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Comparative Study on Shade Drying, Sun Drying and Direct Solar Drying of Mint Leaves

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ABSTRACT

Aromatic herbs are in high demand in food processing industries, Cosmetics, biotechnology and pharmaceuticals. Mint leaves can be used as a flavoring agent in food; they are also valued for their antibacterial and antioxidant properties. Mints (Mentha spp.) are a well-known medicinal and aromatic plant. The mint leaves are used as fresh due to high moisture content. Drying helps to inhibit bacterial growth and decrease water activity. The purpose of this study was to enhance their shelf life and save packaging and shipping costs. A comparative study on the drying process of mint leaves was conducted under shade drying, sun drying and direct solar dryer. Fresh mint leaves were collected from the medicinal block of Krishi Vigyan Kendra Vaishali, Bihar, India. They were washed and the excess amount of water was removed from the surface of the leaves. The various parameters recorded hourly in the experiments were temperature and relative humidity inside and outside the direct solar dryer; the weight of the mint leaves was recorded hourly. Temperature plays a great impact in the drying process. The maximum temperature reached in solar drying up to 56^0 C as compared to 42^0 C in sun drying. The minimum relative humidity reached in the direct solar dryer was 17 percent as compared to 28 percent in sun drying.The drying curve data suggest that the drying displays a falling rate period. Henderson pabis model was fitted for drying processes in shade drying, sun drying and direct solar drying. The highest sensory score is reached with color (8.7), flavor (8.5), appearance (9) and overall acceptability (8.7) when dried in a Solar dryer.

To fabricate a low -cost environment friendly solar dryer is quite a challenging task. The solar dryer was built by locally available ply-wood and low- cost materials. The dryer consists of transparent glass, exhaust fan, wire mesh screen, solar cell. Another challenge is to use the maximum solar radiation inside the solar dryer. Inclination angle of the Transparent glass was made 15^o to get maximum radiation.

***Future scope**: World is suffering from harmful gases originated from burning of fossil fuels. Solar energy is a safer and cleaner energy source. Solar dryer can also reduce up to 34 % CO_2 emission. This study aims to maintain best sensory quality of dehydrated herbs and spices.it is also aiming for low -cost clean drying technology and sustainable development.*

***Keywords:** Medicinal herb, flavoring agent, sensory score, drying rate, mint leaves, moisture content, solar dryer, drying model.*

INTRODUCTION

Mints (Mentha spp.) are a well-known medicinal and aromatic plant. The 25-30 species belong to the Lamiaceae family genus Mentha [4], the large family of perennial herbs [8] and grown all over the world. It has unique herbal qualities, such as antibacterial and antioxidant characteristics [8]. The creeping, uniform stems of this perennial herb have oval, rough-surfaced leaves with serrated margins.

Mint leaves are well-known aromatic, culinary, nutritive, and medicinal herbs that are widely cultivated. The few family of mint that are grown around the world such as Water mint (*Mentha aquatica*), gardenmint (*menthaarvensis*), Spearmint (*menthaspicata*), Peppermint (*menthapiperita*), horsemint (*menthalongifolia),* ginger mint (*menthagracilis*), pennyroyal (*Mentha pulegium*), and pine apple mint (*Mentha suaveolens*). It is used in the treatment of illnesses, particularly in sinus problems, rheumatism, hiccups, and flatulence[1] due to its medicinal value. Mint leaves have the properties of Refreshing, stimulant, stomachic, anti-asthmatic, diaphoretic, anti-septic, and anti-spasmodic. It has therapeutic and aromatic uses. Therapeutic use of mint leaves is a treatment of throat pain, joint pain, headache ,colds, fever, food poisoning, motion sickness,indigestion ,rheumatism and itching.

In addition to medicinal value, it serves a variety of culinary purposes. They can be used as fresh or dried. Mint leaves contain abundant of vitamins A and C, lot of calcium, potassium, iron, phosphorus and other nutrients. They have high moisture content (75 to 80 percent). Drying helps in preventing the growth of bacteria and reducing some unpleasant biochemical processes, makes utilized dried leaves. It is a standard method for removing water from agricultural products since ancient times. Dried leaves can be stored for a long time. It reduces the products' weight and volume [14].

Drying is highly beneficial preservation process to preserve seasonal plants and making it accessible to consumers all year

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round. Drying of mint leaves in a Cabinet dryer for temperatures between (35 to 60^{0}C) and the logarithmic model was found suitable for thin layer Drying behavior [2].The empirical page model [10] has given better results than Fick's model for drying of mint leaves. Drying primarily aims to extend storage duration, reduce packing needs, and reduce transportation loads. Drying in open Sun is the prominent method for preserving agricultural products in Turkey as well as the rest of the world. It is a weather- dependent drying. In this method there is a problem of contamination from dust, soil, sand, insects. It has long drying period. Therefore, the process of drying should be carried out in closed equipment [3] to enhance the quality of dried products. The purpose to conduct this experiment is to study about drying behavior and sensory evaluation of leaves of mint in solar dryer, Sun Dryer and shade drying respectively.

MATERIALS AND METHODS

Fresh mint leaves were collected from the medicinal block of Krishi Vigyan Kendra Vaishali, Bihar, India. They were washed and the excess amount of water was removed from the surface of the leaves. Experiments were carried out in Krishi Vigyan Kendra, Vaishali (25.41°N,85.13°E) during the month April 2023 from 10:00 AM to 6:00 PM. A flow chart has been given for drying process in **fig. 1.** In this experiment comparative study was done between sun drying, direct solar drying and shade drying. 300 gm washed mint leaves were kept on wire mesh tray in (0.36 m^2) area of solar dryer, on a sheet in sun and shade (**Fig. 2 a -c).** The relative humidity, temperature of atmospheric air; relative humidity, temperature of drying air inside the direct solar dryer, weight of the mint leaves were recorded hourly.

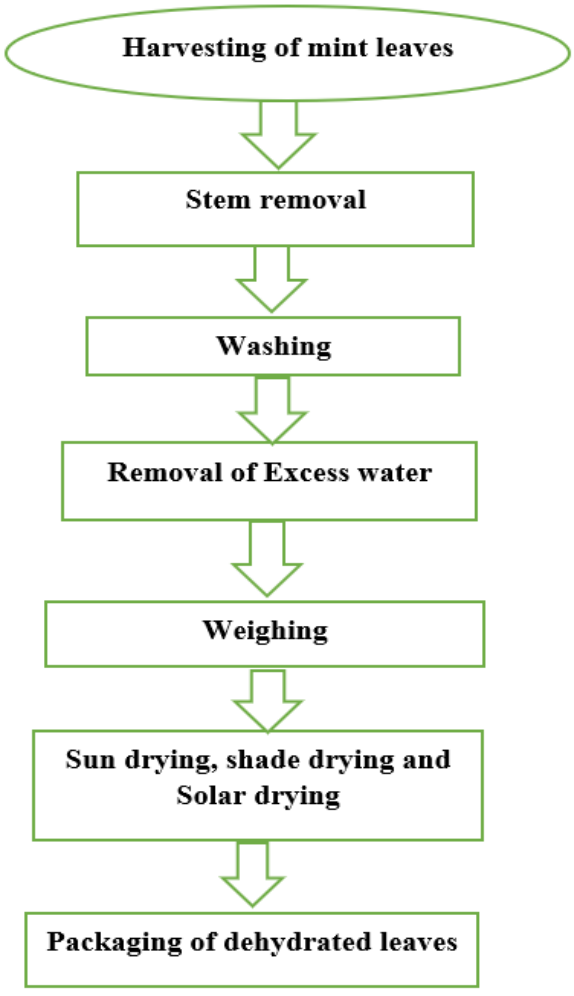

Fig. 1: Flow chart of drying process

Fig. 2 Drying methods

(a) Shade drying *(b) Solar drying* *(C)Sun drying*

Fig 3: Experimental set up direct Solar dryer

The experimental setup is a direct solar dryer (Fig. 3). The top end of this dryer is attached to exhaust fan which is operated by a solar cell (5W). The exhaust fan reduces the humidity inside the chamber. A transparent glass (Thickness 5 mm) is used to cover top of the dryer is to prevent heat losses. Direct Solar dryer is constructed with locally available plywood (Thickness, 12 mm) and inside surface is black painted. The side panel is inclined with 15°.

Moisture content (m) in Kilogram of water per kilogram of material on a wet basis is given below.

$$moisture\ content(\%wb) = \frac{(m_w)}{(m_w+m_d)} = \left(\frac{m_w}{m_T}\right)$$

Where, m_w(Mass of water present in the leaves), m_d (mass of dry matter in the leaves)

Moisture ratio and rate of drying were determined, and the formula was given below.

$$Moisture\ ratio(MR) = \frac{M_T - M_e}{M_O - M_e} = \frac{M_T}{M_O}$$

$$Drying\ rate = \frac{M_{t+dt} - M_t}{dt}$$

MR is simplified to $\frac{M_T}{M_O}$ [1].

Henderson and Pabis Drying model has been fitted according to [6]

$$MR = aexp(-kt)\ (4)$$

The sensory evaluation of the dehydrated mint leaves was assessed by the judges selected from KVK (Krishi Vigyan Kendra) Vaishali, Dr RPCAU, Pusa, Bihar. The organoleptic evaluation was assessed by several attributes like color, flavor, and appearance using a nine -point hedonic scale as given follows. Overall acceptability was calculated by averaging the score. The sensory score was given on the basis of 9 points hedonic scale [13]. Score varied in between (9 to 1) As per the acceptability of consumers.

RESULT AND DISCUSSION

The relative humidity of air inside and outside of solar dryer changes with time) in unloaded condition and loaded with sample (Fig 4-5); the temperature of air inside and outside of the

solar dryer changes with time in unloaded condition and loaded with sample (Fig 6-7) in a direct solar dryer.
The ambient temperature is reached to 38^0 C at 9.30 AM and the maximum temperature of 42 ^{0}C at 12.30 PM in April in without keeping the sample in solar dryer. The drying air temperatures inside the solar dryer were a minimum 44^0 C at 10.30 AM and maximum 57^0 C at 12.30 PM after sample is kept in solar dryer. The RH (relative humidity) of ambient air was minimum (21%) and relative humidity was maximum (30 %) in empty condition. When a direct solar dryer was tested with sample, the initial reading of relative humidity taken at 9.30 AM is (28 %) of drying air after the interval of 2 hours at 12.30 PM minimum relative humidity found was (17%) .

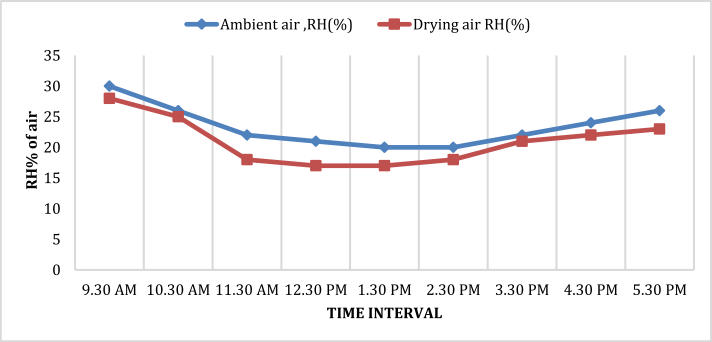

Fig.4 Relative humidity of ambient and drying air in unloaded condition

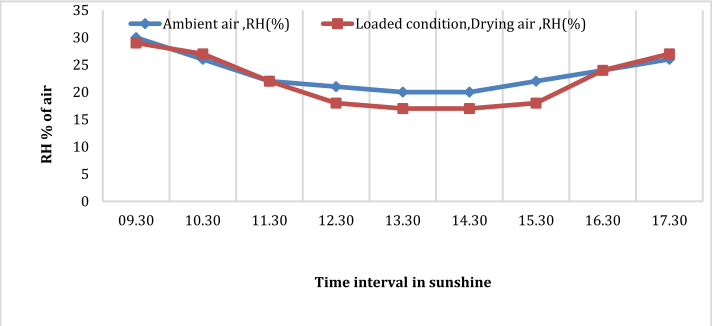

Fig. 5 Relative humidity of ambient and drying air in loaded condition

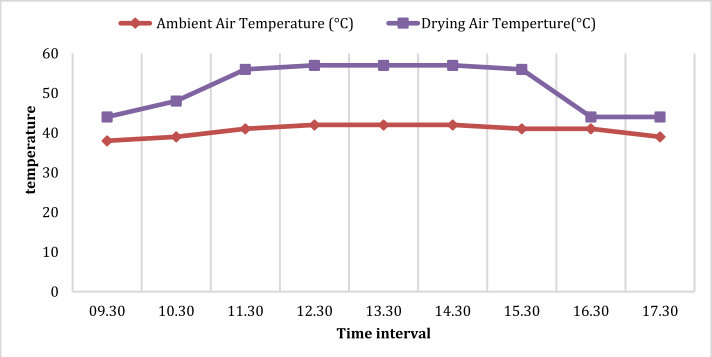

Fig. 6 Temperature of ambient and drying air in unloaded condition

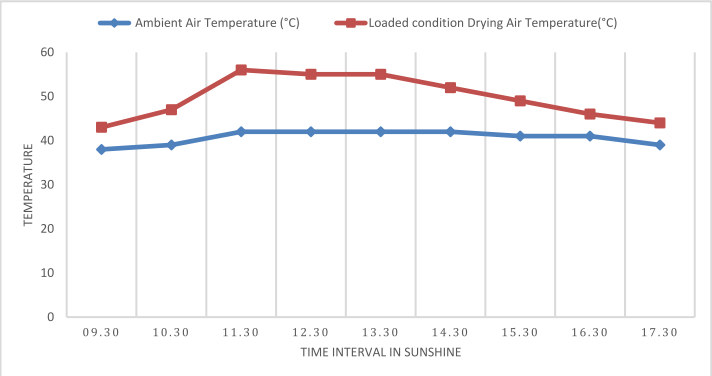

Figure. 7 Change of Temperature in ambient and drying air at loaded condition

Initially moisture content of fresh mint leaves was 86.34 percent (wb). It took 390 minute of drying time in direct solar drying, 510 minutes drying time in the sun drying and 36 hrs time in shade drying to reach upto an equilibrium moisture content of 5.65 %. It was observed in Fig 9 initially, drying rate was high then drying rate started to reduce with time. It was also found that rate of drying was affected by drying temperature of air. The drying temperature was high in solar dryer due to the application of black color coating inside the solar dryer. The Drying rate was low in the shade drying and sun drying because of lower air temperature. The drying temperature inside the solar dryer is increased by 57^0 C at 12 PM. After 150 minute drying temperature begin to decrease but the drying chamber remains hot. The drying rate is decreased very slowly after 300 minute. Similar trends were also observed in sun drying and shade drying. Similar studies were also done on curry leaves in an indirect solar dryer [15]. According to the [9] Bael powder was prepared in solar dryer and the temperature was found 56^0 C in solar dryer. It was also observed in fig 9 constant rate of drying was not found. These findings are quite similar to the earlier research on drying of mint leaves [1; 2; 6; 11].

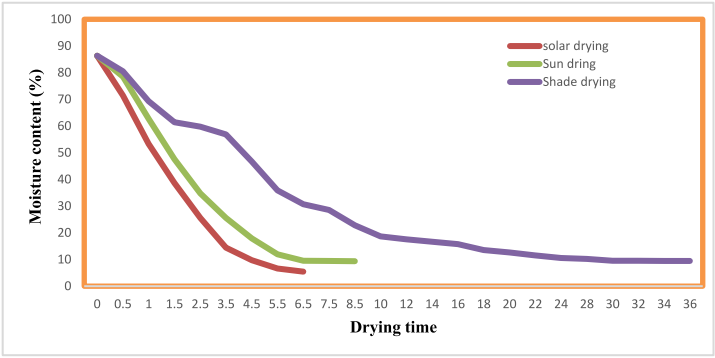

Fig. 8 Moisture Content v/s drying time

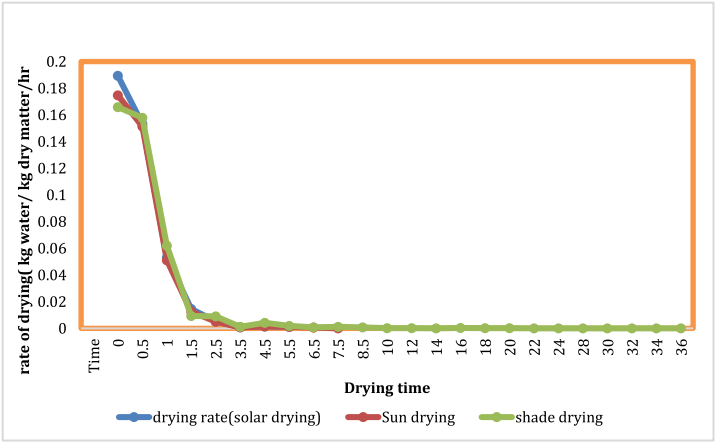

Fig. 9 Drying rate v/s drying time of different drying methods

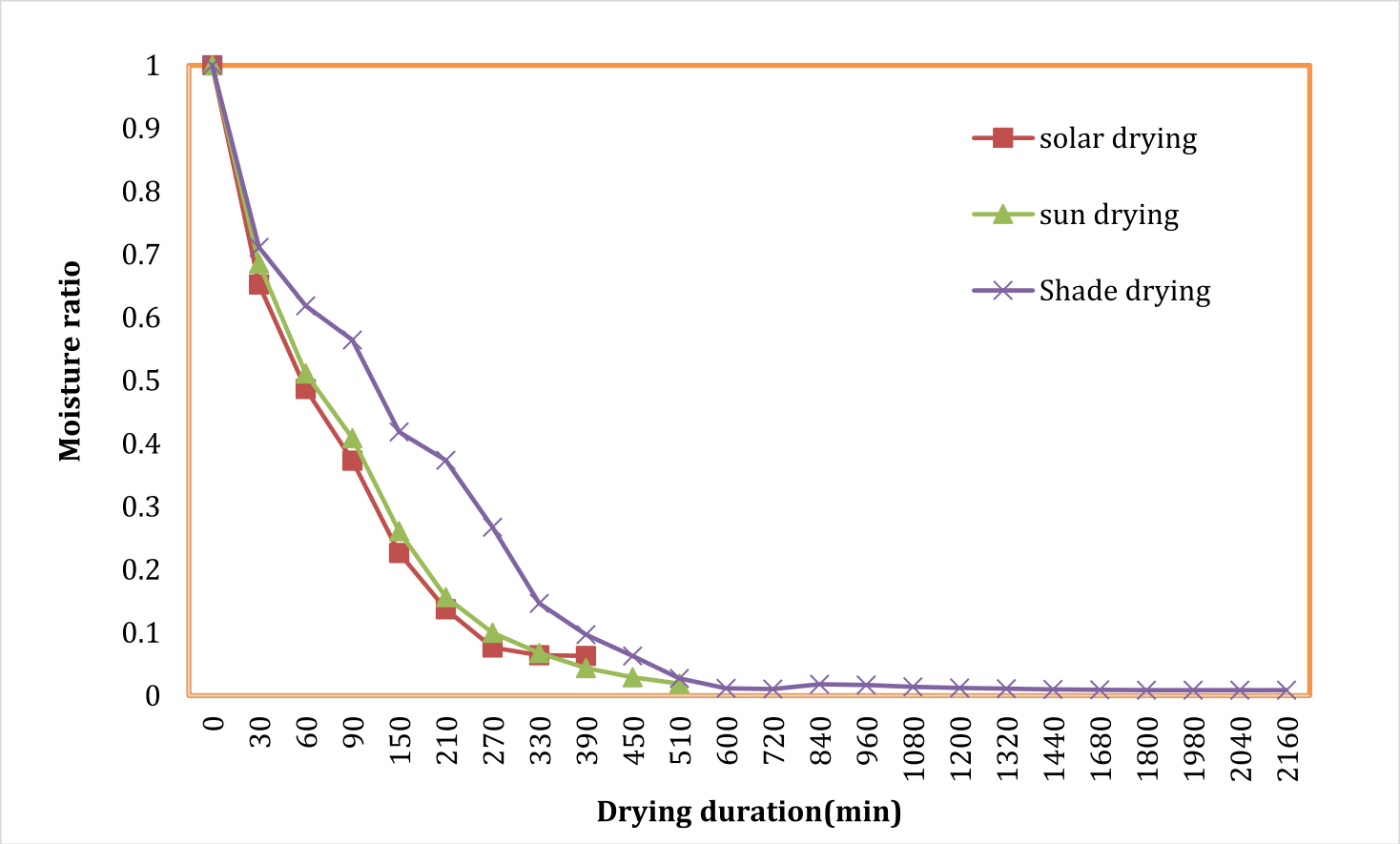

Fig. 10 Change in moisture ratio with drying time

Drying constants and statistical parameters were determined for drying of mint in shed drying, sun drying and solar drying by Henderson pebis model. It was observed that R^2 value of shade drying was 0.99, for solar drying was 0.98 and for solar drying was 0.98. This model was greater than 0.98, indicating a good curve fitting. Results are shown below.

Drying methods	Drying constants	R^2
Shed drying	a = 1.450, k =0.378	0.9877
Sun drying	a = 0.855, k=0.233	0.9817
Shed drying	a = 1.70, k=0.40	R^2 = 0.9938

The score of sensory evaluation of dried mint leaves was found 6 to 9 according to the 9-point hedonic scale for sun drying, solar drying and shed drying. It was observed that the maximum color score 8.7 for solar drying while the minimum color score was 6 for sun drying. The Flavor and appearance score was more than 8 for solar drying while the minimum flavor and appearance sore was more than 6. The overall acceptability was a maximum of 8.7 for solar drying while the minimum overall acceptability was 6.8 for sun drying.

Table.1 Sensory evaluation of dried mint leaves

Drying Methods	Color	Flavor	Appearance	Overall Acceptability
Sun Drying	6	7	6.5	6.8
Solar Drying	8.7	8.5	9	8.7
Shade drying	8.5	8.5	9	8.5

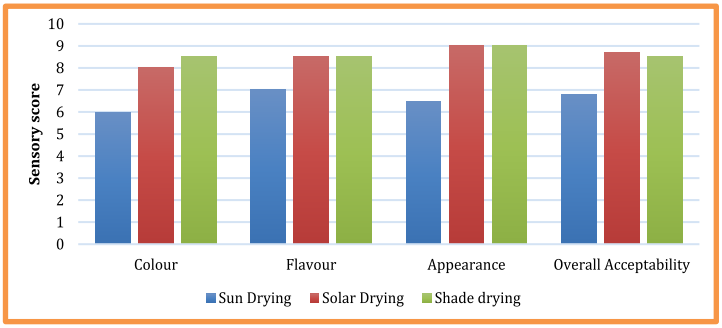

Fig. 11 Sensory evaluation of dried mint leaves

Fig.12 Dehydrated mint leaves in solar dry, sun dry, and shade dry.

CONCLUSION

The maximum temperature reached in solar drying up to 56^0C as compared to 42^0C in sun drying. The minimum relative humidity reached in solar drying was 17 percent as compared to 28 percent in sun drying. The temperature plays a great impact in the drying process. A Comparative study of the drying of leaves of mint was conducted under shade drying, sun drying and solar drying. The drying time of solar drying was lower than that of under shade and sun drying. The drying curve data suggest that the drying displays a falling rate period. Henderson pabis model was suited for drying a thin layer of leaves of mint for shade drying, sun drying and solar drying. Solar drying is the simplest way to dry leaves. It was found that the solar drying method for drying of mint leaves in aspect to color, flavor, appearance and overall acceptability is better than sun drying and shade drying.

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