AROMATIC HERBS WITH MEDICINAL VALUE

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BOOKS ARCADE

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CONTENTS

CHAPTER 1

TRADITIONAL KNOWLEDGE OF AROMATIC AND MEDICINAL PLANTS

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Traditional knowledge refers to the world's indigenous cultures' encounters with their beliefs, knowledge, inventions, customs, arts, spirituality, and other cultural experiences and manifestations. Songs, proverbs, tales, folklore, local laws, common or communal property, and innovations, customs, and rituals are the principal forms of traditional knowledge. These kinds of skills are often passed down via specialized cultural systems like those already mentioned, and frequently by designated community knowledge keepers like elders, Vaidyas, and others. The information is not seen as being private to a single person or small group but rather as communal to the community.

Traditional knowledge, acquired as part of the vast human experiments for maintaining life and growth, may be technical, social, organizational, or cultural. "Traditional knowledge or local knowledge is a record of human achievement in comprehending the problems of life and survival in a very adverse environment," according to the United Nations. The goal of researching TKS, according to Laura Nader, is to "open people's minds to other ways of looking and questioning, to change attitudes toward knowledge, to reframe the organization of science to formulate a way of thinking globally about traditions." The Traditional Knowledge System is described by the United Nations as "a record of human success in grasping the intricacies of existence and survival in sometimes hostile situations. The grand human experiment of survival and progress led to the acquisition of this knowledge, which may be technical, social, organizational, or cultural. For local communities, particularly the disadvantaged, traditional wisdom serves as the foundation for problem-solving techniques[1].

Western Hemisphere Traditional Knowledge

Anthropological investigation of boundaries, power, and knowledge is called Naked Science. New York: Routledge has written on the atoll residents of the western Caribbean islands' nautical prowess. He claims that a few aspects of Caribbean nautical expertise stand out. It has all the characteristics of a useful science. It includes a tremendous quantity of discrete information that must be retained in memory since there are no written records or reference materials. Although the information is well arranged in a methodical fashion, the many ways it is organized provide a lot of redundancy that helps with memory. It uses terms like "drags," "trigger fish," and other extremely abstract concepts named after stars but detached from how stars seem to move. The various proverbs of Ghagh and Bhadduri about agricultural methods and meteorology are widely known and continue to serve as guidance for traditional Indian agriculturalists and scholars. The main distinction between western and Arctic sciences is that whereas Arctic research does not situate people in the natural world and considers them to be inseparable from it, the later systems do. One must keep in mind that Inuit knowledge is transmitted via participatory and individualized methods such as "doing," "hearing about it," and "being there."

The traditional values of resources, such as subsistence values, socio-religious values, and traditional practices of resource usage, served as the foundation for the development of indigenous systems and practices. Myths and tales are examples of our ancestors' heuristic efforts to explain the scientific discoveries they made across the globe and to pass on this information to future generations.

For instance, the stories surrounding the Satisar properly depict the whole geological history of the Kashmir basin. When the sage Vasistha attempted to drown himself, the Satluj River split into hundreds of channels, giving the Satadru its name. The traditions of Parashurama, in which he tosses his Parasu to drive back the water, and so on, were used to illustrate the late Pleistocene retreat of the sea. Rarely is it acknowledged that traditional knowledge systems maintain the wisdom accumulated through centuries of experience, firsthand observation, and oral tradition. The demand for ongoing research into traditional medical practices as used in tribal, aboriginal, and rural locations in general, as well as medicinal plants in particular, has grown significantly in recent years in order to discover novel medications for better and safer societal health care. Folktales and myths are also basically windows into our collective psyche, which is another feature of them. In India, the traditional healthcare system provides a method of support and has long been used to exercise information that has been learned from firsthand experience[2].

The study of traditional knowledge systems calls for a fair description of each system, one that does not begin with the dividing line that only western science can be seen as a knowledge-based system. The primary healthcare needs of around 80% of the world's population are met by traditional medicines. Indigenous people have observed and used plants and animals, developed sophisticated diagnoses, and other innovative ongoing experiments to create tribal remedies. These are the dynamic systems of practices that, with the right circumstances and support, may flourish. A noteworthy example of TKS is the native inhabitants of the Himalayan region's long-standing usage of traditional medicine, which the sages refined and gave scientific form. All of today's widely accepted medical procedures have developed from the traditional or folk sciences that have been practiced by humans since the dawn of civilization itself utilizing locally available plants, animals, and minerals. The local traditional medical knowledge base began to disappear as industrialization and modernity grew. Previously plentiful plants, animals, and minerals are now uncommon, and their traditional uses have also been forgotten. Patients have been compelled to switch to the allopathic medical system and system, which are more profitable and attractively marketed alternatives[3].

Advanced Science

Elite sciences or acknowledged systems of knowledge are those that are well known and widely accepted. Numerous health care systems have been in operation in India for many years. Among the many recognized medical systems, some well-known ones are Ayurveda, Yoga, Naturopathy, the Unani, Siddha, Amchi, or Tibetan systems of medicine, as well as allopathic medicine. All of these systems have as their foundation a well-known and often utilized body of folk medical knowledge.

Relationship between the Two

In the central Himalayan region, as well as other parts of the world, and mountain ecosystems in particular, the Folk medicine system has evolved over a long period of time based on needs and experiences. It is an important natural resource that facilitates development in ways that are affordable, participatory, and sustainable and plays a significant role in resource conservation. Therefore, it may be claimed that throughout millennia, these elite disciplines evolved from the Folk sciences. On the one hand, the Elite Sciences have usurped the Folk Sciences of India, and on the other, they have been portrayed as being in opposition to the Western culture that is modern, logical, and materialistic. In the West, Folk and Elite sciences are often seen as diametrically opposed and mutually incompatible. TKS and Elite sciences did, however, coexist in India in a mutually beneficial and complementary manner. The main motivation for thoroughly researching India's TKS is this. Although Charak, who wrote the Ayurveda, resided in the lower Ganga valley, he was aware of the abundance of medicinal plants in the Himalayas.

The Charak Samhita describes the whole Himalayan area as a rich mine of different therapeutic herbs. Charak has employed hundreds of Himalayan plants in the Materia Medica of Ayurveda in addition to being aware of this abundant flora. It is apparent that the indigenous medical systems must have researched and used the therapeutic characteristics of the native flora. Several significant and widespread medicinal herbs. Traditional Himalayan medicine is a prime example of TKS, which has a significant impact on the lives of the world's impoverished. Agriculture, animal husbandry, ethnic veterinary medicine, resource management, primary healthcare, preventive medicine, psychosocial care, saving and lending, community development, poverty reduction, etc. are some areas where TKS is especially relevant to the poor[4].

Himalayan Traditional Medicine System

The Traditional Himalayan Medicine System is a real-world illustration of TKS, whereby rural populations get traditional medical care for a variety of illnesses, even some which are incurable. They use these age-old techniques to treat their animals as well. These conventional techniques are entirely oral and unrecorded. They often make use of minerals, animal products, tantric activities, and botanical goods including resin, bark, roots, leaves, and fruits. Herbal items are utilized in traditional medical systems to treat illnesses using natural remedies. The following three kinds of natural remedies are divided based on how they are used:Herbal remedies utilized in organized medical systems like Ayurveda and Siddha.Herbal goods utilized in contemporary medicine, based on the active chemical principles of the herbal products; Herbal products used in ethno-medicine or traditional medicine, such as HMS based on oral tradition.

Organic Remedies

The usage of plants to heal different ailments stretches back to ancient times in India. Indigenous peoples created and transmitted their knowledge of medicinal plants and treatments orally, age after generation. Some of this knowledge was organized much later in treatise forms such as the Atharveda, Yajurveda, Charak Samhita, Sushrut Samhita, etc. These organized knowledge systems about medicinal plants and treatments are a part of Ayurveda, the Indian Traditional Medicine System. Villagers continue to use herbal native medicines to treat many common illnesses, such as cough, cold, and fever, headache, and body ache, constipation, dysentery, burns, cuts, and scalds, boils, and ulcers, skin diseases, and respiratory issues, etc. despite the development of rural health services. Household women or elderly people, Pujari, Ojhas, and traditional herbalists provide herbal remedies.

HouseholdWomen

The majority of common illnesses that affect newborns and children are treated by Indian housewives using herbal medications. They may get the herbal medications mostly from their kitchen stock, kitchen garden, village fields, and the village mart. Indian elderly housewives are familiar with the use of rhizomes of Curcuma domestica for cuts, burns, and scalds, fruits of Piper nigrum for coughs and colds, fruits of Trachyspermum ammi and resin of Ferula spp. for stomach problems and whooping cough, seeds of Sesamum indicum for ulcers and boils, etc.Traditional home remedies include the use of infusions of Ocimum sanctum leaves for coughs, colds, and moderate fever, fomentation with hot Ricinus communis and Aloe barbadensis leaves for reducing inflammation, swelling of joints, and sprains, and many more methods.

ElderlyIndividuals

The elderly, Pujari, Ojhas, priests, and others in the villages are familiar with a variety of herbal remedies that grow nearby and use them successfully and without difficulty to treat a number of common maladies and afflictions. All of their services are provided without charge.

OrthodoxHerbalists

Professional herbalists use traditional remedies. Despite being mostly uneducated, they are well-versed in the usage of herbal medicines. They have supplies of cheap medications in store and recommend them for common illnesses. The old-school herbalists run a little store. Another kind of herbalist is a wanderer. There are two subgroups among them: those who administer a ground combination of herbal remedies and those who both prescribe and provide the herbal drugs on their own. The first group of herbalists often sells their unprocessed medications on the side of the road and stores them in glass jars. They often get their narcotics from well-established marketplaces for illicit substances in Northern India. They provide medications mostly for genital diseases as well as tonics and aphrodisiacs. The tuberous roots of Dactylorhiza spp., the roots of Asparagus spp., Withania somnifera, the fruits of Tribulus terrestris and Pedalium murex, the seeds of Mucuna pruriens, Entadapursaetha, the stems of Tinospora cordifolia, the tubers of Pueraria tuberosa, and others are the most frequently observed herbal medicines with them. The second group of herbalists delivers the herbal medicines immediately, without first crushing them, and they only maintain a small quantity of crude medicines on hand to meet daily needs. They often store medications such as fruits from Terminalia chebula, T. belerica, Emblica officinalis, Helicteres isora, bark from Symplocos sp., roots from Withania somnifera, and seeds and oleoresins from other plants. Rheum spp., Aconitum heterophyllum, Picrorhiza kurrooa, Angelica glauca, Nardostachys jatamansi, and the fragrant leaves of Allium govanianum and other Allium spp. are just a few examples of the crude medications that herbalists in the highlands are often seen with[5].

Earlier forms of Folk Medicine Therapy

Indigenous folk sciences are disappearing daily as a result of urbanization, population growth, and ongoing exploitation of herbal reserves and other natural resources. There are several highly successful conventional medical systems. Some traditional remedies are also utilized to treat a number of disorders that are incurable with allopathic treatments. In order to comprehend folk medicine or no literate medical systems, some of these antiquated treatments are discussed below.

1. **Fire Treatment Damana:** In certain locations, a lit Biri is briefly placed on the carious tooth to relieve toothaches. Children's palms are burned on the dorsal side in certain regions of Kumaon with dried Bakaul leaves. The scar is there for the rest of one's life. It is thought that this therapy boosts kids' immune systems and productivity. A properly placed smoldering portion of the Baigan stem is used to cure dog bites and is said to test for rabies. Burning Ghee-batti is used to cure cuts caused by rusty iron objects, which is supposed to prevent tetanus.
2. **Ushna Sek:** Arandi, Dhatoor, Parijat, beeswax, honey, heated sand or bread, chopped lemon, salt, etc. are used to bolster sprained or hair-line shattered bones. Cold and cough remedies include orange fruit or ginger that has been roasted in hot ash. Lehsun tunicated bulb heated with mustard oil is used for rheumatism massage. Cracks that have formed along hands' nails are treated with freshly made, steaming puff bread. To cure mastitis, a lukewarm decoction of ajwain is applied with a mild massage over the mammary glands using a fine cloth. Haldi powder mixed with mustard oil is used as a hot poultice to painful feet.
3. **Aromatherapy:** "Aromatherapy is based on essential oil treatments and is appropriate for treating diseases of the nervous system and the brain." Jaundice is claimed to be cured by inhaling smoke produced by burning dried fruit from Ghiya-turai. Herbal: Sampark Chikitsa During the wedding ceremony, haldi paste is put all over the body to eliminate undesired hair and to treat scrapes, bruises, and wounds. In order to promote birth, a paste made of Gurhal flowers is administered with a gentle massage over the woman's naval. The roots of Kalihari and Apamarg are also utilized for this. To treat eye redness, pine resin is administered to the side of the eye. Additionally, this resin is used as a plaster for cattle legs with fractures. Onion bulb juice is administered to the injured area to treat the irritation brought on by honeybee stings. To treat headaches, the forehead is rubbed with the thick juice of the Gheekwar leaf. Fresh green Bichhu twig is placed to the injured areas to treat sprains[6].
4. **Metal or mineral:** On the painful area, a warm poultice of salt is placed. A sachet of salt is heated on an iron plate and gently rubbed to relieve back and waist discomfort. Fresh Haldi rhizome is mashed with Doob grass and calcium oxide powder, then dusted over

the joints that are afflicted by sprains after being heated in water. Villagers also use singraf topically to treat a variety of musculoskeletal conditions and illnesses.

5. **Suchikadaab:** Religious folks wear Rudrakhash nuts and magnets to ward off bad spirits and to regulate blood pressure. Pressure on the body is produced by massage using mustard oil.

Medicinal Plants of the Himalayas: A Unique Biodiversity

The Himalaya is endowed with a high variety of medicinal plants in addition to other natural resources. The presence of this group in this area is exceptional due to climatic and geographical variability. With a total of 1,748 species, the Indian Himalayan area is a rich source of medicinal plants. The two main uses of Himalayan medicinal plants are for domestic use by the local population and for the production of plant-based pharmaceuticals by the pharmaceutical companies. Since the former is founded on extensive traditional knowledge, the method of resource extraction from its natural environment is, for the most part, methodical. The latter, however, entails continued resource extraction from the wild with complete disregard for the state of the species. Due to their commercial worth and conservation issues, medicinal plants have received more attention in recent years. The main risks to these plants are said to be overharvesting of the rhizome and other portions for medical purposes and the ensuing destruction of natural ecosystems. The Red Data Book of Indian Plants lists seventeen Himalayan medicinal plant species as being among the most endangered.

Uttarakhand's Tribal-Folk Medicinal Plants

As ancient as human civilization itself, using plants as medicine has been associated with people. Since very early times, man has developed a bigger portion of the plants used as medicine by trial and error and selection. It is also clear that man learned more about the medicinal properties of plants growing in nature by studying how animals, birds, and other species used them to treat their maladies in the wild. These skills were passed down from generation to generation. The traditional understanding of herbal treatments contains the foundations of several indigenous systems. Due to the development of modern medical systems over the last several centuries, the widespread knowledge of herbal remedies, particularly in isolated and tribal places, is gradually being lost. Because of the accelerating change in life styles brought on by access to modern developments and the propensity to toss out traditional norms and values, it is imperative that such knowledge of the use of plants for medicinal purposes passed down from generation to generation, particularly by the tribals and people living in remote areas, be documented before it is lost forever. It has been noted that the advancement of civilization is damaging both the environment and culture, and that contemporary society may succumb to its own advancement. Furthermore, it is necessary to document how the knowledge of plant medicinal applications developed among rural communities, indigenous groups, and residents of isolated places. Naturally, the enormous knowledge of the therapeutic applications of medicinal plants is passed down to Uttarakhand, which is a treasure trove of medicinal plants. Several significant traditional tribal medical claims. Around 80% of people in underdeveloped nations, according to a World Health Organization estimate, rely on traditional medicine for their basic healthcare requirements, a large majority of which entail the usage of medicinal plants[7].

Challenges

In certain societies, traditional medicine has been practiced for thousands of years. There are various difficulties when new populations embrace conventional medical practices. Different cultures and geographical areas have adopted traditional medical practices without a corresponding advancement in global standards and assessment techniques.

National legislation and rules

National policies for conventional medicine are uncommon. Due to differences in definitions and classifications of traditional medicine treatments, it is challenging to regulate traditional medicine items, practices, and practitioners. The distribution of products internationally and the disparity in regulations at the national level are both impacted.

Quality, efficiency, and safety

There is little scientific data based on tests conducted to assess the efficacy and safety of traditional medicine goods and practices. Quality of source materials and handling of components throughout manufacturing processes determine the safety, efficacy, and quality of final herbal medicine products.

Sustainability and knowledge

Wild plant populations and farmed medical plants are used as sources of herbal ingredients for goods. To maintain traditional medicine, efforts must be made to conserve both plant populations and knowledge of how to utilize them as medicines.

Usage and patient safety

Many individuals think that just because a remedy is herbal or traditional, it must be safe. In addition to improved training, cooperation, and communication between conventional and nontraditional medical practitioners, it is crucial that patients be made more aware of safe use[8].

WHO reaction

The use of conventional medicine in healthcare has been supported by WHO and it's Member States. In order to assure the safety and quality of the goods, methods, and providers, it primarily attempts to: Support and integrate traditional medicine into national health systems. In order to increase access to care, preserve knowledge, and improve quality, it is important to: Ensure the use of safe, effective, and high-quality products and practices; Recognize traditional medicine as a component of primary health care; and Ensure patient safety by improving the expertise of traditional medicine practitioners.

IPR and traditional knowledge

Concern about the acceptance of traditional knowledge as previous art has been voiced recently. When compared to the relevant previous art, patents have been awarded for conventional knowledge-related discoveries that did not meet the criteria of originality and inventive step. This prior art was made up of conventional knowledge that the patent-granting body was unable to distinguish during the examination of the patent application.

Turmeric

Turmeric is a ginger family plant that produces saffron-colored rhizomes that are used as a spice to enhance Indian cuisine. Due to its special qualities, it is also useful as a color dye, cosmetic, and pharmaceutical component. It has historically been used as medication to treat burns and rashes. Two Indian immigrants working at the University of Mississippi Medical Centre in Jackson were given a US patent in March 1995 for the use of turmeric to treat wounds.

The US claim Office received a lawsuit from the Indian Council for Scientific and Industrial Research disputing the claim on the basis of "prior art," or already known information. According to the CSIR, turmeric has been used for hundreds of years to treat wounds and rashes, thus its usage as medicine is not novel. An old Sanskrit book and a 1953 study from the Journal of the Indian Medical Association were also provided by CSIR. The patent was revoked by the US Patent Office after it sustained the objection. The novelty requirements were not met in the instance of the turmeric. The main danger to the existence of many communities today is the emergence of new technology and the new usage of traditional knowledge-based goods. Today, without the communities' consent or the sharing of revenues, the contemporary cultural industries and industrial sectors commercially exploit traditional knowledge-based goods. This is unequivocally shown, especially in the fields of agriculture and medicine. The bio-prospecting aids scientists in contemporary pharmaceutical research labs in learning how to create new goods or find new applications for old ones. Traditional knowledge is inevitably an intangible component of a biological resource and is often related with biological resources. While some nations believe their current IPR framework protects this kind of information, others do not have particular laws safeguarding it. It is necessary to create a regional strategy to safeguard folklore and other traditional knowledge that is connected to biodiversity, including information linked to agriculture, medicine, and the environment[9].

International Projects

The Convention on Biological Diversity is the first treaty to recognize the importance of indigenous and local populations in the preservation and sustainable use of biodiversity. The Convention lays forth broad requirements for the preservation, ethical distribution of benefits resulting from biodiversity, sustainable use of that biodiversity, and information exchange. Each party must work to create national legislation that: Respects indigenous and local communities' knowledge, innovations, and practices that embody traditional lifestyles important to the conservation and sustainable use of biological diversity; promotes their wider application with the approval and involvement of those who hold those knowledge, innovations, and practices; and encourages the equal treatment of all people under the law. Parties to the CBD are also required to safeguard and promote the use of biological resources in accordance with long-standing customs that are in line with standards for conservation or sustainable use. Create and use indigenous and conventional technology in order to achieve the goals of this Convention. The CBD recognizes States as the proprietors of the natural biological resources in their territory, including their genetic resources, and grants them the sovereign right to use such resources and control who has access to them. According to the CBD, States must make it easier for people to use biological resources, share the benefits that result from their use, and require prior informed permission under mutually agreed-upon conditions for all access.

Folk wisdom and indigenous systems serve as the foundation for traditional knowledge of medicinal and aromatic plants. A valuable natural resource is the system of top science and traditional medicine. Traditional Himalayan medical systems, which include natural systems, old people, and herbalists, are a live example of traditional knowledge systems. Fire treatment, heat therapy, and sampark chikitsa are examples of traditional folk therapies from long ago. As ancient as human civilizationit are Himalayan medicinal herbs and tribal traditional medicines. International variety, policy, safety, knowledge, sustainability, and WHO response are challenges facing traditional medicinal plants. For traditional knowledge systems of aromatic and therapeutic plants, a patent is also necessary. The CBD is the first international accord for the sustainability of indigenous systems and biodiversity[10], [11].

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CHAPTER 2

THREATS TO MEDICINAL AND AROMATIC PLANTS AND SUSTAINABILITY

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We utilize plants, plant components, and plant extracts on a daily basis. The WHO has created a list of more than 21,000 plant species that are utilized in medicine all around the world. They have diverse uses, including as food, medications, coloring agents, detergents, fragrances, and in the cosmetics sector. More than 75 percent of people throughout the globe get their main medical care from local doctors and traditional medications. They provide thousands of individuals throughout the globe a means of support and access to healthcare. The rebirth of public interest in plant-based treatment and the quick growth of the pharmaceutical industry forced a rise in the demand for medicinal plants, which led to overexploitation that put many medicinal plants' existence in danger. However, 15,000 species of medicinal plants are under peril on a worldwide scale due to factors including habitat loss, overuse, invasive species, and pollution. Gene pool depletion affects a lot more people. Governments must support a revised and updated Global Strategy for Plant Conservation that seeks to stop the ongoing loss of plant variety in order to protect this priceless natural resource. Further, since more than 90% of the plant raw material used in India's herbal industry comes from natural habitats, the danger to natural populations of medicinal plants has intensified. It should come as no surprise that the scientific community and business organizations are paying more and more attention to wild plant species utilized for medical reasons. While doing so, these species help local and indigenous tribes, who have used them for ages in traditional treatments[1].

Three Sustainability Dimensions

Regarding medicinal plants, sustainability may be divided into three categories:

Economical

The first focuses on enhancing human health at a fair price. Human health is supported globally by the use of plant medicines. They are extensively safe, very useful, and receiving more and more research. Pharmaceutical medications often have toxic effects, dangerous side effects, and even lethal outcomes. So, the first and most important part of sustainability is to provide natural plant medications that are safe, efficient, and affordable so that they may be utilized instead of more harmful pharmaceuticals.

Environmental

The environmental effect of medicinal plants is a second aspect of sustainability. It is possible to cultivate and harvest wild species in methods that do not harm the environment and may even increase soil fertility and other aspects of environmental health. The natural environment may be kept diversified, healthy, and flourishing via the use of organic agricultural techniques and well planned ways of harvesting. Environmental law often regulates or limits the usage of wild species. Local agricultural communities are unlikely to be aware of relevant rules or regulations, nevertheless. In order to ensure that local communities, individuals, local government, traders, agricultural extension officers, air officers, conservation agencies, industry, and consumers have a greater understanding of the laws affecting the plants that are consumed or harvested, action must be taken in the form of awareness campaigns or education programs. Observance of local, national, regional, and international treaties, conventions, and agreements Native Americans and traditional traditions are a third aspect of sustainability and medicinal plants. As these individuals are uprooted and forcedly assimilated into humanity as a whole, we are losing cultural, linguistic, and cognitive variety all around the planet. Native and traditional people gain economic power when equitable salaries are provided to them.

As a result, people may be better equipped to defend themselves against invasion and aggressive tactics used by mining, petroleum, agricultural, and other industrial enterprises, as well as maintain their customs and cultures and earn a living via activities that are in keeping with their history. These persons can thrive if humane procedures are followed. Ownership of the land and the resources, whether community or private, must be clearly recognized if the potential of wild plant resources is to be explored and utilized responsibly by local farmers. If land tenure is shaky or unclear, farmers have little motivation to participate in development efforts. A lot of rural families, particularly those with limited land of their own, depend on common property areas for harvesting wild plants or plant products that support their household economics and agricultural output.

In addition to providing job possibilities for individuals without land, small farmers, farm laborers, and women and children, common lands also support those without land, small farmers, and farm laborers. The distribution of property rights is a significant problem for local communities and has an impact on how they feel about home gardens and wild harvests. Property rights must be given to the gatherers in the event of wild medicinal plant collecting, provided that laws reinstating sustainable methods are observed, to ensure long-term utilization of the resource. However, the rights must be distributed to the community as a whole rather than to specific people via negotiated agreements with groups of traditional healers or community leaders who may be crucial in regulating or overseeing resource usage.

Current Situation

Many wild species, including many that are utilized by farm families, are endangered with local or complete extinction as a result of habitat loss, fragmentation, or degradation. It is difficult to estimate the numbers, however the 1997 IUCN Red List of Threatened Plants includes 33,370 species that are at least somewhat endangered, or around 11% of all documented species. While certain species are in immediate danger of becoming extinct, local populations of species are considerably more often under peril. Since the household's area of operations for farming and wild collecting is often constrained, these local extinctions affect farm families more than the state of the species in question as a whole. Additionally, since local people have adapted to their own environment, alternatives are often ineffective or inadequate for the region. In Africa, traditional medicine is used for basic healthcare by 80% of the population. In Nepal alone, 323,000 families rely on the sale of wild medicinal herbs for a portion of their income. Worldwide, more than 8000 MAPs with therapeutic and industrial applications have been systematically compiled. Unfortunately, a number of issues are threatening the basic base upon which the species of medicinal and aromatic plants as well as the conventional healthcare system depend. Over the last 10 years, the pace of deforestation has grown by 50%. There are now 6.9% of the world's landmass and between 10.9 and 11.8% of the original cover of intact forests, according to estimates. The habitats of naturally occurring MAPs are shifting as a result of threats. Furthermore, the current intense pressure of the unorganized market would negatively impact the health care delivery system since the bulk of the rural poor rely on traditional medicine for their medical requirements. Without immediate action, significant plant species will be lost to deforestation[2].

Many MAP species are now being harvested at amounts that are substantially below what is sustainable. It is also clear that certain species are being used in ways that are not sustainable. Seven are endangered, 49 are vulnerable, and eight are uncommon of the 227 MAP species that are traded. Despite the fact that the resource assessment identified species that are "at risk" based on the present market scenario, it is crucial to keep in mind that the demand for a certain species might increase substantially in a short amount of time, placing species that are now thought to be safe at danger. Therefore, buyers that are particularly focused on exports can raise their demand for raw materials and so put more pressure on plant populations. This might make unsustainable harvests more likely. Collectors overextend themselves in order to provide for their families due to the high demand and poor prices for the herbs they gather. There is widespread worry about the loss of plant variety. The foundational elements of whole ecosystems are vanishing one by one. The number of plant species that are endangered is progressively rising, according to the 2008 IUCN Red List. There are 8457 vulnerable plant species, 247 of which are located in India's several biodiversity hotspots. Many of them are essential components of regional agricultural production systems and serve as sources of food, fuel, fiber, lumber, medicine, etc.

Dangers to MAPs

A threatened species is one that is thought to be significantly at danger of becoming extinct in the near future owing to stochastic, deterministic, or a mix of the two causes that are impacting its population, or because of its intrinsic rarity. What constitutes a considerable amount of risk and what portion of the future is predictable are two concepts that are difficult to define. Threatened species provide problems in science, business, and ethics. Scientific, since the loss of these linkages would disrupt the evolutionary chains that help us understand the origins of plants. Economic, since these species or at least some of their genes might be valuable in the future, if not right now. Moral, since human behavior that led to the loss or endangerment of an element of nature and a fellow being is to blame. The 1992 Stockholm United Nations Conference on the Human Environment and the International Union for Conservation of Nature and Natural Resources played major roles in raising public awareness of the issue of the danger, depletion, and extinction of plant species.

The latter was crucial in the formation of the Threatened Plants Committee, whose goal was to solicit the assistance of plant specialists from across the globe in gathering information on endangered plant species, their location, and their preservation. During the 1960s, Sir Peter Scott independently invented the Red Data Book idea. According to the severity of the risks they face and the predicted imminentness of their extinction, the Red Data Book classifies species at the threshold of risk. Each species included in the RDB is given a threat category based in large part on a study of the causes impacting its existence and the degree to which these variables have an impact throughout the concerned species' distributional range. Changes in distribution pattern and range, danger level and kind, population biology, etc., are important factors. The danger categories given to species at the national level should not be confused with the IUCN Red Categories, which are applied to species on a worldwide basis[3].

Accountable Elements

The numerous factors that contribute to the extinction of medicinal plants may be divided into five categories: overkill, habitat loss, the effects of weeds that are introduced but subsequently spread and become invasive, pollution, and secondary losses. Overkill refers to the unchecked, intentional collecting and eradication of plants. Numerous planned land conversion activities, including agriculture, habitation, building of roads and dams, industrial development, gravel and sand mining, wetland draining and filling, slash-and-burn, tourism, etc., may result in habitat degradation. Habitat damage may also be a result of desertification. Introduced pests and invasive plants damage ecosystems by displacing native species and altering biogeochemistry, fire patterns, erosion, geomorphology, hydrological cycle, and community structure. Other changes brought about directly or indirectly by exotic invasive organisms include changes to the water table, animal trampling and overgrazing, herbivory by smaller animals, unwelcome competition between the introduced and native organisms, diseases and predation, and the disappearance of symbionts, pollinators, and dispersers. There are many potential sources of pollution, most of which are human-generated. Pollution of the land, water, and air may adversely damage ecosystem components. A combination of two or more of the aforementioned variables may result in secondary losses. Threats to MAPs are mostly caused by habitat loss, fragmentation, and degradation[4].

The Antiquated Plant We Can Still Use

We may take the history of the weed silphion, which was previously employed as a contraceptive, as an illustration of the value of protecting medicinal plants. It seems to have been so successful that the Greeks practically adored it. Now, a plant like this may be of enormous consequence given the population increase that seems to be out of control. Unfortunately, it became extinct because the Greeks utilized it so extensively. The Silphion plant's image was engraved on the bulk of the coins made in ancient Cyrene, a city-state located in what is now eastern Libya, between 570 and 250 BC. This illustrates the huge economic impact this facility had on the city over a four-century period.

The fresh, edible perennial roots and heavily ribbed annual stems of the Silphion plnat were used as a spice, flavoring, and scent. The juice was used as a remedy for a variety of signs and conditions, particularly gynecological disorders; it was a real "multi-purpose species" in the context of contemporary commercial botany. It seems that the arid hinterland is where Silphion was first discovered. It seems that attempts to produce it were unsuccessful, therefore wild plants were still the major source of food. Although overharvesting is thought to be at least one cause of the resource's eventual extinction as an economic resource, no explanations for its disappearance have been presented. What we have is a case of an old medicinal plant being overharvested to the point of extinction. Both the potential income from using plants and the potential danger and failure from overharvesting are reflected in Silphion. Overharvesting and overexploitation: The radial depletion of woody plants around towns or settlements, particularly those utilized as fire wood or for medicinal reasons, is a defining pattern of resource exploitation by many traditional agricultural societies. When the poorest people of the society are forced to go longer or pay more for fire wood, plant materials for building and craft projects, and medicinal plants, this pattern of depletion may have major social repercussions. The demand on natural resources has increased as more urban residents continue to use conventional plant-based treatments. As a result of unsustainable harvesting methods like decortications, some species now face a major danger of population decline and genetic degradation[5].

Additionally, it has been stated that a lot of medicinal plants are under danger as a consequence of unethical business methods by pharmaceutical firms, such as ordering the harvesting of enormous amounts of plant material without taking population sustainability into account. Market demands might sometimes induce overharvesting. There is a commonly held belief that plants that are foraged from the wild are more potent than those that are grown. This concept is sometimes used as a marketing plan. However, it may have the effect of enabling producers to set greater prices. The continual removal of species from the wild for which there is a marketable demand may result in genetic degradation. This is true for a number of species, including Aquilaria spp., which has been recorded from several regions of its range, including India and Vietnam. It is one of the most important non-timber forest products in Asia. Oleoresins are used to dye the fungus-infested wood, and the oil they produce is utilized to make incense, perfume, and certain traditional remedies.

There is a significant demand from the Near Eastern nations, and there is evidence of illicit commerce. Climate change Different plant species will react to climate change in different ways. Some species will persist while using plasticity or selection to adapt to altered environmental circumstances. Other species will relocate to latitudes or elevations that are higher. A few species could become extinct. As a result, the makeup of plant communities will change, new communities will form, and some communities will vanish. The disruption of food webs and co-evolved mutualisms, such as the interactions between a plant and its pollinator or seed disperser, is one of the main concerns of this community reorganization. Both species may become extinct if dependent species no longer co-occur in the same place at the same time. Invasive species, diseases, and pests may expand their ranges, placing additional strain on already vulnerable populations.

A higher emphasis for conservation will be given to preserving biodiverse communities. There are three main options for species in a period of fast climate change: 1) move to suitable environmental circumstances, 2) adapt to the new environmental conditions, or 3) become extinct. 'Weedy' species with short reproductive cycles and broad ecological tolerances are more likely to adapt or move quickly in a changing environment and are more likely to thrive. The danger of extinction is more likely to affect conservative species with strict habitat needs or lengthy generation periods. Approximately one-fourth of all vascular plant species are now threatened in the wild. As many as half of all plant species might disappear over the course of the next century due to expected temperature rises, altered hydrological cycles, and other effects of climate change. Given the significance of plants to earthly life, this is a terrible situation. Although data on plant extinctions directly linked to climate change have not yet been published, monitoring plans may now be built thanks to baseline data being gathered on the distribution, threat status, and ecology of different plant groupings. Plant species that are only found in high-risk settings, such as island or coastal habitats, are likely to suffer from climate change first. To guarantee that alternatives remain accessible for the future, effort on plant conservation has to be stepped up right now[6].

Invasive and Newly Arrived Species

The purposeful human introduction of species, such as trees and fodder crops, which have essentially supplanted the original ecosystems, poses one of the biggest hazards to natural and semi-natural vegetation and is often disregarded. A hazard to productive systems might also come from introduced species. Examples include the trees and shrubs that were introduced into the incredibly diverse Fynbos and Daroo formations of South Africa, which have had a devastating impact and put more than 50% of the component species at risk. Since the 1840s, introduced tropical grasses have become major agents in facilitating deforestation in Central and South America. A number of temperate and tropical grasslands, including those in Australia, California, Africa, Central America, and South America, are negatively impacted by foreign invading species.

Numerous healing plants are already uncommon, endangered, or in risk. The "precautionary principle" also applies to individuals whose status is now unknown and to certain gene pools. To guarantee that the 540 species of highest importance in the major classical systems, as well as those supplied to the international market, are protected in ex-situ reserves, it is urgently necessary to consolidate and formally link the existing herbal gardens and gene banks, as well as reference specimens in herbaria. Strategic planning is required since the spectrum of germ-plasm collected for each species has to be representative. To become collections of genetic resources, plant collections must advance beyond being collections of species references.

Long-Term Strategy

In order to meet the demands of industry for consistent and reliable material supplies and to relieve some of the pressure on medicinal plants originating from natural ecosystems, the low number of medicinal plants currently being cultivated should be increased. The market must choose which plants are chosen for cultivation. About 16 species now have commercially viable variants, the majority of which are grown for export. To choose better genotypes of many more species, much more work has to be done. In order to build high quality plant supply systems, it will be required to make considerable use of the nation's network of nurseries and gardens. Increased information sharing with farmers should include agricultural extension groups, since they are their main point of contact. Promoting ethical, sustainable wild-harvesting is important since current wild-harvesting methods are very unsustainable and are likely to stay that way. The absence of any land rights law, which would have given local populations access to and some degree of control over their resources, is a significant contributing element to this predicament, as is the lack of appropriate knowledge and of pertinent scientific techniques. As a result, it is necessary to provide recommendations and incentives for sustainable wild-harvesting in addition to remedies to these limitations. In addition, a look at the networks of dealers and the amount of illicit trading implies that the main requirement could be the dissemination of socio-economic and market information. On the basis of an awareness of the existing distribution of medicinal plants, it will be required to create innovative strategies for their in-situ conservation and to designate certain genetic reserves. Both wood species and wild relatives of agricultural species are included by this action. It could be necessary to change current government policies regarding protected areas in order to make room for these species. Given that medicinal plants may be used to generate money and restore damaged lands, implementing Joint Forest Management plans in these places would be the sensible course of action. The strategy used should take into account current programs launched by organizations like the Medicinal Plant Conservation Areas Network and other NGOs. These in-situ conservation zones should also be used for other purposes, such as teaching and awareness-raising as well as training in sustainable harvesting techniques[7].

Providing Missing Information

Availability of Resources: For the creation of policies and plans, it will be crucial to comprehend the real distribution of the resources and to investigate their genetic variety. A research framework has to be created since this is a lengthy procedure. Market conditions for certain crops: The absence of socioeconomic information is the other significant information gap. It will be crucial for cultivation efforts to determine which medicinal plants are in the most demand and are appropriate for production, in cooperation with local industries. The demand for and possible profitability of plants must be determined in the initial phase, which is crucial. Additionally, study will be required to determine how market connection may be formed in order to evaluate the benefits to the producers before the plants are introduced into agriculture. There is a sizable gap here that has to be filled.

Agro-Technical Packages for Farm Forestry and Intercropping

Agro-technical packages for culture and propagation need to be designed for the indicated plants of significant commercial importance. In general, the majority of medicinal plants have only been grown as a single crop in certain ecological zones.

As has already been done for the major species cultivated for export, farm forestry and intercropping systems will need to be developed, and there will need to be a shift to a more farm-centered approach that acknowledges that in most cases, medicinal plants will only constitute one of many crop types adopted by farmers.

Considerations for Policy

There are two areas where policy has to be reevaluated: first, in terms of giving locals authority over resources, and second, in terms of how it will be put into practice and enforced. Policies usually lack review and follow-up in this second area. As a result, for instance, the Forest Policy, which asserts tribal rights to forests, has not yet received official sanction through the passage of Acts, and many of the allegedly regulated plant species have not been identified in manuals, making it impossible to determine and, as a result, prohibit their collection. Additionally, it may be beneficial in certain circumstances to alter the forest policy, which prohibits the use of forest areas for any kind of agricultural activity, to permit the growing of medicinal plants in farm and agroforestry systems. Consistent with conventions the resource basis of medicinal plants is covered by a number of Conventions. CBD and CITES are two clear examples. The latter has several policy ramifications for the industry of medicinal plants. These should be settled such that no country becomes monopolistic and that it acknowledges its interdependence with other nations. Any country will continue to gain from advancements achieved in the study of medicinal plants in other nations due to the substantial representation of introduced materials among the exported raw plant resources[8].

Guidelines for Sustainable MAP Use

We must not disregard the significance of protecting wild plant resources, such as medicinal herbs. Numerous people rely on medicinal plants for their food and medical treatment. Additionally, they are essential to the preservation of whole habitats, which support robust, healthy ecosystems and may lessen the consequences of climate change while also assisting in the fight against critical issues like soil erosion and floods. A reliable management and monitoring system must be established in order to ensure the sustainable usage of wild plants in the area. The Forest and National Park Service, collectors and collectors' organizations, and scientific programs should work together to complete it on three levels. Given the danger to naturally occurring MAPs, a number of actions should be done, including: Reasonable and systematic collection. Sustainable collecting is possible if it is done properly, with suitable harvesting methods and post-harvest care that benefit both the collector and the local processor and provide incentives for species conservation for future collection.

Lessening of the collecting pressure. Whether on a little or big scale, in a personal garden or for sustenance, cultivation may ease the demand on MP gathering in the wild. Only with the appropriate authorization in accordance with national and/or international regulations may medicinal plants that are protected by national and international legislation, such as those classified in national "red" lists, be gathered. It is necessary to adhere to the rules of the Convention on International Trade in Endangered Species of Wild Flora. It is necessary to carry out medicinal plant cultivation, collection, and harvesting as well as post-harvest processing of medicinal plant materials in accordance with all applicable laws, environmental regulations, and ethical standards in the community and nation where the activities are taking place. It is necessary to adhere to the rules of the Convention on Biological Diversity. It is important to maintain wild-collected medicinal plants and their habitats together with efforts to preserve forests and farms. Indigenous and local populations must be involved in the conservation of medicinal plants since they are the ones that understand and appreciate plant resources the best.

Support the "forest farming" of species for which there is no commercially available raw material. Approximately two-thirds to three-quarters of the therapeutic plants on the market are still mostly derived from wild populations. Avoid introducing and cultivating non-native plants that might endanger the ecosystems and native flora. Be alert for indications of rising demand for and/or declining availability of species derived from natural sources. Use alternative plant components that are renewable and that adhere to your requirements for medical effectiveness and safety if demand for this species exceeds supply. Before gathering plants from the wild, one should be aware of the biological and ecological restrictions that each species faces. Plants should not be harvested too early in the growing season so that they can bear fruit and produce viable seed for replanting. Likewise, a number of healthy plants should be left in a patch or stand to regenerate, and only those parts of the plant that can be harvested without destroying the plant should be used.

Aside from the effects of trade, there are additional factors that endanger the supply and quality of medicinal plants from which so many of us get therapeutic and financial benefits. The loss of excellent habitat and the introduction, invasion, and proliferation of alien species that outcompete and suffocate local medicinal plants are a few of these problems. Another factor in the decline of biodiversity is poverty. Programs for conservation cannot be effective in a nation where poverty is widespread. Without obvious connections between measures to increase food security for the large and expanding populations of low-income, food insecure people, the overexploitation of wild medicinal plants cannot be stopped. In order to protect regions with a high biodiversity and consequently enhance the natural resource assets of rural communities, efforts should be undertaken to organize local residents.

A broad-based, long-term plan for the protection of globally endangered species may be developed by including locals in conservation efforts. All plant species' gathered quantities are registered and controlled, together with standard information from collectors on the collecting area and estimates of population densities, conservation status, and vulnerability. Scientific and professional studies should conduct thorough population monitoring of endangered species and species with questionable conservation status; testing and oversight of harvesting techniques may be required for thorough monitoring to identify changes in the vegetation[9].

Wild gathering has increased as a consequence of the rising global demand for medical plants and the uncontrolled medicinal plant trade. This often occurs in conjunction with damaging harvesting methods, excessive exploitation, and unregulated trading. In areas where habitat loss and habitat change are serious risks to medicinal plant species, destructive harvesting and overexploitation are not the only challenges facing medicinal plant species. Another issue that is often linked to increasing usage of natural resources and greater trading in endangered species is economic instability. Harvesting and trading may be advantageous for the local economy and ecosystem preservation if they are sustainable and under control. A workable strategy to persuade people to maintain their natural resources and simultaneously reap economic rewards is sustainable wild gathering mixed with fair trade.

International labels must thus include sustainable wild gathering standards in their certification programs. There is an urgent need to raise awareness of and demand for goods that have been fairly and sustainably harvested, particularly in importing nations. This must be a job shared by a variety of parties, including governments, legislators, merchants, processors, consumers, and development and environmental NGOs. Thus, sustainability may raise locals' knowledge of the need of protecting species and their habitats. Worldwide, cultures place a great importance on medicinal herbs. In the next ten years, it is crucial that we strive toward sustainable resource extraction, both for the sake of environment preservation and the welfare of the indigenous local populations who rely on those resources. Their long-term future would be secured by this new strategy[10].

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CHAPTER 3

MEDICINAL PLANT RESOURCES OF INDIA

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Plants have been utilized for food, medicine, and shelter since the beginning of time. Plants have been used as medicines for as long as human civilization has existed. The Sumerian herbal from 2200 BC contains the first known written description of a medicinal plant. Greek physician Hippocrates listed 400 commonly used plants in the fifth century BC. In the first century AD, Dioscorides used 600 plants to create a herbal that would later serve as the foundation for several other works. Herbs have been utilized for countless years for a variety of things, including treating the ill and disabled. The majority of people still utilize a variety of herbs for their health-related advantages. Herbs were believed to keep the body in harmony with nature. Numerous scientific investigations are currently ongoing, with current research following the example of traditional folklore and herbal usage to aid in the discovery of novel western medicines. The effects of herbs on the body, mind, and emotions have also been known to man. Over 80,000 of the 2, 50,000 higher plant species that exist on Earth are crucial for medicine.

India, home to more than 45000 distinct plant species, is one of the world's 12 biodiversity hotspots. With 16 distinct agro-climatic zones, 10 different vegetation zones, 25 biotic provinces, and 426 different biomes, India has an unrivaled variety. About 15 000– 20 000 of these plants have considerable therapeutic potential. However, traditional societies only utilize 7000–7500 species for their therapeutic benefits. Herbal remedies have long been a part of traditional medical practices in India, including Unani and Ayurveda. About 700 species are used in the Ayurveda system of medicine, along with 700 in Unani, 600 in Siddha, 600 in Amchi, and 30 in contemporary medicine. The medications may be made from the whole plant or from various parts of it, such as the leaves, stem, bark, roots, flowers, seeds, etc. Some medications are made from excretory plant materials including gum, resins, and latex. Even the Allopathic medical system has included a number of plant-derived medications[1], [2].

Indian Tradition The usage of medicinal herbs dates back roughly 4,000 years in India. Millions of people still rely on this tradition, which has two streams the codified system and the folk system—all over the nation. Folk system is used in ethnic groups all around the nation. It has been passed down verbally from one generation to the next. Tibetan, Siddha, Unani, and Ayurveda practices are among the codified systems. All of these medical systems depend on plants inextricably for the treatment of diseases, recovery from illnesses, and maintenance of a healthy lifestyle. About 1400 plants are included in different sources related to Ayurveda. We can locate more than 600 plants in the Charaka Samhita, Sushruta Samhita, and Ashtang Hridaya. Perhaps the first text to discuss therapeutic plants is the Rig Veda. The much contemporary Atharva Veda also discusses the medical use of several plants. From a pharmacological perspective, knowledge on therapeutic plants is provided in another literature called Dravya Guna Shastra. Similar to other Indian medical practices, Unani is heavily reliant on medicinal herbs. The rising understanding that natural products are non-narcotic and virtually side-effect-free is a key reason in the popularity of herbal-based formulations. The Indian medical systems place a lot of emphasis on eating a balanced diet and include certain ingredients in meals to boost immunity.

Additionally, a variety of plant compounds having therapeutic qualities are dietary ingredients. For instance, the emphasis in all of these systems is on the fiber and roughage in diet. It is now established that eating insufficient fibre leads to constipation, which in turn causes a host of issues, including cancer. In a similar vein, include fruits and vegetables in your diet every day has been highly advised. Modern science has shown its effectiveness as a source of vitamins, minerals, and other nutrients that may fend against illnesses and infections. Even spices have been shown to have therapeutic qualities. For instance, it has been shown that foods like capsicum, garlic, turmeric, onion, ginger, black pepper, cinnamon, and curry leaf may both prevent and treat numerous illnesses. Plants are employed for both their medicinal and dietary and nutritional worth in the traditional system. Many plant items from the wild or their environs are used by people who live in or near woods and rural regions.

People have been living generally healthy lives as a result of this long-standing tradition, despite the fact that their diets are still lacking due to poverty and other associated circumstances. Bael, for instance, grows naturally in woods and adjacent to populated areas. Its pulp has been used by people as a dietary supplement. It is abundant in tannins and mucin, according to contemporary study. It has a powerful laxative effect and is very nourishing. The fruit pulp treats conditions including giardiasis, dysentery, and diarrhea. Additionally, it strengthens the heart, liver, and stomach. Amla has also been used in chutney, pickles, murabba, and other dishes. It is listed as the most effective revitalizing agent in the "Charaka Samhita." Modern research has shown that amla is very rich in vitamin C and pectin, with more than 150 times the amount of vitamin C found in apples. The fruit also contains tannins, which protect against vitamin C deterioration during preparation and storage. Amla pectin protects the heart by lowering blood cholesterol and preventing platelets from aggregating. The fruit aids in the production of blood and contains lipolytic characteristics that treat indigestion, hyperacidity, and liver diseases. Amla works well as an anti-aging supplement. It swaps out used tissues with fresh ones.

Tamarind is another appropriate illustration. Sauces, chutneys, curries, and other dishes all utilize tamarind. Fruit pulp is also eaten in this manner. Fruit that is still green is used to season cuisine. Pulp contains significant amounts of iron, calcium, potassium, phosphorus, riboflavin, thiamine, niacin, and other vitamins and minerals. Green fruits provide a significant amount of vitamin C. Fruit and other tree components have been shown to contain glycosides and certain alkaloids. Similar protection has been offered by the usage of dietary ingredients like onion, garlic, turmeric, ginger, etc[3].

Herbalism

The plants, which may be utilized in whole or in part for culinary dishes, nutritional supplements, or as a cosmetic or coloring agent. You may get fresh herbs and medicinal plants by foraging for them in the wild, cultivating them in your own garden, or purchasing them from other gardeners and health food shops. It seemed like infectious illnesses were extinct with the germ theory of disease and the development of medicines to treat different infections. Herbalism and traditional treatments are regaining popularity as people become more aware that chemical medications are not necessarily "magic bullets" and may have negative side effects. Our current task is to make sure that valuable botanicals are plentiful for future generations. Herbs may be prepared in a variety of ways for both ingestion and use in therapeutic treatments.

Herbs are known as infusions when they are prepared by steeping in hot water to be consumed as a tea. These dried herbs are known as decoctions when they are boiled in boiling water. These are regarded as herbal ointments if they are combined with additional ingredients and turned into cream. Sometimes a piece of fabric is soaked in an infusion or decoction, wrapped, and used as a herbal compress. Herbal wash is the term used for herbs that are used topically to cleanse and heal. Additionally, herbal baths for healing and relaxation may be made from herbal infusions and decoctions. Always adhere to the suggested doses on your preparations and recipes as utilizing herbs excessively might have the opposite effect of what you are trying to achieve. Even the healthiest plants may become harmful if taken excessively. The Indian Parliament approved the Indian Medical Central Council Act in 1970 with the intention of standardizing Ayurvedic education requirements and establishing certified schools for the discipline's study and investigation.

More than 100 institutions in India provide degrees in conventional Ayurvedic medicine. The leading organization for the promotion of traditional medicine in India is the state-sponsored Central Council for Research in Ayurveda and Siddha. This institute conducts research in the fields of clinical, pharmaceutical, literary, and family welfare. The standard five-and-a-half-year program of graduation is the Bachelor of Ayurveda, Medicine & Surgery degree. It covers eighteen different subjects, including physiology, pharmacology, pathology, modern clinical medicine, clinical surgery, pediatrics, as well as subjects on ayurveda, such as Charaka Samhita, history and evolution of Ayurveda, identification and usage of herbs, and ayurvedic philosophy in diagnostics and treatment. It also includes courses on anatomy with cadaver dissections, physiology, and pathology[4].

Higher Plants Used in Modern Medicine

New medications are developed in large part thanks to medicinal plants. Between 1950 and 1970, almost 100 novel medications based on plants were launched to the American market, including those derived from higher plants, such as deserpidine, reseinnamine, reserpine, vinblastine, and vincristine. Ectoposide, E-guggulsterone, teniposide, nabilone, plaunotol, Z-guggulsterone, lectinan, artemisinin, and ginkgolides were only a few of the novel medications that surfaced globally between 1971 and 1990. Between 1991 and 1995, 2% of medications were launched. Modern treatments have greatly benefited from the use of plant-based medications. For instance, the 1953 isolation of serpentine from the root of the Indian plant Rauwolfia serpentina marked a major advance in the management of hypertension and the reduction of blood pressure.

A component of Phodophyllum emodi called phophyllotoxin is presently utilized to treat lymphomas, small cell lung cancer, and testicular cancer. Drugs made from plants are used to treat cancer, diabetes, jaundice, TB, mental illness, and skin conditions. Strong therapeutic substances are developed with the help of medicinal plants. Through the use of plant material as an indigenous treatment in folklore or traditional systems of medicine, plant-derived medications first appeared in contemporary medicine. Substantial antibacterial capabilities have been discovered in over 64 plants, while substantial antidiabetic characteristics have been discovered in over 24 plants. India has a reputation as one of the oldest civilizations with a wealth of medicinal herbs. India's forests are the main source of a huge variety of aromatic and medicinal plants that are mostly harvested as raw materials for the production of pharmaceuticals and perfumery goods. In Ayurveda, some 8,000 herbal treatments have been standardized. The Yajurveda records 81 species, the Atharvaveda 290 species, the Charak Samhita and Sushrut Samhita describe 1100 and 1270 species, respectively, and these are still used in the traditional formulations of the Ayurvedic medical system. The Rigveda records 67 medicinal plants[5], [6].

Unfortunately, an alarming amount of historic knowledge and many priceless flora are disappearing. Ayurveda and other systems of herbal treatment have reached a highly critical stage due to the increasing destruction of forests, which has affected the accessibility of raw pharmaceuticals. The rich trove of plant and animal variety found in tropical forests, which make up around 50% of them, has already been decimated. Forest cover is vanishing in India at a pace of 1.5 million hectares each year. Only 8% of the geographical region is now remaining, compared to the required 33%. The demise of many vital therapeutic plants is imminent. There are 427 entries for endangered species in the Red Data Book of India, of which 28 are listed as extinct, 124 as endangered, 81 as vulnerable, 100 as uncommon, and 34 as inadequately known[7].

Indian Common Medicinal Herbs

Industry and Medicinal Plants

The country's medicinal plant-based business has an estimated annual revenue of Rs. 42,000,000,000 and is expected to expand at a pace of roughly 20% per year. Numerous individuals get direct and indirect employment from these operations, including hundreds of producers and exporters around the nation. India as a whole trades between 800 and 900 medicinal herbs, of which 700 are gathered in substantial numbers from the woods. Neem, amla, asoka, harara, gulancha, khas, ashwagandha, sarpagandha, etc. are typical examples. Numerous medicinal plant species are under danger as a result of over- and improper harvesting. It is quite probable that these plants will become extinct soon. There is a sizable list of therapeutic plants that are threatened in varying degrees. Acorus calamus, Coscinium fenestratum, Gloriosa superba, Janakia arayalpathra, champa, pipli, Sarpgandha, Bael Asoka, Arjun, and others are a few of them.

One species, Plectranthus vettiveroide, is already extinct in the wild. There is now a National Medicinal Plants Board. 28 plant species have been chosen by the Central Board for the first phase of development and promotion. To reduce strain on the natural supply, incentives are also provided for the cultivation of therapeutic plants. At the state level, similar boards are being established. The extensive protected areas preserve all of the current biodiversity, including the medicinal plants. Additionally, medicinal plants are preserved in botanical gardens. The designation of Biosphere Reserves is another endeavor. Through this program, representative landscapes and regions with a wealth of biodiversity may be preserved. In 1991, the Wildlife Act was revised to cover certain plants. Except for teaching, study, or the creation of a herbarium, the Act forbids the collecting of certain plants from forests or other designated places. Thus, it is possible to safeguard medicinal plants, which are under danger. The designation of forest regions with a high concentration of medicinal plants as Medicinal Plants Conservation regions, which are legally protected, is another endeavor. There are restrictions on taking plants out for commerce. There are now 55 such MPCAs. For the collecting and preservation of significant domestic medicinal and aromatic plants, four national gene banks have also been established. These repositories keep the plants in cryogenic storage as well as living materials, seeds, and genetic material[8].

Act on Biodiversity

The Biological Diversity Act of 2002 was created to safeguard the nation's rich biodiversity and related knowledge. A National Biodiversity Authority, State Biodiversity Boards, and Biodiversity Management Committees in local entities are also mentioned in the legislation. NBA must provide its prior consent before foreign individuals or organizations may use biological resources or related expertise. Prior to acquire any biological resource for use in the commercial sector, Indian enterprises are required to notify the relevant SBB. The activity could be limited by SBB. The materials are open to all Indian people and entities, including "vaids," "hakims," and others, for personal use, study, and the manufacturing of therapeutic products. A Traditional Knowledge Digital Library is also being developed to chronicle the traditional knowledge that is present in the nation.

For people who do not want traditional treatment or who cannot be assisted by conventional therapy, India offers a wide variety of alternative remedies. In India, there are many different alternative medical practices to choose from, including ayurveda and kabiraji. India is said to have used ayurvedic medicine for thousands of years. To treat or comfort the sick patients, it uses a variety of tools and approaches. Ayurveda uses a variety of items, including drugs of a botanical origin.

Numerous herbs and spices that are used in Indian cuisine, including onion, garlic, ginger, turmeric, clove, cardamom, cinnamomum, cumin, coriander, fenugreek, fennel, ajowan, anise, amchur, bay leaf, and hing, among others, are known to have medicinal characteristics. All of them are used in ayurvedic treatment, either as food or medication. The many therapeutic plants that may be found in India are also often employed by Ayurvedic practitioners. On Indian postage stamps, several of these therapeutic plants have been shown. In 1997, the first collection of stamps featuring therapeutic plants was released. Tulsi, Haridra, Sarpagandha, and Ghritkumari were among the four various medicinal plants featured on the stamps in the collection. The Indian Posts and Telegraph Department later released a new series of stamps in 2003 that included four more medicinal plants. Amla, Ashwagandha, Brahmi, and Guggulu are among them[9].

Neem, also known as Margosa, is a widely used and well-known medicinal plant from India. Since neem has been utilized for so many different maladies by Ayurvedic practitioners for so long in India, it is known as sarva roga nibarak in Sanskrit. Neem is often referred regarded as "the village pharmacy" in many tropical nations. In Ayurvedic medicine, almost every component of the neem tree is employed. Poor people in the Indian subcontinent wash their teeth with chewed-up neem branches. Neem oil is used to make cosmetic products including toothpaste, shampoo, balms, creams, and soaps. Neem is used in Ayurveda in a variety of ways to cure anything from diabetes to cancer to skin conditions. In reality, current experts not just in India but also all over the globe, including the USA, are researching the potent and diverse therapeutic benefits of neem.

Potential Market for Phytomedicine

The Indian healthcare system is greatly supported by medicinal plants. The World Health Organization estimates that for their basic healthcare requirements, 80% of the rural population in developing nation’s uses locally accessible medicinal herbs. There are now between 7000 and 7500 kinds of medicinal plants being used by indigenous tribes across India. The majority of the nation's medicinal plants may be found in forests. Among other landscape features like open grasslands, agricultural pastures, in and around fresh water sources, etc., only 10% of the medicinal plants are spread. It should be noted that India is one of those countries that has a history of using its traditional knowledge of medicinal plants to make a significant global contribution. India's rich medical plant legacy, which includes 8000 species and an estimated 40,000 herbal formulations, has worldwide importance in the twenty-first century given the rise in consumer interest in natural goods.

Therefore, it is critical to protect India's priority forest areas' wild populations of medicinal plant variety. The preservation of medicinal plants will help millions of Indians become self-sufficient in terms of their own healthcare. The market for medicinal plants is expanding quickly. The herbal industry had a 1947 annual revenue of Rs. 2 billion. By the end of 2000, the Indian herbal sector had an annual revenue of Rs. 40,000 million. Because of this, India meets 12% of the global demand for medicinal herbs. Only 70 of the roughly 700 species used in trade today are entirely derived from cultivated sources, and 90% of medicinal plants used for domestic and international consumption are now harvested from the wild.

Estimated total sales of phytomedicine in the European Union were around US$ 6 billion in 1991 and US$ 4 billion in 1996; of this amount, almost half were sold in Germany, $1.6 billion in France, $0.6 billion in Italy, and $1.5 billion in Japan. The estimated current global market size is $250 billion. An estimated $1 billion worth of herbal products are sold in India, and about $80 million worth of herbal crude extract is exported, with 50% of that coming from traditional Ayurvedic formulas. In Germany and Russia, medications made from plants are significant. In particular, herbal medicines are imported by a number of nations in order to supplement their use of local traditional medicines.

About 5000 plants are heavily utilized in the traditional medical systems of China, India, the Arab world, and other cultures. India is proud to be sixth among centers of diversity, especially agrodiversity, and tenth among Asia's nations with the highest plant diversity. The country has access to nearly three-fourths of the drugs and perfumery products used worldwide. With over 1, 26,000 species, India is believed to have 8% of the global biodiversity. It is one of the 12-mega biodiversity centers, and the Western Ghats and the northeastern area include two of its hotspots. The holy groves are a little ecosystem that protects biodiversity in its natural state. It would be crucial to take a comprehensive, multidisciplinary approach, have a scientific knowledge of plant systems, new developments, and their conservation for use in the future on a sustainable basis for generating phytomedicines[10], [11].

In India, more than 70% of people utilize herbal medicines for health reasons. For several of these medications, there is a wealth of data based on experience. Numerous universities and institutes in India are also conducting research on herbal medicines and medicinal plants. Several Institutes do scientific and clinical research on the possible health advantages of herbal medicines using a "reverse pharmacological" approach. There are a lot of effective examples going in this approach. These herbal medicines and Indian medicinal plants are also abundant sources of healthy chemicals, such as antioxidants and elements that may be employed in functional meals. In the near future, newer methods that combine proven traditional health concepts with cooperative research and cutting-edge technology will provide significant health improvements, particularly for those without access to more expensive western medical systems.

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CHAPTER 4

GATHERING AND PROCESSING OF AROMATIC AND MEDICINAL PLANTS

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As more and more individuals turn to traditional and herbal medicines for health cures, the globe is seeing a shift in health-seeking behavior. Even in the developed world, the usage of natural goods is rising. This has placed a tremendous amount of strain on natural resources, resulting in tampering with herbal products, unsustainable logging practices that have a negative impact on human health, unclear availability of several therapeutic plant species, and the extinction of these species in the wild. The necessity to create acceptable manufacturing practices for herbal starting materials is shown by examples of medical plant/herbal medication adulteration with hazardous herbal pharmaceuticals. The establishment of Good Field Collection Practices for medicinal plants is crucial for enhancing the quality of the completed goods since the quality of the raw material heavily influences the quality of the finished product.

Since a result, there is a need for standards for the cultivation and processing of medicinal plants and herbal medicines, since they are essential processes in the manufacture of a high-quality final product. Equally crucial are the sanitary collecting and processing of medical plants to keep the microbial load to a minimum and the careful handling of medicinal plants to prevent damage during collection, processing, and storage. All of these issues are covered in this chapter and will aid in understanding the various MAP collecting and processing procedures as well as the essential precautions for good sustainable practice[1].

Current Situation

All herbal medical preparations begin with herbal medications, which are often dried plant parts or plant organs from species that are used medicinally. Between 70 and 90 percent of the 21, 000 plant species identified by the WHO as being used medicinally as plant medications are acquired commercially by harvesting the pharmaceuticals from their natural environments. Traditional medicines are the sole way of treating ailments for local people living in rural places and for those who cannot afford to purchase pricey western treatments. A whopping 90% of the MPs used in such systems are gathered from the forest. Similar to this, the production of essential oils has been broken down into cultivated and wild-gathered woody perennial sources, which account for around 65% of global output, with cultivated herbal sources making up just 30.6% of this total. While there is an increasing need for medicinal plants, some of them are coming under more and more pressure in their natural environment.

It is recommended to conserve and grow therapeutic plants in order to satisfy future demands. Less than 20 plant species are now being grown in India out of the more than 400 that are utilized to make pharmaceuticals by the Indian industry. Due to the utilization of elements including roots, bark, wood, stems, and the whole plant in the case of herbs, more than 70% of plant collections require harmful harvesting. If biodiversity is not managed responsibly, this presents a real danger to genetic stocks and to the variety of therapeutic plants. Some adverse events that have been reported after using specific herbal medicines have been linked to a number of potential causes, such as using the incorrect plant species unintentionally, adulteration with other medicines and/or potent substances, contamination with toxic and/or hazardous substances, overdosing, inappropriate use by healthcare professionals or consumers, and interaction with other medications, resulting in an adverse drug interaction Some of the issues related to the low quality of completed goods are unquestionably brought on by the usage of inferior-quality raw medicinal plant ingredients.

However, compared to food production, quality control for the growth and gathering of medicinal plants as the primary sources for herbal medicines may be more demanding. Because of this, certain nations have lately created recommendations on effective cultivation methods for medicinal plants. Since their rules were developed to satisfy the needs of certain areas or nations, they may not be relevant or acceptable elsewhere. Several nations have created laws to protect MPs. Examples include a Chinese administrative law enacted in 1987 for the "Protection of Wild Medicinal Plant Resources," a Sri Lankan "Action Plan for Conservation of Biodiversity" that includes MP conservation as a project, and a prohibition on the export of all wild MPs from India since 1993.

Justifications for collecting from Natural Environments

The first argument is that all cultivated plant species grow slowly because they take more than five years to mature or reach the point of harvest. This category includes shrubs, trees, and perennials. Agriculture is scarcely feasible for the plant species: For a number of reasons, including symbiotic associations with other plants such in Viscum, Santalum, etc., many species are not suitable for agriculture. Domestication is challenging: In culturing may be challenging, particularly with plants that have evolved erratic blooming and seed germination, among other erratic germination characteristics, as a means of survival. It required 15 years of agricultural research and significant financial outlays to establish a culture of Baptisia tinctoria. More economically than domestication, collecting the cultivation of medicinal plants is more suitable for use in the creation of pharmaceuticals, but only at a greater cost. From a financial perspective, the overall tonnage required is boring, and collecting is a more cost-effective option. Most of the time, businesses only grow those plant species that they use in big quantities or for the manufacturing of derivatives and isolates, where standardization and quality are crucial and incur additional costs for both producers and customers.

Different Collection Techniques

Permits and authorization to gather: The harvester must follow the laws set out by the federal, state, and municipal governments whether the wild harvest is conducted on public or private land. Before harvesting on state-owned public lands, you should get in touch with the relevant state agency. All regulations governing permissible harvests on public lands, including those requiring the filing of harvest data, payment of fees, and other regulations, must be followed.

Additionally, when collecting, the collector should be in possession of all necessary permissions and licenses[2].

1. **Site selection:** It is crucial to assess potential collection locations to make sure that the materials will likely be of high quality and uncontaminated by pollution or other harmful environmental factors. The marketability of the material collected can be affected by the collection site selection.
2. **Habitat for the species:** Carefully selected collection locations should aim to harvest healthy stands of plants that are growing within the species' natural distribution. If a site's history suggests that it may have environmental dangers, such information should be taken into account and harvesting should be avoided.
3. **Collection tools:** Wild-harvested agricultural harvesting equipment must be suited for the task at hand, well-maintained, and clean.
4. **Training:** Ensuring that all staff members have received enough instruction in using the collecting equipment, particularly mechanized equipment, and that equipment is used in a way that guarantees the safety of the operators and prevents or minimizes damage to the collected material.
5. **Identification:** To guarantee that every plant is accurately recognized after harvest, wild plant harvesters must possess the necessary education and expertise. Additionally, purchasing agents that acquire gathered materials are often a reliable source of knowledge on the identification of plants and plant materials. Whenever required, it is essential to enlist the help of a skilled botanist or taxonomist who has the necessary knowledge to positively identify the species that have been gathered.
6. **Abundance:** Only abundant stands of the harvest species should be used for collection. Harvesting should be avoided in areas where the plant is scarce or where it is growing outside of its typical range. Till the population has adequately recovered, avoid harvesting in the same spot as prior harvests.

Rules for Sustainable Collection Methods

One has to take into account various risks related to collecting practices. Extinction and the destruction of genetic diversity are the two fundamental issues. The extinction of an entire plant community may result from overharvesting natural resources. Collectors who harvest these plants from forests, fields, seashores, and other ecosystems create much of the plants that are utilized in consumer goods. Different local conventions in different nations place varied degrees of control and administration of collectors. Only a small number of wild species are harvested by organized harvester organizations.

Good collection practices are necessary for delivering precisely identified and high-quality botanical raw material from wild-harvest sources as well as for preserving the species from overharvesting, regardless of whether collectors work independently or with some level of supervision. Ayurveda, Unani, and Siddha are well-known traditional medical systems in India with substantial social demand. These systems' reliance on medicinal plants makes it necessary to develop certain rules and widely disseminate them in order to encourage ethical harvesting. This would help manage medicinal plant resources more sustainably and with better quality[3].

Controlling the quality of the collection

The topic of analytical identification determination becomes crucial since collected plant medications, particularly those used under their vernacular name, are extremely likely to be mislabeled. The greatest example is the well-known medicine Zarzaparilla, which is either a species of Smilax or, at least in Peru, the root of Rumex obtusifolius. Thus, the main procedure in ascertaining the precise identification of material is pharmacognostic analysis, in conjunction with knowledge of potential alternatives and synonym medications. The significance of pharmacognostic analysis may be best shown by one incident that occurred in the US but fortunately did not result in deaths. Atropa belladonna leaves were included in the herbal tea made from Plantago lanceolata leaves, but they were difficult to tell apart when they were chopped. Since these poisonous Belladonna leaves exhibit many Ca- oxalate crystals in the parenchymatic cells and a distinct, wavy cuticula on the epidermis, a simple microscopic study might have identified the difference.

Since most collectors are uneducated individuals who collect under their original names, most of these mislabeling incidents are inadvertent. Foreign matter is another facet of quality that needs special attention. In comparison to what is permitted by the pharmacopoea's general notifications, collected pharmaceuticals often include a larger proportion of sand, grass, and other non-drug elements of the species. The tests that are detailed for this purpose should thus be carried out with special caution. In general, pesticide levels, heavy metals, and atypical microbiological contamination are of little to no consequence. They seem to be more often in crops grown on fertilized farmland. In order to adhere to excellent agricultural and collecting practice, each of these factors must also be taken into consideration during post-harvest activities.

Maps Processing

The care with which an herb is treated after it is harvested, whether as an agricultural product on a farm or as a wild crafted item in a non-cultivated context, has a significant influence on the quality of the finished product. The harvest must be stabilized immediately after harvesting in order to stop the new material from deteriorating, which is especially sensitive given the naturally existing moisture content of plants. To ensure that product quality is maintained along the chain of custody, from the field to the point of manufacturing, additional actions including washing, cutting, dehydrating, cooling or freezing, packing, and storage must also be correctly carried out. The herbal crop must be handled, stored, and consolidated in a way that prevents the harvested material from deteriorating in transit at the time of actual harvest and shortly after harvest. Cross contamination from other crops and materials, insect or other infestation, product compaction, exposure to the environment, temperature build-up, and overheating are just a few of the threats to product quality. Both excellent farming practice and good collecting practice are affected by these issues.

The removal of alien objects. Check for and eliminate any content that is subpar or clearly alien. Foreign matter comprises dirt, pebbles, insects, other animals, wire, glass, paper, tools or tool parts, and other man-made things. It also contains plant debris from different species or from other sections of the harvested species. Examples of sub-standard material include discolored foliage or blossoms, immature, overripe, or severely damaged fruits, as well as any other material that might prevent the crop from meeting its requirements. While the crop is sufficiently well exhibited to allow for their quick view, do the examination for foreign matter and inferior material[4].

Subsequent Processing

Dehydration: A lot of the plants that are produced or harvested for use in herbal goods need to be properly dried before use, and the people and businesses who harvest the plants are often also those that dry the plant components. Drying conditions have a significant impact on the quality of the traded material by either preserving or degrading naturally existing plant components. Both inadequate and excessive drying may cause compound breakdown, whereas insufficient drying might lead to microbial or mold development. Therefore, maintaining appropriate dehydration conditions is a crucial aspect of post-harvest handling procedures. Plant material may be sold whole, chopped, sliced and sifted, cut into teabags, shredded, or powdered, among other forms. Plant materials may be cut before or after being dehydrated, but grinding to get powder is always done after drying. Operations like cutting and milling must be done in a way that maintains the material's quality and purity. The quality of packed herbal crops will depend on the storage conditions as well as the usage of appropriate packing tools and materials. The following procedures apply to activities for bulk herb storage and packing.

Distillation

To extract essential oils from various plants, several processing techniques are needed. The process of steam distillation, which involves permeating the plant material with steam, is used to extract the majority of oils. The water vapor and essential oils that are emitted when the plant tissues decompose are later collected and cooled. The flammable essential oil separates, condenses, and is simple to isolate. This procedure involves creating the steam in a separate room and piping it into the tank. Compared to the other ways, this is more costly. This is particularly advantageous for plant materials whose oils have high boiling points. For certain oils, the temperature and pressure may be raised using this technique.

Distillation of Water

The simplest and most affordable distillation process is this one. The plant matter is cooked after being submerged in water. Oil is separated from water when the steam and oil vapour are condensed. This technique works well with powdered plant material and flower flowers. 100°C should be the distillation temperature. Care must be taken to avoid letting the plant material come into touch with the hot still walls, which might cause harm. The still should have atmospheric pressure. The time required for distillation varies on the kind of plant material being used. Only a minor quantity of additional oil is produced by prolonged distillation, but undesired high boiling chemicals and oxidation products are also added. Distillation of Solvents may be used to extract essential oils. Hydro-distillation is not appropriate for a variety of goods, such as oils with delicate aromas.

When steam or water distillation might change or damage the fragrant qualities of delicate flower and plant material, or when a plant, like rose absolute and jasmine, has so little oil that steam or water distillation is impossible, solvent extraction is utilized. A concrete is produced via solvent extraction, and an absolute is then purified from the concrete. The plant material is progressively soaked with a hydrocarbon solvent to create concrete. The solvent dissolves the plant's components, including its fatty acids, waxes, and essential oils. The remaining components that make up the concrete are combined once the solvent has been removed. Alcohol is used to separate the essential oil from the other ingredients. Because the fatty acids and waxes are insoluble in alcohol, they are left behind. The alcohol is subsequently removed during a further distillation, leaving just the absolute oil[5].

Supercritical CO2 Extraction:

Supercritical CO2 extraction is the process of extracting essential oils, fragrances, herbal extracts, and spices using carbon dioxide at very high pressure. The organic material is put in a stainless steel tank, and pressure within the tank increases when carbon dioxide is pumped into the tank. The carbon dioxide transforms into a liquid under high pressure and functions as a bonding agent to draw the essential oils from the plants. Reduced pressure causes the carbon dioxide to liquefy once again. Because carbon dioxide is comparatively inert, the procedure is contamination-free. Many carbon dioxide extractions smell more like the live plants and are fresher, cleaner, and sharper than essential oils that have undergone steam distillation. Scientific research demonstrates that carbon dioxide extraction yields essential oils with high medicinal potency. Compared to steam distillation, this extraction technique is less harsh on the plants since it employs lower temperatures. Higher yields are produced, and certain materials, particularly gums and resins, are simpler to handle as a result. Carbon dioxide extraction may be used to produce many essential oils that steam distillation cannot. Many botanicals that are now unavailable might perhaps be acquired in the future using carbon dioxide extraction.

Bulk Labeling and Packaging

To avoid product degradation and avoid additional exposure to potential insect assaults and other sources of contamination, processed medicinal plant materials should be packed as soon as feasible. Permitting a controlled processing flow from the arrival of the raw medicinal plant materials at the premises to the shipment of the processed medicinal plant materials would facilitate effective and sanitary operations;

Optimal state for processing

When creating a quality assurance system, the following factors must to be taken into account and modified for the various stages of production and production locations. Preferably, facilities should be placed in regions devoid of offensive odors, smoke, dust, or other impurities that might cause floods. Within the establishment's limits or in close proximity, all access roads and places should have a firm, paved surface that is appropriate for wheeled vehicles. Ample drainage should be present, and cleaning facilities should be available. Buildings should be planned to give enough workspace and storage space to enable the successful completion of all activities; enabling a controlled flow in processing from the arrival of the raw medicinal plant materials at the premises to the shipment of the processed medicinal plant materials would assist effective and sanitary operations; Permit proper humidity and temperature regulation; Permit partitioning or other methods of separating operations that can result in cross contamination; a) Make cleaning simple and effective; b) Make good hygienic supervision easier; prohibit the entry and harboring of pests, livestock, and domesticated animals; Where appropriate, prohibit direct sunlight from entering a certain region. Prevent the entry of environmental pollutants such as smoke, dust, etc. There should be a plentiful supply of water that is at sufficient pressure and at a reasonable temperature, as well as the right infrastructure for storage, distribution, and good pollution prevention. There should be enough natural or artificial illumination installed throughout the building[6], [7].

Controlling quality when processing

The next step is quality assurance throughout production and processing. This crucial step will guarantee quality throughout the production process. It is also believed that in order to guarantee the availability of true, authentic medicinal plants, it would be preferable to have a centralized agency for marketing the plants. It may also be mandated that everyone only buy certified material from authorized organizations like the Forest Development Corporation or the National Board for Medicinal Plants.

The proper methods for MAP collecting and processing will enhance the manufacturing of pharmaceutical goods' commitment to quality, which will enhance medicine on a national and international level.

Along with changes in health-seeking behavior, traditional and alternative medical practices are being used more often worldwide. In several historic traditional medical systems, including Ayurveda and Uranic in India, Chinese traditional medicine, and its derivatives, medicinal and aromatic plants played an important role. Despite advancements in contemporary western medicine, MAPs continues to play a significant role in preventative and curative therapies in emerging Asian nations. It is generally known that there is a long history of plant-based treatment in the shape of Ayurveda, Siddha, Unani, and other medical systems.

In these systems, plants make up more than 90% of formulations, with minerals, metals, and animal products making up a relatively tiny portion of formulations. Natural forests provide around 90% of the raw ingredients for the medicinal plants that are utilized. However, gathering in natural settings has a unique set of challenges, particularly when it comes to misunderstanding with related species, environmental harm, a lack of skilled staff, etc.

One must adhere to certain rules in order to build good field collection and processing practices for medicinal plants, which are often taken from the wild. These principles help to improve the quality of plant raw materials used in the production of both traditional herbal remedies and contemporary pharmaceutical products. They should be supported by capacity development and independent certification. The long-term sustainability of wild populations and the environments that support them should be guaranteed through MAP collection procedures.

Collection management techniques should specify acceptable collection practices that are suited for each medicinal plant species and plant component utilized, as well as a framework for determining sustainable harvest levels. The gathering of medicinal plants brings up a variety of intricate environmental and social challenges that must be handled locally and on an as-needed basis[8]–[10].

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CHAPTER 5

INVESTIGATION AND EVALUATION OF MEDICINAL AND AROMATIC PLANTS

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In any nation in the world, this percentage of medicinal plants is the greatest percentage of plants used for medical reasons. 7500 of the 17,000 species of higher plants found in India are used medicinally. The vast natural riches of India provided the indigenous people with a special chance to employ many medicinal and aromatic plants. The qualities and uses of the abundant plant resources found in nature are well known to the locals. Aromatic and medicinal plants are under the category of non-timber forest products, which have been utilized extensively from the beginning of human history. Many plants are used by the local population for food, spices, fiber, medicine, handicrafts, and a variety of other uses. Today, medicinal and aromatic plants not only meet local needs, but they also serve as a source of raw materials for several enterprises.

The market for MAPs as raw materials has progressively grown in recent years as a result of India's expanding global herbal goods industry. Pharmaceutical firms from across the world are seeking for active ingredients in these plants to treat a variety of illnesses for which contemporary synthetic drugs are thought to be less successful. The world is paying more and more attention to resin and dyes. The biodiversity of natural habitats has come under a lot of strain as a result of an increase in the trade of medicinal and aromatic plants as well as a resurgence of traditional therapeutic practices. The India system of medicine is now practiced by more than 10000 certified pharmacies, all of which must adhere to certain standards. In addition to these, this method of medicine is practiced by thousands of local "Vaidya’s," herbalists, bonesetters, and tribal physicians.

In this situation, it is always possible to utilize the raw resource for quick financial benefit without taking sustainability factors into account. Surveying and evaluating medicinal and aromatic plants is necessary to determine the amount of stock that is currently present in the wild. What is the current expanding stock and the productivity per unit of time and area? These are the essential issues that management authorities should be able to address when developing sustainable management MAPs at the operational level. What is the maximum harvestable amount or sustainable yield that may be recommended? What particular sustainable harvesting practices in terms of times of year, procedures, and instruments are suitable for each of the aforementioned products [1], [2].

Inventory and Survey

The primary goal of the survey and inventory of medicinal and aromatic plants is to provide us with the knowledge and information we need to understand and record the qualitative and quantitative characteristics, distribution, and abundance of MAPs species within the management area. The inventory of MAPs addresses fundamental issues like: which MAP species do us have, where are they dispersed, and what is the available quantum in the specified range? In addition, it is important to know which species are collected on a large scale and how often each species is discovered. The fundamental stages for inventory are as follows:

Field Investigation

Reconnaissance of the region intended for survey and mapping is the initial stage in any resource inventory. A list of regionally and economically useful species, the kinds of forests, any existing paths, and the size of the area should all be noted during reconnaissance. Plant specimens that are locally utilized as medicine and whose names are unknown must be gathered and maintained during field research. Additionally, it is preferable to capture one or two images of the plants for future identification.

Stratification

Each survey region should be broken into smaller parts based on the first reconnaissance and understanding of the area. The strata may be determined by the landform, the topography, the level of disturbance, the altitude, and the kinds of flora. Because plant species are spread throughout distinct habitats and landforms, stratification is crucial.

Choice and marking of trails and Transects

The trail or transects should be used for sampling inside each stratum. In a rough and mountainous terrain, it is not practical to make a straight line transect, despite the fact that the transect should ideally be put in a random direction. One transect should be one kilometer in length in wooded areas and half a kilometer in alpine meadows. However, the number of transects in each region will vary depending on its size. Both on the maps and in the field, the transect's beginning and finish should be noted. The sample plots would be positioned at various places along each side of the route[3].

The setting up of the Sample Plots

The majority of ecologists support the placement of random plots inside each stratum. However, it is preferable to estimate the number inside the pre-determined plots while conducting a survey of a given species, particularly in a steep and undulating terrain. Through systematic sampling, we may identify changes within the strata and sample them more equally.

Specimens for Collection and Preservation Of Maps

Collection

Gather at least two samples of each aromatic and medicinal plant. The sample need to be fully grown, ideally with a flower and a fruit. Plant material that is ill, infected, or incorrect should not be collected. One twig with leaves and a blossom is sufficient for identification in the case of trees and climbers. Paper bags may be used to preserve different portions of plants, such as roots, subterranean sections, cones, or fruits like acorns, pods, nuts, and berries. In the field notebook, information on the behavior, habitat, bloom color, location, intriguing traits, etc., should be recorded. When collecting plants for a herbarium, the following equipment are particularly crucial: A tiny shovel, knife, scissors, and gloves resistant to thorns might all be very useful. In order to prevent plant damage during your excursion, the specimens you have gathered should be placed in a sturdy bag made of fabric or polythene[4], [5].

Drying and Pressing

Newspaper sheets are used to gently contain the specimens. A flower's components are extremely carefully dispersed so as not to overlap their original form. The specimens must be folded if they are lengthy. You may push, coil, or bend climbers. Before pressing the plant, remove the dirt from the roots. The press has a typical dimension of 30 x 45 cm. The key to creating examples with naturally colored flowers and foliage once the plants are in the press is quick drying. Additionally, it prevents fungus development, leaf shedding, and discoloration. Two to three days are ideal for drying the typical plant. By changing the newspaper sheets or blotters and placing them in the shade, it is a good idea to dry the specimens. Every day, swap out the newspaper sheets or blotters. For the first two days, fleshy plants should be rotated twice daily. Changed specimens that have been carefully pressed under the plant press may be stored for one or two hours under a fan or in the sun.

Mounting, labeling and Poisoning

The specimens must also be poisoned before mounting in order to guard against potential fungal or bacterial attacks. Ethyl alcohol, ammonium chloride, and mercuric chloride are the ingredients in the solution employed for this function. The number of specimens that need to be poisoned determines how much chemical is utilized at one time. 350 g of ammonium chloride and 150 g of mercuric chloride should be dissolved in a little amount of water. Reduce the amount of water to the absolute minimum.

Add 10 liters of 96% alcohol to this. The chemicals may be applied to the specimens by lightly brushing them with them. The specimens may stay in press for a further day or two after poisoning in order to prevent the leaves and petals from wrinkling. A specimen is mounted when it is fastened to a herbarium sheet and a label is placed to the bottom right corner. Specimens are mounted on sheets of herbarium paper that are the normal size. There are many ways to attach the specimen. One typical technique is applying a water-soluble paste on a glass plate, putting the specimen on the paste, and then moving the glued plant to the mounting sheet. To contain seeds, more blooms, or any portion of the specimen, little paper envelopes known as fragment packets are glued to the sheet[6], [7].

The herbarium label is a crucial and significant component of the preserved plant specimens. Although the label's size and form may vary significantly, they will often be rectangular and measure around 10 x 15 cm. The bottom right corner of the primary label is often considered to be the optimum place since it makes the label easier to see when stored in container covers that open to the right.Recording, analyzing, and interpreting data collection A team of 2-3 people will quickly count the medicinal and aromatic plants in the sample plots. A format for storing the data should be created before it is recorded. The existence of perennial water channels, related species, terrain, height, aspects, slope, soil properties, and human pressures like grazing, uprooting, and fire should also be noted in addition to the number of plants.

Data Evaluation

The density, frequency, and cover of each transect or plot may be used to display information on the presence or absence of MAPs, as well as the availability of MAPs in a certain area, forest type, or habitat. The quantity of sample units in which a certain species occurs is known as its frequency. A species' frequency is considered to be 100% if it is present in every sampled plot, and 0% if it is absent from any sampled plots. It is possible to compare species frequency across transects, regions, and management units.

Interpretation of data

The interpretation of an inventory's findings calls for expertise and experience. Because the majority of species are marketed in terms of dry weight, the statistics of density, frequency, and cover are the indirect estimates of the MAPs in a given region. Dry weight estimation in the field is a laborious method that requires damaging sampling. Therefore, it is important to carefully analyze the findings of the density, frequency, and cover tests. The majority of the high-altitude herbs in the state of Uttarakhand are perennial. The quantity available per plant would be indicated by the thickness of the tubers and rhizomes. Before disclosing the existence of these plants to the collector, careful assessment of density and frequency will be required.

Maps of Distribution and Density are Created

It is necessary to assess and present the survey/inventory data in the form of straightforward tables and maps. Planning for conservation and management of MAPs may be aided by maps that show their distribution, abundance, and presence or absence. For the creation of a medicinal pant distribution/density map, the following procedures are required:

Making of a Base Map

Using Survey of India topo sheets at a scale of 1:50,000, this should be created for each block or compartment. It might be preferable to use greater sizes for the smaller regions. The range, block, compartment, main drainage, roads, trails, landmarks, and geographic coordinates should all be traced out using the tracing paper. This would act as the road map.

Aside Information

The following parameters may be shown in various colors on the base map: Strata/vegetation types, administrative divisions, trail/transect alignment, village locations, drainage, and significant features[8]. Distribution and density of MAPs are shown MAPs' presence or absence, significant cover, and density classifications may all be represented in different ways on the base map. Today, remote sensing is a vital and efficient method for creating wide maps of plant cover and further stratifying a region, which may then be used as a basis map for more accurate maps of species distribution.

It's crucial to conduct surveys and assessments in order to determine the quantity of medicinal and aromatic plants that are naturally growing. The reconnaissance survey provides the first information on the MAPs in a certain area, forest type, and habitat for quick mapping and evaluation of aromatic and medicinal plants. Plant species are dispersed within certain habitats and landforms, making stratification crucial. Strata should be based on the topography and land shape, the disturbance regime, the altitude, and the vegetation kinds. For MAPs, sample transects are placed in a random direction in each stratified zone. One kilometer for wooded areas and half a kilometer for alpine meadows should be the minimum length of one transect, and the number of transects in each region will depend on the size of the area[9].

In general, the majority of ecologists advise placing random plots inside each stratum, although in steep terrain, it is preferable to estimate within the pre-determined plots. For the purpose of determining MAPs, sample plots should have a radius of 10 m for trees, 5 m for shrubs or climbers, and 4 rectangular quadrates for herbaceous MAPs. For those plants whose names are unclear during the field survey, a herbarium specimen is a need. Herbarium best practices should then be used. A common data format should be created to capture all the pertinent information while gathering data for a specific sample plot. The density, frequency, and cover of each transect or plot may be used to display information on the presence or absence of MAPs, as well as the availability of MAPs in a certain area, forest type, or habitat. It is necessary to assess and present the survey/inventory data in the form of straightforward tables and maps. Planning for conservation and management of MAPs may be aided by maps that show their distribution, abundance, and presence or absence[10], [11].

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CHAPTER 6

SUSTAINABLE MEDICAL AND AROMATIC PLANT HARVESTING AND MANAGEMENT

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We utilize plants, plant components, and plant extracts on a daily basis. They have diverse uses, including as food, medications, coloring agents, detergents, fragrances, and in the cosmetics sector. From ancient times to the present, medicinal and aromatic plants have been a significant source for human health care. With a very high level of public acceptability, India has a long history of plant-based treatment systems like Ayurveda, Unani, and Siddha. Approximately 8,000 types of medicinal plants are reportedly used in India by 4,635 ethnic tribes, including more than one million folk healers. The usage of alternative and conventional medical approaches has increased globally.

This is partially because these medical systems, which are essentially based on plants, are often secure, efficient, and economical. Due to their enormous potential to benefit humankind as health care goods, medicinal plants must thus be conserved in addition to being used wisely to meet the growing global demand for natural/herbal products. A substantial number of medicinal plant species are in doubt about their availability due to overexploitation, which is causing unsustainable collections from natural forests and their extinction in the wild. Nearly 90% of the medicinal plant raw materials utilized by the manufacturing units are derived from natural forests, often with little regard for environmental and social factors, frequently leading to a harvest that is far more than what is sustainable[1].

Eco-Friendly Harvest

Sustainable harvesting refers to the exploitation of plant resources at levels and via methods that allow the plants to continuously generate the intended goods. The fundamental tenet of sustainable harvesting is that biological resources should only be used up to the point where they can regenerate themselves. According to the Convention on Biological Diversity, sustainable use means "using biological diversity components in a way and at a rate that does not result in the long-term decline of biological diversity, thereby maintaining its potential to meet the needs and aspirations of present and future generations."

Hunting for Maps

To guarantee that the creation of medical plant materials and completed herbal products are of the highest quality possible, medicinal and aromatic plants should be collected within the ideal season or time period. The concentration of physiologically active components does, however, vary according to the stage of plant growth and development, as is well known. As opposed to the overall vegetative production of the desired medicinal plant parts, the quality and quantity of biologically active elements should be used to identify the ideal time for harvest. Plants that have been damaged or plant fragments must be eliminated. It is important to take precautions during harvest to make sure that no noxious plants, weeds, or other objects are mixed in with the therapeutic plant ingredients. Avoiding dew, rain, or unusually high humidity can help you pick medicinal plants in the best circumstances possible. If harvesting takes place in wet circumstances, the material should be moved right away to a facility for indoor drying to speed up drying and minimize any potential negative impacts from elevated moisture levels, which encourage microbial fermentation and mold.

To minimize damage and contamination from dirt and other materials, cutting tools, harvesters, and other machinery should be maintained clean and adjusted. They should be kept inaccessible to cattle and domestic animals and kept in a clean, dry location that is free of insects, rats, birds, and other pests. To the greatest degree feasible, contact with soil should be avoided while harvesting medicinal plant components. Large drop cloths, ideally made of clean muslin, may be used wherever appropriate to act as a barrier between the harvested plants and the soil. Any dirt that adheres to the medicinal plant components should be removed as soon as they are collected if the subterranean sections are being utilized. Raw medicinal plant components should be quickly delivered in a clean, dry environment. They may be transported to a central location for transit to the processing plant in clean baskets, dry sacks, trailers, hoppers, or other well-aerated containers.

All harvest-related containers should be maintained clean and clear of extraneous objects like previously gathered medicinal plants. If plastic containers are utilized, special consideration should be given to any potential moisture retention that might promote the formation of mold. When containers are not in use, they should be kept dry, away from cattle and other domestic animals, and away from insects, rats, birds, and other pests. It is important to prevent any mechanical harm or compaction of the raw medicinal plant components, such as overfilling or stacking of sacks or bags, which might cause composting or otherwise degrade quality. To prevent microbial contamination and loss of product quality, decomposed medicinal plant components should be recognized and removed during harvest, post-harvest inspections, and processing.

Regulation on a Global and National Scale

While gathering any wild medicinal plant product, India has signed a number of international agreements and conventions relating to biodiversity protection. The Convention on International Trade in Endangered Species should be explained to collection managers and collectors. The establishment of a worldwide framework of practice standards for medicinal and aromatic plants is guided generally by the 1993 Guidelines on the Conservation of Medicinal Plants and the 2004 WHO Guidelines on Good Agricultural and Collection Practices for Medicinal Plants. These recommendations don't include specific rules or standards for the sustainable use of medicinal plants or their preservation. The International Standard for Sustainable Wild Collection of Medicinal and Aromatic Plants was created in 2007 by the IUCN's Medicinal Plant Specialist Group[2].

Harvesting Administration

Frequently, the species' root, bark, stem, leaves, flowers, fruits, and seeds are one or more of the parts that make up the legally recognized product. The whole plant is only sometimes utilized as a therapeutic plant product. The broad recommendations for harvesting and post-harvest management apply to every harvested portion, although some plant sections need special attention. Ayurveda and other ancient sciences advise gathering various plant parts at various times of the year. This was maybe done with the best activity of herbs when picked at a certain season in mind. Additionally, it's crucial to harvest plant components when doing so will do the least damage to the plant. The following list includes some crucial considerations that must be made while harvesting different types.

Portions of the Ground

When annual plants are fully grown and mature, the roots must be uncovered. Perennial roots should be taken early in the spring or late in the autumn. Biennial roots should be harvested either in the first year's autumn or second year's spring. To avoid bruising of the epidermis, where the oils normally dwell, which might lead to essential oil loss or their deterioration, the root material that is rich in essential oils should be treated gently. When taproot has to be removed since it is the intended product, damage to nearby plant species should be kept to a minimum. By employing the proper tools, underground components should be recovered with the least amount of digging feasible. It is important to leave adequate subterranean material at the location when collecting the roots of plants that reproduce vegetative in nature. Before packaging the fruit, it must be verified that all components have been fully cleaned and dried to decrease the moisture content.

Annual Plants, Herbs, or Flowers

When gathering complete herbaceous plants or their aerial portions, harvesting should take place during the blooming or bud stage, but before any visible deterioration in any of the plant's components. Never should the whole population of a region be harvested. To make it easier for future collections, sufficient populations should be preserved in nature for regeneration. When the target area is vast, it may be necessary to use mathematical techniques, including computer software, to estimate collection of people from a population in order to maintain uniform harvesting across the habitat. Annuals are particularly vulnerable to contamination and cross-contamination, especially tiny herbs, creepers, and grasses. The annuals may be sorted more quickly after gathering than after drying. It is not advisable to dry aromatic plants or fragile plant components like pistils or stamens in direct sunlight. If they are gathered in damp circumstances, they need to be relocated to the shade as soon as the moisture from the environment has been eliminated[3], [4].

Root Bark

When the tree is experiencing fresh development, the stem bark should not be taken. As much as feasible, older tree branches should be used to gather the bark, leaving the main stem unharmed. It is not recommended to remove the bark from a branch or trunk all at once. If a tree isn't going to be cut down for anything else, like lumber, it shouldn't be girdled by completely removing the bark all the way around. To enable for smooth water and nutrient conduction, bark should be longitudinally peeled. Stem bark shouldn't be removed from the same tree again until enough time has passed for it to fully rebuild. The limbs of young trees or trees should not be used for collection. To achieve full drying, the bark has to be broken into pieces of the proper size. Barks should be dried in direct sunshine unless specifically necessary in certain circumstances.

Wood or a stem

A tree or shrub should only have a few mature branches harvested at a time. You shouldn't cut the same plant's branches every year. The main axis should be collected in cases when the trunk is utilized as a medicinal crop. In order to assist quicker drying, packing, and storage of the product, it should be sliced into smaller pieces. Wood may be processed into tiny chips or shavings to make drying and packing easier. Stems and woods should be dried in direct sunshine unless otherwise necessary in certain circumstances.

Leaves

Unless otherwise stated, herbaceous plants' leaves should be harvested before they bloom. The leaves of mature trees should be gathered as much as possible. The collection might be continued until a later stage if the bioactive components of the leaves do not change with aging. You shouldn't totally peel the leaves off the parent plant. To guarantee that the plant's physiological functions are normal, a certain proportion of leaves should be retained. To make it easier to gather leaves that would otherwise be unreachable, trees, bushes, or their branches should not be cut down. Harvesting tender leaves is not advised unless they are a recognized crop. Throw away any leaves that have become pale, are diseased, deficient, or unhealthy. In general, leaves shouldn't be dried in direct sunshine unless they contain moisture from the outside, in which case they may be dried in direct sunlight for a while and then moved to shade or indirect sunlight as soon as the wetness from the outside is wiped dry.

To promote quicker and uniform drying, the fruit should be flipped occasionally while it is drying. The leaves should be packed only when they have dried completely. Even a tiny quantity of moisture in some leaves might encourage fungal growth, which can ruin the whole batch. To prevent bruising of the leaves, which might cause the essential oil to be lost or degraded, care must be taken while handling leaf material high in essential oils. The best time to harvest the leaves is when growth and leaf output are at their peak. Harvesting leaves should be put off or done in smaller amounts when the environment is challenging for the plants. The pace of harvest should be reduced if the leaf size is falling since this signals a stressed situation. If there is significant pressure from grazing, fire, or other occurrences that might harm the plants, the pace of harvest should be reduced[5].

Blooms and Floral Components

To catch the perfume of the flower, it must be picked just after it blooms or soon after. The flower buds must be harvested in the early morning hours, before the buds open. Shaking the material in these situations will help and encourage the insects to go. Care must be taken while handling flowers that are high in essential oils to avoid bruising, which might cause the essential oils to degrade. It is not advisable to totally collect the blooms from perennial plants like shrubs, trees, and climbers. Similar to this, it is not advisable to pick blooms from an entire population of annual plants at once. To enable the natural processes of pollination, fertilization, fruit/seed development, and distribution, there must be enough blooms left behind on the plants. To guarantee the availability of the necessary active material, floral components such as stigma, anthers, petals, etc. should be harvested at the proper stage of their maturation. Direct sunlight should not be used to dry fragile floral components. Flowers and other floral components from medicinal plants should be packaged in moisture-resistant, well-protected containers out of direct sunlight.

Seeds and Fruits

Except for fruits of the Apiaceous family that split open when dried, which should be harvested without a sure before maturation, fruits and seeds should only be picked when fully developed. When it comes to shrubs and trees, it is best to leave behind a few healthy fruits for future regrowth of the species rather than collecting all the fruits from one plant at once. In a similar vein, it is not advisable to harvest the fruits and seeds from the whole population of annuals at once. It is not recommended to trim branches off trees or bushes to make it easier to harvest fruits and seeds.

Fruits that are immature, diseased, or malformed should be removed and disposed of properly. Fresh fruits from medicinal plant products should be delivered right away after harvesting to cold storage or pulping facilities. Before the fruit is exchanged, the seeds should always be thoroughly removed from the rind. Fruits may be split or sliced into little pieces depending on the produce's needs in order to aid drying and packing. Fruits should be completely dried before being packaged. Fruits should be dissected to make sure there is no remaining natural moisture after randomly selecting a few.

Resins and Gums

While collecting the exudates, the harvester should take precautions to minimize damage to the mother plant. After the exudates have been collected, just a few tiny longitudinal incisions should be made to collect them, and the exposed areas should be well cleaned to prevent any fungal or bacterial infection. Avoid making cuts that are too near to the ground or that cattle or other animals might readily access. The collecting container should be made to resist contamination from rain, bird droppings, and other potential hazards. It should be carefully removed in cases where there is a chance that some extraneous material may mix with the collected gums and resins. Before collecting the exudates from the source tree or shrub once again, give them time to heal. Since most gums and resins are flammable, they should be kept in remote locations and packaged in the proper containers.

While in transportation and storage, resin containers such as those containing damar and saral should be marked "Inflammable Material." To enhance gum/resin flow, no fires should be lit close to the root of the tree. You shouldn't tap young trees. It is necessary to determine the girth of the trees below which tapping of gum or resin is prohibited. In warmer conditions, gum flows more readily. Therefore, tapping should be done on such species between June and October.

Only the specified species should have their galls gathered. The harvester must make sure that the galls are free of any living insects. Galls should be managed after harvest in a secluded area, and the contents should be properly packaged and kept to prevent any contamination of other crops[6].

Post-Harvest Administration

Scrubbing and Cutting

Use potable water to wash the soil still adhering to the gathered vegetables. Produce should be cleaned with potable water after pre-processing methods such as scraping, peeling, or brushing before drying. Any organic or inorganic material that has adhered to it should be cleaned off, and any mother plant parts that don't qualify as genuine medical plant output should also be removed. In order to improve drying while preserving the product's aesthetic appeal, the produce should be sliced into smaller pieces.

Drying

The medicinal herbs should be carefully dried before transport or storage. It is important to record the ideal moisture content of medicinal plant products. Medicinal plants may be dried in a variety of methods, including: in the open air; thinly layered on drying frames, in wire-screened rooms or buildings; in drying ovens/rooms and solar dryers; by indirect fire; baking; lyophilization; microwave; or infrared devices; or, if suitable, in direct sunshine. To prevent harm to the active chemical ingredients, temperature and humidity should be kept under control wherever feasible. The process and temperature employed for drying may have a significant influence on the final medicinal plant components' quality. In order to preserve or reduce the loss of color in leaves and blossoms, shade drying is desirable. Similarly, lower temperatures should be used when processing medicinal plant materials that contain volatile compounds.

It is important to document the drying conditions. It is best to avoid drying medicinal plant material directly on the ground. Medicinal plant products should be spread out on a tarpaulin or other suitable fabric or sheeting if a concrete or cement surface is being utilized. Animals such as cattle and household pets should be kept away from drying areas along with insects, rats, birds, and other pests. The drying time, temperature, humidity, and other factors should be chosen for indoor drying based on the plant component in question and any volatile natural elements, such as essential oils. If at all feasible, butane, propane, or natural gas should be the only heat sources used for direct drying, and temperatures should be maintained below 60 °C.6 Avoid contact between those materials, smoke, and medicinal plant material if additional fire sources are being employed[7].

Labeling and Packaging

To avoid product degradation and avoid needless exposure to potential insect assaults and other sources of contamination, the harvested plant materials should be packed as soon as feasible. The materials used for packing should be clean, dry, undamaged, non-polluting, and meet the quality standards for the relevant medicinal plant materials. Rigid containers should be used to store delicate medicinal plant ingredients. The customer and the supplier should, if feasible, agree on the packaging to be used. All packing supplies should be kept in a spotless, pest-free location that is out of the way of pets, livestock, and other sources of contamination. The scientific name of the medicinal plant, the plant component, the location of origin, the date of cultivation or collection, the names of the growers/collectors and the processor, as well as quantitative information, should all be clearly stated on a label attached to the package. The label must also conform to other national and/or regional labeling regulations and include information about quality approval. A number that clearly indicates the manufacturing batch should be on the label.

Storage

Produce from medicinal plants should never be kept in or close to cow barns or in open spaces. There shouldn't be any pests in the storage area. With the required signboards, the warehouse should be equipped to segregate authorized, rejected, and untested lots. Never place containers or items directly on the floor, particularly gunny bags, jute bags, woven sacks, corrugated boxes, etc. To store hygroscopic and volatile materials, a separate climate-controlled facility should be provided. Each container containing combustible products has to be appropriately marked with that information and kept in closed containers in a safe location[8]–[10].

Over 90% of the medicinal plant raw materials utilized by the production units come from natural forests, sometimes with little regard for environmental and social factors, leading to harvests that frequently exceed sustainable limits. Sustainable harvesting refers to the exploitation of plant resources at levels and via methods that allow the plants to continuously generate the intended goods. To achieve the finest quality medical plant components and completed herbal products, medicinal and aromatic plants should be picked within the ideal season or time period. It is important to take precautions during harvest to make sure that no noxious plants, weeds, or other objects are mixed in with the therapeutic plant ingredients. Avoiding dew, rain, or unusually high humidity can help you pick medicinal plants in the best circumstances possible.

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CHAPTER 7

IN-SITU AND EX-SITU CONSERVATION OF MEDICINAL AND AROMATIC PLANTS

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India, which has 10 biogeographic areas, is one of the top 12 nations in the world for mega diversity. It also features about 40 other locations with a high degree of endemism and genetic diversity. The country's diverse ecological habitats, along with the country's climatic and altitudinal variations, have helped to develop an incredibly rich vegetation, including a rare diversity of medicinal and aromatic plants. These plants serve as an important source of raw materials for domestic and international pharmaceutical industries as well as traditional medical systems. The growing need for medicinal herbs, which is still mostly satisfied by wild gathering, puts persistent pressure on already-scarce resources and causes certain forest species to continue to disappear. Additionally, forestland is losing 1.5 m.ha of its native flora every year, which is a serious issue. Every year, just 8% of the required 33% of the geographic region is left, and this number is rapidly declining. The country's resources for medicinal and aromatic plants are in danger due to overuse to supply the demand of the herbal businesses. About 95% of the therapeutic plants utilized by the herbal industries are gathered from the wild, largely from forests, according to statistics from the Ministry of Environment and Forests[1].

The definition of conservation in the global conservation plan is "the management of human use of biodiversity to yield the greatest sustainable benefit to present generation while maintaining its potential to meet the needs and aspirations of future generations." The words "conservation" and "sustainability," which are complimentary, are used in the definition above. Following is a summary of the World Conservation Strategy's main objectives for biodiversity conservation: maintenance of vital ecological processes and systems that sustain life and support economic activity, preservation of genetic variety and species, as well as sustainable usage of ecosystems and animals that support millions of rural populations and key businesses. Plants used for medicine and fragrance are potential renewable natural resources. Therefore, a long-term, coordinated, scientifically directed action program is required for the protection and sustainable use of medicinal and aromatic plants. The relevant elements of protection, preservation, upkeep, exploitation, conservation, and sustainable usage should be included. It will be preferable to have a comprehensive and methodical strategy that considers the interplay of social, economic, and ecological systems. The in-situ and ex-situ techniques are the two scientific approaches for biodiversity conservation that are most commonly acknowledged[2].

Conservation is Necessary

Because "Sarpagandha" was being over-harvested from its native environment, the Indian government banned its export in 1970. Except when a specific government permit is secured, this restriction is still in effect. Because a significant amount of the plants utilized by these businesses are gathered from the wild. Wherever the collection is damaging, the hazard is greater. The natural ecosystem is now being over-harvested for medicinal and aromatic plants, which are then trafficked without sufficient management and supervision. As a consequence, many significant medicinal and aromatic plants are on the brink of extinction owing to overharvesting for trade, habitat encroachment, habitat destruction, forest fires, and grazing. The Indian herbal sector generates roughly $300 million in revenue annually.

Every year, many tons of medicinal plants are taken from around 165,000 acres of forest area. Most of this MAP collection is done randomly and does not follow any regulatory procedures or accepted management standards. A thorough understanding of the biology of the species in question must serve as the basis for the collection of MAPs, and precautions must be taken to prevent over-exploitation and the gathering of rare and endangered species. Thus, maintaining the natural habitats of endangered medicinal plant species and ensuring their sustainable utilization in less susceptible places are conservation's ultimate goals.

Issues in the MAPs Sector

Given that human cultures in developing nations rely heavily on forest products for their economies and way of life, the ongoing rise in human population is one of the factors raising concerns about our ability to satisfy our daily needs for food and medicine. This tendency is causing the forest and its products to continuously erode, making it difficult to both fulfill demand and preserve valuable bio resources[3].

Expanding Demand

According to the World Health Organization, the annual demand for medicinal plants is now projected to be over US $14 billion. According to a WHO estimate, the market for raw materials derived from medicinal plants is expected to rise by between 15 and 25 percent yearly and reach $5 trillion in value by 2050. Many plants have been over-harvested from the wild as a consequence of the anticipated rise in demand for medicinal herbs, which has led to the extinction of their current populations.

Examples of other north Indian medicinal plant species that have been overused and are now classified as rare or endangered include Aconitum heterophyllum, Nardostachys grandiflora, Dactylorhiza hatagirea, Polygonatum verticillatum, Gloriosa superba, Arnebia benthamii, and Megacarpoea polyandra. In addition, a number of medicinal plant species may become extinct locally due to increasing demand and declining habitats.

Rarer

The introduction of non-native species, habitat alteration, climatic changes, heavy livestock grazing, population explosion, fragmentation and degradation of the population, population bottleneck, and genetic drift are just a few of the many potential causes of rarity in medicinal plant species. Other potential causes include habitat specificity, narrow range of distribution, land use disturbances, and genetic drift. Numerous high-value medicinal plant species have seen population declines over time as a consequence of ongoing exploitation of various wild medicinal plant species and significant habitat degradation over the last 15 years[4].

Enhancing the Legal Market System

The marketing structure in the industry of medicinal herbs is mostly uncontrolled and unfair. In most cases, marginal farmers and laborers are the ones that harvest therapeutic plants. Selling these therapeutic plants provides them with the cash they need to cover their basic expenses for food, healthcare, and children's education. They often don't know the true market values for many different kinds of medicinal plants. In addition to government organizations, there are several other parties involved in the trade of medicinal plants, including herb gatherers, regional intermediaries, urban dealers, wholesalers, manufacturers, exporters, and herbal healers. Numerous varieties of therapeutic plants are marketed in clandestine markets. The industry for medicinal plants is, in general, poorly documented and controlled.

Ecological Preservation

The best method for protecting MAPs is seen to be in-situ conservation, which refers to the preservation of species in their native habitats. It is generally known that "in-situ" or "on-site" conservation, which involves preserving a wild species or stock of a biological community in its native environment, is the most successful and economical method of safeguarding the current biological and genetic diversity. Examples of "in-situ" approaches of conservation include the creation of biosphere reserves, national parks, wildlife sanctuaries, holy groves, and other protected places. In India, a network of protected areas covering 4.5% of the country's total land area, including 15 Biosphere Reserves, 97 national parks, and 503 wildlife sanctuaries.

This network includes several biogeographic zones and biomes with a wide variety of biotic organisms, including fragrant and medicinal plants. In addition to these, several holy groves around the nation, especially in the South, West, and East, are active hubs for the in-situ preservation of medicinal plants. Such a network of conservation areas may greatly contribute to the preservation and sustainable management of our nation's biological riches. Indian residents who live in, in, or around protected forest areas may actively support and participate in the in-situ conservation of medicinal plants. To achieve effective management and usage of medicinal plant resources, the local populace must be included in all stages of conservation programs, including planning, the formulation of policy, implementation, etc.[5], [6].

In 1993, a Danida-supported effort in the three southern states of Karnataka, Kerala, and Tamil Nadu started the conservation of medicinal plants in India. Identification and delineation of MPCAs, community involvement in conservation efforts, and management plans for the conservation areas were all components of the establishment of in situ medicinal plant conservation areas.

With the aid of Medicinal Plant Conservation Areas

To protect medicinal plants within their environments, do this. These areas, which will be known as Medicinal Plants Conservation Areas, will be large enough to reflect the habitat and a healthy biological community in accordance with the island biogeography hypothesis. MPCAs were built in woods that have historically been prized as repositories for medicinal plants. These forests were also readily accessible, generally undisturbed, formed compact micro-watersheds, and were not heavily used by the local population for daily necessities. Rapid Assessment served as the foundation for choosing MPCAs. Through a workshop on conservation assessment and management prioritization, threats to medicinal plants were examined at the state level. The workshop intended to allocate each species to a level of peril based on the estimations of the risks to the population and their habitat using the IUCN's quantitative Red list approach. A network of medicinal plant conservation sites has been established in the states of Orissa, Rajasthan, West Bengal, and Madhya Pradesh as part of the Foundation of Revitalization of Local Health Traditions. In order to cover the various forest types, the distribution and richness of medicinal plants, as well as the ecosystems crucial for them, these locations were chosen in each state. 42 sites in all were chosen for the establishment of the MPCAs for critically endangered and endangered species in these 4 states. There have been no designated MPCAs recorded for the state of Uttarakhand.

Enhancing the conservation of MAPs in PA's

A protected area is a region with a specified geographic scope that has been set aside, governed, and maintained to meet certain conservation goals. This covers wilderness areas, national parks, and nature reserves as well as sustainable use reserves. Except for a few protected areas like the Tipi Orchid Sanctuary in the North East Himalaya and the Valley of Flowers in the North West Himalaya, the majority of India's protected areas are primarily concerned with the preservation of faunal variety. A single protected area dedicated to the preservation of medicinal plants does not exist. The identification and registration of places for the protection of medicinal plants on a priority basis are therefore urgently required[7].

Currently, there are 12 protected areas in Uttarakhand, which account for around 21% of the state's forestland. Since big animals are found in the majority of PAs in the Himalayan foothills, protecting these regions' mammal populations and their habitats is a priority. The richness of medicinal and aromatic plants is often better recognized in the PAs at higher elevations. However, the majority of PAs focus largely on preventing poaching of wild animals, and no specific efforts are made for the management and conservation of medicinal plants in such regions. The majority of PAs lack an effective method for monitoring and inventorying MAPs. The promotion of medicinal plant nurseries and their cultivation as part of eco-development initiatives in the regions around PAs, particularly in Nanda Devi National Park, is noteworthy.

Conservation Ex-Situ

The preservation of biological diversity components away from their native settings is known as ex-situ conservation. Ex-situ, or outside of their natural habitat, gene banks, seed banks, field banks, in vitro plant tissue, artificial propagation of plants, and botanic gardens for research and public awareness, as well as the development of nurseries and home gardens, can all be used to conserve medicinal plants.

Gardens with Plants

Botanical gardens, also known as botanic gardens, are often well-kept parks that feature a variety of fragrant and medicinal plants labeled with their botanical names. In ex-situ plant conservation, botanical gardens may be crucial, particularly for species that are in danger of becoming extinct soon. Many gardens across the globe focus on the study and cultivation of medicinal and aromatic plants, and some even have particular gardens dedicated to these plants or have unique collections of them. A total of 140 botanical gardens exist in India, 33 of which are connected to botany departments at 33 different institutions. Kerala's Tropical Botanical Gardens & Research Institute is a prime example of ex-situ plant variety conservation in India. It is situated in a degraded forest area of the Western Ghats Mountains. The TBGRI's field gene bank initiative, which ran from 1992 to 1999, is now widely recognized as a very successful technique for conserving the genetic resources of medicinal and aromatic plants. This ex situ and in situ hybrid field gene bank of medicinal and aromatic plants is located at TBGRI, Thiruvananthapuram. For the ex-situ conservation of medicinal and aromatic plants, a number of medicinal plant gardens and nurseries have been established in the state of Uttarakhand.

The creation of herbal gardens

The "Herbal Garden's major goal is to protect and promote the medical benefits of the numerous plants that grow erratically in our surroundings and whose qualities help to maintain a balance between man and environment. The Forest Department of Uttarakhand established 4 herbal gardens with the goals of conserving rare species that are difficult to find and unfamiliar to traditional medicine students and practitioners, obtaining authentic raw materials needed for production of traditional drugs from the Department of Traditional Medicine, and demonstrating practical training for traditional medicine students regarding the systematic planning

Garden kitchens

With the aid of the readily accessible fresh water as well as the wastewater from the kitchen and bathrooms, one may construct a kitchen garden by growing various medicinal and fragrant plants that we use on a daily basis in their backyards. This may help with the effective production of our own need for certain "daily-use" medicinal plants, as well as the avoidance of stagnation of unused water, which will be harmful to our health via environmental pollution. Herbs used in cooking may have beneficial medicinal side effects. Additionally, some of the plants planted in the garden are intended expressly to treat diseases or ailments like colds, headaches, or anxiousness[8].

Seed and genetic material gathering

The primary goal of the germplasm collection is to preserve aromatic and therapeutic plants and make them accessible for use in the future. The preservation of fields, tissue culture, cryopreservation, and seed banks are all methods for conserving vulnerable germplasm. The best approach is thought to be seed storage. Recalcitrant seeds, including most tropical species, lose their viability when exposed to the same circumstances as conventional seeds, which may be dried and kept at sub-zero temperatures. Germplasm maintenance in field collections is expensive, takes up a lot of space, and is susceptible to the effects of the environment. Techniques for tissue culture or cryopreservation may also be taken into account in specific circumstances. A fundamental grasp of a plant group's taxonomy, genetic diversity, geographic distribution, ecological adaptability, and ethnobotany, as well as of the geography, ecology, climate, and human populations of the target location, is necessary before wise conservation choices can be made. The following factors are crucial for seed and genetic material collection:

1. When, where, and how should germplasm be collected?
2. How vulnerable is the genetic material?
3. How should genetic reserves be maintained and controlled, and where should they be placed? 4. How ex-situ and in-situ methods contribute differently to a larger conservation plan.

For further multiplication and development, the state of Uttarakhand requires both centralized and decentralized seed and propagule collecting centers, which would contain the known source of the germplasm. Only specially trained staff members shall gather seeds and propagules from the designated MPCAs, conserved forests, sanctuaries, and herb gardens. At such centers, it would be crucial to adhere to the accepted practices for sanitation, source labeling, and germplasm certification[9].

Using Biotechnological Methods

The essential genotypes of medicinal plants must be chosen, reproduced, and preserved, and these tasks need the use of biotechnological technologies. High-quality plant-based medicines might be made via in-vitro regeneration, which has a lot of promise.

Cell culture: Tissue culture is the process of growing new plants from tissue fragments that have been deposited on a sterile, nutrient-rich growth medium. Eventually, the cell clusters that form evolve into tiny plantlets with roots and stems. These plantlets develop into full-sized plants when they are inserted into the soil. The commercial cultivation of medicinal and aromatic plants as well as the preservation of the genetic material of rare and endangered species have both been made possible with the use of this technique. Cryopreservation: It's a good idea to cryopreserve in-vitro cultures of aromatic and medicinal plants. In liquid nitrogen, cryopreservation is a long-term preservation technique that halts metabolic and biochemical activities, as well as cell division. Liquid nitrogen may be used to store a significant quantity of cultivated materials. Since complete plants may grow from frozen cultures, cryopreservation offers a chance to preserve therapeutic plants that are in risk of extinction.

A variety of tissue types, including meristems, anthers/pollens, embryos, calli, and even protoplasts, have been successfully stored by cryopreservation. The primary procedure in the commercial synthesis of secondary metabolites by plant biotechnology is the use of bioreactors. A high yield of the chemical and lower costs as compared to the natural synthesis by plants are the basic requirements in all of this. The ideal environment for large-scale plant production for commercial manufacturing is provided by bioreactors. The output of new secondary metabolites may be increased by genetic transformation, which is a potent strategy. Currently, transformation is utilized to genetically modify more than 120 species from at least 35 families, including a variety of aromatic and medicinal plants. It has been shown that Agrobacterium tumefactions was used to genetically alter Atropa belladona, improving the alkaloid content. Using leaf explants, it has been shown that agrobacterium-mediated transformation of Echinacea purpura is possible.

Laws Governing Conservation

The Indian Forest Act and the Wildlife Protection Act are the two national laws that primarily provide the legal framework for the preservation of nature and natural resources in India. The Wildlife Protection Act deals with Wildlife Sanctuaries and National Parks, whilst the Forest Act mainly addresses the construction of Reserved Forests and Protected Forests within the State. However, other from a few tree species, India currently has no explicit rules or regulations governing the exploitation of any flora. Any plant may be exterminated outside of a national park without breaching the law. State governments also enact laws and regulations in addition to the federal government. The Indian Parliament approved the "Biological Diversity Bill, 2000" in 2002 in order to establish rules for the preservation and ethical distribution of the benefits associated with biological resources. The conclusion of this law is anticipated to have a good impact on the regulation of medicinal plant conservation, collecting, and commerce. The conservation area and the developing area are the two key areas that the Uttarakhand state forest department must define in each Forest Division.

The forest division in question will choose the conservation areas based on their richness of medicinal plants and designate them for in-situ conservation and total protection. In 2001, Uttarakhand's State Medicinal Plant Board was established. The nodal organization for the Board is Herbal Research and Development Institute, located in Gopeshwer. In addition to these organizations, the state of Rajasthan has a cooperative framework for regulating the collecting and trading of medicinal plants called Bhesaj Sangh. The Horticulture Department oversees these district-level collectors' cooperatives. Currently, there are Bhesaj Sanghs working at the district level in 12 of the state's 13 districts, with Udham Singh Nagar district being the lone exception[10].

Therapeutic Plant Conservation Facilities

Numerous government and non-government groups in India have concentrated their efforts on developing the MAPs industry. Numerous organizations carry out activities at the national level, with large institutions supported by the Indian government playing the most significant roles. The Central Institute of Medicinal and Aromatic Plants, National Botanical Research Institute, Central Drug Research Institute, and the Regional Research Laboratories at Jammu, Bhubaneswar, Jorhat, Palampur, Bhopal, and Thiruvananthapuram are among the Council of Scientific and Industrial Research institutions engaged in such programs. In collaboration with the National Bureau of Plant Genetic Research, National Research Center for Medicinal and Aromatic Plants, and Indian Institute of Horticultural Research, the Indian Council of Agricultural Research conducts an All India Coordinated Research Project on Medicinal and Aromatic Plants.

The Department of Environment and Forests, Government of India, is supporting the Botanical Survey of India in its efforts to establish regional circles and experimental gardens in a variety of Indian regions, including Dehradun, Allahabad, Shillong, Pune, Coimbatore, and Port Blair. There are three more stations at Jodhpur, Gangtok, and Itanagar. The Indian Council of Forest Research has started a project to cultivate medicinal plants and create "Vanaspati Vans." The

North-Western Himalayan region's biological variety is preserved by the G.B.Pant Institute of Himalayan Environment and Development, an institution of the Ministry of Environment and Forest, Government of India. Himalayan MAPs are the subject of current study and development at the Herbal study and Development Institute in Gopeshwar. The Kerala-based Tropical Botanical Garden and Research Institute has launched a significant effort on the preservation and sustainable use of peninsular India's rich medicinal plant diversity. The creation of a showcase garden, a field gene bank, an in vitro gene bank, and a seed gene bank are among TBGRI's main projects. This is a component of the G-15 GBMAP initiative, which is funded by the Indian government's Department of Biotechnology[11].

Many aromatic and therapeutic plants are on the danger of extinction due to overexploitation of their natural habitats. 44 plant species are severely endangered, 113 are endangered, and 87 are vulnerable in India, according to the Red List of Threatened Species. According to the World Health Organization, the annual demand for medicinal plants is now projected to be over US $14 billion. According to a WHO estimate, the market for raw materials derived from medicinal plants is expected to rise by between 15 and 25 percent yearly and reach $5 trillion in value by 2050. A long-term, comprehensive, and scientifically based action plan is unavoidably required for the protection and sustainable use of medicinal and aromatic plants. The in-situ and ex-situ techniques are the two scientific approaches for biodiversity conservation that are most commonly acknowledged. A thorough understanding of the biology of the species in question must serve as the basis for the collection of MAPs, and precautions must be taken to prevent over-exploitation and the gathering of rare and endangered species. The preservation of species in their native environments is known as in-situ conservation. Examples of "in-situ" approaches of conservation include the creation of biosphere reserves, national parks, wildlife sanctuaries, holy groves, and other protected places. India has 503 wild life sanctuaries, 97 national parks, and 15 biosphere reserves in total. The preservation of biological diversity components away from their native settings is known as ex-situ conservation. Ex-situ, or outside of their natural habitat, conservation of medicinal plants can be achieved through gene banks, seed banks, field banks, in vitro plant tissue, artificial plant propagation with potential for reintroduction into the wild, botanic gardens for research and public awareness, development of nurseries, and home gardens. All interested parties need to be made more aware of conservation-related concerns and the value of sustainable use. It is important to assist and motivate the local population to take the essential actions to safeguard this priceless resource.

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CHAPTER 8

THE FUNCTION OF AROMATIC AND MEDICINAL PLANTS

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Humans probably benefited from the discovery of medicinal and fragrant plants that served as food and medicine before the notion of history ever existed. Early humans may progress civilization and improve their own and their society's health when they learnt to identify and eat certain plants. Every civilization would adopt traditional medicine as a component of life support systems, using medicinal and aromatic herbs extensively. In order to assess if a plant was useful as food or medicine, it is obvious that the range of accessible plant components would be tasted and evaluated. Today, a wide range of readily accessible herbs and spices are used and savored globally and continue to support excellent health. As the advantages of medicinal and aromatic plants become more widely understood, humanity will increasingly benefit from these plants[1].

There is little question that ancient human existence was challenging from the start. Our ancestors need food for energy and medication for health maintenance in order to live. Hunting animals would provide high-energy foods like meat, but it was surely more difficult to get remedies to heal illnesses. Even if current science has found plants and plant extracts that may treat and cure ailments, it would be difficult to locate and identify plants that have health-enhancing components in ancient times. The earliest known medical records, which were recorded by the Sumerians on clay tablets between 5000 and 3000 BCE, show that people were aware of ailments and that using plants that contained medicines might help preserve and restore health. The Iceman, known as Tzi, was accidentally murdered between 3400 and 3100 BCE in the chilly, high Alps. Evidence of medicinal plants found on his preserved remains implies that other people were also aware of these plants' therapeutic properties. The usefulness of medicinal plants in healing and preserving health is widely acknowledged, despite the fact that the history of our early ancestors and their medicines is fragmentary.

Plants probably survived by creating repellent, unpleasant chemical components that repelled foraging animals since they are vulnerable to grazing animals and insects. Humans might choose which plant tissues to consume based on their observation that particular plant tissues, such as fruit, leaves, or roots of certain species, improved one's mood. Gardens of desirable plants would be created from these humble beginnings to provide food and essential plant elements for human health. Medical treatment has developed throughout time, going from diseases to immunizations, new drugs, and better healthcare facilities that can more precisely identify and treat health issues. Modern medical advancements have made it possible for individuals to live longer, healthier lives. Most illnesses have been beaten thanks to new plant-based medications and antibiotics derived from microflora. Medical labs are able to identify the condition using tissue and blood samples, X-rays, and other materials, assuring the doctor can suggest the right medication in the right dose[2], [3].

Only their senses could be used by our ancient predecessors to evaluate the flavor and therapeutic potential of plants and plant components. However, since then, medicinal and aromatic plants have offered a wide range of advantages, including those related to food flavoring, medications, preservatives, decorations, attractiveness, and personal enjoyment. Since ancient times, knowledge of medicinal and aromatic plants has been handed down from generation to generation, enhancing life and health. Even while not everyone understands the significance of medicinal and aromatic plants, extinctions brought on by climatic changes, plant diseases, or other plant-related threats might wipe out numerous plant species and the advantages we have become used to. The information was passed down to following eras, encouraging many practices.

On the other hand, because of the diverse climatic conditions on earth, numerous distinct and regionally peculiar medicinal and aromatic plants now grow all over the globe. Each civilization's and cultures initial medicines were made from medicinal and aromatic plants and ethnobotany. Knowledge and materials are distributed as a result of human mobility. Dramatic historical events included the discovery of strange plants and the chemical health components discovered inside of them. Due to the scarcity of plant resources, people traversed the world in quest of new spice plants and the habitats in which they thrived. By the seventeenth century, spices were recognized as a kind of medicine, a food preservative, and a flavoring ingredient. By the seventeenth century, significant substances for human health had been identified and created. Plant extracts that serve as templates for brand-new modern treatments were the basis for several synthetic drugs[4].

Medicinal and aromatic plants for Human Use

Food, medicine, entertainment, and healing are just a few of the ways that people have benefited from the remarkable union of medicinal and aromatic plants. The potential of medicinal and aromatic herbs to cure a variety of difficult ailments, such as infectious disorders, cancer, and AIDS/HIV, was one of its main benefits. The National Cancer Institute screens plants for the possible creation of innovative drugs and active plant chemicals for cancer and AIDS/HIV in a number of current partnership research.

Integrated Medicine

Integrative medicine is the use of medicines to conduct an enjoyable life and improve quality of life. Integrated medicine is accepted not only for the treatment of disease, but also for the treatment of presymptomatic conditions, the prevention of illness, or the maintenance of health. Integrated medicine, for instance, includes both conventional treatments and western and eastern medicine.

Every drug has a strong and a weak point; western medicine has the advantage of being able to treat patients fast via surgery, medication, and examination; its weakness is side effects. The advantage of eastern medicine, on the other hand, is that it could restore equilibrium to the body when it comes to persistent and chronic ailments, as well as for kids, the elderly, and expectant women. Its disadvantage can be how long it takes to recover. The appropriate course of action depends on the circumstances, but the capacity to heal oneself with medical help, not a drug that can accomplish it, is the most important factor when contemplating a "cure"[5].

Aromatic and therapeutic plants from Asia

Nowadays, people are interested about things like longevity, disease prevention, detox, and their physical and emotional well-being. Thus, integrative or preventive medicine is valued and acknowledged in modern medicine and daily life. Some medicinal and aromatic plants with Asian origins are used on a daily basis all over the world due to their popularity and variety. The list of commonly used medicinal plants is shown below.

Chinese Pepper

Japan acts as the origin and is located south of the Korean Peninsula. The Japanese pepper, which grows from north to south in Japan, prefers humidity and half-shade. The fruit is a little green berry that ripens in September, turns red, and has one black seed. It is dioecious and may reach a height of 1-3 m. The powerful scent of the peel is used as a spice and a basic medication. Fresh leaves are often used as a condiment and garnish. Chinese historical sources state that in the tenth century, fruits were used as medicine in Japan. The compounds that make up essential oils include citronellal, linalool, isopulegol, geranyl acetate, and -terpineol. Among the therapeutic benefits are antioxidant, stomachic, digestion, and blood circulation improvements. Japanese pepper was a symbol of the fecundity's future prosperity[6].

Kumazasa

The Kuril Islands, Kamchatka, the Korean Peninsula, and Japan are the origins. Rhizome propagation is perennial and grows to a height of 1-2 m on the forest floor of Japanese mountain ranges. In the winter, a leaf's margin becomes white. Because the leaves have an antibacterial effect, they are used to wrap cooked rice. The deodorization is aided with a breath-freshening herb tea made from kumazasa leaves. Chlorophyll, vitamins B1, B2, and K, calcium, magnesium, potassium, and benzoic acid are some of the ingredients. The dried leaves are unprocessed medications that have effects on the digestive, urinary, antibacterial, anti-inflammatory, and detoxification systems.

Dokudami

China, Southeast Asia, and Japan are the origins. Dokudami are rhizome-propagated perennial plants that are 20–30 cm tall and have cold resilience. The whole plant is utilized in cooking and cosmetics. When opposed to flesh, the dried leaves have no unpleasant smell. The herbal tea reduces constipation, hypertension, and strengthens capillaries, and the crude pharmacological effects for diuresis, laxative, anti-inflammatory, and detoxifying. Dokudami is ineffective for sufferers who are weakened, nevertheless. For skin treatment, a tincture is used as body lotion, and crushed flesh leaves may be used to a rash or other dermatological issue. The ingredients of dokudami include rutin, potassium, quercetin, and quecitrin[7], [8].

Asian Mugwort

Since the ninth century, Japanese mugwort has been used as a treatment for dermatitis, stanching, toothaches, stomachaches, and diarrhea in Japan. It is perennial, grows 50–100 cm tall, and has fluff on the back of the leaf. Moxa therapy uses a gathered fluff, and leaf decoction is effective for treating eczema, heat rash, lumbago, and hemorrhoids. Japanese mugwort is a common ingredient in side dishes, steamed rice cakes, dye, and other household items. Vitamins B1, B2, C, D, -carotene, chlorophyll, and minerals make up the components. 1,8-cineole, thujone, -caryophyllene, borneol, and camphor are all present in the essential oil. Anyone who is allergic to asteraceae should use caution.

Expect a medical role Marijuana

Cannabis sativa, often known as marijuana or pot, is a psychoactive narcotic plant used for medical purposes. Tetrahydrocannabinol, also known as THC and cannabidiol, sometimes known as CBD, are the two main components produced by the plant tissues from cannabinoid acids, which are produced in the presence of heat. THC is a plant compound that induces intoxication by activating a brain receptor that starts the intoxication as well as the brain's pleasure reward system. CBD, a non-psychoactive component of marijuana, is thought to have medicinal uses, particularly for seizure control.

Research development and the creation of New Drugs

The pharmaceutical sector is expanding annually, notably in the United States, where it contributed an estimated $790 billion to the national economy in 2014. The degree of family, plant species, and cultivars will be revealed by the organic chemistry of plant materials while developing a novel medication. There are now at least 120 different chemical compounds originating from plants that are regarded as significant medications. The makeup of the chemical and its constituents reveals a special therapeutic activity, and knowledge of and use of conventional medicinal plants revealed the best treatments for the ailment. The data will serve as a guide for creating a new medicine. Ethnobotany and traditional medicinal herbs, including quinine and artemisinin, have the potential to be very useful resources. Once a single chemical had been identified, extraction or synthesis, which is practically the whole drug stage, was now feasible. The substance will become a new medication after a clinical study showed it to be beneficial[9].

Prospects

Only 4478 of the plant species used in plant-based medicines are referenced in a medical regulatory publication, despite the fact that at least 28,187 plant species are now listed as having medicinal uses worldwide. There is a great chance that new drugs may be discovered in the future. As interest in alternative treatment grows, so does the worldwide market for herbal medications. The World Health Organization estimated the yearly worldwide market for herbal medicines to be worth US$60 billion in 2003, and by 2012, it was estimated that the global market for Traditional Chinese Medicine alone was worth US$83 billion. However, the presence of medicinal and aromatic plants is what allows for human survival and the creation of new pharmaceuticals. The most important duty of human beings as the conditions of the planet change is the preservation of plant species and genetic resources. Worldwide, plants are already suffering from the effects of climate change. A study team examined the ranges of 1350 plant species in Europe in the late 21st century under seven different climate change scenarios. By 2080, more than half of the species may be in danger or fragile. It is well established that certain climate change mitigation strategies need a sustained collaborative effort from national and international multidisciplinary scholars.

Despite a lengthy history of usage dating back to ancient times, medicinal and aromatic herbs still have an untapped and limitless potential. Losing genetic resources means suffering a significant loss in the future; as a result, it is important to maintain the harmony of life among humans, animals, and plants. The function of medicinal and aromatic herbs evolves with time, moving from the treatment of sickness to the prevention of disease. The vast amounts of gathered knowledge, information, and materials have to be distributed across the whole planet and passed down from generation to generation. All life has access to the gifts that medicinal and fragrant plants provide[10]–[12].

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CHAPTER 9

PLANTS PROVIDE INDUSTRIAL, AROMATIC AND MEDICAL MATERIALS

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Higher plants are solar-powered biochemical factories that create the essentials for survival from sunshine, air, water, and minerals. Numerous species of higher plants have the capacity to biosynthesize and accumulate amounts of extractable organic compounds that are commercially valuable as chemical feedstocks or as raw materials for different types of industrial, scientific, and commercial uses. Numerous sectors use natural resources, either directly or indirectly, and natural plant products play a significant role in several of them. For instance, the pharmaceutical, cosmetics, food, agrochemical, and chemical industries all make extensive use of phytochemicals. Industrial oils, flavors and fragrances, resins, gums, natural rubber, waxes, saponins and other surfactants, dyes, pharmaceuticals, pesticides, and many specialty products are all derived from economically significant plants.

Drugs like morphine and codeine, cocaine, quinine, curare, and digitalis, fragrances and essences like rose oil and jasmine, industrial raw materials like fatty acids, pine oil, and natural rubber, and pesticides like pyrethrum and nicotine are all well-known plant-derived natural products. These illustrations show how crucial plant-derived natural products have been and will be to humans as a source of medicines, meals, insecticides, and other basic resources. This chapter reviews certain economically significant phytochemicals' distribution, commercial production, usage, and production economics. Primary vs. Secondary Metabolites: General Production Economics Considerations Organic substances generated from plants may be categorized as primary or secondary metabolites. [Informational biopolymers like nucleic acids and structural and catalytically/functionally active proteins are often omitted from this group. Almost all organisms produce primary metabolites, which are chemicals that are extensively disseminated in nature. Such chemicals, which are often concentrated in seeds and vegetative storage organs in higher plants, are essential for both general growth and physiological development.

Man has known from the beginning of time how to gather primary metabolites from plant species or varieties that are metabolite overproducers and accumulators for use as foodstuffs and raw materials. As a result, primary metabolites that are now extracted commercially from higher plants are often bulk compounds with low value and large quantities. These compounds include items like vegetable oils, fatty acids, and carbohydrates [such as table sugar, starch, pectin, different hydrocolloid gums, and cotton] and are typically employed as industrial raw materials, foods, or food additives. These materials are often sold for less than US $1 to $2 per pound, and the majority are easily accessible as commodities on the market. There are, however, several exceptions to this rule. For instance, while certain plants collect significant levels of p-carotene, it is labile and very sensitive to air oxidation and photodegradation. Myo-inositol is also generated by plants, but it is difficult to purify. As a result of the challenging and time-consuming nature of their extraction, separation, and purification, these primary metabolites are costly.

Primary metabolites may sometimes be used as intermediates in the production of very valuable semi-synthetic pharmaceuticals. As an example, stigmasterol generated from soybeans may be employed as an intermediary in the production of steroid hormones[1].Although secondary metabolites are biosynthetically descended from primary metabolites, their distribution in the plant kingdom is more constrained, often being confined to a single taxonomic group.

Convergent evolution is often seen in the separate emergence of secondary metabolites that are not too far away from basic metabolic pathways in relatively unrelated organisms. The well-known examples of this phenomena include nicotine and related alkaloids. Secondary chemicals often play ecologically significant roles in how plants interact with their environment, which is vital for their long-term survival even if they play no visible functions in a plant's primary or "mainstream" metabolism. Secondary metabolites in plants can act as pollinator attractants, chemical adaptations to environmental stresses, defensive, protective, or offensive substances against microorganisms, insects, higher herbivorous predators, and even other higher plants.

Therefore, plant secondary metabolites are by definition biologically/physiologically active substances since they primarily work to fight infectious illnesses, promote weed aggressiveness, and deter herbivores and herbivory. Secondary metabolites are often metabolically costly to create and accumulate, which makes them commonly present in plants in much lesser amounts than primary metabolites from a cellular economics standpoint. However, as these substances have been chosen by evolutionary forces for their relatively powerful biological action, the accumulation of huge amounts of secondary metabolites is often not necessary in nature.

Additionally, secondary metabolites tend to be biosynthesized in certain cell types and at particular developmental phases, in contrast to primary metabolites, which makes their extraction, separation, and purification challenging. Therefore, compared to primary metabolites, secondary metabolites that are exploited commercially as physiologically active substances tend to be higher value-lower volume products. Therefore, many bioactive secondary metabolites might be seen as specialty materials or fine chemicals when compared to primary metabolites.

It is a frequent misperception that the majority of bioactive chemicals obtained from plants are now manufactured synthetically. Secondary metabolites, on the other hand, can have very intricate stereo structures with several chiral centers, which may be crucial for biological activity. As a result, it is expensive and impractical to commercially manufacture many of these complex biomolecules. The Catharanthus alkaloids and the naturally occurring plant-derived pesticide azadirachtin are two examples of secondary metabolites with a high degree of structural complexity.

Primary and secondary plant metabolites that are significant economically do share certain traits. The majority of these no proteinaceous plant chemicals are easily extracted from plant materials using steam distillation, extraction with organic solvents, or extraction with aqueous solvents. They typically have low molecular weights.

The Effect of Biotechnology on the Production of Plant Secondary Metabolites and Plant Proteins

The commercial creation of novel medications and other biologically and catalytically active items made possible via genetic alteration has attracted a great deal of attention as a result of the present biotechnology revolution. However, virtually all of the newly developed or currently being tested rDNA biotechnology-derived medications are mammalian proteins, such as the hepatitis B vaccine and various other vaccines, human insulin, the interferons, monoclonal antibodies, human and bovine growth hormones, and other therapeutic polypeptide hormones, lymphokines, such as interleukin-2; tumor necrosis factor, tissue plasminogen activator, and erythropoietin. Despite the fact that plant proteins are essential to human nutrition, few pure plant proteins, glycoproteins, other conjugated proteins, or protein extracts are employed in the pharmaceutical industry as physiologically active substances. Papain and chymopapain fruit, which are used medicinally as protein digestants and as meat tenderizers; bromelains fruit juice and stem tissue; ficin, a proteolytic enzyme derived from the latex of some tropical fig trees; and malt extract are some examples of economically significant plant-derived enzymes[2].

Specialized plant proteins may be extracted from plant cells and used, but their value is restricted for a number of reasons. First, the use of proteins as biologically active chemicals, such as medications and insecticides, is subject to limitations imposed by their chemical structures and nature. For instance, since they are susceptible to digestive destruction by proteolytic enzymes, most proteins cannot be supplied orally and cannot be efficiently absorbed via insect or mammalian cuticle. The above-mentioned intensely sweet and flavor-modifying and -enhancing proteins, papain, and highly toxic lectins like ricin are examples of plant proteins that are effective when consumed orally. These lectins likely act against herbivores in nature as potent local gastrointestinal poisons that don't necessarily require systemic absorption.

However, the majority of polypeptides must be delivered via injection in order to produce repeatable systemic effects. As a result, proteins are more difficult to make accessible than secondary metabolites, which makes it more difficult to formulate, use, and distribute products. For instance, because to the physicochemical instability of many macromolecules, many potentially effective insecticidal/pesticidal proteins may have a low bioavailability and may be prone to fast disintegration in the field. Therefore, secondary metabolites are more economically beneficial than plant proteins in many applications. Second, the technology to insert and express the genes that code for useful polypeptides in bacteria and yeast is currently available. Since genetically modified microbes can be successfully cultivated in culture, this eliminates the requirement to grow plant cells in order to extract certain proteins. The highly sweet thaumatin proteins, whose genes have been transferred to Escherichia coli and Saccharomyces cerevisiae and generated by microbial fermentation, are one example of this.

Another thing to take into account is the issue of Third World production economics, which may make the manufacture of proteins from whole-plant sources, such as papain and chymopapain, relatively affordable for some time to come. Contrarily, due to the complexity of secondary metabolite production, it is far more challenging to genetically engineer bacteria or yeast to manufacture the complex secondary metabolites that are naturally produced by certain plant species. Contrary to simple proteins, secondary metabolites are not the result of a single gene. Secondary metabolites, often known as complicated biosynthetic pathways, are frequently complex macromolecules that are the byproducts of protracted, multi-step, enzymatically catalyzed reaction cascades. Secondary metabolites are often biosynthesized by the cooperative action of several gene products, i.e., many enzymes, while proteins may be direct gene products. It would be a very challenging task to put together and transfer all of the required biosynthetic machinery into a foreign microorganism, and to have it function there properly to achieve the desired biosynthesis efficiently. This is because secondary metabolite biosynthesis are typically complex biochemical processes.

Furthermore, even relatively basic microbes contain numerous natural enzymes that might catalyze unfavorable side reactions with the target metabolite or with intermediates in its biosynthesis route. This is true even if it were feasible to assemble all of the necessary biosynthetic machinery in these organisms. Therefore, it is likely that the sources of the majority of these complex plant-specific components will continue to be entire plants, specialized plant sections, or cultivated plant cells, at least for the foreseeable future. The whole genetic code needed for effectively encoding and programming the construction of the complex biomolecules known as plant secondary metabolites is present in the complete plant cells. The greatest long-term potential of genetic engineering and related rDNA-based biotechnologies, from the perspective of industries using plant metabolites, lies not in the direct production of plant proteins, but rather in the improvement of the efficiency of the biosynthetic machinery of those plant cells producing extractable plant metabolites of interest. However, it could take some time before plants can be genetically modified and designed at this degree of complexity and structure. As a result, the balance of this chapter will focus on an overview, a debate, and a short discussion of the possibilities for new production techniques based on plant cell culture. This chapter will also examine the production of secondary metabolites from entire plants, which are both scientifically and commercially significant.

Foods and beverages that contain Secondary Metabolites

The vast majority of spices, sauces, teas, and other alcoholic and non-alcoholic drinks, including coffee, kola, and cocoa, owe their distinctive and distinguishing qualities to the pharmacologically and physiologically active secondary metabolites they contain. High prices are occasionally sometimes paid for chemicals recovered from their natural sources, particularly if they are intended for use as food additives or flavoring agents, even if nowadays numerous of their purified components are created through semi- or complete synthesis. The smells and scents of these drugs are often the result of the creation of very complex combinations made up of hundreds of different chemicals. The right compositional balancing of any major, minor, and/or trace ingredients that may be present may often determine the desired organoleptic properties of these substances. For instance, examination of coffee and chocolate produced nearly 700 chemicals, but the particular elements responsible for their smells and scents have not yet been sufficiently determined. They are exposed to the economics of agricultural commodities since many of these complex chemicals are not often treated to considerable purification in commerce and because their parent plants are generated in huge quantities as raw materials. Economically significant volatile oils like rose oil and jasmine are complex mixes that are exceedingly difficult to replicate or replace using combinations of pure components. These chemicals may be particularly challenging to manufacture using current biotechnological approaches, such as plant cell and tissue culture techniques, due to their complicated compositional nature[3].

Reduced Genetic Resources

Despite significant recent advancements in analytical and spectroscopic apparatus, separation science, extraction technology, and analytical techniques, we still know very little about the secondary metabolism of the majority of higher plant species worldwide. In the case of the floras of tropical rainforests, this is particularly true. Despite the fact that the majority of plant species on earth are found in the tropics, it has been estimated that more than half of them are unknown to science and that the majority have never been examined for their chemical composition. For instance, it is believed that no information exists on the chemistry of more than 99% of the plant species that make up Brazil's diverse flora. The majority of the other tropical Latin American nations' floras are likely to have the same characteristics. This lack of information is concerning given the speed at which tropical ecosystems and floras are being destroyed, particularly forests, and this is happening before their plants have been sufficiently cataloged and investigated.

Phytolchemists and other plant scientists may only have a few decades left to search the chemical components of a significant portion of the plant kingdom for potentially useful novel compounds if the current trends of habitat destruction in tropical forests and general global simplification of the biota continue at their current rates.Specialized plant proteins may be extracted from plant cells and used, but their value is restricted for a number of reasons. First, the use of proteins as biologically active chemicals, such as medications and insecticides, is subject to limitations imposed by their chemical structures and nature. For instance, since they are susceptible to digestive destruction by proteolytic enzymes, most proteins cannot be supplied orally and cannot be efficiently absorbed via insect or mammalian cuticle. The above-mentioned intensely sweet and flavor-modifying and -enhancing proteins, papain, and highly toxic lectins like ricin are examples of plant proteins that are effective when consumed orally.

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This is true even if it were feasible to assemble all of the necessary biosynthetic machinery in these organisms. Therefore, it is likely that the sources of the majority of these complex plant-specific components will continue to be entire plants, specialized plant sections, or cultivated plant cells, at least for the foreseeable future. The whole genetic code needed for effectively encoding and programming the construction of the complex biomolecules known as plant secondary metabolites is present in the complete plant cells. The greatest long-term potential of genetic engineering and related rDNA-based biotechnologies, from the perspective of industries using plant metabolites, lies not in the direct production of plant proteins, but rather in the improvement of the efficiency of the biosynthetic machinery of those plant cells producing extractable plant metabolites of interest. However, it could take some time before plants can be genetically modified and designed at this degree of complexity and structure. As a result, the balance of this chapter will focus on an overview, a debate, and a short discussion of the possibilities for new production techniques based on plant cell culture. This chapter will also examine the production of secondary metabolites from entire plants, which are both scientifically and commercially significant [4][5].

Plant cells, important pharmaceutical intermediates and pharmaceuticals might one day be manufactured on an industrial scale, similar to how antibiotics and other compounds are now created by continuous fermentation of microbial cultures. The success or failure of these efforts will be mainly determined by the physiological constraints that are unavoidable as well as by improvements in our understanding of the biological and engineering elements that have an impact on the economics of tissue culture systems. The capacity to get high-yielding, genetically stable cell lines with quicker doubling times, the development of contamination-free culture techniques, and advancements in bioreactor design will undoubtedly play a significant role in the development. Spices, tastes and scents, vegetable oils, soaps, natural rubber, gums, resins, medicines, pesticides, and other key industrial, medical, and agricultural raw materials have long been and will continue to be derived from plant natural products. Some of these items, like morphine and natural rubber, have been classified as strategic resources by the government. While the discovery, commercialization, and further exploitation of the rubber tree were significant aspects of the Industrial Revolution, many of the medicinally significant plant-derived medications have been vital and necessary in ushering in the age of modern medicine. Nevertheless, despite these significant historical contributions, a large number of plant species have never been named and are still unknown to science, and only a small number have undergone any kind of chemical composition survey for physiologically active or other valuable compounds. Therefore, it is logical to assume that more plant sources of valuable elements will soon be identified and exploited. The recent investigation of a number of purified compounds derived from traditional Chinese herbal medicines used to treat cancer, cardiovascular diseases, and central nervous system disorders by a U.S. pharmaceutical company serves as evidence of the pharmaceutical industry's ongoing interest in plant-derived medicines. Sadly, if the current trends of biotic simplification and the loss of tropical forests continue at their current rates, phytochemists and other scientists may only have a few decades left to explore much of the plant world for novel, valuable compounds. Therefore, it is essential that the genetic resources of threatened and underutilized species be maintained to the maximum degree feasible for future generations, who may have the means at their disposal to more effectively exploit and manage them. The relatively routine isolation and structural analysis of potent biologically active plant constituents that are too labile or present in too minute quantities to have been previously characterized is now made possible by recent advancements in chromatographic and spectroscopic instrumentation and techniques. A novel method for the economically viable commercial production of even uncommon or exotic plants, their cells, and/or the compounds they generate may be made possible in the future by advancements in plant cell biotechnology. The continuous use of higher plants as renewable sources of chemicals, particularly for the production of medicinal and aromatic compounds, will be extended and enhanced by these new chemical and biological methods[6].

Immobilization of Higher Plant Cells

Biotechnology, the study of ways to exploit the productive capacity of living cells in industrial processes, and the creation of materials in agriculture, forestry, horticulture, and medicine may be lucrative, is very interested in medicinal plants. Numerous issues with plant biotechnology may be resolved by using tissue cultures, including micro propagation, the manufacture and biotransformation of physiologically active substances, the preservation of plant cells and organs, and the genetic engineering of higher plants. The majority of research investigations on medicinal plants focus on the tissue-culture-based synthesis and biotransformation of pharmacologically potent elements. This topic has been the subject of several reviews. Plants that provide chemicals beneficial in medicine and pharmacy have received extra study. A few examples are Catharanthus roseus, which has the anticancer dimeric alkaloids vincristine and vinblastine, Dioscorea deltoidea, which has the steroidal sapogenin-diosgenin used to make steroids, and Digitalis species, which has cardenolides such as digoxin and digitoxin. The structures of various natural compounds useful in medicine are shown in Figures 1 through 3. These chemicals are found in the plants that have been in vitro propagated.

The potential benefits of immobilized systems over free cell systems for the generation of metabolites inspired the early interest in the immobilization of cultivated plant cells. Since then, it has been shown that cell immobilization has additional beneficial physiological benefits. However, as seen by the remainder of this chapter's contents, despite the consequent rise in the use of immobilized systems for the study of a number of phenomena, focus continues to be on their employment in phytochemical synthesis. Perhaps it is a contradiction that despite the high level of interest in this topic shown by the recent reviews, there hasn't been a corresponding rise in the quantity of research publications.

However, we think that plant cell immobilization will emerge as one of the key strategies employed by plant biotechnologists to develop a variety of commercially feasible, economically viable procedures employing plant cell cultures. Many higher plant cells and protoplasts have been used to show the capacity to immobilize plant cells using different polymeric matrices. No references to the failure to immobilize cultured cells of any of the tested species have been identified in the literature, according to our searches. The rationale and methods for immobilizing plant cells are reviewed in this chapter, with an emphasis on the benefits and drawbacks of the available approaches as well as the scope of their usage[7].

Methods for Immobilizing Plant Cells

The procedures that may be used to immobilize plant cells are briefly described here. For in-depth accounts, the reader is directed to the reviews by Brodelius, Lindsey, and Yeoman.Entrapment the most popular techniques for immobilizing plant cells include trapping the cells in a gel, a solid support, or both.

Gel Trapping

Many of the early studies immobilized plant cells using different gels. In every instance, this was accomplished by first combining an appropriate suspension of plant cells with a solution of the gel-forming chemical, followed by the application of a gel-forming agent. This substance may be thermal, chemical, or ionotropic. The immobilized cell particles typically take the shape of tiny beads that range in size from 2-4 mm. The immobilization matrix that is chosen may have a significant impact on the imprisoned cells' future survival and biochemical activity.

In general, it has been discovered via a number of comparative investigations that cells immobilized in calcium alginate or agarose seem to preserve the most viability and respiratory and metabolic activity. Cell viability is often decreased or cells are killed when immobilized in gelatin or acrylamide, most likely as a consequence of the harsh chemical environment required for gel formation or through exposure to gel monomers.

However, Menthe cells have been successfully immobilized in polyacrylamide, according to reports. Because a variety of viable, metabolically active cultures have been produced using this approach under moderate circumstances, alginate has been the most often employed material. This approach, however, has a number of drawbacks. For both gel initiation and maintenance, alginate needs a relatively high concentration of multivalent cations and a low concentration of phosphate. Additionally, it has poor long-term stability, especially when the imprisoned cells may expand. The cation requirement is solved by using agarose instead of alginate, although the beads' long-term durability is still an issue. Additionally, agarose is rather pricey.

Getting Caught in a Strong Support

Gel immobilization has been utilized in conjunction with solid supports, such as a nylon or polypropylene mesh with Capsicum jrutescens cells that have been immobilized in alginate. However, a more recent procedure has been reported in which the use of a premade reticulate polyurethane foam with a predetermined pore size avoided the need for a gel. At the moment of inoculation, the foam particles are put to the cell culture. As the culture develops, the cells passively infiltrate the foam, become caught within the pores, and eventually colonize every available area. This approach has shown to be quite effective with proper pore size selection and should be broadly applicable to all cultures. The stability, non-phytotoxicity, autoclavability, affordability, and ease of availability of the immobilization matrix, as well as the simultaneous occurrence of the growth and immobilization phases, are benefits of this method. This method is now being scaled up. The second method in this group is a membrane-bound, hollow-fiber reactor system, in which the cells are contained in a space that is encircled by a sizable number of semi-permeable membrane tubes, allowing the medium to pass through at a rate that is adequate. The procedure has no negative impacts on the cells since they are largely left untreated. A variety of plant species have found the technique to be effective. Although the necessary equipment is somewhat costly, it may be used again[8].

There are a variety of methods where the plant cells are immobilized outside of the immobilization matrix rather than inside of it. For instance, Solanum aviculare cells were covalently attached to polyphenylene oxide beads that had been glutaraldehyde activated. After being immobilized, the cells kept up their biosynthetic activity. It has also been established that Datura innoxia protoplasts are linked to cytodex micro carriers through lectin. According to Rhodes and Kirsop, Humulus lupulus cells adhere to a nylon or polypropylene matrix. In a recent publication, Archambault et al. revealed how C. roseus cells spontaneously and quickly bound to a "man-made" substance. It was proposed that the secretion of a polysaccharide substance served as the mediator for this adherence. The cells continued to grow and divide while connected, and full viability was preserved. The stability over the long period was not specified.

Cultures that are "Self-Immobilized"

Essentially, these are highly aggregated cultures where the cells naturally form tight clusters or may be stimulated to do so by adjusting the culture media. This may lead to more or less all of the cells forming aggregates, which in at least one instance proved to be a useful culture system for a variety of species, all of which showed increased synthesis of secondary metabolites when they were aggregated.

Working with the Immobilized

Plant Metabolite Production via Cell Systems The utilization of immobilized plant cell technologies for the manufacture of desired compounds has garnered the majority of attention to far. Immobilized cell systems outperform traditional fermenter systems in a variety of ways, making the former the best option for the in vitro synthesis of several plant metabolites. For the production of secondary metabolites, the benefits and drawbacks of immobilized cell systems can be divided into two main categories: those that relate to bioreactor configuration and those that relate to the physiological effects of the immobilization process itself.

Configuration of the Bioreactor

The accumulation of these compounds is almost always discontinuous in plant cell culture, with the time of accumulation being separated from the period of cell division. This is one of the key general characteristics of plant cell culture that is related to the formation of secondary metabolites.

It has been widely hypothesized that secondary metabolite accumulation by plant cells represents a kind of metabolic differentiation that is dissociated from culture growth. It has been hypothesized that during times of rapid cell division and growth, the use of intermediary metabolites in primary metabolism for example, in protein, lipid, and carbohydrate biosynthesis predominates, while these metabolites are more readily available for alternative ary) pathways when the rate of cell division slows down. As a potential regulatory mechanism during secondary metabolite accumulation in cultivated plant cells, this rivalry between primary and secondary metabolic pathways for shared metabolites has been proposed.

It would follow that restricting culture growth or keeping cells alive longer during the "stationary phase" would facilitate or enable the accumulation of secondary metabolites to continue, and this has actually been shown on several times. For instance, it was shown that transferring cell cultures of Catharanthus roseus to a nitrogen- and phosphate-free media causes anthocyanin accumulation to be both extended and accelerated. The cells' entire viability was maintained by this media, but further cell division was not permitted. Similar to this, Lindsey and Yeoman discovered that in cultures of a variety of Solanaceous species, there is an inverse association between culture growth and alkaloid accumulation. Mantell and Smith give a short overview of the literature on the impact of culture conditions on growth and secondary metabolite output. The main relevance of this phasal pattern of product accumulation for the usage of immobilized cell systems is that a continuous production process is feasible if the product is discharged into the medium.

Once a sufficient volume of immobilized biomass has been created, it is anticipated that it may be easily managed and kept in a protracted production phase for several months or perhaps years. Immobilized cells may be used in continuous processes because they are maintained in a phase that is clearly different from the medium, which is often the sole component that is circulated. This not only lowers the possibility of cell injury but also makes it very simple to separate cells from media. In fact, the majority of the bioreactor designs that have been suggested or are now in use have a separate reservoir for the medium, which is typically pumped throughout the system by gravity and a basic pump. Getting the media properly mixed and aerated is one of the key issues with the large-scale growth of plant cells. Plant cells are sensitive to physical harm as a result of their enormous size, high vacuolization, and weak shear resistance. This leads to the issue. Although there is some debate on the overall significance of shear pressures in relation to plant cell cultures, the separation of the bulk of the medium from the biomass enables any necessary aeration and mixing to be carried out in the second vessel without any danger to the cells.

A lesser amount of medium may also be needed since the presence of cells in the liquid phase prevents issues brought on by the culture's high viscosity. Due to the ability to use smaller reactors, the employment of a relatively simple reactor design, the ease with which the culture medium can be isolated, and the fact that smaller volumes of medium require reduced volumes of extraction solvent/energy requirements for drying etc. in order to isolate the desired product, all of these features should substantially reduce overall process costs in comparison to free-cell systems.

The likelihood of a blockage happening as a consequence of the escape of cells from the immobilization matrix into the liquid phase is one possible issue with systems like this, where the medium is cycled between two vessels. This has been discovered to be especially common in systems that use gel immobilization, where it has been observed that cell growth within the gel matrix can result in significant release of free cells into the circulating medium or complete disintegration of the gel beads. In systems where gel formation is reliant on the chemical make-up of the medium, another issue could surface.

The gel structure may dissolve as a consequence of changes in medium composition that occur throughout the culture period or that are required to promote metabolite synthesis. Alginate-immobilized cells may be successfully cultured for relatively extended periods of time, such as up to 170 days, 180 days, and 220 days.

The Effects of Plant Cell Immobilization on Physiology

Immobilized cell cultures have been used to study the production of a variety of phytochemicals. Although the suitability of such systems for flow-through processes and the potential re-use of biomass initially sparked interest in the use of plant cells in an immobilized state, it was discovered as a rather pleasant and unexpected bonus that in many cases immobilized plant cell systems actually showed increased productivity over the corresponding free-cell systems. This intriguing discovery sparked interest in similar processes on the commercial and academic levels, as well as debate about the potential scientific foundation for such an impact. A thorough investigation of the impact of immobilization on Capsicum frutescens cells in reticulate polyurethane foam in connection to the synthesis of the secondary metabolite, capsaicin, has been published by Lindsey and Yeoman in a number of studies.

In a nutshell, it was discovered that the process of immobilization reduced the rate of protein synthesis and cell division, and that these effects were favorable to a rise in the output of secondary metabolites. In a follow-up to this experiment, we have shown that a reduction in the synthesis of cell wall material, which includes a significant quantity of bound phenolic compounds, is another significant effect of cell immobilization. It is said that this causes a decrease in the demand for and an increase in the availability of the phenolic precursors of capsaicin, tilting the scales in favor of secondary metabolism and enhancing capsaicin production[9].

Cell Aggregation's Effect

The degree of aggregation and cell-cell interaction that occurs is one obvious distinction between free and immobilized cell systems. These characteristics have also been linked to increased/prolonged production in immobilized cultures. As a result of the significant aggregation present in these systems, the degree of inherent heterogeneity in the cultures is inevitably increased. For example, it is obvious that cells within a gel bead or a fully colonized foam block would be exposed to different physical and chemical environments than those on the periphery; there will be variations in illumination, nutrient, O2, CO2 gradients, etc. Of fact, a heterogeneous system like this is closer to what would normally occur in a complete plant. The impact of such "regulatory gradients" on the expression of secondary metabolic pathways, together with greater cellular aggregation and organization and increased "molecular conversation" between component cells, has been previously covered. The immobilization of cell cultures would also work to lessen the concentration gradient between the cytosol and the bathing medium across the plasmalemma, which causes metabolites to leak from the cells. The microenvironment of the cells may be further improved by this protection, which may be brought about by either an increase in cell aggregation or the existence of a gel layer, since it may permit the recycling or regeneration of cofactors crucial to the creation of metabolites. For instance, Brodelius et al. suggested that the effective recycling of endogenous NADPH inside the cells under the circumstances of entrapment is the reason for the comparatively high conversion of tryptamine to ajmalicine-type alkaloids by Catharanthus roseus cells. This trait is also likely a significant contribution to the discovery that immobilized cell systems often exhibit higher cell survival and production stability when compared to free cell systems. Although this topic is covered in more depth in the section that follows, it has shown to be quite significant in connection to the formation of metabolites. According to Alfermann et al., when Digitalis lanata cells are immobilized in alginate, their ability to hydroxylate in order to produce p-methyldigitoxin is about half.

Cellular Interactions

A well-known regulating mechanism in both plant and animal metabolism is the interaction between an end-product and the enzyme responsible for its production. Many secondary plant products have been shown to be under this feedback regulation of metabolite levels. For instance, Hall and Yeoman found that whereas anthocyanin content in C. roseus cell cultures may vary widely, the mean intracellular concentration within the productive cell population did not very much. This finding has been linked to a feedback inhibitory mechanism. According to Lindsey, the incorporation of 14C-labeled precursors into endogenously produced capsaicin may be greatly decreased by adding as low as 10 IJ.M capsaicin to C. jrutescens cells.

These authors also report the enhancement of anthraquinone accumulation by polymeric absorbants in Cinchona ledgeriana cultures. A so-called two-phase system has already been proposed, and increased nicotine production has been observed in tobacco cultures in the presence of the absorbant XAD-4. The identification of elevated quantities of monoterpenoid compounds in Thuja occidentalis cultures and of unknown lipophilic chemicals in crown gall cultures of Matricaria chamomilla has also been made possible by the inclusion of a water-insoluble triglyceride layer in suspension cultures. The buildup of these substances intracellularly, on the other hand, has been linked to a drop in the overall synthesis of diterpenes over time by Salvia miltiorrhiza cells immobilized in alginate, strengthening a feed-back inhibitory mechanism. Additionally, if a two-vessel reactor is used, the shorter contact time between the cells and the product-containing circulating media should lessen the possibility of additional biochemical changes or even biodegradation[10].

The Product Issue

Release we have been openly bullish about the benefits of immobilized plant cell systems up to this point. Product release is one of these systems' possible major limitations, however. That cells must be destroyed in order to extract the desired metabolite runs counter to the whole premise underlying the use of cell immobilization. Therefore, it is crucial that the product can either be forced into the mobile, liquid phase spontaneously or that it can. There are several instances of chemically diverse products that are completely or partially discharged into the culture medium. For instance, Capsicum frutescens cultures produce capsaicin to the point where it is impossible to find any inside the cells. There have also been reports of widespread release of cardenolides, alkaloids, pigments, and terpenoids. Examples of product release that has been induced or enhanced by the immobilization procedure include the release of echinatin from Glycyrrhiza echinata cells that have been trapped in alginate and the release of L-DOPA from Mucuna pruriens cells. According to Miyasaka et al., Salvia miltiorrhiza cells immobilized in alginate released cryptotanshinone three times more than they normally would have. Contrarily, Knorr and Teutonico discovered that Amaranthus tricolor cells released less oxalic acid when immobilized in Ca alginate. These authors outline what seems to be a perfect alternative technique that uses chitosan gel in place of alginate. This substance, which is known to increase the permeability of plant cell membranes, led to an improved release of oxalate from A. tricolor cells and proteases from Asclepias syriaca cells. The broad applicability of this method and the long-term consequences of chitosan immobilization on cell survival are also unknown, however.

The beneficial metabolites created in plant cell culture, the bulk of which are kept intracellularly and are often sequestered in the vacuole, make up just a tiny portion of the examples shown above. Recent research has unequivocally shown that this vacuolar absorption is a highly specialized, carrier-mediated, energy-dependent mechanism, at least for alkaloids. There have been unsuccessful attempts to stop this absorption by permeabilizing the cells with detergent, chemical solvents, osmotic shock, and highly ionic solutions. In order to obtain large product release without permanently harming the cells, it is obviously difficult to permeabilize both the plasmalemma and the tonoplast. Ideally, we would also want to achieve selective product release. Although some early findings are encouraging, there are a number of drawbacks to using such methods. It is ideal to permeabilize every cell, however in highly aggregated systems, this may be challenging. Additionally, because exposure to the permeabilizing agent should be minimized, treated cells must be extensively washed, which ineluctably causes a significant dilution of the liberated product and raises the extraction cost.

Degradative enzymes that may also be secreted along with the product may complicate matters further and need to be inhibited to stop product loss. Chemically induced permeabilization, however, could succeed with further study. Kilby and Hunter, who discovered that short sonication of Beta vulgaris cells caused a significant release of vacuolar pigments into the medium, have lately offered an alternate technique. Although the cultures kept expanding following the treatment, it has not yet been shown that the permeabilized cells truly retain their viability. The selection of "naturally leaky" mutants is the probable best option. The author discovered that Thalictrum minus cell lines that released berberine into the media could be identified using conventional selection procedures. Similar to this, Sato and Yamada identified Coptis japonica berberine-secreting lines, some of which discharged more than 50070 of the berberine generated into the medium. Although it hasn't yet been shown that these mutants can exist and release additional products, it is obvious that they might be incredibly beneficial for cell functions that are immobilized, and further research in this area is eagerly anticipated.

Other Applications for Immobilized Cells

Stability of Culture Systems Immobilized

Other than for the creation of secondary products, all applications for immobilized cell systems make advantage of the cultures' enhanced stability and sustained survival over freely suspended cells. Immobilized cells may be maintained for lengthy periods of time without losing viability if culture conditions are optimized. For instance, Catharanthus roseus and Digitalis lanata alginate-entrapped cells have successfully been kept alive for 220 and 170 days, respectively. Long-term cultures of c: /rutescens cells have also been conducted, lasting up to 180 days in small column bioreactors and more than 90 days larger 5-1 bioreactors. Since freely suspended cultures are not subject to such prolonged periods of sustained vitality, immobilization in and of itself seems to improve the long-term viability of the cultures. It has also been shown that immobilization in polymeric matrix may stabilize protoplasts. Protoplasts were originally immobilized by alginate entrapment by Schnabl et al. They discovered that Vicia/aba protoplasts that were entrapped were more resilient to mechanical and osmotic stress than protoplasts that were floating freely. In subsequent papers, it was shown that protoplasts that had been immobilized in alginate exhibited a delayed onset of several aspects of cell ageing that occur quickly in freely floating protoplasts. This improved stability of immobilized protoplasts has been primarily ascribed to the cross-linked alginate matrix's protective influence on the integrity of the protoplast membrane. Daucus carota and Catharanthus roseus protoplasts have also been effectively immobilized in gel beads and have shown enhanced stability compared to protoplasts that are suspended freely. Protoplasts seem to become more stable when they are immobilized, which has prompted some investigators to propose using them for purposes other than the creation of secondary products[11].

Pollution surveillance

As was previously established, immobilized protoplasts produce ethane at a constant rate over a certain time. However, ethane production rises when these cultures are exposed to a variety of environmental toxins. This prompted these researchers to hypothesize that immobilized protoplasts may serve as the foundation for an easy-to-use bioassay to gauge the degree of environmental contamination. However, the technology has to be improved further before it can be widely used. 4.3 Immobilization's Uses for Researching Biochemical and Cellular Activities in Plant Cells Immobilized cells are a useful method to study a variety of cellular processes due to their stability and long-term survival.

In fact, the method of protoplast immobilization was created to investigate membrane transport, particularly the workings of guard cell processes. Similar to this, Scheurich et al. contend that protoplasts immobilized in alginate may serve as the framework for a system to study how osmotic change affects plant cells. Using protoplasts that have been lectin-mediated bound to the surface of agarose beads may make it easier to do research on cell/cell recognition. Although the potential for employing immobilized cells as fundamental experimental systems seems intriguing, not much fundamental research has been done using immobilized cells as the experimental material up to this point.

Transport and Cell Storage

Immobilization reduces cells' susceptibility to mechanical and osmotic stress, which has prompted some researchers to hypothesize that the method may be useful for transporting and storing protoplasts. The immobilization of freely floating cells may be used to store and transfer cultures, according to Jones and Veliky. 4.5 Improved Immobilized Cell Plating Efficiency Other than in the manufacture of secondary products, the regeneration of cells that have undergone genetic modification may be the most advantageous use of immobilized protoplasts. Using vectors or direct gene transfer, protoplasts are increasingly being employed to introduce foreign DNA into plant cells. The regeneration of whole plants from a single altered cell is one of the biggest challenges in creating transgenic plants with desired agronomic features. The immobilized protoplasts' continued vitality might improve the effectiveness of regeneration. Adams and Townsend created a method that enables immobilization in agarose and subsequent release from it. Shoot regeneration from cells obtained in this way has been demonstrated to be normal, and the plating efficiencies of Lycopersicon esculentum and Solanum tuberosum cells have been enhanced by up to 50-fold. Shillito et al. found that immobilized cells of L. esculentum and Crepis capillaris had improved plating efficiency, and it was proposed that this technique might be useful in microinjection experiments. Additionally, these scientists successfully maintained the development of cells from Brassica rapa and a Petunia hybrida variety that ordinarily did not expand to colonies larger than a few cells. Producing Fine Suspension Cultures (4.6) ironically, techniques for creating fine suspension cultures have evolved from the immobilization of plant cells. Making single-cell suspensions may benefit from the cells that adhere to gel bead surfaces being sloughed off. While Morris et al. reported the continuous creation of fine suspensions of C roseus using a similar approach, Hamilton et al. created single-cell suspensions of Petunia hybrid that stayed as single cells for up to 60 days.

The Suppression of Somatic Embryos

The immobilization of somatic embryos in the creation of "artificial seeds" has garnered a lot of recent attention. Much bigger aggregates of cells may also be immersed in polymeric matrix. Brassica oleracea, Apium graviolens, and Medicago sativa somatic embryos immobilized in alginate have all been successfully developed into full plants. The growing embryo may be fed nutrients and other growth-promoting agents via the encapsulating medium, and asexual embryos are also sometimes able to withstand severe desiccation. Therefore, immobilization technology may be crucial in the future large-scale clonal material production for agriculture[12].

Initially, only a small number of labs conducted studies on the cultivation of immobilized plant cells. Since this cautious beginning, numerous research teams have been interested in immobilized cell technologies in an effort to understand and use their potential. The use of such processes for the production of phytochemicals has received the most attention, and as described here, the physiological and potential financial benefits make them an appealing proposition when the desired product is present in the culture medium. Furthermore, these systems may have extremely broad applications if the right methodologies can be created so that this may be properly accomplished by manipulating culture. However, in many situations, such as those where biomass is a crucial component of the desired end product or where the product is insoluble or cannot be extracted from the cells, conventional fermenter-type bioreactors will continue to be the best option. Additionally, there will always be a preliminary period for the expansion of free cells before immobilization. It has not yet been possible to develop a technique using an immobilized plant cell system that is economically viable.

Unfortunately, Alfermann's Digitalis biotransformation system for converting p-methyldigoxin from p-methyldigitoxin has not progressed above the pilot-plant level because of erratic policy changes in the pharmaceutical business, not because the method was insufficient. Immobilized cell systems are probably going to be most useful for one-step biotransformation processes in the near future. However, there is a lot of progress being made quickly in the area of plant molecular biology, where methods for isolating useful plant genes are being created.

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CHAPTER 10

ANTITUMOR SUBSTANCES: PLANT CELL CULTURE PRODUCTION

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Higher plants include a broad range of anticancer chemicals that may be turned into therapeutic medications. However, the concentrations of these active substances in plants are often quite low, making it difficult to generate them inexpensively or even to find them there. The accumulation pattern of these active compounds is also particularly vulnerable to changes in the environment or geography because of the sluggish pace of plant development. Therefore, substantial quantities and a steady supply of these substances are required for further chemical or clinical tests. One method for resolving this issue is plant tissue culture, and interest in this area of study has increased during the last ten years. Some ways are highly promising for application, despite the fact that this method is still empirical and requires a lot of trial and error to produce the stable cell lines after determining the best growth medium or chemical production conditions. The most current studies on the synthesis of "antitumor chemicals employing plant tissue culture methods are summarized in this chapter[1].

Active Compounds are Categorized

The active plant chemicals that were identified were categorized as shown in Table 4 using tumor cells as a screening approach. Alkaloids, proteins, and ansa macrolides are the only members of the nitrogenous class. Alkaloids (such as homoharringtonine, indicine-N-oxide, ellipticine, and camptothecin) ansa macrolides, diterpenes, lignans, and steroid lactones are the main compounds currently being actively studied, but many new compounds are still being selected from higher plants by intensive screening programs.

Tissue Culture of Plants

Since it is difficult to extract significant quantities of anticancer chemicals from plants, numerous researchers have experimented with the plant tissue culture method. The benefits of plant tissue culture are well-known and include:

1. Culturing conditions, including the chemical and physical environment, may be adjusted to determine the best one for the generation of active compounds.
2. It is possible to choose or enhance production-ready cells by cell cloning, induction of mutation, or differentiation using either chemical agents or the gene engineering technology.
3. It is simpler to investigate cell metabolites or the manufacturing process when the system is understood.

The quantity of anticancer chemicals generated in vitro is often much lower than that from entire plants. As a result, several efforts to increase the production yield have been made. Finding a strong system elicitor is one approach. The fermentation method has been altered and used to plant cell culture for large-scale output. Although the direction may be opposed to cell proliferation, production in plants begins when cells start to differentiate. Therefore, two-phase culture has been suggested, where cells are first cultured in a medium that encourages proliferation and then in a media that is best for differentiation in order to make or accumulate the products.

Methods for Increasing Productivity

Enhancing the environmental circumstances. By adjusting the culturing system's chemical and physical components, ideal conditions may be discovered. These variables include the medium's chemical constituents or phytohormones, pH, aeration, temperature, light, etc. Thble 1: Addition of Precursors contains a list of phytohormone concentrations that cause callus in antitumor-producing plants. The degree of production may sometimes be increased by adding precursors to the culture, but the timing and type of the addition must be carefully considered. 100 J.l.g/I farnesol was added to Tripterygium wilfordii cell culture to boost the synthesis of tripdiolide. Cell line selection. It is feasible to identify the higher-producing strain from the heterogeneous cell mass due to the variation in production levels between individual cells. To create the colony, the cells are typically chosen or cloned, then plated on an agar media. Then, to choose the colony with the highest production yield, the quantity of the active chemicals generated from each colony is assessed using radioimmunoassay or HPLC techniques. The cells may be chosen in one of three ways:

1. When a product has a color as the indication, it is simpler to choose the cells visually.
2. Lack of a certain nutrient or chemical inhibitor: the cells may be chosen by growing in a medium that either lacks that nutrient or has that inhibitor.
3. Production analysis: By creating a quick, accurate technique to test the metabolites, cells with high production yield may be chosen[2].

Morphological Distinctiveness

Although undifferentiated cells have been shown to create secondary metabolites in certain articles, differentiated tissues sometimes produce substantially greater amounts of metabolites. As shown in Table 6, the concentration of cephalotaxine and its esters was more than 60 times greater in plantlets grown in vitro than in suspension cultured cells. According to Flores and Filner, Agrobacterium rhizogenes-induced hairy root cultures have been used to boost production. When cells that have been cultivated in a medium that promotes proliferation are moved to a media that promotes differentiation, in certain situations, it is a good way to stimulate the function of the plants to create the metabolites. Unmoving Cells.

Typically, immobilizing the cells involves using alginate, carrageenan, agarose, etc. Brodelius and Mosbach revealed that immobilized cells may be used to produce indole alkaloids or digoxin. Using immobilized cells in a bioreactor for continuous response is beneficial. The issues that need to be looked at include how to remove the metabolites from the cells and how to prevent treatment-related cell damage. It has been shown that a few plant cells have the ability to produce metabolites outside of the cell.

Podophyllotoxin

The plant Podophyllum petatatum, sometimes known as mayapple, is widespread in eastern North America's deciduous forests. It includes lignans that may affect KB cells, like podophyllotoxins. Podophyllotoxin is used to treat skin cancer and certain viral infections. Some of the semi-synthetic analogs evaluated therapeutically as part of the NCI study were shown to have effects on brain tumor, lymphosarcoma, and Hodgkin's disease (Nissen et al. 1972). Etoposide, a semi-synthetic derivative of podophyllotoxins, has been given FDA approval for sale in the United States and is anticipated to have a large market, as Suffness predicted. Many organizations are doing research on plant tissue culture since podophyllum resin is scarce and podophyllotoxin is expensive. Kadkade tried tissue culture of P. peltaturn and studied the nature of the callus developed in soft agar culture, as well as the impact of light conditions and growth regulators on lignan production. Kin and casamino acid were introduced to the MS medium, and IAA and/or NAA enhanced callus development. Red light and 2,4-D along with kin promoted the highest levels of podophyllotoxin synthesis. Casamino acids may have acted as the precursors necessary for the creation of podophyllotoxin since they promoted both cell proliferation and production. Up to six weeks, it was seen that lignan synthesis and callus development were parallel, indicating that P. peltatum's undifferentiated callus tissue was capable of producing podophyllotoxin. After being dried, crushed, and constantly extracted with hot 900/0 ethanol, the callus tissue. Then, podophyllotoxin was purified using TLC, chromatography on silica gel 60 packed in benzene, chloroform extraction, and methanol extraction[3], [4].

With the aid of triptolide, tripdiolide was first isolated from the African plant Trypterygium wilfordii. These diterpenoids were discovered to be very effective against Lewis lung cancer, leukemias P388 and L1210, and leukemias.Researcher tried tissue culture in a solution that included 3070 sucrose, 1 mg/l kin, and 1 mg/l NAA, which was ideal for callus development. However, it was shown that the cytokinin-like action of 4-chloro-2-diphenylurea boosted the production of tripdiolide up to 70070. Another component that increased output was pH, with pH 6 being more appropriate than pH 7. Through the use of preparative thin layer chromatography, which was created by ethyl acetate, a cytotoxic fraction was extracted with ethanol and separated. By using TLC, UV, and mass spectra, tripdiolide was identified as the pure cytotoxic chemical produced by further purification. Diterpenoids seemed to be present in greater quantities in the callus tissues than in the suspension cultured cells. As can be observed in Table 10, there were around ten and seven times more tripdiolide and triptolide per gram of dried cells, respectively, than there were in the entire plants. In PRL-4 agar medium with 2 mg/l IAA and 100 ml/l coconut milk added as supplements, Kutney et al. stimulated the callus of T. wilfordii. They chose a high-producing strain, TPR 4a, by sequentially transferring the callus. In comparison to intact plants, the production yield was also greater, at roughly 200llg/g dry weight cells[5].

Using vincristine and Vinblastine

Dimeric indole alkaloids vinblastine and vincristine, which were both discovered in Catharanthus roseus, are currently used to treat a variety of human malignancies. The more popular therapeutic medicine, vincristine, is one of the most effective treatments for people with acute leukemia, lymphomas, and solid tumors in children. Similar action is also seen by vinblastine, an effective treatment for Hodgkin's disease. These medications, which have been on the market since the early 1960s, are quite costly since they can only be made from C roseus that is cultivated in the field, where the levels of the plant are very low. In order to produce them, numerous researchers have looked into plant tissue cultures; nevertheless, commercial manufacturing has not been successful. Although Miura and Okazaki observed that tissue cultures accumulate vinblastine, the cytotoxic substance generated by their cell line has not yet been identified. The callus and cell suspension cultures of C. roseus have been used by Kurz et al. and Kutney et al. to produce several vinca-alkaloids, but they have not yet discovered any anticancer alkaloids. The author's team at Allelix, together with Kurz, Kutney, and their associates, recently reported on the enzymatic production of the dimeric alkaloids. They discovered that C. roseus suspension cultures could accumulate 36 mg/l catharanthine, and that this monomeric indole alkaloid could then be combined with a commercially available alkaloid, vindoline, using crude enzymes derived from C. roseus cells in culture, with a conversion yield of 22%[6].

It goes without saying that one of the most crucial jobs in the therapeutic sector is the creation of potent anticancer medications. As a result, other organizations, including those in foreign countries and those with the National Cancer Institute as their major institution, are conducting rigorous screening programs for antitumor chemicals. It makes sense to look for novel anticancer chemicals in the plant world given the widespread usage of folk remedies made from plants since ancient times. Although many active compounds against different tumor systems have been discovered in several plant species, it is a very challenging job to choose the chemical with a promising efficacy as a contemporary pharmaceutical. In actuality, the only plant-derived antitumor medications now in widespread commercial usage are vincristine and vinblastine. However, the discovery of several active substances with distinctive chemical structures in plants tremendously promotes plant tissue culture research since it is often difficult to extract significant quantities of these substances from whole plants. Furthermore, from the perspective of manufacturing costs, plant tissue culture technology is beneficial. Since the clinical trials for drug selection are so stringent, it is difficult to predict which chemical will be utilized as a medicine in the future. However, the scientists are hopeful that this technique will soon be employed for the commercial synthesis of novel plant-derived anticancer compounds[7]–[9].

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CHAPTER 11

UTILIZING GENETIC RESOURCES FROM MEDICINAL AND AROMATIC PLANTS SUSTAINABLY AND PRESERVING THEM FOR GLOBAL HUMAN WELLBEING

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Since ancient times, people have utilized plants to treat and prevent illness, enhance population health, and promote overall welfare. According to the World Health Organization, medicinal and aromatic plants continue to be the foundation of the traditional or indigenous health systems used by the inhabitants of the majority of developing nations. New sources of revenue are becoming available for rural inhabitants as a consequence of the growing interest in medicinal and fragrant plants. Since many MAPs are being collected from the wild, the collecting and selling of MAPs is giving many underprivileged rural families a supplemental source of income.

Due to rising commercial remembrance, mostly unmonitored trading, and habitat destruction, plant species in the wild are now under exponentially escalating pressure. For conservation ideas and methods that must take into account future supply and the requirements of species conservation, in-depth knowledge of the characteristics of the botanical trade is necessary. This information is also needed to analyze the effect of the trade on the plant populations in question.

Human wellbeing and medicinal and Aromatic Plants

Throughout history and throughout cultures, the biological resources of medicinal and aromatic plants have been widely employed for health care and healing rituals. Long before the introduction of pharmaceuticals, cultures relied on their traditional wisdom, traditions, and abilities to prevent, identify, and cure illnesses by using a variety of natural resources. These methods are being used today to benefit local communities and healthcare systems all around the globe. Numerous resources that are utilized for food, culture, and spirituality are also employed as remedies in socioecological environments like these. The use of certain medicinal plants for the treatment of particular ailments was first based on an empiric framework but is now supported by scientific understanding. Today, practically all pharmacopeias throughout the globe recommend plant-based medications that have true therapeutic benefit. Traditional medical practices provide these people more than just health treatment; they are seen as a way of life. Despite significant improvements in public health, many communities have yet to achieve their health and development objectives, and contemporary healthcare systems throughout the world still fall short of meeting the demands of vast segments of the global population.

As a result, health-seeking behavior is becoming more pluralistic or a fusion of several medical systems globally, in both urban and rural environments. 70 to 95 percent of the population in parts of Asia, Africa, Latin America, and the Middle East rely on traditional medicine for basic healthcare. 70% to 90% of the people in nations like Canada, France, Germany, and Italy utilize traditional medicine as "complementary," "alternative," or "nonconventional." Additionally, the proportion of persons who use conventional medication has increased: 42% in the USA, 48% in Australia, 40-50% in Germany, and 49% in France. In conclusion, 80% of the people in those nations heavily depend on plant-based medicines for their medical requirements, and it is predicted that a comparable number of people worldwide may do so in the next decades. Practitioners of complementary and alternative medicine who have had training in conventional medical systems like Ayurveda, Traditional Chinese Medicine, Kampo, Siddha, Tibetan medicine, Unani, and others are officially recognized. According to the WHO, over 25% of pharmaceutical medications used today are derived from plants that were first utilized in traditional medical systems. Compounds originating from plant material are found in 30% of medications marketed globally. Traditional medical expertise has often been used to create new treatments, despite the fact that methods, information, and resources are frequently misused. Controversy surrounds how much traditional medicine may influence drug development, which has affected investment in bioprospecting using ethnobotanical information.

Based on their wider economic usage and value, plants employed in traditional medicine are significant for both domestic and international commerce. Over 500,000 tons of material from these species are sold annually, and it is believed that 60,000 species are utilized globally for their therapeutic, nutritive, and aromatic characteristics. The value of the international trade in plants used as medicines is estimated to be more than $2, 5 billion dollars, and industrial demand is a major driver of this trade. Traditional medicine has an estimated yearly market value of US$ 83 billion and is growing exponentially. There is no comprehensive inventory of all plants used in traditional medicine, but at least 30,000 species are included in the Global Checklist and Natural Products Alert Database, which are under the control of the WHO Collaborating Centre at the University of Illinois in Chicago.

The creation of searchable databases for traditional knowledge about health that guarantee the preservation of associated materials and information is now underway. The Traditional Knowledge Digital Library is a distinctive database project that was created in cooperation between the Council for Scientific and Industrial Research, the Indian Ministry of Science and Technology, and the Ministry of Health and Family Welfare. For about 25,000 subcategories relating to medicinal plants, minerals, animal resources, their therapeutic uses, clinical applications, methods of preparation, modes of administration, etc., the Traditional Knowledge Resource categorization, an innovative hierarchical categorization system, has been devised.

These registers, led by non-governmental organizations, make an effort to mobilize local residents to discuss and document their knowledge and practices in various categories of resource use or practices based on two tenets: first, by documenting them, they establish prior art over the knowledge and resource use, and second, it encourages greater use and practice of the knowledge within the community, eventually reinforcing such use as strong social traditions. Therefore, these papers may be seen as legal instruments to encourage the preservation of communities' rights. These databases serve as helpful illustrations of the need of promoting the creation and enhancement of community knowledge registers and biocultural protocols, as well as their connection to national databases for preservation.

As stated in the text of the Convention on Biological Diversity and the Nagoya Protocol on access to genetic resources and equitable sharing of benefits arising from their commercial utilization, traditional medical knowledge can also serve as an inspiration for industrial research and development processes in bio resource-based sectors. These processes require mechanisms to secure appropriate attribution and sharing of rights and benefits with knowledge holders. The market for herbal remedies is rapidly increasing, driven by factors including cost effectiveness and elevated perceptions of safety. It has been claimed that 80% of medicinal plants are harvested from the wild in nations like India, placing an increasing strain on the environment. One-fifth of the world's medical plant species, or 15,000 species, are currently considered endangered due to overharvesting and habitat destruction. The difficulties of replacement, adulteration, and misidentification across species are also becoming worse due to increased demand and declining numbers.Preserving and using medicinal and aromatic plants sustainably. Over 500,000 tons of materials from these species are sold each year, and it is believed that 60,000 species are utilized globally for their therapeutic, nutritive, and aromatic characteristics.

Trade in pharmacological and Fragrant Plants

A total of 462.8 million US dollars' worth of medicinal plants were imported into Europe as a whole, while 1034.8 million US dollars' worth were exported over the same time period. Both of these figures increased significantly from 1991 to 2002. According to the Secretariat of the Convention on Biological Diversity, the worldwide market for herbs and herbal products has grown significantly over the last three decades. In 2002, sales of herbal goods were projected to be worth US$60,000 million. A significant amount of the 500,000 tons of dried medicinal and aromatic plants that are handled annually on worldwide markets are also traded on national and local marketplaces. The demand for MAP is rising globally, and more than 50% of the plants are collected from the wild. The most well-liked kind of conventional medicine is herbal therapy, which is also the most profitable on the global market. In 2003–2004, Western Europe alone had yearly sales of $5 billion. Only a small number of nations, with three major international trade hubs the United States, Germany, and Hong Kong dominate the trade in pharmaceutical plants. Eighty percent of both imports and exports to the global market come from twelve nations.

The largest markets are in affluent nations, however the majority of pharmaceutical plants are shipped from underdeveloped nations with little to no processing and wild origin. Millions of homes engaged in collecting, typically with women taking the lead, benefit financially from the trade, which also supplies the industrial manufacture of a broad range of domestic and medical goods. Despite the absence of precise statistics, the evidence that is currently available suggests that commerce is growing. 90% of the MAP native to Europe, according to Traffic International, is wild-collected for commercial purposes. The cost difference between wild-collected plant material and farmed plant material is the cause. The total amount of wild plant material gathered in Europe is thought to be between 20,000 and 30,000 tons every year. Consequently, only around 10% of raw materials come from cultivated sources, yet even this might provide more reliable quality and lower adulteration risks than their wild equivalents.

MAP conservation and sustainable usage initiatives A worldwide plant conservation strategy was developed in 2002 with the long-term goal of ensuring that no species of wild flora are threatened and that at least 30% of all plant-based products come from sustainably managed sources. At least 2000 MAP species, of which 1200–1300 are indigenous to Europe, are utilized commercially there. Since the majority of species utilized are still harvested from the wild, the growing interest in MAP's application throughout the world and the rising need for raw materials from different processing sectors have led to a rise in demand for MAP and put strain on natural resources. The major causes for medicinal plants' use, research, assessment, and conservation becoming integral components of market expansion programs include unchecked overexploitation of wild plants, their habitat loss, and modification. The commerce of MAP in Europe still heavily relies on wild collection since the cost of this material is substantially cheaper than that of cultivated origin. Significant factors contributing to the reduction of economically significant wild plant resources used for food and medicine include overharvesting, habitat modification, and climate change. This puts at risk both the survival of wild species and the incomes of collectors, many of whom come from the most underprivileged socioeconomic classes. Developing evaluation techniques and indicators for conservation and sustainable usage must undoubtedly continue. We are now dealing with an unmatched increase in pressure on wild plant populations. Therefore, having a thorough understanding of the characteristics of the global trade in botanicals is: Understanding conservation ideas, putting them into practice, coming up with plans to fulfill future supply demands, and putting species conservation into effect are all necessary for determining how the trade has affected plant populations. Therefore, complementary conservation measures known as in situ and ex situ conservation are being used for MAP species in particular as well as plant genetic resources on other continents, including Europe.

Working group on aromatic and Medicinal Plants

The Steering Committee of the European Cooperative Programmer for Plant Genetic Resources decided to create the Medicinal and Aromatic Plants Working Group in October 2001 after acknowledging the significance of MAP conservation. The Working Group is anticipated to contribute to the creation of the Maps' European-level conservation plan. Legal restrictions, enforced by EU trade laws on endangered MAPs, together with a lack of understanding of biological conditions and the state of biodiversity, call for concerted effort and the participation of European specialists and scientists. The range of operations includes documenting ex situ collections and in situ populations, inventorying MAP genetic resources, evaluating and characterizing MAPs, and developing descriptors at the genus level. Crop-specific characterization and assessment descriptors for ten target species, recording of ex situ collections and in situ populations, and adherence to EURISCO protocols were all agreed upon during the most recent MAPWG conference, which was held in 2009.

The following priority species were chosen by the WG to act as models and for which species-specific descriptor lists were created and published: Achillea millefolium agg., Artemisia absinthium, Carum carvi, Gentiana lutea, Hypericum perforatum, Mentha piperita and M. spicata, Melissa officinalis, Origanum spp., Salvia officinalis, Thymus vulgaris and T. 19 nations from the WG collaborated on the protection and characterization of oregano wild populations across Europe. The major goals were to describe the genetic and chemical diversity of native populations of wild oregano, create an inventory and survey of these populations, and determine the distribution of taxonomically distinct populations throughout Europe. From east to west, a genetic gradient could be seen, but not from south to north.

The oregano populations from the Iberian Peninsula are relatively distantly connected to one another and from the other people in Europe. However, it was possible to see a distinct gradient from east to west. It's interesting to note that the populations of oregano in Norway and Finland do not have the same roots in the Mediterranean as one would expect given their geographic separation.

In order to promote the promotion of their sustainable application, it is possible to create a MAP Programmer for the in situ and ex situ conservation, ethnobotany, characterization, and assessment. An objective of adopting the Fair Wild Standard is to develop the techniques required to carry out an efficient training on wild harvesting of non-wood forest products, concentrating especially on medicinal and aromatic plants. Established networks enable comprehensive morphological characterization and biochemical assessment, as well as an expansion in the scope and efficacy of information about this significant pool of genetic material. Future efforts related to the understanding and management of biodiversity and the protection and use of genetic resources will be supported by the knowledge that has been collected, which is integrated and complementary. Medical and aromatic plant genetic resources should be researched and protected for the benefit of current and future generations since they are essential to promoting human welfare and helping rural communities boost their income.

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CHAPTER 12

MEDICAL AND AROMATIC PLANT INDUSTRY USE

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Due to its many uses in medicine, cosmetics, and nutrition, among other things, medicinal aromatic plants make up a sizable plant group that is of significant interest. Additionally, they offer a crop alternative with species that are in great demand on the present global market. This document's primary goal is to impart fundamental knowledge and abilities regarding the creation, applications, and chemical properties of essences and extracts from medicinal and aromatic plants. It also aims to provide an introduction to the economic significance, uses, and harvesting procedures of the most significant medicinal, aromatic, and seasoning species of plants. The goals of this course are to classify and identify aromatic plants, seasonings, and medicinal plants; to comprehend cultivation methods and successfully apply modern problem-solving techniques; to learn and understand the most significant active constituents; and to recognize the practical applications of this type of plant in the cosmetic, perfumery, food and beverage, and pharmaceutical industries[1].

Map Introduction

Numerous plants provide chemicals that are beneficial to health. About 12,000 of these compounds, or 10% of the total, have been identified as byproducts of secondary metabolism in plants, bacteria, and fungi. These compounds often act as defensive mechanisms for plants against microbes, insects, diseases, predators, or unfavorable environmental factors like drought or high temperatures.

These plants may be treated to get their essential oils or extracts or utilized in part. They are used, among other things, in the food, drug, cosmetic, and fragrance industries. Now referred to as MAPs, the usage of medicinal and aromatic plants has significantly risen in recent years in several nations, including the United States, Europe, India, and China. 2000 or more MAP species, 1000 of which are indigenous to Europe, are traded. Their collecting should be restricted since the increased demand has caused some of their native populations to become reduced. 14 plants have been identified by the WHO as being threatened by overharvesting[2].

History

These plants have been used since the beginning of agriculture. They were initially all collected together until a selective harvesting method and domestication of them were created. Plants have been used medicinally for over a thousand years. The first known graphic record was discovered on a clay table in Mesopotamia. Other sources of information include the Egyptian Papyri, Chinese Pharmacopoeias, Indian Ayurveda Tradition, etc. FAO estimates that between 35,000 and 70,000 plant species have been utilized medicinally in various cultures. The nations with a longer history of using medical plants include China, Hong Kong, Korea, Indonesia, Malaysia, India, Pakistan, Bangladesh, Sri Lanka, and Nepal. In fact, 80% of Chinese medications are made from plants.

Building Maps

MAPs, which are still collected from the wild, have been utilized by all societies throughout antiquity. Consumers have gradually increased their demands for MAPS, both in terms of quality and availability. It is advised to guarantee its protection, an appropriate MPAS cultivation, and a restriction of its collection from the wild since direct collection from the wild now poses a danger for many MAPs survival in their native habitats. The following are the primary benefits of growing aromatic and therapeutic plants:

Testing for quality and homogenizing products:

Buyers of raw materials, such the herbal business or labs, are becoming increasingly picky about the quality of MAPs. The herb must undergo homogenization and a visual examination if it is acquired by the herbal business. Richness in active constituents is necessary if material is bought by a laboratory, in addition to homogenization, and purity is also necessary in the case of essential oils[3].

Maintaining native species in their natural habitats:

Wild herbs including thyme, rosemary, lavender, labdanum, bearberry, and gentian are harvested. One of them is the unsustainable quantity of maps that are now being sold, which is causing their natural habitat to be destroyed and depleted. A substantial conservation effort must be made since several of them, including gentian, bearberry, bog bean, and arnica, are in a very precarious condition. Additionally, MAP adoption on agricultural land need to be considered as a viable alternative in areas with inadequate benefits. Future recommendations for the Common Agriculture Policy, which are intended to reduce crop production of surpluses, suggest that MAPs cultivation might be an appropriate and alternative kind of large agriculture. However, MAPs are better adapted to these specific climatic and soil conditions, particularly the soil's low nutritional content and dryness. Many fragrant, medicinal, and seasonal plants are native Mediterranean species, it is noted.

Choosing advantageous Agro-Organic Conditions

The climate and the soil conditions have a significant impact on the physical, chemical, and organic properties of medicinal plants. One should consider the length of sunshine, the frequency of rainfall, and the temperature range while picking the climate. These elements, together with the temperature differences between day and night, have a direct impact on the physiological and biochemical processes in plants, particularly those involving enzyme reactions. These elements will unavoidably have an impact on both their development and the creation of biologically active compounds. Depending on where they are from naturally, medicinal plants need varied climatic conditions to develop. They must be the same as, or at least comparable to, those in their native environments. It is quite likely that yields would be extremely low and the proportion of active chemicals would be much decreased if one ignored the environment. The majority of medicinal plants need bright, airy locations protected from high winds and late-winter frosts. For the organic production of medicinal plants, cultural sowing alternation is crucial. For the majority of medicinal plants, winter grain crops, leguminous plants, all types of vegetable crops, berries, and fodder cultures make for the best preceding cultures. They are often taken out early, allowing for timely and efficient soil preparation for the next sowing or planting. A single species of medicinal plant may often be cultivated in the same location for a duration of one to five years. The output would often decline after the fifth year and the plants would get afflicted with pests and illnesses[4].

Planning, Selecting, and Fertilizing

Fertilizing

Mineral or organic fertilizers fall under the category of fertilizers. Soil should be fertilized once or twice, depending on the demands, but always just before earthing up or irrigation. The dosage of fertilizer should be determined by taking into consideration the soil's reserves and the species being grown. Artificial nitrogenous fertilizers should not be used since they cause the soil to become acidic, which harms certain of the soil's microorganisms. All of the organic fertilizers listed here contain a lot of nitrogen. For several processes to function properly and govern the growth and development of plants, phosphorus is crucial. During the early phases of growth, phosphorus is heavily utilized. The synthesis of proteins, the nitrogen exchange reactions, and the synthesis of carbohydrates all benefit from potassium. Nucleic acid, ATP, chlorophyll, and protein synthesis all use nitrogen. During the flowering period, it is necessary. The enzymes are made up of microelements, which also activate them[5].

It is a macro element, magnesium. It may be lacking during bud sprout because it contains both an enzymatic cofactor and the chlorophyll structure. The purpose of fertilizing is to provide plants with the nutrient materials they need throughout the duration of their vegetative phase, and sometimes even for years to come. As a result, the times and kinds of fertilizer application are quite variable. Organic farming is committed to preserving and improving soil fertility by using organic fertilizers in a natural manner. Fertilizers may be applied manually, with the use of specific plant storage cultivators, combination seeders, fertilizing equipment, or cultivators. After being allowed to decompose, manure is made from the solid and liquid excretions as well as the padding of living stock animals. The developed manure is suitable for use in farming. Additionally, it is the best for farming for the following reasons: It is made at the farmhouse itself. It contains four essential nutrients: calcium, phosphorus, nitrogen, and beneficial microflora.

It enhances the soil's physicochemical characteristics. Liquid manure is also used in organic farming. It is really animal urine that has been taken directly from the barns and sheds or liquid that has developed as a consequence of degradation and drained from the manure pile. Both pee and liquid manure act quickly. They are mostly composed of nitrogen and potassium, which are readily assimilated by plants. Since the liquid manure is quite potent, it should often be diluted 1:5 with water. Of all the organic forms of manure, bird dung has the most nutrients. It is roughly four times richer in phosphorus and three times richer in nitrogen and potassium than the typical mixed manure produced from livestock animals. Ash is used as an alkali fertilizer. They reduce soil acidity and enhance the activity of microorganisms that fix nitrogen. Whitewashing may also be done using ashes. Compost. Compost is a kind of fertilizer that is often used in agriculture. It is an organic fertilizer composed of live animal dung, urine, wood ashes, unfit for use as fodder weeds, vegetables, etc., as well as bush branches, dried leaves, hay, straw, paper, food scraps, organic waste, and other materials[6].

Technical Preparation

There are several factors to take into account, such as: Monocultures or diversification? That depends on how much money will be made in the future. For instance, monoculture reduces investment expenses but concentrates labor demands on a certain time period, while crop diversity benefits from lower risk and scalability of work. Plant species are chosen based on consumer demand. While the market for certain species is consistent, the demand for other species might vary greatly, necessitating the need for the ability to absorb risk in the future. Because each plant species has unique ecological needs, consideration should be given to the soil and climate. It is highly advised to examine the soil before establishing the plant in order to address any potential nutritional deficiencies. There are MAP species that are highly adapted, nutrient- and water-demanding. A suitable selection of species, variants that are well-adapted, and a homogeneous product are necessary for a satisfactory product yield. Dry plant, essences, etc. might be the medicinal plant that is the aim. It is related to the degree of demand, agricultural technology, resources, and labor, investment costs, and the current intensity of intensive agriculture. It is important to evaluate the availability of water, the field's location, its closeness to suppliers and points of sale, as well as the road system.

The choice of Plant Material

To the greatest extent feasible, seeds and vegetative reproductive organs should have a certification of origin and be free of contamination and chemical treatment. Except during the project's first stages, accessible varieties of organic seed should be used to provide the vegetative material. The use of any genetically modified organism as seed or as vegetative reproduction is prohibited. From a botanical perspective, seeds, sprouts, and all vegetative reproductive organs such as roots, root systems, and tendrils need to be accurately described according to genus, species, and variety/genotype.

Their genetic history should be tracked back to their origin. It is advised to use seeds or sprouts from officially recognized kinds or upgraded populations on a national basis. Additionally, it is preferable that the seeds exhibit the necessary characteristics for planting, such as purity, percent germination, survival, wetness, and authenticity of species and types, and that they were collected the same year or the year before. Initially, cultivars may provide seed, seedlings, or sprouts, and then our plants can be used for propagation. It is best to be able to grow the desired medicinal plant on your own while growing this kind of crop since it is quite difficult to locate plants that are perfectly suited to the edafo-climate conditions in our region. Furthermore, it is noted that European legislation require that any vegetal material used for reproduction come from a private farm, a cultivar, or an organic farm[7].

Harvesting Methods

Plants may be harvested in two ways. –

1. **Natural Plants:**Depending on the plant we want to collect and the purpose we want to give it, we may normally gather wild plants from March through October/November. There is a lot of legislation but not enough that controls the taking of certain species that call for specific approval.
2. **Grown Plants:**After the first or second year of cultivation, they are often harvested. For either 3 to 5 or for 5 to 8 years, they may be farmed. Some plants are only picked once a year, others many times a year, while yet others are only collected every two to three years. The farmer must be aware of when to harvest the plants and which parts are necessary. The best time to choose a plant depends on what component will be utilized. Buds should be picked as soon as they start to bloom.

Harvest Periods

Reproductive cycles vary depending on the species picked and the level of collecting. Thyme, oregano, and lemon balm have cycles of four to five years, lavenders and rosemary of eight to nine years, and mint or purple cornflower of three years. In Europe, the harvesting season begins in the spring and might run until the autumn. While certain species may only be harvested once or twice every season, others can be gathered three or four times. The best quality and concentration of active chemicals can only be obtained by harvesting the plant at the right time, which is determined by the portion of the plant that will be utilized. When plants are sown in the fall, many species are ready for their first harvest by the following summer. Production typically begins after one year. Plants may be harvested once, twice, or three times a year, depending on the circumstances.

For instance, thyme may be harvested three times a year if it is irrigation-friendly. The aerial portions of purple cornflower may be collected three times, tarragon twice, sage three times, Saint John's worth twice if watered, savory two or three times, and lavender once. Lemon balm, like mint, can be harvested three or even four times. Always match the rhythm of production or transformation with the rhythm of collecting. Therefore, the machinery's capacity for harvesting must be precise match to the machinery's capacity for transformation, the available employees' capacity for labor, and the collecting seasons of the species in question.

Processing after Harvest

For medicinal plants, the following post-harvesting procedures are typical. Cutting: Since it improves surface evaporation, it is done to help drying out. The kind of plant and the technologies used both have a role. Washing: To remove dirt and other foreign matter from the plant portion that will be dried, drinking water is utilized. Disinfection is the process of getting rid of harmful microorganisms for people in various methods, up till regulated levels are reached. Chemical treatment: in order to lower the bacterial content to acceptable levels before drying, plants are submerged in chlorinated saline solutions[8].

Physical therapy: Gamma radiation is applied to plants before drying. This technique is employed when chemical disinfection is ineffective or when the vegetable matter originates from regions with consistent yield flows and low levels of inorganic particles. Bleaching is a technique used to stop oxidation. It involves applying a thermal shock by submerging the substance in hot water or steam to prevent the action of oxidizing enzymes. Sulphite: This method seeks to maintain the food's original flavor and color as well as to protect the vegetable matter, postpone the loss of vitamins A and C, and inhibit the development of bacteria. It entails soaking the vegetable matter for a while in a concentrated solution of sulfur dioxide that ranges from 1.2% to 2% in a sealed camera. Additionally, vegetable matter may be submerged in sodium bisulphite or sodium metabisulphite solutions for varying lengths of time and concentrations.

The first transformation

All the steps that are taken to conserve raw materials, choose the components that will be utilized, remove impurities, crush or mill the product, and extract the active compounds are considered transformation. This allows the product to be packaged and labeled in preparation for storage or delivery. It is necessary to follow the stated guidelines for proper manipulation.

Drying

The goal of drying is to reduce the moisture content to less than 10% so that enzymatic activity ceases and bacteria and fungus can't attack and produce mould and quality degradation. Additionally, drying makes transporting the vegetable materials simpler. The issue is that not every medicine has the same level of humidity. The evaporation rate is impacted by the texture of the medicines, which varies. Different sensitivities to temperature are shown by active substances. Drying should take place as quickly as possible without changing the active substance. Humidity after drying must be under 10%. The technique will vary depending on the drug's properties, including its consistency, humidity, and kind and grade of the active component. Compared to glycosides and sugars, alkaloids are more resistive. Essential oils cannot be dried at high temperatures because of their volatility. There are three techniques: suction, heating, and air drying.

Drying by Air

Small quantities of medications with stable active components are processed using this method in warm, dry climates. Since the light would trigger photosynthesis in the medication, drying is done in the shade. The medication is safeguarded against dampness at night. Drying is done with the medicine spread out in thin layers in ventilated, closed-off rooms. Desiccation into the air might happen as the process is sluggish.

Heating up

Since temperature and airflow can be adjusted, this approach, which is the most popular, has the benefit of achieving excellent desiccation. It must be made sure that humidity is quickly removed without affecting the active component. When the temperature is too high, a dry layer forms and the surface rapidly evaporates, limiting further drying. This kind of drying typically occurs at 30 to 40 co., a few degrees more for barks. Ventilation makes sure that air comes into touch with the medication up to the point of water saturation. As soon as the air becomes saturated, it changes. Industrial drying is done in drying tunnels, whereas small-scale drying is done in ovens with air vents. The latter has a heater and a fan at each end. To accomplish progressive drying, the medicine is put in the tunnel on trolleys with many shelves. The heat that is applied to the trolley decreases as it travels down the tunnel[9]. This drying process is used in the industrial setting; the drying rooms were created to handle a certain amount and kind of vegetable matter. The circumstances for this procedure mostly rely on the species that will be dried. The water content of the vegetable matter, its ability to retain water, the maximum drying temperature, and the ambient humidity are the most significant elements influencing the drying process. The quantity and volume of fresh vegetable matter that must dry in a certain length of time must be considered while determining the drying equipment's capability. Forced drying, which includes forcing hot, dry air around a confined space to remove moisture and cold, is an alternative to natural drying by hanging or on trays. Although this relies on the plant's moisture level, it is significantly quicker. Between 32 and 35 oC are the ideal drying temperatures to avoid destabilizing the volatile essences or the active components. To prevent this, it is preferable to shorten the drying process. Vegetable matter may be preserved after it has dried out without fear of biological activities destroying its active components[10]–[12].

Post-drying

After the plant has dried, the section that will be utilized must be removed from the remainder of the plant, along with any foreign objects. Machines with sieves or air tubes that use air currents to separate various densities may be used for the separation process. Metals may be separated as well if magnets are applied.

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CHAPTER 13

MEDICINAL PLANTS AND HERBAL DRUGS

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Plants are sources of non-food industrial goods in addition to being a source of food. These plants are often grown on a huge scale to produce specialist goods or industrial chemicals. One such group of plants is the medicinal plant family, which has an extraordinary wealth of chemical compounds with several medical uses. The World Health Organization defines a medicinal plant as any plant that, either as a whole plant or in one or more of its organs, contains substances that can be used to synthesize useful drugs or that have direct medicinal properties that can be used for therapeutic purposes or have an impact on human health. The entire plant or any of its components, including the roots, stem, leaves, stem bark, fruits, or seeds, may be used to cure or control a disease. These chemical or non-nutrient components of the plants that are therapeutically active are often referred to as phytochemicals, bioactive compounds, or active principles. A remarkable number of contemporary medications have also been identified from these natural plant species, in part because of their usage in traditional medicine. Numerous phytochemicals act as vital medications that are now employed worldwide to treat a wide range of dangerous disorders[1].

Each plant has a variety of phytochemicals that may be used to treat a variety of illness problems. Asthma, fever, constipation, infections of the urinary tract, gastrointestinal, biliary, and skin systems, among other conditions, may all be treated using traditionally used medicinal herbs and their constituents. The plants are used topically in a variety of methods, such as poultices, formulations of various plant mixes, infusions as teas or tinctures, or as component mixtures in porridges and soups that are delivered orally and topically. Utilizing medicinal plants for therapeutic reasons has a long history that reaches back to antiquity. Herbal medicines are mostly made from medicinal herbs. The Chinese, Egyptian, and Ayurveda traditional medical systems all used these herbs extensively. Over the years, medicinal plant products have taken on a highly significant role in the healthcare system and as a substitute source of health-beneficial pharmaceuticals. The growing ineffectiveness and adverse consequences of many contemporary synthetic medications, such as the growth in bacterial resistance, are the main causes of the increased use of medicinal plants. About two-thirds of the global population in poor nations depend on plant-based traditional medicines and herbal treatments for their basic healthcare needs, according to the World Health Organization. In addition to being utilized as a source of raw materials to create a variety of products ranging from traditional to contemporary medications, medicinal plants also have the ability to cure both serious and minor human diseases. Regular scientific research has emphasized the value and contributions of many plant families, including Asteraceae, Apocynaceae, Liliaceae, Rutaceae, Caesalpiniaceae, Solanaceae, Piperaceae, Ranunculaceae, Apiaceae, Sapotaceae, etc., as well as their bioactive compounds in the therapeutic realm. These families also make up a significant portion of nature's wealth.

Therapeutic benefits of medicinally significant bioactive components derived from these plants include beneficial control of the body's physical and mental health as well as effective disease prevention and therapy. However, in order to produce plants as a source of fine chemicals, certain factors must be taken into account. For example, it is important to understand how trade in these ingredients and raw materials is organized and regulated on a national and international level, to identify current market trends and potential future demands, to choose desired crops based on market demand, to consider the viability of the cultivation requirements, and to research the potential need for the produced goods. Over the last several decades, production of commercially significant natural and recombinant bioactive compounds has drawn a lot of interest. It is generally known and well accepted that using medicinal plants to make herbal medicines is both safe and effective. A medical strategy that emphasizes policy, safety/quality/efficacy, access, and rational use of traditional medicine should be in place in order to encourage the appropriate use of traditional medicine and medicinal plant products. Unfortunately, the high population growth increased the need for natural herbal health solutions[2].

Systematics and taxonomy of Plants

Regarding their botanical traits, medicinal plants are very varied. They come from a wide range of plant families and often have identical active principle components. For instance, the Solanaceae family has multiple species that contain alkaloids, whereas the species of Labiateae are distinguished by the presence of several essential oil components. The fundamental taxonomic unit of medicinal plants, like that of other plants, is the species, with the genus consisting of related species. The terms subspecies, variation, and form are used to distinguish various populations of species that thrive in the wild. It is possible for various secondary metabolite profiles to develop as a result of mutation in certain medicinal plants of the same species. Genetic differences may sometimes change a species' chemical makeup. These are referred to as chemodemes or chemical races. Numerous species have shown signs of chemical races, and some of the variable chemicals found in these species include cyanogenetic glycosides in Prunus communis, alkaloids in Duboisia species, and cardiac glycosides in Digitalis purpurea. Both wild and domesticated species are classified into distinct subspecies in an eco-botanical sense. Typically, cultivars are distinguished based on the traits that human civilizations value. The first and most important step in studying and using medicinal plants is accurate identification.

As a result, more emphasis should be placed on the accurate, reproducible experiments needed for plant identification, and the correctly identified plants should be deposited in recognized herbaria. The proper identification and description of medicinal plants has benefited greatly from the use of botanical sciences such as plant systematics, plant morphology, physiology, molecular attributes, and more recently, chemo-differentiation based on plant metabolite information as well as ecological characteristics. High-referenced morphological systems give greater thought to plant morphological characteristics and rate plants in accordance with hereditary and evolutionary principles. The study of gene structure, function, and the mechanism by which genes are replicated and transcribed to control metabolism in botanical classification, in addition to these recent trends in underlying biological processes, have established themselves as effective tools to supplement accurate identification of medicinal plants and seem to have somewhat eased role of secondary metabolites in plant systematics. In addition to assisting in accurate identification, this interdisciplinary collaborative method has also opened up exciting possibilities for the breeding of very potent chemo-cultivars of medicinal taxa[3].

Animal Morphology External shape, arrangement, and interactions with anatomy, or interior structure, are all aspects of a plant's morphology. The implications of morphological structures in medicinal plants have, however, been preserved because the synthesis and accumulation of active chemical components are cell, tissue, and organ specific. For instance, tropane alkaloids are produced in the root system of Datura and Hyoscyamus plants before being transported to the aerial shoot system of the plant. Members of the Lamiaceae family also have glandular hairs that act as storage areas for essential oils. Pharmacognosy heavily relies on morpho-anatomic traits, or the presence or lack of a property, in order to identify crude drugs and detect adulterations. Drug identification is made easier even in dried crude medications by histological features like starch grains, polygonal crystalloids, and secretory features like glandular hairs, lactiferous arteries, schizolysigenous cavities, etc. The morphological characteristics of plants may also change depending on their stage of growth and development and under the influence of ecological variables.

Plant Physiology

Plant physiology is an experimental discipline that studies how the environment and genetic differences affect a plant's life processes and then utilizes that knowledge to describe how a plant behaves. Plant physiology is primarily responsible for the generation and variation of active principles in medicinal plants. From the juvenile to the adult stage, the metabolic processes alter dynamically, which influences the synthesis and accumulation of chemical components that are physiologically active[4].

Metabolic Cycle, Primary and Secondary

Metabolism is the whole of the many chemical activities and reactions taking place simultaneously in every plant cell. While primary metabolism produces primary components like as carbohydrates, proteins, lipids, and nucleic acids, secondary metabolites are primarily formed under various stress circumstances and result in a diverse spectrum of substances that are not present in all species. They are used for specialized functions, such as defense, or to meet a particular environmental demand. Humans use these secondary metabolites created by medicinal plants for a variety of health benefits.

Because of their unique function in plant metabolism, secondary metabolites sometimes referred to as special principles as opposed to universally occurring compounds. These substances are not common across plants since they are typically produced under artificially changed natural circumstances by specific tissues and organs to perform a specific purpose. The essential foundation for their usage as herbal medicines, where people adopt the exact same components that the plants employ for themselves, is their capacity to synthesis a variety of bioactive principles with beneficial effects for humans. For instance, antioxidants produced in plants that provide protection against comparable assaults in them may be employed by man to guard against damages in people caused by oxidative or free radicals. The physiological activity of the plant is primarily what sets medicinal plants apart from other plants. The physiological underpinnings of bioactive component production or accumulation define a taxon's uniqueness. Since the same chemical components may be synthesized in many ways, all plants share the same synthetic pathways. Different plant groups, for instance, are capable of producing structurally related naphthoquinones, such as the synthesis of lawsone in the Balsaminaceae and Lythraceae families and plumbagin in the Droseraceae, Ebenaceae, and Apocynaceae families. The capacity of medicinal plants to adjust their synthesis under environmental stress is a noteworthy characteristic of their physiology. These changes are mostly seen in the metabolism of plant species that contain terpenoids[5].

Biologically Active Chemicals

The relevance of medicinal plants in maintaining human health has been highlighted by the vast variety of pharmacological actions they exhibit, including anti-inflammatory, antibacterial, and antifungal capabilities. The existence of certain compounds in medicinal plants, which trigger particular physiological responses in people, is what gives them their therapeutic value. These phytochemicals have a broad range of physiological and ecological activities and are found throughout the plant world. These bioactive secondary metabolites in plants are mostly used as a kind of chemical defense against diseases, predators, and other biotic and abiotic stressors like pathogens and allopathic agents. Secondary metabolites are the medicinally significant active components of the pharmacological plants. They are comparatively tiny chemical molecules that are widely distributed across the plant kingdom, although it is not always clear how they affect plant life. These metabolites are produced by medicinal plants primarily by oxidation, reduction, substitution, and condensation processes. A wide range of these phytochemicals, including phenolic compounds, flavonoids, alkaloids, tannins, and terpenes, are synthesized and accumulated by medicinal plants. These compounds are used therapeutically or as building blocks for the creation of effective medications. These chemical components that are biologically active come in a wide variety and have distinct physiological effects on the human body. Stems and leaves of most medicinal plants are discovered to be abundant in a wide range of secondary metabolites with noticeable physiological action. The three primary categories of secondary metabolites found in medicinal plants are phenolic chemicals, terpenoids/terpenes, and alkaloids[6].

Phenolic Substances

In the plant world, phenols, also known as phenols or polyphenolics, are chemical elements that are naturally occurring color pigments that give fruits of plants their distinctive hue. They serve a variety of purposes and are crucial to plants. The most significant function may be in protecting plants against viruses and herbivore predators, and as a result, they are used in the management of human pathogenic illnesses. They have low molecular weight and range from simple molecules with a single aromatic ring to intricate and substantial polyphenols. Simple one-ringed phenols and the enormous polymeric structure known as lignin, which is made up of phenylpropanoid units that are cross-linked to one another by heterogeneous chemical bonds, are two examples of plant phenolics. Depending on their functional group, which might be a hydroxyl, aldehyde, or carboxylic group, the physiologically active chemical components found in plants that belong to the phenolic group differ. The majority of phenolic secondary metabolites are aromatic molecules with a carbonyl group attached and a C6-C1 carbon backbone. They may be produced in plants in large part via the shikimic acid system, which produces a variety of aromatic amino acids that are then transformed into phenolic compounds. Other phenolic compounds, such quinones and orcinols, can be produced by the polyketide pathway.

Phenolic chemicals are often produced from both of these routes, including favonoids, pyrones, and xanthones. A significant biosynthetic pathway for secondary metabolism is the erythrose-4-phosphate and phosphoenolpyruvate-based shikimate pathway. A key branching point in metabolism is generated by chorismate, which is formed at the conclusion of this route and serves as a substrate for all future products. These intermediate products serve as the building blocks for the synthesis of a wide range of phenolic compounds, such as tannins and lignans, which are often produced from phenylalanine. The majority of phenolic compounds in plants are produced from phenylalanine by the enzyme phenylalanine ammonia lyase. The phenolic group contains tannins, coumarins, favonoids, and metabolites formed by the modification of aromatic amino acids, as well as those created by the condensation of acetate units.

Simple phenolics, coumarins, favonoids, tannins, lignans, phenylpropanoids, and other subgroups of these larger categories are the primary phenolics found in medicinal plants. Phenols are thought to hinder the development of pathogens. Antioxidant, anticlotting, anti-inflammatory, and immune-stimulating properties of protonated phenol. Phenols are known to prevent platelets from clumping as well as to stop certain enzymes that cause infection. Polyphenols are thought to stop the growth and spread of malignant tumors. Plant favonoids are also known to lower the risk of cardiac disorders and have the potential to act as cancer chemoprotective agents. Additionally, favonoids have been linked to prospective treatments for cancer, ulcers, hepatotoxins, allergies, inflamation, platelet aggregation, free radicals, and ulcers.

Basic Phenolics

Although free phenols are uncommon, phenolic groups are found throughout all plants. Simple phenolics, such as catechol, are substances with at least one hydroxyl group joined to an aromatic ring. Phenylpropanoids, which are defined as secondary metabolites produced from phenylalanine and have a C6C3 carbon skeleton, are some examples of simple phenolics. The majority of them are phenolic acids, which are often the constituents alone or mostly along with terpenoids of essential oils. Asarone and myricetin are two of these substances that are poisonous. Hyperforin, an antidepressant found in medicinal plants, is one of many simple phenolics that have their origins there[7], [8].

Naphthoquinones

These chemicals are also phenolic secondary metabolites that are found in the kingdom of plants. In terms of chemistry, naphthoquinone is an organic molecule produced from naphthalene with one aromatic ring bonded to a quinone component. Lawsone, juglone, and plumbagin are the three most prevalent and widely used naphthoquinones. They may be found in reduced and glycosidic forms in plants. The pharmacological characteristics of naphthoquinones, such as their antibacterial, antifungal, antiviral, insecticidal, anti-inflammatory, and antipyretic effects, are quite significant. Members of the Avicenniaceae, Droseraceae, Ebenaceae, Juglandaceae, Nepenthaceae, and Plumbaginaceae families contain naphthoquinones. Naphthoquinones having hepatoprotective properties may be found in Lawsonia inermis. Naphthoquinone compounds from Juglans regia and Lithospermum erythrorhizon are said to have antibacterial, fungicidal, cytostatic, and anticarcinogenic properties.

Tannins

A subclass of polyphenolic biomolecules known as tannins bind to and precipitate proteins as well as a variety of other organic substances, such as alkaloids and amino acids. Through the process of cross-linking, tannin molecules strengthen the protein's defenses against microbial and fungal assault. For tannin molecules to act as protein binders, they typically need at least 12 hydroxyl groups and at least four phenyl groups. Tannins are often divided into two major categories: condensed tannins and hydrolysable tannins. Gallotannins and ellagitannins are formed when the core carbohydrate molecules in hydrolysable tannins, such as glucose or polyhydric alcohol, are partly or entirely esterified with phenolic acids, such as gallic acid and hexahydroxydiphenic. Proanthocyanidins, another name for condensed tannins, are carbon-carbon bond-bound polymers of favanol units.

They make up a sizable class of secondary metabolic chemicals that are dispersed across the plant world. Shikimic acid, through cinnamic acid, is the biogenetically generated source of simple coumarins. Some essential oils, such cassia oil, cinnamon bark oil, and lavender oil, contain them in significant amounts. Coumarins are structurally classified as benzopyrones because they feature a benzene ring connected to a pyrone ring. More than 40 distinct families of angiosperms contain more than 1400 different types of coumarins that have been identified. Simple coumarins, biscoumarins, furocoumarins, dihydrofurocoumarin, and phenylcoumarins are the several forms of coumarins that may be found in medicinal plants.

They fall under the category of new therapeutic agents because of their bacteriostatic and antitumor characteristics. In certain cancer cell lines, coumarin and its derivatives have shown potential as cellular growth inhibitors. They also possess anti-inflammatory, anti-inflammatory, anti-hyperglycemic, anti-fungal, antibacterial, antiviral, and anti-viral activities. Asteraceae, Apiaceae, Fabaceae, Rutaceae, Oleaceae, and Thymelaeaceae are the families having the highest prevalence of coumarins, correspondingly[9]–[11].

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CHAPTER 14

GOOD AGRICULTURAL PRACTICES AND THE CULTIVATION OF MEDICINAL PLANTS

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Many people believe that medicinal plant resources that are gathered from the wild are more effective than those that are grown. However, greater cultivation helps these natural resources recover and be restored by reducing the magnitude of harvest pressure on wild medicinal plants. Additionally, the potential for medicinal plant products to become better medicines comes from their proper cultivation, where factors like good site selection, good seed material, nutrient input, harvest and postharvest techniques, and management form the merits for their commercialization as well as present opportunities to address issues with medicinal plant production like low bioactive ingredient content, pesticide and toxic contamination, and low bioactive ingredient content.The productivity of the plant biomass, where the active ingredients are produced and regularly accumulates, is crucial to the efficacy of these species' cultivation. The amount and makeup of bioactive chemical components are crucial prerequisites for their use, and as a result, botanical areas are heavily researched.

Good Agricultural Practices and the Cultivation of Medicinal Plants Many people believe that medicinal plant resources that are gathered from the wild are more effective than those that are grown. However, greater cultivation helps these natural resources recover and be restored by reducing the magnitude of harvest pressure on wild medicinal plants. Additionally, the potential for medicinal plant products to become better medicines comes from their proper cultivation, where factors like good site selection, good seed material, nutrient input, harvest and postharvest techniques, and management form the merits for their commercialization as well as present opportunities to address issues with medicinal plant production like low bioactive ingredient content, pesticide and toxic contamination, and low bioactive ingredient content.The productivity of the plant biomass, where the active ingredients are produced and regularly accumulates, is crucial to the efficacy of these species' cultivation. The amount and makeup of bioactive chemical components are crucial prerequisites for their use, and as a result, botanical areas are heavily researched[1].

By providing better and optimal environmental conditions, such as light, temperature, humidity, water, soil, and other additives like nutrients, fertilizers, and pesticides, controlled cultivation practices are intended to increase yield of secondary metabolites and ensure stability in their production, as shown in Figure 1. Intensive care and management are necessary while cultivating medicinal plants, depending on the quality of the plant material, the length of time, and the environmental requirements. In the lack of any scientifically published or recorded cultivation data, traditional techniques of growing should be used. To promote high-quality production and enable the standardization of herbal medicines, good agricultural methods, including appropriate rotation of chosen medicinal plants, should be followed in accordance with environmental appropriateness and other growing needs. Through integrated management of the available water, soil, and biological resources in combination with external inputs that contribute to sustained agricultural production and environmental conservation, conservation agriculture techniques that aim for efficient use of natural resources should be practiced.

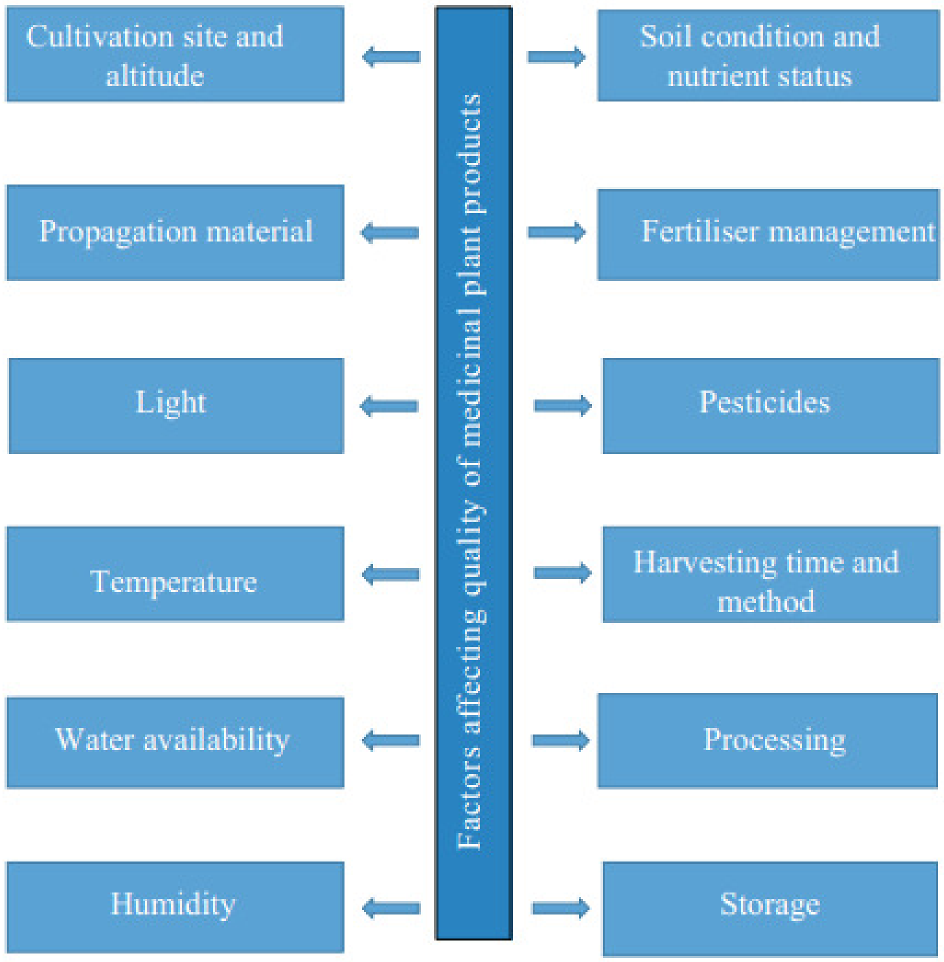

Figure 1: factors impacting the quality of the bioactive chemical components and the development of medicinal plants.

Additionally, there are several additional physiological and environmental elements that are connected with the production of active principles and their concentration in medicinal plants. The following are some of the most significant parameters influencing the development of medicinal plants as well as the quality and quantity of their active chemical components and, therefore, medicinal plant products[2].

Seeds and Other Materials for Propagation Any kind of propagating material, including seeds, need to be of high quality and have a track record of successful breeding. To encourage the healthy growth and development of plants and the production of their chemical products, this material should be as free from illnesses and contaminants as feasible. The standard of propagation material should abide by local laws and be well recorded. Avoid using inferior, fake, and tainted propagation materials.

Site Choice

The most important consideration in the production of medicinal plants in order to satisfy the needs of ecologically homogeneous populations is site selection. Due to variations in soil, climate, eco-geographical conditions, and other variables, cultivation location affects the quality of medicinal plant products, particularly those connected to the active ingredients. It is important to assess the effects of prior land uses on the cultivation site, including any plant protection agent treatments and previous crop plantings. Altitude and slope are essential considerations when choosing a location for the growth of medicinal plants. The elevation of the chosen location or area has a significant impact on the production of effective medicinal plants. Increases in altitude result in a drop in air pressure and temperature as well as an increase in relative humidity, wind speed, and light intensity.

Thus, owing to variations in climatic circumstances, the pattern of flora changes as elevation changes; for instance, at high elevations, Atropa belladonna, Datura innoxia, and Catharanthus roseus exhibit high active principle contents. Aconitum lobelia and pyrethrum both experience an increase in alkaloid concentration as they ascend in elevation, but peppermint experiences a reduction. Additionally, the slope face affects temperature and daily light intensity, all of which have a significant impact on the growth and development of plants. Latitude is another element that affects the makeup of the biomass, such as Atropa belladonna[3].

Light

Since light is a plant's primary external energy source, it has an impact on all aspects of vegetative development, seed germination, stomata opening and closing, photosynthesis, and flowering in medicinal plants. The duration of the day has a significant impact on the growth and development of medicinal plants. The amount of light also has a significant regulatory impact on how well some therapeutic plants operate. The amount of glycosides in Digitalis and the amount of alkaloids in Atropa, Mentha, Coptis, Glycyrrhiza, and Humulus rise in dry, sunny weather with more than 14 hours of daylight. Other plants, including Pelargonium, Citronella, and Pogostemon, produce essential oils at a rate that is over 25% higher when cultivated in settings with fewer than 12 hours of sunshine.

Photoperiodic cycles' impacts on crops including Solanum, Digitalis, Rauvolfa, and Dioscorea have been well-established. In contrast, low light intensity encourages increased active chemical ingredient synthesis in Cephaelis ipecacuanha, requiring the necessity for artificial shade. More menthol is produced in Mentha when plants are exposed to adequate sunlight. Similar to this, when 75% of the incoming light is filtered, the berberine concentration of Coptis japonica rises by 15%. Similar to this, 40% less light resulted in a 30% rise in alkaloid and quinine in Cinchona.

Temperature

It is generally known that the temperature of the atmosphere affects the growth and development of medicinal plants. The main influencing element in the production of medicinal plants, as in other plants, is temperature. Temperature has an impact on both photosynthesis and respiration rates, which both increase with rising temperatures up to a certain point. Similar to how abrupt temperature drops cause ice crystals to develop in plant intercellular gaps, which causes desiccation-related cell death and plant mortality. Increasing temperature to its optimum encourages an increase in the synthesis of these secondary metabolites in many medicinal plants that produce terpenes and alkaloids. The content of a plant's secondary metabolites is influenced by temperature as well.

For instance, at cold temperatures, Papaver somniferum's morphine content rises but its overall principle content falls. Increased production and total pyrethrin concentrations in pyrethrum are also encouraged by low temperature. Atmospheric moisture by interfering with photosynthesis, atmospheric humidity has an impact on many aspects of the growth and development of medicinal plants. Under abnormal circumstances, this results in the formation of greater secondary metabolite content. Relative humidity impacts these plants' shape, structure, and transpiration because it affects water evaporation, condensation, and precipitation.

Water Sources

The most important element for the production of medicinal plants is water availability. Water availability has a significant impact on plant physiology and morphology. Water should be provided according to each medicinal plant's demands. To guarantee that plants aren't over- or under-watered, there should be regulated irrigation and drainage. Although there are variances in how various plant species respond to water restriction, there is a highly intricate link between the availability of water and the best possible production of medicinal plants. It is crucial to take into account how each plant will respond in comparison to how the whole Feld will respond.

Although water stress in general may not be advantageous, carefully timed stress of the right severity may be beneficial with respect to the production of secondary metabolites. In Catharanthus and Rauvolfa, water stress promotes higher secondary metabolite buildup. Atropa and Datura exhibit an increase in alkaloid content when subjected to moisture stress. Contrarily, Cinchona has a reduction in alkaloid accumulation when there is more water available, occasionally to the point where there is no alkaloid content[4].

Soil

One of the most crucial natural resources for sustaining plant development is soil, which gives plants anchoring, nutrition, and mechanical support. In soil with the right ratios of inorganic and organic nutrients, medicinal plants thrive most effectively. The target medicinal plant will determine other factors such as soil type, moisture retention, drainage, pH, and fertility. The majority of medicinal plants can often thrive with enough soil moisture and mild nitrogen levels. Some medicinal plants, including Withania and Cymbopogon, may, however, also flourish on less rich soils.

In general, medicinal plants can tolerate a broad variety of soil pH and texture; for example, Cymbopogon and Cassia show increased yields when moved from light soils to loam and clay loam. Vetiveria is exceptional in that it can tolerate circumstances such as periodic fooding, water logging, and soil alkalinity without adversely affecting the overall oil output and its composition. While plants like Aloe, Vetiveria, and Commiphora are cultivated on high pH soils, Cinchona and Coptis favor acidic soils.

Fertilizers

Management of fertilizer is essential to the growth of medicinal plants. Even though every plant has a unique set of nutrient needs, getting a decent yield often depends on using the right fertilizers chemical or organic in the right amounts. The use of NPK has caused a number of medicinal plants to produce more biomass and active principle content. A rise in the quantity of diosgenin in Dioscorea, an alkaloid in Atropa, and essential oils in Cymbopogon grasses, Vetiveria, and Mentha, for example, are all effects of nitrogen fertilizer application.

Protection and Upkeep

The growth and development characteristics of a certain medicinal plant or its unique component intended for medical use should serve as the basis for the field management procedures. To manage the growth and development of the plant, utilize timely techniques like topping, bud nipping, trimming, and shade. This will increase the quality and output of medicinal plant material. With minimal to no usage of pesticides and herbicides, integrated pest control should be in place. It is necessary to use a variety of pest management techniques, including hand-picking insects, trimming, burning, and pest traps. Chemical pesticides including insecticides, fungicides, herbicides, and rodenticides are used in chemical techniques of pest management. Advanced plant breeding methods that involve genetic engineering to create hybrid types of plants that are resistant to bacterial and fungal assault, however, may be more beneficial. In addition to these, greenhouse effect and natural and artificial hybridization have an impact on the development, growth, production, quality, content, and quantity of medicinal plants as well as the bioactive compounds that make them up[5].

Harvesting

Similar to other commercial plants, the mass production of high-quality crude drugs with desirable active ingredient contents has a scientific basis. Sustainable harvesting practices, such as expert collection practices, time of harvesting, material to be harvested, harvesting techniques, harvesting equipment, proper processing and drying, packaging, and proper storage, are also involved. To guarantee the plentiful production of high-quality medical plant components, medicinal plants should be harvested at the ideal season. The kind of plant and the plant portion that will be utilized influence when to harvest. In order to minimize any potential negative effects brought on by increasing moisture levels, harvesting should be done in the best circumstances possible, avoiding rain, mist, and excessive humidity. The concentration of physiologically active ingredients fluctuates with plant growth and developmental stage; thus, peak quality and quantity of active chemical elements, rather than vegetative yield, should be used to decide harvesting time.

When to harvest a certain medicinal plant should be well-documented and readily accessible information. The greatest care should be used during harvest to prevent the mixing of collected medicinal plant components with weeds, foreign objects, or dangerous plants. To minimize the possibility of contamination from soil and other contaminants, harvesting equipment and other machinery should be maintained clean. To the greatest degree practicable, collected material should be kept out of contact with soil to lessen the microbial burden. Raw medicinal plant materials should be transferred as soon as possible under sanitary, dry circumstances. They may be transferred to a central location in properly aerated containers before being transported to the processing plant. Avoid any mechanical harm or compaction of the raw medicinal plant components that might result in composting or otherwise degrade quality, such as overfilling or stacking of sacks or bags. In order to prevent microbial contamination and loss of product quality, decomposed medicinal plant components should be identified and eliminated during harvest, postharvest inspections, and processing.

Post-Harvest Handling Raw medicinal plant material should be inspected before primary processing begins. This inspection may involve a visual check for contamination by unintended medicinal plants or plant parts as well as an organoleptic assessment, which looks at things like size, color, taste, odor, and damage. The particular materials determine the proper major processing steps. These procedures should be carried out in accordance with any applicable national, regional, or local quality standards, laws, and regulations. Standard operating procedures should be adhered to as much as feasible. If modifications are performed, they must be supported by sufficient test results proving that the medicinal plant material's quality has not been compromised. When arriving at the processing facility, freshly harvested or gathered raw medicinal plant materials should be unloaded and unpacked without delay. In order to avoid microbial fermentation and heat deterioration, medicinal plant materials that are to be employed in the fresh condition should be harvested/collected and brought as soon as possible to the processing facility.

The materials should be preserved as soon as they are harvested or collected and while in transit to the eventual consumer. They may be preserved under refrigeration, in jars and sandboxes, or by enzymatic methods. Preservative use need to be minimized. They must be utilized in accordance with local, national, and/or international laws that apply to both growers/collectors and end users. To reduce harm from microbial infection, the moisture content of the medicinal plant product should be maintained as low as possible wherever it will be utilized in dry form. Pharmacopoeias or other reliable monographs should be able to provide details on the ideal moisture content for certain medicinal plant materials. Medicinal plants may be dried in a variety of methods, including direct sunshine, ovens, indirect light, and open air frames for drying, baking, lyophilization, or infrared devices. The humidity and temperature should be managed to prevent harm to biologically active components. The technique and temperature used for drying have a significant impact on the final medicinal plant product's quality.

For instance, low temperature drying is favored for plant material containing volatile oil, while shade drying is used to reduce loss of flower and leaf color. To lessen the likelihood of mold growth, medicinal plants shouldn't be dried on bare ground and regular drying practices should be used. The section of the plant being utilized, as well as its natural components, should be taken into consideration when determining the drying temperature, time, humidity, and other variables. Certain therapeutic plant materials need specific processing in order to improve purity, avoid pest harm, and increase efficacy. Pre-selection, root and rhizome skin peeling, steaming, pickling, natural fermentation, distillation, roasting, lime treatment, and fumigation are some of the most popular methods of specific processing. The quality of medicinal plant material and subsequent products is also impacted by processing steps including the construction of certain shape formations. Raw and processed medicinal plant materials that have undergone different antimicrobial treatments must be disclosed, the materials must be labeled as necessary, and the antimicrobial treatments must be carried out in line with national and/or regional requirements[6].

Medical Plant Products: Quality and Safety Issues

Due to their greater compatibility with the human body and the fact that plants are abundant sources of phytochemicals, herbal medicines are often recommended as safer alternatives to synthetic pharmaceuticals. A chemical substance or, more often, a combination of chemical compounds produced from plants that work either alone or in combination on the human body to prevent illness and maintain or restore health are known as herbal medications or plant drugs. These plant products are utilized in their natural state or chemical compounds are separated from them in the lab. In certain cases, new medications are created by mixing several isolated chemicals prior to being used. The great majority of herbal medications are isolated from natural sources using non-standardized conventional procedures. This, along with different plant growth environments, issues with various vernacular names, and a lack of standard cultivation, harvesting, and post harvesting procedures frequently result in the addition of impurities, which degrade the quality and effectiveness of natural medicinal products and, in some cases, cause adverse drug reactions. In order to reduce adulteration and preserve the quality of these herbal goods, emphasis has recently been placed on adhering to a set of safety requirements for herbal drugs.

The associated concerns of quality, safety, and efficacy must be taken into consideration when integrating medicinal plant products/herbal medicine into contemporary medical procedures. Quality is of highest importance since it impacts the security and effectiveness of pharmaceutical items. Extrinsic, intrinsic, and regulatory variables all have an impact on the quality of a product. The synthesis and accumulation of active chemical elements in the source medicinal plants might vary in terms of quality and quantity due to species differences, organ specificity, diurnal and seasonal fluctuations, and even within the same species. Environmental conditions, collecting and harvesting techniques, post-harvest phases, manufacturing procedures, unintentional contamination, and purposeful adulteration are extrinsic factors that affect the quality of herbal products. The quality of pharmaceuticals is influenced by a variety of intrinsic characteristics, including species diversity, their unique ecological needs, and the biochemical processes that operate inside them. Regulatory methods may also influence the quality of herbal medicine, with uncontrolled activities often resulting in a reduction in product quality[7].

Misbranding of Herbal Drugs

Intentional or accidental medication adulteration sometimes involves activities where herbal drugs are wholly or partly replaced with subpar goods that may or may not have any therapeutic benefit. There are typically two forms of adulteration: intentional and accidental. When other materials are intentionally substituted for real raw materials, this is known as deliberate or direct adulteration. This practice is mostly promoted by merchants who are hesitant to pay higher costs for better quality herbs and are more likely to buy cheaper goods, which encourages manufacturers and dealers to market lower-quality herbs. Additionally, the scarcity of natural medicines is another element that encourages adulteration. Confusion over the common vernacular names of herbal medications is the cause of inadvertent or unintended adulteration. A genuine medicine that is just partly or completely devoid of the active components may be introduced to the market as a result of inadequate review methods.

This mainly happens with volatile oils. Such adulteration and substitution result in subpar quality and variation from batch to batch. When medications are intentionally tampered with, they are often contaminated or replaced with fake, inferior, or inferior pharmaceuticals. Adulterants are employed to replace inferior commercial types because they are less expensive, inferior, and physically and chemically similar to the original, crude medication utilized. Substitution with inferior medications of superior quality, which have little to no chemical or therapeutic value and are utilized because they resemble real goods morphologically, is another sort of intentional adulteration. Another kind of direct adulteration is substitution with an artificially produced chemical, when an adulterant that closely resembles the original medicine is produced artificially and used in place of the more expensive medications.

The replacement of "exhausted" medications sometimes entails adulterating herbal plant material with identical plant material that lacks the active ingredients. Typically, volatile oils comprising coriander, clove, fennel, and caraway are used for this. In addition to this, synthetic compounds are often utilized as stand-ins to enhance the natural character of the already overused medicine. Citral, for instance, is added to citrus oils like orange and lemon oils. Sometimes, little plants' vegetative portions that are growing next to therapeutic plants are introduced. Drugs that come in powder form are regularly tampered with. Dextrin, for instance, is put to ipecacuanha, tired ginger is added to ginger, red sand wood is added to capsicum powder, and powdered bark is tampered with to make it seem like brick powder.

Other elements, including as growth circumstances, geographic origins, processing, storage, etc., also have an impact on the quality of medications. Drug quality is also impacted by degradation, which is something that raw pharmaceuticals are often prone to, particularly during post-processing stages like storage, which causes the loss of active principles and the development of inactive and sometimes even hazardous metabolites. Deterioration may also be brought on by physical elements including temperature, humidity, oxygen content, and light, either alone or in combination. Elevated temperatures and humidity cause the degradation of the herbs and changes to their physical appearance by speeding enzymatic activity. Oxidation of medication active components due to high oxygen levels often results in resignification or recodification of essential oils. The look of the plant material may alter, break down in certain situations, or even produce an odor when dried herbs are contaminated with bacterial and fungal spores, which is often followed by the formation of mold.

Drugs and Medicinal Plant Products Undergoing Quality Control

Quality control is the procedure involved in preserving the integrity and quality of produced goods. The safety and effectiveness of medications, whether they are herbal or synthetic, depend greatly on their quality control. The quality of an herbal medication is defined as the state of the drug, which is based on its composition, identification, purity, and other physical, chemical, or biological characteristics, as well as its production and storage methods. The study of historic data and methods of medication identification and quality assessment, as well as their interpretation in light of contemporary evaluations, are part of quality control for traditional medicines. Herbal medications are defined as plant components or unprocessed plant products that are transformed into pharmaceuticals by simple processing steps including harvesting, drying, and storage. Herbal drugs' quality is influenced by a number of factors, including the presence of chemically diverse plant material, the inherent complexity of these cultivars, the limitations of simple analytical techniques for identifying and characterizing bioactive constituents, and the fact that herbal drugs are mixtures of numerous constituents whose chemical nature is still unknown.

The primary processing and production of medicinal plant products or herbal drugs, as well as the requirements for an adequate quality assurance system throughout all phases of herbal drug manufacturing, from cultivation, harvesting, and primary processing to handling, storage, packaging, and distribution, directly influence the preparations of crude products. The quality of these medications is predicted to vary since these procedures are subject to variance brought on by variations in geographic location, growth, growing season length, and harvesting time. Since contamination and degradation may happen at any of these steps, it is crucial to create solid farming, harvesting, and manufacturing processes to guarantee the quality and stability of these pharmaceuticals. This will help to retain an individual herbal product's purity and potency. To fulfill the fundamental criteria of being effective and safe, all medications whether they are synthetic or of plant origin—must first pass appropriate clinical studies.

The accurate identification of the plants, whether the product is in pure form, and if the content active ingredients are within the defined limits make up the three key pharmacopoeia factors that serve as the basis for quality control in herbal medicines. In order to create quality control for herbal pharmaceuticals, the accurate identification of the plant material or raw material is essential. To determine the precise identification, both macro- and microscopic studies are utilized, and voucher specimens may be consulted as a source of reference. Markers, which by definition are chemically defined substances of interest for control reasons regardless of whether they have any therapeutic effect or not, may sometimes be utilized. The assessment of pollutants, ash values, heavy metals, afatoxins, pesticides, and other elements are of utmost significance as they are directly related to the safe use of herbal medicines.

Purity is also crucial since it deals with these issues. The kind of preparation, sensory qualities, physical constants, adulteration, pollutants, moisture content, ash content, and solvent residues must all be examined in order to demonstrate purity. To determine the consistent composition of herbal remedies, a number of advanced analytical techniques are used, including photometric analysis, high-performance liquid chromatography, thin-layer chromatography, and gas chromatography. Different ideas, such as "normalization versus standardization," must be utilized depending on whether the active components of the preparation are known or unknown in order to develop pertinent criteria for uniformity[8].

Validation is another crucial factor in the quality control of medications or goods made from medicinal plants. The primary public health issue about the use of herbal products is its validation in order to prevent or limit the sale of contaminated herbal medications, which affects both developed and developing nations. Therefore, in order to prevent the entrance of contaminated and impure versions of any herbal products with the ability to treat and lessen the severity of illness, it is crucial to verify scientific validation and conduct ongoing monitoring of their quality and efficacy. Whether an analytical method is quantitative or qualitative, validation is the process of demonstrating that it is appropriate for its intended use in pharmaceutical methods. In both cases, it involves studies on specificity, precision, accuracy, precision, range, detection, and quantitative limits.

Threats, Issues, and Strategies for Medicinal Plant Conservation and Sustainable Use

The demand for these raw materials increased as a result of the usage of plant-based goods or herbal remedies in healthcare, new dietary trends, and changing market conditions. Wild medicinal plant harvesting on a small scale, primarily for local use, and on a big scale, for commercial supply to markets throughout the world has placed these species under a lot of stress, even endangering their survival. Concern among conservationists over the worldwide danger of extinction of medicinal plants is rising. A plant species may become endangered for a variety of causes, including those that are both natural and human-made. The degradation of habitat is the most important factor leading to species extinction or moving into endangered categories since natural ecosystems are essential to the sustainable conservation of species. The introduction of invasive alien species, over-exploitation, climate change, disease outbreaks, increases in pollution levels, and fre outbreaks are some additional causes that endanger the survival of species.

Natural genetic alterations and genetic modifications brought on by humans both have a significant influence on the survival of species. Destructive harvesting methods, grazing, tilling, and swamp draining only make these challenges to species' survival worse. Additionally, owing to local prohibitions on the use of native species for medical reasons, unregulated commerce in the form of the export of the great majority of medicinal plants to industrialized nations is driving many rich medicinal plant areas to the verge of ecological and economic disaster. One of the main causes of this dilemma is the absence of regulation, either weak or nonexistent, and the lack of openness in law enforcement. Due to the rising worldwide demand for herbal pharmaceuticals as a result of the understanding of shortcomings, the non-holistic character, and side effects of holistic drugs, there has been a significant shift from the collecting of medicinal plants for satiating local requirements to commerce.

The overexploitation of wild medicinal plant populations without regard for sustainability as a result of the lure of short-term profits and inadequate regulations has placed enormous strain on the survival of medicinal plant variety. These elements have elevated the topic of medicinal plant conservation in public conversation. Thus, conservation strategies work to maintain these native plant races by detecting and assessing the use of contemporary scientific techniques. For the preservation of medicinal plants, several tactics are being used. Ex situ and in situ conservation, better and increased management of wild demes, better cultivation, public awareness campaigns, ethical and transparent trade monitoring, and national and international law and regulation are a few of them. From the perspective of the system, in situ and ex situ conservation are both parts of the broader conservation approach for medicinal plants. All other aforementioned subsystems may really be coupled tightly in reality. The plants will continue to develop and flourish in their native environments thanks to the in situ conservation technique. These metrics may be used in a variety of programs for the recovery and restoration of species.

Since the majority of medicinal plants are endemic species, the secondary metabolites that give them their medicinal properties are produced in them in response to those natural endemic environmental conditions, which involve a complex network of relationships with other species already present in the community. As a result, these metabolites may not be expressed in the same content, quality, or quantity under culture conditions. Thus, in situ conservation attempts to preserve not just native plants but whole communities as well, enhancing the connection between resource protection and sustainable usage by expanding the variety that may be preserved. Thus, in situ conservation prioritizes the creation of protected places rather than being species or ecosystem focused. Ex situ preservation works well in conjunction with in situ preservation. To assure their continuous existence and boost their density, ex situ conservation tries to cultivate and naturalize endangered, low-abundance, slow-growing, over-harvested, and disease-prone species. Ex situ methods entail cultivating and preserving medicinal plants in well-regulated ecosystems[9].

In order to secure appropriate supplies, vegetative propagules and seeds of rare and vulnerable medicinal plants are taken from the natural habitat and produced here under controlled conditions. This method relies on a fundamental comprehension of the ecological needs of medicinal plants for their preservation and maintenance, which frequently involves cultivating them in botanical gardens, herbal gardens, seed banks, gene banks, and other agro systems. It also results in the promotion and dissemination of ethno pharmacological knowledge as well as sustainable management for conservation. This is crucial for maintaining the medicinal plant resources needed to produce huge amounts of human-beneficial medications, and it is often an instant activity. Wild-growing medicinal plant species may not sustain high potency when cultivated away from their native habitats in controlled gardens, but it is possible to select and conserve their reproductive elements for future replanting.

Despite being utilized for medicinal purposes since the dawn of time, medicinal plants still have a vast untapped potential for improving human health. With changing times, the function of medicinal plants and their products has expanded dynamically and continuously. This has made it necessary to do more study on medicinal plants in an attempt to uncover potential leads from these natural compounds and create new beneficial pharmacological entities. The manufacturing of high-quality, safe, and effective goods requires close cooperation across several scientific and therapeutic fields. However, concerns like the preservation of ethnobotanical information and biodiversity must be addressed in order to reduce genetic resource loss and avoid upsetting the coexistence of plants and people, which may lead to a variety of ecological challenges. The acquired information about the cultivation and therapeutic use of medicinal plants has to be passed down to future generations and disseminated across the globe in order to make a significant contribution to human health[10], [11].

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CHAPTER 15

RESOURCES FROM MEDICINAL AND AROMATIC PLANTS

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Biodiversity, Management, and Sustainable Use Globally, medicinal and aromatic plants are becoming more and more popular as a source of raw materials for traditional medicine and pharmaceuticals. Millions of people's livelihoods are supported by the more than 85% of herbal medications that are derived from medicinal plants and utilized in conventional healthcare systems. Globally, medicinal plants are important suppliers of novel medications. 90% of the approximately 1300 medicinal plants used in Europe come from wild sources, while in the US, 118 of the top 150 prescription medications are derived from natural sources. Additionally, approximately 25% of prescription medications in affluent nations come from wild plant species, while up to 80% of people in underdeveloped countries rely on herbal medicines for their basic healthcare.

The usage of MAPs is expanding quickly all over the globe because to the rising demand for herbal medicines, natural health products, and secondary metabolites of medicinal plants. Alternative treatments provided by medicinal plants provide developing nations with significant opportunity to create jobs, revenue, and foreign currency. Several human illnesses may be prevented, lessened, or even cured with the use of several traditional healing herbs and their constituent components, which have been proved to have therapeutic efficacy. Around 80% of people in underdeveloped nations rely on traditional medicines for their main healthcare requirements, and use of herbal medications has increased in recent years. It is estimated that there are 800 billion US dollars’ worth of medicinal plants and herbal medicines sold worldwide each year.

With the continuous increase of the human population, MAP species are growing. As a consequence, the status of some high-value MAP species has been jeopardized by the uncontrolled collecting of MAPs from the wild. This result has been generally acknowledged, and it is necessary to domesticate imperiled wild species. As a result, output via cultivation may keep production consistent while easing strain on populations of wild medicinal plants. Additionally, the current strategy will stop environmental deterioration and the loss of wild genetic diversity. However, the supply of MAP species has been negatively impacted by indiscriminate collecting and overharvesting from their native habitats. In a broader sense, the national and worldwide markets are seeing an increase in demand for plant-based medications, health goods, pharmaceuticals, dietary supplements, cosmetics, etc. In order to preserve biodiversity, promote and protect the health of local populations, and produce productivity, urgent attention must be paid to the conservation and sustainable use of medicinal plants.

As a result, strategies for cultivation, sustainable harvesting, and protection from current threats need to be devised for the preservation of MAPs and improvement of local residents' standard of living in that area. In order to fulfill the international duties imposed by the biodiversity treaty, this has emerged as a top priority. As a result, MAP farming is starting to take off as a self-employment market and a viable alternative to the growing of conventional food crops. In order to assess the yield and cost-benefit analyses of grown MAP species and to equip farmers with the necessary technical skills, it was tried to promote the growing of medicinal and aromatic plants in the farmer's field. The global pharmaceutical industry's interest in bio-prospecting has been revived by customers' rising desire for herbal treatments in both developed and developing nations. But since there is no national regulation or effective international agreements on biodiversity protection and sustainable usage, there has been a significant loss of biodiversity and "slaughter harvesting" of medicinal plants. The world's most significant sources of herbal goods are medicinal plants, yet they are vanishing quickly. In order to offer a trustworthy reference for the conservation and sustainable use of medicinal plants, this chapter covers worldwide trends, developments, and prospects for the strategies and approaches for the conservation and sustainable use of MAPs resources. We stressed that for the sustainable use of medicinal plant resources, both conservation methods and resource management should be fully taken into consideration. We have also suggested using biotechnological methods to increase productivity and alter the efficacy of therapeutic plants. In order to enable policy makers at the national and international levels combine livelihood and socioeconomic development with natural resource protection, the current chapter offers a concrete example of economic potential and research on MAPs.

Diversity of Medicinal and Aromatic Plants The more general category of "medicinal and aromatic plants" includes medicinal and aromatic plants, which includes plants used for a variety of adjacent and related uses, such as meals, sauces, and cosmetics. A variety of plant-based goods are increasingly referred to as "botanicals." The largest human use of the natural world, in terms of the number of species addressed individually, is for medicinal purposes. In most medicinal traditions, plants serve as the primary source of medicine's active elements. The overall quantity of medicinal plants on Earth is not known with any degree of accuracy, and quantities and percentages vary significantly across nations and areas. Pharmaceutical and cosmetic items employ more than 10 percent of plant species. The distribution of therapeutic plants is not regular, however, and most of the time, medicinal herbs are taken from the population of wild animals. In fact, over the last several decades, the demand for animal supplies has grown by 8 to 15% annually in Europe, North America, and Asia.

The quick rise in population demand, the rise in the production of herbal pharmaceuticals, and the decline in the usage of chemical drugs have all been influenced by the toxicity and side effects of conventional and allopathic medicines. Among these applications, medicinal plants are important since they serve as both trade goods and traditional remedies that are often employed in far-off marketplaces. Today, the long-standing practice of using medicinal plants for therapeutic purposes has developed into a very lucrative industry on the global market. Many herbal products, including patented medicinal items, food additives, herbal teas, extracts, and essential oils, have been made available. A unique and priceless kind of indigenous knowledge is traditional ethno medicine; it is a cultural resource that may be utilized for the identification and preservation of priceless species as well as the ecosystems in which they exist. Traditional MAPs are defined by the World Health Organization as natural plant products utilized, at least in part, or entirely, to cure illnesses on a local or regional level. Due to its natural makeup and relative lack of side effects, traditional herbal therapy has been utilized for thousands of years in both developed and developing nations. According to the WHO, more than 80% of the world's population now relies mostly on traditional medicines made from plants for their medical needs.

Over 50% of the medications that are now on the market are thought to be derived in some way from medicinal plants. The use of phototherapy is widespread and steadily expanding around the globe. As a result, herbal medicines have become more popular as a return to nature for the treatment of illnesses and pains, bucking the worldwide trend of synthetic substances. Herbs used for medicine have come from nature. The lives of underprivileged people across the globe depend on MAPs. Even today, hundreds of millions of people, primarily in poorer nations, still rely on gathering plant and animal products for a significant portion of their livelihood. The vast majority of therapeutic plant species are exclusively employed in folk medicine. Relatively few people are employed by Traditional Scholarly Medical Systems: 500–600 people are typically employed by Traditional Chinese Medicine, 1430 by Mongolian Medicine, 110–3600 by Tibetan Medicine, 1250–1400 by Ayurveda, 342 by Unani, and 328 by Siddha. Even fewer plant species offer the active components for medicines utilized in Western medicine.

Drugs made from plants are very important in terms of the number of patients treated, despite the tiny number of source species. For human lifestyles, therapeutic plants have almost infinite worth. They significantly improve people's health. Secondary metabolites, which plants need in their natural habitats under certain circumstances of stress and competition and which may not be expressed under monoculture settings, are primarily responsible for the medicinal characteristics of plants. Fast-growing farmed stocks may have considerably lower amounts of active chemicals than slower-growing wild populations, which may be older and contain greater concentrations of active compounds. Although it is anticipated that produced plants will have some distinct qualities from those obtained from their natural environments, it is also evident that some qualities in plants may be purposefully boosted under carefully monitored cultivation settings. Over 50,000 plant species, or more than one-tenth of all plant species, are employed in the production of pharmaceuticals and other health goods. However, medicinal plants are not equally distributed over the globe. For instance, with 11,146 and 7,500 species, respectively, China and India use the most medicinal plants, followed by Colombia, South Africa, the United States, and another 16 nations. The proportion of medicinal plants to total plant species varies from 7% in Malaysia to 44% in India.

Several Factors Lead to the Exploitation of MAPs

With the expansion of human requirements, populations, and commercial commerce, there is a rising need for a broad range of wild species of MAPs. Numerous organizations are advocating for the introduction of wild species into agriculture systems as a result of the growing awareness that certain wild species are being overexploited. Given the current rate of drug discovery and development from plants, as well as the range of estimates of global plant species diversity, the current reliance of commercial drugs on plant sources is greater. They also exclude semi-synthetic and synthetic medicines based on naturally occurring compounds. They estimate the future potential for 540 to 23,490 new drugs discovered from the world's fora. The threats include habitat degradation brought on by increasing human activity, forest decline, the indiscriminate collection of exotic species that threaten native species, increased disease transmission, industrialization, overexploitation, human socioeconomic change and upheaval, changes in agricultural practices, excessive use of agrochemicals, natural and manmade disasters, genetic erosion, etc. Numerous MAPs and their wild populations are threatened by a variety of main and secondary reasons.

MAPs may be used for reasons other than producing medications, and the concerns from overharvesting may be caused, in part, by the collection for non-medical applications. Intensive and expanding commercial collecting. The weakened status of conventional regulations that have historically controlled the use of natural resources has contributed to the growing danger to MAPs. These laws have been shown to be readily overturned by contemporary socioeconomic pressures. The plant supplies for growing local, regional, and worldwide markets are mostly gathered from wild populations in increasing amounts. This is done to serve the regional and international markets.

Need of Destructive Harvesting Methods:

Because MAPs collectors lack training, about half of the material they gather is discarded. Finding sustainable methods to gather therapeutic plants from the wild is so necessary. The majority of people live below the poverty line and indiscriminately take natural resources to supplement their meager earnings. This is one of the main causes of the loss of biodiversity. Destructive harvesting methods might be another danger. Harvesting the bark by down the whole tree or gathering the fruit by chopping whole twigs may significantly harm or even kill the plant. It is damaging to harvest a plant's roots or rhizomes in and of itself.

1. **Genetic Erosion:** Genetic diversity may be lost as a consequence of over use of medicinal plant resources. This might cause issues with genetic degradation in regions with significant MAP diversity. In terms of cultivation-related elements, the loss of genetic variety may result in major issues. Conservationists are cautioned to refrain from making overstated statements in this regard since the erosion of wild plants is extremely little documented and there are very few medicinal plant species that are known to have gone extinct worldwide. Many of the dangers facing medicinal plant species are also endangering the variety of plants as a whole.
2. **Accessibility Problems:** When land is privatized or nationalized, poorer members of the community may have extra difficulties owing to a lack of access to medicinal plants. The rigid individual ownership of land and plant resources, which is replacing previous types of tenure and resource rights where poorer people may be less excluded, is a prominent trend in many developing nations today. When new kinds of conservation areas with stronger protection are created, access may be lost due to nationalization.
3. **Anthropogenic Activities:** The use of plants for food, grazing, and medicine has a significant impact on the sustainability of plant biodiversity over the long term, and certain species are at risk of becoming extinct soon due to this constant pressure. Biodiversity and anthropogenic activity are mutually exclusive. People only chose

species for their own requirements, putting pressure on uncommon species. Increased population, widespread poverty, a lack of knowledge, and inadequate education are the main socioeconomic issues contributing to the tremendous human pressures on the vegetation in the area. These factors together create competition for and overexploitation of the region's natural plant resources. The high commercial value of medicinal species may also be to blame.

The natural habitat for many herbs and trees is disappearing due to the rapidly expanding world population, rising anthropogenic activities, rapidly eroding natural ecosystems, etc. This unsustainable exploitation of Earth's biological diversity is made worse by climate change, ocean acidification, and other anthropogenic environmental impacts.

Dwindling traditional Knowledge Sources:

The understanding of MAPs, which was formerly present in tens of thousands of indigenous societies, is quickly vanishing. Every year, there is a rapid decline in human knowledge of the types, distribution, ecology, management techniques, and ways to extract medicinal plant properties. This process of local cultural diversity loss has been going on for hundreds of years. Certainly, there has been a significant increase in scientific knowledge about MAPs in recent decades, but in many ways, this growth has been underwhelming because such knowledge is frequently unavailable at the field level or is unrelated to the issues faced by land managers, collectors, or growers of medicinal plants. The knowledge-worlds of rural people who live more traditionally often include a significant amount of information about the natural world. Therefore, it is not unexpected that individuals who advocate for local and indigenous cultures may place a high priority on the revitalization of traditional medical systems; this is a tendency that has been seen around the globe.

Worldwide habitat loss and Modification

The ongoing worldwide habitat loss is a crucial component that presents a significant danger to wild populations and species. According to universal consensus, habitat loss, habitat fragmentation, overgrazing by domestic animals, burning, and unsustainable harvesting pose the most direct risks to medicinal plants across the Himalaya. Tourism, mining, and building demands are some of the most immediate local risks. Numerous Himalayan medicinal plants are under risk from climate change.

According to the Intergovernmental Panel on Climate Change, lower latitudes will see lower levels of global warming than higher elevations. However, the populations of medicinal plants in Europe or North America are similarly impacted by habitat loss and modification. Another reason that threatens their survival is the significant devastation of the plant-rich environment brought on by forest degradation, agricultural encroachment, urbanization, etc.

Genetic variety: The genetic diversity of the species that are in demand should also be taken into account. The majority of the plants employed in the phytolpharmaceutical formulations come from naturally occurring growing zones. Because of destructive harvesting methods and excessive harvesting for the manufacturing of medicines with little to no thought for the future, the genetic diversity of medicinal plants throughout the globe is being threatened at an alarming pace. Selection of preferred growth forms and concentrate on certain harvesting locations that may retain particular ecotypes would lead to a deterioration of genetic diversity in wild populations long before unsustainable harvesting techniques result in the extinction of an entire species. •

Rarity of a Species

Prior to the start of conservation activities, it is used to evaluate the danger of extinction for medicinal plants and to identify the species most at risk. It's important to know how uncommon each species is as well as how uncommon species vary from one another. Harvesting pressures may not have the same effects on all medicinal plants. Although they all have an impact on species rarity, overexploitation, indiscriminate collection, unchecked deforestation, and habitat degradation are insufficient to account for any species' vulnerability or resistance to harvest pressure. Numerous biological traits, including habitat specificity, distribution range, population size, species diversity, growth rate, and reproductive system, are associated with extinction risks.

Commercialization is both important and might be detrimental to large-scale farmers. Without it, there would be a little market for goods and no way for individuals living in rural areas to make a living. Therefore, some domestication of the product is preferred. On the other hand, if commercialization grows to the point that foreigners with the resources to invest in and create big monoculture plantations for export markets, it may be detrimental to rural residents.

Plantations may benefit rural residents by providing job opportunities and generating off-farm revenue. Plantations may, however, also manipulate the market to their benefit, for instance by enforcing low salaries that will impede the social and economic advancement of the local populace. Large-scale exports will likely mostly benefit the elite of the nation and maybe the economy. Many medicinal plants are taken from forests in order to supply the developing regional and global markets for healthcare items and the demands of expanding populations.

In situ or on-site conservation

This kind of conservation entails preserving genetic resources in their original settings, or within the environment to which they have evolved, whether as wild or domesticated crop cultivars in farmer's fields. Threat assessment, the creation of a network of medicinal plant forest reserves, the involvement of local stakeholders, botanical, ecological, trade, and ethno medical surveys, the assessment of intraspecific variability of prioritized species, the design of species recovery programs, the establishment of a medicinal plant seed center, among other operational steps, are the key steps for establishing in situ gene banks for the conservation of prioritized medicinal plants. However, no in situ gene banks have been established. The majority of MAPs are endemic species, and their therapeutic benefits are mostly due to the existence of secondary metabolites that react to stimuli in their native settings but may not manifest themselves in culture.

Natural communities and their complicated web of interactions may be preserved in situ by conserving whole communities, including indigenous species. Furthermore, in situ conservation reinforces the connection between resource protection and sustainable use by expanding the amount of variety that may be preserved. Around the globe, in situ conservation efforts have concentrated on creating protected areas and using an ecosystem-oriented strategy rather than a species-oriented one. Rules, restrictions, and the possible compliance of medicinal plants within growing habitats are necessary for successful in situ conservation.

Ex Situ Conservation:

This kind of biodiversity preservation takes place outside of the natural ecosystem, keeping the genetic diversity apart from its original site. Ex situ genetic conservation satisfies current and foreseeable social, economic, and environmental demands. Propagation and molecular diversity evaluation are also included in conservation. This involves a variety of techniques, based on elements like geographical locations, biological traits of plants, accessibility of infrastructure and network to various geographic regions, human resources, and the quantity of accessions in a particular collection. It is done specifically for medicinal plants that are in risk of extinction due to overuse and have poor development, low abundance, and high vulnerability to illnesses that affect new plants. Ex situ conservation, which is often an urgent activity to maintain medicinal plant resources, strives to nurture and naturalize vulnerable species to guarantee their continuous existence and sometimes to generate significant amounts of planting material utilized in the production of medications. In addition to maintaining high potency when cultivated in gardens distant from their original habitats, many species of once-wild medicinal plants may also have their reproductive components chosen and kept in seed banks for future replanting.

In vitro regeneration includes maintaining disease-free conditions, maintaining plant/explant development, retaining regenerative potential, maintaining genetic stability, and guaranteeing that there is no harm done to the living material. It would be extremely helpful to have in vitro multiplication techniques for various red-listed MAPs and recalcitrant taxa that are challenging to multiply by traditional methods. Compared to the in vivo approach, it provides the following benefits: The ability to sustain species for which seed preservation is impractical or inappropriate, the feasibility of disease-free travel and interchange of germplasm because cultures are kept under phytosanitary conditions, and the ability to maintain species. Even more crucial is the repatriation of in vitro raised material into their natural environment and monitoring its performance over a number of years to guarantee consistency with regard to the active ingredients or the marker chemical in comparison to the parents. Gardens with plants: It is crucial for ex situ conservation since they can keep the ecosystems healthy and help rare and threatened plant species survive. Botanic gardens offer many distinctive qualities, despite the fact that live collections often only include a small number of individuals of each species and are thus of limited utility in terms of genetic conservation. They feature a large range of plant species cultivated together under similar circumstances and often have fora with different taxonomy and ecology. Botanic gardens may contribute to the conservation of medicinal plants by creating procedures for their propagation and culture as well as running domestication and variety-breeding projects. According to the Botanical Garden Conservation International 2000 database, there are around 1846 botanic gardens worldwide.

Domestic cultivation is a common and widely accepted technique, despite the fact that medicinal plants that have been gathered from the wild are typically thought to be more effective than those that have been grown. The adoption of novel methods to address issues including hazardous components, pesticide contamination, low concentrations of active compounds, and incorrect identification of botanical origin may be accomplished via cultivation. The yields of active substances, which are nearly always secondary metabolites, may be increased by cultivation under regulated growth circumstances, and production stability is guaranteed.

Good Agricultural Practices:

GAP for medicinal plants have been formulated to regulate the production, ensure quality, and facilitate the standardization of herbal drugs. Cultivation practices are designed to provide optimal levels of water, nutrients, optional additives, and environmental factors including temperature, light, and humidity. By using the existing information to solve numerous issues, a GAP strategy provides high quality, safety, and non-polluting herbal medications. GAP include a wide range of topics, including the ecological surroundings of manufacturing facilities, germplasm, cultivation, collecting, and quality aspects of pesticide detection, macroscopic or microscopic authentication, chemical identification of bioactive chemicals, and metal element inspection. The adoption of the GAP is actively promoted by several nations. To produce regularly used herbal pharmaceuticals, for instance, in areas where such medicinal plants are customarily grown, Chinese authorities have supported GAP.

Growing in popularity is organic farming due to its capacity to develop integrated, compassionate, and enduring production methods for medicinal plants. The objectives of organic medicinal plant farming include guaranteeing the conservation and long-term use of such plants as well as creating material with improved quality and high production. The use of synthetic fertilizers, pesticides, and herbicides is prohibited by many of the North American and European organic certification standards now in effect. This is what defines organic farming. The biological processes of medicinal plants and the ecological balance of ecosystems are both maintained by organic farming, which is kind to the environment and depends on farm-derived renewable resources. The long-term growth and sustainability of medicinal plants is becoming more dependent on organic farming.

Whole some Harvesting Methods:

The wild collection is sustainable as long as the yearly, natural growth of a particular species in a specific place does not exceed the quantity of medicinal plant material obtained there each year. The species may become locally vulnerable if collection outpaces natural growth over many consecutive growing seasons. Destructive harvesting often leads to resource depletion and potentially species extinction for medicinal plants with low abundance and sluggish development. Therefore, it is important to think about how to utilize medicinal herbs sustainably and to develop effective harvesting procedures. Harvesting the roots and the whole plant does greater harm to medicinal plants than only picking the leaves, flowers, or buds. Using the leaves of the plants as a medicine may be a safe substitute for herbal medications comprised of entire plants or roots. In the case of MAPs, conservation theories and management strategies must take into account both the demands of species preservation and future supply.

Natural Reserves:

One of the main reasons for the depletion of medicinal plant resources is the deterioration and destruction of ecosystems. Natural reserves were established as protected areas for significant natural resources in order to maintain and replenish biodiversity. More than 12,700 protected areas have been created worldwide, covering 13.2 million km2 (8.81%) of the Earth's geographical area. Assessing the contributions and ecosystem functions of particular habitats is necessary to conserve medicinal plants by safeguarding important natural habitats. Due to costs and competing land uses, it is impractical to designate every natural wild plant habitat as a protected area. In a protected region, a natural habitat, or a location that is just a short distance from where the plants normally grow, a wild nursery is constructed for the species-focused cultivation and domestication of endangered medicinal plants. Natural reserves and wild nurseries are common examples of how to preserve a plant's medicinal value in its natural setting.

Cry banks for conservation:

Plant cells and meristems may be preserved using cryopreservation techniques for long-term storage of germplasm or experimental material with little upkeep. To help in the preservation of genetic resources, techniques for effectively storing apical meristems in liquid nitrogen must be developed. Germplasm is intended to be stored in cry banks. Cryogenic storage under liquid nitrogen at very low temperatures is the preferred technique for long-term preservation. Cryopreservation studies have been conducted on a variety of in vitro grown materials including meristems/shoot tips, cell suspensions, protoplasts, somatic embryos, and pollen embryos of MAPs species.

Storage of Germplasm

At low temperatures Plant tissue cultures have lately benefited from preservation by undercooling. The goal of this strategy is to keep tissues at low temperatures without ice formation. The immiscible oil is submerged in the plant tissues, creating an emulsion that may be undercooled to relatively low temperatures to avoid ice formation, one of the most harmful effects of low-temperature storage. Valuable germplasm has recently been stored via verification, simplified freezing, and encapsulation-dehydration techniques. The elimination of all or a significant portion of the cells' freezable water at room temperature or zero degrees Celsius may replace freeze-induced cell dehydration in these innovative processes.

Seed Storage Modules:

Typically, seeds are the greatest candidates for storage since they are naturally perennation plant structures that reflect embryos in a state of suspended animation. They may be kept alive at low temperatures for comparatively extended periods of time by appropriately adjusting their moisture content. Now, it is feasible to store things besides seed, such pollen, clones derived from superior genotypes or cell lines with unique characteristics, in vitro grown tissues or organs, or genetically modified material. It is advised to use seed banks to help maintain the biological and genetic variety of wild plant species since they provide a superior means of conserving the genetic diversity of many medicinal plants ex situ than via botanic gardens. The Millennium Seed Bank Project at the Royal Botanic Gardens in Britain is the most notable seed bank. Access to plant samples for a quick assessment of their characteristics is made possible by seed banks, and this knowledge is useful for preserving the surviving natural populations.

Conservation rooted in the community:

The most important level for the preservation of MAPs is the community level. Community knowledge and values should serve as the foundation for the identification of key locations for plant conservation. It might be helpful to identify priority places for improving the management of medicinal plants and to figure out how this can be done via collaborative research and planning between communities and scientists. Various community viewpoints should be taken into account when deciding how to utilize and maintain medicinal plants. Communities wishing to protect their medicinal plants may find support and direction from traditional medical associations, religious figures, and indigenous organizations. By entering into contracts that provide fair and guaranteed pricing for medicinal materials from sustainable sources, the herbal sector may help communities accomplish the conservation of medicinal plants. By entering into agreements that provide benefits in the buffer zones of protected areas or rights of sustainable use inside forest reserves, natural resource managers may help communities maintain medicinal plants. By establishing suitable policy frameworks, governments may help communities protect medicinal plants. Additionally, they are in charge of advisory services, central scientific services, education, and training. The creation of creative conservation case studies, particularly at the crucial community level, and the contribution of analysis to determine best practices are two ways that non-governmental organizations may play catalytic roles. Botanic gardens can provide local populations useful horticultural knowledge and market information. The formation of harvester organizations and the exchange of best practice horticulture knowledge amongst them should be promoted. Cultivation approaches should be transferred to farmers and other stakeholders via training efforts. Investments in training, research, capacity development, and technology transfer may also encourage the corporate sector to support environmental management.

Traditional Management Techniques:

They significantly aid in the preservation of resources, including medicinal plants. These age-old customs, which are mostly founded on cultural and religious beliefs, provide the cornerstone of biodiversity conservation and sustainable usage. Despite the fact that official conservation policies have long ignored them, literature has recognized their success. The fact that traditional management techniques exist and improve conservation suggests that the protectionist paradigm, which forbids local residents from using resources in protected regions, is sometimes unnecessary. If the usage of a natural resource is not harmful to it, there is no need to prohibit use.

Priorities and Action Plans for the future According to the Convention on Biological Diversity, traditional as well as scientific techniques play a crucial part in the systematic approach to medicinal plant conservation. The protection of endangered wild medicinal plants must be a top priority for the approach. The current situation presents a rare chance for government officials, scientists, and NGOs to collaborate, develop strategies to support the traditional healthcare system, and include rural residents in raw material conservation, cultivation, processing, and selling. To preserve the woods and alpine areas while also supplying the increasing need for herbs to help the hill people's way of life, medicinal plants should be grown. It is commonly recognized that one such possibility is the cultivation of aromatic and therapeutic plants. A plan for future requirements is currently being created. By enacting a rule that restricted or outlawed the harvesting of plants and herbs in certain areas, the legal protection of MAPs was first created in 1936.

The Forest Law and the Forest Office of the Ministry of Agriculture, Forestry, and Agrarian Reform govern the usage of medicinal plants from forest areas. The administration and oversight of the nation's natural resources in the protected areas is the responsibility of the Ministry of Environment and Waters. 3.5% of the nation's total land is under a distinct regime of protection, and 82% of the protected territory has been given nature protection status, which corresponds to IUCN categories I and II. Encouraging the usage of medicinal plants and so raising their perceived value may be an efficient way to promote conservation. Appropriate conservation methods, monitoring, and harvesting tactics by the community are highly advised to improve the conservation of medicinal plant resources in the ranch and offset their perceived loss. The fact that herbal medicines meet the healthcare requirements of nearly 80% of the world's population provides a good indication of the significance of the medicinal plant industry. The World Health Organization claims that without herbal medications, "Health for All" cannot be reached. While there is an increase in demand for herbal medicines in poor nations, there are signs that customers in wealthy nations are getting disenchanted with modern treatment and looking for alternatives.

The global pharmaceutical industry's growing interest in bio-efficient international accords on biodiversity protection has led to the "slaughter harvesting" of medicinal plants and a significant loss of biodiversity. The sustainable utilization of resources from medicinal plants does not seem promising given this tendency. Implementing the requirements on conservation and sustainable use of biodiversity and the Patents Act, 2005 properly is one of the urgent issues for protecting the variety of medicinal plants. The pool of our plant genetic resources and traditional knowledge should be adequately protected, and the flexibility provided by TRIPS rules should be completely used. Another crucial area that will play a significant role in maximizing the potential of the medicinal plant industry is capacity development. Assuring that the benefits of trade accelerate development in the poorest nations and for the poorest people is perhaps the biggest hurdle to making trade a good factor for development.

Poverty is often the basis of health issues in developing nations. In order to guarantee that all herbal medications on the market are secure, efficient, of high quality, affordable, and prescribed and used sensibly, a national policy on the use of medicinal plants for herbal medicines has to be created shortly. It is crucial that the interests of the farmers be effectively safeguarded by the availability of cutting-edge technology, services, and credit sources, as well as, most importantly, a strong marketing strategy. Effective clauses in the national policy should guarantee fair benefit distribution to all parties. This would go a long way toward meeting the country's traditional medical demands and assuring the preservation and ongoing use of its medicinal plant resources. However, to make the vision a reality, strategic measures based on study on the challenges mentioned above would be required.

It is important to remember, nevertheless, that not all therapeutic plants can be grown. Because of this, prioritizing and conservation must go hand in hand for the growth of the medicinal plant industry as a whole. We need a solid planning approach, realistic policy, and economic perspective to fully realize this sector's potential. There is an urgent need to conduct in-depth socio-economic and policy research analysis to fill the gaps in our knowledge of the dynamics of the medicinal plant industry since the evidence currently available is insufficient to adequately represent the complex challenges of this sector.

The process of managing the biosphere for the greatest benefit to the current generation while preserving its potential for the future is called conservation. MAPs-based livelihood systems are a viable source of employment and income production for underdeveloped rural areas and are often mediated by market demand. To secure a consistent and regular supply of medicinal plants for the pharmaceutical sector and to stop the depletion of the natural resource base, developing the right framework and technology for the cultivation of MAPs is essential. Farmers, merchants, scientists, and policy planners might benefit from the participatory action research framework method in the context of socio-economic development for rural populations reliant on agriculture for sustenance.

Numerous organizations are advising the introduction of wild species into agriculture systems as a result of the growing awareness that many wild MAP species are being overexploited. Loss of medicinal plants, which are regarded to be material resources, raises concerns about access to healthcare, the security of one's livelihood, and financial stability. Now the major recommendations for future research are as follows: as MAPs have vast potential, their cultivation should be promoted on barren, nonarable, and marginal lands under a participatory management action plan to improve the economy of deprived farmers; strengthening indigenous techniques of MAP cultivation should be encouraged through promoting cost-effective and appropriate rural technologies such as polyhouse, nethouse, polypit, mulching and organic farming; traditional healers, farmers and other stakeholders involved in medicinal plant sectors should be properly registered and officially recognized.

Strict implementation of laws and rules should be enacted to secure community-based traditional knowledge and intellectual property rights and to ensure equitable benefits sharing among the stakeholders; formulation of herbal products and promotion of value-added products of MAPs for possible market opportunities and better return to the farmers; farmers need to be encouraged in the promotion, protection and uses of MAPs by providing incentives and training on the latest activities, development, and policies related to MAPs; and regular backstopping should be promoted through meetings, exposure visits, and capacity building for long-term sustainability .

We are all concerned about MAPs resource conservation because we are unsure of what we are losing and what we will need in the future.

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CHAPTER 16

DISEASE-PREVENTIVE PROPERTIES OF BIOACTIVE FROM MEDICINAL AND AROMATIC PLANTS

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The term "medicinal and aromatic plants," or "MAPs," refers to plants that contain substances with medicinal and aromatic qualities that may have positive effects on human or animal bodies. Secondary metabolites, which are bioactive substances with diverse structural characteristics, are produced by these plants and include substances like alkaloids, anthocyanins, chlorogenic acids, coumarins, essential oils, favonoids, lignans, phenolic acids, resins, tannins, terpenoids, saponins, steroids, etc. Humanity has intelligently used these useful secondary metabolites in a variety of purposes. These bioactive secondary metabolites of MAPs have been employed commercially all over the globe in the beauty and fragrance business, food and beverage industry, pharmaceutical and medical sector, and isolated chemicals and plant extracts.

The identification of several new bioactive secondary metabolites with significant therapeutic potential has previously been facilitated by phytochemical investigation of different species of MAPs, making them "Chemical Goldmines" for new pharmaceutical products and uses. Despite the fact that knowledge of the therapeutic benefits of MAPs dates back thousands of years, technological advancements, the development of analytical techniques for the characterization of compounds, and the acceptance of traditional knowledge have led to a huge increase in their global popularity as consumers turn more and more toward natural and secure products. Even though synthetic pharmaceuticals are mostly employed in contemporary medicine to treat a variety of illnesses, these plants nevertheless play a significant role since they serve as the starting point for the creation of many essential medications.

Additionally, millions of individuals who live in distant and rural places, where traditional medicine is still utilized to treat severe diseases, are unable to get synthetic pharmaceuticals. As a result, MAPs serve as the foundation for several historically acknowledged medical systems, including Siddha, Unani, Siddha, and Indian Ayurveda. The plants also have the advantages of being secure, efficient, widely accessible, and inexpensive.

As was already indicated, current technological developments have enabled the isolation of several novel phytochemicals, opening up a wide range of potential applications for them in medicine. As a result, the chapter will assist in understanding the background of MAPs in traditional medicine, secondary metabolites present in MAPs, and their functions in nature, as well as a glimpse into their biosynthesis, the primary type of secondary metabolites present in MAPs, and their role in preventing disease. Last but not least, the chapter will discuss the secondary metabolites' mechanisms of action, which contribute to their disease-fighting properties [1], [2].

Maps' past and their Secondary Metabolites' Past

The list of how medicinal plants have helped humans is extensive. Additionally, written documents and historical monuments provide enough evidence of this alliance between man and medicinal plants. Without the usage of medicinal plants to cure a variety of ailments, the history of our ancestors would be incomplete, and the understanding they had has been handed down through civilizations. Human migration has resulted in the discovery of new medicinal plants. The key incidents in the history of the use of medicinal and aromatic plants.

The Function of Secondary Metabolites in MAPs in Nature

As was already noted, bioactive secondary metabolites are "chemical goldmines" since they contain an abundance of priceless molecules that may be utilized to create a variety of cosmetics, colors, pesticides, medications, fragrances, and other products. They start off as by-products or intermediates in the biosynthetic process for primary metabolites. Alkaloids, phenylpropanoids, and terpenoids, as well as cyanogenic glycosides, polyketides, and quinones, are major classes of secondary metabolites with basic structures derived from carbon and nitrogen biosynthesis; other secondary metabolites, such as alkylamides and glucosinolates, are secondary metabolites derived from fatty acid and sulfur metabolism.

Secondary Metabolites in Nature: Their Function

Albrecht Kossel first proposed the notion of secondary metabolites in 1910, for which he was given the Nobel Prize in Physiology or Medicine. However, it wasn't until almost 30 years later that Czapek came to the conclusion that these substances are the byproducts of nitrogen metabolism that are formed by "secondary modifications." In contrast to primary metabolites, secondary metabolites are not involved in any fundamental aspects of plant growth, such as development and reproduction. Instead, they play a significant part in the plant's defensive system and guard it against disease, predators, and environmental challenges (such as radiation, oxidants, etc.). By creating anthocyanins, which offer appealing color, and essential oils, which may generate enticing odors, they aid in pollination and reproduction as well. Additionally, they aid in reducing interspecies competition. Furthermore, there are 10,000 times more plant bioactive secondary metabolites than there are primary metabolites. The next section goes into depth about the main purposes of bioactive secondary metabolites in plants as shown in Figure 1[3].

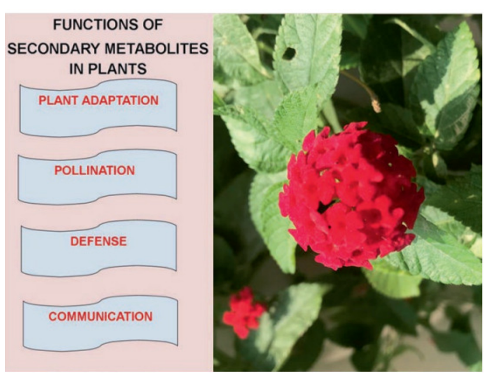

Figure 1:Illustrate the secondary metabolites function in plants.

Animal Adaptation

Around 500 years ago, terrestrial plants began to evolve. This significant step toward dominating the land needed the development of specific secondary metabolites. There were a number of issues that needed to be resolved in order to let plants grow on land, including UV radiation exposure, water deficit survival, structural support, and protection from infections and new herbivores. In order to overcome all of these drawbacks, new biosynthetic pathways were developed, such as those used by early land plants to produce phenylpropanoids to shield themselves from UV radiation and lignin in vascular plants to protect them from wind and plant-eating animals. Then, when insects began to appear on land, pteridophytes began producing cryogenic glucosides to defend themselves[4].

Pollination

Pollination is the process by which plants reproduce, and it often involves one of two methods: biotic, which uses animals like bats, birds, and insects, or abiotic, which uses environmental elements like wind and water. Plants utilize a variety of strategies to attract pollinators, such as beautiful flowers, treats, strong odors, etc., to accomplish pollination. The aforementioned characteristics, nevertheless, may potentially attract undesirable predators rather than desired pollinators. Therefore, in order to overcome these challenges, plants create specific secondary metabolites, leading to the production of irridoid glycosides in the foral nectar of Catalpa speciose. The nectar is poisonous to prospective pollinators like bumble bees and moths but edible to predators like ants thanks to these glycosides. Because secondary metabolites are present, nectar also possesses antibacterial qualities. Similar to how unripe fruits contain harmful metabolites or bitter elements to deter animals from eating them before they are fully ripe. In flowers, flavonols create nectar guides in the shape of concentric rings. These guides are supposed to aid insects in locating the location of pollen and nectar.

Protection Mechanisms

Since plants are the first trophic level in the food-energy pyramid, every creature uses plants as a source of energy, either directly or indirectly. They must thus evolve effective defensive systems in order to live against herbivores as well as to keep themselves safe from pests and microbiological assault. By making plants dangerous and unappealing, secondary metabolites play a crucial part in plant defense. For instance, cyanogenic glucosides in plants cause the creation of toxic hydrogen cyanide in response to herbivore assault[5].

Terpenes may be harmful or just inhibit or repel herbivores, insects, and animals. For example, pyrethroids found in some Chrysanthemum species flowers have an insecticidal effect. Insect repellant essential oils include limonene and peppermint oil. Lignins provide plants the physical fortitude they need to stave off herbivore attacks, but they are also virtually indigestible to herbivores. Certain plants are shielded from UV light that damages DNA by flavones and favanols, which absorb it. Due to their bitter taste, tannins serve as deterrents for herbivores. Even animals like apes, cattle, and deer avoid eating plants containing a lot of tannin. Saponins hurt herbivores by obstructing the absorption of sterol in the digestive tract, or they may destroy cell membranes if taken into the circulation.

Communication

In order to notify other or neighboring plants about dangers, illness, damage, and environmental pressures like wind, harsh weather conditions, etc., as well as to eliminate inter- or interspecies competition, plants communicate with one another. To carry out the aforementioned tasks, plants create volatile secondary metabolites. These flammable substances are carried by the air to surrounding plant species, alerting them to the threat and giving them time to fortify their defenses. Allelopathy, or the release of secondary metabolites by one plant to influence another plant, may have either a beneficial or negative impact. Allelopathic activity has been seen in phenylpropanoids and benzoic acid derivatives. Similar to ferulic acid, caffeic acid limits plant development and germination when it is present in soil.

Bioactive secondary metabolites' pharmacological potential and mode of action 80% of the world's population still relies on traditional medicine to cure a variety of diseases, according to the World Health Organization. Ancient medicine is built on bioactive secondary metabolites, and every day, 3.3 billion people in impoverished countries employ MAPs to treat common diseases. Due to their significant influence on the pharmaceutical and healthcare industries, research on bioactive secondary metabolites has risen significantly over the last 50 years. The authors have made an attempt to collect data on secondary metabolites' disease-fighting qualities over the last five years since compiling substantial data on secondary metabolites is extremely laborious[6].

Microbiological Activity

Due to antibiotics' failure to effectively combat infection-causing germs, antibiotic resistance has become a hazard on a worldwide scale. Researchers have also been compelled to find novel antimicrobial medicines with significant efficacy and fewer side effects to treat pathogenic germs due to the presence and development of new multidrug-resistant strains. Hundreds of publications have been published on the antibacterial activity of these plants and their secondary metabolites against lethal human illnesses as a result of the popularization and development of novel technologies for identifying the bioactive secondary metabolites of MAPs in recent years. In Table 4.3, a few research on the use of MAPs to the control of human and food pathogens are mentioned. Some of the secondary metabolites exhibiting antimicrobial activity are carvacrol, eugenol, linalool, linalyl acetate, menthol, citral, allicin, apigenin, quercetin, epicatechin gallate, epigallocatechin gallate, 3-O-octanoyl--catechin, 2,4,2′-trihidroxy-5′-methylchalcone, cinnamaldehyde, berberine, hermane, verbascosides, coumarin, allyl isothiocyanate, thymol, citronellol, tea tree oil, geraniol, p-cymene, piperine, curcumin, terpenine-4-ol, etc[7], [8].

Diabetes Prevention

Hyperglycemia, a frequent metabolic disease, characterizes diabetes mellitus or diabetes. It causes serious harm to blood vessels, eyes, hearts, kidneys, and nerves in chronic circumstances. Approximately 25% of the world's population has diabetes. It often occurs in two forms: type 1, or insulin-dependent diabetes, in which the pancreas produces insufficient insulin, and type 2, or non-insulindependent diabetes, in which the body loses the ability to utilise the insulin produced, further contributing to an increased blood glucose level. Type 2 diabetes is more common worldwide than type 1 diabetes. Despite the fact that there are many medications available to treat this condition, some of them have side effects include toxicity or a decline in effectiveness after prolonged use. In order to address these issues, the scientific community is always searching for new herbal medications that are simple to get, affordable, and have little side effects. About 509 plants from 140 genera have the potential to treat diabetes. The principal antidiabetic plants include Ficus elastica, Ficus hispida, Artemisia afra, Solanum viarum, Terminalia arjuna, Euphorbia hirta, Allium cepa, Mangifera indica, Phyllanthus amarus, Phyllanthus niruri, Aloe vera, Boerhaavia diffusa, Camellia sinensis, Nelumbo nucifera, Ichnocarpus frutescens, etc. These plants either act as glucosidase or amylase inhibitors. Alkaloids like berberine, boldine, neferin, lupanine, piperine, oxymatrine, sanguinarine, etc.; favonoids like catechin, baicalin, diosmin, genistein, fsetin, luteolin, kaempferol, rutin, naringenin, quercetin, etc.; triterpenoids like betulin, betulinic acid.

Human life would be unimaginable without plants. They serve as the cornerstone of contemporary medicine in addition to providing nourishment. Due to their widespread availability, cheap cost, and little side effects, they are also commonly employed for medical reasons today. Numerous novel varieties of medicinal and fragrant plants, as well as their bioactive secondary compounds, have been discovered thanks to ethno pharmacology research. Medicinal and aromatic plants' metabolites include four bioactive secondary metabolites. The study at this time is mainly concerned with how to isolate these bioactive metabolites into purified forms and utilize them as medications to treat different diseases. Although there has been a lot of study in this area, much more work has to be done to fully understand their method of action. To demonstrate the safety and effectiveness of purified secondary metabolites, clinical studies must also be conducted[9]–[11].

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CHAPTER 17

AROMATIC HERBS AND ESSENTIAL OILS DERIVED FROM MEDICINAL PLANTS

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The pharmaceutical industry is increasingly working on phytochemical extracts, therapeutic plants, and aromatic herbs in an effort to uncover lead compounds, with an emphasis primarily on suitable substitute antiviral medications. For the development and creation of new antiviral treatments, spices, herbal remedies, essential oils (EOs), and distilled natural goods provide a rich supply of components. The analysis of these natural compounds' antiviral processes has shown how they affect both virus-specific host targets and several stages of the viral life cycle, such as viral entry, replication, assembly, and discharge. There are currently no effective or licensed medications to treat CoVs, however several promising natural remedies have been suggested. Given the persistence of the 2019-nCoV outbreak, this review paper will highlight a number of powerful antiviral chemical constituents with known in vitro and in vivo effects that are extracted from medicinal and aromatic plants, natural products, and herbal medicines, as well as their structure-effect relationships.

As this study demonstrates, a variety of potentially beneficial aromatic herbs and phytochemicals, including coronaviruses, are awaiting evaluation and exploitation for therapeutic use against diverse virus families.Numerous illnesses and diseases, including cancer, are brought on by viruses. Complex conditions like type 1 diabetes and Alzheimer's disease have also been connected to viral infections. Infectious outbreaks brought on by newly developing and re-emerging organisms, such as viruses, can represent a severe threat to community health care owing to increasing international travel and fast urbanization, especially if antiviral medication and protective immunizations are not readily accessible. Only a few number of veridical compounds have been licensed for use in therapeutic settings in humans, and some viruses continue to exist despite the lack of effective vaccination[1].When coronaviruses were first discovered in chicken in 1937, they were thought to be very significant pathogenic viruses in animals that sometimes caused colds or minor gastrointestinal diseases in humans. Due to an epidemic in South-East Asia and Canada in the spring of 2003, a novel human coronavirus (CoV) gained significant notoriety. Although the suspect virus at the time did not resemble the human CoVs, it was swiftly identified as the SARS-CoV (Severe Acute Respiratory Syndrome-Coronavirus). SARS-CoV caused more than 7500 illnesses and over 700 fatalities, which alarmed the whole globe.

The development of specific anti-coronavirus vaccines and treatments did not begin until the SARS pandemic of 2002–2003.A new coronavirus has caused significant mortality linked to a contagious respiratory illness. Middle East Respiratory Syndrome Coronavirus is the name of the virus. (MERS-CoV). It was Saudi Arabia that initially reported the existence of this new MERS-CoV. In Wuhan, China, a new coronavirus with human-to-human transmission and a particularly severe disease was identified at the end of December 2019 [8]. SARS-CoV-2 was the name of the virus, and COVID-19 (short for Coronavirus Disease 2019) was the name of the illness it produces.Early on, some of the patients at the epidemic treatment facility in Wuhan, Hubei

Province (China), had some association with a large market for seafood and animals, suggesting that the disease was spread from animal to human. Following that, a growing number of cases seemed to lack access to animal markets, suggesting that the disease was spread from person to person. There are many different types of coronaviruses, which cause gastrointestinal and respiratory diseases in vertebrates. However, certain CoVs, including SARS, MERS, and SARS-CoV-2, have been demonstrated to be particularly harmful to humans. Coronaviruses are a diverse group of viruses that often infect both humans and a wide range of other mammalian species, including cattle, agricultural animals, domestic pets, and bats.

Official recognition of COVID-19 as a pandemic

The coronavirus 2019-nCoV has infected a large number of individuals in China and quickly spread to other areas. The World Health Organization (WHO) announced early recommendations and acknowledged the pandemic of 2019-nCoV as a global health problem on January 30, 2020. According to a study from China's National Health Commission, 14,488 clinical infections including 304 fatalities were discovered there on February 2, 2020.The luxury ship Diamond Princess, which is berthed in Yokohama, Japan, and the cruise ship MS Zaandam from Holland America are two international transports that are now under danger from COVID-19, according to the WHO. More than 182,000 people died as a consequence of the COVID-19 viral infection, which is now recognized as a pandemic. This coronavirus epidemic is regarded as the first coronavirus pandemic. Additionally, it is the first infectious epidemic the WHO has referred to as a pandemic since the H1N1 "swine flu" in 2009. Additionally, many European, Asian, and American nations are now each reporting more than 800,000 instances of COVID-19, which is brought on by the 2019-nCoV, which has infected more than 5,000,000 individuals globally. Of the last three weeks, there had been a 15-fold surge of COVID-19 human cases outside of China and a tripling of the number of afflicted nations. The severity of the illness and the spread of the sickness, as well as the unsettling levels of inaction and complacency shown by many global leaders in response to the pandemic, have the WHO very concerned. As a result, COVID-19 is now considered to be a pandemic. The H1N1 influenza virus affected more than 18,000 persons in more than 214 territories and countries during the last pandemic, according to the WHO[2].

The whole medical profile of COVID-19 is not yet fully understood. The severity of diseases reported has ranged from extremely small (including those with no clinical signs) to severe, including infections that may be fatal. Despite the majority of COVID-19 infections being moderate according to clinical studies to far, a new research from China shows that 16% of cases result in serious disease. Extreme COVID-19 seems to be more contagious in older people and in various age groups with major chronic medical diseases such respiratory illness, cardiovascular disease, and diabetes. Individually, taking precautions and maintaining good hygiene are still highly important, as are using socially awkward behaviors like avoiding crowded locations[3].

The epidemic is still present, thus finding novel treatments, vaccines, and preventative measures as soon as feasible is essential. As well as decreasing exposure and dispersion via social interaction and activities, efficient techniques for early identification, exclusion, and diagnosis of specific individuals are required. There is currently no known treatment for 2019-nCoV infection, despite the fact that effective immunizations and antiviral medications are the most effective ways to treat or prevent virus infections and contaminations. There is a need for identifying alternative, quick therapy or control methods since the development and manufacture of such pharmaceuticals might take many months or years.

Clinical Trials for Coronavirus Infections and Phytomedicine

Based on prior reports and evidence of SARS protection in humans, Chinese medicinal plants may offer additional solutions for COVID-19 prevention in high-risk communities. However, more time-consuming studies are needed to confirm the potential preventive impact of Chinese traditional medicine. While a Cochrane Review looking at the effectiveness of alternative therapies used during the SARS epidemic found that combining herbal and conventional medicine did not lower the mortality rate, it did find that it may improve quality of life, lower the dose of medications like corticosteroids, and reduce the likelihood of deep lung infiltration. A total of 640 SARS patients, including 12 Chinese herbs, took part in the experiment. There was no statistical proof that Chinese herbs reduced mortality more than Western medications when used with them. However, five plants improved the absorption of corticosteroids through lung penetration, four herbs reduced the need for corticosteroid dosages, three herbs improved the quality of life for SARS patients, and one herb cut the length of hospitalization.

More than 80 preclinical research projects on potential COVID-19 treatments are now being carried out in China, some of which use traditional Chinese herbal remedies. In China's database, there are over 15 trials with over 2000 estimated participants in investigations on a variety of traditional Chinese remedies. One of the biggest research is examining shuanghuanglian, a Chinese herbal medicine that contains components from the dried fruit lianqiao (Forsythiae fructus), which is said to have been used to cure illnesses for more than two thousand years. 400 patients are included in the trial, with an experimental group getting standard care as opposed to a placebo[4].

Recent studies suggest that natural remedies, including herbs and oils, may be useful in combating COVID-19. There has been research on using Indian medicines as a kind of treatment for COVID-19 symptoms. The study details the virus' chemical structure, probable mechanisms of action inside the target cells, genetic similarities to SARS and COVID-19, syndrome similarities to SARS, MERS, and the common flu, and more. Current clinical investigations, current diagnoses, and traditional Indian herbal medications that might be developed as COVID-19 therapies.

In order to assist Chinese health authorities in the management of COVID-19, SARS, and H1N1 influenza, and examined historical and clinical data on traditional Chinese remedies to prevent and cure diseases. They discovered that traditional Chinese remedies have been used since ancient times to avoid infectious outbreaks and pandemics. Three studies concentrating on Chinese medicine for the prevention of SARS were conducted as a result of these results. None of the research subjects who received herbal treatments contracted SARS. Based on those findings, 23 Chinese provinces have published COVID-19 preventive programs that make use of suitable Chinese medicine-based herbal remedies:

Radix astragali, or Astragalus membranaceus (Fisch.), dried root. Astragalus mongholicus and Bunge. The active ingredients of Bunge (Fabaceae), a well-known traditional Chinese medicine, may strengthen the immune system and reduce inflammation. In hospitals, astragalus is sometimes also given as an injectable. One of the 50 significant plants used in phytomedicine is radix glycyrrhizae, or liquorice root (dry roots and rhizomes of Glycyrrhiza glabra). The only species in the genus Saposhnikovia is Radix saposhnikoviae, also known as Saposhnikovia divaricate and known in Chinese as fángfng, which means "defend against the wind."

The rhizome of Atractylodis macrocephalae is acclaimed as "the most important Qi herb" (vital energy in Chinese medicine) because it tones and strengthens the spleen. It is the dried rhizome of any adjacent plant, such as Japonica atractylodes, or Atractylodes lancea (Thunb.), Atractylodes chinensis Koidz.A member of the Caprifoliaceae family, Lonicera japonica Flos is one of the most often used herbal remedies. Golden Bell (Fructus forsythia) has long been regarded as a cure-all for patients who are particularly susceptible to skin infection. It contains bioactive components such as caffeic acid derivatives, essential oils (EOs), flavonoids, iridoid glycosides, and terpenoids and has anti-inflammatory, antimicrobial, anticancer, antioxidant, and immune-modulating properties. The plant has shown modest inhibition of leptospira, the influenza virus, and other viruses in addition to broad-spectrum antibacterial action. Additionally, the herb has antipyretic and anti-inflammatory qualities.

According to reports, China has successfully treated SARS in a number of patients using traditional Chinese medicinal plants and fragrant herbs. However, there hasn't been much evidence to support the therapeutic effectiveness of these therapies in COVID-19 patients. In one research, antiretroviral treatment had previously been administered to 135 COVID-19 patients in a prior clinical trial. Additionally, 59 patients got antimicrobial therapy, and 36 patients received anti-inflammatory medication. Comparatively, 124 patients received care from practitioners of Chinese traditional medicine[5], [6].

Glycyrrhiza (G. glabra), ephedra (Ephedra sinica), bitter almond (Prunus dulcis var. amara), gypsum, reed root (Phragmites communis), Amomum, and Trichosanthes (family Cucurbitaceae) were the main Chinese herbs used to treat COVID-19, and their main effects were to relieve cough and boost immunity. In light of the significant role that Kaletra® and traditional Chinese medicinal plants play in the treatment of viral pneumonia, this study recommended that patients receive Kaletra®, a combination of the antiviral medications lopinavir and ritonavir, very early in the course of their illness. Patients should also receive treatment from both Western and Chinese medicines. To understand and traditional Chinese medicinal herbs cure COVID-19, further scientific investigation is needed.

In order to enhance the treatment of patients with coronavirus infection, it is vital to keep developing efficient antiviral chemotherapeutics that are economical, have few side effects, and may also be used in conjunction with other medications. Eliminating these viral infections is difficult and troublesome since there aren't any active antiviral medications or protective immunizations for treating a number of viruses. The development of novel antivirals with novel structure-activity correlations and effective medical and therapeutic treatments against viral infections, however, depends heavily on the biodiversity found in natural products[7], [8].

The ability of a virus to quickly evolve during replication, as demonstrated with HIV and HSV, oseltamivir-resistant influenza viruses, and acyclovir- and nucleoside/nucleotide analog-resistant hepatitis B viruses, is a major issue with antiviral medications that target particular viral proteins or genes. When evaluating the antiviral efficacy of herbal medicine formulations, there are a number of factors to consider, such as the extraction methods used as acetone extracts or methanol fractions have the strongest antiviral activity. Therefore, it is appropriate to specify the correct methodology for extract preparation, the parts of the plants to be used, the appropriate season(s) for material collection, and the specifics of the application modality at the outset of a prospective study on aromatic herbal medicines.

It is recommended that more research be done on the identification of active substances, the description of underlying mechanisms, as well as the analysis of effectiveness and likely in vivo applications, in order to aid in the exploration of potent antiviral chemotherapeutics, even though the majority of research studies in this field are still in their early stages. In order to reduce the risk of infection from drug-resistant virus strains, further study should look at the possibilities of combining these therapies with additional natural substances or with conventional drugs. We believe that natural therapies will continue to contribute significantly to the progress of anti-coronavirus medications, including aromatic herbs, essential oils made from medicinal plants, and pure oil compounds. Even while certain viral illnesses can be controlled with life-prolonging drugs, most people cannot afford them, many viral infections are still fatal and/or untreatable. The creation of safe, efficient, and affordable antiviral compounds is therefore one of the most important and urgent areas of pharmacological research on a global scale[9]–[11].

So, in order to determine if aromatic herbs and ethnomedicinal plants may be used as antiviral medications, scientists and researchers from many medical professions are examining them. The past 50 years have seen extensive study on ethnopharmacology and phytomedicine that led to the discovery of natural antivirals. Numerous conventionally used medicinal and aromatic plants have been said to possess robust and strong antiviral effects. Aqueous, organic, and volatile oils have all generally shown comparable effective qualities.It would seem logical to presume that these goods include various kinds of antiviral components given the considerable number of conventional medicinal plants that have had positive results. Identifying secondary metabolites will show further health advantages. As a result, it is justified that several traditional remedies are often used to prevent viral infections. In the end, it will be crucial to find and create novel antiviral medications from therapeutic plants and herbs to manage the dangers posed by certain pathogenic viruses, such the 2019-nCoV.

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CHAPTER 18

THE BACKGROUND AND RELEVANCE OF MEDICINAL PLANTS AND HERBS

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The phrase "medicinal plant" refers to several different plant species utilized in herbalism. (herbology or herbal medicine). It involves both the study of and use of plants for therapeutic reasons. The Latin word "herb" and the ancient French word here are the origins of the term "herb." Today, the term "herb" is used to describe any component of the plant, including the fruit, seed, stem, bark, flower, leaf, stigma, or root of a non-woody plant. Before, only non-woody plants, such as those that derive from trees and bushes, were referred to as "herbs." These healing plants are also used in certain types of spiritual practices, as well as in food, flavonoids, medication, and perfume. Long before the ancient era, people employed plants for medical reasons. Chinese texts, Egyptian papyrus, and ancient Unani scrolls all discussed the usage of plants.

There is evidence that around 4000 years ago, Unani Hakims, Indian Vaids, and civilizations from the Mediterranean and Europe used plants as medicine. Herbs were employed in healing rituals by indigenous societies in Rome, Egypt, Iran, Africa, and America, while other cultures formed traditional medical systems like Unani, Ayurveda, and Chinese Medicine that systematically utilised herbal remedies. Traditional medical systems are still used extensively on many fronts. The use of plant materials as a source of medicines for a wide range of human ailments has received more attention as a result of factors including population growth, insufficient drug supply, prohibitive cost of treatments, side effects of several synthetic drugs, and development of resistance to currently used drugs for infectious diseases[1].

India has a reputation as one of the oldest civilizations with a vast storehouse of medicinal herbs. India's forests are the main source of a huge variety of aromatic and medicinal plants that are mostly harvested as raw materials for the production of pharmaceuticals and perfumery goods. In India's AYUSH systems, some 8,000 herbal treatments have been codified. The four main systems of indigenous medicine are Ayurveda, Unani, Siddha, and Folk (tribal) remedies. Ayurveda and Unani medicine are the most advanced and popular systems in India. According to recent estimates from the World Health Organization (WHO), 80% of people worldwide depend on herbal remedies for some part of their basic medical requirements. Around 21,000 plant species have the potential to be utilized as medical plants, according to the WHO.

According to information now available, more than 75 percent of the world's population depends mostly on plants and plant extracts for their medical requirements. More than 30% of all plant species have been used medicinally at some point. According to estimates, plant-based medications account for up to 25% of all pharmaceuticals used in industrialized nations like the United States, while they account for up to 80% of all drugs consumed in rapidly growing nations like India and China. As a result, nations like India place a considerably greater value on medicinal plants economically than the rest of the globe. The health care system for the rural population depends on indigenous systems of medicine, and these nations contribute two thirds of the plants utilized in contemporary medicine.

Relevance and Purpose A global "herbal renaissance" is taking place as herbs make a return. In contrast to synthetics, which are seen as being hazardous to both humans and the environment, herbal products now stand for safety. Although herbs have been valued for their therapeutic, flavorful, and aromatic properties for millennia, the modern era's synthetic goods temporarily overshadowed their significance. The mindless reliance on synthetics has ended, however, and people are going back to natural products in the hopes of finding safety and security. Even less is known about what plants are considered fragrant. The adjective aromatic refers to plants that have an aroma, are fragrant, or have a pleasant scent, while the term aroma is meant to also reflect the taste of the substance. (Aromatic herbs).

Spice plants are used to season, spice, flavor, and color meals, beverages, and other food processing sector goods, therefore enhancing their taste. We also often refer to essential oil plants, which store oils in certain organs or plant sections that are later utilized to create essential (ethereal) oils. It is hard to create tight classifications or a useful classification for medicinal and aromatic plants because of the complexity and overlap in the usage of the active substances as well as the large number of plant species involved. Spice, medicine, and essential oil crops include anise, dill, coriander, thyme, and others. Because of this, their unique characteristics are usually ignored and these plants are simply referred to as medicinal plants. The phrase "Medicinal and Aromatic Plants" (2167-0412s) has lately been employed in a somewhat wider connotation to denote the category of medicinal plants that include fragrant (aromatic, ethereal) compounds. Since the use of plants for healing dates likely back to the emergence of Homo sapiens, the natural world has been a source of therapeutic agents for thousands of years. Approximately 80% of the world's population still primarily relies on conventional medicines for their basic healthcare, with the other 20% being heavily reliant on medicinal plants.

A remarkable number of contemporary medications have also been isolated from natural plant species, in part because of their usage in conventional medicine. Surprisingly, this unique group of plants that has been with humans throughout history still lacks a true description. The most common definition of medicinal plants is that they are wild and/or cultivated plants that, according to folklore and written accounts, may be utilized for medical reasons either directly or indirectly. This usage is justified by the fact that these plants contain so-called active elements, also known as active principles or biologically active principles, which have an impact on the physiological (metabolic) functions of living things, including humans. It has been well documented that most developing nations employ traditional medicine and medicinal plants as a normative foundation for the preservation of good health. The extraction and development of several medicines and chemotherapeutics from these plants as well as from conventionally used rural herbal treatments have been linked to an increase in dependence on the usage of medicinal plants in industrialized cultures. Moreover, due to the rising expenses of maintaining one's own health, herbal treatments have gained popularity in these civilizations for the treatment of minor illnesses. In fact, there is a significant danger that many medicinal plants now in use may either become extinct or lose their genetic variety due to commercial and public demand, which has been so high. As the availability of medicinal plants decreases, effective resource management and conservation measures that are based on a thorough understanding of the surrounding medicinal plant usage must be developed. Many discoveries on medicinal and health-promoting plants inspire individuals to go "back to nature" [2].

People need to learn more about natural medicine as the usage of herbal medicines rises. Additionally, we aim to encourage individuals to utilize herbal remedies and learn about its benefits and drawbacks on both the human body and the environment. Research on aromatic and therapeutic plants is expanding quickly. Clinical and preclinical testing are essential parts of the study of medicinal plants. Preclinical testing of plants for medicinal characteristics is crucial in order to authenticate their historical use by herbalists and traditional healers as well as to offer a scientific foundation for their use. This process also gives society access to novel, safe, and effective medicine sources. Plant-based remedies from the kitchen you may find medicinal and aromatic plants wherever, even in the kitchen and the wild. When spice is used in a dish, there are a lot of undiscovered advantages for the consumer.

Garlic, or Alium sativum, has been shown by certain studies to have anti-cancer properties. The Alium cepa or onion is beneficial to human health since it boosts the immune system. Additionally, spices are healthy for the body's immune system, blood circulation, and digestion. People may get the most out of the active compounds in such spices with the proper care. This may help you avoid a lot of ailments. The global magazine Medicinal and Aromatic Plants examines all facets of the development of medicinal crops, medical applications for plants, their active components, and allied companies. This magazine encourages the multidisciplinary sharing of information and ideas in the cultivation of medicinal plants and associated fields[3].

The use of medicinal herbs is seen to be quite safe since there are seldom any negative side effects. The major benefit is that these treatments work in harmony with nature. The usage of herbal remedies may benefit people of all ages and genders, which is a key fact. The ancient academics simply thought that plants were treatments for many illnesses and health issues. To get to precise conclusions on the effectiveness of various plants with therapeutic potential, they carried out detailed research on the subject and tested. The majority of the medications created in this way don't have any negative effects or responses. This is the reason why herbal medicine is becoming more and more well-liked worldwide. These medicinal plants provide logical solutions for the treatment of several interior disorders that are otherwise thought to be challenging to cure. Aloe, Tulsi, Neem, Turmeric, and Ginger are examples of medicinal plants that treat a variety of common illnesses. In many regions of the nation, they are regarded as natural treatments.

It is a well-known fact that many customers use basil (also known as tulsi) in their daily lives for Pooja, preparing medications, black tea, and other activities. Many different plants are used across the globe to honor rulers, serving as a lucky charm. Many patients began planting tulsi and other medicinal plants in their backyard gardens as a result of discovering the use of herbs in healing. The creation of pharmacopoeia, non-pharmacopoeia, or synthetic medications has long relied on the utilization of medicinal plants as a rich supply of components. Aside from that, these plants are essential to the growth of human civilizations all across the globe. Additionally, certain plants are advised for their medicinal benefits since they are regarded as vital sources of nourishment. These plants include ones that produce ginger, green tea, walnuts, aloe, pepper, turmeric, and others. Some plants and the derivatives of those plants are regarded as significant sources of the active chemicals utilized in products like aspirin and toothpaste. Herbs are used for a variety of other things than medicine, such as natural coloring, pest control, food, perfume, tea, and more. Many nations employ various medical plants and herbs to deter ants, flies, mice, and other pests from entering homes and workplaces. Today, medicinal plants play a significant role in the production of pharmaceuticals.

The traditional medicine practitioners provide extremely powerful recipes for treating common illnesses including diarrhoea, constipation, hypertension, low sperm count, dysentery, weak penile erection, piles, coated tongue, menstrual problems, bronchial asthma, leucorrhoea, and fevers. Although the use of herbal medicine has significantly increased over the last 20 years, there is still a dearth of research data in this area. As a result, three volumes of WHO monographs on certain medicinal plants have been issued by WHO since 1999.

The significance of particular plants and their therapeutic properties

To treat wounds, sores, and boils, people use herbs such black pepper, cinnamon, myrrh, aloe, red clover, sandalwood, ginseng, burdock, bayberry, and safflower. Important medicinal herbs that may be grown in a kitchen garden include basil, fennel, chives, cilantro, apple mint, thyme, golden oregano, variegated lemon balm, rosemary, and variegated sage. These herbs are simple to cultivate, beautiful, delicious, and fragrant, and many of them attract bees and butterflies.

By removing the metabolic poisons, several herbs are utilized as blood purifiers to improve or modify a chronic illness. These are sometimes referred to as "blood cleansers." A person's immunity is increased by certain herbs, which lessens illnesses like fever. Some plants also function as antibiotics. The development of bacteria, dangerous organisms, and germs may be inhibited by turmeric. A popular home treatment for cuts and wounds is turmeric. Certain antipyretic plants, including chirayta, black pepper, sandalwood, and safflower, are suggested by traditional Indian medicine practitioners to suppress fever and the generation of heat brought on by the condition[4].

In addition to being scented, cinnamon and sandalwood work well as astringents. In particular, sandalwood is used to stop the outflow of blood, mucous, etc. Some herbs are used to balance the stomach's acid production. Herbs like the root and leaves of the marshmallow. Antacids are what they do. Such herbs preserve the healthy stomach acid required for successful digestion. Indian sages were renowned for having plant medicines that counteract animal poisons and snake stings.

Herbs with savory characteristics include cardamom and coriander. The flavor of the cuisine is improved by the use of other fragrant herbs like peppermint, cloves, and turmeric. Aloe, sandalwood, turmeric, sheetraj hindi, and khare khasak are a few plants with a lot of medical potential that are often used as antiseptics. Certain cough syrups include ginger and cloves. They are well-known for having expectorant properties that encourage the thinning and ejection of mucus from the lungs, trachea, and bronchi. Cloves, wild cherry, cardamom, and eucalyptus are further expectorants.

Herbs that serve to promote healthy blood circulation include chamomile, calemus, ajwain, basil, cardamom, chrysanthemum, coriander, fennel, peppermint, and spearmint, as well as cinnamon, ginger, and turmeric. They are employed as heart stimulants as a result. Some therapeutic plants contain disinfection properties that kill disease-causing microorganisms. Additionally, they prevent the spread of dangerous bacteria that cause contagious illnesses. Herbalists advise using calming herbs since they have a calming impact on the body. They're often used as sedatives.

Aloe, Golden seal, Barberry, and Chirayata are a few fragrant plants that are utilized as gentle tonics. These plants' bitter flavor helps to lower blood toxin levels. They also aid in the eradication of infection. Herbs like Cayenne (Lal Mirch, Myrrh, Camphor, and Guggul) are used as stimulants to boost the activity of a system or an organ. Many different herbs are used as tonics, including giloe, golden seal, aloe, and barberry. They may also be nourishing and revive both healthy and sick people. An open wound or new cut may be efficiently treated with honey, turmeric, marshmallow, and licorice. These plants are known as vulnerary herbs[5], [6].

We are going farther distant from nature as our way of life becomes more technologically advanced. Despite the fact that we are a part of nature, we cannot escape it. Herbs are natural items, thus they have no negative side effects and are also relatively safe, environmentally friendly, and locally accessible. Many plants are traditionally used to treat illnesses associated with certain seasons. To save lives of people, they must be promoted. Currently, these herbal treatments stand in stark contrast to synthetic pharmaceuticals, which are stigmatized as being dangerous to both humans and the environment. Although herbs have been valued for their therapeutic, flavoring, and aromatic properties for millennia, the modern era's synthetic goods temporarily overshadowed their significance. The mindless reliance on synthetics has ended, however, and people are going back to natural products in the hopes of finding safety and security. It's time to advertise them worldwide.

Associated Questionnaire

1. What are the causes of the depletion of wild populations of medicinal plants species?
2. What can be done to ensure the effective conservation of medicinal plant species?
3. Explain how in situ and ex situ conservation methods are used to maintain MAPs.
4. What is in-situ conservation and give some examples?
5. What is ex-situ conservation and how it is useful for medicinal and aromatic plant conservation?
6. Write a detailed note of the in-situ and ex-situ conservation of MAPs?
7. What is a protected area? How many protected areas are there in the state of Uttarakhand and give an example of noteworthy medicinal and aromatic plant conservation?[7]–[9]
8. Write 10 medicinal and aromatic plant species name which are Prioritized species for conservation?
9. How can germplasm collection help in the MAPs conservation?

10. What are the major centers of India that involve in the MAPs conservation and research?

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