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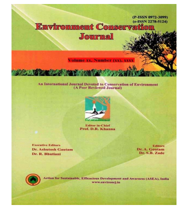

Standardization of post-harvest practices for best quality essential oil production of *Mentha arvensis* L.

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ABSTRACT

***Mentha* species belongs to Lamiaceae family is an important industrial crop, cultivated commercially on large scale. In this study, a common cultivar of M. arvensis with a high essential oil content (Cim Kranti) was investigated to determine the impact of drying techniques for 10 days immediately following harvest on the essential oil content and its chemical profile under three conditions: open field (S1), shade (S2), and ventilated chamber (S3). According to results, significantly higher essential oil (0.723%) with 77.58 % of menthol content was observed in freshly harvested crop on same /1st day of harvest (T_1) than any other conditions. *M. arvensis* was harvested and drying in open field condition (S_1) has showed 0.68% of essential oil having rich amount of menthol (76.86 %) content on fresh sample (T_1) which decline to 0.51% essential oil content with menthol content 76.88% at 10th days after harvest. *M. arvensis* dying in ventilated room (S_3) showed essential oil (0.71%) and menthol content 76.58 % on same day of harvest, which later decreases upto 0.6% essential oil with menthol content 74.32% on 10th day after harvest. Results concluded that the best quality and high yield of essential oil of *M. arvensis* should willingly be distilled fresh just after harvest. It also indicates that postharvest processes should immediately followed harvesting with appropriate drying method to minimize the loss of high quality essential oil.**

Introduction

Aromatic compound especially essential oil is one of the volatile compond in nature. In recent years, farming of aromatic plants have become more popular with increasing demands of essential oil in cosmatic, aromatherapy and other industries. This demand of aromatic crop had created pressure on farmers to supply the high quality raw material or essential oil. In present experiment *Mentha arvensis* crop was seleted to study the post harvest effects because of its high demand of essential oil and large scale farming. *Mentha arvensis* L. known as mints or Japanese mint have total 42 species, 100

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subspecies and cultivars (Salehi *et al*. 2018). It is a perennial aromatic crop and cultivated commercially in different parts of the world. *M. arvensis* with rich amount of menthol are cultivated in countries like America, Europe, China, Brazil, and India. India produce larger amount of essential oil of *M. arvensis* and export in all over the world (Gupta *et al*. 2016). Mentha is a natural sources of menthol and other chemical constituents like menthone, methyl acetate, isomenthol and terpenes. About 70 to 80% menthol content were recorded in an essential oil extracted through hydro-distillation of herb. *M. arvensis* L. possess a fresh cooling and soothing effect on the skin and mucous membranes of the human body, making it a useful ingredient in pharmaceuticals, food and cosmetics preparations as well as beverages (Rawashdeh, 2011). Its also widely used in mouth washes, as flavouring agent in confectionaries and dental creams (Singh and Khanuja, 2007).

Essential oil of mentha has large market with growing demand through out the world. To fulfill the requeriments, farmers needed to cultivate *M. arvensis* on larger field area. These cultivated fields create difficulty for farmers at the time of harvesting and during its transportation and distillation due to limited manpower and facility (distillation units). Maximum farmers having small or medium size field distilled essential oil of their harvested crop on rent basis. They harvested their crops and kept in field for days for later oil extraction. Post harvest storage of aromatic crops are usaully common in rural areas (Rahimi and Farrokhi, 2019). Post harvest losses due to inappropriate handling, drying and storage of mentha crop after harvest, results in damaging the raw material and decreases the quality and quantity of essential oil which effect the product price in market. Poor drying process of aromatic crops after harvest has also affected the essential oil content and biochemical compound. To conquer the challenges, different drying methods were used on harvested crops which can influences the essential oil content without disturbing the quality and yield of oil. Postharvest processes applied immediately after the harvest to protect from the deterioration of crop product. Drying is an important primary process which involves the removal of moisture content with minimum damage. Correct drying of raw material, protect the herb from contamination and preserve the unwanted change in essential oil content and composition quality. Therefore, current trial were performed to study the effects of drying methods on the essential oil yield, oil content and composition of *M. arvensis* and to identify the best storage methods with respect to mainitaing the quality of essential oil and to minimize the loss of essential oil during post-harvest.

Material and Methods

Site description

The experiment was conducted at CSIR-Central Institute of Medicinal and Aromatic Plants (CSIR-CIMAP) Centre, Pantnagar located at coordinates of 29°N, 79.38°E and an altitude of 243.84 m, Uttarakhand, India.

Experimental set up and treatments

The fresh *Mentha arvensis* was harvested and collected in 2019 from the field of CIMAP, research center. A random sampling of 200 g fresh harvested mentha crop was divided in to 3 batches (10 samples each) as treatments with three replicates. 3 batches were divided in open field storage condition (S_1), shade condition (S_2), and ventilated room condition. One sample from each batch was distilled on the same day of harvesting. The observations of essential oil and menthol content were recorded from 1st to 10th day after harvest of mentha and stored under three different conditions.

Extraction of essential oil

The essential oils of fresh and stored samples were isolated by hydro-distillation in a Clevenger type apparatus for 3 hours. The distilled essential oil was dehydrated by adding pinch of anhydrous sodium sulphate and kept in a refrigerator until analysis.

Chemical components of Mentha

Essential oils compounds were characterize by Gas Chromatography carried out on Nucon model 5765 equipped with flame ionization detector (FID) and DB-5 (30 m × 0.32 mm; 0.25 µm film thickness) fused silica capillary columns. Carrier gas was used as hydrogen at 1.0 mL/min. Temperature programming was range from 60-230 °C at 3 °C/min. The injector and detector temperatures were 220 °C and 230 °C, respectively. The injection volume was 0.03 µL neat with a split ratio of 1:40. GC-MS analysis of essential oil was carried out on a Perkin-Elmer Turbo mass Quadrupole Mass spectrometer fitted with PE-5 (Perkin-Elmer) fused silica capillary column (60 m × 0.32 mm; 0.25 µm film thickness). The column temperature was programmed 70 °C, initial hold time of 2 min, to 250 °C at 3 °C/min with final hold time of 3 min, using helium as carrier gas at a flow rate of 1.0 mL/min. The injector and ion source temperatures were 250 °C. The injection volume was 0.06 µL neat with a split ratio of 1:30. 2.5.

Statistical analysis

The numerical data of all the components were subjected to analysis of variance (ANOVA) using randomized block design. Statistical analyses of data were done using statistical calculator.

Results and Discussion

Essential oil percent (%) and oil yield (kg/ha)

The obtained results of essential oil percent (%) and yield (kg/ha) of mentha crop were varied under different storage conditions (S_1, S_2, and S_3) are presented in Table 1 and 2. Storage method has affected the essential oil % of *M. arvensis* from 0.70% to 0.51%, 0.723% to 0.51%, and 0.71% to 0.6% in the S_1, S_2 and S_3 conditions, respectively after 10 days of continuous drying. Significantly higher essential oil (0.723%) on first day after harvest (T_1) showed significant decrease upto 0.51% after 10th day of harvest under S_2 condition. However, the storage methods for 10 days was significantly affected the essential oil yield (kg/ha) and content of mentha with lowest essential oil content S_1T_{10}. Study showed the significant relation of drying storage method in respect to essential oil content and yield of the crop. The literature indicates that alteration in essential oil content and bioactive compound was not entirely depends on drying process but can also be species specific, time duration, temperature, and method of drying (Dehghani *et al*. 2018). In previous study of postharvest method, drying *Lippia citriodora* under high temperature above 30ºC, damage the volatile compound and reduced the essential oil content (Yadegri *et al*. 2013; Ebadi *et al*. 2015). Similar results were observed in *Origanum vulgare* and *Origanum onites*, when herb was dried under 60ºC (Ozdemir *et al*. 2017). Ozdemir found negative impact of high temperature on the essential oil content, yield and its chemical composition of these two crops.

Table 1: Influence of post-harvest storage condition on essential oil (%) and quality of *Mentha arvensis*

Parameters	Essential oil content (%)				Menthol (%)			
Treatments	**S_1**	**S_2**	**S_3**	**Mean**	**S_1**	**S_2**	**S_3**	**Mean**
T_1	0.68	0.72	0.71	0.71	76.86	77.58	76.58	77.01
T_2	0.70	0.71	0.70	0.70	74.61	77.58	75.21	75.80
T_3	0.69	0.69	0.69	0.70	71.4	75.28	75.39	74.02
T_4	0.69	0.69	0.68	0.70	75.3	74.57	74.39	74.75
T_5	0.66	0.67	0.66	0.66	74.98	75.18	75.77	75.31
T_6	0.65	0.65	0.65	0.65	76.7	72.87	73.98	74.52
T_7	0.58	0.59	0.59	0.59	76.36	72.81	74.72	74.63
T_8	0.58	0.55	0.57	0.57	71.75	74.01	74.2	73.32
T_9	0.55	0.54	0.56	0.56	75.4	73.99	74.4	74.60
T_{10}	0.51	0.52	0.54	0.54	76.88	73.80	74.32	75.00
Mean	0.63	0.63	0.65		75.02	74.77	74.90	
Analysis	T	S	T ×S		T	S	T ×S	
SEm±	0.004	0.001	0.0112		0.098	0.026	0.294	
LSD(0.05)	0.011	0.003	0.0315		0.277	0.075	0.833	

T_1: same or first day of harvest; T_2: second day of harvest; T_3: third day of harvest; T_4: fourth day of harvest; T_5: fifth day of harvest; T_6: sixth day of harvest; T_7: seventh day of harvest; T_8: eighth day of harvest; T_9: ninth day of harvest; T_{10}: tenth day of harvest

S_1: open field condition; S_2: under shade; S_3: ventilated room. Treatments with the same superscript letter are not significantly different at alpha=5%.

Table 2: Influence of post-harvest storage on essential oil yield of *Mentha arvensis.**

Storage → Treatment ↓	S1	S2	S3	Mean
T1	170.83	180.83	179.16	176.94
T2	175.00	177.50	175.83	176.11
T3	172.50	172.50	172.50	172.50
T4	172.50	168.30	172.50	171.11
T5	165.80	168.30	164.16	166.11
T6	164.16	162.50	162.50	163.05
T7	145.83	146.66	155.83	149.44
T8	145.83	138.33	150.00	144.72
T9	137.50	134.16	150.00	140.55
T10	129.91	130.00	150.00	136.38
Mean	157.91	157.91	163.25	
Analysis	**T**	**S**	**T*S**	
$SEm_{\pm}$	0.929	0.253	2.787	
$LSD_{(0.05)}$	2.628	0.716	7.880	

****On the basis of estimated herb yield 250 quintal/ha of menthol-mint***

Oil yield (kg/ha)

Maximum oil yield of mentha 180.83 kg/ha and 179.16 kg/ha were observed on the first day of harvest (T_1) in S_2 (shade condition storage) and S_3 condition, respectively (Table 2). 2^{nd} day of storage T_2S_1 oil yield showed essential oil yield 175 kg/ha, which is almost equal to oil yield observed in T_2S_2 (177.5kg/ ha) and T_2S_3 (175.83 kg/ha). Yield of *M. arvensis* essential oil start to decrease continuously till the plant loses its moisture content completely. In S_3 storage condition, essential oil yield decline from 5^{th} day T_5 (164.16 kg/ha) to 7^{th} day T_7 (150 kg/ha) was still higher than the other two conditions. 10^{th} of storage (T_{10}), lowest essential oil yield recorded was 129.16 kg/ha, 130 kg/ha and 150 kg/ha in S_1, S_2 and S_3 condition, respectively. Significant relation was found between different drying days and essential oil yield in T_1S_2 with highest oil yield 180.83 kg/ha and in $T_{10}S_1$ with lowest oil yield 129.91 kg/ha. Out results were match with previous records that essential oil yield of aromatic crops (in this case mentha) dried in open field condition (sun) was affected with decrease in bioactive compounds. Rebey, carried out an experiment which shows increased essential oil content when the sample was dried under shade (Rebey *et al*. 2020). Similar finding were observed in *C. flexuosus* (lemongrass) where essential oil percentage was higher in shade condition than the other conditions (Upadhyay *et al*. 2019). Drying mentha herb in open field condition (S_1) has directly affected the essential oil content from 1^{st} day (T_1) to 10^{th} day of harvest (T_{10}), was due to direct exposure to sunlight and temperature. Present result has recorded maximum essential oil content and oil yield in drying material under ventilated room than any other methods. Drying process under shade was found more suitable than open field condition because of the lower temperature which preserves the damage of trichomes and protects the loss of essential oil content (Thamkaew *et al*. 2020).

Bioactive content (%)

Significantly highest Menthol content 76.86 %, 77.58%, 76.58% were recorded on same or 1^{st} day of harvest (T_1) stored under different post-harvest methods viz., open field (T_1S_1) condition, shade (T_1S_2) condition and ventilated room (T_1S_3) conditions, respectively. The lowest menthol content 71.75%, 72.81% and 73.98% were recorded in different days of harvest stored under open field (T_8S_1), shade (T_7S_2) and ventilated room (T_8S_3) condition, respectively. Menthol content decreases up to 76.88% in ($T_{10}S_1$), 73.8% in ($T_{10}S_2$) and 74.32% ($T_{10}S_3$) on 10^{th} day of harvest (Table 1). Although, there is less consistency in decreasing order of menthol content (76.86 to 76.88%) recorded from 1^{st} day to 10^{th} day of harvest in open field condition (S_1) may be due to uneven exposer of sunlight in each sample as compared other drying condition. Different studies evaluate the influence of drying condition on the essential oil yield and major compounds of *Melissa officinalis L.*, *Mentha piperita*, *Thymus vulgaris*, *Thymus daenensis*, *Salvia hydrangea* and *Pogostemon cablin* and found that dying in high temperature or under direct sunlight involves in evaporating the oil content and volatile compounds in it, which lower the oil yield after distillation (Çalişkan *et al*. 2017; Khanuja *et al*. 2004; Ambrose and Naik, 2013; Mashkani *et al*. 2018; Mahdiyan and Pirbalouti, 2017; Pluha *et al*. 2016). Menthol was the major compound found in essential oil of fresh and dried leaves of *M. arvensis*. High menthol content (77.58%) was found in fresh mentha distilled immediately after harvest. Our results were similar with previous reported data of essential oil composition of *M. piperita*, *Ocimum basilicum* and *L. thymoides* (Gasparin *et al*. 2014; Alves *et al*. 2015; Silva *et al*. 2016). There results showed a change in the percentage of major compound menthol, linalool, methyl chavicol and thymol in sample dried under different condition with temperature above 30°C. Therefore, correct drying method is very important step of postharvest process to minimize the loss of essential oil content and change in chemical profile. Drying under ventilated room or shade can be an appropriate method to obtained better quality essential oil. Numerous studies in past few years have been focused on post harvested management of aromatic plants to increase their shelf-life and maintain the quality of essential oil (Mahmoudi *et al*. 2020).

Conclusion

According to the results, storage at different condition for long period of time has affected the essential oil content of *Mentha arvensis*. Significantly highest essential oil content (0.723%) was collected from first day of harvest as compared to other days of treatments (days after harvest). High menthol content (77.58%) was identified in essential oil collected from fresh leaves of *M. arvensis*. However, Mentha crop stored in ventilated room (S_3) have good impact with minimum loss of essential oil and menthol content as compared to other drying methods. Perhaps this drying process is right in preserving the quality of essential oil and preventing from contamination but still needed more study. Results do not suggest the postharvest drying of crop in open field under direct sunlight. Thus, the results of present study suggest that distillation of *M. arvensis* crop should be done fresh after harvest for better quality and quantity of essential oil.

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Conflict of interest

The authors declare that they have no conflict of interest.

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