Chapter 2

Literature review

2.1 INTRODUCTION

According to the Food and Agriculture Organization (FAO), wild edible fruit plants are defined as plants that grow naturally in self-maintaining populations within natural or semi-natural ecosystems, independent of direct human intervention [1]. In the Indian subcontinent, there are approximately 647 species of wild edible fruit plants, with over 100 species being particularly suitable [1]. The northeast region of India, specifically Manipur, which is situated in the easternmost part of the subcontinent and encompasses Indo-Myanmar vegetation, harbours a diverse array of these wild edible plants [2].

The importance of wild edible plants (WEPs) in sustaining communities across various regions of the world has been extensively documented [3]. Wild edible plants are species that are neither cultivated nor domesticated but are found in their natural habitats and are utilized as a source of food and household income. Throughout human history and across the globe, these plants have played a significant role in the development and sustenance of civilizations. They have particularly been crucial in meeting the food and nutritional requirements of impoverished communities in rural areas. The high diversity of wild edible plants is found in forested regions, where they have adapted to local environments, enabling them to grow with minimal input and

integrate into sustainable farming systems. However, for these plants to gain popularity, it is necessary to compare their nutritional and health benefits with major cultivated plants. Moreover, wild edible plants hold social, cultural, religious, and ritual significance for rural communities, and their domestication can contribute to their conservation and increased utilization [4].

Different geographical regions across the world have witnessed the significant role played by various wild edible plants throughout human history [5]. Impoverished communities worldwide rely on these plants for their sustenance, nutrition, and survival needs, thereby improving rural livelihoods [6–9]. Furthermore, some wild edibles have demonstrated superior nutritional value compared to cultivated plants [10]. Even in present times, agrarian societies supplement their diets, which mainly consist of staple crop plants, with traditional consumption of wild edible plants [11]. Several studies have analysed the chemical composition of wild herbs, spices, fruits, and leafy vegetables used as food sources in different countries. For instance, Achinewhu et al. (1995) [12] characterized and determined the chemical components of wild edible fruits, nuts, herbs, spices, and leafy vegetables found in Nigeria. Notably, some of these plants not only serve as food but also have medicinal properties, utilized by the native population for minor ailments.

One of the earliest reports available on wild edible fruits in India is the paper by Jain in 1963 [13]. The report documented 34 fruits belonging to 33 families consumed by the Gonds tribe in the Bastar region of Madhya Pradesh. Subsequently, several studies by Gaur, 1977 [14], Vartak¸ 1980 [15], Gour and Semwal, 1983 [16], and Negi, 1988 [17] have highlighted the diversity of wild edible fruits used by tribal and rural communities from various parts of the country. These studies have shed light on the significant role of wild edible fruits in the diets of these communities.

In addition to research conducted in India, investigations done in abroad have also provided valuable insights into various aspects of wild edible fruits. This literature review will present a brief overview of the relevant literature, encompassing research conducted from India as well as international sources. It will cover different aspects

of wild edible fruits, including their diversity, seedling survival, growth, and phytochemical characterization. The purpose of reviewing the available literature is to develop a thorough understanding of the evaluation of wild edible fruit plants in Manipur, North-East India.

2.2 DIVERSITY OF WILD EDIBLE FRUITS

The richness of plant species in a particular region is primarily influenced by climatic factors such as temperature, rainfall, and altitude, as well as edaphic (soil-related) and biotic (related to other living organisms) factors [18–21]. Globally, over 7,000 species of wild edible plants (WEPs) have been documented [3]. Among these, approximately 3,000 tropical fruit species have been reported as still unexploited [22].

There is a wide range of edible wild fruit species in different parts of the world. For instance, a report from Kenya revealed around 400 wild edible fruit species [23], Tanzania has documented 700 species [24], Eastern Madagascar has identified 150 species [25], southern Yunnan in China has reported 123 species [26], Swaziland has recorded 110 species [27], Cameroon has documented 300 species, and Uganda has reported 105 species [28]. Additionally, 33 wild edible fruit species have been identified in the Rupandehi district of Nepal [29], and 11 species have been reported in the Dera Ismail Khan district of north-western Pakistan [30]. Notably, Nigerian lowland rainforests exhibit an exceptionally rich diversity of wild fruit species, with species richness in a few hectares surpassing that of the entire vegetation in Europe [31,32]. In Ethiopia, the consumption of 38 to 182 wild edible fruit-bearing species has been reported [33,34]. In India, the documented wild edible fruit species from the Himalayas alone exceed 675 species [35–38], while Arunachal Pradesh has recorded 118 species [39]. The Uttara Kannada district of Karnataka has identified 12 species [40], Orissa has reported 150 species [41], Assam has documented 132 species [42]; Chhattisgarh has recorded 80 species [43], and central Manipur has identified 49 wild edible fruit species from 22 families [2].

The promotion and domestication of these wild fruit species not only contribute to improving the nutritional status and livelihoods of local communities but also serve to protect these species from loss in the wild and contribute to environmental well-being [44–46].

Wild edible plants and fruits have long been connected with the needs, traditions, and cultures of indigenous communities [47–49]. These communities serve as guardians of valuable plant resources and the associated traditional knowledge [50]. Previous studies, such as Reddy et al., 2000 [51] among the Yanadis community in Andhra Pradesh, Shukla and Chakravarty, 2012 [52] among the Rava and Oraon tribes in North Bengal, Mishra et al., 2008 [7] among ethnic communities in Tamil Nadu, and Srivastav et al., 1981 [53] among the Amiches community in Ladakh (J & K), have demonstrated that different tribes extensively utilize several wild fruits for various purposes. Considering the importance of ethno-medicines amongst the tribal people, study to enumerate the ethno-medicinal uses of wild edible fruits among the Mizo tribes of Aizawl district, Mizoram, India. They have documented 60 wild edible fruit species belonging to 35 families which are mostly used to cure gastrointestinal disorders, dermatological problems, respiratory problems, cardio- vascular compliance, ENT diseases, mental problem, muscular illness, bone diseases, gynaecological problem, cancers, snakebite, allergy, and malaria. Therefore, they claimed these valuable therapeutic fruit species are to be critically studied to establish a conservative measure and to preserve these high valued wild edible fruits [54]. Similarly, a study conducted in Mokokchung district, Nagaland, India [55] documented 55 wild edible fruit species from 29 families traditionally used for ethno-medicinal uses and socio-economic purposes. The plants were used for treating gastrointestinal disorders, respiratory ailments, urogenital problems, dermatological problems, fever, cuts and wounds, diabetes, jaundice, cardiovascular problems, nutritional disorders, antidote, bone diseases, cancer, toothache, opthalmia, ENT issues, food poisoning, malaria, and allergies. Furthermore, these fruits also serve important roles in the socio-economic life of rural communities, such as constructional timber, firewood, fodder, charcoal, fish poisoning, dyes, and oil. The

author emphasizes the need for attention and conservation measures to protect these fruits from extinction [55].

Such studies highlight the need for conservation for the better society and stresses the diversity of knowledge among indigenous peoples across different regions.

2.3 STUDY ON SEED GERMINATION, SURVIVAL AND GROWTH MONITORING

Seed germination is a crucial process for the reproduction and survival of flowering plants, including wild edible fruit plants. However, the regeneration of many non-timber forest product species, including wild edible fruit plants, is often poor in natural stands [1]. Factors such as hard and impermeable seed coats, germination inhibitors, improper embryo development, extended seed dormancy, and thick fleshy fruit pulp contribute to seed dormancy and hinder germination even under favourable conditions [56]. Extensive research has been conducted to develop effective seed treatments that can break dormancy and overcome seed coat hardness, promoting faster and maximum germination rates [57–59]. Various methods are employed to overcome seed dormancy, and these methods vary among different species. Common techniques include drying, soaking in cold or warm water to filter chemical inhibitors, mechanical scarification (such as nicking and chipping), and acid scarification, with sulfuric acid being the most commonly used [60]. The survival and growth of wild edible fruit plants are influenced by complex interactions with their environment. Factors such as competition with other plant species, herbivory, disease, and abiotic stresses significantly affect their survival rates and growth patterns [61–63].

Shade netting, a widely used technique in agriculture and horticulture, is employed to modify microclimatic conditions and optimize plant growth [64,65]. By altering microclimatic conditions, including light quantity, quality, canopy coverage, and soil temperature, shade netting has a significant impact on photosynthesis, biomass accumulation, and fruiting patterns in eild edible fruit plants [66,67]. Several studies

have investigated the effects of shade netting on environmental conditions and plant growth. For example, a study investigated the effects of shade nets on microclimatic conditions, growth, fruit yield, and quality of eggplant (*Solanum melongena* L.) [68]. The findings revealed that shade nets created different microenvironments inside the net house, leading to variations in light intensity that affected photosynthetic-related traits. Eggplants grown under shade nets exhibited taller and bushier growth and higher fruit yield compared to those in the open field. Based on the data, the 21% shade net appeared to be the most suitable for growing eggplants during the autumn to early spring period in Carnarvon.

The initial utilization of nets can be traced back to the cultivation of fruits and ornamentals such as apricots, grapes, apples, and cut flowers. Transparent nets were employed to protect against damage caused by hailstorms and wind, while dark-coloured nets were utilized for wind protection [69]. Typically, black-coloured nets have a lifespan of approximately 15 years, while white-coloured nets last for around 10 years [70]. These nets are predominantly used in open-field settings, particularly in fruit tree cultivation, where either a single large structure is constructed to cover multiple trees or individual nets are applied to each tree [71]. Coloured shade nets have the capacity to enhance light scattering, thereby potentially influencing plant development and growth. Moreover, they can modify the spectra of radiation that reaches the plants beneath them, thereby influencing photo morphogenetic and physiological responses [71,72].

As per the findings of Jutamanee and Onnom in 2016 [73], it has been observed that under shaded conditions, leaves exhibit enhanced photosynthetic activity. This can be attributed to the reduced closure of stomata and the decreased photo-inhibitory damage to photosystem II, which occurs when the radiation surpasses the photosynthetic saturation point on clear days. Another study examined the effects of different shade intensities and colours on the growth and chlorophyll content of "Lane Late" navel orange seedlings [74]. The researchers found that leaf number was highest in the 75% and 50% shade net treatments compared to the control, while photosystem II (PSII) and chlorophyll content were highest in the 75% shade treatment. Another

study investigated the effects of shading nets on the growth and fruiting of red-fleshed 'Shih Huo Chuan' pitaya [66]. Shading resulted in increased chlorophyll content in cladodes and increased fruit length, with no effects on fruit width. Shading treatments also influenced total soluble solids content and fruit splitting percentage. Additionally, a separate study focused on the effects of photo-selective netting on the root growth and development of young grafted orange trees in a semi-arid climate [67]. The results confirmed the positive effect of photo selective nets on tree physiological performance, including increased photosynthesis rate and vegetative growth, as well as promoting rapid establishment of young citrus trees.

Furthermore, a study conducted by Mditshwa et al., 2019 focused on the effect of shade netting on subtropical fruit. The findings revealed that shade netting enhances the efficiency of photosystem II, leading to increased leaf numbers in subtropical trees grown under shade nets. Additionally, shade netting improves water use efficiency and helps reduce external fruit disorders such as fruit splitting and sunburn. While some studies have reported the influence of shade netting on phytochemical and nutritional attributes, there is limited research in this area. It is important to thoroughly evaluate and analyse each shade netting system before recommending it for commercial use, considering the considerable effects of shade net colour and shading intensity on tree physiology and external fruit quality [65].

In this regard, this research emphasizes the necessity of seed germination, survival, and growth monitoring in understanding the ability of wild edible fruit plants to reproduce and adapt to their environmental conditions, as well as the potential advantages of shade netting in optimizing their growth, development and productivity.

2.4 PHYTOCHEMICAL, NUTRIENT AND ANTIOXIDANT ANALYSIS STATUS

An appropriate intake of nutrients is necessary for maintaining optimal health. These nutrients, including proteins, fats, carbohydrates, vitamins, and minerals, can be

obtained from a wide range of wild species. Among these species, fruit plants play a significant role as the primary source of essential nutrition for tribal and local communities. There are several relevant studies that have examined the phytochemical composition, nutrient content, antioxidant properties, and bioactive compounds of wild edible fruits in various regions worldwide.

A study on wild fruits of the Amazon, identified various beneficial compounds \which include phenolic compounds, unsaturated fatty acids, carotenoids, phytosterols, tocopherols, flavonoids, vitamin B, vitamin A, and vitamin C. These compounds contribute to the antioxidant effect of the fruits. Additionally, the fruits exhibit other functional properties such as medicinal, antimicrobial, antimutagenic, antigenotoxic, anti-inflammatory, antinociceptive, antidiabetic, and gastroprotective effects. The findings highlight the potential of these Amazon fruits as valuable sources of functional foods. Their phytochemical compositions and corresponding antioxidant activities make them promising for promoting health and well-being [75].

Salih and Yahi (2015) [76] conducted a study in Sudan to assess the nutritional value and antioxidant properties of four commonly consumed wild fruits: doum (*Hyphaene thebaica* L. Mart.), baobab (*Adansonia digitata* L.), tamarind (*Tamarindus indica* L.), and jujube (*Ziziphus spina-christi* L.). Proximate composition, mineral contents, total soluble phenols, total carotenoids, and total antioxidant capacity of the fruit pulps were analysed. The fruits exhibited high mineral content (14-45 mg) and total carotenoid levels ranging from 7 to 16 mg/kg. The total antioxidant capacity, measured using the DPPH assay in a hydrophilic extract, ranged from 120 to 425 µmoles TE/g DW. Based on these findings, the author concluded that these fruits are rich in minerals and antioxidant compounds, making them valuable sources of nutrients with potential health benefits [76].

Evaluation of secondary metabolites and antioxidant activity in 31 edible wild fruits was conducted in Philippines' Benguet province by Barcelo (2015) [77]. Alkaloids, steroid glycosides, saponins, flavonoids, polyphenols, and tannins were found to be present in the fruits. The antioxidant activity of the fruits surpassed that of Vitamin E

(Myra E), ascorbic acid (50 ug/mL), and trolox (1000 uM), except for *Physalis peruviana* (Solanaceae) and *Dillenia philippinensis* (Dilleniaceae). Among the fruits, *Dillenia philippinensis* exhibited the highest antioxidant activity. The study also highlights the antioxidant potential of these edible wild fruits.

The qualitative and quantitative properties of nutritive value and antioxidant properties of *Arbutus parami*, *Ficus palmate*, and *Nitraria retusa* revealed these wild edible fruits possess high pharmaceutical potential. The energy content of these fruits reached 790 kcal/100 g of fresh weight, and they exhibited high quantities of minerals such as potassium, calcium, magnesium, and sodium, as well as essential elements including phosphorus, iron, zinc, and copper. The total antioxidant phenolic compounds content ranged from 10.31 to 16.46 mg/g, with major constituents being tannins, anthocyanins, and carotenoids. The vitamin C content varied between 25.33 and 85.00 mg/100 g of fresh weight [78].

123 species of wild edible fruits belonging to 52 families and 52 genera were used by inhabitants of Southern Yunnan. Among the 123 fruit species, the nutritive value of 52 fruits was evaluated. They also observed that the local inhabitants possess extensive knowledge about the local plants for ethnobotanical studies. It was estimated that approximately 2.5% of the total 4,000 known flowering plants in Southern Yunnan could potentially indicate the presence of edible fruit-bearing plants in other untapped humid tropics, pending further evidence [26].

An investigation on the significant role of wild edible fruits in the diets of tribal and local communities in Kerala identified 218 wild edible fruits. 10 species were selected for chemical analysis for assessment of moisture content, protein, fats, non-reducing and total sugar, fiber, total vitamins, vitamin C, iron, sodium, potassium, and energy value. The results were compared with those obtained from ten commonly cultivated fruits. The study revealed that wild edible fruits exhibited higher nutritional value, despite their less appealing taste and desirability compared to cultivated fruits [79].A study was conducted on approximately 600 fruit species found in arid zone of Rajasthan, India, focusing on ten fruit species with high food value for both rural and

urban areas. The study concluded that among the ten fruits, Ber (*Ziziphus mauritiana*) is significantly richer in protein, phosphorus, calcium, carotene, and vitamin C compared to exotic apple varieties. However, these fruits are often undervalued and underutilized [80].

The main tribe (Badagas) of Nilgiri district, Tamil Nadu, maintains nearly 30 wild edible fruits, although they are unaware of the commercial value of such fruits. The report suggested that these fruits should be conserved and cultivated on a larger scale to uplift the economic status of the local communities in the near future [81].

The nutritional value of *Ficus palmata*, revealed that it is a good source of polyphenolic compounds and flavonoids. These bioactive compounds contribute to its antioxidant properties, which aid in the prevention and therapy of various oxidative stress-related diseases, including neurodegenerative disorders, cancer, and hepatic diseases [82].

The potential for human nutrition of four wild small trees or shrubs (*Arbutus unedo*, *Crataegus monogyna*, *Prunus spinosa*, and *Rubus ulmifolius*) traditionally consumed in the Iberian Peninsula was evaluated. The study considered the activity of bioactive compounds and analysed lipophilic phytochemicals such as fatty acids and tocopherols, as well as hydrophilic antioxidants like vitamin C and organic acids. The study provided the first report on bioactive compounds in wild fruits in relation to their inhibition of lipid peroxidation (b-carotene/linoleate and TBARS assays). The data revealed that these wild edible fruits are rich sources of bioactive compounds, including organic acids, vitamin C, tocopherols, and polyunsaturated fatty acids. They could be considered as functional foods or potential sources of bioactive compounds with antioxidant synergism effect, particularly *Rubus ulmifolius* due to its high tocopherol content [83].

The nutritive value of 15 wild edible fruits consumed by the people inhabited in and around the deciduous forest zone of India was evaluated. The study highlighted the significance of wild fruit species as important nutrient sources for rural populations. The nutritive value of wild species was compared to that of cultivated fruits such as

mangoes, bananas, guavas, papayas, sapotas, pomegranates, and strawberries, based on protein, carbohydrate, and vitamin content. The study revealed higher carbohydrate content in *Mimusiop selengi* compared to mangoes and pomegranates, and higher sugar concentration in *Ziziphus rugosa* compared to sapotas. Moreover, protein content in *Bridelia tomentosa*, *Corissa spinarum*, and *Polyalthia suborosa* was found to be similar to that of cultivated fruits. The study also focus to prioritize the domestication of these fruits alongside popular domesticated fruits such as bananas and mangoes. [41].

Deshmukh and Waghmode (2011) investigated the nutritional food value and medicinal properties of 11 fruit plant species, consumed by tribal communities in the Western Ghats region of Maharashtra. The author concluded that such studies could help inform the younger generation about the importance of wild fruits and their potential to incorporated into commercial crop plants. This might lessen the food scarcity, stimulate the economy in tribal areas, and aid in the regeneration of barren lands [84].

The nutritional composition, phytochemical contents, and antioxidant capacities of two wild edible fruits: *Eugenia operculata* Roxb. and *Antidesma bunius* L was studied. The study involved phytochemical screening of different solvent extracts and evaluation of antioxidant activities using various assays. The results revealed that *E. operculata* fruit exhibited stronger antioxidant activity compared to *A. bunius*, with better scavenging activities and higher total phenolic content (TPC) and total flavonoid content (TFC). The study also found positive correlations between TPC and TFC with antioxidant activity, as well as with vitamin C [85].

Availability, taste, and uses of 32 wild edible fruits of Bodo tribe in Kokrajhar district of Assam, North-East India was investigated by Brahma et al., 2013 [86]. The study emphasized the importance of exploration, documentation, preservation, and popularization of wild fruits as chief sources of food for human consumption. These fruits play a vital role in maintaining a well-balanced diet and promoting a healthy life.

Sharma et al., 2013 [87] studied antioxidant properties, physico-chemical characteristics, and proximate composition of five wild fruits, *Garcinia pedunculata*, *Garcinia xanthochymus*, *Docynia indica*, *Rhus semialata*, and *Averrhoa carambola* of Manipur, India. The fruits were ranked based on their antioxidant activity and reducing power, with *R. semialata* demonstrating the highest antioxidant activity. The study found a strong correlation among the three methods used to determine antioxidant activity and identified a positive correlation between total phenolic content and antioxidant activity [87].

The study on biochemical and molecular analysis of 19 wild endemic fruits of the Manipur, India, highlights the nutritional value and potential of these endemic fruits in combating malnutrition. High levels of ascorbic acid, antioxidant activity, and genetic markers were observed. *Phyllanthus emblica* showed the highest vitamin C content and antioxidant activity [88].

The availability and potential of wild edible fruits (WEFs) are often overlooked in today's society, both at the scientific and farming levels. Limited literature and documentation exist in the public domain, particularly in north-eastern India, where there is no checklist for their availability and growth, and insufficient data on their physicochemical properties. Additionally, the nutritional advantages of WEFs are also overlooked and value-added products receive inadequate marketing support. Furthermore, there is a considerable gap in management and government policies concerning WEFs.

The rural communities in Manipur have traditionally relied on wild edible fruit plants for sustenance, as well as for materials such as fiber, fodder, and natural dyes. These plants have been utilized for medicinal purposes and hold immense cultural, religious, and traditional value. Unfortunately, the availability and survival of these valuable WEF plants are seriously threatened by deforestation and urbanization. Therefore, there is an urgent need for comprehensive scientific research to assess their natural habitat, establishing effective conservation measures, and investigate their phytochemical potential.

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