Chapter 1

Introduction

1.1 BACKGROUND

Throughout human history, fruit crops have been an invaluable resource that provides essential nutrition in our diets. In botanical terms, fruit refers to the matured ovary or the fleshy portion of a flower that has reached a certain level of maturity and is suitable for human consumption. These fruits are abundantly found in forest areas and considered as wild edible fruits (WEFs). Wild edible fruits encompass edible fruit species that are not cultivated but rather collected from their natural habitats [1]. WEFs are among the most collected non-timber forest products (NTFPs). NTFPs are biological products, excluding high-value timber, gathered by humans from wild biodiversity in natural or human-modified environments [2]. Wild food plants, specifically wild edible fruits, are often categorized as underutilized or neglected crops due to their occurrence in the wild or local-scale cultivation, with their economic potential often overlooked, resulting in limited traditional and local uses [3].

Apart from their traditional use as food, wild edible fruits (WEFs) offer several benefits, including medicinal properties and antioxidant effects [4]. These fruits contain essential minerals such as sodium, potassium, magnesium, iron, calcium, and phosphorus, which support immune function and are frequently employed in various formulations of Indian folk medicine [5]. Fruits are also rich in a variety of like

Ascorbic acid, glutathione, and carotenoids are some of the antioxidant compounds found in fruits which protect against oxidative damage caused by reactive oxygen species (ROS) [6]. Wild fruit plants hold great significance as a food source for tribal and rural populations, and their utilization and development have been intertwined with human existence throughout the ages. Marginal and impoverished communities around the world rely on these wild plants for sustenance, nutrition, and improving their livelihoods [7–10]. However, the distribution, abundance, population density, and season availability of these fruits are significantly impacted by anthropogenic pressure brought on by an increase in human population and the effects of climate change. In order to comprehend the structural and functional dynamics of the species, as well as the properties and potential uses. of fruits, it is crucial to evaluate the population structure, seedling survival, growth patterns, and phytochemical characterization of wild edible fruit plants.

1.2 FRUITS IN HISTORY

Fruits have always played a significant role in human society, influencing diets, cultural practices, and agricultural systems. Evidence of fruit consumption originates from diverse sources such as archaeological remains, pictorial representations, and literary accounts. Excavations at Pompeii in Italy uncovered well-preserved fruit remains, revealing ancient Roman consumption practices [11]. The site of Çatalhöyük in Turkey yielded dried grape seeds and fig remains, providing insight into fruit consumption during Neolithic times [12]. Egyptian tomb paintings depict fruit orchards and harvesting scenes, including figs, grapes, and pomegranates [13]. The Mahabharata, an ancient Indian epic, documents the cultivation and consumption of various fruits like mangoes and bananas [14]. Roman naturalist Pliny the Elder's "Naturalis Historia" offers detailed information on fruit cultivation, properties, and uses [15]. Together, these various literatures help us comprehend the historical significance of fruit as a dietary source. These diverse sources collectively contribute to our understanding of the historical significance of fruit as a food source.

Ancient civilizations such as the Greeks, Romans, and Persians made significant advancements in fruit cultivation. They developed advanced horticultural techniques, including grafting and irrigation systems, which boosted fruit production and enhanced fruit quality. This period saw the cultivation of various fruits, such as grapes, figs, dates, pomegranates, and olives, which held significant cultural and economic value [16]. In the late Neolithic and Bronze ages, spanning from 6000 to 3000 BCE, the domestication of Mediterranean fruits such as dates, olives, grapes, figs, and pomegranates took place [17]. Furthermore, citrus, bananas, various pome fruits, and stone fruits were domesticated in central and East Asia and eventually reached the western regions during ancient times. However, it is important to note that some fruits and nuts, including blueberries, blackberries, pecans, and kiwifruits were only domesticated in the 19th and 20th centuries [11]. These advancements in fruit cultivation and domestication have played a vital role in establishing the diversity of today's fruits, with different geographical regions and time periods contributing to the development of diverse fruit species.

The Indian subcontinent has a long history of fruit cultivation and consumption that dates back thousands of years [18]. The influence of the Mughal Empire, reigning over portions of the Indian subcontinent from the 16th to the 19th century, was particularly instrumental in developing fruit cultivation practices. The Mughals introduced and popularized an array of fruits, such as melons, citrus fruits, chikoo , and custard apple, which contributed to the diversification of the region's fruit catalogue [19]. The Indian subcontinent is known for its indigenous fruits like mangoes, guavas, bananas, papayas, and coconuts that are native to the region and have been cultivated for centuries. In recent times, the Indian subcontinent has witnessed advancements in fruit cultivation techniques, including improved irrigation systems, hybridization, and the introduction of modern agricultural practices. These developments have led to increased productivity and the cultivation of a wider range of fruits in the region and meet the diverse demands of a growing population.

In addition to providing nutrition, these fruits have cultural and religious significance in various socio-cultural festivals and rituals. The cultural significance and traditional

knowledge associated with wild edible fruits are profound. Indigenous communities and local populations possess in-depth knowledge of these fruits, including their uses, seasonal availability, and preparation techniques. Wild fruits hold cultural and spiritual importance, often playing prominent roles in traditional rituals, ceremonies, and festivities. The utilization of wild edible fruits not only contributes to the cultural identity of these communities but also forms an integral part of their culinary heritage. Despite the existence of numerous underexploited wild fruit species in India's forests, their economic potential remains largely unknown [23,24].

1.3 DISTRIBUTION OF WILD EDIBLE FRUITS

Wild edible fruits exhibit remarkable diversity, with an estimated 3000 edible fruits and nuts recorded in the tropical regions of both hemispheres. The India sub-continent is particularly bestowed with enormous diversity of wild fruits in its wide range of agro-ecological zones across its tropical, sub-tropical and temperate regions. While certain species are more prevalent in specific habitats like the tropics, sub-tropics, or arid tracts such as the Deccan plateau, Eastern and Western Ghats. Several fruits like *Aegle marmelos*, *Phyllanthus emblica*, *Limonia acidissima*, *Syzygium cumini*, *Tamarindus indica*, *Ziziphus spp*., and *Carissa spp*. can be found throughout the Indian subcontinent. The temperate fruit diversity extends from the northern regions of Jammu and Kashmir to the subtropical plains in the north and even to Arunachal Pradesh in the northeast. According to Mahapatra and Panda (2009) [20], the genetic diversity of wild fruits is particularly rich in the north western Himalayas compare to the north eastern region.

Wild edible fruits represent a vital component of non-timber forest products (NTFPs) as they are not cultivated but rather collected from their natural habitats. The diversity of these fruits is influenced by ecological factors such as climate, soil conditions, and interactions with other organisms. They belong to various plant families, including Rosaceae (wild apples, plums), Rutaceae (citrus fruits), Solanaceae (wild tomatoes, berries), and many others [21,22].

1.4 WILD EDIBLE FRUITS AND FOOD SECURITY

In developing countries, millions of individuals suffer from insufficient food intake and nutritional deficiencies, particularly in relation to staple foods. During periods of food crisis, rural communities depend on wild resources, including wild edible plants, to fulfil their dietary needs. The diversity of wild species contributes to household food security and enriches family diets. By preserving wild fruits and their products, food security can be ensured during the times of scarcity. Wild fruits, which ripen during times of seasonal food scarcity, serve as a suitable supplement to predominantly cereal-based diets by providing essential nutrients. Furthermore, the availability of fruits from various species throughout the year not only enhances food and nutrition but also generates income through their sale. Additionally, the harvesting of wild fruits promotes rural employment and facilitates income generation through processing and value-added activities [20].

Food and nutritional security are key concerns of the world, as evidenced by low food intake and inadequate access to food in underdeveloped countries [25,26]. Eliminating hunger and malnutrition is one of the most fundamental challenges facing humanity [27]. Extensive studies have emphasized the significance of wild edible fruits in addressing food security challenges. For instance, a study conducted in Philippines investigated the role of wild edible plants in enhancing food security among indigenous communities, revealing their crucial contribution in adapting to new settlements and compensating for the gradual decline in prime food sources [28]. The utilization of non-cultivated foods, including wild fruits, as dietary supplements or coping mechanisms during food shortages serves as a vital safety net for rural populations, particularly in Africa [29–31]. Certain wild plants and edible fruits play a vital role in biodiversity and have become valuable sources of livelihood and fallback options for rural households during periods of nutritional stress [32]. In semiarid regions, is it is common for famine victims and those with AIDS to rely on native food plants [33,34]. On the other hand, when arable agriculture fails due to poor rainfall, indigenous fruits help alleviate food shortages in rural households [35]. Empirical evidence has demonstrated that food insecurity in rural Lebanese

communities drives an increased utilization of wild edible plants [36]. In Zimbabwe, the degree of access to and utilization of indigenous fruits has been found to impact vulnerability to poverty, particularly during challenging periods [37]. Wild fruits contribute to diet diversity, flavour, and provide essential micronutrients in otherwise nutritionally deficient diets [32]. Traditional foods not only play a significant role in promoting and maintaining food security but also in preserving cultural heritage and the environments intertwined with them [38].

1.5 ROLE OF FRUIT IN ETHNOBOTANY

Fruits play a significant role in ethnobotany, particularly in traditional and indigenous cultures. They have been utilized for their nutritional, medicinal, cultural, and economic purposes by various communities [39]. In this context, wild edible fruits hold a prominent position, exhibiting the intricate connection between humans and their natural environment. Wild edible fruits grow naturally in forests, woodlands, and other wild habitats and have been used by different cultures for sustenance, medicine, cultural practices, and economic activities [40].

Ethnobotanical studies focusing on wild edible fruits play a vital role in providing valuable insights into traditional knowledge systems, foraging practices, and the utilization of these fruits by indigenous and local communities [41]. The consumption of wild edible fruits contributes to dietary diversity, as they offer a wide range of flavours, textures, and nutritional compositions. This enhances the overall nutritional intake of communities residing near natural ecosystems. The success of food systems in transition lies in effectively incorporating locally available foods, promoting food variety, and preserving traditional food cultures. This process involves empirical research, the formulation of public policies, promotion, and the implementation of applied actions that support multi-sectoral, community-based strategies. These strategies aim to establish connections between rural producers and urban consumers, bridge subsistence and market economies, and harmonize traditional and modern food systems [41,42].

Indigenous communities have developed profound knowledge regarding the identification, collection, and processing of wild edible fruits. This knowledge is often passed down through generations, encompassing awareness of seasonal availability, indicators of ripeness, and appropriate harvesting techniques [43]. Traditional practices related to the preparation and consumption of wild fruits are deeply rooted in cultural heritage and are associated with specific rituals, ceremonies, and social gatherings, further highlighting the cultural significance of these fruits in indigenous societies [44].

The medicinal properties of wild edible fruits have been recognized and utilized by traditional healers and herbalists. These fruits contain bioactive compounds that exhibit potential therapeutic benefits, including antioxidant, anti-inflammatory, and antimicrobial properties. And these wild fruits are used in indigenous medicinal systems, contributing to the treatment of various ailments and the improve overall well-being [45].

Historically, tribal, and rural people identified and collected plants for food and medicine from forests and developed a range of processing methods in accordance with their needs. This knowledge is becoming lost, as a result of modernization and settled agriculture, , a development that might lead to decreased diversity of indigenous diets and poorer nutrition [46]. Different wild edible plants are known for their significant role in all geographical regions of the world throughout the history of humankind [47]. In India, many ethnobotanists have documented several wild edible plants used by tribal and rural communities to fulfil their diverse requirements such as food security, medicines and income sources [48].

1.6 NUTRITIONAL VALUES OF FRUITS

Fruits are a good source of nutrition for humans, and they also provide rich amount of minerals that are essential for the growth, development, and overall health of the human body. Fruits contain high amount of vitamins, most notably vitamin C, minerals, and protein in addition to being a good source of energy [49]. They

contribute significantly to the diet, supplying 90% of the vitamin C, 50% of the ß-carotene (vitamin A), 35% of vitamin B_6, 20% of thiamine, 25% of magnesium, 20% of iron, and 10% of the calories and proteins, as well as the bulk of dietary fibre [50]. Green and yellow fruits are particularly rich in ß-carotene, thiamine, niacin, and folic acid. Additionally, they supply proteins, lipids, organic acids, and other compounds, while consisting of as much as 90% water [50]. Fruits also contain a significant proportion of carbohydrates in the form of dietary fibre. To maintain a balanced diet, a minimum of 85 g of fruit per person per day is recommended [51].

Ascorbic acid (vitamin C) is a vital vitamin supplied by fruits in the diet, with about 90% of a person's dietary requirement being obtained from fruits and vegetables. An average adult requires approximately 50 mg of vitamin C per day [50], which plays a crucial role in various stages of life, acting as a strong reducing agent that helps protect the body from the harmful effects of free radicals [52]. Calcium, phosphorus, iron, and magnesium are among the most important minerals provided by fruits [51].

Furthermore, fruits are abundant in a variety of antioxidant compounds, such as ascorbic acid, tocopherol, glutathione, and carotenoids, which contribute to protection against oxidative damage caused by reactive oxygen species (ROS) [6]. Antioxidants scavenge ROS, inhibit their formation, bind transition metal ions, and repair damage, thereby exerting their protective effects [53].

Certain fruits, especially wild edible fruits, have been known for their nutritional and therapeutic benefits since ancient times [54]. They are also rich in bioactive compounds, primarily polyphenols, which offer a wide range of health-promoting effects [55]. For instance, ellagic acid, a naturally occurring phenolic constituent with antimutagenic and anticarcinogenic activity, is found in fruits like strawberries [56] and other berries [57]. Additionally, fruits are generally low in fat and oil, making them important components of a heart-healthy diet to reduce the risk of coronary heart diseases [58].

1.7 AIM OF THE STUDY

In India, the utilization of wild edible fruits has been predominantly observed among tribal or backward communities scattered throughout the country. These communities heavily rely on gathering wild foods and other forest products from nearby forests for their livelihood. India, with its diverse topography and extreme climate conditions, provides favourable conditions for a wide variety of fruits available throughout the year. The North-Eastern India is endowed with enormous genetic diversity of crops plants, trees, and fruit species. Many such food resources and valuable plants are documented and still many more are to be explored. Studies based on diversity and conservation of WEFs associated with their traditional knowledge and cultural values, its utilisation, and physicochemical properties of WEFs in North-eastern India is minimal.

Manipur, a landlocked state in the north-eastern region of India, possesses varied agroclimatic conditions and diverse soil types, enabling the cultivation of a wide range of tropical, subtropical, and temperate fruit crops. Covering an area of 22.327 sq. kms, Manipur is situated between longitude 98° 03’ E and 94° 78’ E and latitude 23° 83’ N and 25° 68’ N, bordering Myanmar in the east and Chin hills in the southeast [59]. The state is characterized by a significant forest cover of 17,418 sq. km, accounting for approximately 78% of its total geographical area (Directorate of Economics and Statistics, Manipur, 2016-2017).

The rural communities in Manipur depend on wild edible fruit plants for their socio-economic sustenance, as these plants serve as a source of food, fibre, fodder, dyes, and many other subsistence requirements of the people. These wild edible fruits have been utilized by the rural population for income generation and livelihood security since ancient times. Moreover, many of these fruits hold significant ethno-medicinal properties, offering remedies for various ailments [60]. Unfortunately, the local wild fruits of Manipur are facing the risk of extinction due to deforestation and urbanization, unless proper identification and conservation efforts are undertaken.

Despite the considerable genetic diversity of local and indigenous fruits in Manipur, their current availability in the wild and their nutritional attributes have not been thoroughly investigated and documented. Detailed data on their physical properties and bioactive constituents are lacking, as well as information on their growth responses under specific agro-climatic conditions. Therefore, the aim of this study is to assess the wild edible fruit plants of Manipur, located in the north-eastern region of India. The purpose of this study is to investigate the population structure, seedling survival, growth, and phytochemical characterization of selected wild edible fruits. The study has the following specific objectives:

1. Investigation and documentation on population structure of wild edible fruit plants of Manipur
2. Study on seed germination, survival, and growth of the selected wild edible fruit plants
3. Assessment of qualitative and quantitative phytochemical properties of selected wild edible fruits
4. Identification and characterization of bioactive compounds from the potent extract of wild edible fruits

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