for the tribals in the study site without which the main events is considered incomplete. For examples the species *Acmella paniculata, Allium hookeri, Alpinia calcarata, Amaranthus spinosus, Amomum dealbatum, Brassica campestris, Brassica juncea, Caryota mitis, Centella asiatica, Clerodendrum colebrookianum, Dolichos lablab*, *Parkia timoriana*, *Zanthoxylum rhetsa* are the common palant species which are cooked and mixed with traditional soda and chillies. *Capsicum frutescens* is Pounded and seasoned with salt alone while *Solanum melongena* and *Oroxylum indicum* are roasted season with salt and chillies and consumed.

4.4.5.4. Sialhuan/blanching

Sialhuan or blanching is a very common form of traditional preservation where the plants parts are half/ partially cooked for a few minutes and then recooked during the off-season. This recipe is mainly prepared with dried fished/meat and chillies for taste and salt for seasoning. To enhanced flavour, one can choose to include crushed onion, garlic, and ginger according to their preference added as per one's wish.

4.4.5.5. Sathu / local cheese

Sathu also known as local cheese is a traditional delicacy found in the study area. It is made by fermenting locally sourced pigs and cow fats. This unique and flavourful local cheese holds a significant position in the food culture of the region. This local product not only serves a pivotal role in the culinary tradition, but also serves as an important source of income, contributing to the economic generation of the local community. The following plants species are traditionally processed with sathu (*Allium hookeri*, *Bambusa tulda*, *Cajanus cajan*, *Capsicum frutescens*, *Capsicum frutescens*, *Dendrocalamus hamiltonii*, *Dendrocalamus latiflorus*, *Dolichos lablab*, *Parkia timoriana*, *Senegalia pennata*) seasoned with salt traditional soda and green chillies.

4.4.5.6. Fermented vegetables

Fermentation serves as a viable solution for the tribal that enables them to consume even during the off-season. This traditional preservation not only helps in extending the shelf life of vegetables but also enhances their nutritional values. By harnessing the power of fermentation, the tribal effectively preserve vegetables, preserving their flavours, enhancing their nutritional content and extending their shelf-life. This technique addresses the challenges of limited access to fresh produce during certain periods but also showcases the resourcefulness and adaptability of these communities in utilising traditional knowledge to meet their dietary needs. The following plants species are fermented (500 gm of *Brassica campestris*/*Brassica juncea*) are shade dried and pounded manually with wooden pestle and mortar for

half hour. The pounded is then shade dried and stuffed in a container and tightly packed, placed near fire for a week. A teaspoonful of this extract is more than sufficient to season the side dish.

The bamboo taxa generally fermented are (*Dendrocalamus hamiltonii*, *Dendrocalamus latiflorus*, *Dendrocalamus manipureanus*, *Glycine max*) with approximately 1kg of sliced bamboo shoots are kept in a container or a jar of one litre and seasoned with (salt/chilly as desire). The container is then exposed under direct sunlight for a week of two. The longer the exposure betters the quality. Once the shoots get fermented it is then packed into smaller container for any occasion. Generally this fermented shoots is prepared with smoke fermented fish, potatoes and green chillies. They are consumed as side dish. A kilo of smoke pork or beef is mixed with 200 gm of fermented bamboo shoots, green chillies, black pepper, and tomatoes and served as main dish which is locally known as "*Gotuaithu sahou meh*"

4.4.5.7. Bekanthu

Bekanthu or fermented soya bean is an important local diet of the tribal within the study site. A kilogram of soya bean (*Glycine max*) is properly cooked with water and salt. The water is drained and the cooked beans are sun dired and packed. In the other forms of, the cooked beans are stored in large container and let it ferment for a week or so. The fermented beans are then repacked and consumed during the off-season. The fermented beans seasoned with salt, pounded with chillies and consume, while in the other form the fermented beans is cooked with smoke pork or beef. The fermented soya bean dried or wet is hugely commercialized in the market.

4.4.5.8. Meh-Tauh

Meh-tauh is another local food culture where the vegetables are partially cooked (*Diplazium esculentum* and raw *Centella asiatica*) are the main ingredients with badam, seasoned with salt, chillies and oil. *Diplazium esculentum* (chakok) or takok (200gm) is partially fried without oil in a pan. The fried leaves of chakok are

pounded with fried badam, salt and oil. The *Centella asiatica* leaves are however pounded raw with badam, salt and oil.

4.4.5.9. Antuimol/ soup

Antuimawl is another aspect of tribal soup cusine which are the delicacies of all the tribals within the study area. The main ingredient of this local cusine is green vegetables, ginger, garlic, onion, chillies, traditional soda and salt. Most of the plants are consumed in the table are consumed with the above mentioned except Poaceae, *Alocasia fornicata*, *Eurya acuminata* and *Glycine max* .

4.4.5.10. Vokthau kanmeh/fried

Vegetables are fried mostly with extracted pig's fat with Poaceae taxa within the table (Table12) *Diplazium esculentum, Clerodendrum colebrookianum* and *Dysoxyllum gobara* are the most preffered plant species by the tribals within the study site.

4.4.5.11. Em-min/roasting

In the study area, the tribal community employs a method known as *em-min* or roasting to enhance the quality of food. The species which are roasted are *Oroxylum indicum*, *Solanum melongena* and *Amorphophallus napalensis* Young pods of *Oroxylum indicum* is roasted upon fire, once adequately roasted, the outer layer of the pods is delicately scraped off to ensure any impurities before consumption. The pods is then pounded with green chillies, salt and then consumed. This traditional method of preparation is valued by the local community is valued by the local community for its ability to improve the taste and overall appeal of pods as food source. For this reason the plant was considered for phytochemical, nutritional.anti-nutritional and minerals analysis.The fruit of *Solanum melongena* is roasted upon fire and then pounded with garlic, ginger and seasoned with salt which is called *Manta em gawi*. *Amorphophallus napalensis* locally known as *Telhong* holds a significant food source for the tribal within the study site. The tuber is prepared by roasting over fire, followed by washing, cooking and draining. Once

cooked the tuber is pounded using wooden mortar and pestle, then packed. Traditionally the tuber (300gm) is processed with sathu (local cheese 30gm packed) in half liter of water .the other ingredients include chillies and traditional sodas then ready to served. Ocassionally the processed tuber is consumed after being fried. This is known as *Telhong mehbawl.*

4.4.6. Spices and Condiments

A total of 25 numbers of plants were found to be used by the tribals within the study site belonging to 19 genera under 12 families (Table12) and (Fig.2.9).

4.4.6.1. Growth habit

The spices and condiments investigated in the study exhibited a range of life forms, with herb (15 sp.) comprising the largest portion of the collected plant specimens from the study site followed by shrub (7 sp.), tree (2 sp.) and climbers (1 sp.) (Fig.2.7).

4.4.6.2. Parts consumed

The parts of the plants consumed as spices include leaves (7 sp.) constitute the highest number followed by leaves (6 sp.), whole plant (5 sp.), fruit (3 sp.) and bark, bulb, rhizome (1 sp.). The different plant part commonly consumed as spices and condiments are as follows with leaves (5 sp.), whole plant (5 sp.), seed (1 sp.), fruit (3 sp.) bulb, root, bark and rhizome (1 sp. each). Out of the 25 species, 9 species are consumed everyday, 2 species twice a day, while 8 species consumed once a week, 2 species twice a week and 3 species thrice a week. The sources of these spices and condiments varies where 23 species are cultivated in the kitchen garden throughout using the propagating medium as bulb, seed, fruit roots stolon leaves, rhizome wild and layering and the other two are collected from wild (Fig.2.8).

The market value differs depending on their availability and the season. A total of 15 species were valued less than Rs.100 per kg or bundle while the rest (10

species) were priced more than Rs 100/- per kg or bundle. According to the market assessment, the indigenous people in the study area are independent when it comes to growing their own spices and condiments, and over half of their produce has the potential to be traded for money.

Habitat wise, out of the total reported, there were 16 herbs, 2 trees, 7 shrubs and 16 climbers. The following parts were (seed -8, leaves-6, whole plant-5, fruit -3 bark, 1 each rhizome and bulb consumed on daily basis /once or twice a week as per the requirement and the availability of the plants. Seeds (12 sp.) constitute the highest mode of propagation followed by fruit (5sp.), bulb (4sp.), rhizome and roots (2 sp. each) and 1 each through the leaves and layering. Thus, the mode of consumption revealed that the tribal have good knowledge in propagating the spices and condiments and made them available throughout the season.

4.4.6. Taxonomic diversity of spices and condiments

The highest number families used by the tribals from the study site are Amaryllidaceae-4, Fabaceae-1, Solanaceae-3, Rutaceae-3, Apiaceae-3, Lauraceae-2, Lamiaceae-4, Sauraraceae-1, Piperaceae-1, Passifloraceae-1, Pedaliaceae-1 and Zingiberaceae-1 (Fig.2.9).

Table 12. Plants use as spices and condiments with scientific name, family, local name, habit, source, propagation mode, part/s consumed, used frequency and market value

Sl.no.	Scientific name and family	Local name P/T/H//S/Z/V	Habit	Source / Propagation mode	Parts consumed / Used frequency	Market value (Rs/kg)
1.	*Allium ampeloprasum* L. (Amaryllidaceae) MZUH-0177	Nahkhupi /L/S/Z/V	Hb	Cultivated /bulb	Wp /Thrice a week	40/-
2.	*Allium cepa* L. (Amaryllidaceae) MZUH-0176	Phulun Z/P/S/V/G	Hb	Cultivated/bulb	Wp /everyday	70/-
3.	*Allium hookeri* Thwaites (Amaryllidaceae) MZUH-0183	Nakhupi H/L/S/Z/V	Hb	Cultivated / bulb	Wp /everyday	40/-
4.	*Allium sativum* L. (Amaryllidaceae) MZUH-0184	Pangal phulun H/S/Z/V	Hb	Cultivated /bulb	Bulb /everyday	400/-
5.	*Arachis hypogaea* L. (Fabaceae) MZUH-0185	Badam /S/Z/V	Sb	Cultivated / seed	Seed /wice a week	300/-
6.	*Capsicum annum* L. (Solanaceae) MZUH-0178	Malta S/Z/V	Sb	Cultivated/fruit	Seed/everyday	350/-
7.	*Capsicum chinense* Jacq. (Solanaceae) MZUH-0189	Sapmalta /S/Z/V	Hb	Cultivated/fruit	Seed/everyday	500/-
8.	*Capsicum frutescens* L. (Solanaceae) MZUH-0186	Bell pepper P/T/H/L/S/Z/V	Sb	Cultivated/fruit	Seed/everyday	400/-
9.	*Cinnamomum verum J.Presl (Lauraceae*) MZUH-0003	Singguithak P/TS/Z/V	Tr	Cultivated/seed	Bark/once a week	70/bundle
10.	*Citrus* × *limon* (L.) Osbeck (Rutaceae) MZUH-0188	Nimbu /S/Z/V	Sb	Cultivated / layering	fruit & leaves/everyday	150/-
11.	*Coriandrum sativum* L.	Maruai P/T/	Hb	Cultivated/rhizome	Wp/everyday	200/-

	(Apiaceae) MZUH-0175	/S/Z/V				
12.	*Elsholtzia communis* (Collett & Hemsl.) Diels (Lamiaceae) MZUH-0201	Lengmasel Z/P/S/V/G	Hb	Cultivated /seed	Leaves /thrice a week	50 per bundle
13.	*Eryngium foetidum* L. (Apiaceae) MZUH-0025	Pasikhawm P/TZ/V	Hb	Cultivated/seed	Leaves/twice a week	50 bundle
14.	*Foeniculum vulgare* Mill. (Apiaceae) MZUH-0208	Fennel Z/P/S/V/G	Hb	Cultivated/seed	Fruit/once aweek	400/-
15.	*Houttuynia cordata* Thunb. (Saururaceae) MZUH-0114	Aithanglou P /S/Z/V	Hb	Cultivated /roots	Wp/once a week	20/ bundle
16.	*Litsea cubeba* (Lour.) Pers. (Lauraceae) MZUH-118	Seknam Z/P/S/V/G	Tr	Wild/fruit	Raw, fruit/once a week	30/bundle
17.	*Mentha spicata* L. (Lamiaceae) MZUH-0076	Pudina Z/P/S/V/G	Hb	Cultivated /stolon	Leaves/once a week	30/bundle
18.	*Ocimum americanum* L. **(**Lamiaceae) MZUH-0187	Muii Z/P/S/V/G	Sb	Cultivated/Leaves	Seed/once a week	10/bundle
19.	*Passiflora edulis* Sims (Passifloraceae) MZUH-0205	Sapthei Z/P/S/V/G	Cl	Cultivated /seed	Seed/twice a day	300/bundle
20.	*Perilla frutescens* (L.) Britton (Lamiaceae) MZUH-0210	Z/P/S/V/G-Chhawhchi	Hb	Cultivated/Seed	Seed/paste/ roasted /twice a week	50/package
21.	*Piper nigrum* L. (Piperaceae) MZUH-0162	Black peeper Z/P/S/V/G	Hb	Cultivate/seed	Seed/once a week	500/kg dried seed
22.	*Sesamum indicum* L. (Pedaliaceae) MZUH-0181	Sii lian Z/P/S/V/G	Hb	Cultivated /seed	Seed/twice a day	50/package
23.	*Zanthoxylum acanthopodium* DC. (Rutaceae) MZUH-0180	Singjual suak Z/P/S/V/G	Sbb	Cultivated/wild	Seed/once a week	50/bundle

24.	*Zanthoxylum rhetsa* (Roxb.) DC.(Rutaceae) MZUH-0070	Singjual Z/P/S/V/G	Sb	Wild	Leaf/twice a week	50/-bundle
25.	*Zingiber officinale* Roscoe (Zingiberaceae) MZUH-0051	Siing Z/P/S/V/G	Hb	Cultivated /rhizome	Rhizome /everyday	300/-

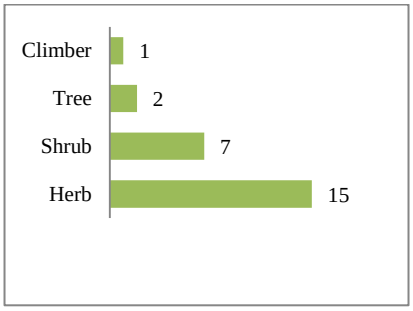


Fig.2.7. Habit of spices and condiments

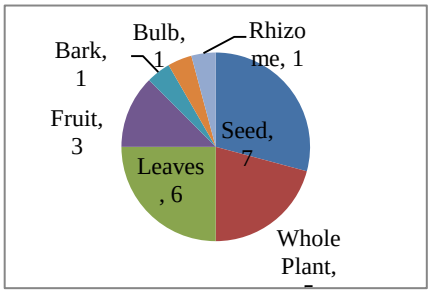


Fig.2.8. Parts consumed

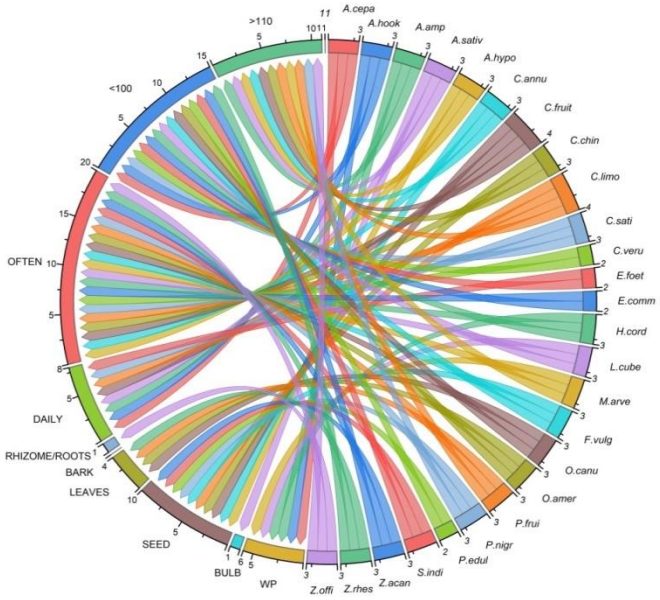


Fig.2.9. Spices and condiments Pie chart depicting frequency of consumption, plants parts and market value.

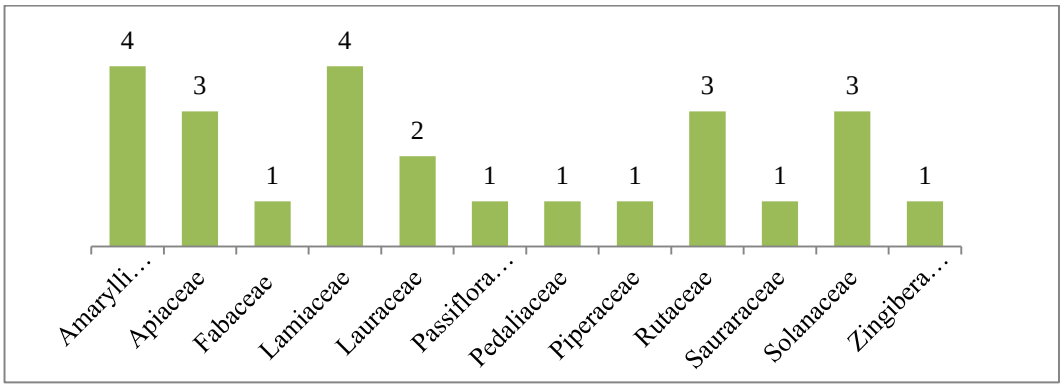


Fig.3. Families of spices and condiments

4.5. Plants in Traditional drinks

A total of 19 plant species belonging to 17 genera in 13 families were found to be utilized locally in making traditional drinks. The drinks are divided into alcoholic and non-alocholic beverages (Table 13).

4.5.1. Growth habit

Out of the 19 plant species the tree (11species) constitute the largest life form habit followed by shrub and herb (3 species each) and climbers (2 species) (Fig.3.)

4.5.2. Parts consumed

Out of the 19 species the fruit (15 species) constitute the highest plant parts followed by pods, grain seed and leaves (1 species each) (Fig.3.1 and 3.5).

4.5.3. Taxonomic diversity of plants for making traditional drinks

The families of the plants used for making traditional drinks under alcoholic beverages include Poaceae-4 sp., Araceae-3 sp., Papilionaceae-3 sp. , Asteraceae -2 sp., Zingiberaceae-2 sp., Brassicaceae-2 sp., Solanaceae-2 sp., Musaceae- 2 sp., Amaryllidaceae, Amaranthaceae, Cucurbitaceae, Apiaceae, Lamiaceae, Pentaphylacaceae, Saururaceae, Bignoniaceae, Apocynaceae, Fabaceae, Rutaceae, Athyriaceae (1 sp. each) (Fig.3.2).

Out of the total 19 traditiona drinks prepared, 9 taxa were used in making alcoholic beverages and 10 taxa for making as non-alcoholic beverages while 8 taxa were used for making both alcoholic and non-alcholic beverages (Fig.3.3.).

4.5.4. Parts used for making Traditional drinks

In the lives of the tribals within the study site both alcoholic and non-alcoholic beverages hold great importance. Among the 19 known species for making traditional drinks, 10 taxa are generally categorised for making non-alcoholic while the remaining 9 taxa for alcoholic beverages (Fig.3.4). However, the fermentation process of these beverages varies depending on the types intended purpose, which involves the addition of "*Tol*"/catalyst.The tribal communities primarily consume

non-alchholic beverages, specifically *Theitui* or cooling drinks to protect themselves from the sunny and humid environment. These refreshing beverages are essential to combat against intense heat and maintain their well-being after a tiresome work from the agricultural field.

The most preferred alcoholic drinks are prepared from *Oryza sativa*, *Ficus semicordata*, *Passiflora edulis, Musa acuminata*, *Vitis vinifera.* Except for *Oryza sativa*, so far, no literature has been published from the other plant species from the state as a whole. The Nagas of Nagaland had consumed the beverages prepared from *Musa acuminata* fruit. Interestingly the tribals have developed a unique method of differentiating between alcohol and non-alcoholic drinks. They locally produce a catalyst known as "*Tol*", derived from rice. This catalyst is utilized in the fermentation process and determines whether a beverage will be alcoholic or non-alcoholics (Peterson, 2013). While the non-alcoholic beverages are highly commercialized locally, the production of alcoholic beverages is primarily reserved for medicinal and health purpose and is in not intended for sale.

Table13. Details of traditional drinks with the associated plants, scientific name, family, local name, habit, plant part used, method of preparation, types of drink, Market value and longevity source, propagation mode, part/s consumed, used frequency and market value

Sl.no	**Scientific name Family**	**Local name**	**Habit/ Plants part used**	**Method of Preparation**	**Types of Drink** NA=Non alcoholic AL=Alcoholic	**Market value Rs./liter**	**Longevity**
1	*Ananas comosus* (L.) Merr. (Moraceae) MZUH-0194	P/H/T/G/V/S/Z - lengthei	Hb/Ft	Decoction and bottled	NA	100/-	1 week
2	*Artocarpus lacucha* Buch.-Ham (Moraceae) MZUH-0103	P/H/T/G/V/S/Z - Tatthei	Tr/Ft	Decoction and bottled	NA	-	3-4 days
3	*Camellia sinensis* (L.) Kuntze (Theaceae) MZUH-0203	P/H/T/G/V/S/Z - Singpite	Hb/Lv	Cured leaves	NA	500/Kg	5-6 months
4	*Citrus limon* (L.) Osbeck (Rutaceae) MZUH-0188	P/H/T/G/V/S/Z Nimbu	Tr/Ft	Raw juice extract And bottled	NA	100/-	1 month
5	*Elaeagnus pyriformis* Hook.f. (Elaeagnaceae) MZUH-0196	P/H/T/G/V/S/Z Sarjuk	Sb/Ft	Raw juice extract And or decoction and bottled	NA	100/-	2 weeks
6	*Ficus semicordata* Buch.-Ham. ex Sm. (Moraceae) MZUH-0032	P/H/T/G/V/S/Z - Theipui	Tr/Ft	Fermented with starter and bottled	AL	200/-	1 month
7	*Garcinia lancefolia* Roxb. (Clusiaceae) MZUH-0205	P/H/T/G/V/S/Z Chengkek	Tr/Ft	Decoction or direct juice extract and bottled	NA and AL	-	1 week
8	*Garcinia sopsopia* (Buch.-Ham.) Mabb. (Clusiaceae) MZUH-0195	P/H/T/G/V/S/Z Vomva	Tr/Ft	Decoction and bottled	NA	100/-	1 week

9	*Glycine max* (L.)Merr . (Fabaceae) MZUH-0191	P/H/T/G/V/S/Z Bekan	Sb/Sd	Powder as a milk	NA	250/-	1 month
10	*Musa acuminata* Colla (Musaceae) MZUH-0200	P/T/G/V/S/Z Nahtang H-Banhla	Sb/Ft	Fermented with starter and bottled	NA and AL	100/-	5-6 month
11	*Oryza sativa* L (Poaceae) MZUH-0197	Buh	Tr/Kr	Fermented with starter and bottled	NA and AL AL	150/-	More than year
12	*Passiflora edulis* Sims (Passifloraceae) MZUH-0206	P/H/T/G/V/S/Z Sapthei	Hb/Ft	Fermented with starter and bottled	NA and AL	300/-	5-12 months
13	*Phyllanthus acidus*(L.) Skeels. (Phylanthaceae) MZUH-0192	P/H/T/G/V/S/Z Suaklu H-Sunhlu	Hb/Ft	Decoction or Fermented with starter and bottled	NA and AL	100/-	2-3 months
14	*Phyllanthus emblica* L. (Phyllanthaceae) MZUH-0080	Suaklu tak	Hb/Ft	Decoction or Fermented with starter and bottled	NA and AL	100/-	5-12 months
15	*Psidium guavaja* L. (Myrtaceae) MZUH-0053	P/H/T/G/V/S/Z Kawlsing	Tr/Ft	Fermented with starter and bottled	NA and AL	-	More than year
16	*Rhus chinensis* Mill. (Anacardiaceae) MZUH-0034	P/H/T/G/V/S/Z - Khongma	Tr/Ft	Decoction and bottled	NA	100/-	1 month
17	*Spondias pinnata* (L.f.) Kurz (Anacardiaceae) MZUH-0056	P/H/T/G/V/S/Z - Zuanmuat Taitaw	Tr/Ft	Decoction and bottled	NA	-	1 week
18	*Tamarindus indica* L.(Asteraceae) MZUH-0059	P/H/T/G/V/S/Z - Tengtere	Tr/Pds	Decoction and bottled	NA	100/-	1 week
19	*Vitis vinefera* L. (Vitaceae) MZUH-0190	P/H/T/G/V/S/Z - Grep	Sb/Ft	Fermented with starter and bottled	NA and AL	300/-	1-2 year

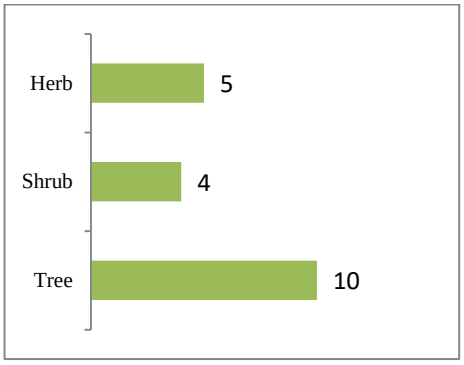


Fig.3.1. Habit of traditional drinks

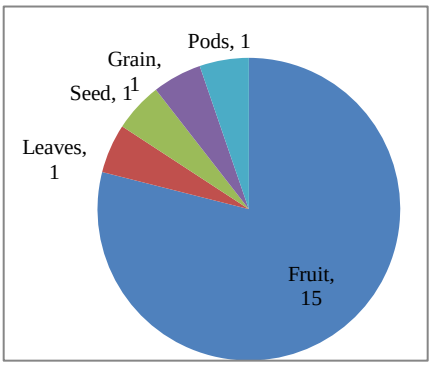


Fig.3.2. Parts consumed

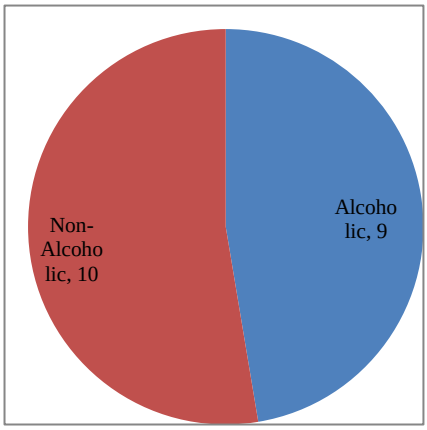


Fig.3.3.Types of beverages

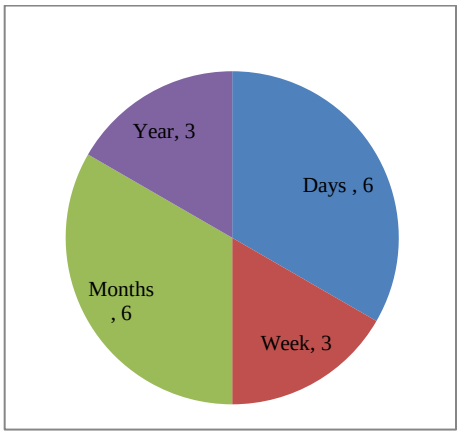


Fig.3.4. Longeveity of beverages

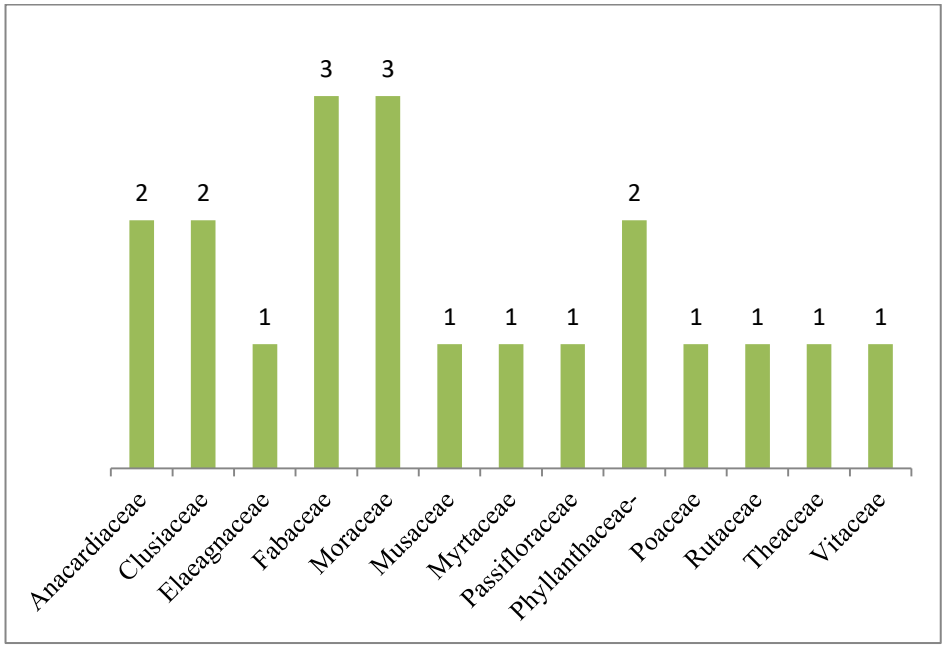


Fig.3.5. Families of traditional drinks

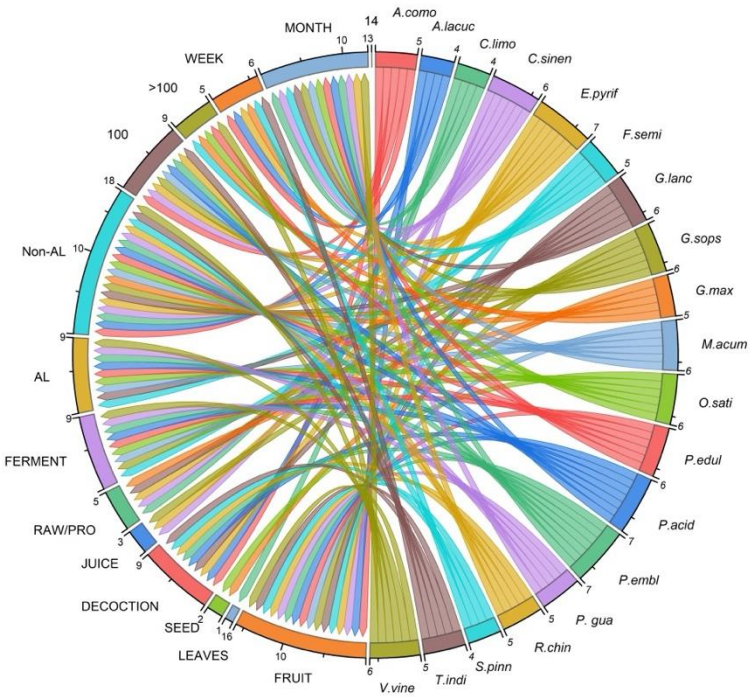


Fig.3.6. Use of plants in traditional drinks from the study sites.

4.5. Ethnoveterinary plants

A total of 15 plant species belonging to 15 genera in 12 families were found to be utilized locally in treating domesticated animals (Table 14).

4.6.1. Growth habit

The ethnoveterniary plant exhibit different life forms that include herb constituting the highest form of life (7 sp.) followed by shrubs (5 sp.), tree(2sp) and climbers-(1 species) (Fig. 3.6).

4.6.2. Plant parts used

Among the plant parts used for various treatments, leaves constitute the highest number (10 sp.) followed by bark-(3 sp.) and roots & seed (2 sp. each). The highest domesticated animal treated using the ethnoveterinary plants are the pig (12 sp), followed by Cow (7 sp),dog (9 species), Goat (4 sp.), Mithun (3 sp.) and Chicken (1 sp.) (Fig.3.7, 3.8, 3.9).

4.6.3. Mode of administration

The mode of administration of the ethnoveterinary treatment is is mainly through ingestion (8 sp.) followed by topical (7 sp.), tie (2 sp.) and boiled & bath (1 sp.each)(Fig.4.).

The remedies for treatment of the following disease sore worm (*Achyranthus aspera* and *Ageratum conyzoides*), bone fracture (*Agave americana*), mange (*Ageratum conyzoides*), burns and cuts (*Aloe vera*, *Blumea lanceolaria, Clerodendrum infortunatum*. eye infection (*Capsicum annum*), wounds (*Artemisia vulgaris*, *Blumea lanceolari*a, *Clorodendrum infortunatum*), dysentery (*Gelsemium elegans, Cannabis sativa*), diarrhoea (*Mikania micrantha*), mastitis (*Curcuma longa*), bloating (*Dillenia indica*), Constipation (*Dillenia indica*), lactogogue (*Zea mays*) for the following domesticated animals pigs, cows, goats, chicken, dogs and mithuns (Fig.3.9).

4.6.3. Taxonomic diversity of ethnoveterinary plants

The highest number of families is Asteraceae-4 and the rest is 1 family each Acanthaceae, Agavaceae, Liliaceae, Cannabinaceae, Solanaceae, Lamiaceae, Zingiberaceae, Dilleniaceae, Fabaceae, Longaniaceae, and Poaceae (Fig.4.1).

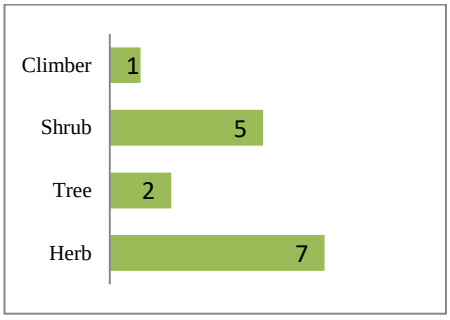
The ethnoveterinary plants along with their uses and mode of preparation are as follows (Table 14).

Table 14. Ethnoveterinary plants with scientific names, local names, habit, part/s used, mode of use, ailments treated, animals, occurrence

Sl .no.	**Scientific name and family**	**Local name**	**Habit/ part/s used**	**Mode of Use/s**	**Ailments**	**Animals**	**Occurrence**
1	*Achyranthus aspera* L. (Acanthaceae) MZUH-0193	P/T//S/Z/V-Mantep H-Buchhawl	Hb/L	Juice	Sore worms	Pigs, goat, sheep and dogs	Wild
2	*Agave americana* L Agavaceae MZUH-0046	P/T/H/S/Z/V-Saidai	Sb/L	Juice	Fracture	Pig,dog,goat, sheep and chicken	Wild, cultivated
3	*Ageratum conyzoides* L. (Asteraceae) MZUH-0047	P/T/S/Z/V-Meiteilou H-Vaihlenlo	Tr/L& Br	Decoction	Sore worms	Pig (Mange)	Wild
4	*Aloe vera* L. (Liliaceae) MZUH-0048	P/T/H/S/Z/V-Aloe vera	Hb/L	Gel	Burns & cuts	Chicken, goat dog, sheep, pig, mithun	Cultivated
5	*Artemisia vulgaris* L. (Asteraceae) MZUH-0041	P/T/H/S/Z/V-Sai	Hb/L	Juice	Cuts & wounds	Cow, dog, goat, pig	Wild
6	*Blumea lanceolaria* (Roxb.) Druce (Asteraceae) MZUH-0036	P/T/H/S/Z/V-Buarze	Hb/L	Leaves	Sore, cuts & wounds	Dogs and pig	Wild and cultivated
7	*Cannabis sativa* L. (Cannabinaceae) MZUH-0133	P/T/H/S/Z/V Kanja	Hb/L	Juice	Dysentry	Pigs and cows	Wild ,cultivated

8	*Capsicum annum* L (Solanaceae) MZUH-138	P/T/H/S/Z/V -Malta	Sb/Sd	Seed	Eye infection	Domesticated chicken	Cultivated
9	*Clerodendrum infortunatum* L. (Lamiaceae) MZUH-0141	P/T/H/S/Z/V Phuihnamchhia	Shrub	Juice	Cuts and wound	Pigs	wild
10	*Curcuma longa* L. (Zingiberaceae) MZUH-0008	P/T/H/S/Z/V Aieng	Hb/Rh	Juice	Mastitis, Wounds, ulcers & sores	Cow, mithun, dogs sheep and goats	Cultivated
11	*Dillenia indica* L. (Dilleniaceae) MZUH-0211	P/T/H/S/Z/V Kawrthinden g	Hb/L	Raw	Bloating , constipation	Dogs , sheep and goats	Wild and cultivated
12	*Erythrina stricta* Roxb. (Fabaceae) MZUH-0098	P/T/H/S/Z/V Fartuah,	Tr/Bk	Necklace	Sore	Cow, pigs and dogs	Wild
13	*Gelsemium elegans* Benth. (Longaniaceae) MZUH-0033	P/T /S/Z/V-namtul H-Hnamtur	Sb/Rt, Bk	Juice	diarrhoes and dysentery	Dog, pigs, mithun, cows, goats	Wild
14	*Mikania micrantha* Kunth (Asteraceae) MZUH-0077	P/T/H/S/Z/V Japan hlo	Cl/L	Juice	Diarrhoea and sysentry	Pig, goats, sheep, cow	Wild
15	*Zeya mays* L. (Poaceae) MZUH-0114	P/T/H/S/Z/V Vaimim	Sb/Sd	Decoction	lactogogue	Pig, goat, sheep, and cow	Cultivated

From the study site 15 plants species were recorded to treat the domesticated animals from various diseases by the tribal communitites that belong to 15 genera of 12 families (Table 14).



Habit of ethnoveterinary plants

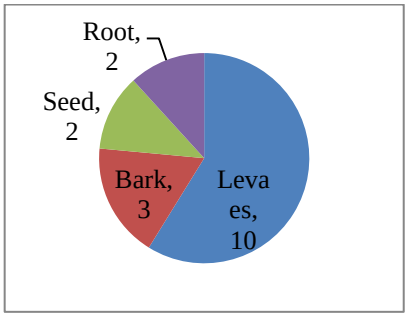


Fig. 3.7. Fig.3.8. Parts used of ethnoveterinary plants

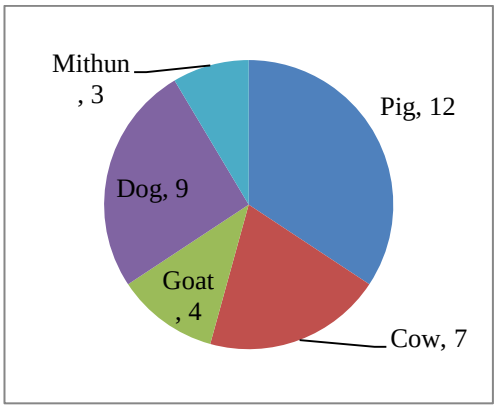


Fig.3.9 Domesticated animals treated ethnoveterinary plants

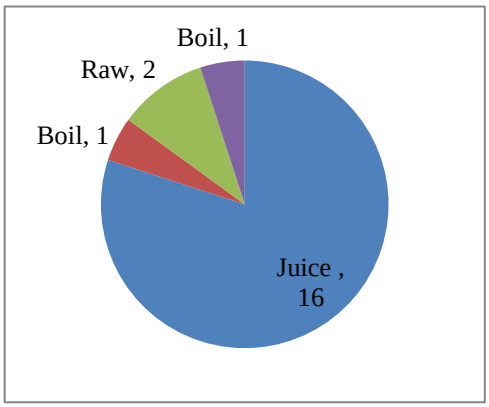


Fig.4. Mode of preparation of

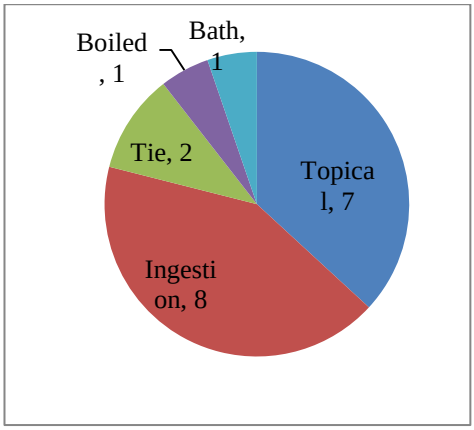


Fig.4.1 Mode of administration plants

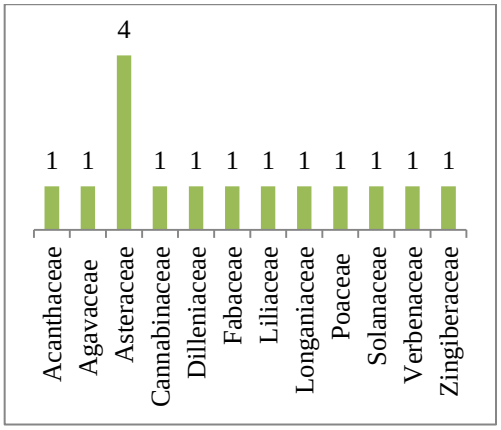


Fig.4.2.Families of Ethnoveterinary

4.7. Medicinal plants

A total of 102 medicinal plants are recorded from the study site belonging to 96 genera and 57 families (Table 15).

4.7.1. Taxonomic Diversity

The families of plants having high number of medicinal values belongs to Fabaceae (11genera), Asteraceae (6 genera) Amaranthaceae (2 genera), Solanaceae (63 genera), Euphorbiaceae (3 genera), Cucurbitaceae (5 genera), Zingiberaceae (4 genera) etc. So, in the survey the commonly preferred medicinal plants belong to Leguminosae, Asteraceae, Euphorbiaceae, Cucurbitaceae, Zingiberaceae, Solanaceae, Yabesh (Prabhu et al., 2021; Irfan et al., 2023). Gymnosperm and Pteridophyte represent one taxon each as *Cycas pectinata* and *Pseudodrynaria coronans* (respectively with the remaining 100 taxa from the angiosperms (Fig.4.6).

The highest number of life forms was trees (34 sp.) followed by herbs (32 sp.), shrubs (25 sp.), climbers (9 sp.) and epiphytes (2 sp.). Herbs were reported to be more common life form in earlier works (Panmei et al., 2019: Singh et al., 2023) however here trees habitat dominante the present study. It this may be possible due to high abundance, easy availability throughout the year of the trees as compared to other life forms (Fig.4.2.)

4.7.2. Plant part used

In the study, leaves were highly utilized plant parts representing 36% of the prescribed herbal medicines while other parts like fruits (19%), barks (17%), roots (16%), rhizomes (2%), stem (3%), whole plant (2%) and others (1% each) formed the other components (Fig.4.3). The indigenous people used leave as main component for herbal medicine preparations due to ease of collection as compared to other plant parts and they are also the sources of various secondary metabolites proven scientifically for their presence (Kaushik et al., 2021). The use of leaves as preferred plant part over others were found to be common among other studies reported from various other ethnic groups of Northeast India (Nurudeen et al., 2023;Tamang et al., 2023: Namsa et al., 2011). The preference for using leaf parts in

ethnomedicinal practices may be attributed to their simple and easily accessible collection methods, along with their year-round availability, which is not the case for other plant parts. Additionally, the collection of leaves is seen as a more sustainable utilization approach by indigenous communities, as opposed to harvesting barks, roots, or uprooting entire plants for medicinal purposes.

Table15. Ethnomedicinal plants with scientific names, family, Voucher No., local names, habit, part/s used, preparation method, ailments treated, animals, occurence

Sl.no	Plant name /Family /Voucher No.	Local names P/H/T/G/V/S /Z	Habit/ Parts Used	Preparation method	Ailments treated	RFC	UV	IUCN status
1	*Abelmoschus esculentus* (L.)Moench (Malvaceae) MZUH-0040	P/T/G/V/S/Z -Mehnal H-Bawrhsaibe	Hb / Fr	Decoction	Constipation (12) Tonic (7)	0.05 0.02	0.25	NE
2	*Achyranthus bidentata* Blume (Amaranthaceae) MZUH-0042	P-Vot lou H-Vangvat tur	Hb / Lv	Raw /Topical	Leech bites (9) Urinary retention and tonic (8)	0.04 0.03	0.23	NE
3	*Acmella oleracea* (L.) R. K. Jansen (Asteraceae) MZUH-0044	P/T/G/V/S/Z -Ansapi H-Ansapui	Hb / Lv	Decoction /Ingestion	Rectal bleeding (4); teeth gum (5) rheumatism (1).	0.04 0.02 0.004	0.51	NE
4	*Agave americana* L. (Agavaceae) MZUH-0046	P-Saidai H-Saipal	Sb / Lv	Raw pound /Ingestion	Fractured bones (23)	0.10	0.27	LC
5	*Ageratum conyzoides* L. Asteraceae MZUH-0047	P/T/G/V/S/Z -Meiteilou H-Vaihlenlo	Hb / Lv	Raw /Topical	Cuts (18) allergy by hairy worms (9)	0.08 0.04	0.32	LC
6	*Aloe vera* (L.) Burm.f. (Asphodelaceae) MZUH-0048	P/H/T/G/V/S /Z – Aloe vera	Hb / Lv	Raw/Topical	Burns (6); insect bites (12); cuts and wounds (10)	0.28 0.05 0.04	0.33	LC
7	*Alpinia roxburghii* Sweet Zingiberaceae MZUH-0043	P/T/G/V/S/Z - Aigebengngong H-Aichal	Hb / Rz	Raw and decoction/ Ingestion	Digestive symptom (13) Bee sting (20)	0.06 0.09	0.39	NE

8	*Alstonia scholaris* (L.) R. Br.(Apocyanaceae) MZUH-0045	P/T/G/V/S/Z -Thuamgiat H-Thuamriat	Tr / Lv, Rt	Decoction	Rheumatism and dysentery (18) kidney stones (19)	0.08 0.09	0.44	LC
9	*Amomum dealbatum* Roxb. (Zingiberaceae)MZUH-0049	P/T/G/V/S/Z -Aigia H-Aidu	Hb / Rz	Decoction	Diuretics (18) dysentery (24)	0.08 0.11	0.5	DD
10	*Artemisia vulgaris* L. (Asteraceae) MZUH-0041	P/T/G/V/S/Z -Gamsai H-Sai	Hb / Rt, Lv	Raw juice	Malaria (6) insect bites (7); Diarrhea (16)	0.02 0.03 0.07	0.34	NE
11	*Averrhoea carambola* L. (Oxalidaceae) MZUH-0012	P/T/G/V/S/Z - Theihelhawt H- Theiherhawt	Tr / Fr	Decoction/raw	Liver diseases (17) fever & cough (9)	0.08 0.04	0.48	NE
12	*Azadirachta indica* A. Juss (Meliaceae) MZUH-0013	P/H/T/G/V/S /Z- Neem kung	Tr /Bk	Decoction/raw	Ulcer (14) Diabetes (15)	0.06 0.07	0.17	LC
13	*Bauhinia variegata* L. (Asteraceae) MZUH-0014	P/H/T/G/V/S /Z-Bible pak H-Vaube	Tr / Lv	Decoction	Diarrhea (17) tonic (6)	0.08 0.02	0.27	LC
14	*Begonia roxburghii* (Miq.) A.DC (Begoniaceae) MZUH-0034	P/T/G/V/S/Z - huthuk H- Sekhupthur	Sb / Lv	Decoction/raw	Diabetes(13) piles (5); tonic (1); trichinosis (14)	0.06 0.02 0.004 0.06	0.61	NE
15	*Benincasa hispida* (Thunb.) Cogn. (Cucurbitaceae) MZUH-0037	P/T/G/V/S/Z - Maipuang H-Maipawl	Cl / Fr	Decoction and raw fruit	Liver diseases (28) constipation (12) tonic (29); preserve corpse (50)	1.3 0.57 0.23	1.08	NE
16	*Bergenia ciliata* (Haw.)	P/T/G/V/S/Z	Sb /Lv	Decoction	tonic (16); pulmonary	0.07	0.5	LC

	Sternb. (Saxifragaceae) MZUH-0038	-Zunkhum dadawi H-Kham Damdawi			affliction (6); diabetes(11); raw leaves against gastroenteritis (9)	0.02 0.05 0.04		
17	*Betula cylindrostachya* Lindl.ex Wall.(Betulaceae) MZUH-0039	P/T/G/V/S/Z -Hiangzau H-Hriangzau	Tr / Bk	Decoction	diabetes (58) ulcer and Digestive (17)	0.27 0.08	0.53	LC
18	*Blumea lanceloria* (Roxb.) Druce (Asteraceae) MZUH-0036	P/T/G/V/S/Z - Bualze H-Buarze	Sb / Lv	Decoction	diabetes (30); diabetic foot ulcer (20) diarrheoa (7)	0.14 0.09 0.03	0.79	LC
19	*Bombax ceiba* L. (Bombacaceae) MZUH-0035	P/T/G/V/S/Z - pat H- Phunchawng	Tr / Bk	Raw	tonsillitis (5)	0.02	0.05	LC
20	*Cajanus cajan* (L).Huth (Asteraceae) MZUH-0011	P/T/G/V/S/Z Behiang H-Behliang	Tr / Lv	Decoction	jaundice (13)	0.06	0.51	LC
21	*Callicarpa arborea* Roxb. (Lamiaceae) MZUH-0010	P/T/G/V/S/Z - Nahkia H-Hnah-kiah	Tr / Sh, Lv	Raw, decoction	ulcer (23); wound (9); worm allergy (9)	0.10 0.04 0.04	0.48	LC
22	*Catharanthus roseus* (L.) G. Don. (Apocynaceae) MZU MZUH-0001	P/T/G/V/S/Z Meisem pak H- Kumtluang par	Hb /Rt	Decoction	vaginal discharge (15); constipation (5)	0.07 0.02	0.23	NE
23	*Centella asiatica* (L.) Urb. (Apiaceae) MZUH-0002	P/T/G/V/S/Z - Tangkuang H-Lambak	Hb/ Lv	Decoction	hypertension (5); diabetes (8); jaundice (11); piles (5)	0.02 0.03 0.05 0.02	0.71	LC
24	*Cinnamomum verum* Presl.	P/T/G/V/S/Z	Tr / Bk	Decoction	tonic (2) mosquito	0.009	0.60	DD

	(Lauraceae) MZUH-0003	Singuithak H-Thakthing			repellant (33); drink as herbal tea(7)	0.15 0.03		
25	*Clerodendrum coleebrokianum* Walp. (Lamiaceae) MZUH-0004	P/T/G/V/S/Z Anphui H-Phuihnam	Sb / Lv	Decoction	Hypertension (8) Diabetes (6)	0.03 0.02	0.35	NE
26	*Colocasia esculenta* (L). Schott. (Araceae) MZUH-0005	P/H/T/G/V/S /Z- Baal	Hb / Lv, Cm	Sap ,decoction	bee sting (5) bone fracture (3) galactogue (14)	0.02 0.01 0.06	0.5	LC
27	*Croton caudatus Geiseler* (Euphorbiaceae) MZUH-0006	P/T/G/V/S/Z - Gamdamdawi H-Rannung damdawi	Tr / Lv	paste,bark decoction	Cancer (7) deworming (2)	0.03 0.009	0.44	NE
28	*Cucumis sativus* L. (Cucurbitaceae) MZUH-0007	Tangmai P /S/Z H-Fanghma	Hb / St	Stem,leaves juice,root decoction	Hypertension (2) Epilepsy (3)	0.009 0.01	0.50	LC
29	*Curcuma longa* L. (Zingiberaceae) MZUH-0008	P/H/T/G/V/S /Z- Ai-eng	Hb / Rz	Raw	Fracture (5) Evil spirit (15)	0.02 0.07	0.41	LC
30	*Cuscuta reflexa* Roxb. (Convolvulaceae) MZUH-0009	P/G/S/Z/T/V -Dialing gui eng H-Dodder (Hruieng)	Ep / St	Raw	hepato-protection (2) Skin infection (7)	0.009 0.03	0.44	LC
31	*Cycas pectinata* Griff. (Cycadaceae) MZUH-0097	P/H/T/G/V/S /Z- Tanglu	Hb / Fr	Decoction	Diabetic (15) Tonic (8)	0.07 0.03	0.27	VU
32	*Cynodon dactylon* (L.) Pers. (Poaceae) MZUH-0017	P/T/G/V/S/Z - Loupa	Hb / Lv	Dried leaves smoked	Gum (8)	0.03	0.33	NE

		H-Phaitual hlo						
33	*Cyperus rotundus* L. Cyperaceae MZUH-0018	P/H/T/G/V/S /Z- Loupaham H-Nu-bengchah	Hb / Lv	Leaves decoction	Ulcer (4) Cuts (7)	0.01 0.03	0.25	LC
34	*Datura metel* L. (Solanaceae) MZUH-0021	P/H/T/G/V/S /Z Tawtawrawt par	Hb / Lv, Fl	Dried leaves smoke	Asthma (7) poison(1)	0.03 0.004	0.25	NE
35	*Daucus carota* L. (Apiaceae)MZUH-0022	P/H/T/G/V/S /Z- Carrot	Hb / Rt	Raw/ decoction	Eye infection (16)	0.07	0.19	NE
36	*Dendrocnide sinuata* (Blume) Chew (Urticaceae) MZUH-0025	P/T/G/V/S/Z - Thakpi H-Thakpui	Tr / Rt	Sliced roots and crab packed put upon charcoal ember is consumed	Jaundice(2); root decoction used for diarrhea (5)	0.009 0.023	0.67	NE
37	*Dillenia pentagyna* Roxb. (Dilleniaceae) MZUH-0026	P/T/G/V/S/Z - Singnahtang H-Kaihzawl	Tr / Bk	Decoction	ulcer (11); piles (3); asthma (2); regulate blood pressure (3)	0.05 0.01 0.01	0.72	LC
38	*Dioscorea glabra* Roxb. (Dioscoreaceae) MZUH-0027	P/H/T/G/V/S /Z- Hakaingou	Sb / Lv	Paste and mustard oil	Rheumatism (15)	0.07	0.41	NE
39	*Drymaria cordata* (L.) Willd. ex Schult (Caryophyllaceae) MZUH-0030	P/T/G/V/S/Z - Meitei lou H-Changkalrit	Sb / Lv	Dried smoke	Sinusitis (4) Boil (6)	0.01 0.02	0.32	NE

40	*Dysoxylum gobara* Buch. (Meliaceae) MZUH-0019	P/T/G/V/S/Z - Singthupi H- Thingthupui	Tr / Sh	Decoction	Ulcer (6) Stomach disorder (2)	0.02 0.009	0.29	NE
41	*Elaeis guineensis* Jacq. (Arecaceae) MZUH-00101	P/H/T/G/V/S /Z Oil palm	Sb / Sd	Topical	headache (4) Rheumatism (6)	0.01 0.02	0.35	LC
42	*Ensete glaucum* (Roxb.) Cheesman (Musaceae) MZUH-0015	P/T/G/V/S/Z - Saisuang H-Saisu	Hb / Sd	Dried seed worn	Convulsion (25).	0.11	0.41	LC
43	*Entada gigas* (L.) Fawc. & Rendle (Asteraceae) MZUH-0102	P/H/T/G/V/S /Z- Linggah Kawi	Cl / Sd	Seed coat with water	Against leech (15) Joint pain (4).	0.07 0.01	0.44	NE
44	*Eryngium foetidum* L. (Apiaceae) MZUH-0025	P/T/G/V/S/Z - Pasikhawm H-Bahkhawr	Hb /Lv	Raw, decoction	Stomachache (3); fever & cough (3); constipation (4); deworming (3); infertility (2)	0.01 0.01 0.0100.009	0.44	NE
45	*Erythrina stricta* Roxb. (Asteraceae) MZUH-0098	P/T/G/V/S/Z - Suangkua pak H-Fartuahpui	Tr / Bk	Decoction	Ulcer (4) Evil spirit (25)	0.01 0.11	0.47	LC
46	*Erythrina variegata* L. Asteraceae MZUH-00103	P/T/G/V/S/Z - Suangkua H-Fartuahpui	Tr / Bk	Dried bark as necklace	Convulsion and epilepsy (17)	0.08	0.42	LC
47	*Eupatorium nudiflorum* DC. (Asteraceae) MZUH-	P/T/G/V/S/Z -	Hb / Lv	Paste	Cuts(2) Allergies (2)	0.009 0.009	0.41	NE

	0024	Meiteilo ngou H-Vailenhlo			Stomachache (3)	0.014		
48	*Euphorbia hirta* L. (Euphorbiaceae) MZUH-0029	P/T/G/V/S/Z - SiMZUHil damdoi H-Kalna damdoi	Hb / Lv	Paste	Galactogue (6) AntiSeptic(2)	0.02 0.009	0.44	NE
49	*Euphorbia roylenea* Boiss. (Euphorbiaceae) MZUH-0028	P/T/G/V/S/Z - Dailing paksah H-Chawng	Sb / Lv	Paste	Jaundice (6); malaria (5); liver enlargement (4); Septic wounds (5)	0.02 0.02 0.01 0.02	0.42	NE
50	*Ficus semicordata* Buch.Ham. ex Sm. (Moraceae) MZUH-0032	P/T/G/V/S/Z - Theipi H-Theipui	Tr / Bk	Raw /Sap `	Boils (8) Jaundice (4) Hepatitis (6)	0.03 0.01 0.02	0.44	LC
51	*Flueggea virosa* (Roxb. ex Willd.) Royle MZUH-0066	P/H/T/G/V/S /Z Saisiak	Sb / Lv	Decoction	chicken pox and measles (15)	0.07	0.47	NE
52	*Gelsemium elegans* (Gardner & Chapm.) Benth. (Urticaceae) MZUH-0033	P/T/G/V/S/Z - Namtul H-Hnam-tur	Tr / Rt, Bk	Root paste and bark decoction	Stomach disorder (27)	0.12	0.32	NE
53	*Helicia excelsa* (Roxb.) Blume (Proteaceae) MZUH-0031	P/H/T/G/V/S /Z- Sial-hma	Tr / Bk	Decoction	Urinary calculus (6) Anti-vommiting (5)	0.02 0.02	0.36	LC
54	*Helicia robusta* (Roxb.) R.Br. ex Blume (Proteaceae) MZUH-0016	P/H/T/G/V/S /Z- Pasaltakaza	Tr / Lv	Leaves,bark decoction	Ovary infection (3); stomachache (5) oligomenorrhea (6)	0.01 0.02 0.02	0.36	NE
55	*Hellenia speciosa*	P/T/G/V/S/Z	Hb / St, Rh	Raw juice,	Ear ache (5)	0.02	0.38	LC

	(J.Koenig) S.R.Dutta (Costaceae) MZU MZUH-0084	- Simbuthut H-Sumbul		rhizome decoction	For-kidney calculus (7)	0.03		
56	*Hibiscus sabdariffa* L. (Malvaceae) MZUH-0086	P/H/T/G/V/S /Z- Anthuk/Anth ur	Sb / Lv	Leaves fruit decoction	Gastric problems (5) Ulcer (9) Stomach disorder (6)	0.02 0.04 0.02	0.35	NE
57	*Homalomena aromatica* (Spreng.) Schott (Araceae) MZUH-0085	P/T/G/V/S/Z - Kangmantri H-Anchiri	Sb / Rt	Dried roots Burnt	Mosquito repellent (6); jaundice (6); influenza (4); ease childbirth/delivery (5)	0.02 0.02 0.01	0.48	NE
58	*Houttuynia cordata* Thunb.MZUH-114 (Saururaceae) MZUH-0087	P/T/G/V/S/Z - Aithanglou	Hb / Rt	Root paste and decoction	Piles (10) Blood purifier (5)	0.04 0.02	0.84	NE
59	*Ilex godajam* Colebr. ex Hook.f.(Aquifoliaceae) MZU MZUH-0088	H- Thinguih-ha-hni	Tr / Bk	Decoction	Diabetes (2) Stomach ache (5)	0.009 0.02	0.53	LC
60	*Imperata cylindrica* (L.) P. Beauv (Poaceae) MZUH-0074	P/T/G/V/S/Z - Bi H-Di	Hb / Rt	Decoction	kidney calculus (16) Deworming (2)	0.07 0.009	0.42	LC
61	*Justicia adhatoda* L. (Acanthaceae) MZUH-0073	P/T/G/V/S/Z - Koldai H-Kawldai parvar	Sb / Lv	Decoction	Jaundice (10); tuberculosis (5) bronchial issue (3); Asthma (2); Menstruation (2)	0.04 0.01 0.009 0.009	0.78	NE
62	*Lablab purpureus* (L.) Sweet (Asteraceae) MZUH-0082	P/T/G/V/S/Z - Bepi H-Bepui	Cl / Lv	Paste	Gastroenteritis (8) Insect bites (11) Jaundice (7) fever & cough (6)	0.03 0.05 0.03 0.02	0.38	NE
63	*Lantana camara* L. (Verbenaceae) MZUH-0083	P/H/T/G/V/S /Z	Sb / Lv, Bk	Decoction	Bad odor (13) Eczema (14)	0.06 0.06	0.5	NE

		Dialing			skin inflammation (15)	0.07		
64	*Lepionurus sylvestris* Blume (Olacaceae) MZUH-0089	P/H/T/G/V/S /Z- Anpangthua m	Hb / Lv	Decoction	Diabetes (15) Bad odour (21)	0.07 0.1	0.61	NE
65	*Leucaena leucocephala* (Lam.) de Wit (Asteraceae) MZUH-0090	P/H/T/G/V/S /Z- Zawngtah lem-	Tr / Sd	Raw, decoction	Constipation (12) ulcer (10) stomach disorder (10)	0.05 0.04 0.04	0.38	NE
66	*Luffa acutangula* (L.) M. Roem (Cucurbitaceae) MZUH-0091	P/H/T/G/V/S /Z- Uumpawng	Cl / Fr	Fruit decoction with equal amount of bark for ulcer	Ulcer (9) oligomenorrhoea (11); deworming (12)	0.04 0.05 0.05	0.38	NE
67	*Mangifera indica* L. (Anarcadiaceae) MZUH-0075	P/T/G/V/S/Z - Hai H-Theihai	Tr / Lv	Equal dried leaves and bark burnt to ash mix with water and consumed for hiccup.leaves decoction	Hiccup (20) Diabetes (8)	0.09 0.03	0.33	NE
68	*Mentha spicata* L. (Lamiaceae) MZUH-0076	P/H/T/G/V/S /Z Pudina	Hb / Lv	Paste and raw	Allergies (16) Gastric problems (18); stomach ache (6)	0.07 0.08 0.02	0.47	LC
69	*Mikania micrantha* Kunth (Asteraceae) MZUH-0077	P/T/G/V/S/Z - Japan lo H-Japan hlo	Cl / Lv	Raw /decoction	Diarrhea (17) Dysentery (10) insects bites (6); cancer (9)	0.08 0.04 0.02 0.04	0.5	NE
70	*Mimosa pudica* L. (Asteraceae) MZUH-0078	P/T/G/V/S/Z - Lonuak	Sb / Lv	equal amount of leaves and roots decoction	Piles (9) Kidney stones (12) Fever & cough (10)	0.04 0.05 0.04	0.42	LC

		H-Hlonuar			Pustule (5)	0.02		
71	*Mirabilis jalapa* L. (Nyctaginaceae) MZUH-0081	P/T/G/V/S/Z - Meisem pak H-Artuk-khuan	Hb / Rt	Roots decoction and paste	Diabetes (15) Allergy (6) ear infection (5); erectile dysfunction (10); tonic (7); dropsy (2)	0.07 0.02 0.04 0.03	0.53	NE
72	*Momordica charantia* L.(Cucurbitaceae) MZUH-0092	P/T/G/V/S/Z - Tangkha H-Changkha	Cl / Fr	Decoction	Lactation (2) Jaundice (2) Diabetics (7) dysentery (4); intestinal worm (1)	0.009 0.009 0.03 0.01	0.40	NE
73	*Morus alba* L. (Moraceae) MZUH-0093	P/T/G/V/S/Z - Singtheimin	Tr/ Fr	Raw	Appetizer (10) Diabetes (6) Dysentery (10)	0.04 0.02 0.04	0.30	LC
74	*Nicotiana tabacum* L. (Solanaceae) MZU MZUH-0094	P/G/V/S/Z-Dum, T-Lho H-Vai-hlo	Sb / Lv	Made into tuibuk	Toothache (36) Cuts and wounds(18)	0.17 0.08	0.64	NE
75	*Oroxylum indicum* (L.) Kurz (Bignoniaceae) MZUH-0095	P/H/T/G/V/S /Z- Archnagkaw m	Tr / Fr	Decoction	Piles (10) Jaundice (10) Cancer (10) Deworming (7)	0.04 0.04 0.04 0.03	0.5	NE
76	*Phyllanthus emblica* Gaertn. (Euphorbiaceae) MZUH-0080	P/H/T/G/V/S /Z- Suaklu H-Sunhlu	Tr / Fr	Raw/ decoction	Diarrhea (10), nausea (14); vomiting (16); jaundice (16); diabetes (14)	0.04 0.06 0.06 0.06	0.96	LC
77	*Prunus persica* (L.) Bastch (Rosaceae) MZUH-0079	P/H/T/G/V/S /Z- Theimul	Tr / Lv	Leaves decoction	Diarrhea (26)	0.12	0.30	NE
78	*Pseudodrynaria coronans* (Wall. ex Mett) Ching (Polypodiaceae)	P/H/T/G/V/S /Z- Awmvel	Ep / Rt	Roots or velamen paste	Skin infection (20); Dysentery (20)	0.09 0.09	0.47	NE

	MZUH-0096							
79	*Psidium guajava* L. (Myrtaceae) MZU MZUH-0053	P/G/V/S/Z-Kawlsing T-Kawlthing H-Kawlthei	Tr / Bk, Fr	Bark pastes or raw/cooked fruit	Toothache (10) Stomach disorder (18); diarrhea (13)	0.04 0.08 0.06	0.48	LC
80	*Rhus chinesis* Mill. (Anacardiaceae) MZUH-0034	P/T/G/V/S/Z-Khongma H-Khonghma	Tr / Sd, Bk, Lv	Decoction	Constipation (26) Stomachache (15) Cuts (19)	0.12 0.07 0.09	0.71	LC
81	*Rubus alceifolius* Poir. (Rosaceae) MZUH-0055	P/H/T/G/V/S/Z-Gamtheikhum Siali-nu-chhu	Sh / Rt, Fr	Decoction/raw	Diabetics (7) Vitamins (25)	0.03 0.11	0.38	NE
82	*Saccharum officinarum* L(Poaceae) MZUH-0061	P/T/G/V/S/Z-Kawltu H-Fu	Hb / St	Juice	Jaundice (18) Hepatitis (8) Toothache (17);constipation (25)	0.08 0.03 0.08 0.11	0.86	LC
83	*Sapindus mukorossi* Gaertn. (Sapindaceae) MZU MZUH-0062	P/G/V/S/Z-Lingshi, T-Lhingsi H-Hlingshi	Tr / Sd	Raw	piles (16) tonsils (6)	0.07 0.02	0.26	LC
84	*Schima wallichii* DC. (Theaceae) MZUH-0065	P/H/T/G/V/S/Z-Khiang	Tr / Bk	Decoction	Ulcer (16) Diabetes (8) Septic wounds (8)	0.07 0.03 0.03	0.38	VU
85	*Scoparia dulcis* L. (Scrophulariaceae) MZU MZUH-0064	P/H/T/G/V/S/Z-Misi suaklu H-Perh pawng chaw	Hb / Lv	Decoction	Diabetes (38) Kidney stone problem (29)	0.18 0.13	0.55	NE
86	*Senna alata* (L.) Roxb.	H-Tui hlo	Sb / Lv	Raw/decoction	Mouth sore (16)	0.07	0.38	LC

	(Asteraceae) MZUH-0067				Ringworm (16)	0.07		
87	*Smilax glabra* Roxb. (Smilacaceae) MZUH-0068	P-Kumleng H-Tluangngil	Cl /Rh, Lv	Raw/decoction pound	Milk powder (15) Diarrhea (28)	0.07 0.13	0.51	NE
88	*Solanum melongena* L. (Solanaceae) MZUH-0063	P/T/G/V/S/Z - Manta H- Bawkbawn	Sb / Fr	Decoction	Hypertension (12) Stomachache (16)	0.05 0.07	0.41	NE
89	*Solanum nigrum* L. (Solanaceae)MZUH-0099	P/T/G/V/S/Z - Anzou H-An-hling	Sb / Lv, Fr	Decoction	Urinary issues (19) Boils and ringworm (6)	0.09 0.02	0.29	NE
90	*Solanum torvum* Sw. (Solanaceae) MZUH-0058	P/T/G/V/S/Z - Anjangkha H-Tawkpui	Sb / Fr	Smoke dried fruits with (doob grass)	Tooth decay (29)	0.13	0.34	NE
91	*Solanum violaceum* Ortega (Solanaceae) MZUH-0057	P /T/G/V/S/Z- Samphokneu H- Samtawkte	Sb / Rt	Root pastes	Epilepsy (9) burns (3) insects bite (6)toothache (7) dysentery (6)hypertension (8); leucorrhea (9)	0.04 0.01 0.01 0.03 0.04	0.47	LC
92	*Spondias pinnata* (L. f.) Kurz (Anacardiaceae) MZUH-0056	P/H/T/G/V/S /Z Tuaiteng/ Tawite	Tr / Lv, Fr	Leaves paste	Ear infection (17) Dysentery (7) Liver infection (8)	0.08 0.03 0.03	0.38	NE
93	*Tamarindus indica* L. (Asteraceae) MZUH-0059	P/H/T/G/V/S /Z- Tengtere	Tr / Sd	Raw	Snakes (12) Constipation (16)	0.05 0.07	0.33	LC
94	*Thottea tomentosa* (Blume) Ding Hou (Aristolochiaceae) MZUH-0060	P/H/T/G/V/S /Z- Nahkhat	Hb / Lv	Raw	Dysentery (49) Diabetes (25)	0.35 0.11	0.90	NE

95	*Trevesia palmata* (Roxb. ex Lindl.) Vis. (Araliaceae) MZUH-0069	P/H/T/G/V/S /Z- Kohteh bel	Sb / Lv	Equal amount of leaves and root decoction	Colitis (6) stomachache (2); high blood pressure (7)	0.02 0.009 0.03	0.41	LC
96	*Trichosanthes cucumerina* L. (Cucurbitaceae) MZUH-0100	P/T/G/V/S/Z - Begul H-Berul	Cl / Fr, Sd	Fruit,sap decoction	Snake bites (7) Anti-helminthic (54) Deworming (70)	0.03 0.25 0.33	0.48	NE
97	*Urena lobata* L (Malvaceae) MZUH-0071	P/ T/G/V/S/Z- Paktehmul haisanteh H-Se-hnap	Sb / Rt	Decoction	Diuretic (8) Diarrhea (15) Dysentery (8)	0.03 0.07 0.03	0.28	LC
98	*Vigna unguiculata* (L) Walp. (Asteraceae) MZUH-0072	P/T/G/V/S/Z - Belawi H-Behlawi	Cl / Lv	Raw	Eye infection (19) Allergy (5)	0.09 0.02	0.45	LC
99	*Zanthoxylum rhetsa* (Roxb.) DC. (Rutaceae) MZUH-0070	P/S/Z- Singjual T/G/V – Thingjuol H-Singjuol	Tr / Lv	Raw/decoction	Leaves decoction for cold and cough (10); rheumatism (5); raw leaf taken for deworming (9) diarrhea(12)	0.17	0.42	LC
100	*Zea mays* L. (Poaceae) MZUH-0052	P/H/T/G/V/S /Z- Vaimim	Sb / Lv, Sd	Decoction of equal amount of leaves and roots, grains decoction	Urinary retention (3) Food poisoning (3) Blood pressure control (4); rheumatism (2) Diuretic (3)	0.014 0.014 0.019 0.014 0.014	0.51	LC
101	*Zingiber officinales* Rose (Zingiberaceae) MZUH-0051	P/ S/Z- Sing T/G/V/- Thing	Hb / Rh	Heated, rizome infusion pounded rhizome with	Chest pain and common cold (7) galactagogue (4) piles (6) relieve pain (5)	0.03 0.01 0.02 0.02	0.21	LC

		H-Sawhthing		salt				
102	*Ziziphus jujuba* Mill (Rhamnaceae) MZUH-0050	P/H/T/G/V/S /Z- Boroih	Tr / Fr	Raw or sun-dried	Appetizer (10); promote sleep (14) enhance liver health (9)reduce anxiety (2)	0.04 0.06 0.04 0.009	0.2	LC

Notes: P- Paite; T- Thadou; H- Hmar; G- Gangte; V- Vaiphei; S- Simte; Z-Zou; Hb-Herb; Sb-Shrub; Tr-Tree; Cl-Climber; Ep-Epiphyte; Lv-Leaves; St- Stem; Fr-Fruit; Fl-Flower; Sd-Seed; Rh-Rhizome; Rt-Root; Bk-Bark; LC-Least Concern; VU-Vulnerable; NE-Not Evaluated; DD-Data Deficient

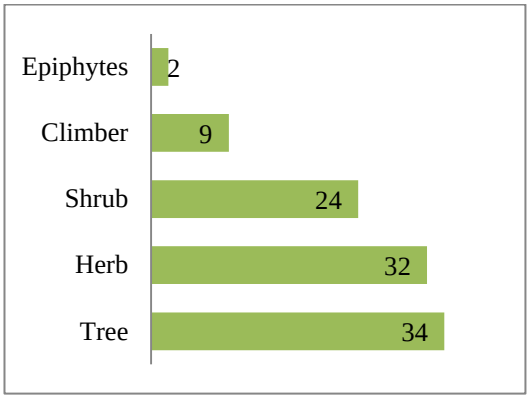


Fig.4.3. Habit of Medicinal plants

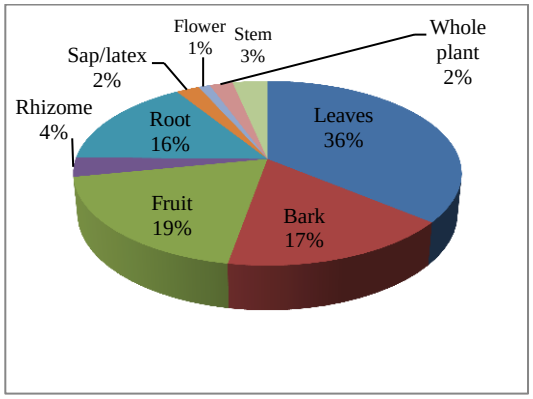


Fig.4.4. Plants parts used

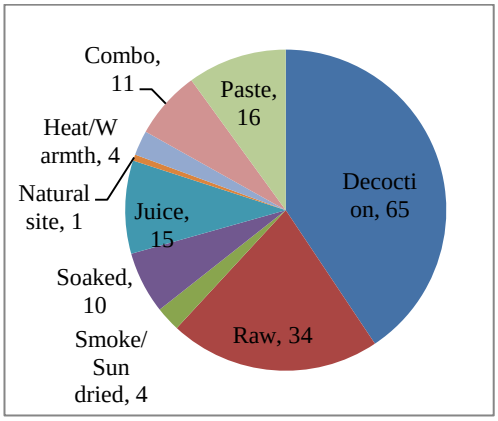


Fig.4.5. Mode of preparation

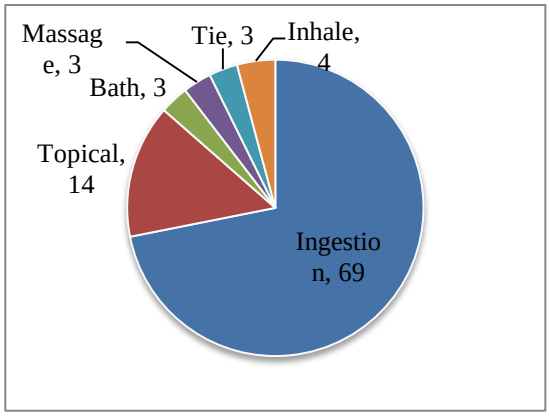


Fig.4.6.Mode of administration

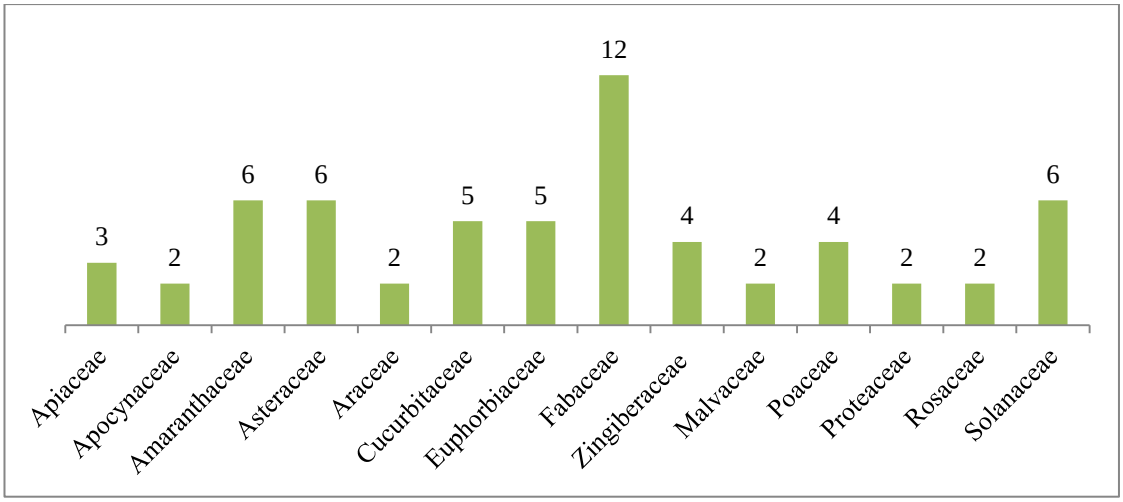


Fig.4.7. Families of medicinal plant with reported species (top 14 selected)

4.7.3. Preparation method and administration route

The Kuki-Chin community in the current study identified nine distinct methods of preparation. The predominant form was decoction (41%), consistent with findings from previous studies (Panmei et al., 2019; Singh et al., 2017). Other preparation methods included paste (18%), soaking (14%), combo (9%), sun/smoked dried (8%), juice (6%), heat/warmth (2%), oil (1.16%), and one instance of natural site preparation (1%) (Fig.4.4). The administration of crude drugs occurred through six different routes. The most prevalent route was oral administration (65%), followed by topical (26%), inhalation (4%), massage (2%), bath (2%), and tie (1%) (Fig.4.5.). Oral administration was primarily employed to address various ailments, including dysentery, diarrhea, fever, high blood pressure, muscle pain, skin diseases, kidney stones, diabetes, rheumatism, and pneumonia, food poisoning, expelling intestinal worms, gastritis, urinary problems, and wound care.

4.7.4. Use value (UV) of medicinal plants

Use value (UV) of the total 102 species ranged from 0.07-1.08 in medicinal plants *Benincasa hispida* scoring the highest UV which is 1.08. It is used in the treatment liver diseases, constipation and tonic and corpse preservation while *Daucus carota* with UV (0.07) are used as indigestion and eye infection.

The study conducted at the site determined the importance of various plants based on their use value (UV). The plants with the highest use value (UV) for medicinal plants are *Benincasa hispida* (1.08), *Thottea tomentosa* (0.90), *Saccharum officinarum* (0.86), *Blumea lanceloria* (0.79), *Justicia adhatoda* (0.78), *Clerodendrum colebrookianum* (0.75), *Dillenia pentagyna* (0.72), *Centella asiatica* (0.71), *Rhus chinensis* (0.71). These plants are considered to be highly important based on their traditional uses and medicinal properties.

On the other hand, the plants with the lowest use value (UV) of medicinal plants are *Sapindus mukorossi* (0.26), *Solanum nigrum* (0.29), *Helicia robusta*

(0.36), *Luffa acutangula* (0.38), *Flueggea virosa* (0.47), *Scoparia dulcis* L. (0.55). These plants have relatively lower use value, indicating that they are less important in terms of traditional uses and medicinal significance in the study area.

Table 16. Fidelity level of the ethnomedicinal plants

Ailments	**Species**	**Np**	**N**	**FL**
Gastro-intestinal ailments (GIA): Diarrhea, dysentery, Deworming	*Mikania micrantha, Smilax glabra Blumea lanceloria ,Psidium guajava Zanthoxylum rhetsa,Thotteatomentosa*	315	315	100
Dermatological infection/diseases (DID): Cuts and wounds: Cuts, wounds, boils, burns	*Nicotiana tabacum, Rhus chinensis Aloe vera, Blumea lanceloria*	62	82	75
Skeleto-muscular system disorder (SMSD): Rheumatism & bone fracture	*Agave americana ,Alstonia scholaris Elaeis guineensis ,Zanthoxylum rhetsa*	71	82	86
Ear nose throat problem (ENT): Tonsillitis, sinusitis	*Drymaria cordata, Bombax ceiba Sapindus mukorossi*	22	26	84
Respiratory disease syndrome (RSD): Asthma, pulmonary affliction bronchitis,	*Datura metel, Justicia adhatoda Bergenia ciliate*	45	48	93
Genitourinary ailments (GUA): Menstrual disorder, infertility, galactagogue, diuretic, diabetes.	*Bergenia ciliata, Cycas pectinata Ilex godajam, Scoparia dulcis Alstonia scholaris*	114	114	100
Nervous system disorder (NSD): Epilepsy, convulsion	*Ensete glaucum, Erythrina variegata Ensete glaucum*	92	105	84
Poisonous bites (PB): Snake/insect bites, bee sting and leech bite	*Trichosanthes cucumerina Aloe vera Mikania micrantha Solanum violaceum Alpinia roxburghii*	61	65	93
Dental care (DC): Tooth and gum disorder	*Acmella oleracea, Cynodon dactylon Nicotiana tabacum, Solanum torvum Solanum violaceum*	119	121	98
Cardiovascular disorder (CSD): Hypertension,low blood pressure	*Dillenia pentagyna**,** Trevesia palmate Clerodendrum glandulosum Solanum violaceum*	114	115	99
Liver and spleen disorder (LSD): Jaundice & Hepatitis	*Cajanus cajan, Dendrocnide sinuate Oroxylum indicum, Cuscuta reflexa*	159	160	99

	Centella asiatica, Saccharum officinarum			
Trichinella Infection and poisoning (TIP): Trichinosis and food poisoning.	*Zea mays, Begonia roxburghii Bergenia ciliata, Lablab purpurea*	41	43	90
Dead body preservation: Corpse embalming	*Benincasa hispida*	50	50	100

4.7.5. Fidelity level (FL%)

The most preferred species for treating ailments were determined with fidelity level. High fidelity value indicate that the healers used same plants to treat same ailments/diseases (Laloo and Hemalatha, 2011) while low fidelity indicates that same plants were used to treat same or other ailments/diseases. The fidelity level (FL%) for medicinal plants ranges from (84-100%) (Table 16).The highest fidelity and most preffered medicinal plants to treat Gastro-intestinal ailments are *Mikania micrantha***,** *Smilax glabra*. *Blumea lanceloria, Psidium guajava*., *Thottea tomentosa***,** *Zanthoxylum rhetsa* against (100%), followed by Genitourinary ailments *Bergenia ciliate* (Haw.) Sternb, *Cycas pectinata* Griff, *Ilex godajam, Scoparia dulcis*, *Alstonia scholaris* (100%), Liver and spleen disorder *Benincasa hispida* for corpse embalming (100%), *Cajanus cajan*, *Dendrocnide sinuata, Oroxylum indicum, Cuscuta reflexa, Centella asiatica*, *Saccharum officinarum* (99%), Cardiovascular disorder *Dillenia pentagyna***,** *Trevesia palmata, Clerodendrum colebrookianum, Solanum violaceum* against (99%), Dental care *Acmella oleracea, Cynodon dactylo*n, *Nicotiana tabacum, Solanum torvum* (98%), Poisonous bite *Trichosanthes cucumerina, Aloe vera, Mikania micrantha, Solanum violaceum , Alpinia roxburghii* (93%) and Respiratory syndrome *Datura metel, Justicia adhatoda, Bergenia ciliata* (93%).

Thus, in our present study, the fidelity test have less significance to find/scale out plants with high healing properties because all the ethnobotanical uses showed high fidelity percent. However, this problem has been overcome by analyzing the data with another effective index *i.e.*, relative frequency of citation.

4.7.6. Relative frequency of citation

The RFC has been dicvided into three groups according to the values of Relative frequency of citation index. (Table 15).The first group contains the plant species with RFC value >0.21. The second group contains plant species with RFC value between (0.101 and 0.20) and the third group contains other less known uses with Rfc value less than 0.20 (RFC <0.20).

The first group of ethnomedicinal plants include (RFC=>0.21) 10 popular plants species with their ethnobotanical uses are *Benincasa hispida* liver diseases (RFC=0.13), constipation (RFC=0.05), Corpse preservation (RFC=0.23), *Betula cylindrostachya*, Diabetics (RFC=0.27), ulcer and Digestive issue (RFC=0.08) *Blumea lanceloria*, Diabetics and diabetic food ulcer (RFC=0.23), diarrheoa (RFC=0.03), cuts and wounds (RFC=0.04). *Phyllanthus emblica*, diarrhea (RFC=0.040, nausea and diabetics (RFC=0.06), Jaundice (RFC=0.07), Cough and vomiting (RFC=0.05), *Saccharum officinarum*, jaundice (RFC=0.08), hepatitis (RFC=0.03), toothache (RFC=0.08), constipation (RFC=0.11), tonic (RFC=0.02) *Scoparia dulcis*, diabetes (RFC=0.18), kidney problem (RFC=0.13), *Thottea tomentosa*, dysentery and ulcer (RFC=0.23), diabetes (RFC=0.11). *Trichosanthes cucumerina* snake bit (RFC=0.03), anti-helminthic (RFC=0.25), deworming (RFC=0.34), *Mirabilis jalapa* Diabetics (RFC=0.07), itching/allergy (RFC=0.02), *Nicotiana tabacum* toothache (RFC=0.17), cuts and wounds (RFC=0.085).

The second group of ethnomedicinal plants includes 7 species *Cinnamomum verum* Presl, mosquito repellant (RFC=0.15), Herbal tea (RFC=0.02), Tonic (RFC=(0.009), *Lantana camara* eczema (RFC=0.06), skin inflammation (RFC=0.07), Dead body embalm (RFC=0.06), *Oroxylum indicum*, piles (RFC=0.04) jaundice (0.04); reduce pain in cancer (RFC=0.03); deworming (RFC=0.03); seed paste as tonic (RFC=0.02), *Smilax glabra*, roots as milk powder (RFC=0.07); diarrhea (RFC=0.13), *Solanum nigrum*, for urinary and kidney issues (RFC=0.09), boils and ringworm (0.02), *Solanum violaceum*, *Urena lobata*, diuretic (RFC=0,03),diarrhea (RFC=0.07); dysentery (RFC=0.03), *Zanthoxylum rhetsa*

(Roxb.), cold and cough (RFC=0.04); rheumatism (RFC=0.02); deworming (RFC=0.04); diarrhea (RFC=0.05).

The third group of ethnomedicinal include 15 species are *Alstonia scholaris*, kidney stones (RFC=19), *Amomum dealbatum*, diuretics (18); dysentery (24), *Begonia roxburghii*, diabetes (RFC=0.06) piles (RFC=0.02); trichinosis (wild boar meat) (RFC=0.0614), *Bergenia ciliata*, tonic (RFC=0.07); pulmonary affliction (RFC=0.026); diabetes (RFC=0.051); gastroenteritis (RFC=0.049), *Callicarpa arborea* Roxb, stomach disorder (RFC=0.07); ulcer (RFC=038); wound (RFC=0.04), allergy (RFC=0.049), *Justicia adhatoda*, jaundice (RFC-0.041); tuberculosis (RFC=0.02); bronchial issue (RFC=0.01); asthma (0.0092) menstruation absent/scanty (RFC=0.009), *Lablab purpureus*, gastroenteritis (RFC=0.038); insect bites (RFC=0.05); jaundice (RFC=0.03); fever & cough (RFC=0.02), *Lepionurus* sylvestris Blume, diabetes (RFC=0.07); cooked leaves with tree bean seed consumed to prevent bad odour of feces (RFC=0.1), *Leucaena leucocephala*, constipation (RFC=0.05); ulcer (RFC=0.0410); stomach disorder (RFC=0.041), *Luffa acutangula*, ulcer (RFC=0.04); oligomenorrhoea (RFC=0.05); deworming (RFC=0.05), *Mikania micrantha* Kunth diarrhea (RFC=0.05); dysentery (RFC=0.04); insects bites (RFC=0.08); cancer (RFC=0.04), *Pseudodrynaria coronans*, skin infection (RFC=0.09); dysentery (RFC=0.09), *Psidium guajava* toothache; (RFC=0.04) stomach disorder (RFC=0.08), diarrhea (RFC=0.06), *Rubus alceifolius* diabetes (RFC=0.03); vitamins (RFC=0.11), *Tamarindus indica*, snake bite (RFC=0.05); constipation (RFC=0.02).

Table 17. ICF of ethnomedicinal plants based on ICPC-2

Ailments category ICPC 2	**Nur**	**Nt**	**ICF**
General and unspecified :Fever (A03),Bleeding(A10) , Cancer (A26),Trichinosis(A86), Allergy(A92), Tonic (A98), Vitamin (B81)	209	24	0.87
Digestive: Stomach ache (D01) , Indigestion (D07) , Nausea(D09), Vomiting(D10), Diarrhoea (D11), Constipation (D12),Jaundice(D13), Piles (D16), Teeth complaint (D19), indigestion (D07),Mumps(D71), hepatitis (D72),Gastroenteritis (D73) , ulcer (D87), Worms (D96), Liver disease (NOS)	1450	99	0.93
Cardiovascular: Hypertension (K25), Blood pressure (K 85)	54	19	0.66

Musculoskeletal: Fracture (L76)	8	2	0.85
Neurological: Headache (N01), Paralysis (N18), epilepsy (N88) Convulsion(N07)	71	7	0.91
Psychological : Sleep disturbance (P06)	14	2	0.92
Respiratory : Sinus (R09), Cough (R71), Boil (R73), Tonsil (R76), Bronchitis (R79), Asthma (R96)	223	24	0.89
Skin : Insect bite /sting (S12), Burn (S14), ring worm (S75)Chronic ulcer (S97), cuts (S18)	246	22	0.91
Urological: Dieuretic (U08) ,Urinary calculus (U95)	105	9	0.92
Respiratory: Cough (R05), Sinusitis (R75), Tonsilitis (R76), Bronchitis (R78), Influenza (R80), Asthma (R96)	131	12	0.91
Endocrine/Metabolic and Nutritional: Diabetics insulin dependent (T89)	88	16	0.82
Female genital: Menstrual problem (X05), Vaginal discharge (X14)	17	3	0.87
***Corpse embalming**	63	2	0.98

4.7.7. Informant consensus factor(ICF)

In the study area, 102 medicinal plants were identified and utilized for treating 57 ailments, categorized into 12 groups according to ICPC-2, encompassing a total of 316 recommended uses. These ailment categories included General and unspecified, Digestive, Cardiovascular, Musculoskeletal, Neurological, Psychological, Respiratory, Skin, Urological, Endocrine/Metabolic and Nutritional, Female genital, and corpse embalming. The ICF values in the current study were classified into 11 different ailments, ranging from 0.8 to 0.92 (Table 17).

From the study the following species were 14 species -*Abelmoschus esculentus, Achyranthus bidentata, Bauhinia variegata, Begonia roxburghii, Benincasa hispida, bergenia ciliate, Catharanthus roseus, centella cialata, Cinnamomum verum, cycas pectinata, ilex godjama, mirabilis jalapa, oroxyllum indicum and Saccharum officinarum are* were used for cuts, while 12 species were -*Ageratum conyzoides, Aloe vera, Blumea lanceloria, Cyperus rotundus, Eupatorium nudiflorum, Nicotiana tabacum, Rhus chinesis, Spondias pinnata, Spondias pinnata, Tamarindus indica, Mikania micrantha, Callicarpa arborea* were used as tonic.52 species were recorded for digestive system troubles like (Stomach ache, Indigestion, Nausea, Vomiting, Diarrhoea, Constipation, Jaundice, Piles, Indigestion, Mumps, Hepatitis, Gastroenteritis, Ulcer, Worms, Liver diseases) *Callicarpa arborea,*

Dysoxylum gobara, Gelsemium elegans, Mentha spicata, Psidium guajava, Dillenia pentagyna, Benincasa hispida, Eryngium foetidum, Leucaena leucocephala, Catharanthus roseus, Rhus chinesis, Tamarindus indica, Phyllanthus emblica, Cajanus cajan, Dendrocnide sinuate, Centella asiatica, ficus semicordata, Homalomena aromatica, Justicia adhatoda, lablab purpurea, Momordica charantia, phylunthus emblicana, Oroxylum indicum, Saccharum officinarum, Artemisia vulgaris, Abelmoschus esculentus, Begonia roxburghii, Houttuynia cordata, Mimosa pudica, Sapindus mukorossi, Zingiber officinales. Ziziphus jujube, Averrhoea carambola, Euphorbia roylenea, Spondias pinnata, Bergenia ciliata, Ageratum conyzoides, Helicia excelsa, Daucus carota, Trichosanthes cucumerina, Croton caudatus, Imperata cylindrica, Luffa acutangula, Zanthoxylum rhetsa, Mikania micrantha, Smilax glabra, Blumea lanceloria, Thottea tomentosa, Solanum violaceum, Solanum torvum, Nicotiana tabacum, Acmella oleracea. 6 plants species were recorded to cure Cardiovascular diseases like *Dillenia pentagyna, Trevesia palmata, Clerodendrum colebrookianum, Solanum violaceum, Centella asiatica, Cucumis sativus.* A total of 4 species were recorded against Musculoskeletal: *Colocasia esculenta, Curcuma longa, Agave Americana, Alstonia scholaris.* 5 plants species were used to treat Neurological disorder: *Elaeis guineensis, Cucumis sativus, Erythrina variegate, Solanum violaceum, Ensete glaucum.* 2 plant species ton treat Psychological issue : *Ziziphus jujube, Amomum dealbatum.*A total of 12 numbers of plants were recorded used for curing Respiratory Problems : *Drymaria cordata , Bombax ceiba, Sapindus mukorossi, Datura metel, Justicia adhatoda, Bergenia ciliata, Averrhoea carambola, Eryngium foetidum, Lablab purpureus, Mimosa pudica, Phyllanthus emblica, Zanthoxylum rhetsa.* A total of 12 plant species were used to cure Endocrine/Metabolic and Nutritional: *Blumea lanceloria, Cycas pectinata, Momordica charantia, Rubus alceifolius, Mikania micrantha, Centella asiatica, Ilex godajam, Lepionurus sylvestris, Mangifera indica, Mirabilis jalapa, Morus alba, Phyllanthus emblica, Schima wallichii, Scoparia dulcis, Thottea tomentosa, Alstonia scholaria.* Plant species of the following were used to cure Female genital issue: *Justicia adhatoda, Catharanthus roseus* and *Cycas pectinata.*

4.7.8. ICF according to ICPC-2

The high values of the Informant Consensus Factor (ICF) in the research indicated a level of agreement among the informants from various ethnic backgrounds. The study site reported a higher prevalence of digestive ailments, which may be attributed to the closed society of the tribal communities residing in that area. These tribes have a cultural practice of consuming fermented foods, smoked wild meat, tobacco, and tobacco-related products as a gesture of politeness and hospitality within their society. Consequently, their lifestyle choices contribute to the utilization of ethnomedicinal plants with a high ICF value for gastro-intestinal ailments (0.93) and dental problems, given their consumption of tobacco and alcoholic beverages. Moreover, the high ICF value observed for skin and respiratory ailments (0.91) can be linked to the main occupation of these ethnic communities, which involves strenuous agricultural work. Individuals above the age of 50 often exhibit physical complications associated with excessive labor. Their occupation also influences their health issues, including dermatological infections, ear, nose, and throat problems, urological ailments (0.92), and respiratory disease syndrome. However, it is noteworthy that the study site demonstrated a relatively low dependence on Endocrine/Metabolic and Nutritional plants (ICF value of 0.82). This could be attributed to the physically demanding nature of their labor; as such diseases are typically associated with lifestyle factors. The aforementioned diseases are prevalent issues in various parts of India due to factors like poor hygiene, consumption of unsafe water, and pollution.

The majority of tribal individuals in the study were involved in cultivation, which increased the likelihood of dermatological infections including cuts, wounds, burns, ringworms, sores, and skin allergies. In such cases, commonly found plant species like *Nicotiana tabacum*, *Rhus chinensis*, *Aloe vera* and *Blumea lanceloria* were used as first aid treatments for emergency infections. The ethnic groups in the study were also known for their hunting practices and consumption of wild meat and plants, which often resulted in trichinosis—a disease caused by roundworms (*Trichinella* sp.) due to the consumption of undercooked or raw wild meat.

Trichinosis and poisoning caused by the consumption of wild plants were typically treated using indigenous knowledge, relying on plants such as *Zea mays*, *Begonia roxburghii*, *Bergenia ciliata*, and *Lablab purpurea*. Female health was a major concern due to limited access to health centre in the vicinity and reservations about sharing their concerns with outsiders. As a result, traditional healers utilized plant species such as *Helicia robusta*, *Solanum violaceum*, *Mirabilis jalapa*, and *Luffa acutangula* to address issues related to white discharges, lactation enhancement, menstrual problems, and facilitating easier childbirth. Additionally, *Acmella oleracea*, *Cynodon dactylon*, *Nicotiana tabacum*, and *Solanum torvum* were integral to their cultural practices for treating dental problems.In addition, two plant species, *Benincasa hispida* and *Lantana camara*, were employed by the tribal community for preserving the corpses of individuals who died unnaturally. Furthermore, traditional healers in the study relied on plants such as *Croton caudatus*, *Oroxylum indicum*, and *Zanthoxylum rhetsa* to administer deworming treatments for children.

Table18. Comparative analysis of selected medicinal plants from the study sites with already reported bioactivities

Species	**Traditional usages**	**Reported Bioactivity**	**References**	**Local use coherent with known Properties**
Alocasia fornicata	Vegetables	Antioxidants, antibacterial	(Haque et al., 2014)	Not known except as local food
Amophophallus napalensis	Vegetables	No such report	-	Not known except as local food
Mikania micrantha	Medicinal	Anti-fungal, anti-parasitic, antibacterial, wound healing, anti-diabetic,	(Sheam et al., 2020)	Diarrhea, dysentery, diabetes, insect bites and cancer
Betula cylindrostachya	Medicinal	No such report	-	Diabetes, ulcer and Digestive symptoms
Smilax glabra	Medicinal	Anti-inflammatory and immune-modulatory effects, antioxidant, hepatoprotective, antiviral,	(Qiao et al., 2022)	Diarrhea & dysentery
Blumea lanceloria	Diabetes, diabetic foot ulcer, dysentery, cuts and wounds	Antioxidant & antibacterial	(Mishra et al., 2015)	Partial yes
Thottea tomentosa	Diarrhea, Dysentry and anitidiabetic	Antioxidant, antibacterial & anti-fungal	(Bora et al., 2022)	Partial
Bergenia ciliata	Diarrhea and diabetics	Antiviral, antidiabetic	(Sapkota et al., 2022)	Yes
Solanum torvum	Tooth decay and gum pain	Cardio and nephro protection, anti-hypertensive, analgesic, anti-inflammatory,	(Darkwah et al., 2020)	Partial yes
Dillenia pentagyna	Stomach ulcer, piles, asthma	Anti-tumor, antimicrobial, inhibits ACE.	(Saiful and Armania, 2014).	Partial yes .

	blood pressure			
Mirabilis jalapa	Diabetes, itching or allergy, ear infection, erectile dysfunction, tonic	Antimicrobial, diuretic anti-inflammatory, and anti-fungal	(Sarray et al., 2020)	Partial yes
Clerodendrum colebrookianum	Hypertension, diabetes and burnt	Antidandruff, anti-diabetic and anti-hypertensive	(Wang et al., 2018)	Yes
Homalomena aromatica	Mosquitorepellent, Liver infection, influenza, ease childbirth/ delivery	Antifungal, larvicidal, hepatoprotective	(Kehie et al., 2017)	Yes
Ficus semicordata.	Boils and mumps	Antioxidant, hepatoprotective, antibacterial	(Gupta and Acharya, 2019)	Partial yes
Benincasa hispida	Liver problem, constipation tonic and Corpse embalming	Anticancer, antioxidant, and analgesic	(Mohammad et al., 2019)	Partial yes
Croton caudatus	Cancer and Deworming	Anticancer, antioxidant, and analgesic	(Shantabi et al., 2020)	Partial yes
Begonia roxburghii	Diabetes, piles, Food poisoning	Analgesic, anti-arthritic, Thrombolytic	(Mobarak et al., 2018)	Partial yes
Gelsemium elegans	Ethnoveterinary plants Poisonous to human beings but used afainst severe stomach-ache	No report	None	None

Table 19. Unique features among the six tribal communities regarding medicinal and WEPs from the study site

Tribes	Ailments/Diseases	Plants	Used methods
Vaiphei	Galactagogue	*Colocasia esculenta*	Sun dried and smoked dried leaves boiled with smoke dried fish fed at first delivery to induce breast milk
Hmar, Paite, Gangte	Asthma and sinusitis	*Drymaria cordata*	Dried leaves smoke inhale till huge chunk of pus or yellowish salivary is withdrawn out
Paite, Thadou	Epilepsy and convulsion	*Erythrina variegata*	Dried bark tie around neck or wrist or ankle
Paite, Thadou, Hmar	Deworming in children	*Trichosanthes cucumerina* *Zanthoxylum rhetsa* *Oroxylum indicum*	Fruit sap Tender shoots and leaves Green pods decoction
Thadou, Paite	Convulsion	*Ensete glaucum*	Beads of fruit worn as necklace
Paite, Zou, Simte	Magico-religious	*Erythrina stricta*	Dried bark worn around waist or wrist to drive away evil spirit
Paite, Hmar	Jaundice	*Dendrocnide sinuata*	Slice roots with crab packed leaves put upon charcoal amber/fire consumed against jaundice
Gangte	Jaundice	*Cajanus cajan*	Leaves decoction consumed
Paite	Diarrhea, dysentery and cancer	*Ensete glaucum*	Stem cuts at soil level, scoop to make depression cover with leaves and allow to collect sap overnight
Paite	Corpse embalming	*Benincasa hispida*	Fruit cut open with (ground with lemon grass) and used to embalm corpse from bad odor
Thadou, Paite, Zou, Hmar	Food poisoning (Wild meat)	*Zea mays*, *Begonia roxburghii*, *Bergenia ciliata*, *Lablab purpurea*	Cooked seed, Raw leaves Raw leaves, Raw leaves

After the detailed study of the previous literatures published from India (Jain and Jain, 2016) and relevant literatures from Manipur like (Gangte et al., 2013; Laishram et al., 2021Panmei et al., 2019; Thangliankhup et al., 2023), it has been found that about 277 species with their 360 numbers of ethnobotanical uses have been reported in the present study. Out of these, 16 local beverages, 15 ethnovetrinary plants, 10 traditional local cusine have been recorded for the first time. A noteworthy finding from the study site is the use of certain plants for medicinal purposes. Despite the poisonous nature of *Gelsemium elegans*, it is employed by experienced herbalists to address severe stomach disorders. The use of leaves of *Cajanus cajan* for liver disorders is a novel finding not documented by others. *Blumea lanceloria* stands out for its diverse applications, including its use as an anti-diabetic agent, for diabetic foot ulcers, dysentery, as well as in the treatment of cuts and wounds. *Betula cylindrostachya* is reported for its effectiveness in managing diabetes, ulcers, and digestive symptoms, while *Scoparia dulcis* is traditionally used for diabetic control. *Thottea tomentosa* finds application as an anti-diabetic control and for alleviating stomach ache. *Smilax glabra* emerges as a remedy against severe dysentery and as a control measure for diarrhoea. These findings underscore the rich traditional knowledge of the herbalists in the study area and reveal unique applications for these plant species (Table18 and Table19).

Two plants have been recorded for their use in narcotics like *Cannabis sativa* and *Nicotiana tabacum*. A total of 7 numbers of plants were recorded for house and furniture construction that *Schima wallichii*, *Calamus erectus*, *Calamus tenuis Bambusa tulda*, *Dendrocalamus latiflorus*, *Dendrocalamus hamiltonii*, *Dendrocalamus manipureanus*, the stem pith of *Ensete superbum* along with "*tol*" or catalyst is pigs feed. Plants of 2 species have been recorded as poisonous for humans as *Gelsemium* elegans and *Datura metel.* The two plants have been reported for the first time.The traditional dish "Mehpok," a common cuisine in the study area, is documented for the first time.

In the present study, the plants reported to be used as fish-poison include *Acmella paniculata*, *Ageratum conyzoides*, *Albizia chinensis*, *Senna alata*, *Senegalia pennata*, *Trevesia palmata*, *Zanthoxylum rhetsa*.

Plants that include *Erythrina variegata*, *Cucurma longa* and tuibuk (traditional tobacco products) are commonly associated with the magico-religious beliefs.

Two plants *Cinnamomum verum* and *Homalomena aromatica* were found to be commonly used as mosquito repellent.

4.7.9. Promising plants for Bioprospection

The most promising plants for bioprospecting were given in (Table 20) in accordance with the the RFC value. The high value of the RFC does not necessary reflect the most promising plant but from the study site it was the best plant for them for medication and their sources of local food. Out of the 103 medicinal plants three medicinal plants were selected for LCMS chromatography and another three plants were selected based on their traditional food prepration.

The three medicinal plants selected for LCMS chromatography were *Betula cylindrostachya* Lindl.ex Wall, *Blumea lanceloria* (Roxb.) Druce and *Thottea tomentosa* (Blume) Ding Hou along with phenolic content and their antioxidant properties to identify the active compounds responsible for their medicinal properties.

Table 20. List of the most promising ethnobotanical species suitable for bioprospecting for future studies with their respective RFC values

Species	Botanical usages	RFC
Alocasia fornicata (Roxb.) Schott.	As food	0.09
Amophophallus napalensis (Wall.) Bogner & Mayo	As food	0.32
Mikania micrantha Kunth.	Dysentry	0.04
Betula cylindrostachya Lindl.ex Wall.	Diabetics	0.27
Smilax glabra Roxb.	Diarrhea	0.13
Blumea lanceloria (Roxb.) Druce	Anti-Diabetics	0.23
Thottea tomentosa (Blume) Ding Hou	Anti-Diabetics	0.11
Bergenia ciliata (Haw.) Sternb	Anti-diabetic	0.05
Solanum torvum Sw	Blood pressure	0.19
Dillenia pentagyna Roxb.	Piles	0.05
Mirabilis jalapa L.	Anti-diabetic	0.07
Clerodendrum glandulosum Lindl.	Hypertension	0.21
Homalomena aromatica (Spreng.) Schott	Mosquito repellent	0.028
Ficus semicordata Buch.Ham. ex Sm.	Boils	0.03
Benincasa hispida (Thunb.) Cogn	Liver diseases	0.13
Croton caudatus Geiseler	Cancer	0.03
Begonia roxburghii (Miq.) A.DC	Piles	0.02
Gelsemium elegans (Gardner & Chapm.) Benth	Stomach problem	0.12
Oroxylum indicum (L.) Kurz	Cancer and as food	0.04

4.8. Qualitative phytochemical testing of medicinal plants

The qualitative results of the three medicinal plant analysis revealed that methanol extract showed the presence of at least one phytoconstituents (Table 21). Following these, methanol extract of different species shows the presence of alkaloid, flavonoid, tannin, saponin, phenol and oil. In *Blumea lanceolaria,* all the test were present except saponin. In *Betula cylindrostachya,* all the test result shows positive. In *Thottea tomentosa* all the phytoconstituent were present except saponin.

Table 21. Qualitative analysis of the three selected medicinal plants

Plants	Alkaloid	Flavonoid	Tanin	Saponin	Phenol	Oil & Fats
Blumea lanceloria	+	+	+	-	+	+
Betula cylindrostachya	+	+	+	+	+	+
Thottea tomentosa	+	+	+	_	+	+

Table 22. Comparative account on total phenol, flavonoid and antioxidant properties of three medicinal plants

Plant species	Total phenol (mg GAE/g DW ±SD)		Total flavonoid (mg QE/g DW± SD)	DPPH IC_{50} µg/ml	ABTS IC_{50} µg/ml
Blumea lanceolaria	54.6±1.4		91.4±2.9	66.9	72.9
Betula cylindrostachya	31.3±1.7		24±1.4	58.76	85.76
Thottea tomentosa	26.8±2		19.7±1.7	49.95	64.95
BHT	-		-	8.9	16.3

4.9. Quantitative phytochemical testing of medicinal plants (Table 22)

4.9.1. Total Phenol content

The total phenol content of methanolic extract of the three different samples were determined from the linear regression curve of standard Gallic acid (Y=0.006x+0.0615, R^2= 0.997) and was expressed as mg Gallic acid equivalents/g dry wt (DW). The results further showed that the maximum content of phenol was observed in *Betula cylindrostachya* (318.61 mg GAE /g DW) followed by *Blumea lanceloria* (54.6 mg GAE /g DW) and the lowest in *Thottea tomentosa* (26.8 mg GAE/g DW).(Fig.4.7)

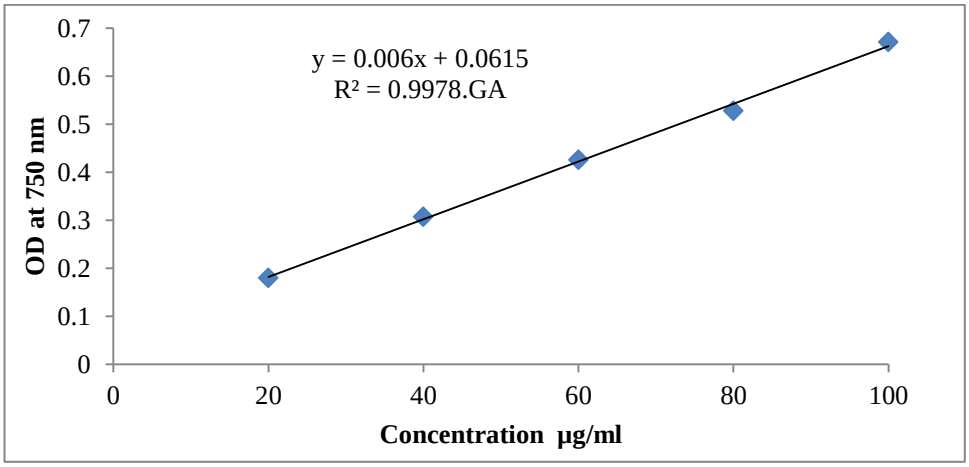


Fig.4.8.Total phenol content of the medicinal plants

The total phenol content of *Blumea lanceloria* is lower with earlier studies of methanolic extract of old leaf *Blumea lanceloria* however higher than the other part of the plants (stem, flowers and young leaves), ethanolic and water extracts (Swaraz et al., 2021).

The total phenol content of *Betula cylindrostachya* is lower with earlier studies of methanolic extract of methanolic extracts of *Betula alnoides* (347 mg/GAE/g DW) (Singla et al., 2018).

The total phenol content of *Thottea tomentosa* is higher than compared to earlier studies of methanolic extract of *Thottea tomentosa,* however lower than than the chloroform and hexane extracts (Bora et al., 2022).

4.9.2. Total flavonoid content

The total flavonoid content was assessed using a standard curve of quercetin, represented by a linear regression equation (Y=0.0009x+0.0007, R2=0.0998) (Fig.4.8). The outcomes were presented in mg quercetin equivalent QE/g dry weight. Total flavonoid content was highest in the extract of *Betula cylindrostachya* (249 mg QE/g DW), followed by *Blumea lanceloria* (91.4 mg QE/g DW) and the lowest was observed in *Thottea tomentosa* (19.7 mg QE/g DW).

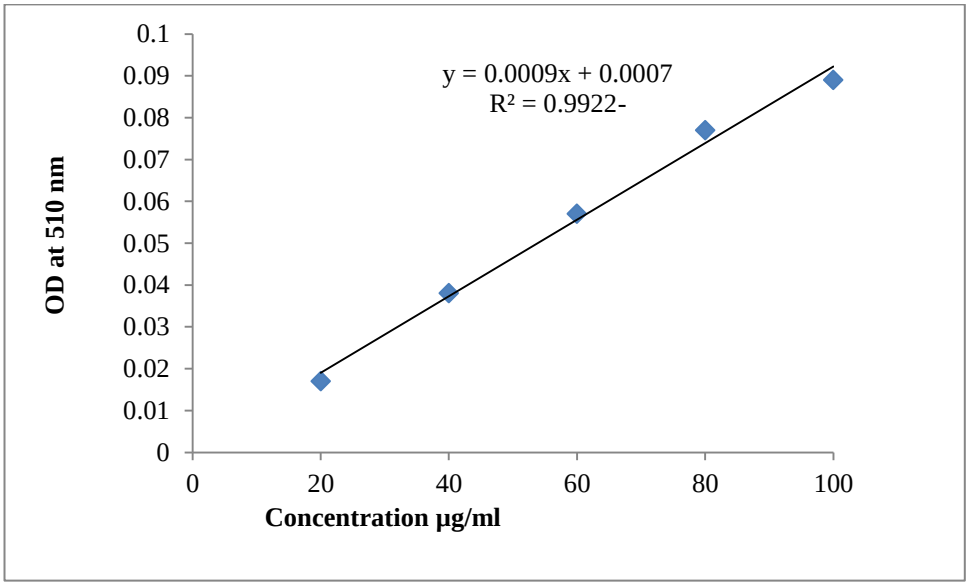


Fig.4.8. Total flavonoid content

The flavonoid content is lower in the methanolic extracts of old leaves, but higher than the other ethanolic and water extracts (Swaraz et al., 2021). The flavonoid content is much lower in the methanolic extracts (347 mg/GAE/g DW) (Singla et al., 2018).The flavonoid content is much lower than the methanolic extracts of *Thottea tomentosa*, and the chloroform and hexane extracts (Bora et al., 2022).

4.9.3. Determination of DPPH free radical scavenging activity

The DPPH radical scavenging activity of methanol extract of the three medicinal plants exhibit concentration-dependent where there is an increase in concentration; the scavenging percentage also increases (Fig.4.9). DPPH assays

shows a significant IC_{50} variation between the three plant extracts ($p<0.05$). The ABTS radical scavenging activity of methanol extract of the three medicinal plants exhibit concentration-dependent where there is an increase in concentration, the scavenging percentage also increases

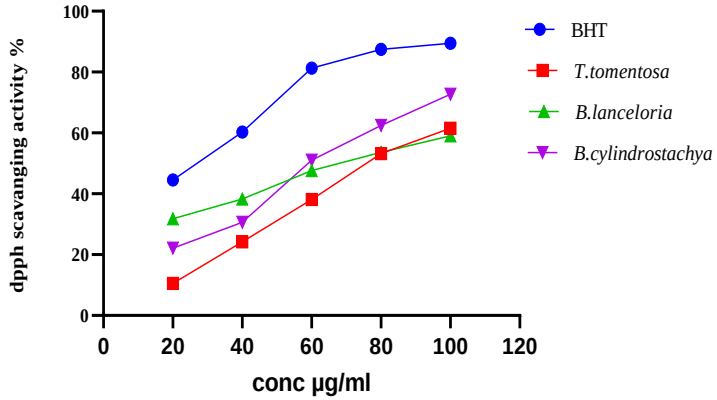


Fig.4.9. DPPH activity (%) of three methanolic plant extract with positive control BHT.

4.9.4. Determination of ABTS free radical scavenging activity

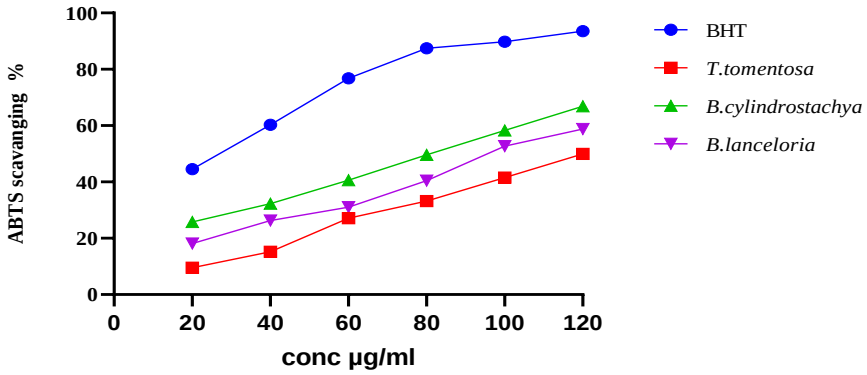


Fig.5. ABTS radical scavenging activity (%) of three methanolic plant extract with positive control BHT.

4.9. LCMS of the three medicinally selected plants

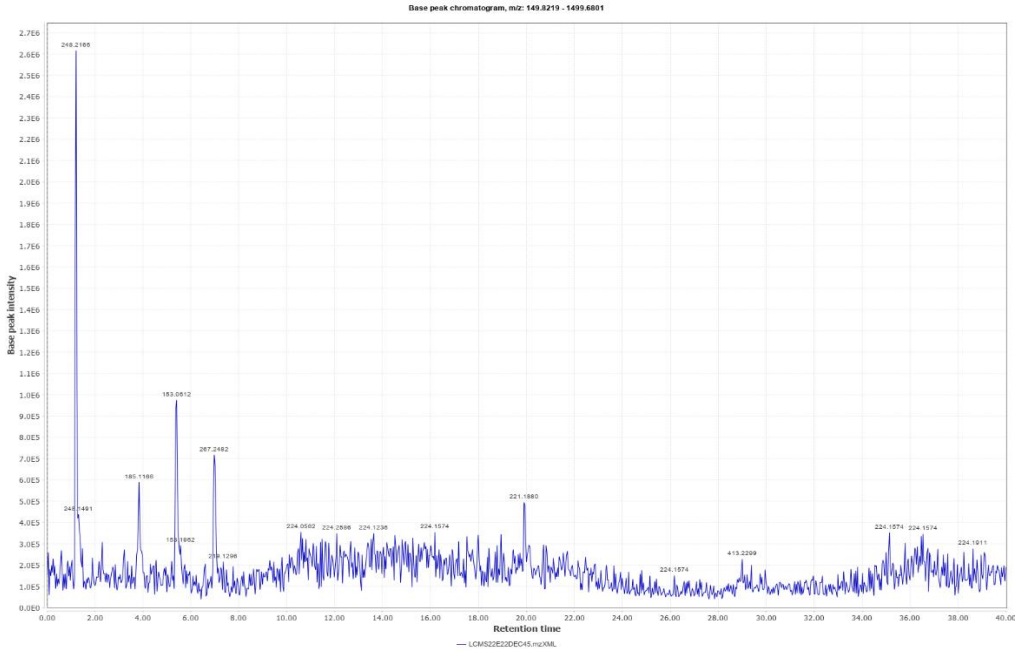


Fig.5.1. Histogram of *Blumea lanceolaria* positive mode

Table 23 . Tentative compounds of *Blumea lanceolaria* positive mode

Times	R.Time	Compound Name	Formula	Exact Mass	Observed Mass
1	0.60	Methyl Jasmonate	$C_{13}H_{20}O_3$	224.141	224.2249
2	2.30	Kaempferol-3-Rhamnoside-7-Rhamnoside	$C_{27}H_{30}O_{14}$	578.163	579.1316
3	5.20	Farnesol	$C_{15}H_{26}O$	222.198	224.1236
4	6.97	Formononetin	$C_{16}H_{12}O_4$	268.28	267.2482
5	7.35	Cystathionine	$C_7H_{14}N_2O_4S$	222.26	2.19.1296
6	8.61	1Isothiocyanato-7(methylsulfinyl)-heptane	$C_9H_{17}NOS_2$	219.075	224.2249
7	29.00	Solasodine	$C_{27}H_{43}NO_2$	413.329	413.2299
8	33.81	1,10-Phenanthroline monohydrate	$C_{12}H_8N_2$	180.068	178.1319

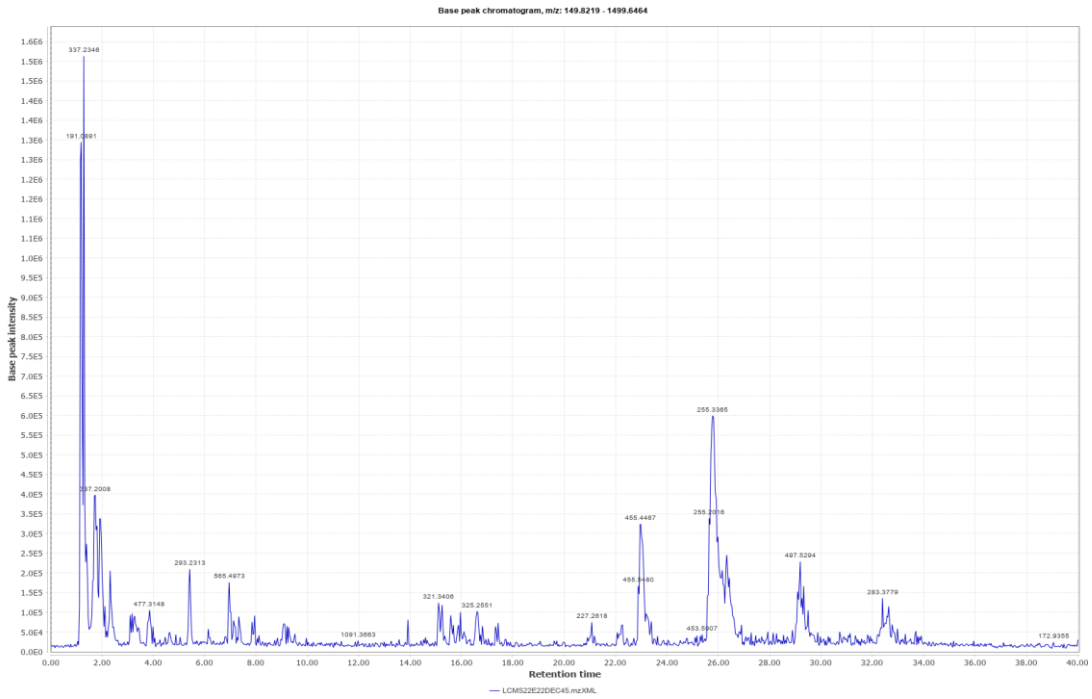


Fig.5.2. Histogram of *Blumea laceolaria* Negative mode

Table 24.Tentative compounds of *Blumea lanceolaria* Negative mode

R.Time	Compound Name	Formula	Exact Mass	Observed Mass
1.19	Quinic acid	$C_7H_{12}O_6$	192.063	191.0891
1.30	Galactinol Dihydrate	$C_{12}H_{22}O_{11}$	342.116	341.2346
1.40	Scopoletin	$C_{10}H_8O_4$	192.042	191.0891
5.42	(+)-Epicatechin	$C_{15}H_{14}O_6$	290.079	291.2313
9.10	Kaempferol-3-O-alpha-L-rhamnoside	$C_{21}H_{20}O_{10}$	432.105	433.2325
15.11	Cytidine-5'-monophosphate monohydrate	$C_9H_{14}N_3O_8P$	323.051	324.3406
15.58	Kaempferide	$C_{16}H_{12}O_6$	300.063	301.2560
15.96	Petunidin	$C_{16}H_{13}O_7$	317.066	318.3859
26.33	Luteolin	$C_{15}H_{10}O_6$	286.047	282.3195
26.43	gamma-Linolenic acid	$C_{18}H_{30}O_2$	278.43	277.3193
32.63	Acacetin	$C_{16}H_{12}O_5$	284.068	283.4117

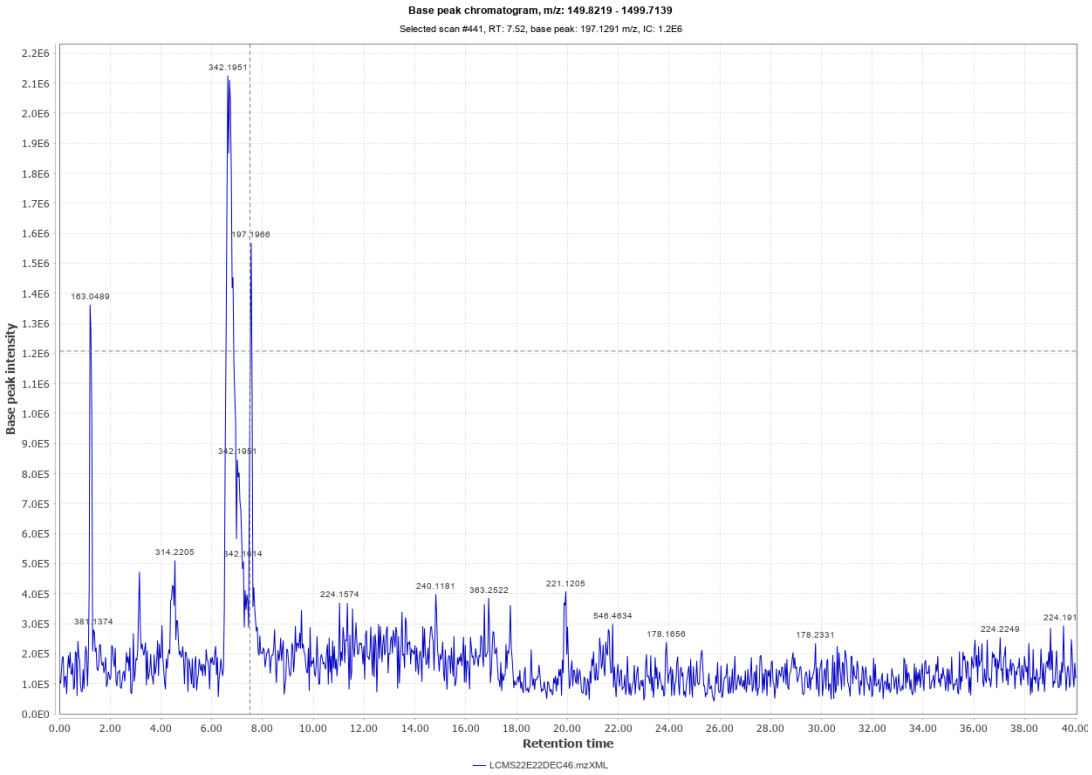


Fig.5.3. Histogram of *Thottea tomentosa* positive mode

Table 25. Tentative compound of *Thottea tomentosa* positive mode

R. Time	Compound Name Thottea tomentosa	Formula	Exact Mass	Observed Mass
0.73	L-Carnosine	$C_9H_{14}N_4O_3$	226.23	224.1236
4.55	Petunidin	$C_{16}H_{13}O_7$	317.066	314.2205
4.86	Rhamnetin	$C_{16}H_{12}O_7$	316.28	314.1192
4.96	3-Hydroxy-DL-kynurenine	$C_{10}H_{12}N_2O_4$	224.21	224.1574
5.51	(+)-Epicatechin	$C_{15}H_{14}O_6$	290.079	297.4675
8.71	3-Hydroxy-DL-kynurenine	$C_{10}H_{12}N_2O_4$	224.21	224.0899
23.90	4-Hydroxy-3-methoxycinnamaldehyde	$C_{10}H_{10}O_3$	178.062	178.1656

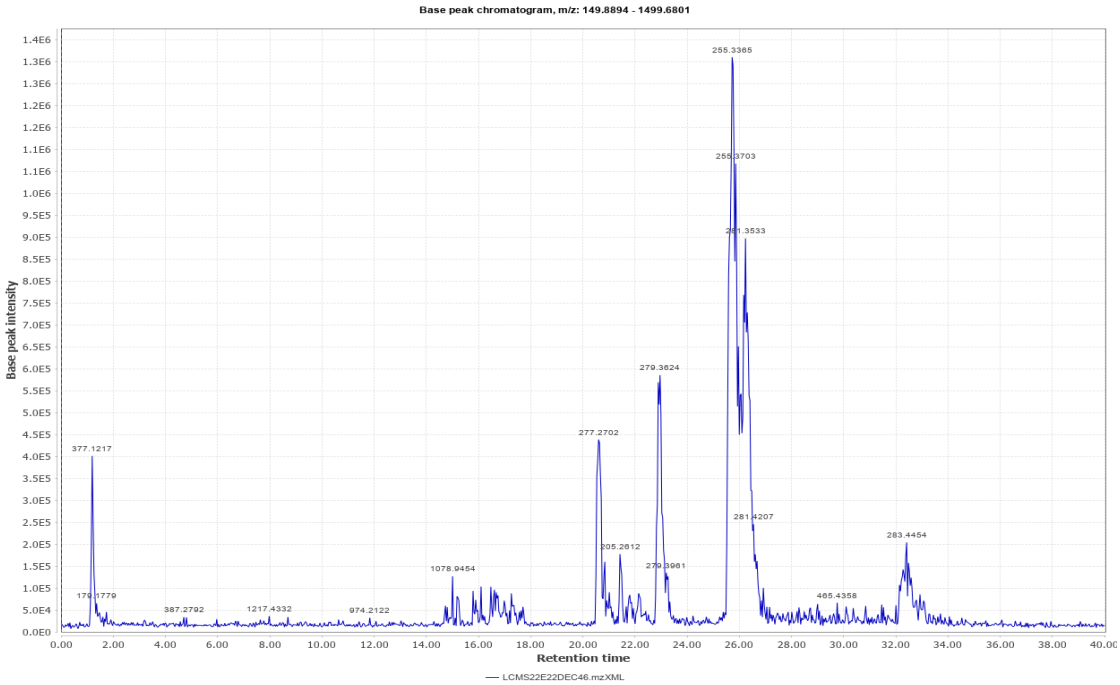


Fig.5.4. Histogram of *Thottea tomentosa* Negative mode.

Table 26. Tentative compound of *Thottea tomentosa* negative mode

R.Time	**Score**	**Compound Name**	**Formula**	**Exact Mass**	**Observed Mass**
16.47	0.821	Chlorogenic acid Hemihydrate	$C_{16}H_{18}O_9$	354.095	353.3648
16.99	0.752	Kaempferide	$C_{16}H_{12}O_6$	300.063	297.2131
20.60	0.982	gamma-Linolenic acid	$C_{18}H_{30}O_2$	278.43	277.2702
22.89	0.996	gamma-Linolenic acid	$C_{18}H_{30}O_2$	278.43	279.3624
26.23	0.953	Luteolin	$C_{15}H_{10}O_6$	286.047	281.3533
26.30	0.975	Xanthosine	$C_{10}H_{12}N_4O_6$	284.075	281.3870
26.61	0.847	Acacetin	$C_{16}H_{12}O_5$	284.068	281.3533
26.92	0.743	Myricitrin	$C_{21}H_{20}O_{12}$	464.095	465.5033

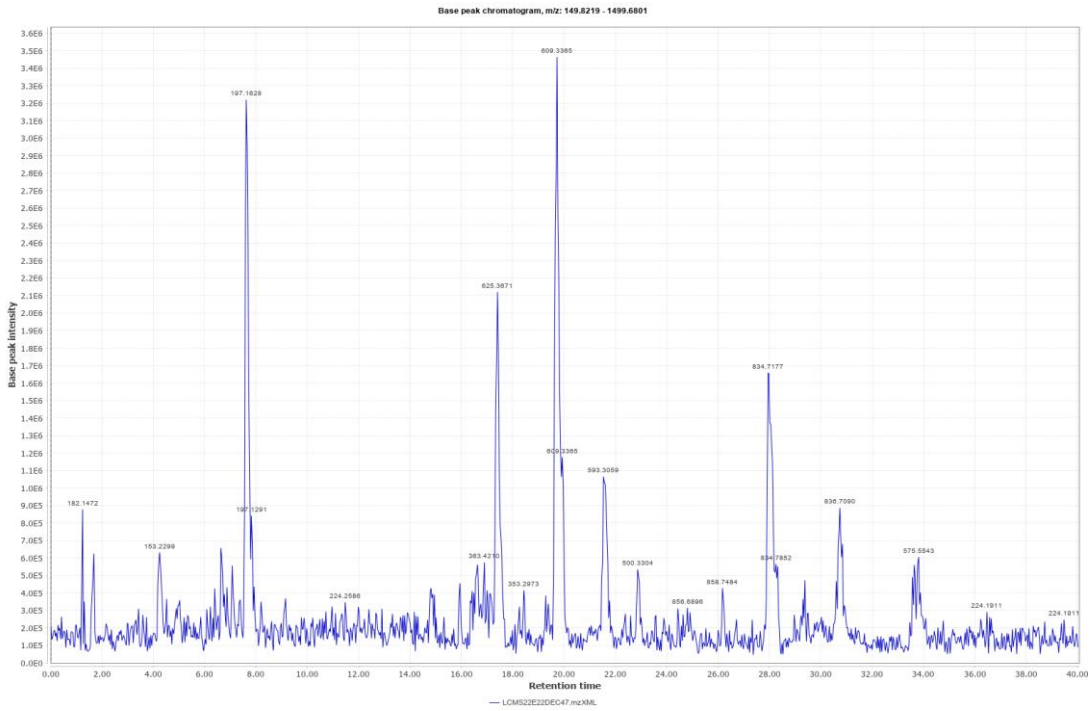


Fig.5.5. Histogram of *Betula cylindrostachya* positive mode

Table 27. Tentative compound of *Betula cylindrostachya* positive mode

R.Time	**Score**	**Compound Name betula**	**Formula**	**Exact Mass**	**Observed Mass**
1.24	0.62	L-Methionine sulfone	$C_5H_{11}NO_4S$	181.04	182.1472
3.43	0.736	L-Carnosine	$C_9H_{14}N_4O_3$	226.23	224.1574
7.08	0.847	Petunidin	$C_{16}H_{13}O_7$	317.066	317.1563
7.62	0.993	4-Hydroxy-3-methoxycinnamic acid	$C_{10}H_{10}O_4$	194.18	197.1628
7.83	0.887	3,4-Dihydroxy-L-phenylalanine	$C_9H_{11}NO_4$	197.19	197.1291
15.94	0.827	Linoleic acid	$C_{18}H_{32}O_2$	280.24	279.2274
17.41	0.81	isorhamnetin-3-O-rutinoside	$C_{28}H_{32}O_{16}$	624.169	625.3671
21.53	0.814	Kaempferol-3-O-beta-D-glucoside-7-O-alpha-L-rhamnoside	$C_{27}H_{30}O_{15}$	594.158	593.3059
29.38	0.676	Kaempferol-3-Rhamnoside-7-Rhamnoside	$C_{27}H_{30}O_{14}$	578.163	575.5880

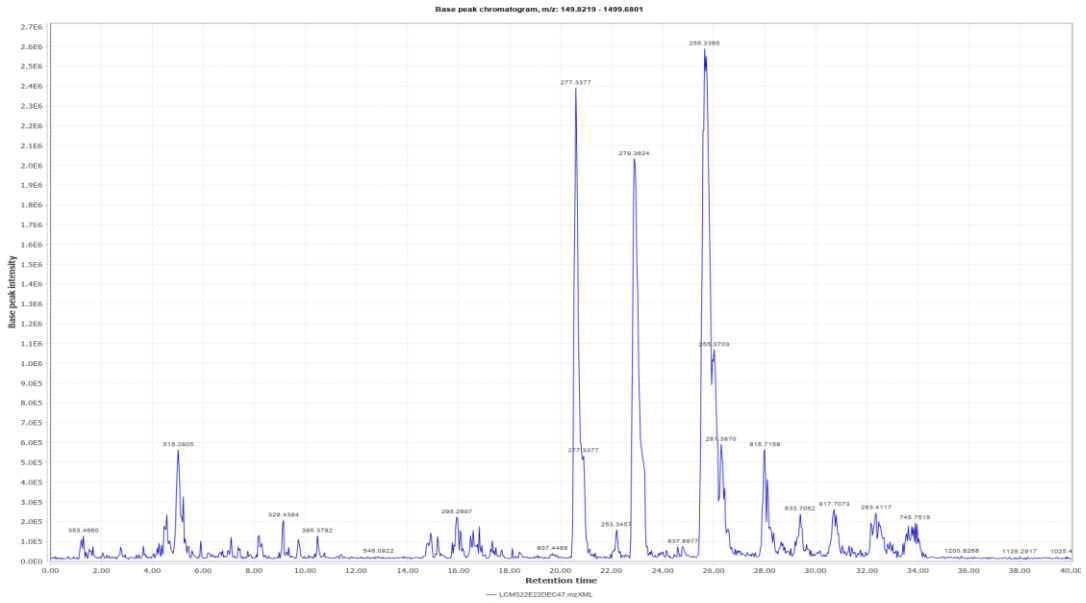


Fig.5.6. Histogram of *Betula cylindrostachya* negative mode

Table 28. Tentative compound of *Betula cylindrostachya* negative mode

R.Time	**Score**	**Compound Name Betula**	**Ion**	**Formula**	**Exact Mass**	**Observed Mass**
14.90	0.864	(+)-Epicatechin	negative	$C_{15}H_{14}O_6$	290.079	293.4337
15.92	0.761	Kaempferide	Negative	$C_{16}H_{12}O_6$	300.063	295.2897
26.29	0.956	Luteolin	Negative	$C_{15}H_{10}O_6$	286.047	281.3870

4.10. Quantitative Phytochemical results of WEPs

The phytochemical analysis of selected wild edible plants (WEPs) was conducted to assess the levels of various bioactive compounds. The following results were observed highlighting the rich phytochemical profile of WEPs, making them a valuable source of bioactive compounds with potential health benefits.

4.10.1. Evaluation of total phenol, total flavonoid and antioxidant properties of three WEPs

4.10.1.1. Total Phenol content

The total phenol content of methanolic extract of the three WEPs both WR and WPand CR and CPwere determined from the standard curve of standard Gallic acid (Y=0.006x+0.0615, R^2= 0.997) and was expressed as mg Gallic acid equivalents/g DW.

The total phenol content of *Alocasia fornicata* Wild (Raw- is 57 mg/GAE/g DW) and Processed-39.7 mg/ GAE /g DW) and Cultivated (Raw-53.8 mg/GAE/g DW) and Processed-45.3 mg/ GAE /g DW). There are significant differences ($P<0.05$) between wild raw and processed and cultivated (raw and processed) (Table 29 & 30).

The total phenol content of *A. napalensis* Wild (Raw- is 58.5 mg/GAE/g DW) and Processed-43.4 mg/ GAE /g DW) and Cultivated (Raw-53.3 mg/GAE/g DW) and Processed-41.3 mg/ GAE /g DW). There are significant differences ($P<0.05$) between WR and WP and cultivated (raw and processed) (Table 31 and 32).

The total phenol content of *Oroxylum indicum* Wild (Raw- is 105.9 mg/GAE/g DW) and Processed-114.2 mg/ GAE /g DW) and Cultivated (Raw-97.8 mg/GAE/g DW) and Processed-112.3 mg/ GAE /g DW). There are significant differences ($P<0.05$) between WR and WPand cultivated (raw and processed) (Table 33 & 34).

Table 29: Total phenol, total flavonoid and antioxidant activities (DPPH and ABTS) of *Alocasia fornicata* from two different sites with raw and traditionally processed samples

A. fornicata	**TPC mg/ GAE /g DW**	**TFC mg/GAE/ g DW)**	**DPPH IC_{50} ±SD µg/ml**	**ABTS IC_{50} ±SD µg/ml**
WR	57 ± 1.2^{a}	33.6 ± 1.1^{a}	80 ± 1.2^{b}	58.3 ± 0.8^{b}
WP	39.7 ± 1.4^{b}	24.2 ± 2.1^{a}	103.5 ± 1.5^{a}	76.7 ± 1.09^{a}
CR	53.8 ± 1.8^{a}	31.5 ± 0.8^{a}	67 ± 1.7^{c}	62 ± 1.15^{b}
CP	45.3 ± 1.9^{c}	26 ± 1.2^{b}	108 ± 1.15^{a}	80.3 ± 1.14^{a}

*means followed by different letters are significantly different according to Duncan's multiple range comparison (DMRTs) ($P\leq0.05$)

*means followed by same letter are not significantly different. Each value was represented as means ±SD (n=3)

*WR-Wild Raw; WP-Wild Processed; CR-Cultivated Raw ; CP-Cultivated process

Table 30. Percentage increment and decrement of *Alocasia fornicata* before and after traditional processing

A. fornicata	**TPC**	**TFC**	**DPPH**	**ABTS**
Wild %↓0r ↑	31.5 ↓	26.7↓	22.7↑	23.9 ↑
Cultivated%↓0r ↑	15.7↓	17.4↓	37.9 ↑	22.7 ↑

Table 31. Evaluation of total phenol, total flavonoid and antioxidant activities (DPPH and ABTS) of *Amorphophallus napalensis* from two different sites with raw and traditionally processed samples

A. napalensis	**TPC mg/ GAE /g DW**	**TFC mg/GAE/ g DW)**	**DPPH ±SD (µg/ml)**	**ABTS ±SD (µg/ml)**
WR	58.5 ± 0.8^{a}	24.9 ± 0.9^{a}	97.4 ± 1.1^{b}	104.2 ± 1.8^{b}
WP	43.4 ± 1.6^{c}	15.9 ± 1.02^{b}	113.1 ± 1^{a}	114.5 ± 0.7^{a}
CR	53.3 ± 1.3^{b}	22.3 ± 1.4^{a}	93.1 ± 1.3^{c}	107.8 ± 1.3^{b}
CP	41.8 ± 1.3^{c}	17.8 ± 1.3^{b}	112.6 ± 2.7^{a}	117.8 ± 1.7^{a}

*means followed by different letters are significantly different according to Duncan's multiple range comparison (DMRTs) (P≤0.05)

*means followed by same letter are not significantly different. Each value was represented as means ±SD (n=3)

*WR-Wild Raw; WP-Wild Processed; CR-Cultivated Raw ; CP-Cultivated process

Table 32. Percentage increment and decrement of *Amorphophallus napalensis* before after traditional processing

A. napalensis	**TPC**	**TFC**	**DPPH**	**ABTS**
Wild- %↑ or ↓	**25.8** ↓	**36.1** ↓	**13.8** ↑	**8.7** ↑
Cultivated - % ↑or ↓	**21.3** ↓	**20.17** ↓	**17.3** ↑	**8.4** ↑

Table 33. Evaluation of total phenol, total flavonoid and antioxidant activities (DPPH and ABTS) of *Oroxylum indicum* from two different sites with raw and traditionally processed sample

O. indicum	**TPC mg/ GAE /g DW**	**TFC mg/GAE/ g DW)**	**DPPH ±SD (µg/ml)**	**ABTS ±SD (µg/ml)**
WR	105.9±1b	62.5±1.2c	32.4±1.3a	47.7±1.5a
WP	114.2±1.8a	72.3±1.2b	25.1±1.9b	37.16±1.3c
CR	97.8±1.4c	65.5±1.2c	35.4±1.3a	50.06±0.7a
CP	112.3±1.7a	78.03±1.4a	22.06±2b	43.13±1.1b

*means followed by different letters are significantly different according to Duncan's multiple range comparison (DMRTs) (P≤0.05)

*means followed by same letter are not significantly different. Each value was represented as means ±SD (n=3)

*WR-Wild Raw; WP-Wild Processed; CR-Cultivated Raw; CP-Cultivated process

Table 34. Percentage increment and decrement of *Oroxylum indicum* before after traditional processing

O. indicum	**TPC**	**TFC**	**DPPH**	**ABTS**
Wild- %↑ or ↓	**7.2** ↑	**13.5** ↑	**22.8** ↓	**22.09** ↓
Cultivated - % ↑or ↓	**12.9** ↑	**16.3** ↑	**37.8** ↓	**14.9**↓

4.10.1.2. Total flavonoid content

The total flavonoid content of the methanolic extract of the three WEPs both WR and WPand CR and CP were determined from the linear regression curve selected plants was determined from the standard curve of Quercetin with a linear regression curve ($Y=0.0009x+0.0007$, $R^2=0.0998$) (Fig.5.9), and the results was expressed as mg quercetin equivalent QE/g dry weight.

The total flavonoid content of *Alocasia fornicata* Wild (Raw- is 33.6 mg/GAE/g DW) and Processed-24.2 mg/ GAE /g DW) and Cultivated (Raw-31.5 mg/GAE/g DW) and Processed-26 mg/ GAE /g DW). There are significant differences ($P<0.05$) between wild raw and processed and cultivated (raw and processed) (Table 29 & 30).

The total flavonoid content of *A. napalensis* Wild (Raw- is 24.9 mg/GAE/g DW) and Processed-15.9 mg/ GAE /g DW) and Cultivated (Raw-22.3 mg/GAE/g DW) and Processed-17.8 mg/ GAE/g DW). There are significant differences ($P<0.05$) between wild raw and processed and cultivated (raw and processed) (Table 31 & 32).

The total flavonoid content of *Oroxylum indicum* Wild (Raw- is 62.5 mg/GAE/g DW) and Processed-72.3 mg/ GAE /g DW) and Cultivated (Raw-65.5 mg/GAE/g DW) and Processed-78.03 mg/ GAE /g DW). There are significant differences ($P<0.05$) between wild raw and processed and cultivated (raw and processed) (Table 33 & 34).

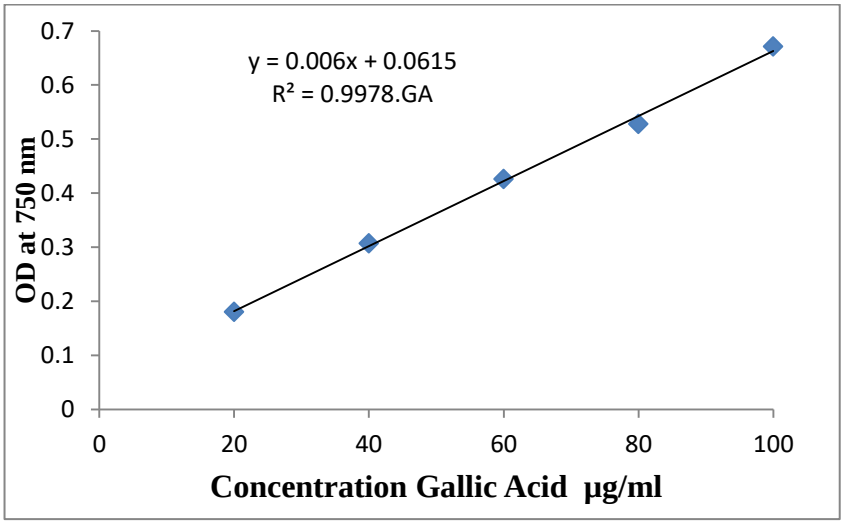


Fig.5.9. Standard curve of gallic acid

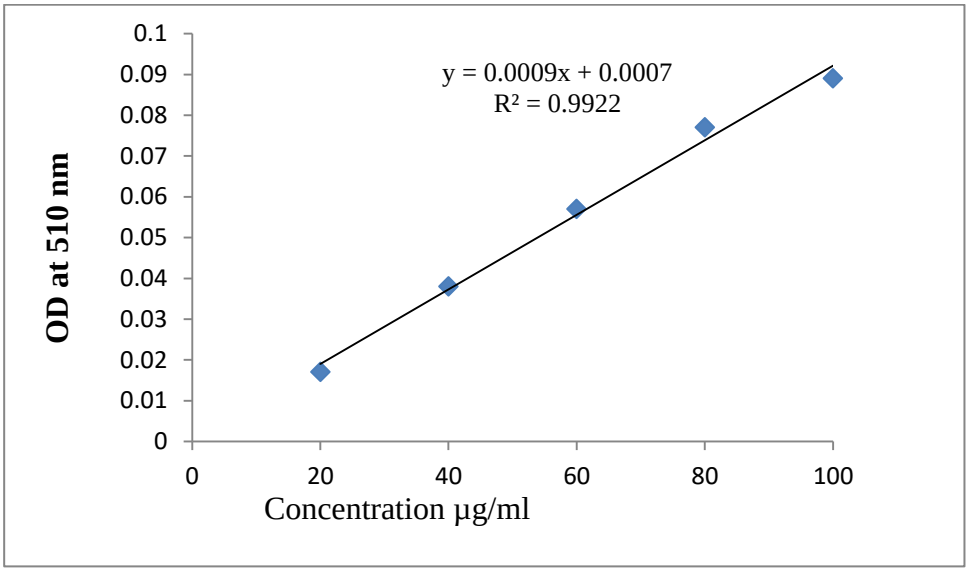


Fig.6.Standard Curve of Quercetin

4.10.1.3. Determination of DPPH radical scavenging activity

The DPPH radical scavenging activity of the methanolic extract of the three WEPs both WR and WPand CR and CP exhibited. A concentration-dependent trend was observed, indicating that the proportion of scavenging activity increased with concentration (Fig.6). DPPH assays also shows a significant IC_{50} variation between the plant's extract ($p<0.05$). In wild plant sample the highest DPPH scavenging activity is in

The DPPH radical scavenging activity of *Alocasia fornicata* Wild (Raw-80 µg/ml) and Processed-103 µg/ml) and Cultivated (Raw-67 µg/ml) and Processed-108 µg/ml). There are significant differences ($P<0.05$) between wild raw and processed and cultivated (raw and processed).

The DPPH radical scavenging activity of *A. napalensis* Wild (Raw-97.4 µg/ml) and Processed-113.1 µg/ml) and Cultivated (Raw-93.1µg/ml) and Processed-112.6 µg/ml). There are significant differences ($P<0.05$) between wild raw and processed and cultivated (raw and processed).

The DPPH radical scavenging activity of *O. indicum* Wild (Raw-32.4 µg/ml) and Processed-25.1 µg/ml) and Cultivated (Raw-35.4 µg/ml) and Processed-32.06 µg/ml). There are significant differences ($P<0.05$) between wild raw and processed and cultivated (raw and processed) (Fig.5.7).

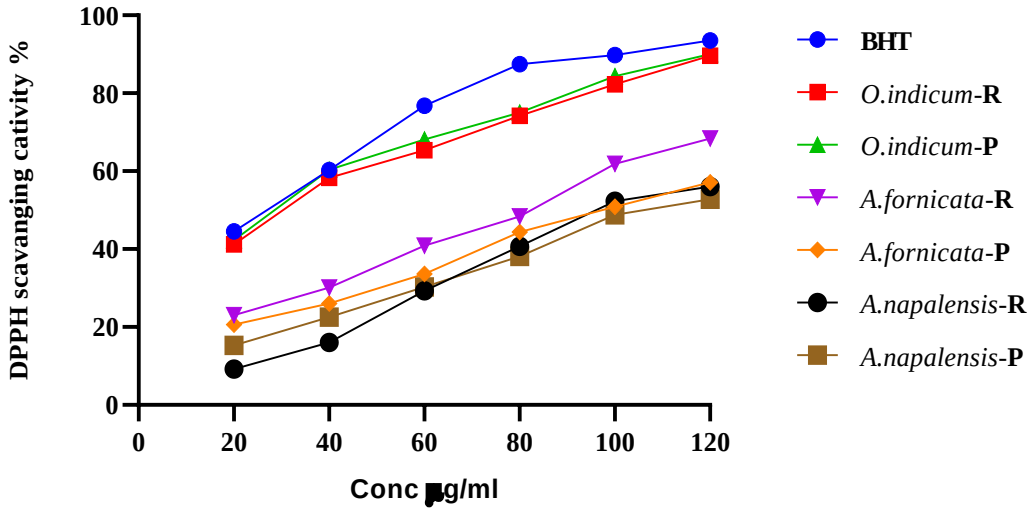


Fig.5.7. Comparisons of DPPH radical scavenging activity (%) of three wild edible plant both WR and WPand CR and CP extract with positive control BHT.

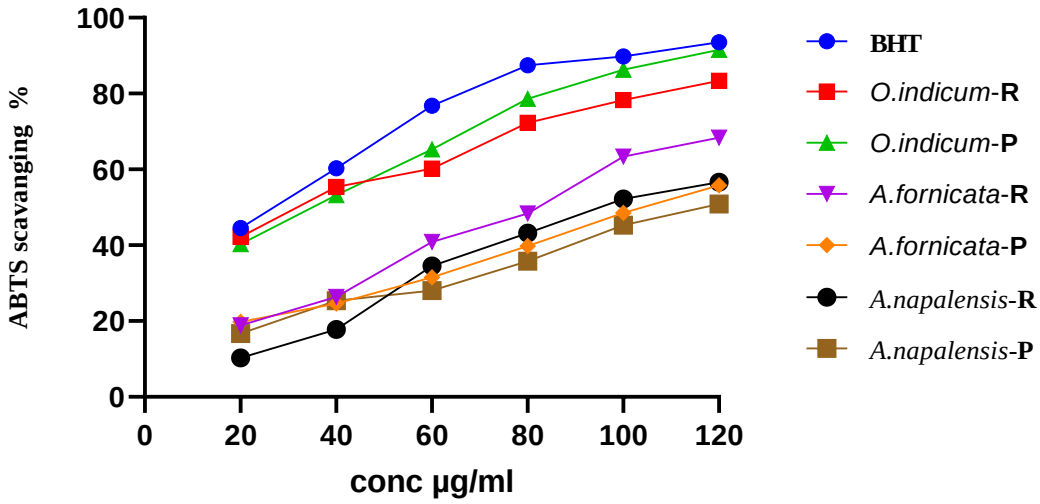


Fig.5.8. Comparisons of ABTS radical scavenging activity (%) of three wild edible plant both WR and WP and CR and CPextract with positive control BHT.

4.10.1.4. Determination of ABTS radical scavenging activity

The ABTS radical scavenging activity of the methanolic extract of the three WEPs both WR and WP and CR and CP exhibited a concentration-dependent trend was observed, indicating that the proportion of scavenging activity increased with concentration (Fig.5.8). ABTS assays also shows a significant IC50 variation between the plant's extract ($p<0.05$). The ABTS radical scavenging activity of *Alocasia fornicata* Wild (Raw-58.3 µg/ml) and Processed-76.7 µg/ml) and Cultivated (Raw-62 µg/ml) and Processed-80.3 µg/ml). There are significant differences ($P<0.05$) between wild raw and processed and cultivated (raw and processed).

The ABTS radical scavenging activity of *A. napalensis* Wild (Raw-104.2 µg/ml) and Processed-114.5 µg/ml) and Cultivated (Raw-107.8 µg/ml) and Processed-117.8 µg/ml). There are significant differences ($P<0.05$) between wild raw and processed and cultivated (raw and processed).

The ABTS radical scavenging activity of *O. indicum* Wild (Raw-47.7 µg/ml) and Processed-37.16 µg/ml) and Cultivated (Raw-50.06 µg/ml) and Processed-43.13 µg/ml). There are significant differences ($P<0.05$) between wild raw and processed and cultivated (raw and processed).

Table 35. Pearson corelation between (TPC & TFC) and (DPPH & ABTS) of the three Wild edible plants (a). *Amorphophallus napalensis* (b) *Alocasia fornicata* (c) *Oroxylum indicum.*

Table 35 (a) *Amorphophallus napalensis*

		DPPH	ABTS
TPC	Pearson Correlation	.877	.621
	Sig. (2-tailed)	.123	.079
	N	4	4
TFC	Pearson Correlation	.716	.345

	Sig. (2-tailed)	.284	.055
	N	4	4
*. Correlation is significant at the 0.05 level (2-tailed).			

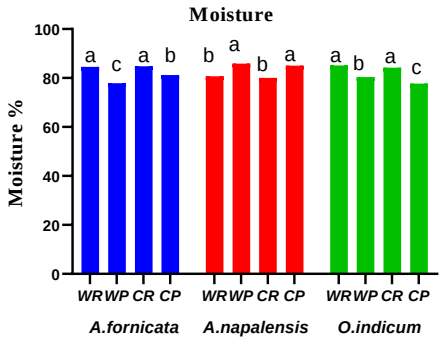
Table 35 -(b) *Alocasia fornicata*			
		DPPH	ABTS
TPC	Pearson Correlation	.917*	.679
	Sig. (2-tailed)	.013	.321
	N	4	4
TFC	Pearson Correlation	.774*	.416
	Sig. (2-tailed)	.026	.284
	N	4	4
*. Correlation is significant at the 0.05 level (2-tailed).			

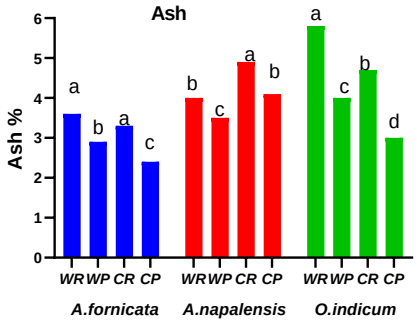
Table 35 (c) *Oroxylum indicum*			
		DPPH	ABTS
TPC	Pearson Correlation	.938	.635
	Sig. (2-tailed)	.062	.065
	N	4	4
TFC	Pearson Correlation	.746	.387
	Sig. (2-tailed)	.144	.413
	N	4	4

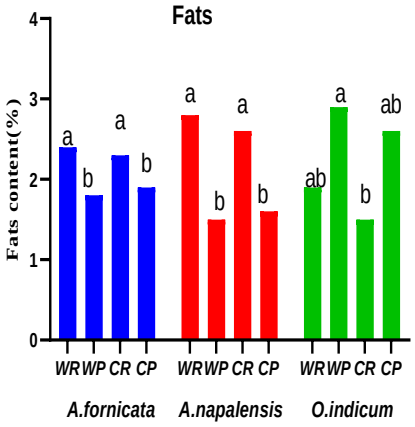
Very strong correlation between TPC with DPPH (R = 0.917,0.877,0.93) and moderate correlation TPC with ABTS (R = 0.67,0.621,0.635), while moderate corelation between TFC and DPPH (R = 0.774,0.716,0.746,) a weak correlation was observed between TFC and ABTS (R = 0.416,0.345,0.387) for *A.Anapalensis A.Fornicata*,and *O.indicum* respectively (Evans, 1996)

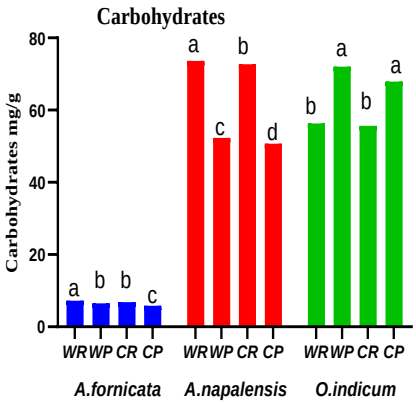
4.11. Nutritional Compositions of the three WEPs

The nutritional analysis of the three selected wild edible plants (WEPs) revealed the following compositions which demonstrate the nutritional richness of the selected WEPs, making them important sources of macronutrients, and minerals as well as the antioxidant potential that contribute to both dietary needs and potential health benefits.









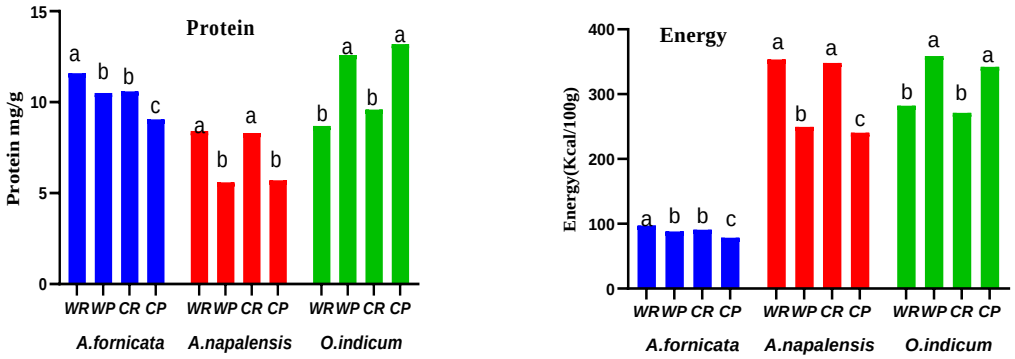


Fig.6.1. Tabulation representation of nutritional analysis of wild and cultivated edible plants (WR:wild raw; WP:wild processed; CR:Cultivated raw;CP:Cultivated processed)

Table 36. Nutritional composition of *Alocasia fornicata* (from two different sites with Raw and Traditionally Culinary Processed samples)

A. fornicata	**Moisture (%)**	**Ash(%)**	**Fats(%)**	**Carbohydrates (mg/g DW)**	**Protein (mg/g DW)**	**Energy (Kcal/100g)**
WR	84.5 ± 30^{a}	3.6 ± 0.20^{a}	2.4 ± 0.12^{a}	7.2 ± 0.12^{a}	11.6 ± 0.3^{a}	97.3 ± 1.4^{a}
WP	77.9 ± 0.24^{c}	2.9 ± 0.11^{b}	1.8 ± 0.12^{b}	6.5 ± 0.23^{b}	10.5 ± 0.2^{b}	88 ± 0.9^{b}
CR	84.8 ± 0.9^{a}	3.3 ± 0.14^{a}	2.3 ± 0.5^{a}	6.8 ± 0.15^{b}	10.6 ± 0.6^{b}	90.7 ± 2.4^{b}
CP	81.2 ± 0.87^{b}	2.4 ± 0.17^{c}	1.9 ± 0.5^{b}	5.8 ± 1.0^{c}	9.06 ± 0.8^{c}	78.4 ± 0.5^{c}

*means followed by different letters are significantly different according to Duncan's multiple range comparison (DMRTs) ($P\leq0.05$)

*means followed by same letter are not significantly different. Each value was represented as means ±SD (n=3)

*WR-Wild Raw; WP-Wild Processed; CR-Cultivated Raw ; CP-Cultivated processed.

Table 37. Percentage increment and decremen of *Alocasia fornicata* before after traditional processing

A. fornicata	**Moisture**	**Ash**	**Fats**	**Carbohydrates**	**Protein**	**Energy**
Wild - % ↑ or ↓	8.8 ↓	19.4 ↓	8.3 ↓	14.47 ↓	9.4 ↓	9.5 ↓
Cultivated -% ↑or ↓	4.24 ↓	27.2 ↓	17.3 ↓	5.8 ↓	14.5 ↓	13.5 ↓

Table 38. Nutritional composition of *Amorphophallus napalensis* (from two different sites with raw and traditionally processed samples

A. napalensis	**Moisture(%)**	**Ash (%)**	**Fats (%)**	**Carbohydrates (mg/g DW)**	**Protein (mg/g DW)**	**Energy (Kcal/100g)**
WR	80.7 ± 0.2^{b}	4 ± 0.11^{b}	2.8 ± 0.5^{a}	73.6 ± 0.2^{a}	8.4 ± 1.2^{a}	353.4 ± 0.9^{a}
WP	85.9 ± 0.3^{a}	3.5 ± 0.3^{c}	1.5 ± 0.7^{b}	52.3 ± 1.2^{c}	5.6 ± 0.5^{b}	249.5 ± 3.3^{b}
CR	80 ± 0.4^{b}	4.9 ± 0.4^{a}	2.6 ± 0.8^{a}	72.7 ± 0.9^{b}	8.3 ± 0.9^{a}	348 ± 0.45^{a}
CP	85 ± 0.4^{a}	4.1 ± 0.5^{b}	1.6 ± 1.2^{b}	50.7 ± 0.7^{d}	5.7 ± 0.3^{b}	240.4 ± 1.3^{c}

*means followed by different letters are significantly different according to Duncan's multiple range comparison (DMRTs) ($P\leq0.05$)

*means followed by same letter are not significantly different. Each value was represented as means ±SD (n=3)

*WR-Wild Raw; WP-Wild Processed; CR-Cultivated Raw ; CP-Cultivated processed

Table 39. Percentage increment and decrease of *Amorphophallus napalensis* after traditional processing

A. napalensis	**Moisture**	**Ash**	**Fats**	**Carbohydrates**	**Protein**	**Energy**
Wild -% ↑ or ↓	6.05 ↑	12.5 ↓	46.42 ↓	28.9 ↓	33.3 ↓	209.4 ↓
Cultivated-% ↑ or ↓	5.8 ↑	16.32 ↓	38.4 ↓	30.2 ↓	31.32 ↓	30.9 ↓

Table 40. Nutritional composition of *Oroxylum indicum* from two different sites with raw and traditionally processed samples

O. indicum	**Moisture (%)**	**Ash (%)**	**Fats (%)**	**Carbohydrates (mg/g DW)**	**Protein (mg/g DW)**	**Energy (Kcal/100g)**
WR	85.1 ± 0.6^{a}	5.8 ± 0.2^{a}	1.9 ± 0.3^{ab}	56.3 ± 3.4^{b}	8.7 ± 0.8^{b}	282 ± 4.3^{b}
WP	80.4 ± 0.8^{b}	4 ± 0.8^{c}	2.9 ± 0.23^{a}	72 ± 1.7^{a}	12.6 ± 1.4^{a}	358.9 ± 5.3^{a}
CR	84.2 ± 0.6^{a}	4.7 ± 0.5^{b}	1.5 ± 0.27^{b}	55.6 ± 1.7^{b}	9.6 ± 0.8^{b}	271 ± 4.2^{b}
CP	77.7 ± 0.9^{c}	3 ± 0.19^{d}	2.6 ± 0.29^{ab}	67.9 ± 1.4^{a}	13.2 ± 1.1^{a}	342 ± 5.7^{a}

*means followed by different letters are significantly different according to Duncan's multiple range comparison (DMRTs) ($P\leq0.05$)

*means followed by same letter are not significantly different. Each value was represented as means ±SD (n=3)

*WR-Wild Raw; WP-Wild Processed; CR-Cultivated Raw; CP-Cultivated processed

Table 41. Percentage increment and decrease of *Oroxylum indicum* after traditional processing

O. indicum	**Moisture**	**Ash**	**Fats**	**Carbohydrates**	**Protein**	**Energy**
Wild - *%* ↑ *or* ↓	5.8 ↓	31 ↓	34.4↑	22.2 ↑	30.9 ↑	21.4 ↑
Cultivated-% ↑or↓	8.3 ↓	0.36 ↓	42.3 ↑	17.9 ↑	26.4 ↑	20.7 ↑

4.12. Evaluation of nutritional contents of three WEPs among the raw and traditionally processed samples

The evaluation of nutritional content between raw and traditionally processed samples of three selected WEPs showed not much significant variations in nutrient composition, influenced by the processing methods. Traditional processing methods, while essential for improving the palatability and safety of WEPs, tend to have minimal impact on minerals and macronutrients like carbohydrates and proteins. These findings highlight the importance of understanding nutrient retention during food preparation to maximize the health benefits of WEPs.

4.12.1. Moisture

The highest moisture content was observed in Raw (wild and cultivated) *Oroxylum indicum* (85% and 84%) followed by *Alocasia fornicata* (84.5% and 84.8%) *and Amorphophallus napalensis* (80.7% and 80%) and Processed (wild and cultivated)-*Amorphophallus napalensis* (85.9% and 85%) followed by *Oroxylum indicum* (80.4%,77.7%) and *Alocasia fornicata* (81% and 77.9%) respectively (Table 36, 37, 38, 39,40) (Fig.6.1).

4.12.2. Ash

The highest ash content in raw (wild and cultivated) *Oroxylum indicum* (5.8% and 4.7%) followed by *Amorphophallus napalensis* (4% and 4.9%) and *Alocasia fornicata* (3.6% and 3.3%) higher than earlier investigation of *Alocasia* species (Bhat et al., 2015). The processed (wild and cultivated) sample was found with highest ash content is in *Amorphophallus napalensis* (3.5% and 4.1%) followed by *Oroxylum indicum* (4% and 3%) and *Alocasia fornicata* (2.9% and 2.4%) (Table 34).

4.12.3. Fats

The highest fats content of Raw (wild and cultivated) is *Amorphophallus napalensis* (2.8% and 1.6%)) followed by *Alocasia fornicata* (2.4% and 2.3%) and *Oroxyllum indicum* (1.9% and 1.5%) and the highest fats content in Processed (wild and cultivated) is *Amorphophallus napalensis* (1.5% and1.6%) followed by *Alocasia fornicata* (2.2% and 1.9%) and *Oroxylum indicum* (2.9 and 2.6%) (Table 36).

4.12.4. Protein

The highest protein content of WR and WP is *Alocasia fornicata* (11.6 mg/g and 10.6 mg/g) followed by *Oroxylum indicum* (8.7 mg/g and 9.6 mg/g) and *Amorphophallus napalensis* (8.4 mg/g and 8.3 mg/g) and the highest protein content in CR and CP is *Alocssia fornicata* (10.5 mg/g and 9.6 mg/g) higher than earlier studies (Basu et al., 2014) followed by *Oroxylum indicum* (12.6 mg/g and 13.2 mg/g) (Table 37).

4.12.5. Carbohydrates

The highest carbohydrates content of WR and WP *Amorphophallus napalensis* (73 mg/g and 72.7 mg/g) followed by *Oroxylum indicum* (56.3 mg/g and 55 mg/g) and *Alocasia fornicata* (7.2 mg/g and 6.8 mg/g) and the highest carbohydrates content of CR and CP *Amorphophallus napalensis* (52.3 mg/g and 50.7 mg/g) followed by *Oroxylum indicum* (72 mg/g and 67.9 mg/g) and *Alocasia fornicata* (6.5 mg/g and 6.4 mg/g) (Table 38).

4.13. Minerals and anti-nutritional Contents (Table 42, 43, 44, 45, 46, 47) (Fig.6.2 and Fig.6.3)

The analysis of minerals and antinutrional contents in the selected Wild Edible Plants (WEPs) revealed the following concentrations given below:

4. 13.1. *Alocasia fornicata*

The minerals composition of *A. fornicata* WR, WP, CR, CP samples - *A. fornicata*

-WR-(Ca-477, Mn-8.6, Fe-35, Zn-3.8, Cu 0.7, Ni-0.02)- mg/100g

-WP-(Ca-490, Mn-7.6, Fe-39.6, Zn-3.6, Cu-3.6, Ni-0.01)- mg/100g

-CR-(Ca-449, Mn-8.4, Fe-33.1, Mn-3.4, Cu-0.7, Ni-0.016)-mg/100g)

-CP-(Ca-456, Mn-7.4, Fe-37, Zn-3.4, Cu-0.6, Ni-0.012)- mg/100g

There are significant no differences between the WR and WP and CR and CP except in Ca and Mn ($P<0.05$).

The anti-nutritional percentage content of *A. fornicata* in WR, WP, CR, CP samples

-Oxalate- (WR-5.4% WP-3.5% and CR-4.6% CP-3.2%)

-Phytate- (WR-3.4% WP-2.0% and CR-3.0% CP-2.0%)

-Saponin- (WR-2.0% WP-1.2% and CR-2.0% CP-1.2%)

-Alkaloids-(WR-2.5% WP-0.8% and CR-2.7% CP-0.9%).

There are significant differences ($P<0.05$) in the anti-nutritional content between the WR and WP & CR and CP in each respective samples.

4.13.2. *Oroxylum indicum*

The minerals composition of *O. indicum* Wild and CR and CPsamples.

-WR-(Ca -307, Mn 5.9, Fe 30.7, Zn-4.4, Cu-0.18, Ni-0.02, Pb-0.002)- mg/100mg

-WP- (Ca-263, Mn-6.2, Fe-34.6, Zn-4.2, Cu-0.17, Ni-0.012, Pb0.012) mg/100mg

-CR- (Ca -307, Mn-6.3, Fe-30.1, Zn -3.3, Cu-0.12, Ni -0.03, Pb-0.003) mg/100g

-CP-(Ca-267, Mn-6.2, Fe -30.5, Zn -3.8, Cu-0.10, Ni -0.03, Pb-0.003) mg/100g.

There are no significant changes ($P<0.05$) except in Ca.

The anti-nutritional percentage content of *O. indicum* WP, WR, CP, CR contents are depicted in the (Table 48, 49, 50, 51, 52, 53)

-Oxalate- (WR-8.2% WP-5.1% and CR-7.6% CP-5%)

-Phytate-(WR-13% WP-5.9 % and CR-11.09 % ,CP-7.9 %)

-Saponin-(WR-15.6% WP-6.6 % and CR-12.6% ,CP-5.3%)

-Alkaloids-(WR-15% WP-7.3% and CR-13.6%, CP-9.3%).

There are significant differences ($P<0.05$) in the anti-nutritional content between the WR and WPand CR and CP in each respective samples.

4.13.3. *A. napalensis*

The minerals composition of *A. napalensis* WR, WP, CR, CP samples

WR– (Ca-423, Mn-7.8, Fe-26, Zn-3.4, Cu-0.4, Ni-0.13)- mg/100g

WP– (Ca-437, Mn-6.2, Fe-30.6, Zn-, Cu-0.2, Ni 0.08)- mg/100g

CR- (Ca-404, Mn-7.5, Fe-32, Zn-4.7, Cu-0.3, Ni-0.2)- mg/100g

CP- (Ca-415, Mn-6, Fe-35, Zn-4.5, Cu-0.10, Ni-0.3)- mg/100g.

There are significant changes ($P<0.05$) except in Zn.

The anti-nutritional percentage content of *A. napalensis* WR, WP, CR, CP samples

-Oxalate- (WR-10.2% WP-6.6 % and CR-10.3% CP-6.6%)

-Phytate- (WR-10% WP-6 % and CR-10 % CP-5.3 %),

-Saponin- (WR-9.9% WP-5,9 % and CR-10% CP-.3%),

-Alkaloids- (WR-2.1% WP-0.9% and CR-2.4% CP-1.4%).

There are significant differences ($P<0.05$) in the anti-nutritional content between the WR and WP & CR and CP in each respective samples.

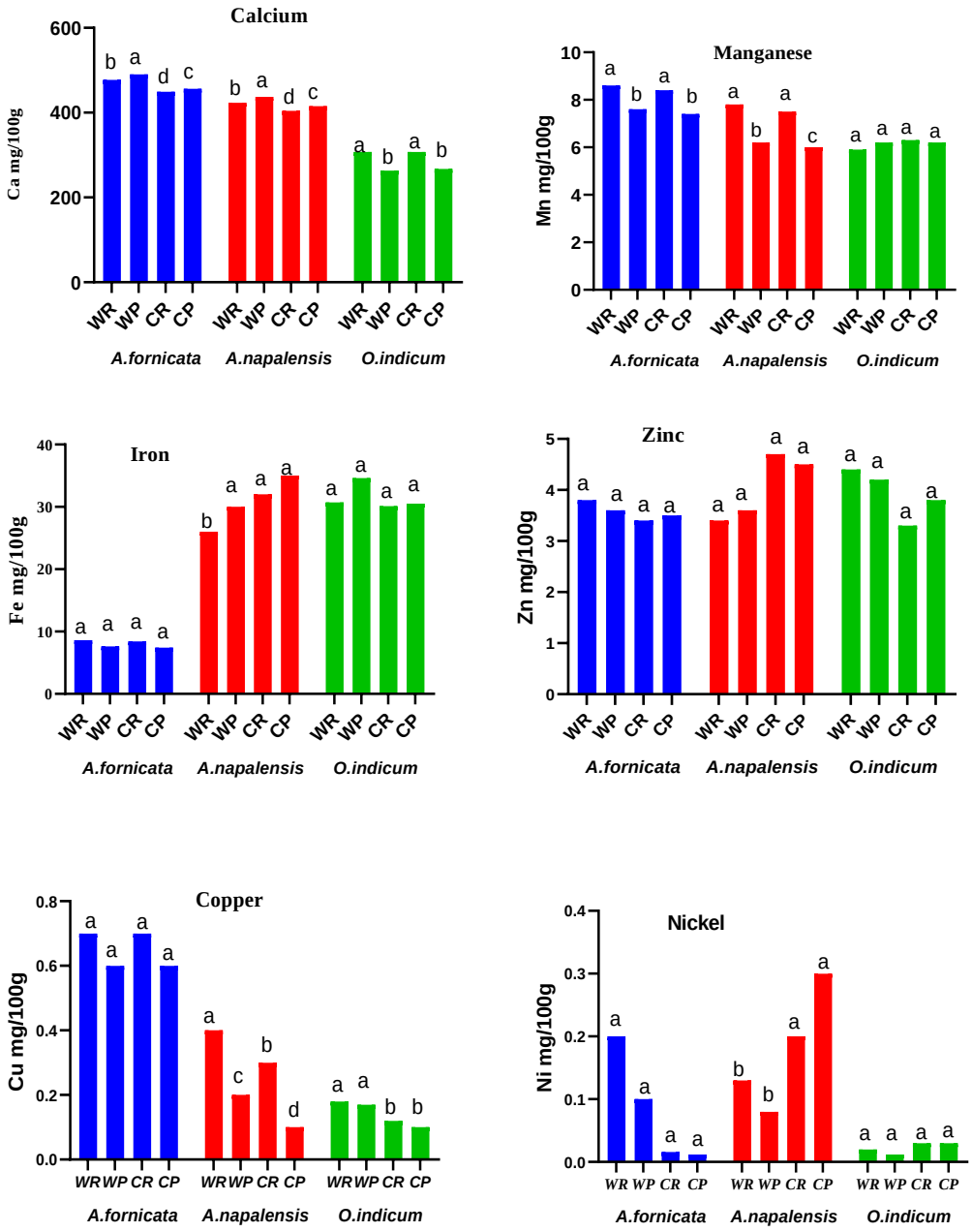


Fig.6.2 Bar graph of Macro and micro-elements

Table 42. Macro and micro-elements of *Alocasia fornicata* (from two different sites with raw and traditionally processed samples

A. fornicata	**Ca mg/100g**	**Mn mg/100g**	**Fe mg/100 g**	**Zn mg/100 g**	**Cu mg/100 g**	**Ni mg/100g**	**Pb mg/100 g**
WR	477±1.4[b]	8.6±.7[a]	35±0.5[a]	3.8±0.8[a]	0.7±0.2[a]	0.2±0.4[a]	-
WP	490±1.1[a]	7.6±0.23[b]	39.6±0.3[a]	3.6±0.2[a]	0.6±0.5[a]	0.1±0.5[a]	-
CR	449±0.5[d]	8.4±0.5[a]	33.1±0.8[a]	3.4±0.8[a]	0.7±0.6[a]	0.016±0.3[a]	-
CP	456±0.7[c]	7.4±0.24[b]	37.±0.37[a]	3.5±0.24[a]	0.6±0.3[a]	0.012±0.6[a]	-

*means followed by different letters within same column are significantly different according to Duncan's multiple range comparison (DMRTs) (P≤0.05)

*means followed by same letter are not significantly different. Each value was represented as means ±SD (n=3)

*WR-Wild Raw; WP-Wild Processed; CR-Cultivated Raw ; CP-Cultivated processed

Table 43. Percentage decrease and increment of *Alocasia fornicata* after traditional processing

A. fornicata	**Ca**	**Mn**	**Fe**	**Zn**	**Cu**	**Ni**
Wild- %↑ or ↓	2.6 ↑	11 ↓	10.2 ↑	5.2 ↓	14.2 ↓	50 ↓
Cultivated - % ↑ or ↓	1.5 ↑	5.9 ↓	10.8 ↑	2.8 ↑	14.2 ↓	25 ↓

Table 44. Macro and micro-elements of *Amorphophallus napalensis* from two different sites with raw and traditionally processed samples

A. napalensis	**Ca mg/100 g**	**Mn mg/100 g**	**Fe mg/100g**	**Zn mg/100g**	**Cu mg/100 g**	**Ni mg/100g**	**Pb mg/100 g**
WR	423±1.5[b]	7.8±0.2[a]	26±1.5b	3.4±0.4a	0.4±0.2a	0.13±0.1b	-
WP	437±1.2[a]	6.2±0.4[b]	30±1.5a	3.6±0.35a	0.2±1.2c	0.08±1.2b	-

CR	404±2.1[d]	7.5±0.3[a]	32±0.8ba	4.7±1.0a	0.3±0.9b	0.2±0.3a	-
CP	415±1.8[c]	6.0±0.8c	35±0.95a	4.5±0.35a	0.1±1.1d	0.3±0.8a	-

*means followed by different letters within same column are significantly different according to Duncan's multiple range comparison (DMRTs) (P≤0.05)

*means followed by same letter are not significantly different. Each value was represented as means ±SD (n=3)

*WR-Wild Raw; WP-Wild Processed; CR-Cultivated Raw; CP-Cultivated processed

Table 45. Percentage increment and decrease of *Amorphophallus napalensis* after traditional processing

A. napalensis	**Ca**	**Mn**	**Fe**	**Zn**	**Cu**	**Ni**
Wild - % ↑ or ↓	3.2 ↑	20.51 ↓	13 ↑	8.3 ↑	50 ↓	38 ↓
Cultivated-% ↑ or↓	2.6 ↑	20 ↓	8.5 ↑	4.2 ↓	66 ↓	33 ↓

Table 46. Macro and micro-elements of *Oroxylum indicum* from two different sites with raw and traditionally processed samples

O. indicum	**Ca mg/100g**	**Mn mg/100g**	**Fe mg/100g**	**Zn mg/100g**	**Cu mg/100g**	**Ni mg/100g**	**Pb mg/100g**
WR	307±1.7[a]	5.9±0.7[a]	30.7±1.6[a]	4.4±0.8[a]	0.18±1.2[a]	0.02±0.08[a]	0.002±0.2[a]
WP	263±2[b]	6.2±1[a]	34.6±1.4[a]	4.2±0.4[a]	0.17±0.5[a]	0.012±0.7[a]	0.003±0.3[a]
CR	307±1.3[a]	6.3±0.7[a]	30.1±2.3[a]	3.3±0.5[a]	0.12±0.9[b]	0.03±0.6[a]	0.003±0.3[a]
CR	267±1.4[b]	6.2±0.9[a]	30.5±4.3[a]	3.8±0.7[a]	0.10±0.6[b]	0.03±0.3[a]	0.002±0.5[a]

*means followed by different letters within same column are significantly different according to Duncan's multiple range comparison (DMRTs) (P≤0.05)

*means followed by same letter are not significantly different. Each value was represented as means ±SD (n=3)

*WR-Wild Raw; WP-Wild Processed; CR-Cultivated Raw ; CP-Cultivated processed

Table 47. Percentage increment and decrease of *Oroxylum indicum* after traditional processing

O. indicum	**Ca**	**Mn**	**Fe**	**Zn**	**Cu**	**Ni**
Wild -% ↑ or ↓	14.3 ↓	4.8 ↑	11 ↑	4.7 ↑	5 ↓	-
Cultivated -% ↑ or ↓	13 ↓	1.5 ↓	-1.3 ↑	10 ↑	16 ↓	-

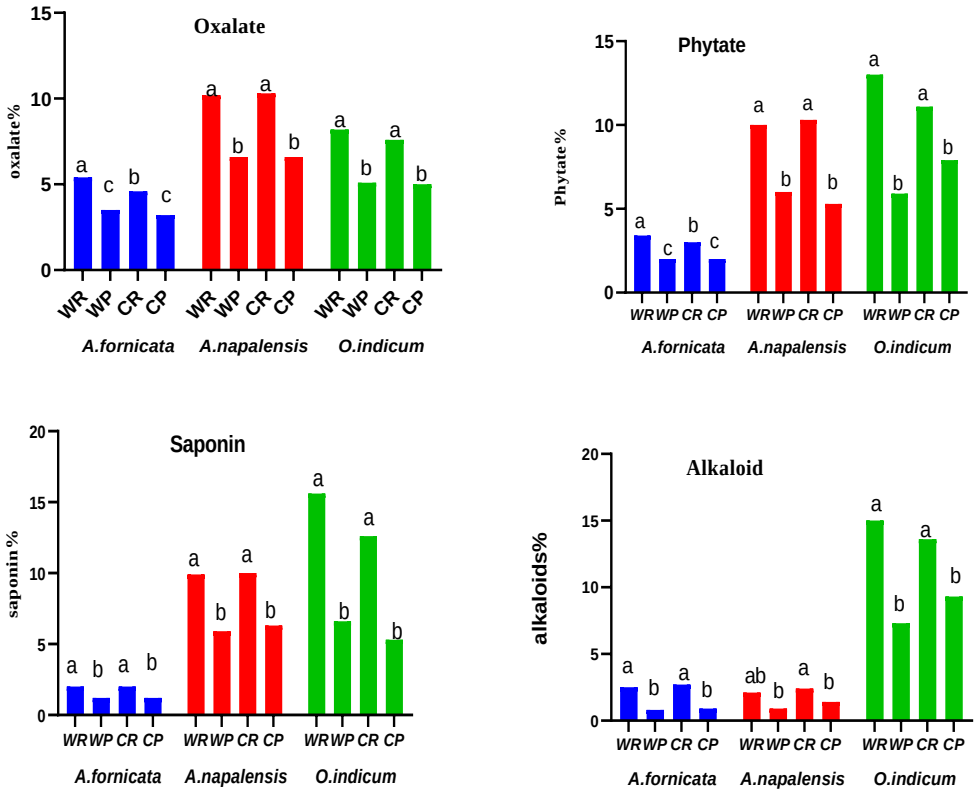


Fig.6.3. Bargraph of Anti-nutritional contents of the WEPs

Table 48. Anti-nutritional contents of *Alocasia fornicata* from two different sites with raw and traditionally processed samples

A. fornicata	**Oxalate %**	**Phytate %**	**Saponin %**	**Alkaloids %**
WR	5.4 ± 0.3^{a}	3.4 ± 0.17^{a}	2.0 ± 0.12^{a}	2.5 ± 0.2^{a}
WP	3.5 ± 0.3^{c}	2.0 ± 0.12^{c}	1.2 ± 0.9^{b}	0.8 ± 0.12^{b}
CR	4.6 ± 0.5^{b}	3.0 ± 0.8^{b}	2.0 ± 1.3^{a}	2.7 ± 0.17^{a}
CP	3.2 ± 07^{c}	2.0 ± 0.6^{c}	1.2 ± 0.25^{b}	0.9 ± 0.5^{b}

*means followed by different letters are significantly different according to Duncan's multiple range comparison (DMRTs) ($P\leq0.05$)

*means followed by same letter are not significantly different. Each value was represented as means ±SD (n=3)

*WR-Wild Raw; WP-Wild Processed; CR-Cultivated Raw; CP-Cultivated processeded

Table 49. Percentage increment and decrease of of *Alocasia fornicata* after traditional processing

A. fornicata	**Oxalate**	**Phytate**	**Saponin**	**Alkaloids**
Wild % ↑ or ↓	35.18 ↓	41.1 ↓	40 ↓	68 ↓
Cultivated % ↑ or ↓	30.4 ↓	33.3 ↓	40 ↓	66.6 ↓

Table 50. Anti-nutritional contents of *Amorphophallus napalensis* from two different sites with raw and traditionally processed samples

A. napalensis	**Oxalate %**	**Phytate %**	**Saponin %**	**Alkaloids%**
WR	10.2 ± 1.3^{a}	10 ± 1.2^{a}	9.9 ± 1.15^{a}	2.1 ± 0.4^{ab}
WP	6.6 ± 0.8^{b}	6 ± 1.1^{b}	5.9 ± 1.2^{b}	0.9 ± 0.23^{b}
CR	10.3 ± 0.8^{a}	10.3 ± 1.7^{a}	10 ± 1.1^{a}	2.4 ± 0.39^{a}
CP	6.6 ± 0.8^{b}	5.3 ± 0.8^{b}	6.3 ± 0.8^{b}	1.4 ± 0.18^{ab}

*means followed by different letters are significantly different according to Duncan's multiple range comparison (DMRTs) ($P\leq0.05$)

*means followed by same letter are not significantly different. Each value was represented as means ±SD (n=3)

*WR-Wild Raw; WP-Wild Processed; CR-Cultivated Raw ; CP-Cultivated processed

Table 51. Percentage increment and decrease of *Amorphophallus napalensis* after traditional processing

A. napalensis	**Oxalate**	**Phytate**	**Saponin**	**Alkaloids**
Wild -% ↑ or ↓	33.9 ↓	40 ↓	40.4 ↓	57 ↓
Cultivated % ↑ or ↓	35.9 ↓	48.5 ↓	37 ↓	41.6 ↓

Table 52. Anti-nutritional contents of *Oroxylum indicum* from two different sites with raw and traditionally processed samples

O. indicum	**Oxalate %**	**Phytate %**	**Saponin %**	**Alkaloids %**
WR	8.2 ± 0.9^{a}	13 ± 1.15^{a}	15.6 ± 1.2^{a}	15 ± 1.15^{a}
WP	5.1 ± 0.4^{b}	5.9 ± 0.7^{b}	6.6 ± 0.8^{b}	7.3 ± 0.88^{b}
CR	7.6 ± 0.88^{a}	11.09 ± 1.2^{a}	12.6 ± 1.4^{a}	13.6 ± 1.2^{a}
CP	5 ± 0.5^{b}	7.9 ± 0.7^{b}	5.3 ± 0.88^{b}	9.3 ± 1.03^{b}

*means followed by different letters are significantly different according to Duncan's multiple range comparison (DMRTs) ($P\leq0.05$)

*means followed by same letter are not significantly different. Each value was represented as means ±SD (n=3)

*WR-Wild Raw; WP-Wild Processed; CR-Cultivated Raw; CP-Cultivated processed

Table 53. Percentage increment and decrease of *Oroxylum indicum* after traditional processing

O. indicum	**Oxalate**	**Phytate**	**Saponin**	**Alkaloids**
Wild- % ↑ or ↓	37 ↓	54 ↓	57 ↓	51.3 ↓
Cultivated-% ↑ or ↓	34.2 ↓	33.6 ↓	57.9 ↓	31.6 ↓

4.14. Principal Component Analysis

The multivariate data information (nutritional, anti-nutritional and minerals) contained in the WEPs WR and WP and CR and CP (Fig.6.4) were analysed using principal component analysis (PCA).The eigen value determine the variation retained by the principal components and the values were 7.9, 3.2, 2.4 and 1.5 for the first four component. The scree plot determines how much principal component were to be considered. The first four component accounts for 88% of the variance.The PCA showed 11 principal components (PC) where components such as PC1, PC2, PC3 and PC4 showed 46.5%,19.1%,13% and 9.4% of variance respectively.

In PC1, variables like oxalate, ash, phytate, carbohydrate, energy saponin, Pb and alkaloid are in positive correlation while Ca and Protein are negatively correlated for WR (*A. fornicata*). In PC2, Moisture, Mn and Zinc are positively corelated while Fe, Fats is in negatively correlated from it.WP-(*A. fornicata*). In PC3, Fats, Mn, Zn, Ni and Cu showed positive correlation while, Fe and moisture are negatively correlated for CP (*A. napalensis*) and WR (*O. indicum*) respectively. In PC4, varibales like Ash, Protein and Ca are positively correlated while Carbohydrate, energy and Pb are in negative correlation for CP (*O. indicum*) and CP (*A. fornicata*) respectively. (Malsawmtluanga et al., 2023)

The biplot from the First two components (PC1 and PC2) revealed that CP and WP of (*A. napalensis*) have high moisture, while oxalate is high in CR (*A. napalensis*). Saponin, phytate, energy and carbohydrate was high in WR (*O. indicum*) while CR and CP (*A. fornicata*) had high Cu and Fe content. The Second two component (PC3 and PC4) showed a high Zn and Ni in WP (*O. indicum*) however a high fats in CR (*A. napalensis*).

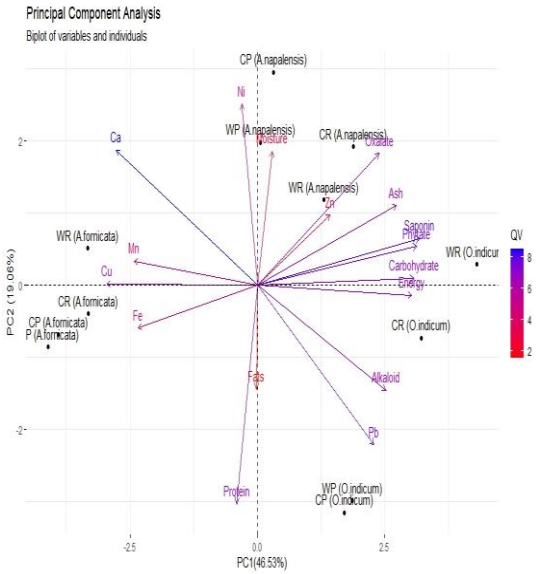


Fig.a

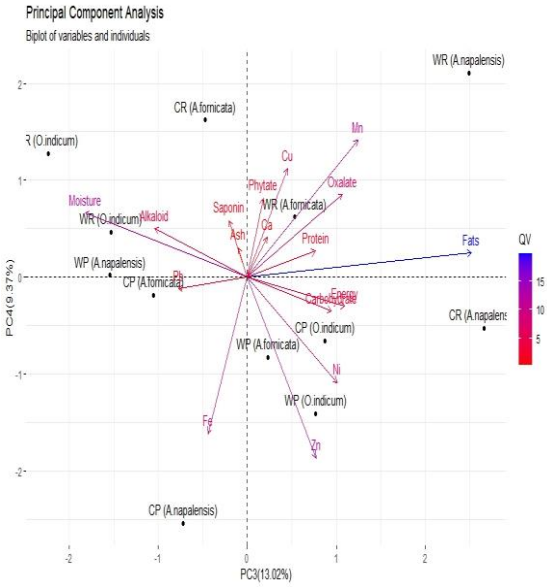


Fig.b

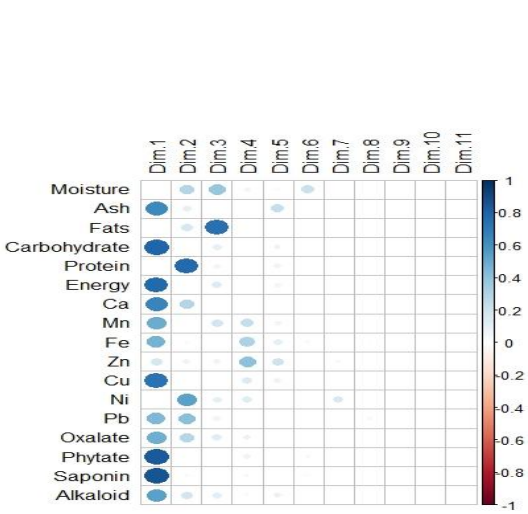


Fig. c

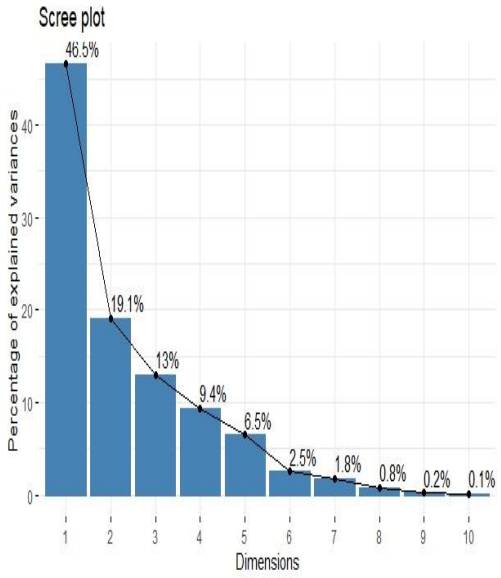


Fig.d

Fig.6.4. Principal component analysis of WEPs with nutrients, anti-nutrients and minerals composition.

(a) Biplot of individuals and variables (PC1 and PC2)
(b) Biplot of individuals and variables (PC3 and PC4)
(c) Principal component and their relation withvariables
(d) Scree plot: contribution of each principal component to total variance

4.15. FTIR analysis of three WEPs

Table 54. FTIR analysis of three WEPs (Abbreviation: R-Raw; P-Traditional Culinary Processed)

Wave number (cm–1)	*A. fornicata*		*A. napalensis*		*O. indicum*		Functional group	References
3800-2300	**R** 3356 2955	**P** 3889 3750 3280 2947 2369	**R** 3750 3279	**P** 3757 3356	**R** 3757 3348 2940 2369	**P** 3757 3287 2932 2369	Phenols, alcohols O-H-Carboxylic acids O-H-Carboxylic acid C-H-alkynes C-H-Alkenes C=C stretch	Awwad et al., 2009; Umashankari et al., 2013
2260-1739	1667	1597			1589	1620 1659	Ester C=O stretch, lipid, triglycerides	Li et al., 2013
1700 – 1470	1474 1427		1566	1720			C=O stretch (carbonyls) C=C stretch	Patel and Adhav , 2018
1469-1399	1427						C–C stretch (in ring)	Arokiyaraj et al., 2022
1400-1290		1404	1404	1404	1404	1367	C–N stretch Aliphatic amines	Mallikarjuna et al., 2020
1275-1150	1226	1219		1234		1219	C-H Stretch vibration Aliphatic amines	(Nagajyothi et al., 2014)
1100-1000	1119	1049	1034	1057	1042	1026	C–O stretch C–O stretch C–N stretch C–OH stretch, carboxylic acid	(Mallikarjuna et al., 2020)
990-800			934	934		926	N-H wag stretch	(Mallikarjuna et al., 2020)
790-690	764	779		772	772	772	C(triple bond)C-HC-H bend stretch vibration,	(Vanaja et al., 2016)

680-400	586	679\ 532 432	532	648	525	517	Alkyl halides,glycogen Halogen compound	(Nagajyothi et al., 2014)

To assess the degree of modification and interaction of functional groups resulting from various culinary treatments, FTIR spectral analysis was conducted on three samples of both Wild and cultivated plants.Any change in the functional groups was interpreted as a result of tissue disintegration produced by the culinary action of blanching (Table 54) (Fig.6.5.6.6 and 6.7).

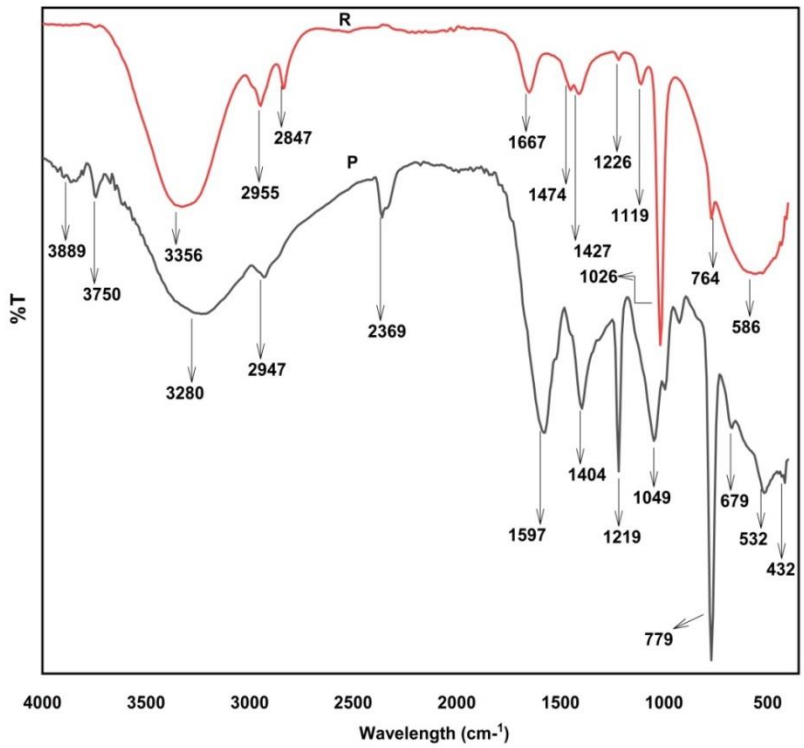


Fig.6.5. FTIR histogram of *Alocasia fornicata* (R=Raw, P=Processed)

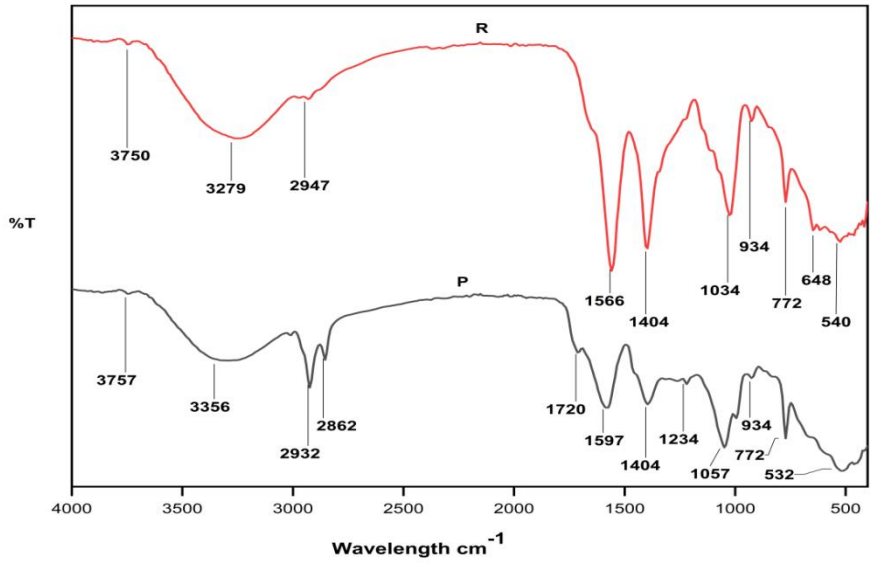


Fig.6.6. FTIR histogram *A. napalensis* (R=Raw, P=Processed)

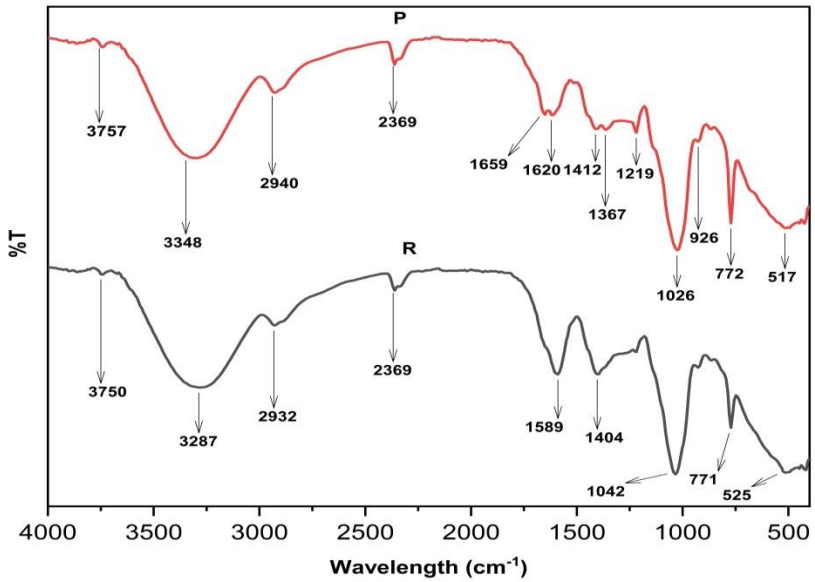


Fig.6.7. FTIR histogram *Oroxylum indicum* (R=Raw, P=Processed)

CHAPTER– 5

Discussion

Ethnobotany is a multi-disciplinary science that involves in documentation of various uses of plant resources by the ethnic people since ages to present days. Research works on various ethnobotany disciplines are being regularly published by the researchers from various parts of the world. In India a huge data base on ethnobotanical work have been published. In Manipur, ethnobotanical works have been carried out amongst the various ethnic communities of the state. However, very less works on ethnobotanical plants have been documented exclusively on the different tribal communities in Churachandpur District, Manipur. Thus, considering the research gap, a study on ethnobotanical works has been undertaken to investigate the traditional use of plants by the seven main tribes of Churachandpur District by employing suitable ethnobotanical indices. The outlook of modern ethnobotany includes documentation of ethnobotanical knowledge and the scientific validation through different bioprospecting approaches. The nutritional, antinutritional and LC-MS technique has been employed for WEPs and medicinal plants.

5.1. Ethnobotany studies of different tribes in Churachandpur District, Manipur

To conduct ethnobotanical explorations, consistent field surveys were carried out in various regions of Churachandpur District, engaging with members of different tribes. These surveys involved visits and interactions with informant across different seasons, spanning a period of 2017-2020. A total of 210 informants, ranging from 15 to 85 years old among the *Paite, Thadou, Hmar, Gangte, Vaiphei, Simte* and *Zou* communities were were interviewed during this survey with the help of semi structured interview method. Among them, 132 were male and 78 were female. Among them, 105 informants are male and 78 are female. The male informants represented various tribes, with 25 from *Paite* and *Thadou*, 20 from *Hmar*, 16 from *Gangte* and *Vaiphei* and 15 from *Simte* and *Zou*. The age distribution of respondents showed that 15% respondent were above 61 years, 22% were in 51-

60 age group, 30% were in 41-50 age group, 21% were in 31-40 and 12% were in 21-30 age group. The lack of traditional plant usage knowledge among the younger generation poses a concern for the future of the community. The study documented 189 plant species with 628 ethnobotanical uses from these diverse tribal communities of Churachandpur district, Manipur. Herbs were found to be the most preferred life form for both food and medicinal purposes due to their abundant availability throughout the year, and their accessibility was noted to be easiear compared to other life forms. The most preferred food and medicinal plants that are available abundantly and all round year.

5.2. Wild Edible Plants (WEPs)

5.2.1. Use value (UV) of WEPs

The Use Value (UV) data for wild edible plant range from 0.09-0.5, with *Hibiscus sabdariffa* and *Allium hookerii* having the lowest and highest values, respectively. Among the WEPs, those wth the highest UV include *Amophophallus napalensis* (0.20), *Alocasia fornicata* (0.19), *Azadirachta indica* (0.18), *Blumea lanceolaria* (0.27), *Calamus erectus* (0.25), *Calamus tenuis* (0.22), *Centella asiatica* (0.22), *Cucurbita maxima* (0.18), *Momordica charantia* (0.18), *Oroxylum indicum* (0.18), *Zanthoxylum rhetsa* (0.20), *Ziziphus jujuba* (0.18), and *Zingiber kangleipakense* (0.18). This value aligns with earlier studies conducted from different study sites from Manipur conducted by Haokip and Ansari (2018) and Lokho (2012). These plants are extensively consumed in various forms and significantly contribute to the local diet.

5.2.2. Fidelity Level (FL)

The Fidelity Level (FL) for WEPs in the study ranges from 62% to 95%.Notable instances of high FL include *Solanum torvum* and *Solanum violaceum* (97%) for treating Toothache, *Oroxylum indicum* against cancer (95%), *Ziziphus jujuba* and *Amomum dealbatum* (92%) for addressing insomnia, *Clerodendrum colebrookianum*, *Cucumis sativa*, *Solanum americanum* and *Solanum torvum* (93%)

for managing High blood pressure, and *Phyllanthus emblica*, *Momordica charantia*, *Centella asiatica* and *Punica grantum* (90%) for their antidiabetic properties. These findings align with earlier studies, where the highest FL was reported for *Bergenia ciliate* and *Ephedra gerardiana* (100%) each (Rehman et al., 2023).

5.2.3. Relative frequency of citation (RFC)

The first group of WEPs includes 10 species, each with its respective Relative Frequency of Citation (RFC): *Amophophallus napalensis* (RFC=0.034), *Blumea lanceolaria* for Diabetics and diabetic food ulcer (RFC=0.23), diarrheoa (RFC=0.03), cuts and wounds (RFC=0.04), *Centella asiatica* (RFC=0.23), *Clerodendrum colebrookianum* (RFC=0.21), *Houttuynia cordata* (RFC=0.27), *Solanum torvum* (RFC=0.24), *Momordica charantia* (RFC=0.031), *Oroxylum indicum* (RFC=0.31), *Solanum violaceum* (RFC=0.20), *Zanthoxylum rhetsa* (RFC=0.038). It is noteworthy to mention that earlier studies with an RFC of 0.036 followed by *Berberis lycium* and *Ephedra gerardiana*, both with an RFC of 0.35 each (Rehman et al., 2023).

5.3. Traditional dishes from wild edible plants

In the study 36 WEPs were recorded for making traditional dishes and the affinity of choices of wild plant consumption was almost similar among different ethnic group in Northeast India, especially Manipur, Mizoram and Nagaland. The most probable reason could be due to their intermixing of culture and tradition and the sharing of resources within the same district. The tribals within the study site had a similar local traditional dishes with those of the neighbouring states like Mizoram and Myanmar however differs slightly in their mode of preperation but no such complex preparation of the recipe (Konsam et al., 2016).The Preparation of Sathu by these tribe were found very similar to the sa-um prepared by Mizoram tribe (Singh et al., 2018) and tangal (ash filtrate) formation were also found to be similar in Assamese ‘Kolakhar’ where banana ashes were used (Kalita and Kander, 2014). But, the preperation of chingal by the Churachandpur tribes does utilized any specific tree

or plant. The Mehpok cuisine, featuring meat cooked with rice grain is a prevalent tradition during the Christmas festival which is also common among the Naga tribe in Manipur (Singh et al., 2018). The rich diversity in these traditional culinary offerings susggests promising opportunities for exploration ans commercialization these diverse traditional culinary food products, there is potential for exploration and commercialization (Singh and Singh, 2007).

5.4. Spices and condiments

The tribal people of Churachandpur district consumed 26 plants species as spices and condiments in their day to day life. Two species out of the 26 recorded plants were collected from the wild and the rest are cultivated which are in alignment with earlier studies (Kumar et al., 2003). Leaves are the most common parts consumed followed by seed and whole plants which are similar to earlier studies (Panmei et al., 2015). Cultivation and post-harvest technology will be a better option for these areas to increase the turn over where the plants are organically produced. The absence of cold storage and marketing facilities shorten the life of the foods and the economic yield.

5.5. Traditional drinks

A total of 19 plants species were recorded from the study site used by various tribal communities which are quite similar with earlier studies in the neighbouring states like Assam and Mizoram (Saikia and Bori, 2022; Borah et al., 2019; Thanzami and Lalhlenmawia, 2020).

5.6. Ethnoveterinary Plants

A total of 15 plants species were recorded to treat the domesticated animals by the tribal communities representing 15 genus from 15 families for the treatment of 15 kinds of ailments/diseases. The most commonly treated domesticated animals include pigs, dogs, cows, goat and chicken. Mithun, semi-domesticated animals was also treated using the etnoveterinary plants. In the neighbouring district 36 plant species and genera belonging to 29 families used for treating as many as 17 ailments

of domestic animals (cows, dogs, buffaloes, pigs, etc. have been documented based on ethnoveterinary surveys (Dutta et al., 2022).

5.7. Medicinal plants

5.7.1. Use value(UV) of medicinal plants

Use value of the total 102 species ranged from (0.07-1.08) in medicinal plants *Benincasa hispida* scored the highest Use Value which is 1.08. It is used in the treatment liver diseases, constipation, tonic and corpse preservation while *Daucus carota* L (UV=0.07) are used as indigestion and eye infection. However, in earlier studies the highest UV was in *Swertia cordata* (0.28) while the lowest is in *Sophora molli* (0.07).

5.7.2. Fidelity level (FL)

The most preferred species for treating ailments were determined with fidelity level. High fidelity value indicate that the healers used same plants to treat same ailments/diseases (Patel et al ., 2011) while low fidelity indicates that same plants were used to treat same or other ailments/diseases. The fidelity level (FL%) for medicinal plants ranges from (84-100%).The highest fidelity and most preffered medicinal plants to treat Gastro-intestinal ailments are *Mikania micrantha***,** (100%) which is also similar to earlier studies (Jamir et al., 2022), followed by Genitourinary ailments *Bergenia ciliate* (Kumar and Tyagi, 2013) Liver and spleen disorder *Benincasa hispida* (Shakya et al., 2020).

5.7.3. Relative frequency of citation

The first group of ethnomedicinal plants include (RFC=>0.21) 10 popular plants species with their ethnobotanical uses are *Benincasa hispida* (Thunb.) liver diseases (RFC=0.13), constipation (RFC=0.05) which is also similar to earlier studies (Bhattacharjya et al., 2023)

5.8. Phytochemical Contents of WEPs

The total phenol and flavonoid content of *Alocasia fornicata* decrease in the processed samples of both wild and cultivated ones with 31.5% and 15.7% respectively, which shows a consistency with earlier studies (sukumaran et al., 2021) as the cooking was done in an open container and this eventually reduced the antioxidant properties (DPPH and ABTS). Roasting generally increase the phenols, flavonoid and antioxidant properties (Delgado at al., 2022) followed by blanching process, however this roasting of blanched or partially cooked samples have no effect as the water was drained, where the soluble phenols and flavonoids could have leached into the water solution.

The total phenol and flavonoid content of *A. napalensis* decrease in the processed of both wild and cultivated samples (25.8% and 21.3% respectively), this is in consistentcy with earlier studies of *A. paeoniifolius* (Suriya et al., 2022). The cooking also reduced the antioxidant properties of the samples due to leaching of the compounds into the cooking water which is also in alignment with the earlier studies of cooking greenpeas and other vegetables (Zhou et al., 2022)

The total phenol and flavonoid content of *O. indicum* decrease in the processed of both Wild and Cultivated samples (7.2% and 12.9% respectively), this is in consistentcy with earlier studies of roasting of *samh* (Ahmed et al., 2020:Peng et al., 2021) The roasting also increase the antioxidant properties of the samples due Millard reaction that gradually change the chemical structure leading to the formation of new compound s which release flavor, however the over roasting reduced the chemical properties (Srikanth et al., 2021).

5.9. Pearson's Correlation Coefficient between Antioxidant Activity (DPPH and ABTS) with Total Phenol and Flavonoid Contents of the three WEPs

The correlation coefficient measured the relationship between the total phenolic content (TPC), total flavonoid content (TFC) of methanol extracts with DPPH, ABTS. The correlation was categorized based on the value of strength between the

two variables as: very strong (1.0– 0.80), strong (0.79–0.60), moderate (0.59–0.40), weak (0.39–0.20), and very weak (0.19–0.00) (Evans, 1996).

Study in *Alocasia fornicata* revealed that there is very strong correlation between TPC with DPPH (R = 0.917) and moderate correlation with ABTS (R = 0.679), while TFC and DPPH (R = 0.774) showed moderate correlation and a weak correlation was observed between TFC and ABTS (R = 0.416)

Study in *Amophophallus napalensis* revealed that there is very strong correlation between TPC with DPPH (R=0.877) and moderate correlation with ABTS (R= 0.621), while TFC and DPPH (R=0.716) showed moderate correlation and a strong correlation was observed between TFC and ABTS (R= 0.945).

Study in *Oroxylum indicum* revealed that there is very strong correlation between TPC with DPPH (R=0.938) and moderate correlation with ABTS (R=0.635), while TFC and DPPH (R=0.856) showed moderate correlation and a weak correlation was observed between flavonoid and ABTS (R=0.583).

5.10. Nutritional, antinutritional and minerals analysis of selected WEPs

Wild edible plants (WEPs) are important resources of minerals, and other nutritional contents that could prevent and treat diseases (Narzary et al., 2013). Wild edibles are used to fulfil the requirements of vitamins, proteins, fats and minerals of the local inhabitants. WEPs are used as a component of tribal foods all over the world consumed in the form of fruits, shoots, leaves, twigs, flowers, roots, tubers, stems, pith, etc. (Priyadarshini et al ., 2024). Evaluation of nutritional, mineral, anti-nutritional contents of WEPs is a necessary step in determining their nutritive value and their potential hazard of presence of anti-nutritional factors affecting the availability of dietary components. Earlier studies have suggested that WEPs contribute a significant part of balance diet and are recommended to consume more to reduce the risk of diseases like coronary heart attack, cancer, diabetes, etc. (Aregheore, 2012).

5.10.1. Moisture

The moisture content is the amount of water present in the plants and it determines the actual quality of the food before intake. Moisture content affects the chemical and physical properties of food, which in turn impact the stability and freshness of food products during extended period of storage (Nelson, 2010). In the present study, all the three plants possessed moisture content ranging from 84% to 85% in WR and CR and the 77.7% to 81% WP and CP in as mentioned above. The moisture varies in the same species due to many environmental factors like humidity, harvested period of time, and temperature (Deb et al., 2019). Determination of moisture content is also necessary to calculate the contents of other food constituents.

The highest moisture content was observed in WR and CR of *Oroxylum indicum* (85% and 84%) followed by *A. fornicata* (84.5% and 84.8%) and *A. napalensis* (80.7% and 80%) and WP and CP in *A. napalensis* (85.9% and 85%) followed by *Oroxylum indicum* (80.4% and 77.7%) and *A. fornicata* (81% and 77.9%) respectively. The moisture contents is lower in respect of the amount of the moisture content of some common vegetables like bitter gourd (92.4%), broad beans (85.4%) and also lower than the commercially available nutritive edibles like apple (85.56%) and broad bean (85.4%) (Kause et al., 2023).

There are significant differences ($P<0.05$) between the WR and WP and CR and CP in each respective samples. Moisture content increased in cooked *A. napalensis* due to water absorption which might be attributed to the change in cellular structure. Cooked *A. napalensis* absorbed a higher significant amount of water (Wild-6.1% and Cultivated 5.8 %) respectively, which is in agreement with earlier study (Guerrero et al., 2023). However, the blanching methods of *A. fornicata* contradicts with the earlier studies as there was a significant decrease in the moisture content (Wild-8.8% and Cultivated-4.2%).This contradict with the earlier research studies of blanching and cooked (Zhang et al., 2019) as the blanching process was followed by roasting.

The roasting process significantly decrease ($P<0.05$) the moisture content and the percentage decrease in moisture was better in cultivated than wild plant samples (Cultivated-8.3 % than Wild-5.5 %). The decrease in moisture content may be linked to dehydration due to the increase in temperature during dry roasting conditions (Tenyang et al., 2017). Some studies have shown that low moisture content of food is a desirable phenomenon as the microbial activity is reduced. Thus, low moisture content in food samples increases the storage time of food product indicating that roasted *A. fornicata* and *O. indicum* plants roasted at 70°C for 30 min can be stored for a longer time and will be less prone to microbial attack during storage, which is in alignment with earlier studies (Manasa , 2013).

5.10.2. Ash

Estimation of ash content is an index of mineral contents and also signifies the total mineral contents in the edibles. Although mineral contents denote a lesser amount of dry matter, often less than 7% of the total minerals, they play a key role in physicochemical and nutritional point of view (Datta et al., 2019).

In this study, the highest ash content in WR and CR *Oroxylum indicum* (5.8% and 4.7%) is found higher than earlier study on the same plant reported by (Devanathan et al ., 2014) followed by *A. napalensis* (4% and 4.9%) with higher value reported in earlier study on blanched yam by Harijono et al. (2013) and *A. fornicata* (3.6% and 3.3%) found higher than earlier investigation in *Alocasia* species by (Bhat et al., 2014).The WP and CP ash content found highest in *A. napalensis* (3.5% and 4.1%) followed by *Oroxylum indicum* (4% and 3%) and *A. fornicata* (2.9% and 2.4%). The different modes of culinary process determine the percentage decrease or increase values. There are significant differences ($P<0.05$) between the WR and WPand CR and CPin each respective sample except in *A .fornicata* in the present study.

Ash is an important quality parameter of the amount of total minerals present in a biomass. It is clearly observed that all the species face a significant loss in total ashes and therefore in their macroelements and microelements content due to the

high-water solubility of minerals in cooking *A. napalensis* (wild-12.5% and cultivated-16.32%) and blanching (wild-19.4% and cultivated-27.2%). The highest reduction in ash content was noted in roasted samples comparing to other two culinary processes reported by (Abd razak ., 2017) which may be due to reduction in moisture content during roasting (wild-31.03% and cultivated-36.7%). This decrease will gradually increase with increasing roasting time which could be attributed to the loss of vegetable part during roasting (Mbah et al., 2013). The rise in ash content observed in the roasted samples in this study can be attributed to the decrease in moisture content.

5.10.3. Fats

Fat is an important dietary component that serves a variety of physiological roles in our bodies. linoleic and linolenic acids which can be obtained only from the food and helps in the absorption of lipid-soluble vitamins like vitamin A and carotene in the body They are essential for adjusting blood clotting, inflammation and brain growth (Gopalan et al., 2004). The highest fat contents of Raw (wild and cultivated) is in *A. napalensis* (2.8% and 1.6%)) followed by *A. fornicata* (2.4% and 2.3%) and *O. indicum* (1.9% and 1.5%) and the highest fats content in Processed (wild and cultivated) is *A. napalensis* (1.5% and1.6%) followed by *A. fornicata* (2.2% and 1.9%) and *O. indicum* (2.9 and 2.6%).

There are significant differences ($P<0.05$) between the WR and WPand CR and CPin each respective samples. The fats content of the three samples differs in the mode of culinary process. In Blanching and cooking methods there was significant reduction in the fats content in both process *A. fornicata* (wild- 8.3%,and cultivated-17.3%) and *A. napalensis* (wild-46.42% and cultivated-38.4%). The decrease in the fat contents is in agreement with the earlier reported studies in *Colocasia* leaves with soaking and blanching treatments. The minimum loss in fat content was observed in blanching (*A. fornicata)* wild-8.3% (* no significant losses) and significant loss in cultivated-17.3%, but in cooking (*A. napalensis*) the maximum loss was witnessed in both wild-46.2% and cultivated-38.4%, which is in agreement with linear decrease in the fat contents of *Colocasia* leaves (Gupta et al., 2019). However, there was a

significant increase in the fat contents in the roasting methods of *O. indicum* (Wild 34.4% and 42.3 % respectively). The rise in fat content observed could be attributed to the breakdown of bonds between fat and the pod matrix induced by heat, resulting in the effective release or mobilization of oil reserves in the pods after roasting. The fat content compares favourably with that of quality protein maize flour (Cuevas-Rodriguez et al., 2004) and earlier studies in microwave treatment increases fat content (Inchingolo et al., 2013: Grewal et al., 2017).

5.10.4. Protein

Proteins are essential nutrients required for building the body and should be supplied in adequate amounts in the diet. The dietary proteins which get broken down into amino acids used by the body for various functions like proper functioning of antibodies, hormones and enzymes regulation, growth and tissues repair etc. (Gopalan et al., 2009).

The highest protein content of Raw (wild and cultivated) is *A. fornicata* (11.6 mg/g and 10.6 mg/g) followed by *Oroxylum indicum* (8.7 mg/g and 9.6 mg/g) and *A. napalensis* (8.4 mg/g and 8.3 mg/g) and the highest protein content in Cultivated (wild and Cultivated) is *A. fornicata* (10.5 mg/g and 9.6 mg/g) higher than earlier studies (Basu et al., 2014) followed by *O. indicum* (12.6 mg/g and 13.2 mg/g) which is higher than pod studies in Malaysia (Bhat et al., 2013) and *A. napalensis* (5.6 mg/g and 5.7 mg/g) which is lesser than *A. paeoniifolius* from Puducherry by Suriya et al., (2022). There are significant differences ($P<0.05$) between the WR and WPand CR and CPin each respective samples.

Boiling process significantly reduced the protein content of *A. napalensis* (wild-33% and cultivated-31.32%) as the heat treatment denaturate the proteins into smaller peptides and amino acids and get dissolved into the liquid medium which is in agreement with other studies in cooking process (García-Herrera et al., 2020). In this case of *A. napalensis*, the tuber was fully cooked to allow easy pounding and

thus the protein decrease can be justified. Leaching account for the protein losses in protein concentration was also studies in boiled soybean (Amadi et al., 2022).

Blanching in *A. fornicata* cause a significant reduction in the protein (Wild-9.4% and Cultivated-14.5%) which is in accordance with earlier studies of *Raphanus* species which may be due to the leaching of soluble proteins that took place because of the blanching temperature (Reis, 2023).

Roasting process caused significant increase in protein. It is possible that the gradual removal of moisture during roasting is responsible for the observed rise in protein content (Tenyang et al., 2022). However in the case of *A. fornicata* the blaching process decrease protein (Wild-9.4% and Cultivated-14.5 %) because blanching process was followed by roasting where the former process account protein concentration losses (Oluwalana, 2011) .The reduction in protein may be attributed to the protein denaturation during roasting process (El-Beltagi, 2011) here Maillard reactions between protein and sugars protein and also depending on the raw material types, their composition and processing conditions (Pérez-Burillo et al., 2019).

The roasting of *O. indicum* cause significant protein increase in Wild- by 0.9% and Cultivate by 26.4%, which is possible due to the gradual removal of moisture where roasting process was responsible for the observed rise in protein contents (Anyalogbu et al., 2015) and our finding is also in consistent with an increase in 52.5% in the roasting of sweet potato reported by Eke-Ejiofor and Onyeso (2019) and apricot protein increment reported by Kilinc et al. (2022). Roasting also cause significant rise in different types of protein in chickpea (Kaur and Prasad, 2023).

Roasting causes intracellular water evaporation that triggers chemical reaction and changes lignocellulosic structure and promotes protein denaturation, which may result in a greater availability of plant phenolic compounds in the matrix. However, further roasting can decomposed the protein quality due reactive

compounds which react again with protein in the Maillard reaction (Rizki et al., 2015).

5.10.5. Carbohydrates

Carbohydrates are energy-providing compounds that include starch, glucose, lactose, and sucrose, among the most common ones. They serve as the primary constituents found in abundance within various fruits and vegetables, supplying essential energy for the human body(Ahsan, 2021).

The highest carbohydrates content of Raw (wild and cultivated) *A. napalensis* (73 mg/g DW and 72.7 mg/g DW) followed by *O. indicum* (56.3 mg/g DW and 55 mg/g DW) and *A. fornicata* (7.2 mg/g DW and 6.8 mg/g DW) and the highest carbohydrates content of Processed (wild and cultivated) *A. napalensis* (52.3 mg/g and 50.7 mg/g DW) followed by *O. indicum* (72 mg/gDW and 67.9 mg/g DW) and *A. fornicata* (6.5 mg/gDW and 6.4 mg/g DW). This carbohydrate level was in agreement with the studies on wild edible vegetables reported by the Bodos of North-East India (Basumatary et al., 2017). There are significant differences ($P<0.05$) between the WR and WPand CR and CPin each respective samples except Raw (Wild and Cultivated) *O. indicum*.

The carbohydrate content decreased in both blanching and cooking processing. The decrease in the carbohydrates is higher in the cooking than blanching process in *A. napalensis* (Wild-28.9% and Cultivated-30.2%), *A. fornicata* (Wild-14.47%, and Cultivated-5.8% no significant reduction) respectively which aligned with earlier studies (García-Herrera et al., 2020). The blanching followed by roasting does not have an increase in the carbohydrates as available carbohydrates or soluble sugars may also be dissolved during the blanching process, which agreed with the earlier studies (Alam et al., 2016).

The roasting increases the protein level in *O. indicum* significantly (Wild-22.2% and Cultivated-17.9%), which is also in alignment with recent studies by Oracz et al. (2023) that the elimination of water during roasting is responsible for the

subsequent increase in ash and total carbohydrate content. This change in the carbohydrate content may also be caused by other factors and the increase in carbohydrate content after roasting may be attributed to both the degradation of proteins and lipids, the formation of new compounds through the Maillard reactions and the release of cell wall-bound compounds during heat treatment. (Rodríguez-Bencomo et al., 2015). This, however, is in contrast with earlier studies reported by Adeyeye (2010). It is a well-known fact high levels of carbohydrate content can be directly correlated to the presence of low-fat content (Bhat and Karim 2009), which also holds true in our present study. The high protein content in *O. indicum* pod flour highlighted its significance as a crucial nutrient source.

5.10.6. Energy value

The calorific value of selected WEPs in the present investigation ranges between 78.4 to 353.4 Kcal/100g which was almost similar with the reported calorific value (29.48 to 390.42kcal/100g) from the fresh samples reported by (Narzary et al.,2015). Calorific value comparisons of the already investigated plants showed that the studied samples surpass standard commercial vegetables and fruits. Furthermore, the calorific value in *A. fornicata* (WR-97.3,WP-88,CR-90.7,CP-78.4 Kcal/100g) in the present investigation was found higher than those commercial fruits like an apple (58 kcal/100g) (Sundriyal and Sundriyal, 2004) and vegetables like broad beans (48Kcal/100g) (Gopalan et al., 2004). The calorific value of *A. napalensis* are WR-353, WP 4-249.5, CR-348, CP-240.4 Kcal/100g, which was also almost equivalent to broken rice (Ren et al., 2021) and yam flour (Leng et al., 2019). The calorific value in *O. indicum* include WR-282, WP-358.9, CR-271, CP-342 Kcal/100g which closely equal to the beko of Malaysia (Bhat et al., 2013) and rice bran as studied by Zhang et al. (2019) with values of 26 Kcal/100g as reported by Gopalan et al. (2004) and Sundriyal and Sundriyal (2004) (Table 53). These findings suggest that WEPs offer a substantial calorific value, making them a viable recommendation for the formulation of various nutritional supplements. They can be effectively integrated into flour formulations, particularly the tubers of *A. napalensis*,

which are occasionally regarded as famine food in the southern part of Churachandpur district bordering Myanmar.

Table 55. Comparative account of energy of the three wild edible with commercial fruit.

Wild edible plants	Energy (Kcal/100g)	Energy (Kcal/100g)	Other species and commercial crops
A. fornicata	WR-97.3 WP-88 CR-90.7 CP-78.4	97 112	Potato (Rashmi and Negi, 2022)
A. napalensis	WR-353.4 WP-249.5 CR-348 CP-240.4	372	Broken rice Yam (Leng et al., 2019)
O. indicum	WR-282 WP-358.9 CR-271 CP-342	366 1308.15	Rice Malaysia Beko (Bhat et al., 2009)

5.10.7. Minerals and anti-nutritional factors

Minerals play a crucial role in maintaining proper body functioning and overall health. The human body requires over 100 mg of macro-mineral nutrients, including Potassium (K), Calcium (Ca), Sodium (Na), and Magnesium (Mg). Additionally, less than 100 mg of micro-minerals or trace elements such as Iron (Fe), Zinc (Zn), Copper (Cu), and Manganese (Mn), are essential. These micro minerals, also known as trace elements, are vital for various physiological and biological functions in the human body. The intake of these essential elements is primarily obtained from fruits and vegetables (Guardia and Garrigues, 2015; Gopalan et al., 2009).

5.10.7.1. Calcium

Calcium (Ca) is an important macronutrient that aids in the development and maintenance of strong teeth and bones, as well as in the regulation of human blood and extracellular fluids. Calcium deficiency can cause a variety of health problems,

including but not limited to back pain, rickets, digestive disorders, osteoporosis, irritability, premenstrual stress, and uterine cramps. (Heaney, 1993; Hasling et al., 1991).

In the present investigation the highest Calcium content is in the order *A. fornicata* > *A. napalensis* >*O. indicum*. The reported calcium level is higher than *Dryopteris filix-mas* which is 279 mg/100g, however found lower than (*Enhydra fluctuans* with the value 902 mg/100g) reported from WEPs of Bangladesh by (El Anany, 2015).

5.10.7.2. Manganese

Manganese (Mn) is essential for the formation of bones and plays an important role in many enzymes, including phosphoenol pyruvate carboxy-kinase and manganese-specific glycosyl transferase. Manganese deficiency can cause bone irregularities, poor hair development, and skin rashes (Pavani and Naika, 2021).

The highest manganese content is in the order *A. fornicata* > *A. napalensis* > *O. indicum*. The reported Mn level is higher than those of some common edibles like banana (0.27 mg/g) and spinach (0.1mg/g dry tissue) (Gopalan et al., 2009). However, lower than guava seed (119.72 mg/100g) reported by Mohammed et al. (2015).

5.10.7.3. Iron

Iron (Fe) is an essential element for the synthesis of hemoglobin and the proper functioning of the central nervous system. It plays a critical role in blood and muscle composition and is necessary for the oxygen transport within the body. Additionally, Iron (Fe) holds a fundamental position in the metabolic processes of carbohydrates, proteins, and fats. Regular consumption of iron rich vegetables prevents the iron-deficiency anaemia (Pasricha et al., 2021).

The highest Iron content is in the order *A. fornicata* > *A. napalensis* >*O. indicum*. The iron content of the present study is higher than leafy *Talium triangulae*

(10.9 mg/100g as reported by Ilelaboye et al. (2013) and higher than *Rumex pulcher* (1.26mg/100g) as reported by García-Herrera et al. (2020). However, they are considerably lower when compared to some common vegetables like spinach (253 mg/100g dry tissue), banana (30mg/100g dry tissue) (Gopalan et al., 2009).

5.10.7.4. Copper

Copper (Cu) is another essential trace element that the human body cannot produce naturally. It plays a crucial role as a component of enzymes that facilitate the incorporation of iron into red blood cells, thereby preventing anemia. Copper deficiency can cause heart arrhythmias, anaemia, and other health problems. (Govindan, 2022). The highest Iron content is in the order *A. fornicata* > *A. napalensis* >*O. indicum*

The amounts of Cu in our study were observed between (0.12 to 0.4 mg/100g) dry tissue which are below the permissible limit of WHO (4 mg/100g) in foods. The Copper (Cu) contents in the estimated plants were considerably lower when compared to common edible vegetable and fruit like spinach (1.3 mg/g), broad beans (0.017 mg/g), brinjal (0.012 mg/g), cucumber (0.09 mg/g dry tissue) (Gopalan et al., 2009).

5.10.7.5. Zinc

Zinc (Zn) is required for the production and maintenance of DNA, as well as for the growth of human tissues, which is especially important for the health of ligaments and tendons. Low zinc levels might cause growth retardation, pneumonia, diarrhoea, and foetal developmental problems (Hambidge, 2000).

The highest Zn content is in the order *O. indicum*> *A. napalensis* > *Alocasia fornicata*. The Zn levels of the studied plants plants are similar to the levels reported in various wild and leafy vegetables in India as reported by Seal (2020).However, the Zn contents of the studied plants are considerably higher when compared to some common edibles like spinach (5.3 mg/100g), apple (4 mg/100g) and banana (15 mg/100g dry tissue) (Gopalan et al., 2009).

5.10.7.6. Lead (Pb) and Nickel (Ni)

Lead (Pb) and nickel (Ni) are heavy metals that easily get collected as a pollutant in soils and sediments. Although plants do not need them, they can absorb and store it in various sections of their structure according to earlier studies (Sharma and Dubey 2005), consuming lead-containing vegetables can cause both chronic and acute poisoning, with negative effects on the liver, kidneys, vascular system, and immune system, and the ingestion of food containing often implicated in chronic bronchitis, emphysema, impaired pulmonary function, and fibrosis (Nkwunonwo et al., 2020). However, the lead and nickel amounts reported in the studied plants are negligible or are below the World Health Organization's acceptable limit (0.2 g/g dry tissue, and 0.1mg/100g) respectively. Studies have shown that processing practices may have a positive effect on the reduction of toxic elements in foodstuffs (Hanaoka et al., 2001).

5.11. Changes in Phytochemical Constituents in WEPs

5.11.1. *Alocasia fornicata*

Blanching of *A. fornicata* followed by the roasting made a significant increase of Ca content (Wild-2.6% and Cultivated-1.5%) which is in agreement with the earlier studies (Malhotra et al., 2023), where the increase availability of free Ca in the *A. fornicata* inflorescence which otherwise found in bound form with oxalic acid that got released due to blanching (Savage and Dubois, 2006; Vanhanen and Savage, 2013). However, the value is less while comparing with earlier studies (Moses et al., 2022) which agrees with the finding of De Corcuera (2004), who suggested that depending on the type and duration of blanching. The blanching methods increase the Ca can be attributed to a significant decrease in Wild-35.18% and Cultivated-30.4% samples due to oxalic acid concentration upon soaking before blanching (Oscarsson and Savag 2007). Oxalic acid binds with calcium and Iron ions to form mineral oxalates and thus preventing their absorption (Vanhanen et al., 2013) where a strong correlation between oxalic acid and calcium as well as between

oxalic acid and iron also justifies the trend. The Fe content have no significant changes which is in agreement with earlier blanching studies (Hsu et al., 2003).

In this present study, blanching in pressure cooker resulted very slight percentage increment but no significant changes in both Zn and Cu-(Wild-5.2%,14.2%) and -(2.8%,14.2%) respectively. However, this is in contrast to earlier studies as Zn and Fe they can be linked to other molecules inhibiting their water solubilisation (Amalraj and pius 2015). The slight increment in the zinc, copper and iron may be due to the leaching of zinc ions from cookers and utensils of the pan surface (Katzenberg et al., 2000; Quintaes et al., 2004: Feitosa et al., 2018). However, in this study phytate is significantly reduced in Wild-41.1% and Cultivated-33.3% which is in agreement with earlier studies (Gidamis et al., 2003; Kumar et al., 2023). The Mn is significantly decreased in Wild-11% and Cultivated-11.9% samples respectively which is in agreement with blanching as in Nigerian *Amaranthus* (Moses et al., 2022).

Heavy metals Ni was much more lower than earlier studies collected from the kotta dam in soil, water and three plant analysis (Nazir et al., 2015) and there was no significant decrease after blanching (50%) which is in agreement with studies in maize species (Drewnowska et al., 2017). However, lead was not detected.

The high level of saponin in *A. fornicata* sample could be the possible cause for its characteristic bitter taste. The natural tendencyof saponins to ward off microbes and are good candidates for treating fungal infections (Okwu and Omodamiro, 2005). These compounds have been reported to serve as natural antibiotics, which help the body to fight infections and microbial invasion (Sodipo et al., 2000). The anti-nutritional factor of the inflorescence was reduced significantly affected after blanching and roasting. Blanching significantly reduced the saponin in Wild by 57% and Cultivated by 57.9 % respectively, alkaloids in Wild by 51.3 % and cultivated by 31% respectively. The above findings agree with earlier reported blanching process followed by roasting of the *A. fornicata* inflorescence (Indriasari and Kumalaningsih, 2016).

5.11.2. *Oroxylum indicum*

Roasting was carried out *O. indicum* in both Wild and CR and CPin an oven as descried ealier. There are significant differences ($P<0.05$) in the anti-nutritional content between the wild and cultivated samples and between Raw and Processed samples. The roasting of *O. indicum* significantly reduced the calcium (Wild-14.3% and Cultivated-13 %) which is in agreement with earlier studies (Devanathan ,2020) and also the reduction in roasting of guava seed (El Anany et al., 2015) and roasting of coffee beans (Dippong et al., 2022) but contradicts with earlier studies (Ferguson et al., 1988). Mn and Zn were not effect by roasting which aligned with earlier studies (Dippong et al., 2022), however at higher temperature the Mn content of sunflower seeds decreases significantly (Tenyang et al., 2022) but the Mn content increased significantly during the soaking treatments (Chauhan et al., 2022). Yet, in another studies there were no significant differences between the Cu and Zn contents of roasted sunflower seeds at 60 and 80°C for 30 min. which could be the consequence of increased temperature (Umoren et al., 2007) that initiated the release of some minerals (Seena et al., 2006:Tenyang et al., 2017). In this study, there are no significant changes in the Fe , Cu, Ni and Pb, another studies however revealed the Calculated calcium/phytate/zinc molar, a better index for predicting Zn bioavailability due to a kinetic synergism that exists between Calcium:Zinc ions that formed Ca: Zn: phytate complex, that is less soluble than phytate complex formed by either ions alone (Davies, 1979) which also approved the significant reduction of the phytate (Wild-54% and Cultivated-33.6%) and oxalate (Wild-37% and Cultivated-34%) respectively in our study. The differences in the elemental concentrations might be due to factors related to variety, soil type, fertilizers, and pesticides used in cultivation, as well as technological processes (Debastiani et al., 2019).

The saponin content was significantly reduced in Wild-57% and cultivated-57.9% and alkaloids Wild - 51.3%, Cultivated -31.6% respectively which correlates with earlier studies on roasted seeds of *Senna occidentalis* (Akbar and Akbar, 2020) However, this study contradicts with th earlier studies where alkaloids and saponin

content increase during roasting of three varieties of marble vine *(Dioclea reflexa)* (Ajatta et al., 2019).

5.11.3. *Amorphophallus napalensis*

Cooking was carried out in both Wild and cultivated samples of *A. napalensis* as described earlier. It was observed that there are significant differences *($P<0.05$)* in the anti-nutritional content between the wild and cultivated samples and between Raw and Processed samples and vice-versa.

Cooking methods depicted different results of Ca, Fe, Zn and Cu, because these minerals can be linked to other molecules inhibiting their water solubilisation (Burgos et al., 2007: Zor et al., 2022). However, cooking of *A. napalensis* for more than 30 min also led to a significant increase in calcium (Wild-3.2% and Cultivated-2.6%) and iron (Wild-13%and Cultivated -13%) which may be attributed to a significant decrease in oxalic acid (Wild-33.9% Cultivated -35.9%) which aligned with earlier studies (Savage, and Dubois 2006;Vanhanen and Savage 2013). Recent studies established a strong correlation between oxalic acid and calcium and oxalic acid and iron which justified this trend. Iron oxalic acid binds with calcium and iron ions to form mineral oxalates and thus preventing their release (Oscarsson and Savage 2007). The significant reduction of phytate in (Wild-40 % and Cultivated-48.5%) respectively also testified the binding phytate with minerals like Fe, Zn, which is in agreement with earlier studies (Agte et al., 1997; Gupta et al., 2015). Cooking of *A. napalensis* also significantly decrease Mn (Wild-20.51% and Cultivated -20%) because of the leaching due to the change in cellular structure on heating (Gidamis et al., 2003).

Cooking is generally expected to bring about a decrease in mineral content due to leaching but the specific increase in calcium and iron in this study might be because of a reduction in oxalic acid and phytate that released the bound minerals (Kumar et al., 2023).However, the Mn in recent studies remains stable (García-Herrera et al., 2020). Cooking significantly reduced both saponin (Wild -40%, Cultivated-40%)-and alkaloids (Wild -68%, Cultivated-66%) respectively. Our study

is in agreement with earlier study (Ezeocha and Ojimelukwe, 2012) where the reduction increased with increment in cooking duration.

Heavy metals Ni was much more lower than earlier studies collected from the kotta dam in soil, water and three plant analysis (Nazir et al., 2015) and there was decrease after cooking (Drewnowska et al., 2017). In this study the decrease in Ni was not found significant (Wild-38% and Cultivated-33%) respectively. Lead was however not detected in the plant samples.

The present study provided the in-depth analysis and assessments of nutritional contents, associated anti-nutritional factors, mineral contents, phenoic compound and their antioxidant properties of three WEPs collected from wild and cultivated conditions with their comparative values even among the raw and the traditional culinary processed forms which will contribute valuable insights into the nutrional composition and health benefits of these plants. Additionally, exploring sustainable cultivation practices, post harvest technologies, and marketing strategies for these wild edibles can enhance their economic potential and promote their utilization as healthy food options. This holistic approach will not only benefit local communities, but also contribute to the broader fields of nutrition, food science and biodiversity conservation.

5.12. FTIR of WEPs

5.12.1. *Alocasia fornicata*

The changes occurring in the functional groups of inflorescence studied by FTIR spectroscopy and the spectral obtained is presented in Fig.6.4. The broad and strong absorption bands observed at (3000-4000) *Alocasia* Raw (3356 cm^{-1}) Processed (3889, 3750, 3280, cm^{-1}) indicates alcohol-phenol (–OH) groups (carboxylic acid) (Wani et al., 2016). The O-H group plays a role in diminishing the activities of free radicals, potentially aiding in the reduction of rancidity in foods. The absorption bands observed in the FTIR spectra of Raw and Culinary-treated (Blanched-Roasting) A. fornicata fruit exhibited a consistent pattern, suggesting the similarity of compounds present in each treatment. The characteristics band of Raw

(2955 cm^{-1}) Culinary treatment (2947 cm^{-1}) in the fruit confirmed the carboxylic acid (C–H) bond stretching and bending vibrations both symmetric and asymmetric (Kacurakova et al., 2000), while bands observed at Raw-1667cm^{-1} and 1597 cm^{-1} raw are due to peptide group of proteins (C=O) (Jan et al., 2019). A vibrational stretch in the carbonyl (C=C) group at 1474 cm^{-1} was observed in the raw sample but not in the Culinary treatment. Additionally, a vibrational stretch in the C-C (aromatics) group was present at 1474 cm^{-1} in the raw sample and at 1404 cm^{-1} in the culinary treatment. This difference may be attributed to the culinary treatment releasing aldehydes and ketones, which contribute to the characteristic flavor and aroma of the fruit. The alcohol-phenol functional group was impacted by the culinary treatment, while the carboxylic acid group remained unaffected. This supports the idea that culinary treatment enhances the release of phenolic compounds in food materials. A decrease was noted in the absorption bands of carbonyls (1900 cm^{-1} to 1600 cm^{-1}) and the peptide group (1620 cm^{-1} to 1700 cm^{-1}) of protein with the heat treatment. These observed changes may be responsible for the development of aroma and flavor attributed to the Maillard reaction. The decrease in the peptide absorption band in the roasted fruit be attributed to denaturation of protein developed desirable compounds and increase aroma and flavor, associated to the Maillard reaction (Rozan et al., 2022). Absorption at 2,921 cm^{-1} depicts CH_3 asymmetric stretching vibrations in aliphatic chains of protein (Akbari et al., 2020). absorption bands around 3,300–3,600, 2,900, 1,150, and 1,000–1,100 cm^{-1} are due to starch present which has an OH, C–H, C–O–C, and C–O functional group. Further, C–O–C ring vibration on starch results in an absorbance peak of approximately 700–900 cm^{-1} (Abdullah et al., 2018).

5.12.2. *A. napalensis*

The changes occurring in the functional groups of the tuber studied by FTIR spectroscopy and the spectral obtained is presented in (Fig.6.5) The broad and strong absorption bands observed at (3000–4000) *A. napalensis* Raw (3750 cm^{-1}) Processed (3757 cm^{-1}) indicates alcohol-phenol (–OH) groups (carboxylic acid) (Gani et al., 2016). The O-H group plays a role in diminishing the activities of free radicals,

potentially aiding in the reduction of rancidity in foods. The FTIR spectra of Raw and Cooked A. napalensis corm exhibited an identical pattern of absorption bands, indicating the similarity of compounds present in each treatment.The characteristics band of Raw (2947 cm^{-1}) Cooked (2932 cm^{-1}) in the corm confirmed the carboxylic acid (C–H) bond stretching and bending vibrations both symmetric and asymmetric (Kacurakova et al., 2000) while bands observed at Raw-1566cm^{-1} and Cooked (1720 cm^{-1}) are due to peptide group of proteins (C=O) (Gani et al., 2019). A vibrational stretch in the carbonyl (C=C) group was observed in Cookedcorm but no in the raw sample. A vibrational stretch (C–N stretch vibration) was observed in the cooked corm at (1234 cm^{-1}) in the cooked corm but not in the raw sample. This difference might be attributed to the impact of Cooking, which releases aldehydes and ketones, contributing to the characteristic flavor and aroma in the fruit. The alcohol-phenol functional group was influenced by the culinary treatment, whereas the carboxylic acid was unaffected. The decrease was observed in the absorption band of carbonyls (1900 cm^{-1} to 1600 cm^{-1}) and peptide group (1620cm^{-1} to 1700 cm^{-1}) of protein with the heat treatment, changes observed may be responsible for the development of aroma and flavour attributable to Maillard reaction (Jan et al., 2019). Absorption at 2,921 cm^{-1} depicts CH_3 asymmetric stretching vibrations in aliphatic chains of protein (Akbari et al., 2020). absorption bands around 3,300–3,600, 2,900, 1,150, and 1,000–1,100 cm^{-1} are due to starch present which has an OH, C–H, C–O–C, and C–O functional group. Further, C–O–C ring vibration on starch results in an absorbance peak of approximately 700–900 cm^{-1} (Abdullah et al., 2018).

5.12.3. *Oroxylum indicum*

The changes occurring in the functional groups of *Oroxylum indicum* studied by FTIR spectroscopy and the spectral obtained is presented in the Fig.6.6. The broad and strong absorption bands observed at (3000-4000) *Oroxylum indicum* -Raw (3750, 3287 cm^{-1}) Processed (3757, 3348 cm^{-1}) indicates alcohol-phenol (–OH) groups (carboxylic acid) (Gani et al., 2016). this O–H group reduces the activities of free radicals and could help reduce rancidity in foods.Wave number range of 3200–3600 cm−1 was due to hydroxyl groups (OH) of phenols and available N-H in

amines II, *Oroxylum indicum* -Raw (2932 cm^{-1}) and processed (2940 cm^{-1}),.The existence of peaks in the wave number range of 2000–3000 cm−1 indicates the characteristic of stretching C-H bonding in Methyl groups Raw (2369 cm^{-1} and Roasting (2369 cm^{-1}) respectively. Bands observed at Processed -1659, 1629 cm^{-1} and which were more prominent than Raw (1589 cm^{-1}) due to peptide group of proteins (C=O) (Jan et al., 2020).

A vibrational stretch in the carbonyl (C=O) group was observed in the raw sample at 1367 cm^{-1} but not in the Roasted sample. This difference could be attributed to the effect of Roasting, which releases aldehydes and ketones, contributing to the characteristic flavor and aroma in the fruit. The alcohol-phenol functional group was influenced by the Roasting operation, while the carboxylic acid was not affected. This supports the idea that Roasting enhances the release of phenolic compounds in food materials. The presence of a peak in the range of 1220–1800 cm^{-1} indicates stretching C=O bonding (Amide I) in the samples. A peak in the range of 1500–1600 cm−1 indicates the presence of stretching C=O bonding (Carboxylic group).The observed peak in Roasting (1367) cm^{-1} is probably because C-O stretch vibration structure, and the observed peak in roasting (1219) cm^{-1} is probably because C-N stretch vibration, aliphatic amines (Timilsena et al., 2016). According to the FTIR Spectra roasted samples, the intensity and sharpness of peaks increased in 1500–1600 cm^{-1} and 1200–1300 cm^{-1} indicating the effect of roasting on amounts of amides, amino acids, aldehydes, and esters. The creation of melanoidins during the roasting process is probably the most important reason for changes in amounts and intensity of peaks in the FTIR spectrum (Hatamian et al., 2020).

5.13. Phytochemical Analysis of Medicinal Plants

The methanolic extract of the three medicinal plants that include *Blumea lanceloria, Betula cylindrostachya and Thottea tomentosa* evealed the presence of many important plant bioactive compounds like carbohydrate, fats, alkaloid, flavonoid, phenol, tannin and saponins.These results were also in accordance with the previous studies which showed the presence of phenol, alkaloid, flavonoid,

saponin in many medicinal plants (Singh et al., 2021). The methanolic extract of *B. lanceloria* showed positive for all test except saponin which is similar to earlier studies (Lalmuanthanga et al., 2019). *Betula cylindrostachya* showed positive results for the entire test which is also in accordance with the earlier literature (Wani et al., 2020). The methanol extract of *Thottea tomentosa* also showed positive result except saponin which is in aligment with the earlier studies (Bora et al., 2022).

Phenols and flavonoids are antioxidant compound responsible for anti-inflammatory, antimicrobial, anti-allergic, and anti-cancer agents (Oragwu, 2012**).** In the present study, total phenolic content (TPC) of methanol extract of the three medicinal plants varies from 26.8 mg GAE/g DW to 54.6 mg GAE/g.The TPC of *thottea tomentosa* determined was 26.82 mg GAE/g DW in the present study, which was much lower than the previous work reported by Bora et al. (2022). The TPC of *B.lanceloria* was found to be 54.6 mg GAE/g DW higher than earlier reported (Mishra et al., 2015)

The phenolic content of *B. lanceloria* is found lower in the present study as compare to the methanolic extracts of old leaves of *B.lanceloria*, but found higher in reports with ethanolic and water extracts (Swaraz et al., 2021).The phenolic content of *B. cylindrostachya* is much lower in the methanolic extracts with a value of 347 mg/GAE/g DW compared to the earlier studies in leaves of *Betula* sp. as reported by Singla et al. (2018).The phenolic content is much lower than the methanolic extracts of *T. tomentosa* and the chloroform and hexane extracts (Bora et al., 2022).

The flavonoid content of *B.lanceloria* is found lower as compare to the methanolic extracts of old leaves, but again found higher while comparing with the ethanolic and water extracts as reported by Swaraz et al. (2021).The flavonoid content of *B. cylindrostachya* is much lower in the methanolic extracts of already reported study with a value of 347 mg/GAE/g DW by Singla et al. (2018).The flavonoid content of *T. tomentosa* was found much lower than the methanolic, chloroform and hexane extracts of previous studies from Assam by Bora et al. (2022). Regarding the work on LC-MS studies on these three medicinal plants, no

previous record was found as the present report was the fist on these plants to identify the bioactive compounds and showing the need for future bioactivity studies.

5.13.1. Pearson's Correlation between Antioxidant Activity (DPPH and ABTS) with Total Phenol and Flavonoid Contents

The correlation measured the relationship between the total phenolic content (TPC), total flavonoid content (TFC) with their antioxidant activity analysed through by using DPPH, ABTS free radical scavenging activities. The correlation were categorized based on the value of strength between the two variables as very strong (1.0– 0.80), strong (0.79–0.60), moderate (0.59–0.40), weak (0.39–0.20), and very weak (0.19–0.00) (Evans, 1996). Table 35

The present study revealed that there is very strong correlation between TPC with DPPH (R=0.903) and moderate correlation with ABTS (R=0.657), while TFC and DPPH (R=0.490) showed moderate correlation and a weak correlation was observed between TFC and ABTS (R=0.416) which is in consistent earlier studies by (Hesam et al., 2012). A high correlation between DPPH and TPC and moderate correlation was also reported by (Fitriansyah et al., 2017)

Table 56. Comparative account of the compounds isolated through LCMS result of with *Blumea lanceloria* with already reported compounds and bioactivities

Sl.no	Compound name	Biological activity	Group	References
1	Kaempferol-3-rhamnoside-7-rhamnoside	Anti-hyperglycemic effect	Phenols	Ning et al., 2019)
2	Solasodine	Antioxidant, hepatoprotective neuroprotective, and anticancer activities	Steroid	Deshmukh et al., 2022
3	7-Hydroxy-4-methylcoumarin	Choleretic drug, cancer cells by inhibiting DNA gyrase	Phenols	Zhou et al., 2022
4	Epicatechin	Anti-inflammatory	Flavonoid	Monika et al., 2023
5	Quinic acid	Lowering blood glucose	Cyclohexane	El-Askary et al.,

			carboxylic acid	2022
6	Scopoletin	Anti-inflammatory effects, anti-aging, anti-cancer, anti-microbial, antioxidant, cardioprotective, diuretic, hepatoprotective	Coumarin	Akkol et al.,2022
7	Kaempferide	Anti-inflammatory	Flavonoid	Alam et al., 2016
8	Quercetin-3-glucuronide	Pulmonary injury	Phenol	Yu et al., 2023
9	Luteolin	Skin cancer, hypouricemia effects	Flavonoid	Juszczak et al, 2022 Yuan et al., 2021
10	Phloridzin	Antihyperglycemic effect, anti-inflammatory effects, hepatoprotective effects, antitumuor, antibacterial and antioxidants activity	Phenolics	Adamcová et al., 2022

Table 57. Comparative account of the compounds isolated through LCMS result of with *Betula cylindrostachya* with already reported compounds and bioactivities

Sl. no	Compound Name Betula	Biological activity	Group	References
1	Petunidin	Antioxidant, Anticancer cells and also it reduces the risk of heart attack	Phenol	Zheng et al., 2022
2	4-Hydroxy-3-methoxycinnamic acid (Ferulic acid)	Anti-obesity and anti-hyperglycemic properties.	Phenol	Ulpathakumbura et al., 2023
3	Luteolin	Skin cancer Hypouricemia effects	Flavonoid	Juszczak et al., 2022
4	Linoleic acid	Anti-inflammatory	Fatty acids	Fristiohady et al., 2023
5	Kaempferol-3-O-beta-D-glucoside-7-O-alpha-L-rhamnoside	Anti-tumor and antioxidant activity	Flavonoid	Akter et al., 2022
6	isorhamnetin-3-O-rutinoside	Promote apoptosis of human myelogenous erythroleukaemia cells	Flavonoid	Boubaker et al., 2011
7	Epicatechin	Anti-inflammatory	Flavonoid	Monika et al., 2023
8	Kaempferide	Anti-inflammatory	Flavonoid	Alam et al., 2020

Table 58. Comparative account of the compounds isolated through LCMS result of with *Thottea tomentosa* with already reported compounds and bioactivities

Sl. no	Compound Name	Biological activity	Group	References
1	Rhamnetin	Anticancer activity Antitumor agents in HCC cells Against breast cancer anti-inflammatory activity	Flavonoid	Medeiros et al., 2022
2	Epicatechin	Anti-inflammatory	Flavonoid	Monika et al., 2023
3	Farnesol	Anti-cancer and anti-inflammatory effects, And also alleviate allergic asthma, gliosis, and edema.	Sesquiterpene alcohol	Yilmaz et al., 2022
4	4-Hydroxy-3-methoxycinnamaldehyde	Anti-inflammatory and antioxidant properties	Isoflavonoid	Liu et al., 2020
5	Flavanone	Ulcerative colitis Antidiabetics	Phenols	Cai et al., 2023 Azhar et al., 2023
6	Petunidin	Antioxidant, Anticancer cells and also it reduces the risk of heart attack	Anthocyanidin	Liu et al., 2023
7	Acacetin	Anti-inflammatory and anti-cancer Cardiovascular	Flavone	Singh et al., 2020 Wu et al., 2022
8	Gamma-Linolenic acid	Antioxidant properties Anti-cancer activity in NSCLC cells	Fatty acids	Kawish et al., 2022
9	Luteolin-3',7-di-O-glucoside	Hypouricemia effects, antioxidant and anti-inflammatory	Flavonoids	Yuan et al., 2021
10	Myricitrin	Chronic wounds, antidiabetic	Flavonoid	Pujari et al., 2021

The LC-MS result of *B. lanceloria* (19 compounds), *B. cylindrostachya* (8 compounds) and *T. tomentosa* (10 compounds) tabulated in Table 55, Table 56 and Table 57 constitute the positive and negative mode. The identified compounds mostly contain the phenols, flavonoids and other phenolic derivatives. To the best of our knowledge there, no other literature has been found for comparsion regarding the three wild medicinal plants. The LCMS detection of several phenolic and flavonoids compounds could justify the observed antioxidant activity. Additionally, the isolated

compounds from these three medicinal plants have already demonstrated various biological activities, including their anti-diabetic properties, which aligning with their reported use as ethnomedicinal plants against diabetes from the study sites. Therefore, future research work regading bioactivities, pharmacological assessments, and clinical studies of the isolated compounds from these three medicinal plants is essential. This will provide a more comprehensive understanding of their therapeutic potential and contribute to the development of novel drugs for various health conditions especially for anti-diabetic and anti-cancerous drugs. Additionally, further investigations into the traditional uses and folklore associated with these plants, as well as community based conservation strategies will be crucial for preserving the rich ethnobotanical heritage of the Churachandpur district.

CHAPTER–6

Conclusion and Summary

Wild edible plants (WEPs) serve as crucial supplementary foods globally, particularly during periods of seasonal food scarcity, acting as a "buffer food" to alleviate local communities' food insecurity. Documenting these plants is vital due to their rapid depletion from various human activities. Ethnobotanical and phytochemical research plays a pivotal role in conservation efforts, economic benefits, and the establishment of regional food identities. The thesis work presents an in-depth ethnobotanical exploration conducted to explore the traditional knowledge of plant usage within the diverse tribal communities residing in Churachandpur District (Undivided), Manipur, a northeast Indian state. The region is characterized by its unique flora and there is intimate relationship between the indigenous communities with their surrounding plant life. The present study aims to document, analyse and understand the traditional uses of plants by various ethnic groups inhabiting the district.

The study spans across 5 subdivisions comprising 57 villages during 2017-2020, engaging informants from seven major tribes, namely *Paite, Hmar, Gangte, Simte, Zou,* and *Vaiphei*. Employing a multidisciplinary approach, the ethnobotanical information was systematically collected through semi-structured interviews with the informants representing various fields such as agriculturist, herbalist, animal drovers and church leaders to collect comprehensive data on the uses of plants, local knowledge and cultural significance. All the studied plants were collected from the study sites, identified and made into herbarium specimens based on standard procedures and deposited in Herbarium, Department of Botany (MZUH), Mizoram University.

Quantitative indices, including Informant Consensus Factor (ICF), Fidelity Level (FL), Use Value (UV) and Relative Frequency of Citation (RFC) were employed for the WEPs and medicinal plants to analyse the data. The study documented a total of 78 WEPs from 65 genera and 46 families with *Solanum*

emerging as most diverse genus with four species. Traditional dishes were prepared using 36 taxa from 28 genera across 20 families, again dominated by *Solanum* with two species. Additionally, 26 plant species under 19 genera from 12 families were recognized for their use as spices and condiments, with *Capsicum* contributing two species. In the context of traditional beverages, 19 plant species from 16 genera and 13 families were recorded, with *Phyllanthus* exhibiting the highest diversity with two species. Ethnoveterinary uses identified for 15 plant species from 15 genera and 15 families. The study also meticulously documented 102 medicinal plants from 90 genera and 56 families, with *Solanum* featuring prominently with highest number of 4 species. So, the genus *Solanum* holds great ethnobotanical significance from the present study site.

The study highlights the significance of various plant species, including *Oryza sativa, Ficus semicordata, Passiflora edulis, Musa acuminata* and *Vitis vinifera* in the preparation of traditional alcoholic beverages. While *Oryza sativa* has been documented, the lack of literature on the other species within the state underscores the need for further research. Exploring these underreported plants could provide valuable insights into their ethnobotanical, nutritional, and economic potential. Another noteworthy finding from the study site is the use of certain plants for medicinal purposes. Despite the poisonous nature of *Gelsemium elegans*, it is employed by experienced herbalists to address severe stomach disorders. The use of *Cajanus cajan* leaves for liver disorders is a novel finding not documented by anyone for its specific uses. *Blumea lanceloria* stands out for its diverse applications, including its use as an anti-diabetic agent, for diabetic foot ulcers, dysentery, as well as in the treatment of cuts and wounds. *Betula cylindrostachya* is reported for its effectiveness in managing diabetes, ulcers, and digestive symptoms, while *Scoparia dulcis* is traditionally used for diabetic control. *Thottea tomentosa* finds application as an anti-diabetic control and for alleviating stomach ache. *Smilax glabra* emerges as a remedy against severe dysentery and as a control measure for diarrhoea. These findings underscore the rich traditional knowledge of the herbalists in the study area and reveal unique applications for these plant species.

This comprehensive ethnobotanical study not only contributes to the understanding of traditional plant knowledge but also emphasizes the cultural significance of plant resources in the daily lives of indigenous communities. The findings have implications for biodiversity conservation, sustainable resource management, and the preservation of traditional practices in Churachandpur district.

Three WEPs that include *Alocasia fornicata*, *Amorphophallus napalensis* and *Oroxylum indicum* were selected with the aim to conduct detailed phytochemical analysis and nutritional evaluation. The investigation involved the comparison of raw and traditionally culinary processed samples from both wild and cultivated sites, considering various nutritional parameters, phytochemical content, antioxidant activity, anti-nutritional factors and mineral composition. Nutritional analysis revealed that the selected WEPs exhibited substantial nutritive value with minimal anti-nutritional factors which affect the nutritional quality. The minerals analyzed included calcium (Ca), zinc (Zn), copper (Cu), nickel (Ni), lead (Pb) and iron (Fe). Additionally, phenol and flavonoid content, as well as antioxidant properties measured by DPPH and ABTS assays were assessed.

Samples of *Alocasia fornicata* that underwent traditional processing results in a significant reduction in anti-nutritional factors in both cultivated and wild by 31.5% and 15.7% respectively without compromising mineral content, except for calcium and manganese. The total phenol and flavonoid content of *A. fornicata* increased after processing, enhancing antioxidant capacity. The FTIR results suggested that Maillard reaction during traditional processing led to significant changes in functional groups, preserving flavours and improving nutritional value.

Amorphophalus napalensis experienced a decrease in phenol and flavonoid content in traditionally processed samples collected both from the wild and cultivated ones by 25.8% and 21.3% respectively. Also, traditionally processed samples of *A. napalensis* significantly reduced the anti-nutritional factors while impacting the mineral contents, with the exception of zinc (Zn). However, these samples retained antioxidant properties showcasing its potential their free radical scavenging activity. This processing method aimed to enhance the nutritional quality

and safety of the plant, demonstrating its potential as a valuable food source with improved health benefits.

Traditional processing of *Oroxylum indicum* led to a reduction in anti-nutritional factors and an improvement in mineral content, excluding calcium. The processed samples of *O. indicum*, both from wild and cultivated sources, exhibited an increase in total phenol and flavonoid content by 7.2% and 12.9% respectively. The antioxidant capacity after roasting improves, conferring the scavenging activity of the roasted samples health benefits.

The FTIR results indicated that Maillard reaction causes significant changes in the pods, preserving flavours and improving the nutritional value. With the functional groups showed no major alterations, the possibility of new compound formation due to Maillard reaction was suggested. Further, improvement in processing techniques, such as stir frying, sous-vide, or infrared radiation, could be explored for enhanced results.

The qualitative analysis of three medicinal plants namely, *Blumea lanceloria, Betula cylindrostachya* and *Thottea tomentosa* indicated the presence of alkaloid, flavonoid, tannin, saponin, phenol and oil. Saponin was absent in *B.lanceloria T. tomentosa,* while all tested compounds were present in *B. cylindrostachya*. The quantitative estimation of methanolic extracts of the three medicinal plants revealed phenol and flavonoid contents are responsible for antioxidant compounds. The phenol and flavonoid content observed was highest in *B. lanceloria >B. cylindrostachya > T. tomentosa*. The results further showed that the maximum content of phenol was observed in *B. cylindrostachya* (318.61 mg GAE/g DW) followed by *Blumea lanceloria* (54.6 mg GAE/g DW) and the lowest in *T. tomentosa* (26.8 mg GAE/g DW).

Furthermore, the methanol extracts of the three selected medicinal plants exhibited potent antioxidant activity as evidenced by their scavenging effects on DPPH and ABTS activity. The LCMS results identified compounds with potential anticancer potential in these selected medicinal plants, suggesting that further

investigations into the anti-inflammatory, anti-cancer, antibacterial, and anti-rheumatic could be valuable. This study represents the first reported LCMS identification and characterization of components from the these three medicinal plants *B. lanceloria, B. cylindrostachya* and *T. tomentosa* supporting their traditional uses and providing scientific evidence for their antioxidant and anti-diabetic activities which may be attributed to the high content of phenols and flavonoids.

The ethnobotanical exploration highlighted the rich traditional knowledge of WEPs among the Churachandpur tribal communities, emphasizing the popularity and unique food preparations of certain WEPs. Quantitative analysis of these ethnobotanical data highlighted the popularity of specific wild edibles such as *Amorphophallus paeoniifolius, Alocasia fornicata, Colocasia esculenta, Phyllanthus emblica* and *Centella asiatica*. The study documented unique ethnic food preparations that employed various processes to enhance nutritional content, prolong shelf life, and improve palatability. Additionally, the study uncovered the traditional use of specific plants in corpse embalming to their uses as antidote against food poisoning that include *Benincasa hispida, Centella asiatica, Zanthoxylum rhetsa*.

The LCMS results of the three medicinal plants indicated the presence of compounds with potential anticancer and antidiabetic properties. This discovery suggests that further research on these three medicinal plants, reported for their anti-diabetic properties could yield novel compounds with therapeutic potential. So, the present study of these medicinal plants provide a first-hand knowledge opening avenues for further research and exploration of their therapeutic potential particularly in the context of anti-diabetic applications.

The study emphasizes the importance of preserving and understanding traditional knowledge in the context of both wild edible and medicinal plants, contributing to the broader understanding of the biodiversity in the region and associated cultural significance. Also, as researchers continue to explore and validate the medicinal properties of plants for potential discovery of novel compounds that could lead to novel drug discovery. So, the ethnobotanical study in Churachandpur district not only sheds light on traditional practices, but also offers a promising

pathway for future pharmacological investigations and development of innovative medicinal products.

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PHOTO PLATE -1

WEP, Medicinal plants, Spices and condiments.

Abelmoschus esculentus

Achyranthus aspera

Agave Americana

Ageratum conyzoids

Aloe vera

Alpinia roxburghii

Alstonia scholaris

Ammomum dealbatum

Artemisia vulgaris

Averrhoea carambola

Azadiracta indica

Bauhinia variegate

Begonia roxburghii

Benincasa hispida

Berginia ciliata

Betula cylindrostachya

Blumea lanceloria

Bombax ceiba

Cajanus cajan

Callicarpa arborea

Catharanthus arborea

Centella asiatica

Cinnamon verum

Clerodendron glandulosam

Colocasia esculenta

Croton caudatus

Cucumis sativa

Cucurma longa

Cuscuta reflexa

Cycas pectinata

Cyperus rotundus

Datura metel

Daucus carota

Dendrocinide sinuate

Dillenia pentagyna

Dioscorea glabra

Drymaria cordata

Dysoxylum gobara

Elaeis guinensis

Ensete glaucum

Entada gigas

Eryngium foetidum

Erythrina stricta

Erythrina variegate

Eupatorium nudiforum

Euphorbia hirta

Ficus semicordata

Fluggea virosa

Euphorbia roylenea

Gelsemium elegans

Helicia excels

Helicia robusta

Hellenia speciosa

Hibiscus sabdariffa

Homaloema aromatic

Houttuynia cordata

Ilex godajam

Imperata cylindridrica

Justicia adhatoda

Lablab purpureus

Lantana camara

Lepionurus sylvestris

Leucaena leucocephala

Luffa acutangula

Mangifera indica

Mentha spicata

Mikana micrantha

Mimosa pudica

Mirabilis jalapa

Momordica charantia

Morus alba

Nicotiana tabacum

Oroxylum indicum

Phyllanthus emblica

Prunus persica

Psidium guajava

Rhus chinensis

Rubus alceifolius

Saccharum officinarum

Sapindus mukorossi

Schima wallachi

Scorparia dulcis

Senna alata

Smilax glabra

Solanum melongena

Solanum nigrum

Solanum violaceum

Spondia pinnata

Tamarindus indica

Thottea tomentosa

Trevesia palmata

Trichosanthus cucumerina

Urena lobata

Vignia unguicalata

Zanthoxylum rhesta

Zea mays

Zingiber officinalis

Ziziphus jujuba

Senegalia pennata

Amorphophallus nepalensis

Amorphophallus.bulbifera

Allium hookeri

Avverhoea.carambola

Aesculus.hippocastanum

Atrocrapus lacucha

Atrocarpus.heterophyllus

Amaranthus spinosus

Bambusa tulda

Bauhinia variegata

Blumea lanceloria

Baccurea ramiflora

Bruinsmia polysperma

Calamus erecta

Calamus tenius

Cissus repanda

Citrus auranium

Citrus auranium

Clerodendron coleobrookeanium

Caryota mitis

Cycas pectinata

PHOTO PLATE -7

Coix lacryma

Cucumis sativa

Ipomea batatas

Dendrocalamus latiflorus

Dednrocalamus manipurensis

Diplazium esculentum

Piper excelsum

Ensete superbum

Eurya acuminate

Glinus oppositifolius

Gnetum gnemon

Rueilla macrophylla

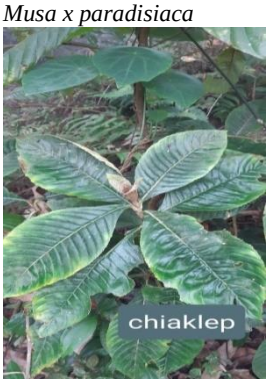
Musa balbisiana

Musa x paradisiaca

Plantago major

Psophocarpus tetragonolobus

Punica grantum



Rubus ellipticum

Senna occidentalis

Solanum torvum

Syzygium cumini

Raphanus mauritiana

zingiber kangleipaknensis

Allium cepa

Allium sativum

Arachis hypogea

Capsicum annum

Capsicum chinensis

Coriandum sativum

Elsholtzia communis

Litsea cubeba

Menthe arvens

Foeniculum.vulgare

Ocimum americanum

Perilla fruetescens

Piper nigum

Passiflora edulis

Sesamum indicum

Zanthoxylum acanthipodium

Alocasia fornicate

Brassica rapa

Brassica juncea

Glycine max

Parkia roxburghii

Ananas comosus

Camella sinensis

E.pyriformis

Garcinia lanceifolia

Cannabis sativa

Dillenia indica

Oryza sativa

Pyhllanthus acidus

Psidium guajava

Vitis vinifera

Photo plate-3. Traditional dishes/Recipe


mehpok


bekanthu


salad/sialhuan


sathu


sathu meh


mehhuan bai


vaimim


tomato roast


antam um


ankam sialhuan


zongtah malta


phulun sathu

Appendix 1

Questionnaires on Ethnobotanical Data Collection of Wild Edible plants

1. Informants' detail

Name/min : .....
Gender : Male / Famale
Age/ kum : .....
Tribe:

2. Ethnobotanical importance of wild edible vegetables

Plant :Local name: .....
Habit / apoudan: .....
Mode of consumption/ siam dan : .....
Part used:.....
Availability Season / awm hun : 1) Whole year / kumteng

Medicinal value (If any)/ Damdawi atan a hmanna :
.....
Use report for other disease treatment (Natna dang a hmanna):
.....

I ..... hereby give my full consent and willingly accepted to participate in this study and declare that the information provided by me during the course of interview was true and accurate to the best of my knowledge.

Appendix-II

Questionnaires on Ethnobotanical Data Collection of medicinal plants

1. Informants' detail

Name/min : .....

Gender : Male / Famale

Age/ kum : .....

Tribe:

Occupation: village headman/pastor/berbalist/agriculturist/etc……

Education qualification: illetrate/high school /secondary/graduate/etc …

2. Medicinal usages

Plant: Local name: .....

Habit / apoudan: .....

Mode of preperation/ siam dan : .....

Part used:.....

Availability Season / awm hun : 1) Whole year / kumteng

From.....to..... (Month)

Mode of administration: decoction/raw/paste/…….

Use report for other disease treatment (Natna dang a hmanna):

.....

3. Ailments treated:

Digestive ailments/ eye/ear infection/…….

Headache/sinusitis/tonsillitis/allergy etc…….

Diabetics/ ulcer/foot diseases/etc…….

Others unspecified diseases:……

I ..... hereby give my full consent and willingly accepted to participate in this study and declare that the information provided by me during the course of interview was true and accurate to the best of my knowledge.

PAPERS PRESENTED

1. Presented paper on **Informants consensus factor of ethnomedicinal plants used by the tribal in Churachandpur District,Manipur** at *The 12th Annual convention of association of Biotechnology and Pharmacy (ABAP) & International conference on Biodiversity, Environment and Human Health: Innovations and Emerging Trends (BEHIET 2018)* at Mizoram University.

2. Presented paper on **Diversity of wild edible plants used by the Paite ethnic tribe in Manipur**, at the National seminar on Biodiversity, Conservation and Utilization of Natural resources with reference to Northeast India (BCUNRNEI) on march 30-31st March 2017 at Mizoram University

3. Presented paper on **Food security through traditional preservation of plants by the tribal in Churachandpur District**, Manipur. On the national conferences on E merging trends in Environmental Research at the Dept. of environment science Pachhunga University College, Aizawl. On the 31-2nd Nov 2019.

4. Present poster on **The art of making gun powder by the tribal in Churachandpur, Manipur,** on the International symposium on plant taxonomy and ethnobotany organised by the Botanical survey of India under the Ministry of Environment, Forest and Climate Change. On the 13-14th Feb 2020.
5. Presented paper on **Nutritional and mineral composition after traditional culinary treatments of three wild edible plants from Churachandpur, Manipur**, on the National conference on recent advances in plant neology with special references to North-East India, at dept. of Botany, Mizoram University from April 20-21st 2023.

PUBLICATIONS

1. **Thangliankhup, K**., Gouda, S., & Khomdram, S. D. (2023). Ethnomedicinal plants of Kuki-Chin tribes in Kaihlam wildlife sanctuary of Manipur, India. *Acta Ecologica Sinica*, *43*(4), 628-643.
2. Malsawmtluanga, C. D., Lalbiaknunga, J., & **Thangliankhup, K**. (2023). Proximate Analysis, Mineral Contents, and Antioxidant Activities of Wild Edible Mushrooms from India. *International Journal of Medicinal Mushrooms*, *25*(8).

BIO-DATA

Name : K.THANGLIAN KHUP

Father's Name : K.Tuanzahau

Mother's Name : Henching

Date of Birth : 19th January 1984

Permanent Address : H.no-77 LL, Zenhang Lamka, Near CCPur Police Station, Churachandpur, Manipur -795128.

Educational Qualification

Sl. no	Examination passed	Subject	Year	Board/ University	Division	Percentage Of Marks
1.	HSLC	Regular	2001	MBSE	Second	53%
2.	SSCE	Science	2003	COSEM	Second	55%
3.	B.Sc	General	2007	Delhi University	Second	53%
4	M.Sc	Botany	2013	Manipur University	First	67%

Ph.D Registration and date : MZU/Ph.D./1027 of 26.05.2017

Department : Botany

Title of research : Ethnobotanical diversity and phytochemical study of selected plant species in Churachandpur, Manipur.

Supervisor : Dr. Khomdram Sandhyarani Devi

PARTICULARS OF THE CANDIDATE

Name	: **K.THANG LIAN KHUP**
Degree	: Ph.D.
Department	: Botany
Title of research	: Ethnobotanical diversity and phytochemical study of selected plant species in Churachandpur, Manipur.
Date of admission	: 17.08.2016
Approval of research proposal	
DRC	: 24.04.2017
BOS	: 01.05.2017
SCHOOL BOARD	: 26.05.2017
MZU Registration No	: 1600795
Ph.D. Registration No & Date	: MZU/Ph.D./1027 of 26.05.2017
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(Prof. F. LALNUNMAWIA)
Head
Department of Botany

ABSTRACT

ETHNOBOTANICAL DIVERSITY AND PHYTOCHEMICAL STUDIES OF SELECTED PLANTS SPECIES IN CHURACHANDPUR DISTRICT, MANIPUR

AN ABSTRACT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

K.THANG LIAN KHUP
MZU REGISTRATION No.: 1600795
Ph.D. REGISTRATION NO: MZU/Ph.D./1027 of 26.05.2017

DEPARTMENT OF BOTANY
SCHOOL OF LIFE SCIENCES
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BY

K.THANG LIAN KHUP

Department of Botany

Supervisor

Dr. KHOMDRAM SANDHYARANI DEVI

Submitted

In partial fulfillment of the requirement of the Degree of Philosophy in Botany of Mizoram University, Aizawl.

Abstract

An ethnobotanical study was conducted to explore the traditional knowledge of plants used by the different tribes of Undivided Churachandpur District, Manipur India. The study was executed under 5 subdivisions (57 villages) representing seven major tribes in including Paite, Hmar, Gangte, Simte, Zou, and Vaiphei. Ethnobotanical information was collected through semi-structured interviews with community members' .i.e. agriculturist, Herbalist, Animal drover, Church leader etc. The data was quantified using indices as Informant Consensus Factor (Fic), ICPC-2 code, Fidelity Level (FL), Use Value (UV), Relative Frequency of Citation (RFC). A total of 78 **wild edible** plants from 65 genera and 46 families were documented in the study area. Solanum was the most diverse genus, contributing four species. A total of 36 **traditional dishes** belonging to 28 genera across 20 families, with Solanum again dominating with two species. Additionally, 26 plant species were documented for **spices and condiments**, represented by 19 genera from 12 families, with capsicum contributing the most with two species. In **traditional beverages**, 19 plant species from 16 genera and 13 families were recorded, with Phyllanthus being the most diverse with two species. **Ethnoveterinary** uses involved 15 plant species from 15 genera and 15 families. Furthermore, the study documented 102 **medicinal plants** from 90 genera and 56 families, with Solanum contributing the highest number of genera (4 species). Lastly, four wild edible mushrooms with high market value were recorded in the study sites.

Three wild edible plants were selected from two different sites (Wild and Cultivated) to evaluate (the Raw and Traditional culinary process) on **Nutritional** quality, **phytochemical** (phenol and flavonoid content), **antioxidant** (DPPH and ABTS), **anti-nutrition** (oxalate, phytate, saponin and alkaloids) and **Minerals** content (Ca, Mn, Zn, Cu, Ni, Pb and Fe). Nutritional analysis of selected wild edible plants showed the presence of a good amount of nutritive value, reduced the anti-nutritional value, minerals content and showed good amount of phenol and flavonoid content.

From the study, the traditional processing of ***Alocassia fornicata*** significantly reduced the anti-nutritional factors which in turn does not affects the minerals content except Ca and Mn. The total phenol and flavonoid content of *Alocasia fornicate* decrease in the processed of both Wild and Cultivated samples (31.5% and 15.7% respectively), Despite significant reduction in antioxidant properties due to the reduction of the phenol and flavonoid after the process, the processed food sample still scavenged free radicals and is reliable source of nutrients and antioxidants as their functional groups still remained intact. The technique of processing however can be improved by steaming, stir frying and sous-vide the plant instead of blanch-roast.

The traditional processing of ***Amorphophallus napalensis*** significantly reduced the anti-nutrional factors and the minerals content except Zn. The total phenol and flavonoid content of ***A.nepalensis*** decrease in the processed of both Wild and Cultivated samples (25.8% and 21.3% respectively), however, retained antioxidant capacity after processing still allowed the plant to act as a free radical scavenger in the body, conferring health benefits. The technique of processing however can be improved by steaming the plant instead of cooking.

The traditional processing of ***oroxylum indicum*** significantly reduced the anti-nutritional factors however improves the minerals content except Calcium. The total phenol and flavonoid content of ***O.indicum*** increase in the processed of both Wild and Cultivated samples (7.2% and 12.9% respectively). The antioxidant capacity after roasting improves, conferring the scavenging activity of the roasted samples health benefits. The functional group in the FTIR results proves that Maillard reaction cause a significant changes in the pods, it also preserved the flavours and improves the nutritional value. The technique of processing however can be improved by (stir frying and Sou-vide or infrared radiation) the plant instead of cooking. The FTIR result indicated that there are no major changes in the functional groups however there could be formation of new compounds due to Maillard reaction.

The qualitative results of the three medicinal plant analysis revealed that methanol extract showed the presence of alkaloid, flavonoid, tannin, saponin, phenol and oil.

In *blumea lanceloria* species all the test were present except saponin. In *Betula cylindrostachya* all the test result shows positive. In *Thottea tomentosa* species all the test result were present except saponin.

Quantitative estimation of methanolic plant extracts of the **three medicinal plants** revealed the presence of phenol and flavonoid responsible for antioxidant compounds. The phenol and flavonoid content observed was highest in *Blumea lanceloria >Betula cylindrostachya > Thottea tomentosa.* The results further showed that the maximum content of phenol was observed in *betula cylindrostachya* (318.61 mg GAE /g) followed by *Blumea lanceloria* (54.6 mg GAE /g) and the lowest in *Thottea tomentosa* (26.8 mg GAE/g).

The plant methanol extract also showed potent antioxidant activity with a marked scavenging effect on DPPH and ABTS activity. These results further indicated other secondary metabolites could also be responsible for antioxidant activities other than flavonoids. The plants with high antioxidant potential may be suggested for further analysis of anti-inflammatory, anti-cancer, antibacterial, and anti-rheumatic, as observed from the tentative compound of the LCMS results. The LCMS identification and characterization of components from the three medicinal plants is the first reported. The compounds obtained from the three plant extracts suggest that this species justifies further study. The results of this study also provide a scientific support to some medicinal uses ***Betula lanceloria, Betula cylindrostachya*** and ***Thottea tomentosa***. The antioxidant and anti-diabetic activities may be attributed to the high content of phenols and flavonoids.

The ethnobotanical exploration revealed Churachandpur tribal communities possess a wealth of traditional knowledge on wild edible plants, their food values and therapeutic properties. Quantitative prioritization showed popularity of certain wild edibles like ***Amorphophallus paeoniifolius, Alocassia fornicta, Colocasia esculenta, Phyllanthus emblica and Centella asiatica***. Unique ethnic food preparations were also documented involving processes to enhance nutrition, shelf life and palatability. Another unique feature of the study area is the mode of corpse

embalming using *Benincasa hispida* , *Centella asiatica*, *Zanthoxylum rhetsa* against food poisoning.

The LCMS results of the three medicinal plants showed that certain compounds which show anticancer properties were also detected and thus further studies on these three medicinal plants reported for the first time against anti-diabetic could be a potential source of novel compounds.