ISSN: 0975-833X

Available online at http://www.journalcra.com

International Journal of Current Research

Vol. 16, Issue, 11, pp.30702-30727, November, 2024
DOI: https://doi.org/10.24941/ijcr.48075.11.2024

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

REVIEW ARTICLE

ORIGIN, TAXONOMY, BOTANICAL DESCRIPTION, GENETICS AND CYTOGENETICS, GENETIC DIVERSITY, BREEDING AND CULTIVATION OF MINT

***K.R.M. Swamy**

Retd. Principal Scientist & Head, Division of Vegetable Crops, ICAR-Indian institute of Horticultural Research, Bangalore-560089

ARTICLE INFO

Article History:
Received 14th August, 2024
Received in revised form
27th September, 2024
Accepted 20th October, 2024
Published online 30th November, 2024

Key Words:

Mint, Origin, Taxonomy, Botanical Description, Genetic Diversity, Breeding.

****Corresponding author:***
K.R.M. Swamy

ABSTRACT

Mint belongs to the family Lamiaceae, Subfamil Nepetoideae, Tribe Mentheae, genius *Mentha* and species *Mentha spicata* L. English name is Mint. The aromatic plant gets its name from the Greek mythological figure, Minthe, a nymph who is believed to have transformed into the fragrant plant after an affair with the god of the underworld, Pluto. The word "mint" descends from the Latin word *mentha* or *menta*, which is rooted in the Greek words *mintha*, *minthē* or *mintē* meaning "spearmint". The plant was personified in Greek mythology as Minthe, a nymph who was beloved by Hades and was transformed into a mint plant by either Persephone or Demeter. This, in turn, ultimately derived from a proto-Indo-European root that is also the origin of the Sanskrit *-mantha, mathana* (*premna serratifolia*). References to "mint leaves", without a qualifier like "peppermint" or "apple mint", generally refer to spearmint leaves. In Spain and Central and South America, mint is known as *menta*. In Lusophone countries, especially in Portugal, mint species are popularly known as *hortelã*. In many Indo-Aryan languages, it is called *pudīna*. The taxonomic family Lamiaceae is known as the mint family. It includes many other aromatic herbs, including most of the more common cooking herbs, such as basil, rosemary, sage, oregano, and catnip. As an English colloquial term, any small mint-flavored confectionery item can be called a mint. In common usage, other plants with fragrant leaves may be called "mint", although they are not in the mint family. ndian names of Mint are Pudina Patta (Hindi), Puthina/Pudhinaa (Tamil), Pudina (Telugu), Pudina (Kannada), Pudina (Marathi), Hara Pudina (Punjabi), Fudino/ Phodina (Gujarati), Putiyina/Pudhinaa (Malayalam), Pudyanu (Kashmiri), Pudina (Bengali), Pudina (Punjabi), Pudina (Urdu), Pudina, Putiha (Sanskrit). *Mentha* is an industrial crop that is widely cultivated for its essential oil, the major constituent of which is l-menthol, a monocyclic monoterpenic alcohol. The essential oil, menthol and other chemical constituents of *Mentha* are used for a variety of purposes in the food, perfumery and pharmaceutical industries. Japan started commercial production of mint around 1870 AD. During that time, the product was called Japanese mint and Japan was the only commercial producer. After the Second World War, Brazil started producing mint commercially as it was found in the country's forests. Later on, the production of mint spread to other South American countries. The cultivation of mint also began in other countries such as China and India in around 1960. Initially, India was an importer of menthol but, after the green revolution in 1986, mint took off as an agricultural commodity. Later developments and improvements have made the cultivation of mint more economical. There are several varieties of mints which include different species, hybrids and special selections that are grown all over the world. In this review article on Origin, Taxonomy, Botanical Description, Genetic Diversity, Breeding and Cultivation of Mint are discussed.

Citation: K.R.M. Swamy. 2024. "Origin, Taxonomy, Botanical Description, Genetics and Cytogenetics, Genetic Diversity, Breeding and Cultivation of Mint*". International Journal of Current Research*, 16, (11), 30702-30727.

INTRODUCTION

Mint belongs to the family Lamiaceae, Subfamil Nepetoideae, Tribe Mentheae, genius *Mentha* and species *Mentha spicata* L. (Ahmad *et al.,* 2020; Davuniversity, 2024; Wikipedia, 2024). English name is Mint (Kumar, 2024). The aromatic plant gets its name from the Greek mythological figure, Minthe, a nymph who is believed to have transformed into the fragrant plant after an affair with the god of the underworld, Pluto (Mishra, 2023). The name Mentha is derived from Classical Greek mythology, from Minthe, (Minthê), who was a beautiful Cocythian (river nymph) beloved by Hades (Pluto) god of the

underworld. Minthe was metamorphosed into dust by Hades's wife, Demeter, but Hades caused the fragrant mint plant to grow from the dust. The etymology of "mint" is from the old English minte (= mint plant), which is derived from Proto-Germanic, through Latin from the Ancient Greek, and is akin to old Norse. At the base of Mt. Minthe, there was a temple dedicated to Hades and a grove for Demeter (Ovid Met. 10) Near Pylos, Greece, Mt. Minthe is thought to be a location of the origin of triploid sterile spearmint (2n = 3x = 36), which likely arose from the introgression of the conspecific endemic ancient amphidiploid Mentha spicata (2n = 4x = 48) and the diploid M. longifolia (2n = 2x = 24) (Vining *et al*., 2020). The word "mint" descends from the Latin word *mentha* or *menta*, which is rooted in the Greek words *mintha*, *minthē* or *mintē* meaning "spearmint". The plant was personified in Greek mythology as Minthe, a nymph who was beloved by Hades and was transformed into a mint plant by either Persephone or Demeter. This, in turn, ultimately derived from a proto-Indo-European root that is also the origin of the Sanskrit - *mantha, mathana* (*premna serratifolia*). References to "mint leaves", without a qualifier like "peppermint" or "apple mint", generally refer to spearmint leaves. In Spain and Central and South America, mint is known as *menta*. In Lusophone countries, especially in Portugal, mint species are popularly known as *hortelã*. In many Indo-Aryan languages, it is called *pudīna*. The taxonomic family Lamiaceae is known as the mint family. It includes many other aromatic herbs, including most of the more common cooking herbs, such as basil, rosemary, sage, oregano, and catnip. As an English colloquial term, any small mint-flavored confectionery item can be called a mint. In common usage, other plants with fragrant leaves may be called "mint", although they are not in the mint family (Wikipedia, 2024).

Indian names of Mint are Pudina Patta (Hindi), Puthina/Pudhinaa (Tamil), Pudina (Telugu), Pudina (Kannada), Pudina (Marathi), Hara Pudina (Punjabi), Fudino/ Phodina (Gujarati), Putiyina/Pudhinaa (Malayalam), Pudyanu (Kashmiri), Pudina (Bengali), Pudina (Punjabi), Pudina (Urdu), Pudina, Putiha (Sanskrit) (Patel, 2022; Vikaspedia, 2023; Niftem, 2024).

Common names and cultivars (Wikipedia, 2024).

There are hundreds of common English names for species and cultivars of *Mentha*. These include

- Apple mint - *Mentha suaveolens* and *Mentha* × *rotundifolia*
- Banana mint - *Mentha arvensis* 'Banana'
- Bowles mint - *Mentha villosa* and *Mentha* × *villosa* 'Alopecuroides'
- Canada mint - *Mentha canadensis*
- Chocolate mint - *Mentha* × *piperita* 'Chocolate'
- Corsican mint - *Mentha requienii*
- Cuba mint - *Mentha* × *villosa*
- Curly mint - *Mentha spicata* 'Curly'
- Eau de Cologne mint - *Mentha* × *piperita* 'Citrata'
- Field mint - *Mentha arvensis*
- Flea mint - *Mentha requienii*
- Ginger mint - *Mentha* × *gracilis*
- Gray mint - *Mentha longifolia*
- Green mint - *Mentha spicata*
- Grey mint - *Mentha longifolia*
- Japanese peppermint - *Mentha arvensis* var. *piperascens*
- Japanese mint or Japanese medicine mint - *Mentha spicata* 'Abura'
- Kiwi mint - *Mentha cunninghamii*
- Lemon mint - *Mentha* × *piperita* var. *citrata* and *Mentha* × *gentilis*
- Marsh mint - *Mentha aquatica*
- Meadow mint - *Mentha* × *gracilis* and *Mentha arvensis*
- Mojito mint - *Mentha spicata* 'Mojito'
- Moroccan mint - *Mentha spicata var. crispa* 'Moroccan' and mints collected in Morocco
- Pennyroyal - *Mentha pulegium*
- Peppermint - *Mentha* × *piperita* and sometimes *Mentha requienii*
- Pineapple mint - *Mentha suaveolens* 'Variegata' and *Mentha suaveolens* 'Pineapple'
- Polemint - *Mentha pulegium*
- Red raripila mint - *Mentha* × *wirtgeniana*
- Round leaf mint - *Mentha suaveolens*
- Spearmint - *Mentha spicata*
- Strawberry mint - *Mentha* × *piperita* 'Strawberry'
- Swiss mint - *Mentha* × *piperita* 'Swiss'
- Tall mint - *Mentha* × *wirtgeniana*
- Tea mint - *Mentha* × *verticillata*
- Toothmint - *Mentha* × *smithiana*
- Water mint - *Mentha aquatica*
- Woolly mint - *Mentha* × *rotundifolia*

Mint leaves create a cool sensation in the mouth. Toothpaste, mouthwash, breath mints, and chewing gum are all commonly flavored with mint. In addition to freshening breath, mint adds flavor to foods and drinks – everything from ice cream and tarts to lemonade and cocktails to meat dishes (especially lamb). There are many varieties of the mint plant, and most fall under the genus mentha. Because mint plants spread quickly, gardeners tend to grow them in containers. When planted directly into the ground, they can become invasive and take over a garden (WebMD, 2023). Mint leaves can make tea or an essential oil. Mint grows natively on all continents except Antarctica. Peppermint and spearmint are likely the most commonly used mint varieties, but many others exist, such as wild mint and water mint. Some plants referred to as "mint" also fall under the genus monarda. Both mentha and monarda genuses are within the same family, called Lamiaceae. Monarda mints include horsemint, catmint, and stonemint. All varieties of mint leaves may be used fresh, in dried herb form, brewed as a tea, or concentrated in an essential oil (WebMD, 2023).

Mint has a long history, possibly originating in Europe and the Mediterranean, where it was regarded as the symbol of hospitality, and proliferated from there to most other parts of the world. The name is believed to have been derived from a Greek legend of the nymph Minthe, who attracted the attention of Hades. Hades' wife, the jealous Persephone, attacked Minthe and was in the process of trampling her to death, when Hades turned her into the herb. The Romans brought mint and mint sauce to Britain; they strewed mints in feasts and banquets as a token of welcome to their guests. Mint was then taken to the USA by the pilgrims aboard the Mayflower. In Asia, the Japanese had distilled peppermint oil for several centuries and the oil was used to produce menthol. Early descriptions and analyses of the menthol in mint were carried out in the nineteenth century (Taneja and Chandra, 2012). *Mentha* is an industrial crop that is widely cultivated for its essential oil, the major constituent of which is l-menthol, a monocyclic monoterpenic alcohol.The essential oil, menthol and other chemical constituents of *Mentha* are used for a variety of purposes in the food, perfumery and pharmaceutical industries. Japan started commercial production of mint around 1870 AD. During that time, the product was called Japanese mint and Japan was the only commercial producer. After the Second World War, Brazil started producing mint commercially as it was found in the country's forests. Later on, the production of mint spread to other South American countries. The cultivation of mint also began in other countries such as China and India in around 1960. Initially, India was an importer of menthol but, after the green revolution in 1986, mint took off as an agricultural commodity (Taneja and Chandra, 2012). Later developments and improvements have made the cultivation of mint more economical. There are several varieties of mints which include different species, hybrids and special selections that are grown all over the world. While the species that make up the *Mentha* genus are widely distributed and can be found in many environments, most *Mentha* species grow best in tropical/subtropical conditions and in moist soils. Due to their tendency to spread unchecked, mints are considered invasive (Taneja and Chandra, 2012).

Menthol mint (*Mentha arvensis* L.) is a genus of about 25 species of the family *Lamiaceae* is widely used in the food, flavourings, pharmaceutical and cosmetic industries. In addition to being a popular flavouring for food, confectionery and cigarettes, natural menthol has a cooling, soothing effect on the skin and mucous membranes of the human body, making it a useful ingredient in pharmaceuticals and cosmetics. Worldwide, approximately 10,000 tonnes of natural menthol and 2000 tonnes of synthetic menthol are used by the pharmaceutical, cosmetic and cigarette industries every year. Until about 15 years ago, the bulk of the world's corm mint came from Brazil and China. China and India subsequently overtook Brazil and, more recently, India has led the world in the production of this useful plant and its products (Lal, 2013). An adaptable and stable cultivar usually refers to a cultivar's ability to perform consistently, across a wide range of years/environments . Several biometrical methods including univariate and multivariate ones have been developed to assess stability. Among them the most widely used are the regression coefficient the environmental variance. More recently, the AMMI stability value (ASV) based on the AMMI (Additive Main Effects and Multiplicative interactions) model's PCA1 and PCA2 scores for each cultivar/cultivar Purchase. This AVS is in effects the distance from the coordinate point to the origin in a two dimensional scatter gram of PCA 1 scores against PCA 2 scores (Lal, 2013). For testing a number of cultivars of menthol mint crop in a number of years the multi-year yield trials are the most important experiments in mint breeding programme. Accordingly, effective model of statistical analysis related to multi-year trials can help plant breeders to make faster genetic improvement in a number of statistical models. Among them AMMI model was found very powerful model for the above purpose. The practical interest of combining high levels of mean yield and yield stability has led to the development of the yield reliability concept, where a reliable cultivar is characterized by consistently high yield of essential oil across the years/environments. The use of a yield reliability index facilitates, cultivar selection or recommendation, as the mean yield and the yield stability are combined into a unique measure of genotype merit (Lal, 2013). Studies of cultivar by environment interactions (G × E) and stability have been reported very meagre on mint crop. However, no stability and reliability studies have been performed for menthol mint cultivars and tested together in a multiyear essential oil yield trial. The objectives of present study were to evaluate the essential oil yield of ten commercial cultivars namely, Kosi, Kushal, Saksham, Kalaka, MAS-1, Himalaya, CIMAP-Saryu, Sambhaw, Damroo and Gomti of menthol mint (*M. arvensis* L) released by CSIR-CIMAP, Lucknow (India), for commercial cultivation in different years in India and to determine their stability and reliability for cultivar recommendations (Lal, 2013).

Mint is a herbaceous plant of the family Lamiaceae. It is distributed worldwide. The herb as a whole, its essential oils, or major chemical constituents are used for their flavor in various types of foods, confectionary, food preservatives, and antimicrobial agents to control the food-borne pathogens besides their usage in cosmetics and healthcare (Prakash *et al.,* 2016). Gas chromatography and gas chromatography–mass spectrometry analysis of mint essential oil revealed the presence of mono- and sesquiterpenoides (Prakash *et al.,* 2016). The major constituents of mint oil are menthol, carveol, carvone, piperitone, piperitone oxide, menthone/isomenthone, dihydrocarvone, menthyl acetate, linalool, 1,8-cineol, limonene, α-humulene, δ-cadinol, etc. as well as other minor constituents. Some of these compounds are used as food preservatives and flavor because of their antifungal, antibacterial, and sprout suppressant activity. Mint oil thus can be a good source of natural antioxidants, to prevent the food

material from pathogenic organisms, and inhibiting sprouting in stored food like potato (Prakash *et al*., 2016). *Mentha* essential oils or their active ingredients can be used as an encapsulated product with matrices over long periods of time using controlled release of aroma to reduce the fast evaporation during storage and application (Prakash *et al.,* 2016).

Australia, South Africa and North America (Sania Kabir *et al*., 2017). Classification of genus Mentha is complicated due to elevated incidence of polyploidy, wide range in the morphology and numeral variation in chromosomes, recurrent inter-specific hybridization and vegetative spread. Natural inter-specific hybridization occurs with high frequency both in cultivated and wild population of Mentha. Several cytological, morphological, chemical and molecular markers have been reported to reveal relationship among Mentha species (Sania Kabir *et al*., 2017). The most common species of the genus Mentha found in Pakistan are *M. pulegium, M. arvensis, M. spicata, M. longifolia, M. piperita* and *M. rolyana*. Although, some cultivars of Mentha have been domesticated but no attempt has been made to analyze variability among different populations of this plant. Information on genetic variation of the available germplasm is fundamental to its domestication, improvement and management. This could also provide information on the evolving process and distribution of the germplasm in different isolated regions (Sania Kabir *et al*., 2017). An understanding of the extent and organization of genetic diversity among Mentha species could be useful for both its genetic improvement and conservation. It is difficult to distinguish phenotypically similar cultivars using morphological and physiological methods or isozyme analyses (Sania Kabir *et al.,* 2017). The limitation of these analyses is that they are phenotypic based and affected by environment. The development of Polymerase Chain Reaction (PCR) technique has revolutionized the field of molecular biology. Molecular markers offer the best estimate of genetic diversity since they are independent of the confounding effects of environmental features (Sania Kabir *et al*., 2017). The DNA fingerprinting technique of Randomly Amplified Polymorphic DNA (RAPD) provides an unlimited number of markers which can be used for various purposes (Sania Kabir *et al.,* 2017). RAPD markers can be generated using short arbitrary primers to amplify genomic DNA, giving a genotype-specific pattern of bands. RAPD markers are the most widely used molecular technique for DNA fingerprinting. The RAPD technique has become an increasingly popular tool in genetic studies (Sania Kabir *et al*., 2017). Mentha species have been assessed for genetic relationship and cultivar identification by using RAPD markers. Present study was undertaken to have an estimate of genetic diversity among local and exotic germplasm of mint collected and maintained at Plant Genetic Resources Institute (PGRI), National Agriculture Research Center (NARC), Islamabad. RAPD markers were employed to figure out the relatedness of germplasm (Sania Kabir *et al*., 2017).

The millennia of human effort involved in the domestication of economically important agricultural and horticultural crops is documented and broadly discussed among plant evolutionary biologists (Darwin, 1859; Darlington, 1963; Zohary, 1969; Zohary, 1984; Zohary, 2004). Plant domestication, the genetic modification of a wild form to create an altered plant to meet human needs, has produced many plants incapable of existing in the wild (Doebley *et al*., 2006). This "domestication syndrome" (Hammer, 1984) involves a combination of traits that are different from those of the wild progenitors. These domesticated plants may have larger fruit or grains, robust growth habits, loss of sexual fertility, loss of bitterness, or synchronous flowering. These plants may not compete successfully in the natural world (Vining *et al*., 2020). Seed propagated agronomic crops, many of which display domestication syndrome, have undergone stabilizing selection to protect fertility. Grain crops have rigid protection for sexual reproduction with streamlined development of flowers, fruits, and seed. Chromosomes behave normally at meiosis and deviants do not survive to reproduce. Chromosomes are balanced with little pollen or seed sterility. In contrast, clonally propagated fruit crops, which also display domestication syndrome, not only tolerate but also promote the reduction of pollen and seed fertility and lower chromosome stability. Parthenocarpy, unequal ploidy levels, aneuploids, and other innovative mass production solutions reduce seed set without reducing fruit production. At the next level, crops maintained by clonal propagation and grown for their non-reproductive organs have the most drastic disruptions to their flowering and fruiting systems. This group demonstrates bizarre chromosomal segregation and unusual ploidy levels. Mint species are an exemplar of this category (Vining *et al.,* 2020). Multiple species of mint have been used for medicinal purposes by humanity from prehistory. From savory herbs produced in monasteries to single-family needs of the kitchen garden, commercial peppermint production for menthol, and essential oil extraction from other mint species, mints represent a significant global economic commodity (Vining *et al.,* 2020). The objectives of this manuscript are to describe the domestication of mint and its uses to humanity. Trait and genotype examples and a summary of the preservation of Mentha genetic resources and global genebank operations will be presented. Present breeding improvements and future possibilities considering future genetic analysis will be projected (Vining *et al*., 2020).

Mentha is a strongly scented herb of the Lamiaceae (formerly Labiatae) and includes about 30 species and hybrid species that are distributed or introduced throughout the globe (Vining *et al.,* 2020). These fragrant plants have been selected throughout millennia for use by humans as herbs, spices, and pharmaceutical needs. The distilling of essential oils from mint began in Japan and England but has become a significant industrial product for the US, China, India, and other countries (Vining *et al*., 2020). The US Department of Agriculture (USDA), Agricultural Research Service, National Clonal Germplasm Repository (NCGR) maintains a mint genebank in Corvallis, Oregon. This facility preserves and distributes about 450 clones representing 34 taxa, hybrid species, advanced breeder selections, and F1 hybrids (Vining *et al*., 2020). The majority of mint accessions and hybrids in this collection were initially donated in the 1970s by the A.M. Todd Company, located in Kalamazoo, Michigan. Other representatives of diverse mint taxa and crop wild relatives have since been obtained from collaborators in Australia, New Zealand, Europe, and Vietnam (Vining *et al*., 2020). These mints have been evaluated for cytology, oil components, Verticillium wilt resistance, and key morphological characters (Vining *et al*., 2020). Evaluation and characterization includes essential oil content, disease resistance, male sterility, and other traits for potential breeding use. These accessions can be a source for parental genes for enhancement efforts to produce hybrids, or for breeding new cultivars for agricultural production (Vining *et al*., 2020). Propagules of Mentha are available for distribution to international researchers as stem cuttings, rhizome cuttings, or seed, which can be requested

through the GRIN-Global database of the US National Plant Germplasm System, subject to international treaty and quarantine regulations (Vining *et al.,* 2020).

Among different essential oils produced in India today, *Mentha arvensis* (menthol mint) oil holds prominent position in terms of acreage under the crop production and domestic consumption and export to the world market. Today India is the largest producer and exporter of natural menthol in the world. The annual turnover of the menthol industry has been in the range of ` 3,500–4,000 crore during the past one decade (Suryavansh *et al.*, 2021). Menthol mint is presently cultivated in more than 2.50 lakh hectares land of North India. It is believed that over 5 lakh farming families grow menthol mint crop contributing 75–80% global menthol mint oil produce. Uttar Pradesh contributes about 70–75% of the total national production of menthol mint oil (Suryavansh *et al*., 2021). Menthol mint yields 130–150 kg mint oil/ha (single harvest) giving a net profit in the range of ` 60–70,000 in about 3 and a half months. Taking the lesson of success of menthol mint cultivation from the farmers of UP, the area under mint is now spreading to other states in the country including Bihar, parts of Punjab. CSIR, in its efforts to improve the socioeconomic status of people in the country who are at the bottom of the pyramid of life, is focusing to bring S&T interventions in the areas of health, agriculture, and energy, resulting in equitable and inclusive growth (Suryavansh *et al.,* 2021). One such classic example of the proper utilization of a CSIR technology for the economic empowerment of rural India is the cultivation of superior varieties of mint, commonly called *Pudina.* India today dominates the world market contributing about 80% (30,000 tons) of menthol mint in various forms – Menthol crystals and powder, demontholised mint oil, and arvensis oil. Mint cultivation occupies 300,000 ha across the country (Suryavansh *et al.,* 2021). Over 90 % of the mint cultivated area is covered by CSIR developed varieties. Continuous development and deployment of improved high-oil yielding, short duration, location-specific varieties and related agrotechnologies is a part of CSIR success stories in promoting Mint cultivation. Further value-addition has taken place through improved distillation process and products. Most importantly, CSIR, with its mint production enhancement technologies has generated employment to the extent of 648 lakh man days in the farms and 162 lakh man days in the industry (Suryavansh *et al*., 2021).

Plants possess thousands of bioactive compounds, which are nontoxic and largely effective substitutes with an almost negligible negative consequence. A lot of physiological beneficial activity of these bioactive compounds has been observed, for instance, antimicrobial, antineoplastic, antioxidant, hypoglycemic, analgesic, antidiarrheal as well as wound care properties. These plants contain natural products, which are present in pure form and in a combined form that can be obtained by extraction. The chemical diversity of such plants cannot be matched with others so there are boundless opportunities. As a result of greater demand for chemical diversity in the selection process, in search of natural produce, awareness has increased regarding eatable floras globally. Medicinal uses of herbal plants have increased because of various types of bioactive compounds. These bioactive compounds help in the treatment of various types of diseases (Wani *et al*., 2022). Due to the development of negative effects and microbial resistance to the drugs which are synthesized chemically, experts turned to ethnopharmacognosy. These phytochemicals are not only safe but also effective replacements with negligible side effects. There are thousands of plants in this world with health benefits. It should be our priority to introduce such plants to all so that the advantages of such plants can be experienced by one and all. In the present review paper, our main aim was to highlight the chemical constituents and main health benefits of the mint plant (Wani *et al*., 2022). The genus Mentha L. (Lamiaceae) can be found globally and also in many environments. Mentha commonly called Mint is a collection of about 15–25 plant species. Because of its medicinal value, there is a huge demand in both the food and pharmaceutical industries. In our day-to-day life, mint is used for its flavoring and health beneficial properties. Presently, it is one of the most economically significant medicinal and aromatic crops. Mint is the richest source of antioxidants, as quantified by various antioxidant activity tests. Extract of mint possesses good total phenolic and flavonoid contents (Wani *et al.,* 2022). The Mentheae tribe of Nepetoideae subfamily belongs to the Lamiaceae family. In the 65 genera of tribe Mentheae, more than 3000 names of genus Mentha have been published and most of them are illegitimate names. Their taxonomy is challenging because the nature of hybridization of the genus is easy. Hybrid seeds yield variable offspring; they can multiply by vegetative propagation. This variability has come with an outbreak of species and subspecific taxa. During 1911–1916 in Central Europe, one taxonomist published 434 new mint taxa. Fresh sources identify between 18 and 25 species (Wani *et al.,* 2022).

The mythological tale about *Minthē* is relevant for our purposes, even though it has been claimed to be a recent creation instead of going as far back as the mythological time of the Mediterranean World. It is not attested in an early or archaic source, but in a classical one: the *Geography* by the historian and geographer Strabo (Touwaide and Appetiti, 2023). In his study of Greece, Strabo comes to the Peloponnese, in the south-west part of which is Pylos, capital of the kingdom of Nestor, a hero of the Greek expedition against Troy. Strabo briefly tells the following mythological story, which relates the genesis of Mint, the plant, from the transformation of a human (Touwaide and Appetiti, 2023). Near Pylos, towards the east, is a mountain named after Minthē, who, according to myth, was loved by Hadēs. She was trampled underfoot by Korē and transformed into garden-mint, the plant which some call *Hēdyosmos*. Furthermore, near the mountain, is a precinct sacred to Hadēs. This plain is fertile; it borders on the sea (Touwaide and Appetiti, 2023). Going beyond the anecdotical nature of the tale—whether it is an expression of the mythological thinking or a recent creation, all its elements are significant as they reveal a natural history of Mint translated into mythology as the history of a transformation. Minthē was a Nymphē, a young girl symbol of nature, freshness, and water. And of long-life. Minthē, specifically, was seduced by Hadēs, the king of the Underworld. Korē, Hadēs's wife, most commonly known as Persephonē, probably caught them by surprise, crushed Minthē under her foot, and transformed her into the plant that bears her name. Significantly enough, the region is fertile, close to the sea, with high humidity. To this, Strabo adds another name of Mint, *hēdyosmos*, which means literally with a sweet smell (Touwaide and Appetiti, 2023). We thus have here the genesis of a plant expressed in a mini-history inserted in a broader geographical description as a cameo, which relates the coming to being of a plant in a typically Mediterranean place, mountainous, yet fertile and possibly moist, with such qualities as freshness and longevity, the latter being particularly expressed by the opposition to the world of the death from which Persephonē saved Minthē by subtracting

her from her husband. Interestingly—and apparently contradictorily—Persephonē also is a goddess of fertility. She protected the young Nymphē from her husband, not only because of her jealousy, but possibly also by solidarity within the female world. Whatever the motivation, this component of the story clearly hints at a plant that escapes death, that is, a plant that is particularly resistant. This is particularly the case of *Mentha* species, which might grow excessively and become invasive, being almost weeds (Touwaide and Appetiti, 2023). Although the story stopped here, with the transformation of Minthē into a plant, it was not over. In the rituals of Persephonēs' cult, representing and celebrating the yearly cycle of natural life with alternances of lethargy (Winter), growth (Spring), production (Summer), and preparation for the next year (Autumn), Minthē was present in a certain way, as Mint was mixed in the beverage that the participants in the Eleusinin Mysteries shared in the ritual, the *kukeōn* (cyceon). Translating again the ancient tale in botanical terms, Mint is associated with the Spring and the growth of cereals, to which it adds a note of freshness and sweetness (Touwaide and Appetiti, 2023).

Future R&D initiatives must be strengthened in light of establishing biotechnological tools and comprehending secondary metabolic pathways to build designer chemotypes of mint that can generate desirable essential oil components for commercial exploitation. There is a need to find chemotypes with metabolic blockages in essential oil production pathways that can accumulate specific essential oil components not generally found in the wild through ongoing breeding efforts and research of wild mint germplasm (Gupta *et al.,* 2023). To help traditional marginal farmers succeed economically, cultivars resistant to biotic and abiotic stresses might be introduced in newer agro-climatic zones. While better comprehending the biological actions of essential oil components, a new area for investigating new applications of essential oils needs to be explored (Gupta *et al.,* 2023). Menthol mint cultivars are grown on more than 200,000 ha in Indian states, producing 25,000–28,00 tonnes of essential oil annually (Gupta *et al.,* 2023). Mints, including different species, hybrids, and high-yielding varieties, are grown worldwide (Gupta *et al.,* 2023). Mint species contain antioxidants, phenols, anthraquinones, tannins, other phytochemicals, and essential oil. However, China, Japan, North Korea, India, Paraguay, Thailand, Taiwan, and Vietnam are the most significant producers and exporters of menthol mint, followed by the United States, India, and China (Gupta *et al*., 2023). Owing to the crop's rich medicinal and aromatic properties and the significant demand for essential oil and its value-added products on a national and worldwide scale, the later developments and advancements of the mint crop are currently more cost-effective. The market for mint oil and its related products is expected to grow by 3–5% annually while further research is needed to develop genetic advancements (Gupta *et al.,* 2023). In this review article on Origin, Taxonomy, Botanical Description, Genetic Diversity, Breeding and Cultivation of Mint are discussed.

ORIGIN AND DISTRIBUTION

Mint of Mentha dates back to Greek mythology where it was grown across expanses of land fields.3 In Greek mythology, Menthe was a nymph loved by Pluto, God of the Underworld. Proserpine, Pluto's first love, was so jealous of the beautiful nymph that she morphed her into a plant so she would be trampled upon in the pathways of mortals on earth (Mint, 2008). Today, the most popular types of mint are peppermint and spearmint. They are found growing commercially most commonly in southern California, Michigan, northern Indiana, the Pacific Northwest as well as in Europe and other areas commonly along stream banks or in waste lands with damp soil. Michigan is the most popular production location of peppermint oil in the United States (Mint, 2008). The Lamiaceae family includes the perennial aromatic herb genus *Mentha*, primarily in temperate and sub-temperate climates. Mint has a long history, possibly originating in Europe and the Mediterranean. It was regarded as the symbol of hospitality and proliferated from there to most other parts of the world. The nymph Minthe, who caught Hades' attention in a Greek fable, is the name's source. The envious Persephone, Hades' wife, attacked Minthe and was about to crush her to death when Hades (Gupta *et al*., 2023). All *Mentha* species and natural hybrids include essential oils. Some of these taxa have been used historically for more than 2000 years due to their aromatic qualities. Today, all continents, except Antarctica, are home to *Mentha* taxa, whether native or naturalized (Gupta *et al*., 2023). The cultivation of Japanese or corn mint originated from Brazil and China. Subsequently, China and India overtook Brazil and more recently India has taken the leading position in cultivation of this essential oil yielding plant (NHB, 2024). Mint is a *perennial plant* which grows in moist soils. Coming from the *Lamiaceae* family, it has small bluish-white, mauve, pink or lilac flowers. It propagates by *pollination* (method of reproduction of flowering plants, mainly thanks to insects such as bees), but also through *rhizomes***,** the horizontal root-type structure containing food reserves. These rhizomes grow underground, with stems appearing above ground at regular intervals. The name 'mint' is thought to come from Greek mythology, more precisely from a nymph named Minthe who was transformed into a plant (Alimentarium, 2024). Among the mints, Japanese mint is cultivated on a large scale in Brazil, Paraguay, China and India. Peppermint is grown in USA, Morocco, Argentina, Australia and on a small scale in many European countries. USA is the major producer of peppermint and spearmint. In India, the total area under mint cultivation, which is mostly confined to Uttar Pradesh and the Punjab is around 10,000 ha (Davuniversity, 2024). *Mentha*, also known as mint (from Greek *míntha*, Linear B *mita*), is a genus of flowering plants in the mint family, Lamiaceae. It is estimated that 13 to 24 species exist, but the exact distinction between species is unclear. Hybridization occurs naturally where some species' ranges overlap. Many hybrids and cultivars are known. The genus has a subcosmopolitan distribution, growing best in wet environments and moist soils (Wikipedia, 2024).

TAXONOMY

Mentha is a strongly scented herb genus of the Lamiaceae (formerly Labiatae) and includes 18 species, 31 subspecies or botanical varieties, and 11 recognized hybrid species. The mint family includes diverse additional aromatic genera, such as mountain mint (Pycnanthemum L.), lavender (Lavendula L.), sage (Salvia L.), rosemary (Rosmarinus L.), and oregano (Origanum L.), which are grown commercially for essential oils that are distilled from leaves and stems. Mint shoots and leaves are used for medicinal and aromatic purposes, such as dried organic extracts, distillates, condiments, and food flavorings. Likewise, Mentha includes many

commercially valuable species, including peppermint (*Mentha ×piperita*), Scotch spearmint (M. ×gracilis), native spearmint (*M. spicata*), American wild mint (*M. canadensis*), and corn mint (M. arvensis), which are cultivated in different parts of the world for their culinary and medicinal properties. Plants in this genus are herbaceous, rhizomatous, perennial, and aromatic, with smooth, wide-spreading underground stems, which are square in cross-section. The leaves are arranged in opposite pairs, and the white, pink, or purple flowers are produced in clusters (Vining *et al*., 2020). Since the time of Linneaus, more than 3,000 specific epithets have been reported for Mentha. As a measure of mint species taxonomic diversity, the Global Biodiversity Information Facility (GBIF) network includes more than 740,000 locality data points from 454 Mentha taxa with occurrences throughout the world. The plethora of names and occurrences of hybrid and naturalized mints have created confusion in the literature. Wild species of mint hybridize readily, and over evolutionary time, native hybrid-species swarms developed in conspecific regions. Subsequently, minor variances have achieved species rank. The Plants of the World database describes 39 taxa including, 24 species and 15 hybrid species (Vining *et al*., 2020). The *Mentha* genus is a member of the commercially significant and medicinally useful Mentheae tribe, as well as the mint family Lamiaceae, subfamily Nepetoideae. As a result, precise *Mentha* species identification requires molecular identification. Because of the complexity and ambiguity of the classification of the genus *Mentha*, this research is the first time carried out in the Hazara region in Khyber Pakhtunkhwa, Pakistan. The goal of the most recent study was to verify the accuracy of the morphological and molecular parameters of *M. arvensis, M. royleana, M. spicata, M. piperita***,** and *M. longfolia***.** Applying the molecular markers *mat K,* genetic variations in five specimens of Mentha were examined. Gene-specific primers were utilized throughout the DNA amplification process. Consensus sequences were produced from each Mentha specimen using Bio Edit software by meticulously sequencing the PCR data. By BLAST examination of consensus nucleotide sequences for each *Mentha* species and every query sample indicated similarity to gene bank sequences. The determined species of the genus *Mentha* are organically different according to the NCBI analysis, nucleotide diversity, nucleotide discrimination, haplotype diversity, and phylogenic analysis through MEGA software. All *Mentha* species have a total haplotype diversity of 0.9989 with a nucleotide diversity of 0.01379. Nucleotide sequences of *Mentha* species were correlated for phylogenetic analysis, and the neighbor-joining tree and Maximum Parsimony were constructed. Neighbor-joining trees and maximum parsimony verified that these species are authentic. Additionally, this investigation solved a slight problem in the identification of flora in the field of botany (Siddique *et al*., 2024).

Mentha is a genus belonging to the family of Lamiaceae, whose plants are among the most aromatic and spread in diverse environments worldwide, having simple, characteristic leaves with pleasant scent. *Mentha* taxonomy is highly complicated and includes about 42 species and 15 hybrids, with hundreds of subspecies and cultivars (Tafrihi *et al*., 2021). Eleven naturally occurring hybrids have been produced from the species *M. arvensis* L., *M. aquatica* L., *M. spicata* L., *M. longifolia* L., and *M. suaveolens* Ehrh; most hybrids are infertile but can propagate due to their highly invasive rhizome. Plants of this genus are perennial and are used for essential oil production, mainly in USA, India, China, and Iran. Fresh and dried plant materials of *Mentha* species are widely used in industry as part of confectionaries, flavor enhancing agents, pharmaceuticals, cosmetics (Tafrihi *et al*., 2021). Some *Mentha* species are given in Table 1 (Tafrihi *et al*., 2021).

Table 1. Scientific names *Mentha* species

Scientific Name
M. aquatica L.
M. piperita 'Lavendula'
M. arvensis L.
M. canadensis L.
M. longifolia L.
M. piperita L.
M. piperita f. citrate
M. pulegium
M. spicata L.
M. suaveolens
M. suaveolens 'Variegata'
*M. x piperita*f. *citrate* 'Chocolate'
M. *suaveolens* × *piperita*

Mint belong to the family Lamiaceae Lindl. (Labiatae Juss.) which is one of the highly diversified angiosperm family of the world. It contains 7852 species under 250 genera which are distributed worldwide but mostly in the Mediterranean, Irano–Turanian, and Eastern Asiatic regions . Lamiaceae are characterized as herbs or shrubs, often aromatic with ethereal oils, with usually four-sided stems, opposite or whorled leaves, a verticillaster, or thyrse inflorescence (flower solitary and axillary in some), and zygomorphic (rarely actinomorphic), usually bilabiate flowers having a superior ovary, often deeply four-lobed by formation of false septum with a gynobasic style. The fruit is a schizocarp of usually four nutlets or a berry or drupe. Lamiaceae is represented by 72 genera and 435 species in India and is ranked ninth among the largest families; with 60 genera and 225 species in West Himalaya; 42 genera and 110 species in Himachal Pradesh; 49 genera and 143 species in Uttarakhand state, and is ranked the seventh largest family. The family has clear affinity for cooler climate thus have higher diversity in the Himalaya in general and West Himalaya in particular. Uttarakhand state contains high diversity of Lamiaceae members as nearly one-third of the species of the whole of India are found in the state. The family Lamiaceae contains large number of economically important medicinal, culinary herbs, fragrance plants, food plants, and a large number of cultivated ornamental plants. Mint is one of the important economic plants of the family which are aromatic and used variously. The genus *Mentha* L. contains around 38 accepted species worldwide mainly concentrated in the Europe and West Asia (Prakash *et al.,* 2016) (Table 2).

Table 2. List of *Mentha* Species in the World

S. N.	*Mentha* Species	S. N.	*Mentha* Species	S. N.	*Mentha* Species
1.	*Mentha alaica* Boriss.	2.	*Mentha aquatica* L.	3.	*Mentha arvensis* L.
4.	*Mentha australis* R. Br.	5.	*Mentha canadensis* L.	6.	*Mentha carinthiaca* Host
7.	*Mentha cervina* L.	8.	*Mentha cunninghamii* (Benth.) Benth.	9.	*Mentha dahurica* Fisch. ex Benth.
10.	*Mentha dalmatica* Tausch	11.	*Mentha darvasica* Boriss.	12.	*Mentha diemenica* Spreng.
13.	*Mentha dumetorum* Schult.	14.	*Mentha gattefossei* Maire	15.	*Mentha gayeri* Trautm.
16.	*Mentha gentilis* L.	17.	*Mentha grandiflora* Benth.	18.	*Mentha japonica* (Miq.) Makino
19.	*Mentha kuemmerlei* Trautm.	20.	*Mentha laxiflora* Benth.	21.	*Mentha locyana* Borbás
22.	*Mentha longifolia* L.	23.	*Mentha maximilianea* F.W. Schultz	24.	*Mentha micrantha* (Fisch. ex Benth.) Heinr.Braun
25.	*Mentha pamiroalaica* Boriss.	26.	*Mentha piperita* L.	27.	*Mentha pulegium* L.
28.	*Mentha pyramidalis* ten.	29.	*Mentha requienii* Benth.	30.	*Mentha rotundifolia* (L.) Huds.
31.	*Mentha royleana* Wall. ex Benth.	32.	*Mentha saturejoides* R. Br.	33.	*Mentha smithiana* R.A. Graham
34.	*Mentha spicata* L.	35.	*Mentha suaveolens* Ehrh.	36.	*Mentha verticillata* L.
37.	*Mentha villosa* Huds.	38.	*Mentha villosa-nervata* Opiz		

Mentha species are strongly aromatic perennial, often rhizomatous or stoloniferous herbs. Upper leaves are sessile or subsessile; blade margin dentate, serrate, or crenate. Floral leaves are similar to stem leaves or reduced; bracts lanceolate to linear, more or less distinct. Flowers appear in many flowered (two to six) verticellasters in axillary or terminal spikes. Flowers are small, bisexual, variously shaped, and, unlike most other members of the family, are actinomorphic. Calyx are campanulate or tubular, five-toothed, regular or two-lipped, 10–13 nerved. Corolla four-lobed, funnelform, regular, or slightly irregular. There are four stamens, equal, divaricate, erect, exserted in bisexual flowers, filaments glabrous, two anther cells, parallel; pollen six-colpate, subprolate, tegillate. Style exserted, equally two-cleft at apex. Nutlets smooth or reticulate (Prakash *et al.*, 2016). The genus *Mentha* is represented by six species in India of which four species, *Mentha arvensis* L., *Mentha longifolia* (L.) Huds., *Mentha piperita* L., and *Mentha spicata* L. are common in Uttarakhand. Among these *M. longifolia* (Horse mint) is exclusively temperate wild specie with considerable variation in morphology and three varieties of it *M. longifolia* (L.) Huds. var *longifolia*, *M. longifolia* var. *incana* (Willd.) Dinsm., *M. longifolia* var. *royleana* (Benth.) Hook.f. are known between 1200 and 3200 m altitude range in Uttarakhand. *Mentha arvensis* (corn mint), *M. piperita* (Peppermint), and *M. spicata* (Spearmint) are commonly cultivated up to 2500 m altitude as pot herbs, or sometimes occur in a semiwild state. All *Mentha* species have been known to the natives for a long time and are called *Podina* in Uttarakhand. These species are commonly used to provide flavoring and coolant, in sauces, and are medicinally used in indigestion, vomiting, malarial fever, or as culinary herbs (Prakash *et al.,* 2016). Mentha is a member of the tribe Mentha in the subfamily Nepetoideae. The tribe contains about 65 genera, and relationships within it remain obscure. Authors have disagreed on the circumscription of Mentha. For example, *M. cervina* has been placed in Pulegium and Preslia, and *M. cunninghamii* has been placed in Micromeria. In 2004, a molecular phylogenetic study indicated that both *M. cervina* and *M. cunninghamii* should be included in Mentha. However, *M. cunninghamii* was excluded in a 2007 treatment of the genus. More than 3,000 names have been published in the genus Mentha, at ranks from species to forms, the majority of which are regarded as synonyms or illegitimate names. The taxonomy of the genus is made difficult because many species hybridize readily, or are themselves derived from possibly ancient hybridization events. Seeds from hybrids give rise to variable offspring, which may spread through vegetative propagation. The variability has led to what has been described as "paroxysms of species and subspecific taxa"; for example, one taxonomist published 434 new mint taxa for central Europe alone between 1911 and 1916. Recent sources recognize between 18 and 24 species (Vikaspedia, 2023).

Mentha is a member of the tribe Mentheae in the subfamily Nepetoideae. The tribe contains about 65 genera, and relationships within it remain obscure. Authors have disagreed on the circumscription of *Mentha*. For example, *M. cervina* has been placed in *Pulegium* and *Preslia*, and *M. cunninghamii* has been placed in *Micromeria*. In 2004, a molecular phylogenetic study indicated that both *M. cervina* and *M. cunninghamii* should be included in *Mentha*. However, *M. cunninghamii* was excluded in a 2007 treatment of the genus. More than 3,000 names have been published in the genus *Mentha*, at ranks from species to forms, the majority of which are regarded as synonyms or illegitimate names. The taxonomy of the genus is made difficult because many species hybridize readily, or are themselves derived from possibly ancient hybridization events. Seeds from hybrids give rise to variable offspring, which may spread through vegetative propagation. The variability has led to what has been described as "paroxysms of species and subspecific taxa"; for example, one taxonomist published 434 new mint taxa for central Europe alone between 1911 and 1916. Recent sources recognize between 18 and 24 species (Wikipedia, 2024).

Species (Wikipedia, 2024).

Plants of the World Online recognized the following species:

- *Mentha alaica* Boriss.
- *Mentha aquatica* L. – water mint, marsh mint
- *Mentha arvensis* L. – corn mint, wild mint, Japanese peppermint, field mint, banana mint
- *Mentha atrolilacina* B.J.Conn & D.J.Duval – slender mint
- *Mentha australis* R.Br. – Australian mint
- *Mentha canadensis* L. – Canada mint, American wild mint

- *Mentha cervina* L. – Hart's pennyroyal
- *Mentha cunninghamii* (Benth.) Benth. – New Zealand mint
- *Mentha dahurica* Fisch. ex Benth. – Dahurian thyme
- *Mentha darvasica* Boriss.
- *Mentha diemenica* Spreng. – slender mint
- *Mentha gattefossei* Maire
- *Mentha grandiflora* Benth.
- *Mentha japonica* (Miq.) Makino
- *Mentha laxiflora* Benth. – forest mint
- *Mentha longifolia* (L.) L. – horse mint
- *Mentha micrantha* (Fisch. ex Benth.) Heinr.Braun
- *Mentha pamiroalaica* Boriss.
- *Mentha pulegium* L. – pennyroyal
- *Mentha requienii* Benth. – Corsican mint
- *Mentha royleana* Wall. ex Benth.
- *Mentha satureioides* R.Br. – native pennyroyal
- *Mentha spicata* L. – spearmint, garden mint (a cultivar of spearmint)
- *Mentha suaveolens* Ehrh. – apple mint, pineapple mint (a variegated cultivar of apple mint)

Other species (Wikipedia, 2024).

There are a number of plants that have mint in the common English name but which do not belong to the genus *Mentha*:

- *Agastache* sp. – known as horse mints
- *Calamintha* sp. (syn. *Clinopodium*) – known as calamints
- *Clinopodium acinos* (syn. *Acinos arvensis*) – known as backle mint
- *Elsholtzia ciliata* – known as comb mint, crested late summer mint
- *Melissa officinalis* – known as balm mint
- *Nepeta* sp. – known as cat mint or catnip
- *Origanum* sp. – known as rock mint
- *Persicaria odorata* – known as Vietnamese mint
- *Sideritis montana* – known as sider mint

Hybrids (Wikipedia, 2024).

The mint genus has a large grouping of recognized hybrids. Those accepted by Plants of the World Online are listed below. Parent species are taken from Tucker & Naczi (2007). Synonyms, along with cultivars and varieties where available, are included within the specific nothospecies.

- *Mentha* × *carinthiaca* Host - *M. arvensis* × *M. suaveolens*
- *Mentha* × *dalmatica* Tausch - *M. arvensis* × *M. longifolia*
- *Mentha* × *dumetorum* Schult. - *M. aquatica* × *M. longifolia*
- *Mentha* × *gayeri* Trautm. - *M. longifolia* × *M. spicata* × *M. suaveolens*
- *Mentha* × *gracilis* Sole (syn. *Mentha* × *gentilis*) - *M. arvensis* × *M. spicata* – ginger mint, Scotch spearmint
- *Mentha* × *kuemmerlei* Trautm. - *M. aquatica* × *M. spicata* × *M. suaveolens*
- *Mentha* × *locyana* Borbás - *M. longifolia* × *M. verticillata*
- *Mentha* × *piperita* L. - *M. aquatica* × *M. spicata* – peppermint, chocolate mint
- *Mentha* × *pyramidalis* Ten. - *M. aquatica* × *M. microphylla*
- *Mentha* × *rotundifolia* (L.) Huds. - *M. longifolia* × *M. suaveolens* – false apple mint
- *Mentha* × *suavis* Guss. (syn. *Mentha* × *amblardii*,[16] *Mentha* × *lamiifolia*,[17] *Mentha* × *langii*,[18] *Mentha* × *mauponii*,[19] *Mentha* × *maximilianea*,[20] *Mentha* × *rodriguezii*,[21] *Mentha* × *weissenburgensis*[22]) - *M. aquatica* × *M. suaveolens*[23]
- *Mentha* × *verticillata* L. - *M. aquatica* × *M. arvensis*
- *Mentha* × *villosa* Huds. (syn. *M. nemorosa*) - *M. spicata* × *M. suaveolens* – large apple mint, foxtail mint, hairy mint, woolly mint, Cuban mint, mojito mint, and *yerba buena* in Cuba
- *Mentha* × *villosa-nervata* Opiz - *M. longifolia* × *M. spicata* – sharp-toothed mint
- *Mentha* × *wirtgeniana* F.W.Schultz (syn. *Mentha* × *smithiana*) - *M. aquatica* × *M. arvensis* × *M. spicata* – red raripila mint

Species Distribution: Mentha L. has a cosmopolitan native range. The Mentha distribution map (Kew Science) included 163 countries, provinces, and regions for native distribution and 43 regions of introduction. Considering the tendency for species hybridization within this genus and the successful expansion strategies of mint around the globe, we used a conservative estimation to develop global richness maps. We separately examined world occurrences of point data within GBIF data for each of the 17 species.

We filtered out the introduced, naturalized, and cultivated locality data, keeping only natural endemic occurrences. We used climatic and topographic predictors to model likely occurrence for the 17 individual species maps. The data for the separate species maps were merged to produce the global species richness maps. These maps can be used for applied research or conservation planning and investigating the processes that have shaped these patterns. While the highest diversity of present day species occurs in Western Europe, significant endemic mint species occur in Eastern and Western North America, Asia, Southern Australia, and Tasmania. In addition to this natural species diversity, hundreds of thousands of data points of introduced, naturalized, and cultivated mint occur throughout five continents. The multitude of global mint occurrences speak to the global success of this genus, starting from Centers of Diversity in Europe, Asia, North America, and Australia and spreading throughout the globe. The ease of propagation by seeds and clonal propagules, such as rhizomes and cuttings, and the survivability of the plants during harsh and undesirable climactic conditions, allow for spread and diversification. The utilitarian application of mint for human pharmaceutical, food, and cosmetic needs encouraged domestication and cultivation throughout the world and across multiple cultures (Vining *et al*., 2020).

The following seven types of mint all have one thing in common:

They not only smell and taste like mint, but also have a completely different aroma (Regina, 2024).

Lemon mint (*Mentha gentilis* var. *citrata*): Another mint that was given its name because of its aroma is lemon mint. Indeed, its leaves exude an intense citrus smell. It is therefore ideal for teas, lemonades, desserts and cocktails. Lemon mint can grow up to 40 cm tall, is perennial and hardy (Regina, 2024).

Pineapple mint (*Mentha suaveolens variegata*): The leaves of the pineapple mint actually give off a slight pineapple aroma. It is therefore particularly suitable for desserts, punch or cocktails. The leaves of this mint species are also striking: they are variegated green and cream-coloured. Thus, the pineapple mint is a real eye-catcher in the bed or pot. However, it is not completely hardy in all areas and should be overwintered indoors. At about 25 to 60 cm tall, pineapple mint is also not as fast-growing as other mint species (Regina, 2024).

Orange mint (*Mentha piperita* var. *citrata* 'Orangina'): Orange mint also exudes an intense, fruity aroma reminiscent of bergamot or Earl Grey. It is therefore well suited for cooking, for example, with sauces or vegetables. Orange mint grows 50 to 80 cm tall and almost as wide. It produces purple flowers on dark red stems from July to September. Orange mint is very fast-growing and spreads quickly in the garden. The aroma of orange mint develops best in the sun, which is why it is also suitable as a container plant for sunny balconies (Regina, 2024).

Chocolate mint (Mentha x piperita var. *piperita* 'Chocolate'): If you like mint chocolate or After Eight, you will love this type of mint. Namely, it combines mint and chocolate aromas in one plant. However, the aroma is very subtle, not too intense and is perceived differently by everyone. Chocolate mint may smell and taste intensely of chocolate to one person, while another may not notice the smell at all. Chocolate mint plants grow between 40 and 60 cm tall and bloom bright purple from July to September (Regina, 2024).

Basil mint (Mentha × piperita var. *citrata* 'Basil'): Another mint with a special aroma is basil mint. The taste is very reminiscent of basil, the smell of Italian dishes. The name Bastardo is also Italian, as basil mint is also called. The scent and taste of the leaves are nevertheless still very minty and also slightly peppery. The red-stemmed mint is wonderful for salads, sauces and pestos. Basil mint grows 40 to 70 cm tall and can grow up to 1 m wide (Regina, 2024).

Strawberry mint (*Mentha* species 'Strawberry'): Another rarity among the mints: the strawberry mint. This one actually tastes almost nothing like mint, but – you guessed it – strawberries. It is good to use in the kitchen for teas, lemonades or cocktails. Strawberry mint plants grow only 30 to 50 cm tall and bloom pink, but often spread strongly by runners (Regina, 2024).

Banana mint (*Mentha arvensis* 'Banana'): The banana mint is a variation of field mint (*Mentha arvensis*). This was grown in France and the leaves actually give off an intense smell of bananas. You can experiment with the herb in the kitchen and use it for desserts or drinks. Plants of banana mint are small, grow 30-50 cm tall and also do not spread excessively (Regina, 2024).

Important Species of Mint (Patel, 2022; NHB, 2024; Smpbodisha, 2024; Niftem, 2024)

Japanese mint/MentholMint *(Menthaarvensis):* Japanese mint is aprimary source of menthol. The fresh leaves contain 4-6.0% oil. The main constituents of the oil are menthol (65-75%), menthone (7-10%) and menthyl acetate (12-15%) and terpenes (pipene, limonene and comphene). Japanese mint (*Mentha arvensis* var *piperascens*) is an aromatic herb of temperate region. The oil and its principal aroma-compound menthol have cooling and gastro-stimulant properties, for which it is used in pharmaceuticals, food flavour, confectionery, cosmetics, beverages and related industries. In India, it is grown over around 50,000 ha land. The area has grown enormously during the last 3 years in tarai districts of Uttar Pradesh, and parts of Punjab and Haryana. India has emerged as a large exporter of its oil and menthol to world market, particular 37 to the USA.

Pepper mint *(Menthapiperita):* The fresh herb contains essential oils ranging from 0.4 to 0.6%. The constituents of peppermint oil are almost similar to Japanese mint oil. However, the menthol content is lower in peppermint oil and varies between 35-50%. The other constituents are menthyl acetate(14-15%),menthone(9-25%) menthoufuran andterpenes likepineneandlimonene.

Peppermint (*Mentha piperita*) is an allied mint crop with relatively long- stalked opposite lanceolate leaves. The plants are 50-80 cm tall, bearing globular flowering spikes. It bears purplish blossom in terminal spikes. The common black Mitcham variety (introductory) is vigorous growing hardy plant and prefers cool sub-temperate climate. Since growth and yield of peppermint is not very high in tarai track of Uttar Pradesh, it is not grown here in large areas. It is cultivated on a small scale in Punjab and parts of Himachal Pradesh. The cultivation practices PM FME – Mint and Mint Product Processing are similar to those of Japanese mint. It has lower oil content (0.25%), the average oil yield being 80kg/ha from a fertile land having well-managed plantation. The oil has 50-50% menthol, sweet in taste and of superior odour. It is mainly used in pharmaceutical preparations. It fetches much higher price than oil of Japanese mint.

Spear mint *(Menthaspicata):* The principal constituent of spearmint oil is carvone (57.71%) and other mmor constituents arephellandrene, limonene, L-pinene and cinelole. The oil isusedmostly asa flavouring in toothpastes and as food flavouring in pickles and spices, chewing gum and confectionery, soaps and sauces. Spearmint (*Mentha spicata*) is another important mint. Its oil is rich in carvone (65%) content and emits caraway like odour. The oil is useful in dentifrice, confectionery and pharmaceutical products. It bears lanceolate stalkless, light green leaves and narrow, long, terminal flowering spikes with lilac flowers, attaining a height of up to 60 cm. Two commercial varieties have been evolved in India. Of them, Punjab Spearmint is an erect growing with quadrangular purple-green, hairy stem, production 20q/ha of fresh herb. It contains 0.57% oil, the oil yield being 120 litres/ha containing 68% carvone. The other variety MSS 5 is relatively vigorous in growth, yielding 250-300q/ha of fresh herb or 150kg of oil from commercial plantations. It is cultivated in smaller area in Punjab and foothills of Uttar Pradesh. It fetches higher price.

Bergamot mint *(Menthacitrate):* Linalool and linalyl acetate are the main constituentsof Bergamot mint oil. The oil is used directly in perfumes. Cosmetic preparations like scents, soaps, after-shave lotions and colognes also contain this oil. Bergamot mint Bergamot mint or lemon mint (*Mentha citrate*) is a fluorescent aromatic herb, robust in growth like Japanese Mint. It has similar broad ovate leaves but 2without a distinct inflorescence. The flowering vertices are borne in upper part of the stem in axil of leaves. The oil has an odour reminiscent of lavender oil due to its containing high linalool (45-50%) and linalyl acetate (45%) contents. The yield of herb and oil is similar to Japanese mint. A high-yielding variety, Kiran, produces 150kg of oil/ha, containing 48% linalool. The Cultivation practices are similar to those of other mints. It grows well in subtropical, fertile plains of north India. About 50-60 tonnes of oil is produced in the country annually, fetching price akin to oil Japanese mint .

All are herbaceous plants, readily sending out runners (rainy season) and stolons (winter), which develop new roots and shoots at the nodes and form plants. The entire aerial shoots together with foliage is a source of essential oil rich in menthol, carvone, linalool and linanyl acetate having use in pharmaceutical preparations and flavour industry. For the past four decades, mints are commercially cultivated in India. Of these, the Japanese Mint, yielding menthol is grown extensively in northern India. Other major producing countries are China and Brazil and to a smaller extent Thailand and Vietnam (NHB, 2024).

Among the different *Mentha* species and hybrids, those that have achieved economic importance are as follows.

Cornmint: Extremely menthol-rich essential oils (up to 80% menthol) are produced by *Mentha arvensis* var. *piperascens*, mainly plants cultivated since antiquity in Japan and during recent years in China, India, and Brazil. The cornmint plants are distinguished by their leafy at apex inflorescence, which consists of remote flower verticillasters. The cornmint oil (also known as Japanese or Chinese or Brazilian peppermint oil) is valued as a source of l-menthol, which is generally obtained by simple freeze-crystallization. The dementholized oil is used as inexpensive, rather harsh peppermint-like oil (Kokkini *et al*., 2003).

Pennyroyal: The leaves and flowering parts of *Mentha pulegium* L. (European pennyroyal) plants grown wild in western and central Europe as well as in the Mediterranean region are traditionally used for the preparation of teas and, to a limited extent, for food flavoring (soups, stuffings). *M. pulegium* is distinguished from the other mint species by its inflorescence, which consists of remote verticillasters but is not leafy at apex. Furthermore, *M. pulegium* is distinguished from the other mint species by the calyx, which has unequal teeth (weakly two-lipped), while the corolla tube is gibbous beneath. The North American pennyroyal is *Hedeoma pulegioides* (L.) Pers., an annual plant growing in North America, which has a similar odor to *M. pulegium* (Kokkini *et al*., 2003).

Peppermint: *Mentha* × *piperita* L., a sterile hybrid of the species *M. aquatica* L. (Figure 2) and *M. spicata*, is probably the most important commercial aromatic herb in the world today from the standpoint of the size of the area cultivated for oil distillation. The peppermint leaves have a characteristic, sweetish, strong odor and an aromatic, warm, pungent taste, with a cooling aftertaste. The essential oils of *M*. × *piperita* cultivated plants are characterized by the preponderance of menthone, isomenthone, and the different isomers of menthol. Peppermint oil finds wide application in the flavoring of chewing gums, sugar confectionery, ice creams, desserts, baked goods, tobacco, and alcoholic beverages. It is also frequently employed in the flavoring of pharmaceutical and oral preparations (Kokkini *et al.,* 2003).

Spearmint: Under the vernacular name 'spearmint,' different *Mentha* species and hybrids producing carvone-rich essential oils are commerically exploited. In particular, two main 'types' of spearmint – Native and Scottish – are widely cultivated, mainly in the USA but also in China, Europe, and South Africa, for the commercial production of their essential oil. The native spearmint oil is obtained either from the species *M. spicata* L. (Figure 2) or from the sterile hybrid *M*. × *villoso-nervata* Opiz. (*M. longifolia* L. × *M. spicata*), whereas the Scottish spearmint oil is produced from the hybrid *M*. × *gentilis* L. nm. *cardiaca* Gray (*M. arvensis*

L. × *M. spicata*). Spearmint plants are familiar garden herbs, and they are often used to flavor vegetables, soups, meat and fish sauces, and salads. The spearmint oil, characterized by the high participation of carvone, dihydrocarvone, and their related alcohols and esters, is mainly used in the flavoring of chewing gums, toothpastes, and other oral products (Kokkini *et al.,* 2003).

The best mint species and varieties

The following is an overview of mint classics: mints that are very good for tea, mints that are mainly found wild, and more exotic mints with special flavours. You have probably heard of the following five types of mint (Regina, 2024).

Peppermint (*Mentha x piperita*): Peppermint is the classic among the mint varieties and is often found in gardens and on balconies. However, it is unclear where this type of mint originally comes from. What is certain is that it is a cross between the brook mint (*Mentha aquatica*) and the green mint (*Mentha spicata*). It is valued above all for its high menthol content and its peppery-spicy aroma. In cultivation, it is undemanding, perennial and hardy (Regina, 2024.

Spearmint (*Mentha spicata* Syn. *Mentha viridis*): Even if the name is not that common, spearmint is arguably the most commonly used of the mint varieties. It is this type of mint that gives toothpaste, chewing gum or sweets their minty taste. It originally comes from Europe but is now also widespread in large parts of Asia and Africa. Spearmint is very fast-growing and runner-forming. It can grow up to 130 cm tall. Spearmint blooms in white and purple from July to September (Regina, 2024).

Water mint or brook mint (*Mentha aquatica*): Both the names water mint and brook mint refer to the same type of mint: *Mentha aquatica*. It originated in Europe and is now found in large parts of Africa and Europe. As the name suggests, this mint enjoys wet conditions. That is why they are mainly found in the wild on banks, ditches, moors and wet meadows. The peculiarity of the seeds of this type of mint is that they only spread over the water. Water mint grows about 50 to 60 cm tall, forms spherical, light purple inflorescences between July and August, and is well suited for planting along pond edges in the garden (Regina, 2024).

Pennyroyal (*Mentha pulegium*): This mint species can grow 10 to 50 cm tall and bears delicate purple flowers from May to September. Pennyroyal looks very similar to peppermint. However, caution is advised as the pennyroyal is poisonous. While the stamens of peppermint are as long as the petals, the stamens of pennyroyal extend well beyond the tubularly fused petals. In the past, pennyroyal was still used as a remedy, but today it is not used due to its toxicity. The pennyroyal should not be picked as it is under nature protection and classified as endangered on the Red List. In the garden, it is well suited for the fragrance bed (Regina, 2024).

Mojito mint (*Mentha nemorosa*): Mojito Mint is also called Hemingway mint or cocktail mint. The reason is obvious: the aromatic herb is often used to mix refreshing cocktails and drinks such as Mojito or Hugo. It was probably the result of a cross between *Mentha spicata* and *Mentha suaveolens*. Mojito mint grows between 40 and 80 cm tall and is very fast-growing. In summer, from early July to late August, it also blooms bright purple
and attracts numerous insects (Regina, 2024)

The next four types of mint have a long tradition in countries where tea drinking plays an important role. No wonder, then, that these mints are all particularly good for making tea (Regina, 2024).

Moroccan mint (*Mentha spicata* var. *crispa* Morocco): Moroccan mint originates from North Africa. As the name suggests, it is very appreciated especially in Morocco and drunk as tea with a lot of sugar. But it is not only the cooling, refreshing taste that makes this mint so popular, but also its compact growth and easy care. Moroccan mint grows between 30 and 60 cm tall, the leaves are lanceolate and jagged at the edges. The flowers of the Moroccan mint are delicate purple (Regina, 2024).

Nana mint (*Mentha spicata* var. *crispa* 'Nane'): The name nana mint can actually refer to three types of mint: the species *Mentha spicata* var. *crispa* 'Nane' or *Mentha* x *piperita* var. *piperita* 'Nana' – and also the Moroccan mint described above is sometimes called nana mint. However, the actual nana mint is *Mentha spicata* var. *crispa* 'Nane'. Nana mint is often also known as Turkish mint, since there and in North Africa it is often drunk in combination with black tea and sugar. In these regions, it is also often used to flavour oriental dishes. It can grow 30 to 60 cm tall, is perennial and hardy. The flowers of Turkish mint are white-pink and appear from July (Regina, 2024).

English mint (Mentha × piperita 'Mitcham'): English mint is an old cultivated form from England from the Mitcham area. It is probably an accidental cross of a garden mint with wild water mint (*Mentha aquatica*). This type of mint is characterised by its intense flavour with a lot of spiciness. It is therefore used for tea, soups and desserts. The leaves of English mint are green and turn

red. The plants grow up to 80 cm tall, are perennial and strong-growing. The flower appears between July and August (Regina, 2024).

Apple mint or round-leaved mint (*Mentha suaveolens*): Apple mint is also called round-leaved mint. This is due to its specially shaped leaves: namely, they are oval. It is called apple mint because its leaves actually smell and taste like apple. Because of its mild aroma, apple mint is well suited for teas. Nowadays, apple mint is widespread in large parts of China, Turkey, North Africa and Central Europe. Apple mint can grow up to 100 cm tall and is extremely vigorous. It blooms lilac in the summer. It also likes it moist and is therefore often found in wet meadows, wet roadsides or along ditches, but also tolerates dryness better than many other mint species (Regina, 2024).

The following mints can all be discovered in the wild – in fields or along paths. Nevertheless, they can of course also be planted and cultivated in the garden or in pots (Regina, 2024).

Field mint (*Mentha arvensis*): Field mint is also called corn mint and is a wild mint species. It is common in all temperate regions in the Northern Hemisphere. The plant usually grows from 5 to 30 cm tall and blooms pink to purple. It prefers moist, nutrient-rich sites and is less vigorous than its cultivated siblings (Regina, 2024).

Horse mint (*Mentha longifolia*): The native horse mint is also called forest mint and is found in the temperate zones of Eurasia to Southern Africa. In Central Europe, it is often found in low mountain ranges and in the lower altitudes of the Alps. It needs wet, nitrogen-rich soil to grow well. Therefore, it is often encountered near rivers or next to agricultural land. The long-leaved, fluffy-haired horse mint grows up to 130 cm tall and bears pink to purple flowers between July and September (Regina, 2024).

Corsican mint (*Mentha requienii*): Corsican mint is also called tender mint and is found only on three islands in the Mediterranean: Corsica, of course, but also Sardinia and Montecristo. The peculiarity of this type of mint is that it does not grow upright, but rather like a carpet. It forms lawns and gives off an intense, pungent odour. This mint is also used to make the Crème de Menthe liqueur. Due to its Mediterranean origin, Corsican mint is not hardy and therefore needs protection in the cold season (Regina, 2024).

Synonyms (Taneja and Chandra, 2012).

- *Mentha aquatica* L. – Water mint or Marsh mint
- *Mentha arvensis* L. – Corn mint, Wild mint, Japanese peppermint, Field mint, pudina *Mentha asiatica* Boriss. – Asian mint *Mentha australis* R. Br. – Australian mint
- *Mentha canadensis L.*
- *Mentha cervina L. – Hart's* pennyroyal
- *Mentha citrata* (Ehrh.) – Bergamot mint
- *Mentha crispata* L. – Wrinkled-leaf mint
- *Mentha dahurica* Fisch. Ex. Benth. – Dahurian thyme
- *Mentha diemenica* Spreng. – Slender mint
- *Mentha gattefossei Maire.*
- *Mentha japonica (Miq.) Makino*
- *Mentha kopetdaghensis Boriss. Mentha laxiflora Benth. – Forest mint*
- *Mentha longifolia (L.) L. Mentha sylvestris L., Horse mint*
- *Mentha pulegium L. – Pennyroyal*
- *Mentha requieni Benth. – Corsican mint*
- *Mentha sachalinensis* Briq. – Garden mint
- *Mentha satureioides* R. Br. – Native pennyroyal
- *Mentha spicata* L. – *M. viridis, M. cordifolia,* Spearmint, Curly mint
- *Mentha suaveolens* Ehrh. – Apple mint, Pineapple mint (a variegated cultivar of apple mint)
- *Mentha vagans* Boriss. – Gray mint *Mentha grandiflora* Benth.

Toxicity: When consumed in large amounts, mint may cause adverse effects. Peppermint oil on the skin can cause irritation and rashes. It should not be applied to the face. More research is needed on the long-term effects of regularly consuming mint, so it's best to consume it in moderation (WebMD, 2023).

BOTANICAL DESCRIPTION

The morphology of some of the main *Mentha* species

Mentha arvensis: An erect plant with a single stem, which is glabrous at the bottom with a few hairs near the top to a few branches. The leaves, which are arranged in opposite pairs are serrate, lanceolate to elliptical in shape and shiny dark green in colour, occasionally with a purple tinge. They are quite large in size at approximately 9.5 cm long and 2.5 cm wide, and have short hairs on the underside with sparse hairs above. The flowers are mauve in colour, approximately 5 mm in length and arranged in whorls in leaf axils. The plants have a minty aroma (Taneja and Chandra, 2012).

Mentha piperita: A herbaceous rhizomatous perennial plant growing 30–90 cm tall with smooth stems. The leaves are 4–9 cm long and 1.5–4 cm broad, dark green in colour with reddish veins, an acute apex and coarsely toothed margins. The leaves and stems are usually slightly hairy. The flowers are purple, 6–8 mm long with a four-lobed corolla about 5 mm in diameter. They are produced in verticillasters around the stem, forming thick blunt spikes. Flowering occurs generally from mid to late summer (Taneja and Chandra, 2012).

Mentha spicata: A herbaceous rhizomatous perennial plant growing 30–100 cm long with a wide-spreading fleshy underground rhizome. Stems and foliage may be hairless or hairy. The leaves are serrate 5–9 cm long and 1.5–3 cm wide. The flowers are produced on slender spikes, each flower pink or white and 2.5–3 mm in diameter (Taneja and Chandra, 2012).

Mentha longifolia: Also known as wild mint or horse mint found in Africa, in tropical and temperate regions of Asia and Europe. In South Africa, three different sub-species are recognized (Codd, 1983). It is a fast-growing perennial herb that is generally 0.5–1 m high, which can reach up to 1.5 m. The leaves are lanceolate, coarsely hairy and sparsely toothed at the edges. They are 45–100 mm long and 7–20 mm wide and their colour varies from light and dark green to grey. The small flowers are crowded into spikes at the tip of the stems, and vary from white to mauve throughout the winter months (Taneja and Chandra, 2012).

Mentha citrata: A smooth, dark green plant dotted with yellow glands. The leaves are finely toothed and tinged with purple at the edges. There are very conspicuous lines of yellow glands on the purple calyx (Taneja and Chandra, 2012).

Mentha pulegium: An extremely resilient variety that can grow even in very poor soil. It is a groundcover plant with small leaves and mauve flowers (Taneja and Chandra, 2012).

Mentha requieni: A mat-forming groundcover plant. The leaves are small, mosslike and bright green in colour. The plant grows best in light shade (Taneja and Chandra, 2012).

Botanical Description: The plants generally grow to be one to two feet tall and emit a fresh aroma. The leaves and stems tend to be slightly hairy. Leaves generally grow to be one and a half to three and a half inches long and a half an inch to one and a half inches wide. Peppermint has purple flowers. Peppermint is best known for the oil that can be extracted from the plants. The oil can be used for both medicinal and culinary purposes. When placed on the tongue, it produces a hot, tingly sensation, which fades into a cooling feel. The cooling is due to the menthol which makes up a majority of the chemical composition of the essential oil extracted from the plant. Peppermint oil is made up of 59.17% menthol. An essential oil can also be extracted from spearmint. It is less potent than peppermint's essential oil and is mainly used for cooking. Its main component is carvone, a type of terpenoid (Mint, 2008). Mint species are characterized by wide-spreading stolons that grow both under and above ground and have erect, square, branched stems. The leaves are oblong to lanceolate in shape, arranged in opposite, have serrated edges and are often downy. There may be a variety of colours, including dark green, grey-green, purple-blue and occasionally pale yellow. The white or purple flowers are produced in false whorls known as verticillasters. The corolla has two lips and four sub-equal lobes, with the upper lobe usually the largest. The fruit is a small, dry capsule containing one to four seeds (Taneja and Chandra, 2012).

Mints are the aromatic and perennial herbs, having overground and underground stolons, which are quite widespread. They also have square, erect, and branched stems. The arrangement of their leaves is in opposite pairs, from oblong to lanceolate with the downy approach and sharp edges. The color profile of Mentha leaves is quite broad ranging from blue, dark green, grayish green to purple, and it could be pale yellow. Mentha flowers are being produced in false whorls also known as verticillasters, and their color range is from white to purple. A flower having two-lipped corolla portion withfourlobesanditsfruithas1–4 seeds, covered with a stony layer (Ahmad *et al.,* 2020). Mints are aromatic, almost exclusively perennial herbs. They have wide-spreading underground and over ground stolon's and erect, square, branched stems. The leaves are arranged in opposite pairs, from oblong to lanceolate, often downy, and with a serrated margin. Leaf colours range from dark green and grey-green to purple, blue, and sometimes pale yellow, The flowers are white to purple and are produced in false whorls called verticillate. The corolla is two-lipped with four subequal lobes, the upper lobe usually the largest. The fruit is a nutlet, containing one to four seeds (Vikaspedia, 2023).

Japanese mint is a perennial ascending herb growing about 60-80 cm. in height and under favourable conditions may attain a height up to 100 cm. It is propagated mainly by its stolons. Leaves are lanceolate-oblong, sharply toothed; petiole is small about

5mm. in length. The leaf lamina varies from 5 to 15 cm. The leaf surfaces mainly lower side is covered with dense hairy growth of glandular trichomes. Flowers are borne in axillary and terminal verticillate, abundant in number, purplish in colour. The flowers are small with corolla measuring 4-5mm., calyx 2-3mm., narrowly deltoid and acuminate. It does not produce seed and propagation is through vegetative means only. Japanese mint is a vigorously growing branched, hardy perennial, attaining up to 1m height in rich fertile lands. The herb is covered with soft tomentum all over and bears broadly ovate leaves over terete, violet tinged quadrangular stems. It gives out long, narrow, axillary flowering spikes profusely, containing lilac flowers. Being of hybrid origin, it rarely sets seed. The crop is commercially raised through underground stems called stolon's, though suckers given out in rainy season also easily give out roots on planting, producing new plants (Niftem, 2024). Spearmint is a flowering, aromatic herb or groundcover in the Lamiaceae (mint) family native to Europe. In its natural haibtat it is found growing in moist fields and pond or lake margins. It can be distinguished from other mints by its almost hairless (glabrous) leaves that are attached to the stem with a very to almost non-existant petiole (sessile). The small lilac, pink, or white flowers appear in terminal spikes in late summer and can be sheared after bloom to remove flower spikes and stimulate new vegetative growth. Leaves have a strong spearmint fragrance and taste, and may be used to flavor teas, in salads, as a garnish or in pot pourris. The genus name comes from Minthe or Menthe, a water nymph in Greek mythology, who was transformed by Persephone into a mint plant in revenge for Minthe's ongoing affair with Hades (husband of Persephone). The species name means spike. This upright perennial thrives in full sun in organically rich, well-drained, moist soils growing quickly 1 to 2 feet high and wide with bright green leaves and shoots. It does tolerate partial shade and a wide range of soil types, but does not do well in dry soils. The square stems can root wherever they touch the ground and it also spreads by rhizomes. Soil barriers can restrain rhizomatous spread if plants are grown in borders or other areas where spread is unwanted **(**Plants, 2024**).**

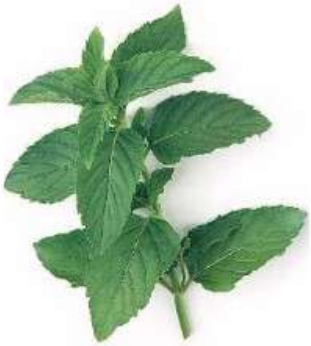
Mints are aromatic, almost exclusively perennial herbs. They have wide-spreading underground and overground stolons and erect, square, branched stems. Mints will grow 10–120 cm (4–48 inches) tall and can spread over an indeterminate area. Due to their tendency to spread unchecked, some mints are considered invasive. The leaves are arranged in opposite pairs, from oblong to lanceolate, often downy, and with a serrated margin. Leaf colors range from dark green and gray-green to purple, blue, and sometimes pale yellow. The flowers are produced in long bracts from leaf axils. They are white to purple and produced in false whorls called verticillasters. The corolla is two-lipped with four subequal lobes, the upper lobe usually the largest. The fruit is a nutlet, containing one to four seeds (Wikipedia, 2024). Mints have square stems and opposite aromatic leaves. Many can spread vegetatively by stolons and can be aggressive in gardens. The small flowers are usually pale purple, pink, or white in colour and are arranged in clusters, either forming whorls or crowded together in a terminal spike. The flowers are not typical of other members of the family, having four rather than five united petals. The volatile oils are contained in resinous dots in the leaves and stems (Petruzzello, 2024). Important species and Botanical description of mint is shown in Fig. 1 & 2**.**

Floral Biology: Having healthy flowers in our garden is more important than we think. This is not only an aesthetic issue, but also of vital importance for the balance of the ecosystem and the survival of plants. Healthy flowers are essential for attracting pollinators, such as bees and butterflies, which are responsible for carrying pollen from one flower to another, thus allowing reproduction and seed formation. In addition, healthy flowers are indicators of fertile, well-nourished soil, which benefits not only the plants around them, but also the entire garden ecosystem. Taking care of our flowers and keeping them free of diseases and pests is essential to ensure their health and longevity. This involves watering them properly, providing them with the necessary nutrients, and protecting them from extreme weather conditions. We should also be on the lookout for possible signs of illness or stress, such as yellowing or wilting leaves, and take steps to treat these problems in time. In short, having healthy flowers in our garden not only gives us a wonderful visual spectacle, but also contributes to the natural balance and beauty of our environment (Green, 2024).

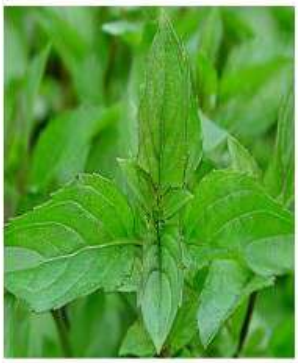
The mint plant plays a key role in pollinating our flowers. Did you know that this aromatic herb has the power to attract pollinators? Yes, that's right, bees and other beneficial insects are attracted to the sweet aroma and nectar that mint produces. These small flying creatures perch on mint flowers and, in doing so, carry pollen from one flower to another, allowing fertilization and seed formation. It's fascinating how a simple plant can play such a crucial role in the life cycle of flowers. Not only does mint attract pollinators, but it also provides them with a place to rest and feed. Its soft, fragrant leaves offer shelter and food to bees, butterflies, and other nectar-seeking insects. In addition, peppermint contains natural chemical compounds that stimulate the appetite of pollinators, keeping them interested and engaged in the task of pollinating. So if you want to have healthy and beautiful flowers in your garden, don't forget to include a mint plant. Not only will you enjoy the fresh aroma and flavor of this herb in your meals, but you'll also be contributing to the well-being of your flowers. It's amazing how something so simple can make such a huge difference in our natural environment! (Green, 2024). Self-pollination in Indian Mint is a fascinating process. Pollen from the stamens falls directly onto the pistils within the same flower, leading to fertilization. While this method ensures reproduction, additional pollination can occur through external agents. Cross-pollination enhances genetic diversity, increasing seed viability and resilience in the plant. Bees are the primary pollinators of Indian Mint, drawn in by the vibrant colors and enticing scents of the flowers.

Japanese Mint (*Mentha arvensis*)

Pepper Mint (*Mentha piperita*)



Spear Mint (*Mentha spicata*)

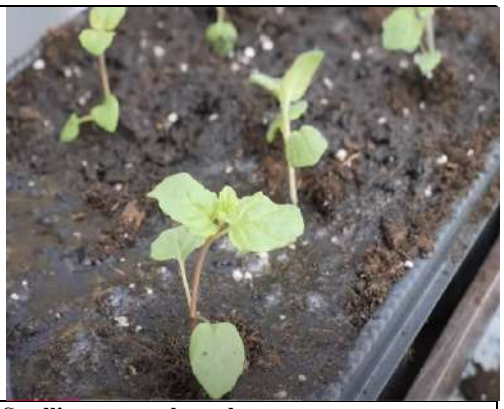


Bergamot mint (*Mentha citrata*)

Fig. 1. Species of Mint

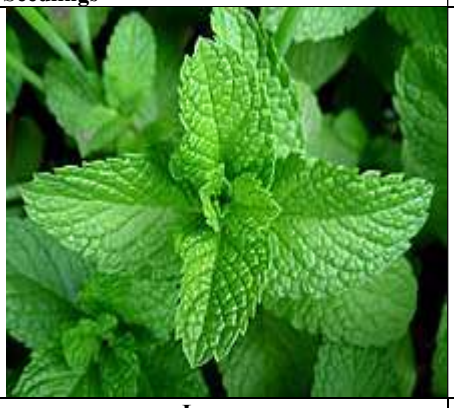
Mint Seeds

Seedlings



Seedlings transplanted

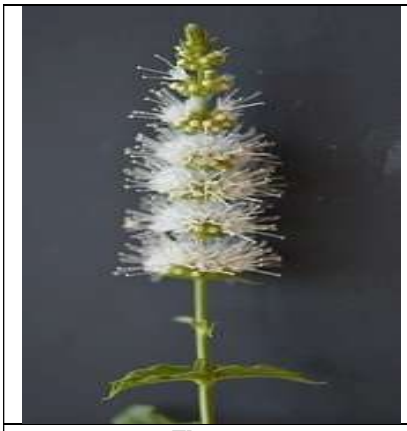
Young plant



Leaves

Plant

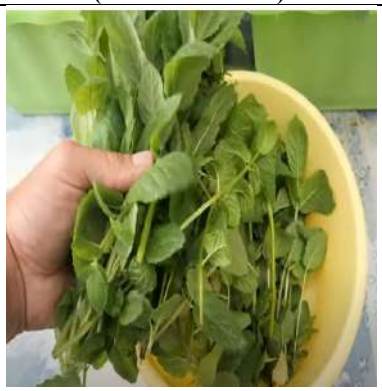
Continue …



Flowers (should be cut off)

First cutting

Watering



Cut shoots

Field

Field

Fig. 2. Botanical Description

Their role is crucial, as they effectively transfer pollen while foraging. Butterflies also play a significant part, attracted by the nectar. Other visitors, like moths and hummingbirds, occasionally stop by, contributing to the pollination process (Rankel, 2024). Hand pollination can be a rewarding way to ensure the successful reproduction of Indian Mint. Follow these straightforward steps to enhance your gardening experience. First, locate the male parts of the flower. These are the stamens, which are covered in pollen. Next, find the female parts, specifically the pistil, located at the center of the flower. This is where the magic of fertilization happens. Now it's time to gather some pollen. Use a small brush or a cotton swab to gently collect pollen from the stamens. Be gentle to avoid damaging the flower while ensuring you have enough pollen for the next step. With your collected pollen in hand, carefully apply it to the stigma of the pistil. This transfer is crucial for fertilization. Make sure to cover the stigma well to increase the chances of successful pollination. Timing is everything in hand pollination. Aim to perform this task during the morning when the flowers are fully open. This is when the flowers are most receptive, maximizing your chances of success. By following these steps, you can effectively hand pollinate Indian Mint and contribute to its growth and vitality. This hands-on approach not only boosts your gardening skills but also deepens your connection to the plant. As you explore the world of pollination, consider how you can support pollinators in your garden (Rankel, 2024).

GENETICS AND CYTOGENETICS

The genus Mentha consists of perennial aromatic herbs of about forty species, distributed in the temperate regions of the world, mostly of the Northern hemisphere. Commonly known as mints, they have been used from very ancient times both in medicines and for culinary purposes. A few species like *M. rotundi*]*blia, M. pulegium, M. requieni* are also grown as horticultural plants. Where they have been introduced for culinary purposes, they have freely hybridized with local species and producing intermediate forms, thus making the nomenclature very difficult. Previous work on chromosomes of Mentha has shown that the species are very polymorphic and different chromosome races are found in the same species. Chromosome counts of these have been made from young leaves fixed in acetic alcohol stained with orecin. The chromosome numbers determined for different species are given in Table 3 (Sobti, 1965).

It will be seen that the genus Mentha falls into two groups cytologically --the pulegium group native to the mediterranean region with basic chromosome number x = 10 and the arvensis-spicata group with basic chromosome number x = 6 or 12 is found in North temperate regions. It has been reported that the diploid form of *M.,arvensis* as 2n = 12. The race of *M. arvensis* growing in India have 2n = 72 and the geographical range of this extends from Western Himalayas in Kashmir to Ladakh. It is interesting to note that this chromosome number is also found exclusively in *M. arvensis* growing in British Isles. *M. arvensis* Linn. var. *piperascens* Holmes the Japanese mint, which is extensively grown for menthol has 2n = 96 and is probably of hybrid origin. A colchicine-induced tetraploid of this plant known as the Jammu Mint has 2n = 192.

Table 3. The chromosome numbers determined for different species

Sl. No.	Introduction number	Name of the species	Locality	Chromosome number
1	2	3	4	5
		$x = 6$ or 12		
1	296/61	*Mentha longifolia*	Kashmir	$2n=24$
	2547/62	do.	Jammu	$2n=24$
	195/60	do.	Kulu	$2n=24$
	2455/62	do.	Ladakh	$2n=24$
	1217/61	do.	Kew	$2n=24$
	1004/60	*ssp sylvestris*	Bangalore	$2n=24$
	105/60	var. *royleana*	Kulu	$2n=36$
	2435/62	*M. longifolia*	Banihal (Kashmir)	$2n=48$
2	5324/60	*M. rotundifolia*	Germany	$2n=24$
	1201/61	var. *variegata*	Kew	$2n=24$
3	1207/61	*M. cordifolia*	Kew	$2n=36$
	1049/60	do.	Kulu	$2n=36$
	249/60	do.	Local	$2n=48$
	1215/61	var. *brevifolia*	Kew	$2n=36$
4	1216/61	*M. niliaca* var. *alopecuroides*	Kew	$2n=36$
	1211/61	var. *villosa*	Kew	$2n=48$
5	1200/61	*M. spicata*	Kew	$2n=36$
	1205/61	var. *laciniata*	Kew	$2n=48$
	1213/61	*M. muelleriana*	Kew	$2n=48$
6	1214/61	*M. sapida*	Kew	$2n=48$
7	299/60	*M. piperita*	Kashmir	$2n=48$
	1443/61	do.	Dharamsala	$2n=48$
	1210/61	do.	Kew	$2n=48$
	1208/61	do.	Kew	$2n=48$
	138/60	var. *officinalis*	Kew	$2n=48$
	132/60	var. *vulgare*	Kew	$2n=72$
		Colchicine-induced polyploid		$(2n=144)$
8	1212/61	*M. smithiana*	Kew	$2n=54$
9	S302/60	*M. gentilis* Linn.	Kew	$2n=54$
	1203/61	var. *variegata*	Kew	$2n=54$
	1204/61	var. *gracilis*	Kew	$2n=54$
10	593/60	*M. arvensis* var. *javanica*	Kashmir	$2n=72$
	246/60	*M. arvensis*	Ooty	$2n=96$
	95/60	var. *piperascens*	Japan	$2n=96$
		Colchicine-induced polyploid	"Jammu Mint"	$(2n=192)$
11	1209/61	*M. citrata*	Kew	$2n=96$
	2368/62	do.	Oxford	$2n=96$
12	1206/61	*M. dumetorum*	Kew	$2n=96$
13	1202/61	*M. verticillata*	Kew	$2n=96$
		$x = 10$		
14	S304/60	*M. pulegium*	Kew	$2n=40$
	243/60	do.	Sanasar (Kashmir)	$2n=40$
15	S319/60	*M. gattefossei*	Germany	$2n=20$

The same chromosome number 2n = 96 has been observed in *Mentha citrata, M. dumetorum, M. verticillata* received from Kew and Oxford. In the spicata group the chromosome numbers found vary from 2n = 24 in *M. rotundifolia* to 2n = 36, 48 in *M. niliaca* and *M. eordifolia* and 2n = 72 in the black peppermint *M. pipperita* var. *vulgare*. This mint has again been treated with colchicine to produce a colchiploid with chromosome number 2n = 144. Heimans (1938) reported the chromosome number of *M. longifolia* as 2n = 18. During the present studies the chromsome number of *M. longifolia*, collected from Kashmir, Ladakh, Jammu and Kew, has been found to be 2n = 24 (Sobti, 1965).

The genus *Mentha* of the family *Labiatae* consists of 15 species placed in two subgenera: *Pulegium* and *Menthustrum.* Six of these species, *M. pulegium* L., *M. rotundifolia* (L.) Huds, *M. viridis* L. (M. *spicata* L.), *M. longifolia* (L.) Huds. (*M. spicata* L. var. *longifolia* L.), *M. arvensis* L. and *M. aquatica* L., are widely distributed throughout Europe and Asia, and also naturalized to America. *M. requienii* Benth., a small creeping mint, is found in Corsica and Sardinia, and *M. tomentosa* D'Urv. *(M. microphylla* C. Koch) is found in Greece. The remaining seven species are indigenous to Australia and New Zealand. Later, *M. gattefossei* Maire was found in northern Africa and *M. japonica* Makino was found in Japan. Besides, *M. piperita* L. (peppermint) and *M. gentilis* L. (*M. cardiaca* Gerade; scotch spearmint) are believed to be interspecific hybrids. These two hybrid species, along with *M. spicata* including var. *Crispate* (common spearmint) are cultivated in Europe and America, while *M. arvensis* var. *piperascens*

(Japanese mint) is cultivated in Japan. All species are perennial. Several cytological investigations suggested that *Mentha* is a group of polyploids, with different chromosome numbers reported for each of the several species. This may be due to taxonomic confusion among the species or due to species complexes having cytotypes with different chromosome numbers. There are still many unsolved problems in the genus *Mentha, e.g*. different chromosome numbers within the same species, the nature of ploidy, especially auto- or alloploidy, basic chromosome number and role of polyploidy in evolution (Ikeda and Ono, 1991).

GENETIC DIVERSITY

Genetic diversity was explored among 20 Mentha accessions through randomly amplified polymorphic DNA (RAPD) markers. All the used markers produced 60 band, on average 6 bands per primer. Size of the amplified products ranged from 250bp to 4500bp. Highest size band was amplified by OPA-12 primer while, OPA-11, OPA-16, and OPB-3 produced smallest band. Similarity between the accessions ranged from 0-78%, maximum (100%) difference was observed among seven pairs of accessions. Dendrogram based on unweighted pair group method of arithamtic means (UPGMA) divided 20 mint accessions into three main clusters and catnip and jangli podina as two distinct accessions. This information could be useful in proper management and expansion of mint germplasm (Sania Kabir *et al.,* 2017). Genetic relatedness was examined among 5 Mentha species (*M. longifolia subsp. typhoides, M.longifolia subsp. schimperi, M. spicata, M. sativa, M. peperita*) distributed in Egypt, using Randomly Amplified Polymorphic DNA (RAPD) analysis. The six decamer arbitrary primers utilized amplified 114 bands, with an average of 19 fragments per primer. The size of the amplified products ranged from 100 bp to 3000 bp. The largest size fragment was amplified by the primer N8, while primers P13 and B12 produced the smallest fragments. Similarity between the species ranged 0.28- 1.00 were observed between the five pairs of species. A dendrogram based on unweighted pair group method of arithmetic means (UPGMA) divided the 5 mentha species into three main clusters. These results may provide useful basic knowledge needed in mint germplasm management and expansion as well as breeding programs (Ibrahim, 2017).

Peppermint and spearmint clones derived from cobalt 60 gamma irradiation and peppermint seed fertile clones and hybrids were evaluated for resistance to Verticillium dahliae in inocula-tion tests in the greenhouse. Mutant and fertile clones and hybrids varied significantly for wilt resistance. One peppermint mutant clone, three peppermint hybrids, and four peppermint fertile clones had low but varying wilt-severity values. Native spearmint and mutant lines derived from native spearmint had high levels of resistance. The wilt-severity scale used to assess disease levels was correlated with the number of CFU of V. dahliae from inoculated stems (Johnson and Cummings, 2000). The U.S. essential mint oil industry requires sexually reproducing germplasm to insure its long-term sustainability. A lack of genetic diversity and clonal-reproduction in cultivated commercial mints combine with multiple risk factors, such as disease and abiotic stress sensitivity to threaten the continued production of this important specialty crop. Peppermint and spearmint are sterile polyploid hybrids that are not amenable to conventional breeding for crop improvement. The barriers to reproduction in this crop are not entirely understood, but a failure in meiosis due to a lack of paired chromosomes is one of the main impediments. By testing genome size in mint, we are able to estimate chromosome copy number and will be able to manipulate genetic material to enable breeding and improvement of mint for the first time. An alternative mechanism to improve sterile vegetatively propagated crops is transgenic manipulation, or genetic engineering. This is possible in mint and multiple transgenic mint plants have been made. For this method to be useful in the improvement of mint the genes introduced into the mint genomes need to be stably expressed year after year of vegetative propagation. We do not yet know whether transgenes in cultivated mints, which are both species hybrids and polyploids, are subject to periodic silencing or are faithfully and stably expressed over multiple cycles of propagation. We will determine the expression stability, and the mechanism of any identified instability in this crop to allow scientists and growers to make educated decisions about future improvement efforts. Genetic improvement of mint is necessary for the long-term sustainability of this important U.S. specialty crop. Without these approaches there is little hope for varietal improvement or the survival of the mint industry in the U.S. (USDA, 2024).

BREEDING

Germplasm: The Mentha collection of the USDA, NCGR in Corvallis, Oregon, includes representatives of approximately 450 accessions of 13 species and 10 hybrid species plus cultivated types. This working genebank maintains the primary collections as plants in containers in greenhouse or lath house environments. Most of these plants represent diverse wild species collections from 57 countries. Most mints in this collection were originally donated to the USDAfromDr. Merrit J. Murray, breeder at A.M. Todd Company, Kalamazoo, Michigan, dating back to the 1970s. At that time, the Todd Company decided to discontinue their mint breeding program and donated the collection to Dr. Chester Ellsworth Horner, USDA researcher in Corvallis, Oregon. Dr. Al Haunold assumed responsibility upon Dr. Horner's retirement and subsequently donated the collection to the NCGR in the mid-1980s. At present, 216 mint accessions at the NCGR are species or advanced breeder selections originally donated from M. J. Murray. Other representatives of diverse mint taxa including wild accessions have since been obtained from breeders and taxonomic collaborators in the US, Australia, New Zealand,Europe, and Vietnam. Besides maintaining diverse species representatives, the NCGR collection includes advanced breeder lines, cultivar and germplasm releases, and what are referred to as

"donor-named selections," where the NCGR has kept the names provided by donors (Vining *et al*., 2020). Germplasm acquisition is the first step in a germplasm management program. Germplasm can be collected indigenously as well as introduced from exotic sources. The availability of genetic variety, existing collections, the risk of gene erosion, the economic significance of the crop, and breeders' needs are considered when determining the priorities for germplasm collection. MAP collection of MAPs received relatively less importance than field crops in India and worldwide. Further, only a small (Gupta *et al*., 2023). Like any crop that is important to the economy, the development of improved lines depends on preserving diversity. Field mint is often grown vegetatively and is amenable to clonal selection techniques. To provide a uniform, consistent quality of the economic product, conservation is required to maintain the state of the lines. Genetic resources are a part of the biological diversity that integrates the least or the genetic diversity within species (Gupta *et al.,* 2023).

Breeding

The present invention relates to a mint cross-breeding method. The mint variety with high yield, better resistance, high oil yield and high menthol content is used as the seed-parent. Mint hybrid seeds can be obtained through castration, pollen collecting and pollination. The obtained hybrid mint plants are performed with individual plant selection, and good individual plants that accord with breeding objects are performed with asexual propagation. By using the cross-breeding method of the present invention, the seeds producing ability is high, the maturity degree of the obtained seeds is high, and the method is suitable for the breeding of new variety of min (Patents, 2024). The invention discloses a breeding method of a new variety of mint with high essential oil content, which comprises the following steps:

- Hybridizing 68-7 serving as a female parent and 73-8 serving as a male parent to obtain a batch of hybrid seeds;
- Seeding in next spring to obtain hybrid seedlings, observing the growth potential of each plant, measuring the agronomic characters of the plants, extracting mint oil, detecting the quality of the oil and screening out good plants; and
- Expanding propagation by use of the underground rhizome, further observing and measuring the agronomic characters of the plants, extracting mint oil, detecting the quality of the oil and screening out good strain. The screened-out good strain has the advantages of vigorous growth, high grass yield, high oil yield, good mint oil quality and relatively strong stress resistance (Patents, 2024b).

Varieties: An improved variety of menthol mint (*Mentha arvensis*), christen as "CIM-Kranti", has been developed through half-sib progeny selection from the parent variety 'cv. Gomti'. The new variety is cold and frost tolerant and has the potential to produce higher oil (10-12%) i n summer cropping season when compared to all other popular commercial cultivars of menthol mint. More importantly, during winter season (September – January) also when all other mint varieties suffer senescence due to cold and frost conditions, 'CIM-Kranti remains green in the field and grows vigorously to yield two to three times more essential oil and (100 kg/ha) along with sucker production (250-300 q/ha). This plant is distinct in terms of leaf morphology and DNA profile and can be propagated vegetatively to maintain uniformity. Hence, this newly developed variety is suitable for commercial cultivation of menthol mint to generate additional income to farmers without any additional input for cultivation during winter besides its usual cultivation as a summer crop (Bahl *et al.,* 2013).

Kosi: The high-yielding variety Kosi developed through half-sib progeny selection, is tall with robust growth and wider adaptability in different parts of the country. The variety is early maturing by about 10 days, and the essential oil is containing 75–78% menthol. On an average it gives 100-125 q/acre herb yield with oil content of 0.6–0.7%. It gives the highest herb and oil yield when harvested at 150 days after planting. The per capita productivity of a superior variety *Kosi*, enabled farmers to take this crop as a bonus between *Rabi* and *Kharif* (Suryavansh *et al*., 2021).

CIM-Saryu: Another high-yielding variety developed with large canopy and huge biomass. The leaf fall is less as compared to other varieties and is also tolerant to sudden rainfall at maturity. The variety yields 140–150 kg essential oil /ha containing 78–80% menthol (Suryavansh *et al*., 2021).

CIM-Kranti: The improved variety 'CIM-Kranti' of menthol mint has been developed through half-sib progeny selection. The variety is cold and frost tolerant and has the potential to produce higher oil (ffi100 kg/ha oil having 80% menthol) when grown in winter compared to all popular commercial varieties. However, during winter (September to January) when all other varieties suffer senescence by the cold and frost conditions, CIMKranti remains green in the field. During this period, the variety CIM-Kranti growing vigorously yields two to three times higher essential oil, compared to the popular commercial varieties Kosi and CIM-Saryu. The oil yield during the main summer crop from this variety is 10–12% higher compared to the best check varieties. Hence, this variety is suitable for commercial cultivation to generate additional income without any extra input during both winter and summer seasons (Suryavansh *et al*., 2021).

CIM-Vishisht: The variety CIM-Vishisht rich in pulegone was developed through a half-sib progeny selection in menthol mint cultivar, Shivalik. The new variety has the potential of yielding 60 kg/ha of essential oil rich in pulegone in the range of 65–68%. The pulegone has wide usage in aromatherapy, flavouring agents, perfumery, etc. and also can be chemically converted into some other important compounds like menthone, carvone or thymol and into high value commercially important menthofuran through biotransformation. Therefore, this new variety CIM-Vishisht will be helpful in opening new avenues for industry and research (Suryavansh *et al*., 2021). Some of the prominent varieties of mint developed by CSIR include: Sambhav, Ganga, Damroo, Neerkalka, CIM-Indus, CIM-Patra, Anant Carvomint, and CIM-Madhuras. Neerkalka is a hybrid mint plant developed by employing sexual crossing between *Mentha arvensis* and *Mentha spicat.* It has high oil yield and shows combined characteristics typical of both parent plants. Another CSIR developed variety of mentha, CIM-Indus contains menthofuran, one of the major aromatic constituents of the essential oil extracted from the leaves of *Mentha piperita*. Another high menthofuran containing mint genotype is CIM-Patra, which is an ideal candidate for commercial utilization. Yet another CSIR developed variety of sweet smelling peppermint *(Mentha piperita)* christened CIM-Madhuras produces characteristic essential oil having medicinal, therapeutic and beverage properties (Suryavansh *et al*., 2021). Himalaya, Kalka, Shivalik, Kosi, Gomati, EC-41911, Kulkrail, Kiran, MSS-1, MSS-5 Punjab spearmint-1, Hybrid-77, Saksham and Kushal (Davuniversity, 2024; Niftem, 2024; NHB, 2024; Smpbodisha, 2024).

Uses

Mint is used in cosmetics, culinary purposes, flavouring and perfumery. Mints, the evergreen herb (foliage), on distillation yield essential oils containing a large variety of aroma-chemicals in varying composition. These oils and their aroma-chemicals in pure form command a large and world-wide demand in trade. By and large, Japanese mint, peppermint, spearmint and bergamot mint are extensively cultivated for their oil and aroma-isolates like menthol, carvone, linalyl-acetate and linalool for use in pharmaceutical, food flavour, cosmetics, beverages and allied industries. In recent years, a number of minor constituents of these oils have also come to generate demand for several uses (Kumar, 2024). Mint leaves are used fresh or dried to make teas, jams and desserts. Essentila oil can be extracted from the leaves and is used as a flavouring (Plantvillage, 2024a). High quality Mint makes for a phenomenal herbal tea. Sacred Blossoms high quality herbal teas that include Mint are; Angel, Turtle, Breathe, and of course our famous pure Chocolate Peppermint. Our local farming friends also provide high quality mint products such as foot cream, herbal throat spray and breath mints (Sacred, 2024).

Mint tea: Peppermint tea is often used to settle the stomach and aid digestion, and may help in the treatment of stomach ailments and digestive problems such as irritable bowel syndrome and constipation. Mint tea is also used to relieve stress and aid sleep. Peppermint in particular helps to relieve stress-related symptoms such as migraine, headaches and stomach upsets. Peppermint tea has a number of other benefits, including curing nausea, relieving menstrual cramps and other muscle spasms, soothing skin rashes, boosting alertness, and even controlling herpes simplex. It also acts as a strong diuretic. The antioxidant properties of water extracts of various Mentha species are also of interest. It was observed that the antioxidant properties were directly related to the phenolic contents of the extract, with M. piperita extract displaying the strongest effect (Taneja and Chandra, 2012).

Mint as a Functional Ingredient: As a condiment and salad dressing known as chutney, mint is frequently used. They grind various spices, including fennel seeds, black salt, black pepper, and chillies, along with the mint, into a paste that includes onion, garlic, ginger, tomato, raw mango, and other vegetables. In pharmaceutical therapies and as a spice, Mentha piperita, popularly known as peppermint, has a reasonably long history of safe use. Among the peppermint's powerful and beneficial constituents are menthyl esters, dimethyl sulphide, cadinene, amyl alcohol, acetaldehyde, pinene, pugelone, phellandrene, and limone. The mint has isolated amounts of several different compounds with potential health benefits, including alpha- and beta-thujone, alpha-pinene, terpinolene, sabinene, gamma-terpinene, fenchone, citronellol, and ocimene. In traditional medicines, mint has a reputation for providing relief. This liquid is the essential oil and better known as peppermint oil, with menthol as its principal constituent (Arshad *et al.,* 2023).

Constituents of Mint: Mint contains various chemical compounds that contribute to its flavor and properties, including: Menthol: Responsible for the cool, refreshing sensation associated with Mint, this constitute is known to change the way the brain registers pain and taste. Menthone: Structurally related to menthol its another compound contributing to Mint's flavor and aroma. Pulegone: An organic compound found in many plants, it is classified as a monoterpene. Cineole (Eucalyptol): Traditionally used as a cough suppressant this constitute is known to help support purification. Volatile Oils: Also responsible for some of the aromatic qualities (Sacred, 2024). Pudina leaves or mint leaves are nutritious. They contain various nutrients and have no sugar. As per the United States of Agricultural Research (USDA), the nutritional value of mint leaves is good. 100 gm of mint leaves contains 3.75 gm of protein, 70 Kcal of energy, and 8 gm of dietary fibre (Ambatkar, 2024).

Health Benefits of Mint Leaves (Ambatkar, 2024).

Pudina has a variety of qualities that make it a possible treatment for a variety of illnesses. The following list includes some possible pudina benefits or uses of mint:

Pudina Helps in Indigestion: Additionally useful for treating indigestion and upset stomach, mint may also help with other digestive issues. When food remains in the stomach for a long period of time before moving on to the remainder of the digestive system, it can cause indigestion. When taken with meals, peppermint oil has been proven in numerous trials to speed up the passage of food through the stomach, potentially relieving symptoms of this kind of indigestion.

Pudina Helps in Irritable Bowel Syndrome: An illness of the digestive system that is common is irritable bowel syndrome (IBS). Digestive symptoms like gas, bloating, stomach pain, and changes in bowel patterns are what define it. While dietary modifications and medication are common treatments for irritable bowel syndrome (IBS), studies suggest that using mint leaf oil as an herbal cure may also be beneficial Because menthol relaxes the muscles in the digestive tract, it may help relieve the symptoms of irritable bowel syndrome. Peppermint oil includes this chemical.

Pudina Helps in Diabetes: There are potential advantages to using pudina, or mint leaves, in the treatment of diabetes. Flavonoids and antioxidants found in mint leaves have the potential to help control blood sugar levels. Additionally, they can help increase insulin sensitivity, which is important for diabetics. Additionally, mint leaves give a pleasant flavour and perfume to a variety of dishes and beverages without increasing the number of calories or sugar.

Pudina Helps in Inflammation or Swelling: Pudina, or mint leaves, have long been used for their anti-inflammatory qualities. Pudina leaves contain menthol, a natural analgesic and cooler that helps lessen swelling and inflammation in different body areas. Pudina leaves have the potential to alleviate inflammatory disorders like arthritis, muscle soreness, and joint pain when applied topically or taken internally. Menthol's cooling properties help relieve inflamed tissues and the pain that comes with inflammation.

Allergic reaction: Although it is used in many consumer products, mint may cause allergic reactions in some people, inducing symptoms such as abdominal cramps, diarrhea, headaches, heartburn, tingling or numbing around the mouth, anaphylaxis, or contact dermatitis (Wikipedia, 2024).

Insecticides: Mint oil is also used as an environmentally friendly insecticide for its ability to kill some common pests such as wasps, hornets, ants, and cockroaches (Wikipedia, 2024).

Room scent and aromatherapy: Known in Greek mythology as the herb of hospitality one of mint's first known uses in Europe was as a room deodorizer. The herb was strewn across floors to cover the smell of the hard-packed soil. Stepping on the mint helped to spread its scent through the room. Today, it is more commonly used for aromatherapy through the use of essential oils (Wikipedia, 2024).

Side Effects of Pudina: The following are a few possible side effects of Pudina: Pudina and its essential oils when consumed in typical food quantities are generally safe, with very few reports of adverse consequences. But spearmint can cause allergic reactions in certain people. Pudina used topically is generally safe; adverse reactions are uncommon. Vomiting and diarrhoea may occur if a significant amount of pudina's essential oils are consumed (Ambatkar, 2024). Although there are many pudina benefits, you should be cautious and follow specific safety measures when adding them to your diet or taking them as medicine. The following are important safety measures to remember (Ambatkar, 2024): Take caution when using mint leaves if you are pregnant or nursing a baby. While it's generally accepted that eating small amounts of mint leaves as part of a balanced diet is harmless, using essential oils or supplements containing mint may be dangerous. Before using mint leaves medicinally while pregnant or nursing, speak with a healthcare provider. Before using mint leaves medicinally, check with your doctor if you are taking any prescription drugs to prevent any potential interactions. Young children should use mint leaves, especially the essential oil, with caution. Infants and small children shouldn't be given mint essential oil internally since it may have negative effects or respiratory discomfort. Use mint leaves sparingly and watch for any negative reactions when incorporating them into dishes intended for young diners.

Potential Risks: Because mint is an herbal remedy, you should consult with your doctor before taking it or any other supplement. Still, mint is safe for most people, and consuming it doesn't typically cause side effects. Allergies to mint are uncommon. In people who are allergic to mint, an interaction with the herb can trigger asthma symptoms. For this reason, people who are allergic to mint should avoid it completely. Other may issues include (WebMD, 2023).

The Oil Mainly Used in Perfume Industry: For the past four decades, mints are commercially cultivated in India. Of these, the Japanese Mint, yielding menthol is grown extensively in northern India. Other major producing countries are China and Brazil and to a smaller extent in Thailand and Vietnam. Commercial or hybrid (Niftem, 2024).

CULTIVATION

Propagation: Mint is a rapidly growing plant which is very easy to grow. It is best grown in partial shade to full sun and is generally very hardy, tolerating temperatures down to -29°C. Care should be taken with variegated varieties which may scorch in full sun. Mint is very fast growing which can lead to it invading gardens quickly unless controlled. The best soils for planting mint are rich and moist with a slightly acidic pH between 6.0 and 7.0. Mint is readily propagated from seeds, cuttings or by dividing an established plant. Seeds should be planted in the Spring or in the Fall in areas that are free from frost. Seeds should be sown to a depth of 6 mm. Seedling should be thinned after emergence such that the plants are spaced 46 to 61 cm apart. Established mint can be easily divided for transplanting by taking some branches along with a portion of root. Many people choose to keep mint in containers or sink the containers into the ground when planting to prevent mint from spreading uncontrollably. Mint is very vigorous and should be pruned regularly to keep the plants in check. Remove any unwanted runners and pinch the tips of the plants back regularly. Mint may be fertilized in the Spring with a slow release fertilizer to supply it with nutrients throughout the growing season. Pinch of any flowers that form to conserve the flavor of the leaves. Essential oil content is reduced during bloom. In areas with mild winters, mint can be moved to a sheltered area of the garden to overwinter, otherwise the plant can be cut to the ground in the Fall. Container grown mint plants can be brought indoors. Mint leaves can be harvested as soon as the plants have reached 8 to 10 cm in height. Cut leaves and stems with a sharp knife or scissors. If harvesting whole stems, cut the stem at about 2.5 cm from the soil line (Plantvillage, 2024a).

Cultivation: It is a matter of investigation that inspite of claims of high herb yield, oil yield and menthol content in the oil, the farmers have reaped on an average 1200kg. of oil per ha. for more than last two decades showing a marginal increase over these years. Mint can be propagated vegetatively through stolons and runners. By and large, most area under the crop is propagated by planting live juicy 8 to 10 cm. long stolons (underground stems) during early spring season. The seed rate used is 400-450 kg. of stolons per ha. and the spacing varies from 40 to 60 cm., depending upon soil fertility and the kind of the intercultural implements used. In northern India, planting of Japanese mint is suitable from first week of February to second week of March. The plot should preferably be the best piece of land. It should be given high level of FYM during land preparation. Around 200 sq.m. plot is required to produce stolons for 1 hectare. Mature plants of chosen variety brought from a reliable nursery should be planted at 30 X 30cm (NHB, 2024). The nursery for the stolons is planted in August. The nursery is given frequent irrigation avoiding stagnation of water. Stolons are produced in autumn and are ready for use during the months of January to March. To obtain the stolons , the soil is opened manually or mechanically. These stolons can be used immediately or within a fortnight or so. The field should be ploughed and harrowed thoroughly and divided into beds of suitable size to facilitate irrigation and make it free from weeds and stubbles. In each bed, lines are opened at a distance of 40 to 60 cm depending upon the variety and inter-culture implement used. The furrows are opened about 5 to 6 cm deep manually or through tractor driven harrow. Within a furrow, stolons are placed in rows at 10 cm. distance and furrows are closed with top soil. The bed is irrigated immediately after placing the stolons (NHB, 2024). On an average, 4 quintals of stolons are required for planting in one hectare of land. The stolons sprout in about 2 to 3 weeks when planted in February. Generally the planting should be done early depending upon ground temperature. Ten irrigations are given during summer season at intervals of 10-12 days whereas another 4-6 for autumn crop harvested in late October. In order to obtain luxuriant growth, sufficient fertilizers and water must be applied to mint crop. A minimum water of about 100 mm is required to obtain good crop yield. Water logging during rainy season should be avoided by providing adequate drainage. In case of heavy soils and the soils prone to water logging, it is preferable to cultivate mint on ridges. The frequency of irrigation can also be reduced by 25% through the application of leaf mulches @ 5 t/ha. The recommended dose for chemical fertilizers is Nitrogen 120 kg, phosphorus 60 kg and potassium 40 kg per ha. The entire quantity of P and K along with one-fifth of N is mixed with the soil at the time of planting, the remaining four-fifth of N is given as top-dressing twice for each harvest in available split doses. About 20 tonnes of well-rotten FYM, 150 kg DAP and 100 kg MOP per hectare are applied at the time of planting. Subsequently, half of N in the form of calcium ammonium nitrate or urea is applied in 2 split doses at 30 and 60 days after planting and similar quantities for ratoon crop at 25 days and 45 days of the harvest (NHB, 2024). By and large, 4 to 14 weeks after planting is crucial period for weed control. The crop requires intensive weeding and this is the most expensive cultural operation which contributes to a higher yield of the crop. Weeding with hand or mechanical hoes within the first six weeks of planting does control weeds.

This process can be repeated once and rarely twice at an interval of about two to three weeks, after the first weeding. Since weeding and hoeing accounts for 30% of the cost of cultivation, use of wheel hoes either driven by hand or bullock drawn helps in reducing cost on interculture. Several pre-and post application of weedicides are recommended but these weedicides cannot control monocot weeds after the rainy season. Therefore best method is to combine manual, mechanical and chemical methods. Some of the effective herbicides includes Oxyflurofen (0.5 kg a.i. / ha), Pendimethalin (0.75 a.i. / ha), Simazine and Atrazine (1 kg a.i. / ha). The best procedure is to first apply a weedicide followed by manual or mechanical weeding at 8 to 10 weeks when mulching should also be applied. The rotation of mint crop with other food crops is found to be a good way of controlling weeds. Continuous cropping of any of the mints is not advisable.The best rotaion is Mint : Rice and Mint : Potatoes and Mint : Vegetables : Peas etc. depending upon cropping system followed in the region (NHB, 2024).

Harvesting and Yield: The crop planted through stolons in January and February is harvested twice i.e., in June and October months. It is harvested at flowering on dry sunny days. The crop maturity is determined by distillation of crop sample in Clevenger's apparatus. If it gives is reached in 105-110 days of sprouting for first harvesting and 80-90 days after the first cut is taken for the second crop. The crop is cut 10 cm above through sickle and left in the field for 4-6 hr for wilting. It loses 50% of its moisture and then chopped into small pieces and distilled in a steam distillation unit. Harvesting on cloudy or rainy day decreases menthol content in its oil significantly. An average of 30 tonnes/ha of herbage yield in 2 cuts is takes in a year, producing 150 kg of oil. Higher yields are obtained from a well-managed plantation. The oil, golden-yellow in colour, is a mobile liquid, contains 70-80% menthol. The oil is dried of adhering moisture and stored in aluminium or mild steel containers. Filled up to the brim and stored in a dry cool godown. The first crop is harvested after 100-120 days of growth and the second harvest in about 80-90 days following the first harvest. The fresh herbage at harvesting stage contains 0.5 to 0.68% of oil and is ready for distillation after wilting for 6-10 hrs. The wilted crop is cut 10cm. above the ground by means of a sickle on bright sunny days, since harvesting on cloudy or rainy days decrease the menthol content in the oil. The average yield is 20 tonnes of fresh herbage per ha. in two harvests, which, in turn, yields around 250 kg. of oil in a year (Niftem, 2024).

Plant protection (Suryavansh *et al*., 2021).

Insect pests

- Termite (*Odentoterms obseus*): Termites attack the underground parts of the plants and damage the roots
- and the stems of mentha.
- Cutworm (*Agrotis* spp.): Cutworms cut the young plants at the ground-level. They remain hidden near the base of the plants during day-time.
- Jassid and Whitefly: The attack of these sucking pests adversely affects the plant growth and oil content.
- Hairy caterpillars: Hairy caterpillars, if appearing in an epidemic form, cause serious damage by feeding on the leaves and the tender stems. When young, they feed gregariously. The grown up caterpillars may migrate from one field to another.

Diseases: Root rot and Stem rot (*Rhizoctonia bataticola*): The infected portion shows brown lesions which turn dark and later increase in size. The leaves wither and die. Infected plants should be uprooted and destroyed. Planting stock should not be from an infected field. Mentha farming should be avoided year after year in the same field.

Post Harvest Management

Storage of Harbage: Mint herbage should be shade dried for about a day before it is distilled. Care should be taken so that decomposition of the herbage does not initiate during the drying process. There would be some reduction in oil yield if wilted herbage crop is stored for a longer period of 2-3 days. As such, storage of herbage for a longer period is not recommended (Niftem, 2024).

Distillation: The recovery of oil from the herb is 0.5-0.8%. Oil is obtained through steam distillation. The oil is of golden yellow colour, containing not less than 75% menthol. The duration of steam distillation is 2-2.5 hours for complete recovery of the oil. About 80% of the oil is received in the receiver in about one hour's time. The oil that is received later is richer in menthol. The fresh or semi dried herbage is placed in a tank and treated with passing steam under pressure. The steam that comes out of the tank is then passed through a condenser. The condenser receiving the steam, carrying the oil extracted from the herbage in the tank is kept constantly cool by circulating cold-water over/around it. The condensed oil and water mixture is collected in a receiver. Since the water and oil have different densities, oil floats on the surface of the water in the receiver. The oil is skimmed off and collected (Niftem, 2024).

Purification of Oil: The oil that is skimmed off must be cleaned of traces of water that it may carry. For this purpose, a separator funnel is used. Treating with anhydrous sodium sulphate and decanting removes any remnant moisture in the oil. The whole process is highly critical. Steam rectification process may be applied in case the colour of the oil changes due to rusting (Niftem, 2024).

Storage and Packaging of Oil: PVC drums of good quality (20-200l capacity) and galvanized iron (GI) drums or aluminium containers are suitable for short-term and long-term storage respectively. The containers should be kept in cool and dark place (Niftem, 2024).

Mint and Mint Product Processing: Mints belong to the genus Mentha, in the family Labiatae (Lamiaceae) which includes other commonly grown essential oil-yielding plants such as basil, sage, rosemary, marjoram, lavender, pennyroyal and thyme. Within

the genus Mentha there are several commercially grown species, varying in their major chemical content, aroma and end use. Their oils and derived aroma compounds are traded world-wide (Niftem, 2024).

REFERENCES

Ahmad, R.S., *et al*., 2020. Introductory Chapter: *Mentha piperita* (a Valuable Herb): Brief Overview. From the Edited Volume Herbs and Spices. Edited by Muhammad Akram and Rabia Shabir Ahmad

Alimentarium. 2024. Mint. https://www.alimentarium.org/en/fact-sheet/mint

Ambatkar, N. 2024. Pudina Leaves Health Benefits, Nutritional Value, Uses and Much More!. https://www.truemeds.in/blog/pudina-leaves-health-benefits-and-uses

Arshad, M.K., *et al*., 2023. Mint (Mentha): A Herb and Used as a Functional Ingredient. Scholars International Journal of Traditional and Complementary Medicine, 6(3): 38-52.

Bahl, J.R., *et al*., 2013. Registration of a high yielding cold-tolerant menthol mint variety-CIM-Kranti of *Mentha arvensis.* Journal of Medicinal and Aromatic Plant Sciences, 35(3-4): 184-189

Civilwar. 2021. Civil War Medicinal Herb Garden – How Mint Was Used As A Remedy. https://www.civilwarmed.org/mint

Davuniversity. 2024. Mentha (Mint). https://www.davuniversity.org/images/files/study- aterial/Medicinal%20and% 20aromatic% 20crops.pdf

Green. 2024. The secret to healthy, pollinated flowers: the mint plant. https://be.green/en/blog/the-secret-healthy-pollinated-flowers-the-mint-plant

Gupta, S., *et al*., 2023. Industrial mint crop revolution, new opportunities, and novel cultivation ambitions: A review. Ecological Genetics and Genomics, 27(3): 100174 https://www.sciencedirect.com/science/article/abs/pii/S2405985423000150

Hocking, D. 2007. Mint growing. https://www.dpi.nsw.gov.au/agriculture/horticulture/vegetables/commodity-growing-guides/mint-growing

Ibrahim, H.M.M.. 2017. Assessment of Genetic Diversity and Relationships of Five Mentha Species Using RAPD Marker. Current Science International, 6(2): 271-277

Ikeda, N. and Ono, S. 1991. Cytogenetics of the Genus *Mentha.* In: Developments in Plant Genetics and Breeding, Volume 2, Part B, Pages 565-580

Johnson, D. A. and Cummings, T. F. 2000. Evaluation of mint mutants, hybrids, and fertile clones for resistance to Verticillium dahliae. Plant Dis., 84:235-238.

Kippes, N., Tsai, H., Lieberman, M. *et al.* 2021. Diploid mint (*M. longifolia*) can produce spearmint type oil with a high yield potential. Sci Rep., 11: 23521 (2021). https://doi.org/10.1038/s41598-021-02835-6

Kokkini,S., *et al*., 2003. herbs | Herbs of the Labiatae. In Encyclopedia of Food Sciences and Nutrition (Second Edition), 2003

Kumar, P. 2024. Microsoft Word – Mints. https://www.academia.edu/36397825/Microsoft_Word_Mints

Lal, R.K. 2013. Adaptability patterns and stable cultivar selection in menthol mint (*Mentha arvensis* L.). Industrial Crops and Products, 50: 176-181

Lianah, L., *et al*., 2023. Chemical characterization of mint (Mentha spp.) germplasm from Central Java, Indonesia. Biodiversitas 24: 4307-4313.

Mint. 2008. https://academics.hamilton.edu/foodforthought/Our_Research_files/mint.pdf?q=the-mint-plant-and-its-uses

Mishra, S. 2023. Mint: Facts, uses, benefits and tips to grow and care. https://housing.com/news/mint/?gad_source=1&gclid=Cj0KCQiAlsy5BhDeARIsABRc6ZutYVEC3PNQe0K9RUfISRvNb3

NHB. 2024. Mint. https://www.nhb.gov.in/Horticulture%20Crops/Mint/Mint1.htm

Niftem. 2024. Reading Manual for Mint and Mint Product- Processing Under PMFME Scheme. National Institute of Food Technology Entrepreneurship and Management Ministry of Food Processing Industries. http://www.niftem.ac.in/site/pmfme/lmnew/mintwriteup.pdf

Patel, A. 2022. An introduction of Mint. ResearchGate. *https://www.researchgate.net* › publication › 36290990...

Patents. 2024. Mint hybridization method. https://patents.google.com/patent/CN101455175A/en

Patents. 2024a. Hybrid mint plant named 'Neerkalka'. https://patents.google.com/patent/USPP12030P2/en

Patents. 2024b. Breeding method of new variety of mint with high essential oil content. https://patents.google.com/patent/CN104488697A/en

Pearson, K. 2024. 8 Health Benefits of Mint. https://www.healthline.com/nutrition/mint-benefits#TOC_TITLE_HDR_10

Petruzzello, M. 2024. Mint. The Editors of Encyclopaedia Britannica. https://www.britannica.com/plant/Mentha

Plants. 2024. *Mentha spicata* . https://plants.ces.ncsu.edu/plants/mentha-spicata/

Plantvillage. 2024a. Mint. https://plantvillage.psu.edu/topics/mint/infos

Prakash, O., *et al*., 2016. Mint (*Mentha spicata* L.) Oils. Pp 561-572. In Essential Oils in Food Preservation, Flavor and Safety

Rankel, K. 2024. Ultimate Guide to Pollinating Indian Mint. https://greg.app/pollinate-indian-mint/

Regina. 2024. Types of mint: refreshing types & varieties for the garden and balcony. https://plantura.garden/uk/herbs/mint/types-of-mint

Sacred. 2024. Mint - Benefits and How to Grow(*Mentha spp.*). https://www.sacredblossomfarm.com/mint

Sania Kabir, Riffat Tahira, Muhammad Naeemullah and Atif Jamal. 2017. Molecular Characterization of Genetic Diversity of Mint Gene Pool through RAPD Markers. International Journal of Agriculture Innovations and Research, 2(4): 271-277

Siddique, H., *et al*., 2024. Genetic Diversity and Phylogenetic Study of Genus Mentha From Hazara Region, Khyber Pakhtunkhwa, Pakistan. Journal of Population Therapeutics and Clinical Pharmacology, 31(2), 2598-2606.

Smpbodisha. 2024. Standard Cultivation Procedure For Pudina. https://smpbodisha.in/admin/data/ckeditor/images/100520222990149144_Pudina.pdf

Sobti, S.N. 1965. Chromosome Numbers in Species of Mentha. https://www.ias.ac.in/article/fulltext/secb/062/03/0145-0148

Suryavanshi, P., Kumar, D. and Mazeed, A. 2021. Menthol mint cultivation - Step towards Atmanirbhar Bharat. Indian Horticulture, 66(2): 10-13. https://epubs.icar.org.in/index.php/IndHort/article/view/114656

Tafrihi, M., *et al*., 2021. The Wonderful Activities of the Genus *Mentha*: Not Only Antioxidant Properties. Molecules, 26(4):1118. doi: 10.3390/molecules26041118

Taneja, S.C. and Chandra, S. 2012. Mint. Pp 366-388. In Handbook of Herbs and Spices (Second Edition), Volume 1, 2012

Touwaide, A. and Appetiti, E. 2023. Herbs in History: Mint. https://www.ahpa.org/herbs_in_history_mint

USDA. 2024. Genetics and Breeding of Mint. Purdue University. https://reeis.usda.gov/web/crisprojectpages/0223587-genetics-and-breeding-of-mint.html

Vikaspedia. 2023. Excellent Health Benefits of Mint. https://vikaspedia.in/health/ayush/ayurveda-1/ayurvedic-herbal-healing/excellent-health-benefits-of-mint

Vining, K.J., *et al*. 2020. Crop Wild Relatives as Germplasm Resource for Cultivar Improvement in Mint (Mentha L.). Front. Plant Sci. 11:1217. doi: 10.3389/fpls.2020.01217

Wani, S.A., *et al*. 2022. Mentha: A review on its bioactive compounds and potential health benefits. In: Quality Assurance and Safety of Crops & Foods. https://qascf.com/index.php/qas/article/view/1129/1115

WebMD. 2023. Health Benefits of Mint Leaves. https://www.webmd.com/diet/health-benefits-mint-leaves

Wikipedia. 2024. Mentha. From Wikipedia, the free encyclopedia. https://en.wikipedia.org/wiki/Mentha

****