How to Cite:
Rehman, S., & Rubab, S. (2022). Solar radiation impact on drying parameters of mint (Mentha spicata L.). *International Journal of Health Sciences*, *6*(S6), 3235–3246. https://doi.org/10.53730/ijhs.v6nS6.10053

Solar radiation impact on drying parameters of mint (Mentha spicata L.)

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***Abstract*---**This paper presents a kinetic study of solar dehydrated mint (Mentha spicata L.) with no prior treatment. The drying kinetics of mint leaves dried in Domestic Solar Dryer in terms of colour attribute, moisture content, drying time, non enzymatic browning, water activity, rehydration ratio were calculated. This study is very useful for household scale drying of mint leaves to optimize drying process and to achieve superior quality dried product at home maintaining its colour and aroma without incurring huge cost.

***Keywords*---**convection, enzymatic reactions, moisture content, texture, water activity.

Introduction

Mentha spicata is sweet-smelling aromatic plant having many gastronomic and curative values. Its vegetation fresh or dried has remedial significance. It is used equally in fresh and dried out forms in diverse cordon bleu. The Mentha leaves have diverse use indifferent types of salads, soups, sauces, juices [1,2,3]. Dried mint is used in the traditional cooking in Kashmir valley which enhances flavor of the dish. Mint grows effortlessly in Kashmir valley but is not obtainable throughout the year because of inconsiderate weather conditions. The genus belongs to the *Labiatae* family and has many varieties having diverse characteristics. A significant quality parameter is its colour. The menthol there helps to lessen irritable bowel syndrome symptoms by comforting the muscles of the alimentary canal [4]. It can be effectual in relieving additional digestive troubles like disturbed stomach and dyspepsia [5]. Studies reveal that mint is

used in relieving the obstruction in nose[6]. It is referred that breathing the fragrance of this herb can lead to wellbeing of brain function [7]. This herb has numerous health benefits. However cannot be grown during the winter season because of the inconsiderate weather from the November to April [8].

Fresh mint is usually preferred over dried mint because long term storage of the mint is an issue. In order to keep it unimpaired, it needs to be dehydrated. Typically it is dried out in open sun, however open sun drying manifest discoloration of herbs and loss of aroma thus remains repugnant for the consumer. Furthermore the insect, pest infestation, bird droppings, rodent attack, chances of rain etc spoils the product. Such drying condition leads to stern losses in the quantity and quality of the dehydrated product. The scientist developed diverse types solar drying systems for which drying characteristics of mint are reported [9,10,11]. The solar drying system make use of solar power to amplify the temperature and dry out the food substance, which is favorable in plummeting wastage and helps in safeguarding of agricultural produce. The practice of such dryers is restricted to the group of researchers. Many types of dryers have been developed on the industrial level and are being used for the commercial purpose incurring high capital and maintenance cost. Consequently due to the shortcomings, researchers necessitate to develop a domestic dryer so as to minimize the loss of surplus vegetables produced during the summer season and to preserve the herbs for longer period with superior quality of dehydrated produce. During the drying process, initially liquid is removed swiftly eliminating free water, and then drying speed is reduced steadily in proportion to the product liquid reduction as already reported [12]. The bound liquid present in the food can be the motive for the fungal intensification and lessen the life span.

Materials and Method

Fresh mint procured from the local kitchen garden, as shown in figure 1(a) was properly washed, not de-stemmed and slightly dried up with blotting paper. The sample weight on the sensitive scale was found to be 500 g. Mentha was laid on the mesh trays of the dryer which is natural convective in nature and does not necessitate any exterior agency for the exclusion of water as it is provided with two vents for exchange of air. It is constructed from locally available willow wood, is portable weighing 5 kg which can be lifted effortlessly. The prototype of dryer can be seen in figure 1(b). The moisture content of the herb during the drying process is determined by difference in weight of the sample at different stages of drying which is recorded in Figure 2.

Fig 1. (a): Fresh Mint

Fig 1 (b): Mint drying in Solar Dryer

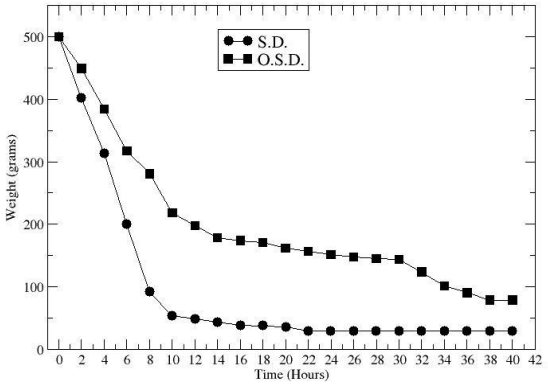

Figure 2. Variation of weight versus drying time

Dipping moisture content was calculated by measuring the weight decline of the mint all through the drying course. Initially the weight abridged considerably

indicative of moisture content loss of the sample; gradually the weight lessening became slow. Slow drop of weight indicates the bound moisture being dehydrated in the product. The endurance of the dehydrated herb increases by solar drying. The aroma, colour and other parameters remain intact.

Results and Discussion

The quality evaluation of any dried food products is determined by its color, brightness, texture changes, water activity, moisture content and steadiness over time. The parameters have certain standards which the prototype should adhere to. The quality analysis was done on that basis.

Determination of Colour

Colour has an imperative function in food satisfactoriness by the consumer, and it may influence taste, perception of sweetness, and pleasantness [13. Numerous reactions take place during thermal processing that affect the hue. The widespread are degradation of chlorophyll pigment furthermore Maillard reaction and oxidation of ascorbic acid takes place as a consequence of browning reactions [14]. Quality of product was evaluated on basis of colour and the parameters of colour [lightness (L^*), redness (a^*), yellowness (b^*)] were calculated at the start and the end of the dehydration phase, by colour difference meter (Model CM-508 d Minolta co., Japan). For reference white tile was used and values of L*, a*, b* were recorded for the same. The measurements were done at the right angle avoiding the contact of exterior light source. According to the colour meter model, the L^* measures the whiteness, ranges from (black at 0 to white at 100). The a^* measures green when negative and red when positive and the b^* measures blue when negative and yellow when positive. Hue angle, h^* is the feature of colour correlated to the perceived colour and measures what the eye is able to perceive [15]. The colour parameters are related to the browning reaction where a decrease in L^* values, and increase in a^* values and a decrease in h^* values indicate more browning [16, 13]. The High value of Hue angle indicates less browning and vice versa, while chroma is a measurement of strength of colour such as intensity or saturation. [17]. The values of ΔE, Hue angle and chroma were calculated using the equations:

$$C^{*2} = \sqrt{(a^{*2} + b^{*2})}$$

$$\Delta E = \sqrt{(L^* - L^*_{ref})^2 + (a^* - a^*_{ref})^2 + (b^* - b^*_{ref})^2}$$

$$H^* = \tan^{-1}\{\frac{b^*}{a^*}\} \quad for\ a > 0, b > 0$$

$$H^* = 180 + \tan^{-1}\{\frac{b^*}{a^*}\} \quad for\ a < 0, b > 0\ \&\ a < 0, b < 0$$

$$H^* = 360 + \tan^{-1}\{\frac{b^*}{a^*}\} \quad for\ a > 0, b < 0$$

The values of Chroma, hue Angle and Δ E are summarized in Table 1.The table indicates better results for the samples dried in the solar dryer in comparison to open sun dried samples and better colour is evident in the Figure 3(a) and Figure 3(b) also, consequently more acceptance by the consumers.

Table 1
Colour parameters for fresh, solar dried and open sun dried mint

Herb	Colour Parameters					
Mint	L*	a*	b*	H*	C*	ΔE
Fresh	45.22	-15.63	57.3	254.742	59.39	41.245
Open sun dried	16.29	-4.58	55.68	265.29	55.868	34.42
. Solar dried	22.30	0.54	39.06	261.38	28.562	6.79

Fig 3. (a): Solar Dried Sample

Fig 3. (b): Open SunDried Sample

Texture Changes

Texture is an imperative in dehydrated herbs which is also associated to colour. The dehydration affects the texture in the herbs as cell wall and the vacuole of the cell changes in dimension. Properties of middle lamella and turgor pressure are the significant parameters to determine the texture of the tissue which is already present in the reference [18, 19]. The texture analysis was done using TA-XT2, Stable Micro Systems, UK. The analyzer was fitted with a 2mm probe, and the maximum force required to pierce each product was measured as outlined by Chapman and others (2010) [20]. The results yielded indicate better texture for the solar dried samples in comparison with open sun dried samples.

Water Activity determination

Water Activity (aw) is one of the most significant factor in determining quality and safety of food. There is a water activity limit under which microorganisms are prevented from increasing [21]. It affects the shelf life, safety, texture, flavor and aroma of foods. By dropping the value of water activity spoilage of herb can be reduced to huge extent. On performing the water activity analysis on the water activity meter (Pre- Aqua Lab, Water Activity Analyzer), it is observed Solar dried mint has the water activity value of 0.492± 0.12 while it was 0.536 ± 0.12 for open sun dehydrated mint which is elevated in comparison to solar dried sample.

Moisture Content

The water content in the herbs becomes one of the main causes for their spoilage during the preservation period. If the value of moisture content exceeds 10% it leads to expansion of microorganisms in food [22]. Therefore it becomes imperative to trim down the value of moisture content so as to boost the shelf life of the produce. Thus for this reason samples of mint were dehydrated in the prototype dryer and in the open sun. The loss of water content is determined by the weight loss which is expressed in the figure 3. Moisture content analysis was done on the Halogen based Moisture analyzer. Initial moisture content of the mint is 79 %. The 5 g sample of open sun dried mint was powdered and placed in the tray of pre-heated Moisture Analyzer and the chamber was sealed. The moisture content value was found to be 10.72 % for open sun dried sample. For the samples dried in Solar Dryer, it was found that the moisture content reduced to 6.05 % which seems to be better value in contrast to the open sun dried value. The variation of moisture content versus drying time is plotted and expressed in figure 4.

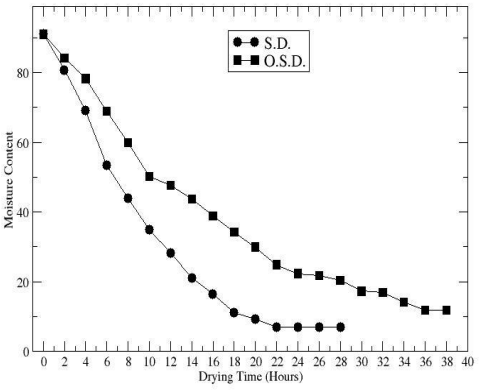

Figure 4. Variation in the moisture content of open sun dried sample and solar dried sample

Rehydration Ratio

Rehydration test is done by dipping 5 g of sample in 60 ml of water separately in a beaker and covered with a watch glass. The sample is heated gradually and brought to boil. Boiling continued for 20 minutes which allow the sample to rehydrate and absorb water sufficiently. The sample is removed from the water and excess water is strained from the sample. The rehydrated mint is weighed again. The rehydration ratio is calculated using the formula given by expressed as equation [23].

$$\text{Rehydration ratio} = W_b / W_a$$

W_b = weight of sample after rehydration
W_a = weight of sample before rehydration

Rehydration results shows that solar dried sample is rehydrated better in comparison to the open sun dried sample as is depicted in figure 5.

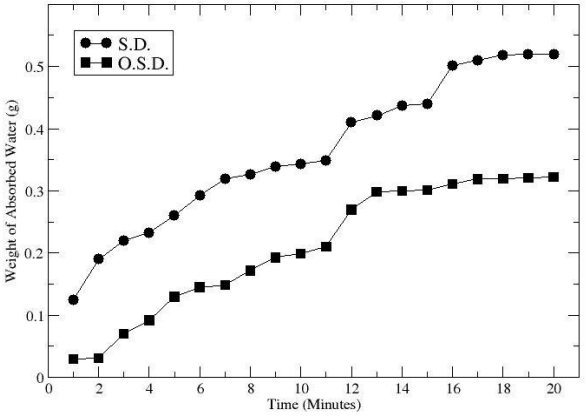

Figure 5. Rehydration value of solar dried and open sun dried samples.

Shrinkage

During drying process the loss of moisture from vegetable leads to structural collapse, shape deformation and capillary contraction [24]. This shrinkage of vegetables depends on the loss of the moisture from the cells. The shrinkage of food materials during drying is a common physical phenomenon which affects the textural quality and taste of the dried product. The shrinkage of food material depends on many factors like material characteristics, mechanical properties, micro-structure, and drying conditions as calculated by Mohiuddin [25]. The shrinkage is measured by the equations:

$$S = \frac{A}{A_0}$$

Where A = Initial area of the product
A_o = Final area of the product

The shrinkage percentage is measured in terms of equation

$$SKG(\%) = (1- \frac{A}{A_0}) \times 100$$

The observed value for the shrinkage were measured and it was found that the solar dried samples show better results in comparison to that of the open sun dried samples and shrinkage is related with the rehydration values, lesser shrinkage leads to better rehydration.

Determination of Ascorbic Acid (Vitamin C)

The dried samples were tested for the presence of Ascorbic acid, in order to find out how much of vitamin is vanished due to drying. The determination of Ascorbic acid in the fresh and the dried samples was done by 2,4-Dichlorophenol Indo-phenol dye method. The dried samples were soaked separately for few hours and ground to make a paste so that the content of vitamin will be determined perfectly. The samples dried in open sun showed the colour change of titer at just 1 ml indicating absence of Ascorbic acid in the sample The Solar dried sample gave titer value at 4 ml leading to the presence of Vitamin C around (3 - 4 mg) per 100 g which is low value but enhanced than open sun dried sample. It indicates that during cutting, washing, drying of mint Vitamin C is reduced, as it is water soluble vitamin. Moreover it indicates that the open sun drying completely destroys the Vitamin C content in the food. Vitamin C is heat and light sensitive vitamin and its loss depends on the exposure to light and the duration for which it is exposed to light [26, 27]

Browning Reactions

Browning not only reduces the visual quality of vegetables but also leads to undesirable change in flavor and nutrition loss [28]. Browning in the eatables is high at water activity value of 0.5 - 0.8 [29, 30] which lead to the Milliard reactions in the food products. The value of absorbance of UV in the sample extract at 420 nm wavelengths is taken as a measure of non enzymatic browning. The samples of 5 g of dehydrated mint were soaked in 100 ml of 60% alcohol for 24 hrs and then filtered. Absorbance of the filtrate was recorded at 420 nm with the help of a UV- spectrophotometer (double beam UV-Vis Spectrophotometer UV S-704 SS) using 60% alcohol as blank and the observation is expressed in terms of optical density given by [31] The analysis done revealed that the samples dried in open sun has more browning in comparison to the samples dried in Solar Dryer. The absorbance and transmittance of the sample is given in Table 2 and comparison can be seen in Figure 6. The browning index of the samples using the L*A*B* values is calculated by the equation as given by (Palou *et al.*) [32].

$$B.I = \frac{[100\ (\ x - 0.31)]}{[\ 0.172\ ]}$$

$$where\ x = \frac{\left[a + 1.75\,L\right]}{[\ 5.645\ L + a - 0.3012\ b\ ]}$$

The change in color is linked with the changing the browning index of the herbs and its nutritional value. The solubility cause degradation of flavor and induces textural changes.

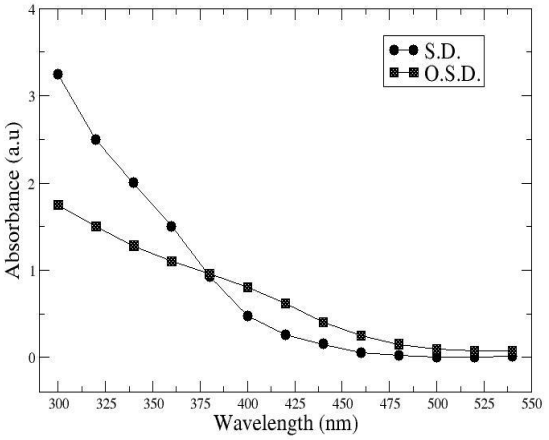

Figure 6. Variation of Absorbance with Wavelength indicating the transmittance

Table 2
Proximate Composition of Raw & Dried Mint

Type	Moisture content(%)	Water Activity	Vitamin C mg/100g	Absorbance	Transmittance%
Fresh	89 ± 0.53	0.964±0.12	18± 0.36	-	-
Open Sun Dried	10.72 ± 0.45	0.536±0.12	Nil	0.516	30
Solar Dried	6.05 ± 0.45	0.492± 0.12	3.4 ± 0.73	0.063	85-90

Conclusion

Dried mint is widely used throughout the globe for its medicinal importance, aroma and flavor. Usually the preferred drying method is to dry the herb in open sun which leads to the discoloration of the herb. The Prototype of fabricated Solar

dryer prevent samples from the direct exposure of the UV rays and hence preserve samples from discoloration. The drying time is reduced, drawbacks of open sun drying are abridged by the solar drying and preserve the nutritive values of the samples. The reduction in the water activity and moisture content of the solar dried sample specify that the sample can be preserved for longer duration.

Acknowledgments

The authors acknowledge the Head Department of Physics, NIT Srinagar Dr M.A. Shah for the support extended during the course of work.

References

1. The Columbia Electronic Encyclopedia, Columbia: Columbia University Press, 2005.
2. Park KJ, Vohnikova Z, Brod FPR, Evaluation of drying parameters and desorption isotherms of garden mint leaves (*Mentha crips* L.). J. Food Eng., 51: 193-199,2002.
3. Thompson A K, Fruits and vegetables (2nd ed.) pp: 273. Oxford: Blackwell Publishing, UK, 2003.
4. Merat S, Khalili S, Mostajabi P, Ghorbani A, Ansari R, The effect of enteric-coated, delayed-release peppermint oil on irritable bowel syndrome. Dig Dis Sci. 55(5):1385-90. doi: 10.1007/s10620-009-0854-9. Epub 2009 Jun 9. PMID: 19507027, 2010.
5. Dalvi S S, Nadkarni P M, Pardesi R, Gupta K C. Effect of peppermint oil on gastric emptying in man: a preliminary study using a radio labelled solid test meal. Indian J Physiol Pharmacol; 35(3):212-4. PMID: 1791066, 1991.
6. Eccles R, Jawad MS, Morris S. The effects of oral administration of menthol on nasal resistance to airflow and nasal sensation of airflow in subjects suffering from nasal congestion associated with the common cold. J Pharm Pharmacol. ;42(9):652-4. doi: 10.1111/j.2042-7158.1990.tb06625.x. PMID: 1981905,1990.
7. Moss M, Hewitt S, Moss L, Wesnes KModulation of cognitive performance and mood by aromas of peppermint and ylang-ylang. International Journal of Neuroscience. 118 (1):59-77. doi: 10.1080/00207450601042094. PMID: 18041606. 2008.
8. Bhat H. A., Rubab S., A study of domestic energy usage patterns in the Kashmir valley: pilot survey of households, International journal of Ambient Energy, volume 30(3) 125-1362009.
9.] Kumar A., Kumar V., (2017) Experimental Investigation on Drying of Mint Leaves (*M. pulegium*) in Solar Tunnel Dryer, International journal of pure and applied bio-science ISSN: 2320 – 7051 *Int. J. Pure App. Biosci.* 5 (2): 682-689 DOI: http://dx.doi.org/10.18782/2320-7051.2498
10. Dattatreya M. Kadam (2011),Thin layer convective drying of mint leave , Journal of Medicinal Plants Research Vol. 5(2), pp. 164-170, 18 January, ISSN 1996-0875
11. Sallam Y.I, Aly M.H. , (2015) Solar drying of whole mint plant under natural and forced convection Journal of Advanced Research 6, 171–178
12. Doymaz I. Convective air drying characteristics of thin layer carrots. Journal of Food Eng; 61(3):359–64, 2004.

13. Hawlader, M.N.A Perera,. C.O and Tian M, Properties of modified atmosphere heat pump dried foods. Journal of Food Engineering, 74: 392– 401, 2006.
14. Barreiro J.A, Milano M, and Sandoval A.J., Kinetics of colour change of double concentrated tomato paste during thermal treatment. Journal of Food Engineering. 33 (1): 359-371, 1997.
15. Mohammadi, A. Rafiee S, Emam-Djomeh Z,. and Keyhani, A. "Kinetic models for colour changes in Kiwifruit slices during hot air drying".World Journal of Agricultural Sciences, 4 (3): 376–383, 2008.
16. Rocha A., and. Morais, A. Shelf life of minimally processed apple (cv. Jonagored) determined by colour changes.2003.
17. Villamiel, M., del Castillo, M.D. and Corzo, N., Browning Reaction in Food Biochemistry & Food Processing edited by Hui, Y.H. USA: Blackwell Publishing, 2006.
18. Jackman R.L., Stanely D.W., Perspectives in the textural evaluation of plant foods, Trends in Food Science nad Technology, 6(6), pp 187 – 194,1995.
19. Chiralt, A. Martinez- Navarette, N. Martinez- Monzo, J, Talens, P. Morago, G. Ayala Fito, P. , Changes in mechanical properties throughout osmotic processes, Cyroprotectant effect, Journal of food engineering, 49 (2-3). Pp 129-1352001.
20. Chapman, J.S.; Jefferies, L.K.; Pike, O.A.; Sensory and Nutritional Quality of Split Peas (Pisum Sativum) Stored up to 34 Y in Residential Storage. Journal of Food Science 2010, 75, (3), 163-166
21. Sachin V., Jangam, Chung Lim Law, Drying of Foods, vegetables and Fruits (Volume 1), ISBN 978-981-08-6759-1, 2010.
22. Ong, S.P. and Law,C.L. Hygrothermal Properties of various Foods, Vegetables and Fruits, in DryingofFoods, Vegetables and Fruits- Volume 1, Ed. Jangam, S.V.,Law, C.L. and Mujumdar, A.S., ISBN – 978-981-08-6759-1, Published in Singapore, pp. 31-58. 2010.
23. Srivastava R. P., Kumar S. Fruits and Vegetable Preservation Methods and Practices, (International Book Distribution Co, Luckhnow), 1993.
24. Luo, Y. and Barbosa-Canovas, G.V. 1997. Enzymatic browning and its inhibition in new apple cultivars slices using 4-hexylresorcinol in combination with ascorbic acid. Food Science and Technology International 3(3): 195–201.
25. Topuz, A. A novel Approach fo Color Degradation Kinetics of Paprika as a function of Water Activity. LWT-Food Scienceand Technology41 (9): 1672-1677. 2008.
26. Lueng, H.K.,. Influence of Wter Activityy on Chemical Reactivity. In Water Activity: Theory and Application to Food, edited by by Rockland, L.B., and Beuchat, L.R., New York; Marcel Dekker, Inc. 1987
27. McMinn, W.A.M and Magee, T.R.A., Kinetics of Ascorbic Acid Degradation and Non- Enzymatic Browning in Potatoes; Food and Bioproducts Processing 75 (4); 223-231.1997.
28. Mayor L, Sereno A.M., Modelling Shrinkage During Convective Drying of Food Materials: A Review: Journal of Food Engineering 61 (3): 373 – 3862004.
29. Mohiuddin M., Imran M., Khan H, Comprehensive Reviews in Food Science and Food Safety Shrinkage of Food Materials During Drying: Current Status and Challenges (2018).

30. Tannenbaum, S.R.,Young V.R., Archer, M.C., Vitamins and Minerals, In Food Chemistry edited by Fennena, O.R., New York Marcel Dekker, Inc. 1985.
31. Gupta M.K., Sehgal V.K. et al, Effect of process parameters and storage length on quality of dried cauliflower during storage, Indian Journal of Traditional Knowledge, Vol. 11(1), 177-184 2012.
32. Palou, E., A. López-Malo, G. V. Barbosa-Cánovas, J. Welti-Chanes and B. G.
33. Swanson. 1999. Polyphenoloxidase Activity and Color of Blanched and High Hydrostatic Pressure Treated Banana Puree. J. Food sci. 64: 42-45.
34. Gede Budasi, I. & Wayan Suryasa, I. (2021). The cultural view of North Bali community towards Ngidih marriage reflected from its lexicons. *Journal of Language and Linguistic Studies*, *17*(3), 1484–1497
35. Akbarov, A. N., & Xabilov, D. N. U. (2021). The condition of the oral cavity in patients who have had a viral infection COVID-19. International Journal of Health & Medical Sciences, 4(4), 381-383. https://doi.org/10.21744/ijhms.v4n4.1796