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## Research Article

# STUDIES ON MECHANICAL DRYING OF TAMARIND FRUITS

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**Abstract:** For effective de hulling and deseeding of tamarind fruits optimal moisture is required. The mechanical tamarind dryer consists of feed hopper, conveyor belt, a blower and coil type heater. The blower is operated by a half hp three phase motor. The belt drying unit is operated by a two hp gear motor. Drying studies were conducted at three different temperature (50, 60 and 70°C) and three different air flow rates (3.5, 5.0 and 7 $m^3$/min). At air flow of 7$m^3$/min at 60°C the moisture content of tamarind fruits can be reduced from 20 % (d.b) to 12.5% (d.b.) in a period of 50 minutes. In sun drying the moisture content of tamarind fruits can be reduced from 20% (d.b) to 13% (d.b) in a period of 8 hours 15 minutes. The sample dried at 60°C was found better in color.

**Keywords:** *Tamarind, Mechanical drying, Sun dying, Solar drying, Colour, Moisture*

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## Introduction

The tamarind tree mostly grows as wild, although it is cultivated to a limited extent. Tamarind fruits begin to ripen during the months of February-March. The pods are allowed to ripen on the tree until the outer shell is dry and thereafter harvested and the shells are removed manually. The pulp is separated from the seeds and fibers and dried in the sun to reduce its moisture level. A typical tamarind pod contains about 55% pulp, 34% seed, and 11% shell and fiber [1]. Tamarind pulp has an excellent keeping quality when dried properly and cured with salt.

The unit operation in tamarind fruit processing involves dehulling, drying, deseeding and packaging operation. The dehulling process is carried out to remove outer hull portion of the tamarind fruit. After dehulling, the tamarind fruits have to be dried, before deseeding operations. The moisture content has to be reduced around 12 percent dry basis for effective deseeding operation. Through many methods of drying are available for the continuous operations of deseeding, a mechanical conveying type dryer is ideally suitable [2]. The drying kinetics of pepino fruit (*Solanum muricatum*) was carried at various temperatures 50, 60, 70, 80 and 90°C. The Guggenheim, Anderson and De Boer model were suitable to depict the desorption data. Monolayer moisture content from 0.10 to 0.14 g water $g^{-1}$ d.m [3]. A thin-layer drying of jujubes in a convective dryer under controlled conditions of temperature and velocity. The drying process took place both in the accelerating rate and falling rate period and observed that higher temperature reduced the drying time, indicating higher drying rates of jujubes [4]. Hawthorn fruit was dried in a convective dryer at 50, 60 and 70°C of air temperatures and 0.5, 0.9 and 1.3 ms^(-1) of air velocities. The experimental data obtained during the drying process were fitted to eleven different mathematical models [5]. Tamarind seeds with initial moisture content of 18 ± 0.25% dry basis were oven dried with forced air ventilation, at controlled temperatures of 45, 60, 75 and 90 °C in four repetitions. The drying of tamarind seeds, the Midilli model was selected for the range from 45 to 60 ºC and the Two terms mode was selected for the range from 75 to 90 ºC [6]. Tamarind drying kinetics was studied under open sun and at cabinet dryer at 50°C, 60°C and 70°C.

In mechanical drying of tamarind at 70°C had highest moisture removal rate followed by mechanical drying at 60°C [7]. Drying behavior of pretreated and whole tamarind seeds under thin layer condition in the temperature range of 40 to70°C at constant air velocity of 2 ms-1 was studied. Equilibrium moisture contents of tamarind seed were determined at three different temperatures at 30°C to 70°C and three relative humidity (30 to70%) using a standard static method. Drying of tamarind seeds at 70°C of 1 cm bed thickness showed best results [8]. The quality and sensory characteristics of tamarind leather as affected by drying methods. Tamarind leathers were dried by two different methods *i.e.* cabinet drier (70°C) and solar drier (54±4°C). Drying methods considerably influenced the color changes of tamarind leathers, that tamarind leathers dried by cabinet drier revealed darker color values (0.138±0.01) than that dried by solar drier (0.043±0.03) [9]. The effect of sulfur pretreatment and the drying process (hot air and/or microwaves) on the color, mechanical properties, and ascorbic acid, vitamins A and E, and total carotenoid content of apricot. The best results in combination or not with mild-hot air, to obtain dried apricots, without needing to apply sulfur pretreatment [10]. The convective drying of fruits is the most implemented drying technique to stabilize fruits and to increase their shelf life [11].

Moisture content plays a major role to avoid stickiness during deseeding operation. The current deseeding operation is very difficult due to stickiness of the tamarind fruit. This can be avoided through feeding dried tamarind fruits in a continuous manner. Hence, the objective of study is to study different methods of drying on tamarind fruits, drying kinetics of tamarind fruit at different temperatures and different air flow rate and optimize the required drying conditions for tamarind.

## Materials and Methods

### Raw Material Preparation

Fresh tamarind pods were collected from Agricultural Engineering College and Research Institute, FarmKumulur, Lalgudi taluk, Trichy district, Tamil Nadu and used for the study.

The samples were then graded based on maturity *viz*., immature and matured tamarind pods. Only matured and sound tamarind pods was selected and used in the present study.

**Mechanical drying**

The developed dryer consists of the following parts:

a) Feed hopper
b) Drying unit
c) Blower unit (heating coil and blower)
d) Heating unit
e) Motor with gear box
h) Variable auto transformer
i) Power transmission system
j) Recirculation unit

The feed hopper (75x40x5 cm) with a capacity of 10 kg was fitted just above the fluted roller for effectively feeding tamarind into the dryer.

**Drying unit**

Drying unit consisted of an endless wire mesh of 35 cm width, rolling over two end pulleys, kept at a distance of 250 cm. The wire mesh was connected with chains on both sides to avoid slippage. Also, the wire mesh was allowed to roll on the idlers kept at a distance of 20 cm to avoid sagging. Strips of 2 cm height and 35 cm length made up of mild steel was fixed on the wire mesh with a spacing of 15 cm for effectively conveying the tamarind fruits during the drying operations. Totally, 37 numbers of strips were fitted for uniform conveying and drying of dehulled tamarind. The drying chamber was enclosed with galvanized iron sheet for avoiding the heat loss.

**Blower unit**

The blower unit comprised of a centrifugal fan for blowing air in the dryer. The air flow can be controlled by the adjustment provided in the blower ranging (3.5 to 7$m^3$/min). The blower case housed a centrifugal fan which blows ambient air to the heating coil. Avariable auto transformer was connected to the blower which helps to adjust the power (Watts) to vary the temperature.

**Heating unit**

The heating unit consist of four heating coils that having 1000 watts capacity. The temperature of the heating unit is regulated by the temperature controller. Heat will be transferred to the conveyor unit by hot air through the PVC pipes.

Onehp single phase electrical motor of 1500 rpm was connected to the speed reducer for reducing up to 10 rpm of the conveyor.

**Procedure**

The dryer was adjusted to a preset temperature for about half an hour prior to the experiment to achieve the steady state. The experiments were carried out for drying dehulled tamarind fruits at three selected temperatures of 50, 60 and 70 °C. The air flow of the blower was varied at three levels as 3.5, 5.0 and 7.0 $m^3$/min with the feed rate of 5 kg. Initially, the dehulled tamarind fruit sample was taken at 19% moisture content (w.b.). The reading was taken every ten minute interval with three replications of temperatures and air flow. The dehulled tamarind fruit moisture content was reduced to 11-12 percent (d.b.) which helps to deseed the tamarind fruit without any loss. The following parameters were estimated.

**Moisture content**

The moisture content of tamarind fruits was determined as per the standards of American Society of Agricultural Engineers [12]. The samples were placed in a hot air oven at 103±2°C for 1h. The moisture content of the sample was calculated by using the formula

Moisture content ($w.b$) =((W1-W2))/W1 ×100
Moisture content (d.$b$) =((W1-W2))/W2 ×100
Where,
W1 = Initial weight of sample, g
W2 = Final weight of sample, g

**Colour**

The colour of tamarind was measured using Hunter lab colour flex meter (M/s. Hunterlab, Reston, VA, USA; model CFLX-45). For each drying experiment, the colour measurement was made on five dried samples and the average colour value was determined and compared with that of fresh sample.

The tamarind pulp was taken on a glass slide and its color was determined by employing a Hunter color meter. The values 'L*' denote brightness, 'a*' indicate redness or greenness with positive and negative values, and 'b*' indicates yellowness or blueness with positive and negative values. The readings were taken after each combination of treatments. Before sun and mechanical drying, the color values of L*, a* and b* of dehulled tamarind fruit were recorded.

The samples were also died in open sun and solar drier.

Fig-1 Mechanical dryer for tamarind

**Result and Discussion**

**Mechanical drying**

**Drying of Tamarind Fruit at 50°C at different air flow rates of 3.5, 5.0 and 7.0 $m^3$/min**

Effect of air flow rate on drying of tamarind fruits [Fig-2]. It was found that at airflow rates 3.5 m3/min time required to dry the fruits to a moisture from 20 percent on (d.b.) to 12.3 percent (d.b.) was found to be 1 h 40 min. For 5.0 m3/min it was 1 h 20 min. For 7.0 m3/min it was 1 h 10 min. As the air flow increases time of drying reduced. Similar results are reported for hawthorn fruit [5].

**Drying of Tamarind Fruit at 60°C at different air flow rates of 3.5, 5.0 and 7.0 $m^3$/min**

Effect of air flow rate on drying of tamarind fruits is shown in [Fig-2]. From the fig, it was found that at airflow rates 3.5 m3/min time required to dry the fruits to a moisture from 20 percent on (d.b.) to 12.24 percent (d.b.) was found to be 1 h 10 min. For 5.0 $m^3$/min it was 1 h. For 7.0 $m^3$/min it was 50 min. Similar results are reported for jujubes [4].

**Drying of Tamarind Fruit at 70°C at different air flow rates of 3.5, 5.0 and 7.0 $m^3$/min**

Effect of air flow rate on drying of tamarind fruits is shown in [Fig-2]. From the fig, it was found that at airflow rates 3.5 $m^3$/min time required to dry the fruits to a moisture from 20 percent on (d.b.) to 12.37 percent (d.b.) was found to be 1 h . Similar results are reported for hawthorn fruit [5].

**Effect of air temperature and air flow rate on color**

For the airflow rates of 3.5, 5 and 7 $m^3$/m with the feed rate of 5 kg/h at 50°C, the average color values were found to be L*= 58.3 ± 2.1, a*=2.1 ± 1.6 and b*=15.4 ± 0.1 at the moisture content of 12.3 percent (d.b.;L*=50.53 ± 1.2, a*=2.17 ± 1.6 and b*=14.3 ± 1.and L*= 49.5 ± 1.2, a*=2.3 ± 1.2 and b*=13.3 ± 0.4 respectively. For the airflow rates of 3.5, 5 and 7 $m^3$/m with the feed rate of 5 kg/h at 60°C, the average color values were found to be L*= 56.29 ± 1.7, a*=2.3 ± 0.5 and b*=14.8 ± 1.2 at the moisture content of 12.24 percent (d.b.), L*=48.7 ± 1.3, a*=2.5 ±0.8 and b*=13.2 ±1.5 and L*= 46.6 ±1.1, a*=2.9 ± 1.5 and b*=11.5 ±1.3 respectively. The effect of airflow rate on colour of tamarind fruit at 600c air temperature is shown in [Fig-3]. From the fig it was found that L value decreased with increase in air flow Similar trend was recorded for other temperatures also.

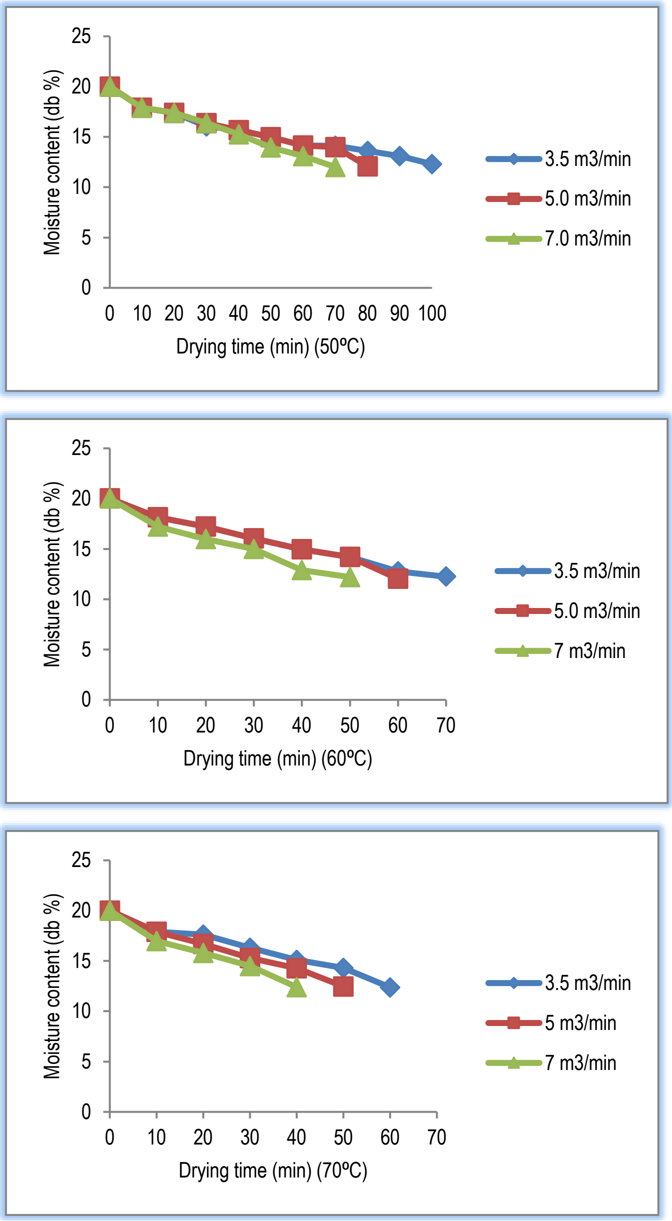


Fig-2 Effect of air flow and temperature on moisture content of tamarind

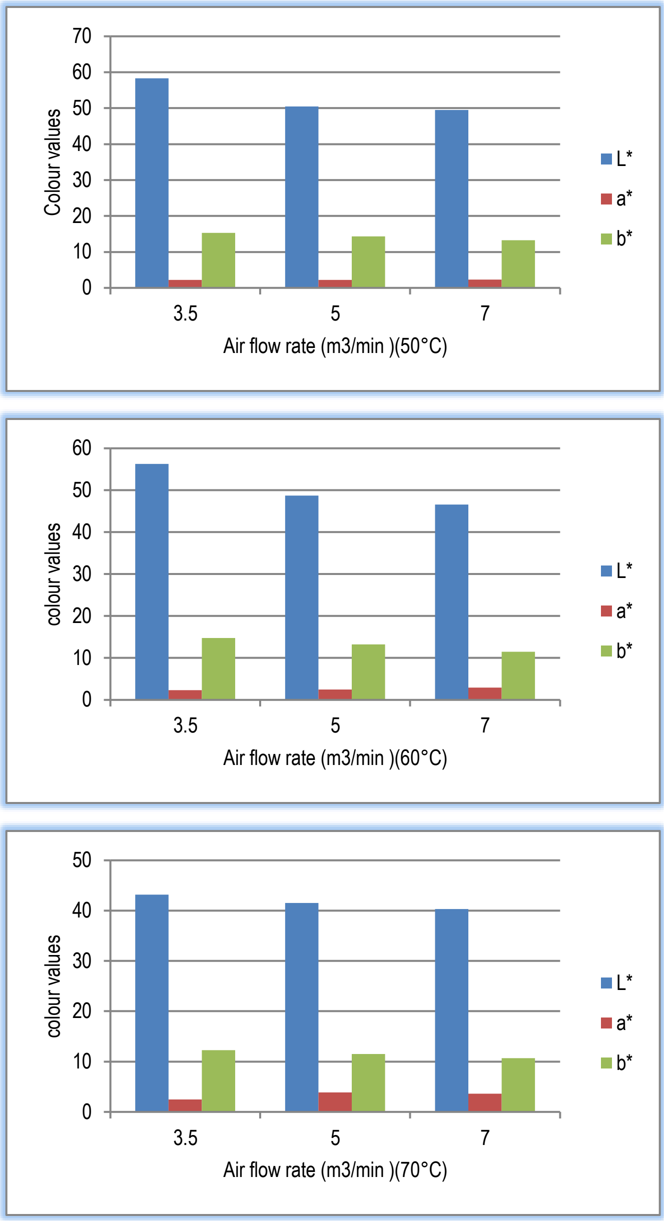


Fig-3 Effect of air flow and temperature on Color of tamarind

For the airflow rates of 3.5, 5 and 7 $m^3/m$ with the feed rate of 5 kg/h at 70°C, the average color values were found to be L*= 43.2 ± 1.3, a*=2.5 ± 0.6 and b*=12.3 ± 1.1 at the moisture content of 12.37 percent (d.b.); L*=41.5 ± 1.3, a*=3.9 ± 0.2 and b*=11.5 ± 1.2 and L*= 40.3 ± 1.2, a*=3.6 ± 0.1 and b*=10.7 ± 1.1 respectively.

The ‘L*’ value indicates the brightness or darkness and ‘b’ value indicates the yellowness or blueness, which are generally decreased after drying and the ‘a’ value, indicates the redness or greenness which is generally increased after drying. Similar results are reported for hawthorn fruit [5].

The flow rate of air is increased the ‘L*’ value indicates the brightness or darkness and ‘b’ value indicates the yellowness or blueness, which are generally decreased after drying and the ‘a’ value, indicates the redness or greenness which is generally increased after drying.

The decrease in L value may be due to Maillard reaction. The increase in a value may be due to pigment formation during Maillard reaction. Similar results are reported for jujubes [4].

When compared to sun, solar and mechanical drying the color values of mechanical drying is found to be better than others. When the air flow rate and temperature increased, the drying time decreased.

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The hot air temperature required for mechanical drying can be controlled by using thermostat; in the case of solar drying, we can’t control the air temperature. Therefore, the drying process is uniform in mechanical drying. The total time required for drying under mechanical drying is comparatively lower than sun drying.

## Conclusion

For effective dehulling and deseeding of tamarind fruits optimal moisture is required. The stickiness of the tamarind fruit is a major problem during deseeding. In this concern the pre drying of the tamarind reduce the stickiness by removing the moisture content to an optimized level of 11-12 percent (d.b.). The study revealed that in mechanical drying at 60° C produced samples with better color. At 60°C the moisture content of tamarind fruits can be reduced from 20 % (d.b) to 12% (d.b) in a period of 50 minutes.

**Research Category:** Agricultural Engineering

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**Study area / Sample Collection:** Farm Kumulur, Lalgudi taluk, Trichy district, Tamil Nadu

**Cultivar / Variety / Breed name:** Tamarind

**Conflict of Interest:** None declared

**Ethical approval:** This article does not contain any studies with human participants or animals performed by any of the authors.
Ethical Committee Approval Number: Nil

## References

[1] Bhattacharya S., Bal S., Mukherjee R.K., Bhattacharya S. (1993) *Journal of Food Engineering*,18(1), 77-89.
[2] Muzaffar K., Kumar P. (2017) *Journal of Food Processing and Preservation*, 41, e12781.
[3] Elsa Uribe, Antonio Vega-Gálvez, Karina Di Scala, Romina Oyanadel, Jorge Saavedra Torrico and Margarita Mirand (2009) *Food and Bioprocess Technology*, 4(8), 1349-1356.
[4] Xiao-Kang Yi, Wen-Fu Wu,Ya-Qiu Zhang, Jun-Xing Li and Hua-Ping Luo (2012) *Mathematical Problems in Engineering*, 4, 1-18.
[5] Serdar Aral, Ayşe Vildan Beşe (2016) *Food Chemistry*, 210, 77-584.
[6] Weder N. Ferreira Junior, Osvaldo Resende, Gleyce K. I. Pinheiro, Diene G. Souza and Kelly A. de Sousa (2020) *Revista Brasileira de Engenharia Agrícola e Ambienta*, 37-43.
[7] Karpoora N., Pandian S. and Rajkumar P. (2014) *Trends in Biosciences*, 7(23), 3844-3851.
[8] Mohite A.M., Mishra A. and Sharma N. (2016) *International J. Seed Spices*, 6(2), 19-23.
[9] Ghada H. Abdel Rahman, Abdel Halim R.A. and El Rakha B.B. (2017) *Journal of Agri-Food and Applied Sciences*, 5(1), 1-5.
[10] García-Martínez E., Igual M., Martín-Esparza M.E. (2013) *Food Bioprocess Technol*., 6, 3247-3255.
[11] Castro A.M., Mayorga E.Y., Moreno F.L. (2018) *Journal of Food Engineering*, 223, 152-167.
[12] Anon (2009) *National commodity and derivatives exchange limited, Mumbai, India.*