Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2020; 9(3): 1519-1528
Received: 10-03-2020
Accepted: 14-04-2020

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Peppermint a medicinal herb and treasure of health: A review

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DOI: https://doi.org/10.22271/phyto.2020.v9.i3y.11525

Abstract
High demand for aromatic herbs in the sectors of biotechnology, cosmetics, medicinal and food industries has enhanced their market values. Peppermint (*Mentha piperita* L.) is a prominent medicinal herb and largely acknowledged by medicinal and food processing industries due to its excellent health benefits. Though it is used as a flavoring agent in foods, they are mostly recognized in the world for their antimicrobial and antioxidant features. Peppermint oil and its other by-products are generally used for candies, teas, mouth freshener, toothpaste, beverages, alcoholic liqueurs, jellies, syrups, ice creams, cough drops, chewing gums, confectioneries, soaps, detergents, and mosquito repellents. It is a highly perishable and seasonal plant, therefore, it needs to be dried and make it available throughout the entire year. The drying of peppermint mint herbs is targeted to enhance the storage time, minimize the packaging and transport cost. Various studies on drying of mints were collected and analyzed the drying kinetics, to regulate the effect of several drying methods on drying time, drying rate and to improve its quality in terms of color and other characteristics. The present paper reviews the health aids of peppermint such as anti-viral, anti-bacterial, anti-inflammatory, anti-fungal, anti-asthmatic, allopathic, spasmolytic, anti-headache, anti-septic, and radioactive properties in detailed. Thus, peppermint has a wide scope of future research and studies and needs to be utilized its potential benefits for human prosperity.

Keywords: Peppermint, peppermint oil, medicinal herbs, drying of mints

Introduction

Mints (Mentha spp.) are popular aromatic and medicinal herb and it has a huge family of perennial herbs and usually cultivated globally, to acquire its superior herbal features such as antimicrobial and antioxidant properties (Kadam *et al*., 2011; Nayak *et al*., 2011) [64, 90]. This perennial herb has creep regular branches and their leaves are an oval-shaped, rough surface with serrated margins. The genus Mentha belongs to the Lamiaceae family and includes 25 to 30 species (Hawryl *et al*., 2016) [57]. It was inborn to Europe, grows naturally in the northern USA, Canada, and produced worldwide (Hocking and Edwards (1955) [59]; Kavrayan and Aydemir (2001) [70]. It is largely developed in the Mediterranean region as the core fragment of the vegetation. The world production of peppermint was about 92, 296 tonnes in 2014, led by Morocco contributing more than 90% of the world total (FAOSTAT, 2017) [45]. In India, Mint is generally produced in southern parts of the Himalayan zone covering Himachal Pradesh, Haryana, Punjab, Uttar Pradesh, and Bihar (Kripanand *et al*., 2015) [75]. This genus can be originated in many environments but best raised in moist soils and wet atmospheres. Due to their wide range of tolerance characteristics, it can also be grown in full sunlight (Maffei, 1999) [81]. Mints plant has about 10-120 cm height and can extend above an unstated region. Particular mints are labeled as invasive, because of their propensity to grow widely (Park *et al*., 2002) [98]. Most of the mint species are commercially seed sterile and nurtured by underground stolons (runners or rootstock) of existing plants (Douhan and Johnson, 2001) [34]. The stolons having high moisture content thus spoil promptly due to dryness and cannot be preserved for a longer period (Douhan and Johnson, 2001) [34]. The main ample active compounds of mints (Mentha spp.) are limonene, cineole, menthone, menthofuran, isomenthone, menthyl acetate, isopulegol, menthol, pulegone and carvone (Alankar, 2009; Rohloff, 1999) [5]. Further components include flavonoid glycoside (e.g. Narirutin, Luteolin-7-o-rutinoside, Isorhoifolin, and Hesperidin, etc.), polyphenols (e.g. Rosmaric acid, Eriocitrin, Cinamic acid, Caffeic acid, and Narigenin-7-oglucoside); luteolin-diglucoronide and eriodictyol glucopyranosyl-rhamnopyranoside were also purified from aerial parts of mint (Areias *et al*., 2001; Umezu *et al*., 2001; Clark and Menary, 1980; Croteau and Venkatachalam, 1986; Mascher *et al*., 2001) [9, 131, 27, 31, 86].

Several authors reported that (Wealth of India, 1962; Park *et al*., 2002; Columbia Electronic Encyclopedia, 2005; Thompson, 2003) [98, 129] mint leaves are mostly consumed either fresh or dried manner in the different form of serving dishes such as vegetable gravies, chutney, salad dressings, flavoring and garnishing of soups, meats, desserts, jellies, vinegar, tea infusions, and iced drinks, etc. They are originally recognized for their special qualities such as refreshing, anti-bacterial, stimulative, diaphoretic, stomachic, and anti-spasmodic. It reliefs against cold, flu, fever, anorexia, nausea, motion sickness, food poisoning, rheumatism, hiccups, wounds, cramping, diarrhea, earaches, gassiness, esophagus and sinus illnesses (Saeidnia *et al*., 2005; Colak *et al*., 2008; Keifer *et al*., 2008; Therdthai and Zhou, 2009; Akpinar, 2010; Nayak *et al*., 2011) [112, 29, 70, 128, 90]. The best mint species with marketable or medical practice are shown in Table 1.

Table 1: The list of supreme ample mint species and their utility

Species	Usage	References
Menthaspicata L.	Medication	Fitsiou *et al*. (2016) [47]
Menthasuaveolens	Ornamental Intake	Wang *et al*. (2016) [134]
Mentharequienii Benth.	Ornamental Consumption	Gaurav N. (2016) [49]
Menthapulegium L.	Medication	Nogueira *et al*. (2016) [92]
Menthapiperita L.	Medication, Ornamental consumption, commercial	Coban and Baydar (2016) [28]; Mallick *et al*. (2016) [85]; Gras *et al*. (2016) [53]
Menthacitrata Ehrh	Medication	Bokhari *et al*. (2016) [21]
Menthalongifolia L.	Medication, Commercial	Mahmoudi *et al*. (2016) [84]; Diop *et al*. (2016) [32]
Menthacardiac	Medication	Saji N. (2016) [115]
Menthaarvensis	Medication	Bharti *et al*. (2016) [18]
Mentha Canadensis	Weed	Yingying *et al*. (2016) [137]
Mentha flavoring	Ornamental consumption, Medication	Nair B. (2000) [89]; Jenner *et al*. (1964) [63]

Constituents and applicability of peppermint

Peppermint (*Mentha piperita, also known as Mentha balsamea*) is a perennial herbal medicine and belongs to the mint family *Lamiaceae*as shown in Fig. 1. Due to its strong anti-oxidant and anti-microbial properties, and the presence of active constituents, it plays a vital role in building up the immune system and enhancing appetite (Dorman *et al*., 2003; Yalcin *et al*., 2012) [33, 136]. The peppermint plant is a cross hybrid between watermint (*Menthaaquatica*) and spearmint (*M. spicata*) (Khalil *et al*., 2015) [71]. Indigenously, it is a plant of the Mediterranean region but also cultured in Europe, Asia, North America and extensively spread in various parts of the world (Abdel-Wareth and Lohakare, 2014; Beigi *et al*., 2018) [1, 6]. Peppermint has smooth dark green leaves with squared stems and blunt oblong bunches of pink lavender flowers. As with the help of stolons (underground stems), peppermint plants can be produced widely over a large area. Natural hybridization of peppermint with different wild species leads to yield a wide range of species of mint. The two most prominent varieties, popularized among the growers are black and white peppermint. Black peppermint has purplish stems, mostly cultured in the United States and also known as English peppermint or Mitchammint. Whereas, white peppermint has the lowest productivity and fetches higher commercial value due to its oil of desirable odor.

Fig 1: Peppermint leaves

Peppermint leaves hold resilient sweetish odor and a spicy flavor with a freshening after mastication. The peppermint is a dynamic and good source of numerous minerals such as Na, Mg, K, Ca, Cr, Fe, Co, Cu, Zn, and Se (Padmini *et al*., 2010) [10]. It comprises around 0.5% to 4% essential oils, that are having the composition of about 25% to 78% menthol, 14% to 36% menthone, 1.5% to 10% isomenthone, 2.8% to 10% menthyl acetate, and 3.5% to 14% cineol (Grigoleit and Grigoleit, 2005; Bupesh *et al*., 2007; Aziz *et al*., 2011; Beigi *et al*., 2018) [54, 24, 14, 6]. Menthol, correspondingly named as peppermint camphor and it is used pharmaceutically as a relaxing balm. The essential oil of peppermint is obtained either from garden-fresh mint leaves or dried leaves by a hydro- distillation process. Peppermint oil is having compounds of mainly monoterpene and sesquiterpene hydrocarbons, phenyl propanoids, and its oxygen derivatives (Adamiecand Kalemba, 2006) [3]. Clean and unadulterated oil of peppermint is found to be almost colorless. It contains mainly of menthol and menthone with some additional minor components includes pulegone, menthofuran, and limonene. Depending on its various factor such as topographical region, mint maturity, treatment, handling and storage environments of peppermint leaves, their chemical constituents may get differ (Riachi and Maria, 2015; Ansari et. al., 2000; Chen and Zhong, 2015; Beigi *et al*., 2018) [110, 7, 25, 6]. The major oil-producing nations are Bulgaria, Italy, China, and the USA, which gives nearly 90% of global peppermint oil production. Additionally, peppermint is a good source of polyphenol and thus exhibits resilient antioxidant qualities.

Duke (1985) [85] and Diwedi *et al*., (2004) [37] highlighted some of the principal uses of the peppermint oil encompass as a flavoring of pharmaceuticals, dental preparations, mouthwashes, cough drops, chewing gums, candies, confectionery, alcoholic liqueurs, perfumery, soaps and detergents, and mosquito repellant. Mint oil tends to utilize it as environmentally friendly insecticides and pesticides for its capability to destroy various pests like wasps, hornets, ants, and cockroaches. Peppermint essential oil is extensively used in pharmaceutical industries either for exterior or interior usage. For interior usage, mint oil is utilized in flatulence, nausea, and gastralgia due to its presence of methanol as it tastes pleasant (Diwedi *et al*., 2004; Edris *et al*., 2003) [37, 40]. Methanol is one of the major constituents of peppermint and broadly used for nasal congestion (Eccles 1994; Eccles 2003) [38, 39], stuffiness and migraine problems (Haghighi *et al*., 2010) [55] and musculoskeletal pain (Patel *et al*., 2007) [99]. Due to its native antiseptic and anesthetic qualities, mint oil has a wide scope of exterior application in rheumatism, neuralgia, congestive headache, and toothache. As tobacco has a sour flavor, therefore extracts of peppermints in the form of an additive are usually employed in cigarettes, because it provides soothing throat without any bitterness.

The prescribed amount of peppermint essential oil for intake in adults was mentioned that capsules consisting of around 0.2 to 0.4 ml of oil, thrice per day (Khanna *et al*., 2014) [72]. Ocak *et al*., 2008 [93]; Toghyani *et al*., 2010 [130]; Abdel-Wareth and Lohakare, 2014 [1] were reported some effective evidence associated with usage of peppermint constituents on broilers for their nutritional growth and results shows that peppermint leaves support to strengthen the lives of broilers during their early stage as well as helps to enhance the egg properties. Khempaka *et al*., (2013) [73] stated that peppermint shows the valuable impacts on antioxidant activity, collection of abdominal fat, and ammonia creation in broilers. Abdel-Wareth *et al*., (2019) [2], suggested that peppermint leaves can be used to raise the economic efficacy of broiler meat production and they have recommended the most optimum feed dosage (15g/kg peppermint leaves or 52 mg/kg menthol) for boilers chicks, to boost up their growth.

Antiviral properties of peppermint

The world is dealing with terrible communicable viral diseases since lots of viruses have a high resistance capability as compared to other microorganisms and this generates major health issues in humans as well as in animals (Fiore *et al*., 2008) [46]. Treatment of viral diseases creates a challenging condition worldwide, because of a lack in the accessibility of merely insufficient powerful antiviral medicines (Vijayan *et al*., 2004) [133]. Some researchers clarified that several peppermint extracts have potential sources of antiviral characteristics (Brand *et al*., 2016; Shalaye *et al*., 2016; Bekhit *et al*., 2011) [23, 122, 17]. The antiviral characteristics of diverse peppermint extracts (Aqueous, alcohol, and essential oil) are shown in Table 2.

Table 2: Numerous antiviral characteristics of peppermint

Extracts	Virus	Citations
Essential oil	HSV-1	Reichling *et al*. (2009) [105]; Edris (2007) [41]; Shaaban *et al*. (2012) [119]
	HSV-2	Reichling *et al*. (2009) [105]; Shaaban *et al*. (2012) [119]
Aqueous	HSV-1/2	Moradi *et al*. (2016); Santoyo *et al*. (2014)
	HIV-1	Geuenich *et al*. (2008) [50]
	Influenza A virus	Shaikh *et al*. (2014) [121]
	Newcastle disease virus and VACV in egg	Arora *et al*. (2010) [11]
	Semliki Forest	Singh *et al*. (2015) [123]
Alcohol	Influenza A virus	Kunnumakkara *et al*. (2009) [77]
	HSV	Reichling *et al*. (2008) [104]

Anti-bacterial properties of peppermint

In the current scenario, there are huge demands for medicinal plants as secondary metabolites because of their applications in pharmaceutical units in the form of antimicrobial agents (Mahboubi and Kazempour, 2014; Almajano *et al*., 2008) [82, 6]. Some scientists revealed that peppermint oil and its extracts show the strong barrier against the growth of various microbes such as Escherichia coli, Salmonella pullorum, Comamon asterrigena, Streptococcus faecalis, Acinetobactersp, Streptococcus thermophiles, Lactobacillus bulgaricus, Staphylococcus pyogenes, Staphylococcus aureus, Streptococcus pyogenes, Serratiamarcescens, Mycobacterium avium, Salmonella typhi, Salmonella paratyphi A/B, Proteus vulgaris, Enterobacteraerogenes, Yersinia enterocolitica and Shigella dysenteriae (Shaikh *et al*., 2014; Bohnert*et al*., 2016; Sun *et al*., 2014) [121, 125]. Many studies highlight that peppermint oil is having the maximum zone of inhibition (11.58 to 17.24 mm ± 0.87 SD) as compared to extract acquired from peppermint stem with the zone of inhibition of 15.82 mm ± 3.56 SD and thus peppermint shows the maximum antibacterial characteristics (Shaikh *et al*., 2014) [121].

Anti-fungal properties of peppermint

Researcher's statistics showed that peppermint has excellent anti-fungal properties against Candida albicans, Aspergillus Albus, and dermatophytes fungi (Oumzil *et al*., 2002). Mentha spicata oils presented optimum anti-fungal property against Aspergillus fumigatus (zone of inhibition = 16 mm ± 0.5 SD) and A. niger (zone of inhibition = 14 mm ± 0.5 SD) (Bansod and Rai, 2008) [15].

Allelopathic properties of peppermints

Allelopathy is a key factor for the agricultural ecological system and influences the maturity, value, and developmental capacity of any plants (Goga *et al*., 2016; Shah *et al*., 2016) [52, 120]. Mahdavikia and Saharkhiz, (2016) [83] were recommended that peppermint extracts with a concentration (10% v/v) repressed the development of the tomato saplings. Skrzypek *et al*., 2015 [124] stated that aqueous peppermint extracts with a concentration of 15% v/v, declines the vitality index as well as photochemical and non-photochemical quenching in sunflower.

Anti-inflammatory properties of peppermint

Inflammation is considered as a vigorous factor mostly answerable for the occurrence of countless dreadful diseases includes tumor, septic shock, atherosclerotic, diabetes, and abdominal obesity (fatness) (Ku and Lin, 2013) [76]. Few reports presented that peppermint constituents have played a significant role in preventing diseases like angiogenesis and inflammation (Kaefer and Milner, 2008; Kale *et al*., 2008) [65, 66]. Liu *et al*., (2014) [80] reveal that the practical usage of methanol of peppermint on L1210 tumor cells results in cytotoxic impacts.

Spasmolytic properties of peppermint

Consumption of peppermint oil lowers down the calcium inflow in the large intestine as well as jejunum (lies between ileum and duodenum) (Sadraei *et al*., 2016) [111] and thus, provides relaxation in the gastrointestinal tract (Nissen and Lau 2016) [91]. Menthol and oil of peppermint obstructed the calcium deposition motion in rats, pig atrial and papillary muscles, and broilers retinal neurons (Harris 2016; Jain *et al*., 2016) [56, 62].

Peppermint claim as a therapy for spastic bowel (Irritable bowel syndrome)

Irritable bowel syndrome (IBS) is considered as a long-lasting illness with dysfunction of bowel categorized by occurrence in signs of diarrhea, costiveness as well as anxiety or pain, and having additional symptoms such as swelling, bowel urgency, and inadequate emptying of the bowel. (Rees *et al*., 1979; Chey *et al*., 2015; Harris, 2016) [103, 26, 56]. IBS influences around 9% to 23% of peoples throughout the world (Saha, 2014) [114]. Peppermint oil can be used as a non-toxic and operative intervening action for a spastic bowel disorder. It lessens the symptoms of spastic bowel by preventing the calcium inflow in the gastrointestinal tract and potassium depolarization in the ileum (Korterink *et al*., 2015; Egan *et al*., 2015; Shaikh *et al*., 2014; Sagduyu, 2002) [74, 42, 121, 113]. Peppermint oil facilitates decisive impressions on inflammatory itching, serotonin, and cholinergic sense organ of the gastrointestinal tract and also effective against vomiting and nausea (Tate, 1997) [127]. Thus, peppermint herbs considered as extensively used for therapy of spastic bowel syndrome.

Anti-headache properties of peppermint

Historically, the herbal plant has been recognized for the medication of headache illness (Levin, 2012) [79]. Peppermint oil and its by-products intake ensure the purpose of headache healing. A report showed that the combined usage of peppermint and eucalyptus oil has efficiently relaxed the patients suffering from headache discomfort (Gobel *et al*., 1994) [51].

Radioactive features of peppermint

Alcohol extract of peppermint with the optimal quantity of 100 mg/Kg repeated for 3 days was found efficient against radiation-induced morbidity and mortality (Kaushik *et al*., 2012) [68]. It was reported that extracts of peppermint leaves exhibited effective anti-oxidant as well as free radical scavenging properties and successively it was found useful against radiation sources (Samarth *et al*., (2006) [116]. Gardiner (2000) [48] also advised that peppermint extract having extensive potential properties for radioprotection and chemoprevention, includes quick retrieval of bone marrow, immunity, efficient antioxidant features.

Drying of peppermint and other medicinal leaves.

Peppermint leaves have many applications in both fresh and dried forms. The dried leaves are extensively consumed in different cuisines as well as in medicines (Hedrick, 1972) [58]. Drying process of aromatic and medicinal herbs consists of removal of water up to a level at which microbial spoilage and deterioration reactions are highly minimized (Rocha *et al*., 2011) [107]. On one hand, drying of the peppermint leaves prevents deterioration and increase shelf life of the product, but on the other hand, it may alter their vibrant aroma and flavor (Consuelo *et al*., 2003) [30]. Volatile aroma compounds are the most sensitive components in the process of drying. Changes in the concentrations of the volatile compounds of mint during drying depend on several factors, such as drying conditions (temperature, air velocity), moisture content, variety and age of the plant, climate, soil, and harvesting method (Asekun *et al*., 2007; Tarhan *et al*., 2010; Braga *et al*., 2009; Rohloff *et al*., 2005) [12, 126, 22, 108]. There are several works done to study the effect of drying on oil yield and composition of various aromatic and medicinal herbs.

Blanco *et al*. (2000) [19] conducted studies to show the effect of different temperatures in the drying process on the amount and quality of essential oils of peppermint (*Mentha piperita* L.). They observed that higher drying temperature sharply decreased the essential oil content (% v/w) from 1.0% (40 °C) to 0.14% (60 °C) and 0.12% (80 °C). They also concluded that the higher drying temperatures affected the composition too.

Omidbaigi *et al*. (2004) [37] studied the influence of different drying methods, including sun, shade, and oven at 40 °C, on quantitative and qualitative traits of the essential oil from Roman chamomile (Chamaemelum Nobile L. All. var. flora plena). The oil content of the shade-dried flowers was the largest (1.9% w/w) compared to sun-drying (0.4% w/w) and oven-drying at 40 °C (0.9% w/w). They further stated that the drying methods had no effect on the number of chemical components of the essential oil but had a significant effect on their proportion.

Sefidkon *et al*. (2006) [118] investigated the influence of drying and extraction methods on yield and chemical composition of the essential oil of Satureja hortensis. They found that the oil content of the shade-dried sample, obtained by hydro-distillation, was higher (0.94%) than that of the steam-distilled (0.27%). The results showed that extraction by hydro-distillation gave the best results for *S. hortensis*, based on oil yield and carvacrol percentage.

Pirbalouti *et al*. (2013) [100] studied the effects of drying methods on qualitative and quantitative properties of essential oil of the purple and green basil landraces aerial parts under sunlight, shade, oven, microwave, and freeze-drying treatments. They indicated that the highest essential oil yields (v/w on a dry weight basis) were obtained from shade-dried tissue in both landraces followed by the freeze-dried sample of the purple landrace and the fresh sample of green landrace. Increasing the drying temperature significantly decreased the essential oil content of all samples. The percentage of methyl chavicol in the oil decreased significantly when the plant material was dried in the oven at 60 °C or microwaved.

Rahimmalek and Goli (2013) [101] evaluated six drying treatments (sun, shade, oven 50 °C, oven 70 °C, microwave, and freeze-drying) for essential oil yield, composition and color characteristics of *Thymys daenensis* subsp. *daenensis*. Celak leaves. They concluded that the highest essential oil yield was obtained by freeze-drying (1.7%). However, despite relatively low essential oil yield in microwave drying, it had many advantages such as shortening of drying time, high color quality, and increased major compounds of thyme leaves.

Argyropoulos and Muller (2014) [10] investigated the impact of hot-air drying on essential oil content and composition of lemon balm leaves (Melissa officinalis L.) at different temperatures. They observed that the essential oil loss was proportional to drying temperature (16%, 23%, and 65% at 30, 45, and 60 °C, respectively). They also reported that the pronounced changes in the major essential oil components occurred at 60 °C.

Drying methods and kinetics

The hot air drying is the most commonly used method, but it leads to thermal damage and severely reduces the volatile compounds of herbs as well as the color (Antal *et al*., 2011) [8]. However, in the recent decade, many researchers have reported some advanced methods of drying aromatic herbs such as microwave drying, infrared drying, freeze-drying, and fluidized bed drying, which may have the potential to overcome these problems.

Sun drying

The open-air sun drying of thyme and mint leaves was investigated by Ismail and Beyribey (2013) [61]. They obtained the drying times as 440 minutes for thyme and 420 minutes for mint from the initial moisture content (73.80% for thyme and 84.70% for mint) to the final moisture content (7.6% for thyme and 4.85% for mint). L* values of fresh and dried herbs were found as 40.25 and 35.70 for thyme and as 44.01 and 33.08 for mint, respectively. The effective diffusivities were determined as 2.2571×10^{-10} m^2/s for thyme and as 1.2768×10^{-10} m^2/s for mint.

Muller *et al*. (1989) [88] used a greenhouse-type solar dryer for mint drying. They observed that the drying process from an initial moisture content of 80% (w.b.) to a final moisture content of 11% (w.b.) took 3-4 days.

Tray drying

Doymaz (2005) studied on the thin-layer drying behavior of mint leaves for a temperature range of 35-60 °C in a cabinet dryer. It was observed that the effective diffusivity varied from 3.067×10^{-9} to 1.941×10^{-8} m^2/s and increased with the air temperature. An Arrhenius relation with an activation energy value of 62.96 kJ/mol expressed the effect of temperature on the diffusivity.

Advanced drying methods

Ozbek and Dadali (2007) [96] investigated the drying kinetic of mint leaves in a microwave oven at various microwave output powers and sample amounts. Drying time decreased considerably with an increase in microwave output power and with a decrease in sample amount of mint leaves. This technique can be successfully used to dry mint leaves as compared to sun drying and hot air drying. Average drying rates of mint leaves at a constant rate period ranged from 0.571 to 3.083 g water/g dry base/min at various microwave output powers (from 180 to 900 W) and followed by falling rate period. On the other hand, average drying rates at a constant rate period ranged from 1.395 to 0.386 g water/g dry base/min for the sample amounts between 25 and 100 g and again followed by falling rate period.

Ertekin and Heybeli (2014) [44] studied the effects of thin-layer infrared drying of mint leaves. Drying time was obtained between 18 and 38 min at drying temperatures of 60-80 °C. The lightness and yellowness of the dried mint leaves were significantly increased when compared with fresh samples. The high drying temperature yielded in darker, less green and more yellow mint leaves. When the 38 models compared according to the statistical values, the rational function model (model-32) for drying temperatures of 60 and 70 °C and Modified Henderson Pabis-II model (model-5) were superior to the others.

Rubinskiene *et al*. (2015) [110] evaluated the effect of drying methods on the chemical composition and color of peppermint (Mentha piperitanL.) leaves. The highest content of essential oil (0.77%) and chlorophyll (1.69%) was found in the cv. 'Peppermint'. Chlorophyll *a* to *b* ratio was different in the fresh peppermint leaves: in the cv. 'Peppermint' it was 1.35 and in the cv. 'Krasnodarskaja'-1.44. Peppermint leaves were dried using active ventilation, convection, infrared, vacuum, microwave, and freeze-drying methods. The highestcontent of essential oil (0.64-0.68% of dry mass) was found in the variously dried peppermint leaves of the cv. 'Krasnodarskaja'. The lowest content of essential oil (0.08% and 0.065% of dry mass) was determined in microwave dried herbs. The highest content of chlorophyll was found in the freeze-dried peppermint leaves (715.0 mg/100 g of dry mass) of the cv. 'Peppermint'. Regardless of the drying method, significant differences between the ratio of chlorophyll *a* to *b* were observed in the dried herbs of the cv. 'Krasnodarskaja'. The fresh and dried peppermint samples of the cv. 'Peppermint' had the lowest brightness L* value (from 22.61 to 35.24) and the lowest yellowness b* values (from 9.35 to 17.00). The biggest changes in greenness a* value were in microwave dried peppermint leaves.

The effect of oven drying at 30 °C and freeze-drying on the volatile compounds in thyme and sage has been minor, whereas losses at 60°C were 43% in thyme and 31% in sage (Venskutonis, 1996) [136]. Ratti (2001) [102] found out that freeze-drying can be used to avoid damage caused by heat, producing a product with superior physical and chemical qualities is considered a costly and time-consuming process.

Ataei *et al*. (2015) [13] studied on vibro-fluidized bed heat pump drying of mint leaves. The effective coefficient of moisture transfer of the samples was increased with air temperature and varied from 4.26656×10^{-11} to 2.95872×10^{-10} m^2/s for heat pump drying (HPD) method, and 3.71918×10^{-11} to 1.29196×10^{-10} m^2/s for none-heat pump drying (NHPD) method. The color indices for temperatures of 40 and 50 °C were very close to each other, whereas by increasing temperature to 60 °C, a remarkable loss of green color was observed. The highest phenolic content was found in methanolic extract for HPD at 60 °C, and NHPD at 50 °C contained the lowest amount of phenolic compounds. NHPD treatments showed lower antioxidant activity compared to HPD treatments at the same temperature due to the longer drying times.

Kadam *et al*. (2010) [64] conducted experiments on the thin layer convective drying of mint leaves. They stated that the drying time varied from 240 to 390 min to dry a 300 g of mint leaves samples at temperatures from 45 to 65 °C. The average thickness and moisture content of fresh mint leaves were 0.26 mm and 470.78% (d.b.), respectively. Drying temperatures had no significant effect on the color of dried mint leaves. The two-term model with the highest r^2 value of 0.998 represented thin layer drying behavior of mint leaves in the tunnel dryer. Effective moisture diffusivity was observed to increase with the increase in drying air temperature and ranged from 1.2325×10^{-10} to 2.6568×10^{-10} m^2/s.

Kane *et al*. (2009) [67] evaluated the drying parameters and sorption isotherm of mint leaves (M. pulegium). They found that the effective diffusivity varied from 1.9871×10^{-11} to 1.4221×10^{-10} m^2/s and increased with the air temperature. An Arrhenius relation with an activation energy value of 57.12 kJ/mol expressed the effect of temperature on the diffusivity.

Park *et al*. (2002) [98] studied the drying parameters and desorption isotherms of garden mint leaves (Mentha Crispa L.). The sorption curves for the temperatures of 30 °C and 40 °C were better fitted with the pegleg model. The 50ºC desorption isotherm was similar to the 40 °C model. The values of calculated effective diffusivity for drying at 30 °C, 40 °C and 50 °C of air temperature and 0.5 and 1.0 m/s of air velocity ranged from 4.765×10^{-13} to 2.945×10^{-12} m^2/s. The effective diffusivity increases as air temperature and air velocity increases.

Conclusion

Since ancient times, herbs have fascinated the scientific attention of the biotechnology, cosmetic, pharmaceutical, and food industries and subsequently used for many purposes such as medicinal, flavoring, beverages, dyeing, fragrances, and other industrial practices. Concerning to well-being prosperities of peppermint, it can be stated that peppermint herb has enormous capabilities to handle human ailments, besides it has a great career in global trade. There is a need to explore more about its physicochemical characteristics as well as their compound's reaction to the human physique, to its maximum possibilities. Apart from its cheap and economic profits, some studies must be carried out about their side effects and harmfulness during the intake of peppermint. Drying is a strategy to preserve the perishable, perennial peppermint and consequently offers the product to be available during out of stocks. This study could be helpful to obtain a better aroma, the flavour of dried mint leaves powder, or the extraction of essential oil and its by-product from peppermint to its maximum efficiency by using the finest drying process and kinetics. These dehydrated peppermint leaves can be utilized for making spices, chilies powder to scatter on several kinds of foods. In the present scenario, there is a huge demand for the essential oil of peppermint across the world and in various urban nations, it can be categorized as a benchmark for medical and nutritional studies.

References

1. Abdel-Wareth AAA, Lohakare JD. Effect of dietary supplementation of peppermint on performance, egg quality, and serum metabolic profile of Hy-Line Brown hens during the late laying period. Anim. Feed Sci. Technol. 2014; 197:114-120.
2. Abdel-Wareth AA, Kehraus S, Südekum KH. Peppermint and its respective active component in diets of broiler chickens: growth performance, viability, economics, meat physicochemical properties, and carcass characteristics. Poultry science. 2019; 98(9):3850-3859.
3. Adamiec J, Kalemba D. Analysis of microencapsulation ability of essential oils during spray drying. Drying Technol. 2006; 24:1127-1132.
4. Akpinar EK. Drying of mint leaves in a solar dryer and under open sun: Modelling, performance analyses. Energ. Convers. Manage. 2010; 51:2407-2418.
5. Alankar S. A review on peppermint oil. Asian J. Pharm. Clin. Res. 2009; 2:27-33.
6. Almajano MP, Carbo R, Jimenez JAL, Gordon MH. Antioxidant and antimicrobial activities of tea infusions. Food Chem. 2008; 108:55-63.
7. Ansari M, Vasudevan P, Tandon M, Razda R. Larvicidal and mosquito repellent action of peppermint menthapiperita) oil. Biosci. Rep. 2000; 71:267-271.
8. Antal T, Figiel A, Kerekes Bm Sikolya L. Effect of drying methods on the quality of the essential oil of spearmint leaves (*Mentha spicata* L.). Drying Technology: an International Journal. 2011; 29(15):1836-1844.
9. Areias F, Valentao P, Andrade P, Ferreres F, Seabra R. Phenolic fingerprint of peppermint leaves. Food chem. 2001; 73:307-311.
10. Argyropoulos D, Muller J. Changes of essential oil content and composition during convective drying of lemon balm (Melissa officinalis L.). Industrial Crops and Products. 2014; 52:11-124.
11. Arora R, Chawla R, Marwah R, Arora P and Sharma R. Potential of complementary and alternative medicine in preventive management of novel h1n1 flu (swine flu) pandemic: Thwarting potential disasters in the bud. J. Evid. Based Complementary Altern. Med. 2010; 10:1-16.
12. Asekun OT, Grierson DS, Afolayan AJ. Effects of drying methods on the quality and quantity of the essential oil of *Mentha longifolia* L. subsp. *capensis*. Food Chem. 2007; 101:995-998.
13. Ataei ASM, Sadeghi M, Babak B, Minaei S, Naser H. Vibro-fluidized bed heat pump drying of mint leaves with respect to phenolic content, antioxidant activity and color indices. Chem. Ind. Chem. Eng. Q. 2015; 21(2):239-247.
14. Aziz EE, Gad N, Khaled SM. Effect of cobalt on growth and chemical composition of peppermint plant grown in newly reclaimed soil. Aust. J Basic. Appl. Sci. 2011; 5:628-633.
15. Bansod S, Rai M. Antifungal activity of essential oils from indian medicinal plants against human pathogenic aspergillus fumigatus and a. Niger. World. J Med. Res. 2008; 3:81-88.
16. Beigi M, Torki-Harchegani M, Pirbalout AG. Quantity and chemical composition of essential oil of peppermint (Mentha × piperita L.) leaves under different drying methods. Int. J Food Prop. 2018; 21:267-276.
17. Bekhit AE, Cheng VJ, McConnell M, Zhao JH, Sedcole R *et al*. Antioxidant activities, sensory and anti-influenza activity of grape skin tea infusion. Food Chem. 2011; 129:837-845.
18. Bharti N, Barnawal D, Shukla S, Tewari SK, Katiyar R, *et al*. Integrated application of exiguobacterium oxido tolerans, glomus fasciculatum, and vermicompost improves growth, yield and quality of mentha arvensis in salt-stressed soils. Ind. Crops Prod. 2016; 83:717-728.
19. Blanco MCSG, Ming LC, Marques MOM, Bovi OA. Drying temperature effects in peppermint essential oil content and composition. Acta Horticulturae. 2000; 569:95-98.
20. Bohnert T, Patel A, Templeton I, Chen Y, Lu C. Evaluation of a new molecular entity as a victim of metabolic drug-drug interactions-an industry perspective. Drug Metab. Disposdmd. 2016; 115:690-696.
21. Bokhari N, Perveen K, Al Khulaifi M, Kumar A, Siddiqui I. *In vitro* antibacterial activity and chemical composition of essential oil of mentha arvensis linn. Leaves. J Essent Oil Bear Pl. 2016; 19:907-915.
22. Braga AMP, Pedroso MP, Augusto F, Silva MA. Volatiles identification in pineapple submitted to drying in an ethanolic atmosphere. Drying Technol. 2009; 27:248-257.
23. Brand YM, RoaLinares VC, BetancurGalvis LA, Duran Garcia DC, Stashenko E. Antiviral activity of colombianlabiatae and verbenaceae family essential oils and monoterpenes on human herpes viruses. J Essent Oil Res. 2016; 28:130-137.
24. Bupesh G, Amutha C, Nandagopal S, Ganeshkumar A, Sureshkumar P, Saravana KM. Antibacterial activity of Menthapiperita L. (peppermint) from leaf extracts-A medicinal plant. Acta. Agric. Slov. 2007; 89:73-79.
25. Chen H, Zhong Q. Thermal and uv stability of β-carotene dissolved in peppermint oil microemulsion by sunflower

lecithin and tween 20 blend. Food Chem. 2015; 174:630-636.
26. Chey WD, Kurlander J, Eswaran S. Irritable bowel syndrome: A clinical review. Jama. 2015; 313:949-958.
27. Clark R, Menary R. Environmental effects on peppermint (menthapiperita l.). I. Effect of any length, photon flux density, night temperature and day temperature on the yield and composition of peppermint oil. Funct. Plant Biol. 1980; 7:685-692.
28. Coban O, Baydar NG. Brassinosteroid effects on some physical and biochemical properties and secondary metabolite accumulationin peppermint (menthapiperita l.) under salt stress. Ind. Crops Prod. 2016; 86: 251-258.
29. Colak N, Kuzgunkaya E, Hepbasli A. Exergetic assessment of drying of mint leaves in a heat pump dryer. J Food Process Eng. 2008; 31:281-298.
30. Consuelo Diaz-Maroto M, Soledad Perez Coello M, Gonzalez Vinas MA, Dolores Cabezodo M. Influence of Drying on the Flavour quality of Spearmint (*Menthaspicata* L.). J Agric. Food Chem. 2003; 51(5):1265-1269.
31. Croteau R, Venkatachalam K. Metabolism of monoterpenes: Demonstration that (+)-cis-isopulegone, not piperitenone, is the key intermediate in the conversion of (−)-isopiperitenone to (+)-pulegone in peppermint (mentha piperita). Annu. Rev. Phys. Chem. 1986; 249:306-315.
32. Diop SM, Gueye MT, Ndiaye I, Hadji E, Fauconnier GL. Chemical composition of essential oils and floral waters of menthe longifolia (l.) huds from senegal. Am. J Essent Oils Nat. Prod. 2016; 4:46-49.
33. Dorman HJD, Kosar M, Kahlos K, Holm Y, Hiltunen R. Antioxidant properties and composition of aqueous extracts from *Mentha* species, hybrids, varieties, and cultivars. J Agric. Food Chem. 2003; 51:4563-4569.
34. Douhan LI, Johnson D. Vegetative compatibility and pathogenicity of verticilliumdahliae from spearmint and peppermint. Plant Dis. 2001; 85:297-302.
35. Doymaz I. Thin-layer drying behaviour of mint leaves. J. Food Eng, 2006, 370-375.
36. Duke JA. CRC Handbook of Medicinal Herbs, CRC, Boca Raton, FL, 1985, 307-308
37. Dwivedi S, Khan M, Srivastava SK, Syamasunnder KV, Srivastava A. Essential oil composition of different accessions of Mentha× piperita L. grown on the northern plains of India. Flavour and fragrance J. 2004; 19(5):437-440.
38. Eccles R. Menthol and related cooling compounds. J Pharm. Pharmacol. 1994; 46:618-630.
39. Eccles R. Menthol: Effects on nasal sensation of airflow and the drive to breathe. Curr. Allergy Asthma Rep. 2003; 3:210-214.
40. Edris AE, Shalaby AS, Fadel MA, Wahab A. Evaluation of a chemo type of spearmint (Menthaspicata L.) grown in Siwa Oasis, Egypt. Eur. Food Res. Technol. 2003; 218:74-78.
41. Edris AE. Pharmaceutical and therapeutic potentials of essential oils and their individual volatile constituents: A review. Phytother. Res. 2007; 21:308-323.
42. Egan M, Connors EM, Anwar Z and Walsh JJ. Nature's treatmentfor irritable bowel syndrome: Studies on the isolation of (−)-mentholfrom peppermint oil and its conversion to (−)-menthyl acetate J. Chem. Educ. 2015; 92:1736-1740.
43. Ertekin C, Yaldiz O. Drying of eggplant and selection of a suitable thin layer drying model. Journal of Food Engineering. 2004; 63:349-359.
44. Ertekin C, Heybeli N. Thin-layer infrared drying of mint leaves. J Food Process. Preserv. 2014; 38(4):1480-1490.
45. FAOSTAT. "Peppermint production in 2014; Crops/Regions/World list/Production Quantity (pick lists)". UN Food and Agriculture Organization, Corporate Statistical Database (FAOSTAT). Retrieved 26 September, 2017.
46. Fiore C, Eisenhut M, Krausse R, Ragazzi E, Pellati D *et al*. Antiviral effects of glycyrrhiza species. Phytother. Res. 2008; 22:141-148.
47. Fitsiou E, Mitropoulou G, Spyridopoulou K, Tiptiri-Kourpeti A, Vamvakias M *et al*. Phytochemical profile and evaluation of the biological activities of essential oils derived from the Greek aromatic plant species Ocimum basilicum, Mentha spicata, Pimpinella anisum and Fortunella margarita. Molecules 21. 2016; (8):1069.
48. Gardiner P. Peppermint (menthapiperita). Longwood Herbal Task Force, 2000, 1-22.
49. Gaurav N. An experimental text book on phytochemical analysis and antimicrobial activity of menthapiperita. Onlinegatha, 2016.
50. Geuenich S, Goffinet C, Venzke S, Nolkemper S, Baumann I. Aqueous extracts from peppermint, sage and lemon balm leaves display potent anti-hiv-1 activity by increasing the virion density. Retrovirology. 2008; 5:1-16.
51. Gobel H, Schmidt G, Soyka D. Effect of peppermint and eucalyptus oil preparations on neurophysiological and experimentalalgesimetric headache parameters. Cephalalgia. 1994; 14:228-234.
52. Goga M, Antreich SJ, Backor M, Weckwerth W, Lang I. Lichen secondary metabolites affect growth of physcomitrella patens by allelopathy. Protoplasma. 2016; 20:1-9.
53. Gras A, Garnatje T, Bonet MA, Carrio E, Mayans M *et al*. Beyond food and medicine, but necessary for life, too: Other folk plant uses in several territories of catalonia and the balearic islands. Ethnobiol Ethnomed 2016; 12:23.
54. Grigoleit HG, Grigoleit P. Pharmacology and preclinical pharmacokinetics of peppermint oil. Hytomedicine. 2005; 12:612-616.
55. Haghighi AB, Motazedian S, Rezaii R, Mohammadi F, Salarian L *et al*. Cutaneous application of menthol 10% solution as an abortive treatment of migraine without aura: A randomised, double-blind, placebo-controlled, crossed-over study. Int. J Clin. Pract. 2010; 64:451-456.
56. Harris LA. Treating irritable bowel syndrome: A fresh andminty approach to an old therapy. Dig. Dis. Sci. 2016; 61:334-336.
57. Hawryl M, Niemiec M, Słomka K, Waksmundzka-Hajnos M, Szymczak G. Micro-2d-tlc separation of phenolics in some species of mint and their fingerprints on diol bonded polar stationary phase. Acta Chromat. 2016; 28:119-127.
58. Hedrick U. Edible Plants of the World. Dover, New York, 1972, 388-89.
59. Hocking GM, Edwards LD. Cultivation of peppermint in Florida. Economic Botany. 1955; 9:78-93.
60. Iscan G, KIrimer N, Kurkcuoglu MN, Baser HC, DEMIrci F. Antimicrobial screening of menthe piperita essential oils. J. Agri. Food Chem. 2002; 50: 3943-3946.

61. Ismail O, Beyribey B. Open-air sun drying in thrace region of greece: the experimental investigation of thyme and mint leaves. Latin Am. App. Res. 2013; 43:137-142.
62. Jain PK, Das D, Jain P, Jain P. Pharmacognostic and pharmacological aspect of bacopamonnieri-a review. Innovare JAyurvedicSci. 2016; 1:7-11.
63. Jenner P, Hagan E, Taylor JM, Cook E and Fitzhugh O. Food flavourings and compounds of related structure i.e. acute oral toxicity. Food Cosmet Toxicol. 1964; 2:327-343.
64. Kadam M, Dattatreya, Goyal RK, Singh KK, Gupta MK. Thin layer convective drying of mint leaves. J Med. Plants Res. 2011; 5(2):164-170.
65. Kaefer CM, Milner JA. The role of herbs and spices in cancer prevention. J Nutr. Biochem. 2008; 19:347-361.
66. Kale A, Gawande S, Kotwal S. Cancer phytotherapeutics: Role for flavonoids at the cellular level. Phytother Res. 2008; 22:567-577.
67. Kane Ethmane CS, Ahmed Sid MAO, Kouhila M. Evaluation of drying parameters and sorption isotherms of mint leaves (*M. pulegium*). Revue des Energies Renouvelables. 2009; 12(3):449-470.
68. Kaushik P, Mathur M, Rawat N, Dutt P. Radioprotective effectof alcoholic extract of menthapiperita (linn) on swiss albino miceexposed to whole body gamma irradiation: A preliminary study. Int. J Pharm. Bio. Sci. 2012; 3:598-610.
69. Kavrayan D, Aydemir T. Partial purification and characterization of Polyphen oloxidase from peppermint (menthapiperita). Food Chem. 2001; 74:147-154.
70. Keifer D, Ulbricht C, Abrams TR, Basch E, Giese N *et al*. Peppermint (menthax piperita) an evidence-based systematic review by the natural standard research collaboration. J Herb Med. 2008; 7:91-143.
71. Khalil AF, Elkatry HO, El Mehairy HF. Protective effect of peppermint and parsley leaves oils against hepatotoxicity on experimental rats. Ann. Agric. Sci. 2015; 60:353-359.
72. Khanna R, MacDonald JK, Levesque BG. Peppermint oil for the treatment of irritable bowel syndrome: A systematic review and meta-analysis. J Clin. Gastroenterol. 2014; 48:505-512.
73. Khempaka S, Pudpila U, Molee W. Effect of dried peppermint (Mentha cordifolia) on growth performance, nutrient digestibility, carcass traits, antioxidant properties, and ammonia production in broilers. J Appl. Poult. Res. 2013; 22:904-912.
74. Korterink JJ, Rutten JM, Venmans L, Benninga MA and Tabbers MM. Pharmacologic treatment in pediatric functional abdominal pain disorders: A systematic review. J Pediatr. 2015; 166:424-431.
75. Kripanand SM, Guruguntla S, Korra S. Effect of Various Drying Methods on Quality and Flavor Characteristics of Mint Leaves (*Menthaspicata*L.) J Food Pharm. Sci. 2015; 3:38-45.
76. Ku CM, Lin JY. Anti-inflammatory effects of 27 selected terpenoid compounds tested through modulating th1/th2 cytokine secretion profiles using murine primary splenocytes. Food Chem. 2013; 141:1104-1113.
77. Kunnumakkara AB, Chung JG, Koca C, Dey S. Mint and its constituents. In Molecular targets and therapeutic uses of spices: Modern uses for ancient medicine. 2009; 9:373-401.
78. Lebert A, Tharrault P, Rocha T, Marty-Audouin C.The drying kinetics of mint (MenthaspicataHuds.). J Food Eng.1992; 17:15-28.
79. Levin M. Herbal treatment of headache. Headache. 2012; 52:76-80.
80. Liu X, Sun Z-L, Jia A-R, Shi Y-P, Li R-H *et al*. Extraction, preliminary characterization and evaluation of *in vitro* antitumor and antioxidant activities of polysaccharides from mentha piperita. Int. J Mol. Sci. 2014; 15:16302-16319.
81. Maffei M. Sustainable methods for a sustainable production of peppermint (mentha x piperita l.) essential oil. J. Essent. Oil Res. 1999; 11:267-282.
82. Mahboubi M, Kazempour N. Chemical composition and antimicrobial activity of peppermint (menha piperita L.) Essent. oil. 2014; 20:36.
83. Mahdavikia F, Saharkhiz MJ. Secondary metabolites of peppermint change the morphophysiological and biochemical characteristics of tomato. Biocatal. Agric. Biotechnol. 2016; 7:127-133.
84. Mahmoudi R, Katiraee F, Tajik H, Abbas A. Inhibitory effect of mentha longifolia l. Essential oil against listeria monocytogenes using transmission electron microscopy. Int. J Vet. Sci. Res. 2016; 17:14-23.
85. Mallick B, Sinha S, Roy D. Evaluation of antioxidative potential of field grown and tissue culture derived mentha piperita L. Plants. Int. J Curr. Microbiol. App. Sci. 2016; 5:382-391.
86. Mascher H, Kikuta C, Schiel H. Pharmacokinetics of menthol and carvone after administration of an enteric coated formulation containing peppermint oil and caraway oil. Arzneimittelforschung. 2001; 51(06):465-469.
87. Moradi MT, Rafieian-Kopaei M, Karimi A. A review study on the effect of iranian herbal medicines against *in vitro* replication of herpes simplex virus. Avicenna J Phytomed. 2016; 20:1-11.
88. Muller J, Reisinger G, Kisgeci J, Kotta E, Tesic M, Muhlbauer W. Development of a greenhouse-type solar dryer for medicinal plants and herbs. Solar Wind Technol. 1989; 6:523-530.
89. Nair B. Final report on the safety assessment of mentha piperita (peppermint) oil, mentha piperita peppermint) leaf extract, menthe piperita (peppermint) leaf, and mentha piperita (peppermint) leaf water. Int. J Toxicol. 2000; 20:61-73.
90. Nayak S, Kumar A, Mishra J and Tiwari GN. Drying and testing of mint (Mentha piperita) by a hybrid photovoltaic-thermal (PVT)-based greenhouse dryer. Dry. Technol. 2011; 29:1002-1009.
91. Nissen L, Lau E. Old drug new indication: Antihistamine forthe pain in your stomach? Aus. Pharm. 2016; 35:32-35.
92. Nogueira MVC, De Lima Castro SAB, De Amorim AM, Maia RM, Paulillo LCMS Ethnobotanical survey of plants from the caatinga with possible therapeutic uses. Int. J Curr. Microbiol. App. Sci. 2016; 5:767-772.
93. Ocak N, Erener G, BurakAk F, Sungu M, Altop A, Ozmen A. Performance of broilers fed diets supplemented with dry peppermint (Menthapiperita L.) or thyme (*Thymus vulgaris* L.) leaves as rowth promoter source. Czech J Anim. Sci. 2008; 53:169-175.
94. Omidbaigi R, Sefidkon F, Kazemi F. Influence of drying methods on the essential oil content and composition of Roman Chamomile. Flav. Frag. J. 2004; 19(3):196-198.

95. Oumzil H, Ghoulami S, Rhajaoui M, Ilidrissi A, Faid M *et al*. Antibacterial and antifungal activity of essential oils of menthe suaveolens. Phytother. Res. 2002; 16:727-731-767.
96. Ozbek B, Dadali G. Thin-layer drying characteristics and modelling of mint leaves undergoing microwave treatment. J Food Eng. 2007; 83:541-549.
97. Padmini E, Valarmathi A, Usha Rani M. Comparative analysis of chemical composition and antibacterial activities of Menthaspicata and Camellia sinensis. Asian J Exp. Bio. Sci. 2010; 1(4):772-781.
98. Park KJ, Vohnikova Z and Brod F.P.R. Evaluation of drying parameters and desorption isotherms of garden mint leaves (*Mentha crips* L.). J Food Eng. 2002; 51:193-199.
99. Patel T, Ishiuji Y, Yosipovitch G. Menthol: A refreshing look at this ancient compound. J Am. Acad. Dermatol. 2007; 57:873-878.
100. Pirbalouti AG, Mahdad E, Craker L. Effects of Drying Methods on Qualitative and Quantitative Properties of Essential Oil of Two Basil Landraces. Food Chem. 2013; 141(3):2440-2449.
101. Rahimmalek M, Goli SAH. Evaluation of Six Drying Treatments with respect to Essential Oil Yield, Composition and Color Characteristics of Thymys daenensis Subsp. Daenensis. Celak Leaves. Ind. Crops Prod. 2013; 42:613-619.
102. Ratti C. Hot air and freeze-drying of high-value foods: A review. J Food Eng. 2001; 49:311-319.
103. Rees W, Evans B, Rhodes J. Treating irritable bowel syndrome with peppermint oil. BMJ. 1979; 2:835-836.
104. Reichling J, Nolkemper S, Stintzing FC, Schnitzler P. Impact of ethanolic lamiaceae extracts on herpesvirus infectivity in cell culture. Res. Compl. Med. 2008; 15:313-320.
105. Reichling J, Schnitzler P, Suschke U, Saller R. Essential oils of aromatic plants with antibacterial, antifungal, antiviral, and cytotoxic properties-an overview. Forsch. 2009; 16:79-90.
106. Riachi LG, De Maria. C.A.B. Peppermint antioxidants revisited. Food Chem. 2015; 176:72-81.
107. Rocha RP, Melo EC, Radunz LL. Influence of drying process on the quality of medicinal plants: a review. J Med. Plants Res. 2011; 5(33):7076-7084.
108. Rohloff J, Dragland S, Mordal R, Andiversen TH. Effect of harvest time and drying method on biomass production, essential oil yield, and quality of peppermint (*Mentha piperita* L.). J Agric. Food Chem. 2005; 53(10):4143-4148.
109. Rohloff J. 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. 1999; 47:3782-3786.
110. Rubinskienė M, Viškelis P, Dambrauskienė E, Viškelis J, Karklelienė R. Effect of drying methods on the chemical composition and colour of peppermint (Mentha× piperita L.) leaves. Zemdirbyste-Agriculture. 2015; 2:102.
111. Sadraei H, Asghari G, Alipour M. Anti-spasmodic assessmentof hydroalcoholic extract and essential oil of aerial part of pycnocy clacaespitosaboiss and hausskn on rat ileum contractions. Res. Pharm. Sci. 2016; 11: 33-37.
112. Saeidnia S, Gohari AR, Yassa N, Shafiee A. Composition of the volatile oil of achillea conferta dc. From iran. DARU. 2005; 13:34-36.
113. Sagduyu K. Peppermint oil for irritable bowel syndrome. Psychosomatics. 2002; 43:508-509.
114. Saha L. Irritable bowel syndrome: Pathogenesis, diagnosis, treatment, and evidence-based medicine. World J Gastroenterol. 2014; 20:6759-6773.
115. Saji N. 1-vinylcyclohex-3-ene carbaldehyde and 4-vinylcyclohex-1-ene carbaldehyde for use in flavour and oral care composition; U.S. Patent. 2016; 9:283-159.
116. Samarth RM, Panwar M, Kumar M and Kumar A. Retracted: Radioprotective influence of mentha piperita (linn) against gamma irradiation in mice: Antioxidant and radical scavenging activity. Int. J Rad. Biol. 2006; 82:331-337.
117. Santoyo S, Jaime L, García-Risco MR, Rodríguez A and Reglero G. Antiviral properties of supercritical co2 extracts from oregano and sage. Int. J Food Prop. 2014; 17:1150-1161.
118. Sefidkon F, Abbasi K, Bakhshi KG. Influence of drying and extraction methods on yield and chemical composition of the essential oil of Satureja hortensis. Food Chem. 2006; 99(1):19-23.
119. Shaaban HA, Ghorab AH, Shibamoto T. Bioactivity of essential oils and their volatile aroma components: Review. J Essent. Oil Res. 2012; 24:203-212.
120. Shah AN, Iqbal J, Ullah A, Yang G, Yousaf M. Allelopathic potential of oil seed crops in production of crops: A review. Environ. Sci. Pollut. Res. 2016; 20:1-14.
121. Shaikh S, Yaacob HB, Rahim ZHA. Prospective role in treatment of major illnesses and potential benefits as a safe insecticide and natural food preservative of mint (mentha spp.): A review. Asian. J Biomed. Pharm. 2014; 4:1.
122. Shalaye M, Asaad A, Qureshi M, Elhussein A. Anti-bacterial activity of peppermint (mentha piperita) extracts against some emerging multi-drug resistant human bacterial pathogens. J Herb. Med. 2016; 22:152.
123. Singh R, Shushni MM, Belkheir A. Antibacterial and antioxidant activities of mentha piperita l. Arabian J. Geosci. 2015; 8:322-328.
124. Skrzypek E, Repka P, StachurskaSa, Barabasz KB, Mozdzenk. Allelopathic effect of aqueous extracts from the leaves of peppermint (mentha ×piperita) on selected physiological processes of common sunflower (helianthus annuus l). Not. Bot. Horti. Agrobot. Cluj. Napoca. 2015; 20:43-48.
125. Sun Z, Wang H, Wang J, Zhou L, Yang P. Chemical composition and anti-inflammatory, cytotoxic and antioxidant activities of essential oil from leaves of mentha piperita grown in china. Plo. S. one. 2014; 9:12.
126. Tarhan S, Telci I, Tuncay MT, Polatci H. Product quality and energy consumption when drying peppermint by rotary drum dryer. Ind. Crop Prod. 2010; 32(3):420-427.
127. Tate S. Peppermint oil: A treatment for postoperative nausea. J Adv. Nurs. 1997; 26:543-549.
128. Therdthai N, Zhou W. Characterization of microwave vacuum drying and hot air drying of mint leaves (MenthacordifoliaOpiz ex Fresen). J Food Eng. 2009; 91:482-489.
129. Thompson AK. Fruits and vegetables 2nd ed. Oxford. Blackwell Publishing. UK, 2003, 273.
130. Toghyani M, Toghyani M, Gheisari B, Ghalamkari G, Mohammadrezaei M. Growth performance, serum biochemistry and blood hematology of broiler chicks fed different levels of black seed (Nigella sativa) and

peppermint (Menthapiperita). Livest. Sci. 2010; 129:173-178.
131. Umezu T, Sakata A and Ito H. Ambulation-promoting effect of peppermint oil and identification of its active constituents. Pharmacol. Biochem. Behav. 2001; 69:383-390.
132. Venskutonis PR. Effect of drying on the volatile constituents of thyme (*Thymus vulgaris* L.) and sage (*Salvia officinalis* L.). Food Chem. 1996; 59(2):219-227.
133. Vijayan P, Raghu C, Ashok G, Dhanaraj S, Suresh B. Antiviral activity of medicinal plants of nilgiris. Indian J Med. Res. 2004; 120:24.
134. Wang J, Li R, Tan J, Jiang ZT. Chemical composition of essential oil of grapefruit mint (mentha suaveolens ×piperita) from China. J Essent. Oil Bear Plant. 2016; 19:1047-1050.
135. Wealth of India. A Dictionary of Indian Raw Materials and Industrial Products. Council of Scientific and Industrial Research, New Delhi, 1962, 6.
136. Yalcin S, Yal S¸ Cin K, Uzunoglu HM, Duyum, Eltan O. Effects of dietary yeast autolysate (Saccharomyces cerevisiae) and black cumin seed (Nigella sativa L.) on performance, egg traits, some blood characteristics and antibody production of laying hens. Livest. Sci. 2012; 145:13-20.
137. Yingying L, Haitao L, Xiaohua L, Lixia Z. Diversity of tropical plant resources in yunnan province and its conservation. J Landsc. Res. 2016; 8:90-92.