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Phytochemical Composition of Mint (*Mentha*), its Nutritional and Pharmacological Potential

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ABSTRACT: *Current studies were made to investigate the phytochemical, nutritional and medicinal importance of the mint plant. Mint plantgenerally contains menthol (40.7%), menthone (23.4%), methylacetate (0.7-23%), eucalyptol (1-13%), carveol (0.31%), piperitone (3.20%) and fiber (1.75%±0.1). The important nutritional contents include iron (0.262%), calcium (0.158%), phytic acid (0.00092%), proteins (0.6%), vitamin E (9.89±0.15%), ascorbic acid (0.96±0.06%) and axerophthol (0.426±0.05%). Mint is one of most familiar plants that iswidely cultivated throughout the planet. The plant finds immense importance in the pharmaceutical and food industry. The plant also finds colossal applicationsas anti-microbial, anti-oxidant, anti-bacterial and anti-inflammatory agent. The promising capability of the plant towards the field of therapeutic drugs development has been widely investigated.*

Keywords: *Mint, Phytochemistry, Nutritional Importance, Pharmacological Potential, Mineral contents*

INTRODUCTION

Plants find an immense significance due to their nutritional (Rehman and Adnan, 2018; Naseer et al., 2019) and medicinal (Rehman et al., 2018; Saeed et al., 2020) applications and they are widely investigated for the same reason (Kamran et al., 2020; Hussain et al., 2021). *Mentha piperita* (peppermint) is a common medicinal plant which possesses numerous health benefits for human beings and has received a greater attention from pharmaceutical as well as food industries (Loolaie et al., 2017). Itis a sterile hybrid of spearmint (*Mentha spicata*) and water mint (*Mentha aquatica*) (Murray et al., 1972). Mintplant (Fig. 1) belongs to the family “Lamiaceae” and is widely cultivated almost everywhere. The plant finds extensive applications in mint-flavored consumer products, food, confectioneries and in herb tea preparations due to its unique sweat smell and flavor. It also finds wide medicinal/pharmaceutical applications due to its antimicrobial, anti-inflammatory, anti-emetic, anti-spasmodic, carminative, diaphoretic and analgesic properties and is used to treat bronchitis, anorexia, flatulence, colitis, nausea, migraines, headaches, anaesthetic, myalgia and liver complaints (Heywood et al., 1978; Foster, 1990; Chevallier, 1996; Lange et al., 2011). The aerial part of peppermint contains oil, synthetic resin, flavonoids, fatty acids, vitamins, minerals and hydroxy acid. The peculiar flavour constituents are synthesized and accumulated in trichomes present on the leaves surface and are responsible for creating a feeling of coolnessin the mouth (Seif et al., 2019).

Keeping in view the world-wide general use of mint in food and other industries, current studies were performed to review it chemical composition, nutritional and pharmacological potential.

Fig. 1. Mint Palnts
(https://www.goodhousekeeping.com/home/gardening/a20705630/how-to-grow-mint/)

DISCUSSIONS

Phytochemical Composition

The term “phytochemical composition” refers to the presence of biologically active compounds in plants. The phytochemicals impart color, flavor and smell to the plants. They also contribute towards impartinga defense mechanismto the plants against diseases (Okwu, 2005). Some studies used SPME-GC/MS (solid-phase micro-extraction coupled with gas chromatography/mass spectrometry), to verify and confirm the presence of monoterpene compounds in flower and leaves of *pipperita*. It was found that peppermint is rich in compounds such asmenthyl acetate, neomenthol and menthol inolder plant parts (basipetal direction), whereas younger plant parts (acropetal direction) were found enriched with isomenthone and menthone. In contrast to the leaves, flowers contain higher concentration of mentho furan (Rohloff, 1999). The analysis of volatile oil of peppermint (*Mentha x piperita L.*) by GC/FID and GC-MS indicates the presence of menthone (23.4%) and menthol (40.7%). The presence of 1, 8-cineole, limonene, menthyl acetate, β-caryophyllene and β-pinenehas also been reported in peppermint plant (Schmidt et al., 2009). Table 1 displayed the proximate analysis of spearmint leaves.

Table 1: Proximate analysis of spearmint leaves (Sulieman et al., 2011)

Parameter	Value
Fiber (%)	6.200 ± 0.003
Carbohydrate (%)	10.39 ± 0.15
Ca (mg/100g)	1.3
Protein (%)	1.75 ± 0.10
K (mg/100g)	2.5
Fat (%)	2.200 ± 0.003
Moisture (%)	76.010 ± 0.033
Na (mg/100g)	7.2
Fe (mg/100g)	24

About 300 various compounds have been identified in peppermint leaves that contain volatile oil. The terpenic category has the foremost outstanding features and is comprised of 9% of sesquiterpenes and 52% of monoterpenes, whereas other groups like lactones (7%), aldehydes (9%), aromatic hydrocarbons (9%), alcohols (6%) and a smaller proportion of miscellaneous components (8%) have also been reported. Among monoterpenes, menthol is a chief component (35-60%) followed by menthyl acetate (0.7-23%), menthone (2-44%), menthofuran (0.3-14%), 1,8-cineole (eucalyptol) (1-13%), isomenthone (2-5%), limonene (0.1-6%)

and neomenthol (3-4%), whereas β-caryophyllene is the major sesquiterpene (1.6-1.8%). Flavor and medicinal properties are owed to the presence of menthol that is a very active constituent, whereas esters like menthyl acetate are

Table 2: Percentage (%) composition of essential oil of *Mentha Piperita* (Ben et al., 2019)

Sr. No.	Compounds	Formula	Retention Time	%
1	Methyl acetate	$C_{12}H_{22}O_2$	16.35	0.68
2	Isomenthol	$C_{10}H_{20}O$	17.29	0.28
3	Limonene	$C_{10}H_{16}$	8.30	8.00
4	Menthol	$C_{10}H_{20}O$	18.25	33.59
5	1,8-cineole	$C_{10}H_{18}O$	8.48	2.80
6	Δ-Cadinene	$C_{15}H_{24}$	21.92	0.27
7	Caryophyllene	$C_{15}H_{24}$	17.33	1.95
8	Carveol	$C_{10}H_{16}O$	19.99	0.31
9	Piperitone	$C_{10}H_{16}O$	19.09	3.20

responsible for minty taste and specific aroma (Riachi and De Maria, 2015). Table 2 shows the percentage (%) composition of essential oil of *Mentha piperita.*

About 98.17% different terpenic hydrocarbons are present in *Mentha piperita*'s leaves. Its various constituents are commercially utilized as flavorer and find applications in pharmaceutical, food and cosmetics industries. Menthol is employed as a staple in toothpowder, confectionary, toothpaste, mouth fresheners, analgesic balms, chewing tobacco, perfumes, cough drops, chewing gums and candies. Tobacco industry consumes about 40% of the entire oil followed by confectionary and pharmaceutical industries (Singh et al., 2015). Mint plants are also rich in microelements. The color of leaves is because of the presence of pigments such as carotenoids and chlorophylls and is one of the important quality indicators. Color parameters are important for freshly cut and processed herbal plants. During processing (drying) of herbs, color changes from bright green to brown due to the degradation of chlorophyll. The degradation results in the loss of magnesium ions and thus the conversion of chlorophyll into pheophytin. Chlorophyll is a green tetrapyrrole pigment which acts as a photoreceptor of sunshine energy during photosynthesis. Chlorophyll content depends upon factors such as water availability, amount of nutrients, candlepower, pollution and vegetation period (Nguyen et al. 2019; Tarasevičienė et al., 2019). There were investigations on the volatile components of essential oils obtained from stolon leaf, stolon stem, shoot leaf and shoot stem of *Mentha ravens* is grown in semi-arid tropical climatic environment. All these oils were found to contain menthol as their major component; its lowest concentration was found in stolon (runner) stem oil (43.7%) while the shoot stem oil contained the highest percentage (78.16%). The stolon (stem and leaf) oils contain α-phellandrene and terpinolene also some significantly considerable amounts of menthol, menthone and limoneneas compared to the shoot oils. The shoot (leaf and stem) oil was found to consist of β-caryophyllene oxide (Rajeswara et al., 1999). No yields of essential oil from the underground rhizomes of corn mint plants have been reported. The occurrence of menthofuran (0.01-0.04%) was determined through coupled gas-liquid-thin-layer chromatography in original essential oils obtained from plants grown in Argentina, Formosa, Brazil, India and Japan (Nigam and Levi, 1964).

M. piperita contains menthyl acetate (2-11%), isomenthone (2-8%), menthofuran (1-10%), menthone (15-32%), terpene (1-7%), menthol (33-60%), and eucalyptol (5-13%). Moreover, *M. piperita* leaves contain rosmarinic acid (59-67%), 19-23% of polyphenols, that embody eriocitrin, hesperidin (6-10%) and luteolin 7-orutinoside (7-12%). *M. Piperita* has alternative bioactive compounds like bitter substances, betaine, carotenes, tannins, vitamin B caffeic acid and topherols (Kamiloglu et al., 2012; Berdowska et al., 2013). Gas chromatography (GC) and thin layer chromatography (TLC) was used to analyze the chemical composition of peppermint oil (Hart and Shears, 1996). Like other medicinal plants, the yield and phytochemicals of peppermint essential oils are influenced by various factors such as environmental conditions, geographical location, and agro-climatic requirements of the crops. The commercial production of peppermint (*Mentha piperita L.*) highly depends on the essential oil composition, ecological conditions and genetic structure affecting yield. The adaptation ability of *M. piperita* depends on the soil conditionand is more favorably grown in temperate climate areas (Ben et al., 2019).

Nutritional Importance

The herbal plants have numerous health advantages which may be attributed to the presence of important nutritional contents. Both the dried and fresh mint samples were found to contain important macro-minerals (magnesium, potassium, sodium and calcium) and micro-elements (copper, iron, manganese and zinc). Generally, both (the dried and fresh herbs) contain larger quantities of Na, Ca, Mg, K and P minerals. However, the mineral composition is higher in the dried peppermint due to an increased quantity of dry matter content. Potassium is the most abundant macro-element present in peppermint leaves. These macro-minerals (Na, Ca, Mg, K and P) are structural elements in tissues and play their role in acid-base balance as well as in cellular and basal metabolism. The trace minerals such as Cu and Zn are considered very important in enzyme, hormone and vitamin activity (Özcan et al., 2005). The important nutritional contents of *P. aromaticus* are displayed in Table 3 (Khare et al., 2011; Rout et al., 2012).

Table 3: Nutritional Content of *P. amboinicus*
(Khare et al., 2011; Rout et al., 2012)

S. No	Principle components	Nutrient Content
1.	Soluble Oxalate	0.02%
2.	Phytic acid	0.00092%
3.	Insoluble dietry fibers	1.56%
4.	Soluble dietry fibers	0.31%
5.	Trace metals	
	+ Iron	0.262%
	+ Zinc	0.0003%
	+ Copper	0.00012%
	+ Chromium	0.000022%
6.	Minerals	
	+ Calcium	0.158%
	+ Phosphorus	0.016%
	+ Potassium	0.138%
	+ Sodium	0.0047%
	+ Magnisium	0.088%
7.	Vitamins	
	+ Ascorbic acid	0.003%
8.	Proteins	0.6%

Minerals are essential to retain the strength of bones and for the normal functioning of heart, kidney, nerves, muscles and heart. The plant contains significant quantity of iron (0.262%) whichis an essential component of hemoglobin. Hemoglobinis responsible to circulate oxygen throughout the body. Hemoglobin carries about 2/3 of the body's Fe and its deficiency results inanemia. Mint is also comprised of total xanthophylls (0.356 mg/g of dry weight of the plant) which include violaxanthin, leutin, zeaxanthinics and neoxanthin. The presence of such ingredients makes *P. amboinicus* an excellent z dietary supplement (Purseglove, 1987).

Plectranthus rotundifolius tubers were reported to contain 4.72% ash, 1.36% lipid and fibre, 5.26% carbohydrate, 5.85% protein and 82.81% moisture. They also showed the presence of significant amounts of Ca, K, Na, Ba, Ag, Sr, Se, As, Ga, Zn, Cu, Co, Ni, Fe, Mn, Cr, Al and Li indicating that *P. rotundifolius* is an excellent source of minerals. The presence of sufficient quantity of antioxidant vitamins (9.89 ± 0.15 mg/g wet weight of vitamin E, 0.96 ± 0.06 mg/g wet weight of vitamin C and 0.426 ± 0.05 mg/g wet weight of Vitamin A) indicates that these tubers may serve as a good source of vitamins; the vitamins due to their antioxidant nature, also have an excellent ability to scavenge free radicals. The antioxidant nature of *P. rotundifolius* tubers is reflected from the presence of significant quantities of antioxidant enzymes such as Glutathione S Transferase (19.68 ± 0.10 units/mg protein), Glutathione Peroxidase (31.97 ± 0.05 units/mg protein), Catalase (0.167 ± 0.16 units/mg protein) and Superoxide Dismutase (0.0651 ± 0.06 units/mg protein). Therefore, it can be concluded that *P. rotundifolius* tubers possess an excellent potential as a good nutritional source (Devi et al., 2018).

Peppermint relationship with nutrients was studied in terms of herb feed and drilling. The influence of NPK in numerous doses on the assembly of seasoning was recorded and an increase in nutrients between 23-86% was found as compared to manage variant (Jeliazkova et al., 1997). The influence of nutrition or plant food has been studied each on healthy and aromatic plants with respect to plant growth, biomass (herb), essential oils amount and the nutrients content (Khalid, 2012). The nutrients management effect on the peppermint production was studied and found that P and K square measure accumulated in peppermint plants throughout the season with a high correlation (R2 = 0.838) for P and (R2 = 0.894) for K (Brown et al., 2003). The influence of nutrients concentration and salinity on some physiological indices and oil production on peppermint and lemon flower was noticed and raised levels of electrical physical phenomenon (EC) and NaCl were reported to have reduced the quantity of biomass in each species studied (Tabatabaie and Nazari, 2007). Influence of atomic number 26 concentration in relation to the volatile oil production in Japanese peppermint was studied by Misra Associate in Nursing Sharma and 5.6 μgL^{-1} of Few as found an optimum concentration. In Japanese mint, the effect of water stress has been additionally studied and a vital reduction in gas exchange, the assimilation space, recent and dry matter content, pigment, carotenoids, micronutrients and volatile oil production was found (Misra and

Sharma, 1991). The individual and combined influence of Fe and atomic number 30 on herbs production and volatile oil in peppermintwas studied and a higher influence of iron compared to othermetal in individual application was determined. The results show that oil content, fresh weight, and chlorophyll content increased by increasing the supply of Iron. The suitable level of Zn supply was determined to be 5 mg Zn kg^{-1} and the optimal level of Fe supply was determined to be 10 mg Fe kg^{-1} (Pande et al., 2007).

Pharmacological Importance

Herbs are ancient sources of drugs, flavoring, beverages, dyeing, cosmetics and fragrances. Therefore, they have attraction for cosmetics, biotechnology, food and pharmaceutical industries. Mint (*Mentha spicata*) and Peppermint (*Mentha piperita*) are among the important members of the "Labiatae" family. It's a vital herb that in the dried form is used as drugs e.g., as a stimulant and carminative. The essential oil of the plant has been reported to demonstrate useful medicinal, insecticidal, antiviral, antifungal and inhibitor properties (Chauhan and Agarwal, 2013). The oil contains larger amounts of 1, 8- cineol, terpene and dihydrocarvone (Hussain et al., 2010). The characteristic smell of flavourer is due to the presence of "carvone" compound. The leaves of peppermint area unit are extensively utilized in herb tea and for cooking purpose to feature flavor and aroma. The essential oil obtained is widely used in food, merchandise, dental, mouthwashes, alcoholic liquors, prescription drugs, cosmetics and soaps. Additionally, it has been found to possess antiseptic, antipyretic, antimicrobial medicine, astringent, medication, stimulating, agent and anti-aging properties (Ali et al., 2002). The distinctive smell and flavor of this asteroid dicot genus species is thanks to its high Menthol content. The essential oil obtained can also be employed as carminative, stimulant, for allaying nausea, ejection, antiseptic and has some additional industrial worth too. The foremost important and abundant elements of the essential oil are isomenthone, menthyl acetate, menthol, menthofuran and menthone. The flavonoids particularly narirutin, luteolin-7-O-rutinoside, isorhoifolin, hesperidin, diosmin, rosmarinic acid and eriocitrin isolated from the plant importantly show anti-allergic effects. Menthone is additionally an important ingredient of the plant (Girme et al., 2006). Besides, the essentialoil depicts antifungal and bactericide properties.

The prime constituents of the oil are: menthofuran, isomenthone, menthone, pulegone and menthyl acetate. The leaves contain isorhoifolin, flavonoid glycosides, eriocitrin, hesperidin, carotenes, choleneluteolin-O-rutinoside and azulenes. Flavoring reduces an internal organ voidance time in dyspeptics. The binary compound and ethyl alcohol extracts exhibit medicinal potential against an extremely contagious infective agent that causesillness of cows as well as showsantiviral activity against rinderpest virus (Badal et al., 2011). Other than its extensive use in the cooking and kitchen, mint is additionally utilized in ancient system of medication and the range of medical activities of mint is broader enough (Šarić-Kundalić et al., 2009). Mint was used as a medicative herb to treat chest pain, gastralgia and its unremarkably employed in the form of tea as a stimulant digester and treats biliary disorders, enteritis, alleviate abdomen pain; dyspepsia, gastritis, viscous acidities, aerophagia, spasms of the bladder, flatulence, epithelial duct and colic (Arumugam et al., 2008; Abbaszadeh et al., 2009; Kunnumakkara et al., 2009).

Antimicrobial Activities

P. amboinicus extract, when transformed to vital oil, contains multitudinous biological components. Phytochemical compounds possessed by mint plants show antimicrobial activity against many microorganisms such asyeast and mould (Sandhya et al., 2011; Negi, 2012; Swamy et al., 2015). Spearmint oils also demonstrate antimicrobial activities against *E.coli* bacteria (Sulieman et al., 2011).

Antioxidant Activities

The volatile oil present in *P. amboinicus* possesses a massive inhibitor property against stress created in cell line induced by carcinoma that possibly isdue to the presence of phytochemicals Carvocrol and thyme camphor (Manjamalai and Grace, 2012). Anti-oxidant activity of lycopene and β-carotene prevents the oxidative stress and increases the biodisposability of vascular nitric oxide (Ciccone et al., 2013).

Antibacterial Activities

Mint essential oils and extracts are successfully being employed in different food product as well as it shows flavor medicament activities against acid ovoraxcitrulli i.e. a bacterium chargeable for watermelon blotch. These results prompt the chance of exploiting the flavorer as an associate in nursing medicament agent to treat contaminated seeds (Choi et al., 2016).

The anti-bacterial activities of peppermint oils are because of menthone and menthol that act against standard antimicrobial agent "Chloramphenicol" (Janssen et al., 1987).

Anti-Inflammatory Activity

The resolvent extract of P. amboinicus shows excellent medicinal activity. The reduced percentages of the paw swelling were noticedin the teams treated with 350 (33%) and 250 (41%) extract of the P. amboinicus. These paw swellings were treated from Indocin, a non-steroidal and anti-inflammatory drugs (Gurgel et al., 2009). The volatile oil from genus "Mentha" specie is employed locally to treat tissue layer inflammation and is also used as an ingredient in analgesic creams. After approval for internal use, the oil from genus Mentha specie is additionally accustomed to treat irritable gut syndrome, duct discomfort and hurting, inflammation of the oral mucous membrane, myodynia, amenorrhoea and period, associate degreed redness, discomfort from emission cramps and is employed as anmedicine (Diop et al., 2016). Table 4 displays the therapeutic effects of various *Mentha* species.

Table 4: Therapeutic effects of different *Mentha*species

Mentha Species	Country	Therapeutic Effect
M. speciata	Brazil	For the discharge of parasitic worms
	India	Carminative, Stimulant, fever antispasmodic. The boiled leaves extract is used to relieve hiccup and as anti-inflammation agent
	Morocco	Leaf and stem extract for tiredness and headache
M. rotundifolia	Iran	For the treatment of intestinal colic and flatulent dyspepsia
	Spain	Hypotensive
	France	Tonic, stomachic, stimulative, anti-inflammatory carminative, choleretic, nsecticidal and sedative
M. piperita	India	Peppermint oil has been used to cure inflammation of the oral mucosa. bowel syndrome and antispasmodic
	Finland	Peppermint uses to cure cough and bronchitis flatulence, irritable bowel syndrome, indigestion,

nausea and vomiting

Mint is additionally used as buccodental bar as its leaves have potencyto discolor teeth. Contemporary mint-leave area units utilized in manduction as mouthwashes reduce animal tissue pain (Lamendin et al., 2004). Mint is employed in creating dentifrices because it provides freshness to breath. A lot of studies are being done on contributions of mint leaves to prevent cavity and plaque and it is a fact that mint leaves extractproduces unfavorable circumstances for microorganism (Balakrishnan, 2015). In addition, peppermint gums facilitate the cleanliness of teeth. Mint oils and their derivatives are also employed as seasoning agents throughout the globe (especially in food), pharmaceuticals, and perfumery. Mint flavor in combination with peppermint and *Mentha arvensis* is the most vital flavour which is used in citrus and vanilla. Mentha plant herbs are cultivated for dry leaves production in Federal Republic of Turkey, Nigeria, Greece, Bulgaria, Spain, Germany, Poland, Egypt, Morocco, Israel, UK, China and Morocco (Alu'datt et al., 2018; Kapp, 2015).

CONCLUSIONS

Mint plant generally contains menthol, menthone, methylacetate, eucalyptol, carveol, piperitone and fiber. The important nutritional contents include iron, calcium, phytic acid, proteins, vitamin E, ascorbic acid, and axerophthol. Mint species have colossal contributions in the production of bioactive therapeutics agents. Because of its aromaticity, the plant possesses great commercial values. It has traditionally been used as a food seasoning and to treat cold and fever. Some of the modern medicinal uses of the plant include its applications to treat gastro-intestinal and cardio vascular disorders. In addition, antimicrobial, anti-ulcer, anticancer, insecticidal, anti-diabetic and anti-inflammatory activities are some of the plethora of its biological potentials and traits. The prime reason of the pharmacological potential of the mint plant is the presence of a wide range of bioactive phytochemicals. Different chemical compounds present in the mint leaves extract open up numerous avenues of its applications in a number of fields such as cosmetics, food and pharmaceuticals. The summarized information in the paper helps to understand the chemical composition of the mint plant as well as its nutritional and pharmaceutical importance.

REFERENCES

1. Abbaszadeh B, Valadabadi SA, Farahani HA, Darvishi HH (2009). Studying of essential oil variations in leaves of Mentha species. Afr. J. Plant Sci., 3(10): 217-221.
2. Ali MS, Saleem M, Ahmad W, Parvez M, Yamdagni R (2002). A chlorinated monoterpene ketone, acylated β-sitosterol glycosides and a flavanone glycoside from *Mentha longifolia* (Lamiaceae). Phytochemistry, 59(8): 889-895.
3. Alu'datt MH, Rababah T, Alhamad MN, Gammoh S, Al-Mahasneh MA, Tranchant CC, Rawshdeh M. (2018). Pharmaceutical, Nutraceutical and Therapeutic Properties of Selected Wild Medicinal Plants: Thyme, Spearmint, and Rosemary Therapeutic, Probiotic, and Unconventional Foods 275-290: Elsevier.
4. Arumugam P, Priya NG, Subathra M, Ramesh A (2008). Anti-inflammatory activity of four solvent fractions of ethanol extract of *Mentha spicata L.* investigated on acute and chronic inflammation induced rats. Environ. Toxicol. Pharmacol., 26(1): 92-95.
5. Badal RM, Badal D, Badal P, Khare A, Shrivastava J, Kumar V (2011). Pharmacological action of *Mentha piperita* on lipid profile in fructose-fed rats. Iran. J. Pharm. Res.: IJPR, 10(4): 843-848.
6. Balakrishnan A (2015). Therapeutic uses of peppermint-a review. J. Pharm. Sci. Res., 7(7): 474-476.
7. Ben HA, Touj N, Hammami I, Dridi K, Sulaiman AA, Hamdi N (2019). Chemical Composition and in vivo Efficacy of the Essential Oil of *Mentha piperita L.* in the Suppression of Crown Gall Disease on Tomato Plants. J. Jap. Oil Chem. Soc. 68(5): 419-426.
8. Berdowska I, Zieliński B, Fecka I, Kulbacka J, Saczko J,Gamian A (2013). Cytotoxic impact of phenolics from Lamiaceae species on human breast cancer cells. Food chemistry, 141(2): 1313-1321.
9. Brown B, Hart J, Wescott M, Christensen N (2003). The critical role of nutrient management in mint production. Better Crops, 87(4): 9-11.
10. Chauhan SS, Agarwal R (2013). Evaluation of antibacterial activity of volatile oil from *Mentha spicata* L. J. drug deliv ther., 3(4): 120-121.
11. Choi O, Cho SK, Kim J, Park CG, Kim J (2016). Antibacterial

properties and major bioactive components of Mentha piperita essential oils against bacterial fruit blotch of watermelon. Arch. Phytopathol. Pflanzenschutz., 49(13-14): 325-334.

12. Ciccone MM, Cortese F, Gesualdo M, Carbonara S, Zito A, Ricci G, De Pascalis F, Scicchitano P,Riccioni G (2013). Dietary intake of carotenoids and their antioxidant and anti-inflammatory effects in cardiovascular care. Mediators inflamm., 2013.
13. Devi V, Aswathy A, Biju P (2018). Nutritional Evaluation of *Plectranthus rotundifolius* Tubers. Trends Biosci., 11(7): 1048-1053.
14. Diop SM, Guèye MT, Ndiaye I, Ndiaye EHB, Diop MB, Heuskin S, Fauconnier ML, Lognay G (2016). Chemical composition of essential oils and floral waters of *Mentha longifolia* (L.) Huds. from Senegal. Am. J. Essent. Oil. Nat. Prod., 4(1): 46-49.
15. Girme A, Bhalke R, Ghogare P, Tambe V, Jadhav R, Nirmal S (2006). Comparative in vitro anthelmintic activity of *Mentha piperita* and *Lantana camara* from Western India. Dhaka Univ. J. Pharm. Sci., 5(1): 5-7.
16. Gurgel APaD, Da Silva JG, Grangeiro ARS, Oliveira DC, Lima CM, Da Silva AC, Oliveira RA, Souza IA (2009). In vivo study of the anti-inflammatory and antitumor activities of leaves from *Plectranthus amboinicus* (Lour.) Spreng (Lamiaceae). J. Ethnopharmacol., 125(2): 361-363.
17. Hart CA, Shears P (1996). Color atlas of medical microbiology: Mosby-Wolfe.
18. Heywood VH, Moore D, Dunkley J, King C (1978). Flowering plants of the world (Vol. 336): Oxford University Press Oxford.
19. Hussain AI, Anwar F, Nigam PS, Ashraf M, Gilani AH (2010). Seasonal variation in content, chemical composition and antimicrobial and cytotoxic activities of essential oils from four Mentha species. J. Sci. Food Agric., 90(11): 1827-1836.
20. Hussain S, Sajjad A, Butt SZ, Muazzam MA (2021). An Overview of Antioxidant and Pharmacological Potential of Common Fruits. Sci. Inq. Rev., 5(1): 1-18.
21. Janssen A, Scheffer J, Svendsen AB (1987). Antimicrobial activity of essential oils: a 1976-1986 literature review. Aspects of the test methods. Planta med., 53(05): 395-398.

22. Jeliazkova E, Zheljazkov V, Craker L, Yankov B, Georgieva T. (1997). NPK fertilizer and yields of peppermint, *Mentha x piperita*. Paper presented at the II WOCMAP Congress Medicinal and Aromatic Plants, Part 3: Agricultural Production, Post Harvest Techniques, Biotechnol. 502: 231-236.
23. Kamiloglu S, Toydemir G, Boyacioglu D, Capanoglu E. (2012). Health perspectives on herbal tea infusions: Phytotherapeutics II (Vol. 43), Chapter: 1, Publisher: Studium Press LLC, USA
24. Kamran M, Hussain S, Abid MA, Syed SK, Suleman M, Riaz M, Iqbal M, Mahmood S, Saba I, Qadir R (2020). Phytochemical composition of *moringa oleifera* its nutritional and pharmacological importance. Postepy Biol. Komorki, 47(3): 321-334.
25. Kapp K (2015). Polyphenolic and essential oil composition of Mentha and their antimicrobial effect. Division of Pharmaceutical Biosciences Faculty of Pharmacy Doctoral Programme In Drug Research University of Helsinki.
26. Khalid KA (2012). Effect of NP and foliar spray on growth and chemical compositions of some medicinal Apiaceae plants grow in arid regions in Egypt. J. soil sci. Plant Nutr., 12(3): 581-596.
27. Khare RS, Banerjee S, Kundu K (2011). *Coleus aromaticus Benth*- A nutritive medicinal plant of potential therapeutic value. Int. J. Pharma Bio Sci., 2(3): B488-B500.
28. Kunnumakkara A, Koca C, Dey S, Gehlot P, Yodkeeree S, Danda D,Sung B. (2009). Molecular targets and therapeutic uses of spices modern uses for ancient medicine. Edited by Aggarwal BB, Kunnumakkara AB: Singapore: World Scientific Publishing Co. Pte. Ltd.
29. Lamendin H, Toscano G, Requirand P (2004). Buccodental phytotherapy and aromatherapy. EMC Dent, 1: 179-192.
30. Lange BM, Mahmoud SS, Wildung MR, Turner GW, Davis EM, Lange I, Baker RC, Boydston RA,Croteau RB (2011). Improving peppermint essential oil yield and composition by metabolic engineering. Proced. Natl. Acad. Sci., 108(41): 16944-16949.
31. Loolaie M, Moasefi N, Rasouli H, Adibi H (2017). Peppermint and its functionality: A review. Arch. Clin. Microbiol., 8(4): 54.

32. Manjamalai A,Grace D (2012). Volatile constituents and antioxidant property of essential oil from Plectranthus amboinicus (Lour). Int. J. Pharm. Biol. Sci, 3: 445-458.
33. Misra A, Sharma S (1991). Critical concentration of iron in relation to essential oil yield and quality parameters of Japanese mint. Soil Sci. Plant Nutr., 37(2): 185-190.
34. Murray MJ, Lincoln DE, Marble PM (1972). Oil composition of mentha aquatica-M. Spicata F1 hybrids in relation to the origin of XM. Piperita. Can. J. Genet. Cytol., 14(1): 13-29.
35. Naseer S, Hussain S, Zahid Z (2019). Nutritional and antioxidant potential of common vegetables in Pakistan. Rads J. Biol. Res. Appl Sci., 10(1): 36-40.
36. Negi PS (2012). Plant extracts for the control of bacterial growth: Efficacy, stability and safety issues for food application. Int. J. Food Microbiol., 156(1): 7-17.
37. Nigam IC, Levi L (1964). Essential Oils and Their Constituents XX: Detection and Estimation of Menthofuran in *Mentha arvensis* and Other Mint Species by Coupled Gas-Liquid—Thin-Layer Chromatography. J. Pharm.Sci., 53(9): 1008-1013.
38. Okwu D (2005). Phytochemicals, vitamins and mineral contents of two Nigerian medicinal plants. Int. J. Mol. Med. Adv. Sci, 1(4): 375-381.
39. Özcan M, Arslan D, Ünver A (2005). Effect of drying methods on the mineral content of basil (*Ocimum basilicum L.*). J. Food Eng., 69(3): 375-379.
40. Pande P, Anwar M, Chand S, Yadav VK,Patra D (2007). Optimal level of iron and zinc in relation to its influence on herb yield and production of essential oil in menthol mint. Commun. Soil Sci. Plant Anal., 38(5-6): 561-578.
41. Purseglove J. (1987). Tropical Plants. Dicotyledons: Longman Scientific and Technical: London, UK.
42. Rajeswara Rao B, Bhattacharya A, Mallavarapu G, Ramesh S (1999). Volatile constituents of different parts of cornmint (*Mentha arvensis L.*). Flavour Fragr. J., 14(5): 262-264.
43. Rehman A, Adnan M (2018). Nutritional potential of Pakistani medicinal plants and their contribution to human health in times of climate change and food insecurity. Pak. J. Bot, 50(1): 287-300.

44. Rehman A, Hussain S, Javed M, Ali Z, Rehman H, Shahzady TG, Zahra A (2018). Chemical composition and remedial perspectives of *Hippophae rhamnoides linn*. Postepy Biol. Komorki, 45(3): 199-209.
45. Riachi LG, De Maria CA (2015). Peppermint antioxidants revisited. Food Chem., 176: 72-81.
46. Rohloff J (1999). Monoterpene composition of essential oil from peppermint (*Mentha piperita L.*) with regard to leaf position using solid-phase microextraction and gas chromatography / mass spectrometry analysis. J. Agri. Food Chem, 47(9): 3782-3786.
47. Rout OP, Acharya R, Mishra SK, Sahoo R (2012). Pathorchur (*Coleus aromaticus*): a review of the medicinal evidence for its phytochemistry and pharmacology properties. Int. J. Appl. Biol. Pharm. Tech., 3(4): 348-355.
48. Saeed M, Naseer S, Hussain S,Iqbal M (2020). Phytochemical Composition and Pharmacological Effects of *Cassia Fistula*. Scientific Inquiry and Review, 4(1): 59-69.
49. Sandhya S, Sai KP, Vinod KR, Banji D, Kumar K (2011). Plants as potent anti diabetic and wound healing agents-a review. Hygeia. J. D. Med., 3(1): 11-19.
50. Šarić-Kundalić B, Fialová S, Dobeš C, Ölzant S, Tekeľová D, Grančai D, Reznicek G,Saukel J (2009). Multivariate numerical taxonomy of Mentha species, hybrids, varieties and cultivars. Sci. Pharm., 77(4): 851-876.
51. Schmidt E, Bail S, Buchbauer G, Stoilova I, Atanasova T, Stoyanova A, Krastanov A, Jirovetz L (2009). Chemical composition, olfactory evaluation and antioxidant effects of essential oil from *Mentha x piperita*. Nat. Prod. Commun., 4(8):
52. Seif SM, Mehrafarin A, Khalighi SF, Sharifi M, Naghdibadi H (2019). Review on anatomical, phytochemical and pharmacological properties of peppermint (*Mentha piperita L.*). J. Med. Plants., 18(69): 16-33
53. Singh R, Shushni MA, Belkheir A (2015). Antibacterial and antioxidant activities of *Mentha piperita L*. Arab. J. Chem., 8(3): 322-328.
54. Sulieman AME, Abdelrahman SE, Abdel Rahim A (2011). Phytochemical analysis of local spearmint (*Mentha spicata*) leaves and detection of the antimicrobial

activity of its oil. J. Microbiol. Res., 1(1): 1-4.

55. Swamy MK, Sinniah UR, Akhtar M (2015). In vitro pharmacological activities and GC-MS analysis of different solvent extracts of Lantana camara leaves collected from tropical region of Malaysia. Evidence-Based Complementary and Alternative Medicine, 2015.
56. Tabatabaie SJ, Nazari J (2007). Influence of nutrient concentrations and NaCl salinity on the growth, photosynthesis, and essential oil content of peppermint and lemon verbena. Turk. J. Agric. For., 31(4): 245-253.
57. Nguyen, DT, Nguyen MT, Vo TXT (2019). Comparative analysis of the bioactive compound, pigment content and antioxidant activity in different parts of *Pouzolzia zeylanica* plant.
58. Tarasevičienė Ž, Velička A, Jarienė E, Paulauskienė A, Kieltyka-Dadasiewicz A, Sawicka B, Gajewski M (2019). Comparison of Chemical Composition and Colour Parameters of Different Mentha Genus Plants Grown under Organic Conditions. Not. Bot. Horti Agrobot. Cluj. Napoca., 47(1): 92-99.