Comparative studies on dehydration of mint (Mentha arvensis) by open sun drying, solar drying and hot air cabinet drying

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ABSTRACT
One of the processes to increase the shelf life of the food products is drying and dehydration. Vegetables may be dried by different methods like solar drying, open sun drying and other mechanical methods so that they can be available during the lean season. In this study, mint was subjected to drying after giving two different treatments and their respective physical and chemical parameters were evaluated. An increase in chlorophyll content, flavonoid content and Vitamin A content was observed in all of the dried samples as they become concentrated source of nutrients. However, a decrease in polyphenol content and Vitamin C content in all of the samples was found. Drying rate of solar dryer was higher than hot air dryer and open sun drying. The aroma of dried mint was maintained in solar dried samples but was lost in hot air dryer and open sun drying.

Key words: Mint leaves (ML), Solar Dried Mint (SDM), Hot Air Dried Mint (HADM), Open Sun Dried Mint (OSDM).

INTRODUCTION
Mint (Mentha arvensis) belongs to the Labiatae family, which comprises a wide number of species, varieties and hybrids. It helps to treat colds, flu, fever, poor digestion, motion sickness, food poisoning and for throat and sinus ailments (Ozbek and Dadali, 2007; Doymaz, 2006). Mint as flavoring agent falls behind vanilla and citrus flavors (Arslan et al., 2010).

Menthol is mostly responsible for the spasmylic nature of peppermint. It stimulates bile flow, reduces the tone in the esophageal sphincter, facilitates belching, and has antibacterial properties (Fleming, 1998 and Tyler, 1992). It is used as a local anesthetic agent in cold and cough preparations (lozenges and syrups) and in liniments for insect bites, eczema, poison ivy, hemorrhoids, toothaches, and musculoskeletal pain (Murray, 1995; Peirce, 1999). It is used as an antitussive in chest rubs or inhaled as a steam vapor. It also provides a local anesthetic action on the lungs and throat, suppressing the cough reflex (Robbers and Tyler, 1999).

MATERIALS AND METHODS

Materials: The fresh mint (Mentha arvensis) leaves were procured from local market, Hisar. They were washed by running under tap water and stored in a refrigerator at about 5°C until they were taken for studies. Prior to experiments, the mint leaves of almost same size, appearance and degree of maturity were manually selected, trimmed, and washed under running tap water. Defective leaves, stings were removed, if any.

Thermal treatment: Thermal treatment of the leaves was carried out by immersing the fruit slices in boiling water for an assigned time period i.e. water blanching (4 minutes) and steam blanching (4 minutes) and drained for 1 min. The boiled leaves were then transferred to ice water bath (ratio of ice to water was 1:4) for 2 minutes to halt the heating process and drained for 1 min. An uncooked sample with no treatment was used as a control.

Equipments and apparatus: Drying experiments were performed on a continuous convective hot air dryer, solar dryer and open sun drying. The solar dryer was constructed in the Department of Food Technology, GJUS&T, Hisar. The hot air drying temperature can be automatically controlled by regulating the required voltage to the heaters inside the air channel. The accuracy of the temperature was ±1°C by carefully control. A digital electronic balance in the measurement range of 0-210 g and an accuracy of 0.01 g was used for the moisture loss of samples.

Evaluation of physical parameters of mint.

Determination of moisture content: Moisture content of un-treated as well as treated samples was estimated just before drying treatment was measured by hot air oven drying method (Ranganna 1986). The samples were dried at 100°C till the constant weight was obtained. Weight of the samples was determined after cooling it in desiccators. It is expressed in percentage (%). The initial moisture content was then used for the determination of the moisture ratio. The loss in weight during drying was used to determine the moisture content of the samples during the drying process. Moisture content was determined using formula:

\[
\text{Moisture content (% dry basis)} = \frac{\text{wt. of water (removed)}}{\text{wt. of dried samples}}
\]
**Chlorophyll estimation** was carried out on a sample taken from the absorption at 645 nm. Total chlorophyll (in the total chlorophyll in an 80% acetone extract) was quantified using spectrophotometry based on the Beer-Lambert Law. Chlorophyll was quantified with a (80% acetone) blank and calculations of respective samples were made up to 100 ml with 80% acetone. This process was repeated for all the samples. The absorbance of the extract was read at 645 and 663 nm against the solvent to make up for the clear washings were collected in the beaker. The volume was made up to 100 ml with 80% acetone. This process was repeated for all the samples. The absorbance of the extract solutions was read at 645 and 663 nm against the solvent (80% acetone) blank and calculations of respective samples using spectrophotometer. Chlorophyll was quantified with a spectrophotometer based on the Beer-Lambert Law. The equations of Arnon (1949) were used for quantification of the total chlorophyll in an 80% acetone extract:

\[
\text{Total chlorophyll (mg/mL)} = 20.2 \times (A_{645} + 8.02(A_{663}))
\]

Where, \(A_{645}\) is the solution absorbance at 663 nm and \(A_{663}\) is the absorption at 645 nm.

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**Drying Rate**: Drying rate was calculated as weight of water removed per unit time per unit weight of the dried sample.

\[
DR = \frac{W_r}{t \times W_i}
\]

Where,
- \(W_r\) is weight of water removed from the sample
- \(t\) is time taken to remove \(W_r\)
- \(W_i\) is bone dry weight of the sample

**Sensory evaluation**: The different attributes of the product were evaluated by a panel of 10 judges using a 9-point Hedonic rating scale (Ranganna, 1986). A ten member sensory panel consisting of 4 male and 6 female students, who were familiar with the attributes, investigated the sensory qualities of mint leaves and control. Panelists evaluated the sample attributes against a control sample with a cooking effect. Panelists were comfortably seated in booths and served with separate plates of the cooked vegetables. Panelists evaluated samples for color, taste and texture characteristics on a 9 point descriptive scale with 9 = Like extremely, 8 = Like very much, 7 = Like moderately, 6 = Like slightly, 5 = neither like nor dislike, 4 = Dislike slightly, 3 = Dislike moderately, 2 = Dislike very much, 1 = Dislike extremely.

**Rehydration Ratio**: To calculate the rehydration parameter, the dried sample was placed in a hot water bath at 100°C for 10 minutes. Then, the amount of rehydration is calculated by the equation presented below:

\[
RR = \frac{M}{M_0}
\]

Where,
- \(RR\) = rehydration ratio
- \(M\) = sample weight after placing it in the hot water bath
- \(M_0\) = sample weight before placing it in the hot water bath

**Evaluation of chemical parameters of mint.**

**Chlorophyll**: Chlorophyll estimation was carried out according to Arnon (1949) and Brown and Hooker (1977). This procedure was carried out in dim light in order to reduce photo-destruction of the pigments. Healthy fresh green vegetables of the above mentioned green species were collected and 1 gram of each was weighed and finely cut and ground to a fine pulp with the addition of 20 ml of 80% acetone using a mortar and pestle. This process was repeated four times till the residues became almost colorless. The mortar and pestle was also washed with 80% acetone and the clear washings were collected in the beaker. The volume was made up to 100 ml with 80% acetone. This process was repeated for all the samples. The absorbance of the extract solutions was read at 645 and 663 nm against the solvent (80% acetone) blank and calculations of respective samples using spectrophotometer. Chlorophyll was quantified with a spectrophotometer based on the Beer-Lambert Law. The equations of Arnon (1949) were used for quantification of the total chlorophyll in an 80% acetone extract:

\[
\text{Total chlorophyll (mg/mL)} = 20.2 \times (A_{645} + 8.02(A_{663}))
\]

**Beta-carotene**: Beta-carotene estimation was carried out according to Srivastava and Kumar (2003). About 5 g of fresh mint samples were taken and crushed in 10-15 ml acetone, adding few crystals of anhydrous sodium sulphate with help of petroleum ether. The process was repeated twice and transferred the combined supernatant into a separating funnel. Then, 10-15 ml petroleum ether was added to it and mixed thoroughly. Two layers separated out on standing. The lower layer was discarded and upper layer was collected in a 100 ml volumetric flask. The volume was made up to a volume of 100 ml with petroleum ether. Optical density was recorded at 452 nm using petroleum ether as blank.

\[
\text{B-carotene (µg/100g)} = \text{O.D.} \times 13.9 \times 10^4 \times 100/\text{wt. of sample x 560 x 1000}
\]

**Ascorbic acid**: The most satisfactory chemical method of estimation are based on the reduction of 2,6-dichlorophenol-indophenol by ascorbic acid and those based on the reaction of dehydroascorbic acid with 2,4-dinitrophenylhydrazine (AOAC, 1995). Firstly, standardization of dye was required. 5 ml of standard ascorbic acid solution was taken and 5 ml of HPO was added to it. This was filled in a micro burette with the dye. It was treated with the dye solution till pink colour persisted for 15 sec. The dye factor i.e. mg of ascorbic acid per ml of the dye was determined by using the following formula: 0.5/titre value.

\[
\text{Mg. of ascorbic acid per 100 g or ml} = \frac{\text{titre x dye factor x volume made up x 100}}{\text{wt. or volume of aliquot of extract or fractions in methanol}}\times \frac{\text{wt. of sample taken for estimation}}{\text{for estimation}}
\]

**Total phenolic content**: Total phenolic content was determined according to the method of Chun et al. (2003). Extract (0.3 ml) was placed into test tubes followed by the addition of 1.5 ml of Folin-Ciocalteu’s reagent (diluted 10 times with water) and 1.2 ml of sodium carbonate (7.5% w/v). The test tubes were covered with parafilm, vortexed and allowed to stand for 30 min. The absorbance was measured at 765 nm against a reagent blank. If the sample absorbance exceeded 1, the sample was diluted appropriately to give reading less than 1. A standard calibration curve was prepared by using gallic acid. Total phenolic content was expressed as Gallic Acid Equivalents (GAE) in mg per 100g of fruits. As ascorbic acid contributes to the formation of blue molybdenum-tungsten complex, absorbance originating from it was corrected by measuring an ascorbic acid calibration curve.

**Flavonoid**: The total flavonoid contents were measured by a colorimetric assay (Zhen et al., 1999; Zou et al., 2004). A 100.0 µl aliquot of extracts or fractions in methanol was added to a 10 ml volumetric flask containing 4 ml of distilled water. At zero time, 0.3 ml 5% sodium nitrite was added to the flask.

The amount of chlorophyll present in the sample was expressed as mg/g.
After 5 min, 0.3 ml of 10% aluminium chloride was added. At 6th min, 2 ml of 1 M sodium hydroxide was added to the mixture. Immediately, the mixture was diluted to volume with the addition of 2.4 ml distilled water and thoroughly mixed. Absorbance of the mixture, pink in color, was determined at 510 nm versus a blank containing all reagents except samples of extracts or fractions. Rutin was used as standard for the calibration curve. Total flavonoid content of the extracts and fractions were expressed as mg rutin equivalents (RE) per gram of sample (mg/g).

**Statistical analysis:** The data obtained on quality characteristics after experimental trials as mentioned above were statistically analyzed to attain the best treatment for drying of mint leaves. The analysis tool provided in the SPSS was used for analysis.

**RESULTS AND DISCUSSION**

**Evaluation of physical parameters of mint.**

**Moisture content:** In case of mint, highest moisture content was found in water blanched hot air dried sample and lowest was found in un-blanched solar dried sample. There was a significant difference between moisture content of differently treated and differently dried mint (Table 1). The moisture content in solar dehydrated samples was lower as compared to conventional method dried samples, because, solar dryer is more efficient than the conventional methods as reported in earlier studies also (Dhotre, 2012). It was observed that the temperature inside solar dryer was about 8-10°C higher as comparison to hot air dryer and open sun drying and the time taken by solar dehydrator was also less as compared to other methods. This could have led to more moisture removal in solar dryer than other methods (Fig.1)

**Drying rate:** There was a significant difference in differently treated and differently dried samples of mint (Table 1). There is a better drying rate of solar dehydrator than hot air dryer and open sun drying methods specially blanched samples (0.688). As shown in Fig.2, blanched vegetables have higher drying rate as it was found that pretreatment of food materials have been investigated to improve the effect of drying (Piga et al., 2004). Blanching as a form of pretreatment has been reported to increase the drying rate of some fruits including, pepper (Turhan et al., 1997) and peach slices (Kingsly et al., 2007). The graphical representation of Table 1 is given in Fig.2

**Rehydration ratio:** The shape and size of all the samples significantly differed from the fresh ones due to shrinkage resulting from the removal of large quantities of water. The

![Fig 1: The difference in moisture content of mint after drying.](image1)

![Fig 2: The difference in drying rate after different treatments and drying](image2)

<table>
<thead>
<tr>
<th>Table 1: Physical Parameters of Mint</th>
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<tbody>
<tr>
<td><strong>SAMPLES</strong></td>
</tr>
<tr>
<td>Unblanched Solar Dried</td>
</tr>
<tr>
<td>Water blanched Solar Dried</td>
</tr>
<tr>
<td>Steam blanched Solar Dried</td>
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<tr>
<td>Unblanched Hot Air Dried</td>
</tr>
<tr>
<td>Water blanched Hot Air Dried</td>
</tr>
<tr>
<td>Steam blanched Hot Air Dried</td>
</tr>
<tr>
<td>Unblanched Open Sun Dried</td>
</tr>
<tr>
<td>Water blanched Open Sun Dried</td>
</tr>
<tr>
<td>Steam blanched Open Sun Dried</td>
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</tbody>
</table>
ability of the dried product to regain its original mass analyzed in terms of RR. It may be noted that higher rehydration ratio indicates better product. There was a significant difference between differently treated and differently dried rehydration ratio of mint leaves (Table 1, Fig. 3). The rehydration ratio in case of mint was in accordance with Kaur et al. (2008). Pretreated samples gave much higher RR values compared to those of control samples and as in accordance with Doymaz and Ismail, 2010.

**Sensory evaluation:** The results showed that unblanched solar dried mint have the maximum overall acceptability (7) and open sun dried mint have the lowest acceptability (4). Unblanched solar dried mint has the maximum acceptability of aroma, taste and color which is better than other dried samples. It was found that both aroma and color was maintained in solar dried samples of mint. The results are statistically significant. The graphical representation of Table 1 is given in Fig. 4.

**Evaluation of chemical parameters of mint.**

**Chlorophyll content:** There was a significant difference between chlorophyll content differently treated and differently dried mint leaves (Table 2). There was an increase in chlorophyll content after water blanching (27.02 mg/lt) as water or steam blanching at 80°C for three minutes resulted in greater chlorophyll retention in the product (Ahmed et al., 2001). The results showed significant increase in all the chlorophyll content in the dried samples of the vegetables making them a concentrated source of nutrients and is in accordance with Joshi and Mehta, 2010. The graphical representation of Table 2 is given in Fig. 5.

**Flavonoid content:** The table shows the highest flavonoid content in water blanched solar dried mint. The results showed significant increase in the flavonoid content in almost all the dried samples of vegetables making them a concentrated source of nutrients (Joshi and Mehta, 2010). Chen et al. (2011) observed that the total flavonoid contents of orange (Citrus sinensis) peel extracts decreased with lower heating temperature (<80 °C) and increased with higher heating temperature (>90 °C). Hot air dryer was at lower temperature (42°C) so there is not any significant increase in flavonoid content. The pictorial representation of Table 2 is given in Fig. 6.
Table 2: Chemical Parameters of Mint

<table>
<thead>
<tr>
<th>SAMPLES</th>
<th>Chlorophyll content (mg/lt)</th>
<th>Flavonoid content (RE mg/lt)</th>
<th>Polyphenol content (GAE mg/100 g)</th>
<th>Vitamin A (I.U.)</th>
<th>Vitamin C (mg/100g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh sample</td>
<td>10.95±0.98</td>
<td>2.27±0.01</td>
<td>1.05±0.01</td>
<td>3.55±0.01</td>
<td>33.2±0.2</td>
</tr>
<tr>
<td>Unblanched Solar Dried</td>
<td>12.75±2.01</td>
<td>11.63±1.10</td>
<td>0.68±0.00</td>
<td>3.95±0.01</td>
<td>33.2±0.1</td>
</tr>
<tr>
<td>Water blanched Solar Dried</td>
<td>27.02±1.02</td>
<td>20.15±1.00</td>
<td>0.05±0.01</td>
<td>7.32±0.01</td>
<td>15.9±0.1</td>
</tr>
<tr>
<td>Steam blanched Solar Dried</td>
<td>16.38±1.02</td>
<td>8.09±1.00</td>
<td>0.08±0.00</td>
<td>9.34±0.01</td>
<td>16.0±1.0</td>
</tr>
<tr>
<td>Unblanched Hot Air Dried</td>
<td>11.06±1.03</td>
<td>9.15±1.00</td>
<td>0.67±0.00</td>
<td>3.11±0.01</td>
<td>16.0±2.0</td>
</tr>
<tr>
<td>Water blanched Hot Air Dried</td>
<td>11.46±0.03</td>
<td>9.66±1.00</td>
<td>0.03±0.01</td>
<td>6.90±0.10</td>
<td>16.0±1.0</td>
</tr>
<tr>
<td>Steam blanched Hot Air Dried</td>
<td>13.65±1.00</td>
<td>5.07±1.00</td>
<td>0.07±0.00</td>
<td>8.68±0.01</td>
<td>30.0±1.0</td>
</tr>
<tr>
<td>Unblanched Open Sun Dried</td>
<td>10.99±1.00</td>
<td>9.75±1.00</td>
<td>0.04±0.01</td>
<td>7.21±0.00</td>
<td>15.7±0.1</td>
</tr>
<tr>
<td>Water blanched Open Sun Dried</td>
<td>15.80±1.10</td>
<td>9.68±1.00</td>
<td>0.04±0.01</td>
<td>7.21±0.00</td>
<td>15.7±0.1</td>
</tr>
<tr>
<td>Steam blanched Open Sun Dried</td>
<td>11.27±0.98</td>
<td>6.78±0.89</td>
<td>0.07±0.10</td>
<td>7.91±0.00</td>
<td>16.0±1.0</td>
</tr>
</tbody>
</table>

Polyphenol content: The results also showed significant decrease in the polyphenol content in case differently treated and differently dried mint. The decrease in phenolic compounds was in accordance with the studies of Myojin et al. (2008) and Wen et al. (2010). These researchers reported that the phenolic compounds in the vegetables studied were sensitive to heat and the heat treatment caused a significant loss of phenolic content which leached into the water (Fig. 7).

Vitamin A: As shown in table 2, maximum vitamin A content was found in steam blanched solar dried mint (9.34 I.U.). The results showed significant increase in Vitamin A in all of the differently treated and dried samples of the vegetables making them a concentrated source of nutrients and results are in accordance with Joshi and Mehta, 2010. The graphical representation of Table 2 is given in Fig. 8.

Vitamin C: The results (Fig. 9) shows significant decrease in Vitamin C in almost all of the differently treated and dried samples of the vegetables as Vitamin C is a heat labile vitamin and is destroyed when exposed to direct sunlight and heat due to oxidation (Joshi and Mehta, 2010).

CONCLUSION
In the present study, various processing treatments were applied on mint leaves. These processing treatments were water and steam blanching followed by solar drying, open sun drying and hot air dried. Then studies the effect of different processing treatments on physic-chemical properties were studied. Drying of food products is very important because it is the easiest and the most common
way of food preservation. Drying increases shelf life of the product.

Fresh mint leaves take 8 hours in solar dryer and 11-16 hours in hot air dryer and open sun drying. After drying, it was found that there is an increase in chlorophyll content, flavonoid content and Vitamin A content in all of the samples. There was a decrease in Vitamin C content in all of the samples. Drying rate of solar dryer was higher than hot air dryer and open sun drying. In case of sensory evaluation, color was maintained by hot air dryer because it was at low temperature (42°C) but somewhat degraded in solar dried samples. The aroma of all the leaves was maintained in solar dried samples but was lost in hot air dryer and open sun drying. Samples dried in solar dryer makes concentrate of nutrient during drying. Un-blanched samples work more efficiently for drying. In short, solar dryer was more efficient than the conventional methods like hot air dryer and open sun drying.

REFERENCES