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# Experimental Investigation on Drying of Mint Leaves (*M. pulegium*) in Solar Tunnel Dryer

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**ABSTRACT**

*Drying is a most important method to reduce the moisture content from product to increase the self-life and quality of the product, which can be used for medicine purpose and non available purpose. During experiment different parameters for mint leaves was calculated under this study such as variation of temperature, collector efficiency, moisture content and solar intensity. In this study was used semi transparent polythene as a collector with size of 200 micron. During experiment with in six days air velocity was varies .51 to 1.21 m/s and average relative humidity was varies 41 to 57 % and exhaust fan speed was constant during this study that means it was 500 rpm. The average temperature inside solar tunnel dryer was varies 54 to 59 ˚c. Finally moisture content in mint leaves was 6.2 % and it's observed that relative humidity decrease with increase temperature and moisture content also decrease. Collector efficiency was varied from 44% to 56%.*

***Key words:*** *Mint Leaves, Solar dryer, tunnel dryer, tray dryer. Color value, dehydration, infrared.*

## INTRODUCTION

Drying is one of the essential unit operations performed to increase the shelf life of agricultural / horticultural produce and it is one of the most practical methods of preserving food and the quality of horticultural produce. If the drying process is not completed fast enough, growth of microorganisms will take place as a result of the high relative humidity. This often leads to severe deterioration of the quality of the product. Traditionally, the food products are dried by spreading in open sun in thin layer. Though this method is economical and simple, it has the draw backs like; no control over the rate of drying, non-uniform drying, chances of deterioration due to exposure of products against rain, dust, storm, birds, rodents, insects and pests which results in poor quality of dried products.

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Whereas, solar drying system leads to fast rate of drying and exposure of products against rain, dust, storm, birds, rodents, insects and pests are avoided. This method is practiced until today for certain products because of the advantages of simplicity and economy. However, open sun drying has some drawbacks. Open sun drying requires longer drying time and product quality is difficult to control because of inadequate drying, high moisture, fungal growth and encroachment of insects, birds and rodents and others. Open sun drying also requires a large space. Drying is usually conducted by vaporizing water in the product. Thus, the latent heat of vaporization must be supplied. Airflow is also required to remove the vapor away from the product. The lower the humidity of hot air supplied to the drying chamber is, the better the drying rate, as the less humid air can carry more moisture from the product surface than the more humid air. Generally, increasing the temperature and velocity shortens the drying time. However, for heat-sensitive products, such as food and pharmaceutical products, high temperature decreases product quality. In this case, drying at low temperature and humidity is required to maintain the fresh color of the product using the desiccant system. Without the use of the desiccant system, high temperature is required to obtain low humidity. The same product dried with different techniques produces different levels of product quality. Ashok Kumar *et al*[3].

Mint essential oil and menthol are extensively used as flavorings in drinks, chewing gum and desserts; see mint candy and mint chocolate. The substances that give the mints their characteristic aromas and flavors are Menthol and the Polygene. The mint family, Lamiaceae, includes many other aromatic herbs, including most of the more common cooking herbs, including basil, rosemary, sage, oregano and catnip. In common usage, several other plants with fragrant leaves may be erroneously called a mint. Mint leaves are often used by many campers to repel mosquitoes. It is also said that extracts from mint leaves have a particular mosquito killing capability. However, the only compound scientifically proven to repel mosquitoes is desert. Mint oil is also being used as an environmentally friendly insecticide for its ability to kill some common pests like wasps, hornets, ants and cockroaches. Mint was originally used as a medicinal herb to treat stomach ache and chest pains. During the middle ages, powdered mint leaves were used to whiten teeth. Mint tea is a strong diuretic. Mint also aids digestion. Menthol from mint essential oil (40 – 90 %) is an ingredient of many cosmetics and some perfumes. Menthol and mint essential oil are also much used in medicine as component of many drugs, and are very popular in aromatherapy. A common use is as an antipruritic, especially in insect bite treatments (often along with camphor). It is also used in cigarettes as an additive, because it blocks out the bitter taste of tobacco and soothes the throat. In order to preserve this seasonal plant, and make it available to consumers during the whole year, it undergoes specific technological treatments; such as drying[4,11]. Drying provides a very useful preservation. Generally, a part of the mint may be tied in small bundles and hung up, or the leaves and flowering tops spread on a screen and dried in the shade. Drying is one of the oldest methods of food preservation, and it represents a very important aspect of food processing. The main aim of drying products is to allow longer periods of storage, minimise packaging requirements and reduce shipping weights[10]. Solar drying is the most common method used to preserve agricultural products in the world and also Morocco. However, it has some problems related to the contamination with dust, soil, sand particles and insects, and being weather dependent. Also, the required drying time can be quite long. Therefore, the drying process should be undertaken in closed equipments to improve the quality of the final product[5].

Leek (Allium porrum L.) is classified in the family liliaceae. The vegetative parts of its are odor-free, and only during tissue damaging the volatile flavor principles are generated. This family is distributed throughout most regions of the temperate world including Europe, Asia, North America and Africa and has a long history as sources of therapeutic principles[15]. Mint (Mentha spicata L.) is a perennial crop grown primarily for its oil, called menthol. This is widely used in the food, flavorings, pharmaceutical and cosmetic industries. Also, the cooling and soothing effect of natural menthol made it a useful ingredient in pharmaceuticals and cosmetics[2].

Parsley (Petroselinum crispum L.) is a nutritious herb, grows in Europe and Asia. The fresh or dried leaves, roots and seeds of this plant are used in the food, cosmetic and pharmaceutical industries to produce drugs, essential oil and spices[1]. Drying is the oldest method of preserving food. The main aim in drying agricultural products is to decrease water content to certain level, at which, microbial spoilage and deterioration chemical reaction are greatly minimized[8].

**This work aims to:**

- Study influence of temperature on the adsorption- desorption isotherms of mint (*M. Pulegium*);
- Study the drying kinetics for four temperatures at two air flow rate of mint (*M. Pulegium*);
- Determine the characteristic drying curve (CDC);
- Fit the drying curves with thirteen mathematical models;
- Determine the effwctive diffusivity and the activation energy.

## MATERIALS AND METHODS

The experiment was conducted in the department of farm machinery and power engineering SHIATS Allahabad on the effect of drying on the storage and dried quality of mint leaves. The fresh mint leaves was collected from local market

**Table: 1 Selection of product**

| SI NO: | PRODUCT | ENERGY (Kcal) | PROTEIN (gm) | Fats (%) | Sugar (%) | PRESENT WATER (%PER 100gm) |
|---|---|---|---|---|---|---|
| 1 | Mint Leaves | 45 | 13 | 11% | 4 | 69.5 |

**Drying process of solar tunnel dryer**

Solar drying experiments were carried out for mint. Fresh mint leaves is cut into thin slices of 4 mm and the initial moisture content is measured by oven-drying method, maintained at a temperature of 105∘C for 24 hours by taking 200 g sample (1). Total of 8000 grams of mint leaves is spread uniformly on eight trays for solar drying equally in all eight trays. The exhaust fan is then switched on. The air that is passed through inlet gets heated up and is made to flow into the drying chamber, where mint leaves are loaded in eight trays. During the experiment, ambient temperature, relative humidity and wind velocity, solar insulation, inlet and outlet temperatures of the collector, and temperature of all the trays inside the chamber were recorded by digital instruments on hourly basis from 8.00 am to 5.00 pm. During the experiment, all the drying trays are weighed on hourly basis until the product acquires constant weight, that is, equilibrium moisture content.

**Fig. 1: Solar tunnel dryer**

**Fig. 2: Drying of mint leaves in solar tunnel dryer**

**Fig. 3: After drying mint leaves**

## Moisture Content

Moisture content was determined by hot air oven method recommended by Ranganna[13] for fruits and vegetables which had successfully been used for potato, carrot, etc[6,9].

Moisture content was calculated by

M .C. % (w.b.) = weight of moisture / weight of the sample

$$= \frac{(w+w_1) - w_2}{W} x100$$

**Where,**

**w** = Net weight of sample taken, g

$\mathbf{w_1}$= Weight of the dish, g

$\mathbf{w_2}$= Weight of dish + Oven dried sample, g

## Moisture Loss

Based on review of earlier works[7,9], the moisture loss (percentage) was characterized using the following equation.

$$\text{Moisture loss (\%)} = \frac{\textit{weight of initial moisture} - \textit{weight of final moisture}}{\textit{Initial mass of sample}} \times 100$$

## Rehydration Ratio (RR)

The rehydration ratio of dried tomato slices was determined as the ratio of rehydrated mass to the initial dehydrated mass, which gives a measure of the ability of dried tomato slices to reabsorb water. A sample of 5 g of the dried tomato slices was placed in a 250 ml beaker containing 150 ml of boiling distilled water. The contents were boiled for 5 min to allow the slices to rehydrate. After rehydration, the free surface water on the tomato slice was removed before assessing the rehydrated mass[3]. Triplicate measurements were done and the average values are reported here.

$$\text{Rehydration Ratio} = \frac{Wr}{Wd}$$

**Where,**

**Wr =** Rehydrated sample mass, g

**Wd=** Initial mass of the sample before rehydration, g

## Initial Moisture Content

Initial moisture content of onion samples were determined by hot air oven drying method as recommended by Ranganna[14]. A brief description of method is presented below:

A thin layer of finely divided asbestos (gooch grade) was spread over a flat bottom metallic dish and dried at 110$^o$ C in hot air oven for one hour then covered, cooled and weighed.

$$IMC = \frac{M_1 - M_2}{M_0} \times 100$$

**Where,**

**IMC=** Initial moisture content of sample, % (w.b.)

**$M_0$=** Initial weight of sample taken, 5 g

**$M_1$=** Weight of sample before oven drying plus weight of dish with cover, g

**$M_2$ =** Weight of dried and desiccated sample plus weight of dish with cover, g.

**Moisture Content during Drying Experiment**

Moisture content of the samples during drying was computed through mass balance. For this purpose, weight of the sample during drying was recorded at predetermined time interval. The following formulae were used to calculate the moisture content.

$$MC = \frac{W - W_{d'}}{W_{d'}} \times 100$$

**Where**,

M.C.= Moisture content, % (d.b.)

W = Weight of sample at any time, g

$W_d'$= Weight of bone dry material, g

**Weight of Bone Dry Material was calculated as**

$$W_{d'} = W_i \left( \frac{100 - mc'}{100} \right)$$

**Where**,

$W_i$ = Initial weight of sample, g

mc′= Moisture content of sample, % (w.b.).

**Moisture Ratio (MR)**

The instantaneous moisture (M) at one hour interval is calculated from the drying data, the initial moisture content (Mo), and equilibrium moisture content (Me) are calculated from the drying data. Then the moisture ratio at any time interval is given by

$$\text{Moisture ratio MR} = \frac{M - Me}{Mo - Me}$$

**Efficiency of Collector**

The inlet temperature (Tin) and outlet temperature (Tout) of the Evacuated tube collector are recorded at one hour time interval. The mass flow rate (mc) of the air is recorded. The solar insulation (I) is recorded at one hour time interval. With aperture area (Ap), Specific heat of air (Cpc) and number of Evacuated Tubes (N) are known; the efficiency of the evacuated tube is given by

Evacuated collector Efficiency

$$= \frac{\text{Mc Cpc (Tout} - \text{Tin)}}{\text{NApI}}$$

**Table: 2 Day by Day Variation of Solar Isolation, Wind Velocity, and Temperature for mint leaves**

| Sl.No | Days (8am-5pm) | Average Solar Isolation W/m2 | Average Wind Velocity m/sec | Average RH in % | Average Ambient Temp °C | Average Drier Inlet °C | Exhaust Fan Seed (rpm) |
|---|---|---|---|---|---|---|---|
| 1 | 8-06-2015 | 1285 | .51 | 55 | 40.0 | 57 | 500 |
| 2 | 9-06-2015 | 1288 | .58 | 45 | 44.8 | 59 | 500 |
| 3 | 10-06-2015 | 1290 | .79 | 57 | 41.6 | 61 | 500 |
| 4 | 11-06-2015 | 1292 | .97 | 42 | 43.9 | 64 | 500 |
| 5 | 12-06-2015 | 1291 | 1.18 | 50 | 45.0 | 63 | 500 |
| 6 | 15-6-2015 | 1287 | 1.21 | 41 | 44..2 | 62 | 500 |

## DISCUSSION

**Experimental Evaluation of Collector Performance of solar tunnel dryer**

For the evaluation of Collector Performance of solar tunnel dryer, the minimum wind velocity was found .51m/sec and maximum wind velocity 1.21 m/sec is selected for actual drying experiment according to the need of the mint leaves drying requirement since at low flow rates the exit encounters higher temperature. The ambient temperature of the air varied from a minimum of 40.5°C and the maximum of 45 °C. The relative humidity of air was varied from a minimum of 44% to a maximum of 53%. The inlet temperature of air to the collector varied from 55°C to 59°C.This shows that the atmospheric temperature in the solar tunnel drier. The data used to determine the solar tunnel dryer efficiency corresponding to solar radiation varied from 1285 W/m$^2$ to 1292 W/m2. The average collector efficiency varied from a minimum of 45% and a maximum of 55%. The collector efficiency increases with increase in solar radiation and it attains a maximum of 66% at end of the day. The moisture content was observed varied from a maximum 69.1% and minimum 6.2%. The moisture content also decreases with increase drying temperature. The average moisture ratio was found from a maximum 1 and minimum 0.

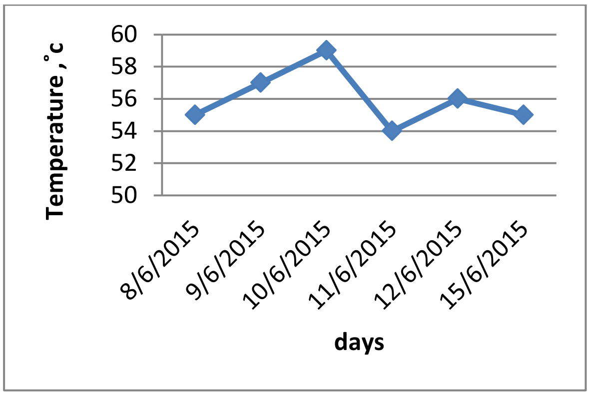


**Fig. 4: Variations of Temperatures**

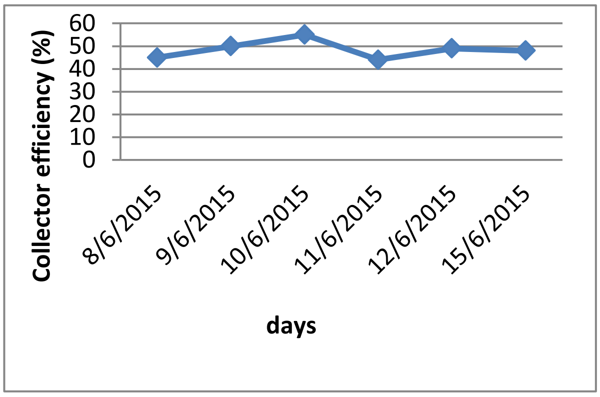


**Fig. 5: Variations of solar Collector Efficiency**

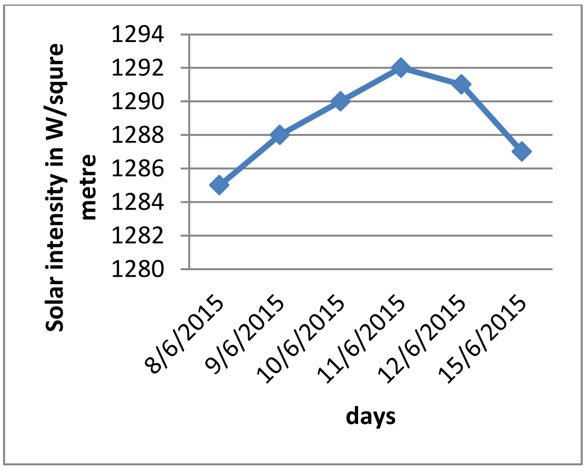


**Fig. 6: Variation of Solar Intensity**

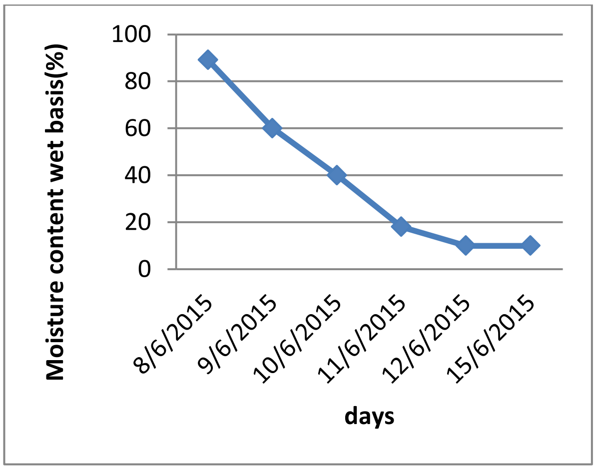


**Fig. 7: Variation of Moisture Content**

**Thin Layer drying of Agriculture Products**

The temperature rises that can be obtained with this solar tunnel dryer are appropriate for agriculture product drying. The Solar tunnel dryer Collector under study connected to a drying chamber. The drying chamber consists of eight trays which are loaded with mint leaves for drying. The dried products of solar drying were obtained after 6days.

**Mint Drying**

The product loaded was mint leaves having an initial moisture content of 69.1 % (wb). The final moisture content of 6.2 % was obtained in 6 day of solar tunnel dryer, whereas. The experimental conditions of onion slices are shown in Table-1, while the variation of moisture content (MC) (Figure 6) is illustrated. It is observed that the moisture removal is high initially and then gets reduced exponentially (1), this may be because of the moisture removal first from the surface and followed by the movement of moisture from internal part of product to its surface. Before solar drying the weight of mint leaves was 8kg and after solar drying was .880 g.

## CONCLUSION

Dehydrated mint leaves have the potential to become an important value added product because of relatively inexpensive, easily and quickly solar tunnel dryer and rich in several nutrients, which are essential for human health. The solar tunnel dryer used in the present study reduces the drying period of mint leaves considerably. Solar drying of mint leaves takes nearly half the time as compared to sun drying. The minimum drying period of 6 days is required for mint leaves to achieve equilibrium moisture in solar tunnel solar dryer. The solar tunnel drier collector efficiency varied from 44 % to 56 %. This dryer can be used to dry different products simultaneously and products that cannot be dried in natural sun drying. The most important advantage of using solar tunnel dryer is that it can be used to dry products even during no sunshine and winter season as it makes use of semi-transparent polythene.

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