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Development of process technology for preparation of Bael fruit powder

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Abstract
Bael occupies an important place not only nutritionally but therapeutically as well. It has a woody-skinned and it is difficult to be used by hand, so it is not very popular as a fresh fruit for table purpose. In this study value added dried products were made to enhance its shelf life & utilize this important medicinal fruit around the year. Two types of sample were prepared 1) raw Bael 2) pretreated Bael sample. The drying of raw and pretreated Bael was carried out in solar cabinet dryer separately. The various parameters like moisture content, relative humidity, moisture content, weight loss were determined during experiment. The samples were examined for Color, flavor, appearance, taste, overall acceptance by a panel of judges (10) and average score was calculated. The statistical analyses of data were carried out which gives the different equations of degree two (R^2 value) for different two samples.

Keywords: Bael, quality, solar cabinet dryer, pre-treatment, Sensory, storage

1. Introduction

The total production of fruit and vegetables in the world is around 370 MT. India ranks first in the production of fruit with an annual output of 32 MT. India contributes 10% to the world fruit production. Bael tree, which is the only species in the genus *Aegle*, grows up to 18 meters tall and bears thorns and fragrant flowers. It has a woody-skinned, smooth fruit 5-15 cm in diameter. The skin of the fruit is so hard that it must be cracked open with a hammer. That is why Bael is not very popular as a fresh fruit for table purpose. It occupies an important place among the indigenous fruits not only nutritionally but therapeutically as well. The roots, leaves, fruits, bark and leaves all have high medicinal value. Since the fruit takes around eleven months to ripe after the fruit is set on the tree. So, it is not available to the people throughout the year. Ripe stone apple is more prone to spoilage because of higher rate of catabolic activities. So, it has short life but have excellent processing attributes. It can be processed into various products such as fruit juices, jams, jellies etc. Further there is a growing demand of health drinks based on indigenous fruits. The Bael fruit can be eaten fresh or dried. If fresh, the juice is strained and sweetened to make a drink and is also used in making sherbets, a refreshing drink where the pulp is mixed with tamarind. If the fruit is to be dried, it is usually sliced first and left to dry by the heat of the sun. Manufacturing of value added products may be useful in establishing the utilization of the fruit year around. Most of the Indian farmers have lack of adequate knowledge regarding the proper method of harvesting, handling, packaging, transport, and storage and processing. The fruit and vegetable processing industries in India is highly decentralized. There is 30-35% post-harvest loss of Bael occurs only in 15-20 days. Thus there is a need of preparing value added products from ripe Bael fruit pulp to enhance its shelf life & utilize this important medicinal fruit around the year.

The improved solar cabinet dryer designed and developed in the Department of Processing and Food Engineering, College of Agricultural Engineering, Pusa. It is simple and direct type. Its cost is low because it can be easily fabricated by use of locally available materials. The developed solar cabinet dryer can be used for drying vegetables, fruits and other crops in batches of small 20-25 kg quantity. This improved solar cabinet dryer was used for the study of developing a suitable process technology to prepare dried fruit powder out of ripe Bael.

2. Objectives

1. To evaluate the effect of pre-treatment on drying as well as quality characteristics of Bael pulp.

2. To evaluate quality & sensory characteristics of reconstituted drink with prepared powder.
3. To test the performance of developed solar cabinet dryer for quality drying of Bael pulp.

3. Solar Dryer
The solar dryers are based on hot box principle. Solar dryer used for drying of agricultural produce are mainly of three types depending upon the mode of exposure of produce to sunlight.

3.1 Direct Type
In these unit's material to be dried is placed in enclosure with a transparent cover and side panel. Heat is generated by absorption of solar radiation on the product itself as well as on the internal blackened surface of drying chamber. This heat helps in separating the moisture from drying product and in addition serves to heat air in the enclosure resulting in removal of this moisture by circulation of heated moist air. Direct type solar dryers are generally useful for crops spread in single layer or layer of two to three unit thicknesses but comparatively thin layer.

3.2 Indirect Type
The solar radiation in this type of dryer is not directly incident on the material to be dried. Air in the solar collector is heated up which is conducted to the drying chamber to evaporate moisture from produces. Indirect type dryers are mostly used for crops which are sensitive to light and for drying large volumes of crops. Since heated air from collector is ducted to drying chamber force circulation is quite essential.

3.4 Mixed Type
In these dryers the materials are subjected to pre-treated air of solar heated and action of incident radiation. The combine action furnishes the heat requirement to complete the drying operation. These dryers are most suitable for quicker drying and for higher capacity ranges at the materials which are not sensitive to light.
In direct type dryers, the air circulation is recovered by natural convection. In case of indirect dryers forced circulation is essential.

3.5 General Instructions for Installation of Solar Dryer to achieve Higher Efficiency
1. The collector surface of dryer should always face sun as far as possible to keep the incident angle of the solar radiation as minimum. This can be achieved by seasonal and durenal tracking of sun.
2. The solar radiation collector should be tilted at an angle equal to the latitude (L^o) of the place, where it is installed for fired position of dryer or L^o +10^o in winters and L^o - 10^o in summers.
3. If collector itself is drying platform when tilling is not possible, glazed surface should be inclined to 6% upto 25^o and 15% at 40^o latitude to get maximum transmittance through transparent cover and also for better convection effect.
4. For air heating collector, a clear space for minimum of 25 mm should be provided between glazed surface and black surface.
5. Proper arrangement should be provided to remove rain water and condensed water from the glazed surface, especially in the direct type solar dryer.

4. Materials and Methods
This chapter deals with working principle of solar dryer, its specification, preparation of Bael pulp, drying procedure, pre-treatment carried out during the experimentation. A view of Traditional method of preparation of Bael sarbat & view of solar cabinet drier under loaded condition can be seen in Fig.4.1 and Fig. 4.2 respectively.

4.1 Solar Cabinet Dryer
The solar cabinet dryer consists of Main frame (cabinet), tray, transparent cover, and Insulation overall size of the dryer is 1219 mm × 762 mm × 1077 mm.

Main Frame
Main frame has been fabricated out of locally available MS sheet of 20-gauge thickness in the form of a cabinet having base areas of 1219 mm × 762 mm. The side panels have been fabricated inclined at an angle of 31^0 with respect to horizontal after a height of 304.8 mm from front end and height of 762 mm at the rear end. The inside faces of base, tray and side walls are painted with black paint. Four exit holes of diameter 25.40mm are drilled on the rear wall for air flow of moist air.

Tray
A tray has been provided for holding the material to be dried inside the drying chamber. The tray is placed such that it could be moved freely on the angle iron frame.

Transparent Cover
A polythene sheet of 0.2 mm thickness has been used as a transparent cover. This polythene sheet has been provided on the top of dryer.

Insulation
Four side walls and the base of cabinet made of MS sheet of 20-gauge thickness serve as natural insulation for the dryer.

4.2 Experimental Research Plan
Independent Variable
1) Pre-treatment: a) Ra
2) Pre-treated with potassium meta bisulphite (K_2HSO_4)

Dependent Variables
1) Drying time & drying rate
2) Moisture content
3) Quality of the product:
A) Sensory evaluation for different quality attributes (colour, appearance, flavor, taste, overall acceptability)
B) Storage life

4.3 Sample preparation
Fresh good quality Bael was procured from local market of pusa. It was properly washed in running water thoroughly in fresh water to remove dirt, dust and insects if any. It was weighed on electronic weighing machine of sensitivity: .01/.1 G. Shell and pulp was separated by hammer and knife. Fiber and seed was separated from pulp by adding measured and amount of water. Weight of fiber and seed was taken. Final weight of strained sample was taken. Now the prepared sample was spread uniformly in the drying tray and then inserted into the drying chamber of cabinet dryer.
For preparation of pre-treated Bael sample same process was done as explained above but in extra .2 % potassium meta

bisulphite (K_2HSO_4) was added. Now the prepared sample was spread uniformly in the drying tray and then inserted into the drying chamber of cabinet dryer.

Fig 4.1: Traditional/local method **Fig 4.2:** solar drier under loaded condition

4.4 Measurement and Determination Techniques

The drying of raw and pre-treated Bael was carried out in solar cabinet dryer separately. Various parameters like moisture content, relative humidity, moisture content, weight loss were determined during experiment. Hourly ambient air temperature as well as drying air temperature was measured with the help of mercury thermometer (range: - -10 to +110^{0}C). Hourly relative humidity of ambient air as well as drying air was measured with the help of hygrometer (range: 0 to 100%). The reading was taken every hour starting from 10:00 AM to 5:00 PM. The samples were kept in dryer at 10:00 am till 5:00 pm. At the end of the day the whole sample was taken out of the dryer wrapped in plastic sheet kept at a dry place in the laboratory.

Determination of Moisture Content and Weight loss

Moisture content of fresh raw (untreated), and pre-treated was determined with the help of standard hot air oven. The samples were dried in the hot air oven at 105 ± 5^{0}C for 30 hours (taking into consideration the time of power failure also some of the important specifications are as follows: -

Temperature range- Ambient to 250 ± 1^{0}C.

No. of trays -Two

Operating voltage - 220 V AC.

Size -60 × 60 × 60 cm^3

Hourly weight loss of all two samples of Bael was measured with the help of digital electronic balance (sensitive: 0.01/0.1G) by sampling technique. In this technique three different samples taken from three different places (left, right, and centre) of the tray were weighed. Moisture content of raw and pre-treated samples was determined by keeping in hot air oven. Moisture content was determined on wet basis. The moisture content M (%w.b.) is:

$$M = \frac{W_m}{W_m + W_d} \times 100$$

W_d =Dry Weight of wet material

W_m =Weight of moisture evaporated, Kg

=Initial weight of sample – Bone dry weight of sample

=28.877- 4.525 =24.352

Initial weight of sample = $W_m + W_d$ = 24.352 + 4.525 = 28.877

So, m.c (%w.b.) M= 24.352/28.877 = 0.8433 = 84.33 %

Final moisture content can be determined by equation

$$\frac{W_m}{W_1} = \frac{m_1 - m_2}{100 - m_2} = \frac{M_1 - M_2}{100 + M_1}$$

Where,

W_1 = Initial Weight of wet material = $Wm + Wd$ (Kg)

W_m = Weight of moisture evaporated, Kg

M_1, M_2 = Initial and final moisture contents (%d.b.)

m_1, m_2 = Initial and final moisture contents (%w.b.)

For example, for pre-treated sample of Bael

W_1 = 28.877 gm.

W_2 = 19.798 gm.

W_m = 9.079 gm.

m_1 = 84.33 %

Now, 9.079 /28.877 = (84.33 – m_2) / (100 – m_2)

m_2 = 77.2%

For further drying it will be initial moisture content and using equation again final moisture content after certain period of drying can be calculated.

Determination of Bulk Density

Bulk density was calculated by putting the ground bael powder in beaker of volume 50cc. the powder were fill unto the top of the beaker after that weight of powder was taken and bulk density was calculated by using the formula:

Bulk density (Kg/m^3) = Mass / Volume

4.5 Quality of Dried Bael

Dried Bael samples were evaluated for their quality (*viz.* Color, flavor, appearance, taste & overall acceptance) by physical observations. After drying the dried samples of Bael were stored in desiccators for studies after 5 months. After 5 months the samples were taken out and their bulk density, quality evaluation was determined. The sensory evaluation of samples was done in standard format by a panel of judges (10) and average score was calculated.

5. Results and Discussion

Prepared dried flake (Fig A) of raw Bael as well as pretreated Bael was grind by grinder and it had been seen that both of the powder (Fig B) passes through the sieve of size 0.125 mm.

Fig A: Dried Bael Flake

Fig B: Dried Bael powder

5.1 Variation in Temperature and Relative Humidity under Unloaded Condition

The hourly temperature and relative humidity of drying air and ambient air were recorded from 10:00 AM to 17:00 PM and plotted in Fig. 5.1. It can be seen from Fig. 5.1 that the ambient air temperature was in increasing trend from morning to noon and was maximum 38^{0}C during 13.00 PM and decreasing in the afternoon it was minimum recorded as 32^{0}C at 17:00 PM. Similar trend was observed in case of drying air temperature. The temperature of drying air inside the dryer was observed to be 64^{0}C as maximum temperature at 13:00 PM with corresponding ambient air temperature of 38^{0}C which shows a temperature difference of 26^{0}C above ambient air temperature. relative humidity of air inside and outside the dryer is plotted for drying air and ambient air in Fig. 5.2. It can be seen from Fig. 5.2 that the ambient air relative humidity was maximum 55 per cent at 10:00 AM and it was minimum recorded as 48 per cent at 13:00 PM and 15:00 PM that the drying air relative humidity was maximum 50 per cent at 10:00 AM and it was minimum recorded as 21 per cent at 13:00 PM.

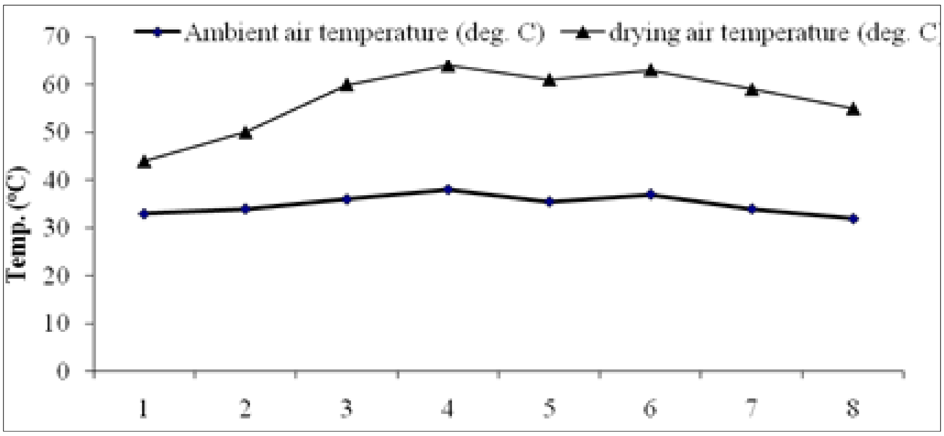

Fig 5.1: Variation of air temperature inside and outside the dryer for unloaded condition

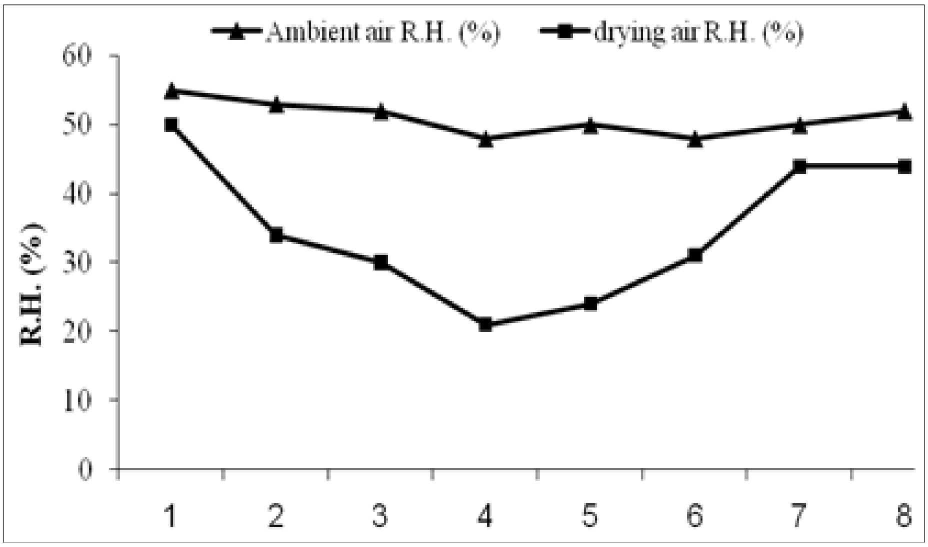

Fig 5.2: variation of relative humidity with time under unloaded condition

5.2 Variation in Temperature and Relative Humidity under Loaded Condition

Hourly temperature and relative humidity of ambient as well as drying air inside and outside the dryer for raw Bael are plotted in Fig. 5.3 and Fig. 5.5 respectively. Similarly, it is plotted for pre-treated Bael in Fig. 5.4 and Fig. 5.6 respectively.

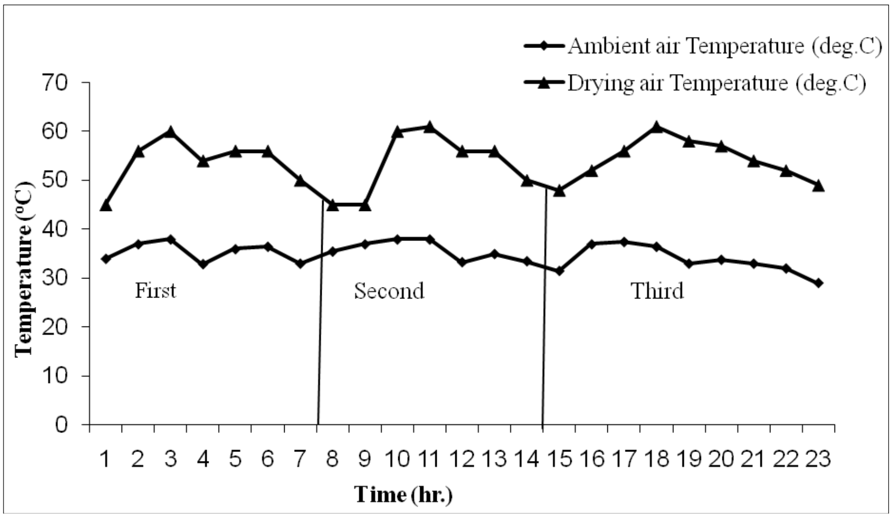

Fig 5.3: variation of air temperature, inside and outside the dryer for few beal sample

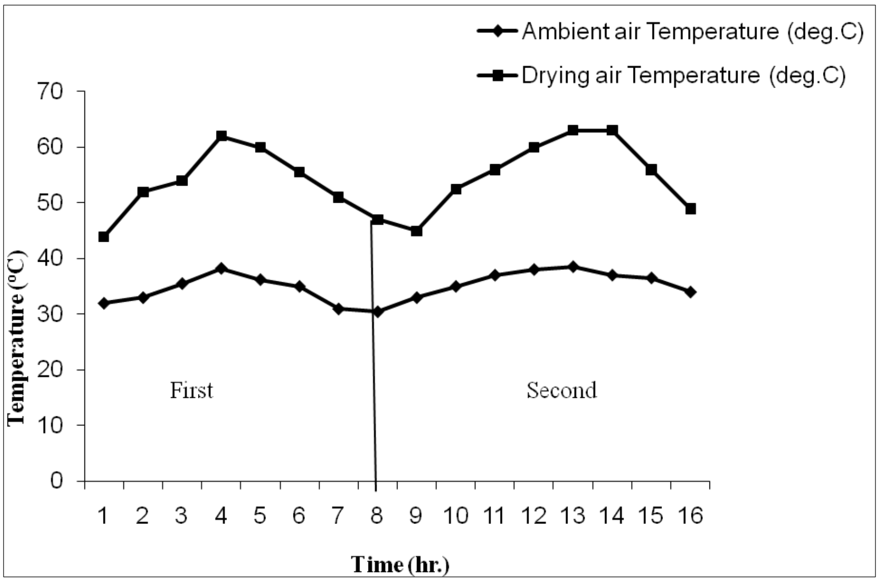

Fig 5.4: variation of air temperature inside and outside the dryer for pre-treated samples

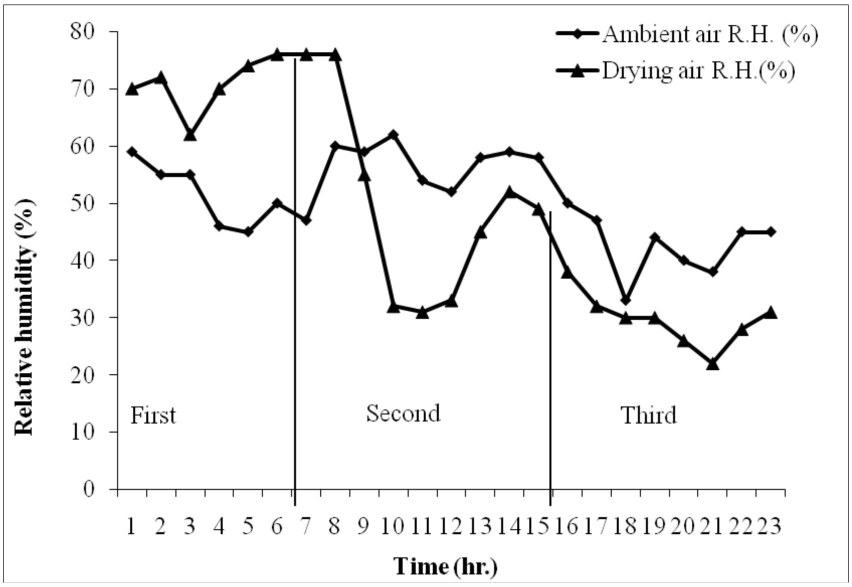

Fig 5.5: Variation of relative humidity inside and outside the dryer for raw sample

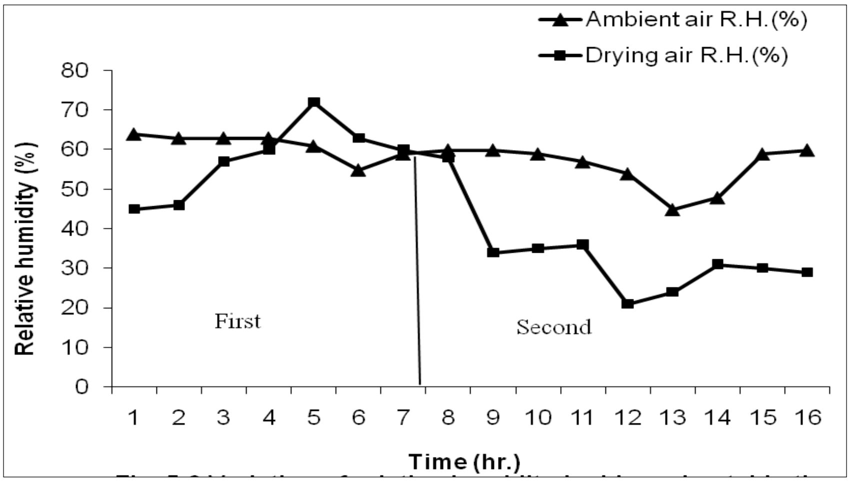

Fig 5.6: Variation of relative humidity inside and outside the dryer for pre-treated sample.

Variation in Temperature and Relative Humidity for Raw Bael

It can be seen from Fig. 5.3 that the ambient air temperature was in increasing trend from morning to noon and Similar trend was observed in case of drying air temperature also. Maximum ambient temperature was 38^0C and corresponding drying air temperature was observed as 61^0C which shows a temperature difference of 23^0C above ambient air temperature. Ambient air was minimum recorded as 29^0C. Drying air temperature was minimum in the morning at 10.00 AM. Minimum drying air temperature as on first, second and third days of drying was 45^0C, 45^0C & 56^0C, respectively. The maximum drying air temperature recorded were 60^0C, 61^0C, 61^0C on the respective days.

It can be seen from Fig. 5.5 that the ambient air relative humidity was maximum 62 per cent on second day of drying at 11.00 AM and it was minimum recorded as 33 per cent at 11:00 AM on third day of drying and drying air relative humidity was maximum 76 per cent on first day of drying at and it was minimum recorded as 22 per cent on third day of drying at 14:00 PM. Minimum drying air relative humidity as on first, second and third day of drying were 62 per cent, 31 per cent, 22 per cent respectively. The maximum drying air relative humidity were 76 per cent, 55 per cent and 32 per cent on the respective days of drying. The lowest relative humidity was observed at 12.00 noon to 15.00 PM in most of the batches of drying.

Variation in Temperature and Relative Humidity for Pretreated Bael

Similar trend of variation of Temperature and R.H as observed for Raw bael was observed for pre-treated also. Maximum ambient temperature 38.5^0C and corresponding drying air temperature was observed as 63^0C which shows a temperature difference of 24.5^0C. Ambient air was minimum recorded as 31^0C. Drying air temperature was minimum in the morning at 10.00 AM. Minimum drying air temperature as on first and second day of drying was 44^0C, 45^0C respectively. The maximum drying air temperature recorded were 62^0C, 63^0C on the respective days.

It can be seen from Fig. 5.6 from that the ambient air relative humidity was maximum 64 per cent on second day of drying at 10.00 AM and it was minimum recorded as 45 per cent at 14:00 PM on second day of drying and drying air relative humidity was maximum 72 per cent on first day of drying at and it was minimum recorded as 21 per cent on second day of drying at 13:00 PM. Minimum drying air relative humidity as on first and second day of drying was 45 per cent and 21 per cent respectively. The maximum drying air relative humidity 72 per cent and 36 per cent on the respective days of drying.

It is clear from the Fig. 5.3 and Fig. 5.4 that maximum drying air temperature was obtained during drying of pre-treated sample. Variation of drying air temperature in comparison of ambient air temperature for both raw as well as for pre-treated revealed the performance of solar cabinet dryer was good.

5.3 Drying Characteristics in Solar Cabinet Drying of Bael

The data of moisture content of Bael under raw and pre-treated condition at different time were plotted in Fig. 5.7 and Fig. 5.8.

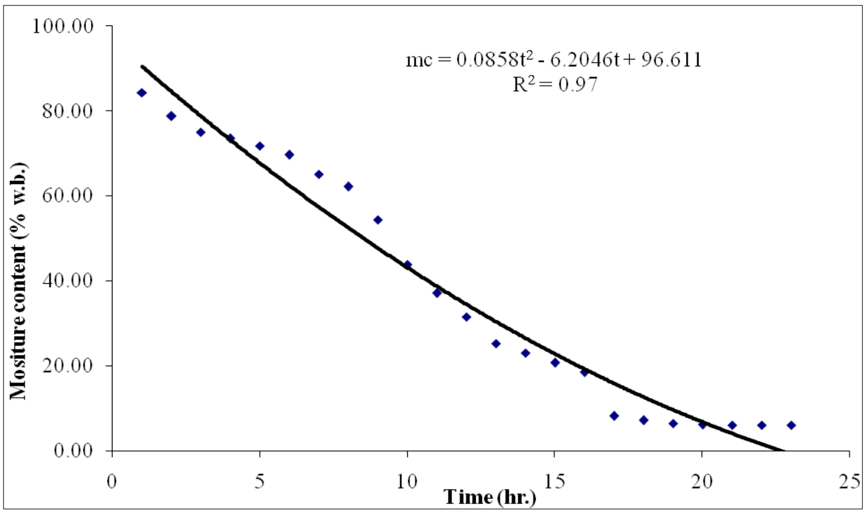

Fig 5.7: Variation of moisture content with time during solare cabinet dryer of raw beal sample

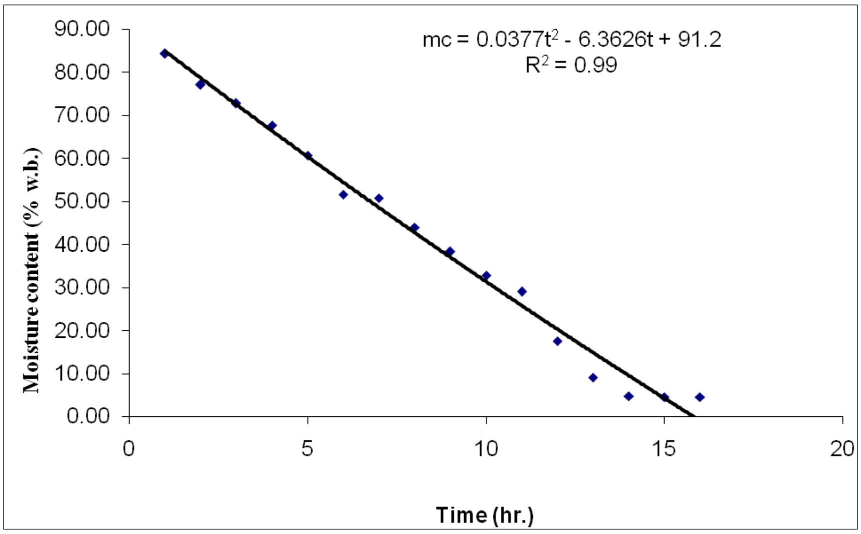

Fig 5.8: Variation of moisture content with time during solar cabinet drying of pre-treated beal

Drying Characteristics of Raw Bael Pulp

The initial moisture content of raw sample of Bael was 84.33 per cent (w.b.) at 10:00 AM it was kept in the dryer from 10:00 AM to 17:00 PM. At the end of the first day the moisture content (w.b.) reduced to 62.203 per cent (w.b.). It is obvious from the Fig. 5.7 that the drying rate was moderate on first day, drying rate increases on second day. Higher temperature enhanced the drying rate of raw sample. The drying is steepest on second day & moisture content of sample reduced to 18.5 per cent (w.b.). On third day the temperature of drying air was observed 61^0C as maximum which facilitated in drying of Bael sample to a constant value of moisture content 5.98 per cent (w.b.).

Drying Characteristics of Pre–treated Bael pulp

Solar cabinet drying of pre-treated Bael sample took only two days in which the moisture content of samples ceased to a constant value of 4.603 per cent. It is obvious that solar cabinet drying rate is affected by temperature as well as relative humidity. High temperature and low relative humidity facilitates in quick drying of Bael samples. Chemical treatment also facilitates the Bael drying. The solar cabinet drying curves obtained in Fig. 5.7 and Fig. 5.8 resembles the standard drying curves obtained during drying of Bael samples in other standard dryers. The statistical analyses of data's were carried out which gives the different equations of degree two (R^2 value) for different two samples are:

For Raw /Untreated Sample

$mc = 0.0858t^2 - 6.033t + 90.492$ ($R^2 = 0.97$)

For Pre-treated Sample

$mc = 0.0377t^2 - 6.288t + 84.875$ ($R^2 = 0.99$)

Where,

mc = moisture content (%, w.b.)

t = drying time (min.)

Coefficient of regression (R^2) shows the correlation between experimental data and predicted values. Equations of higher values of coefficient of regression (R^2) show the least diversion of experimental data from the predicted value.

5.4 Quality of Dried Bael

Different quality attributes of dried Bael samples *viz*. Color, moisture content, bulk density were determined and enlisted in Table 1.

Table 1: Physical quality evaluation of dried Bael sample.

Quality attribute	Raw sample	Pre-treated sample
Colour	Dark brown	Light brown
Density (kg/m^3)	869 kg/m^3	1008 kg/ m^3
Moisture content (% w.b.)	5.98 per cent	4.603 per cent

Sensory Evaluation of Prepared Drink

It can be seen from Table 2 and 3 that marks of pre-treated was slightly higher than raw sample but slightly lower than fresh drink. Overall acceptability of all sample got 8.5 marks or above. So it can be concluded that the overall acceptability of both of the sample pre-treated and raw was very good.

Fig C: View of prepared drink made by dry beal

Fig D: Panel of judges during sensory evaluation

Table 2: Sensory Evaluation of Quality of Fresh Drink of Bael

Sl. No.	Quality attributes	Score/marks out of 10
1	Color	8.5
2	Appearance	8.75
3	Flavor	8.5
4	Taste	9
5	Overall acceptability	9

Table 3: Sensory Evaluation of Quality of Dried Samples of Bael

Sl. No.	Quality attributes	Score/ marks out of 10			
		Dry Flake		Bael Drink	
		Raw/ untreated	Pre-treated	Raw/ untreated	Pre-treated
1	Colour	8	8.5	7.5	8
2	Appearance	8	8.5	8	8.5
3	Flavour	7	8	7.5	8
4	Taste	8	8.5	9	9
5	Overall acceptability	8.5	9	8.5	9

Storage of Dried Bael
All the samples packed in polyethylene bags were stored in desiccators. No significant difference was observed in sensory quality scores of overall acceptability during five months of storage. Hence it can be stored for 5 to 6 months safely without any deterioration.

6. Conclusion
From the present study following conclusion can be drawn.
1. The developed solar cabinet dryer was suitable for drying Bael. Samples were dried in 2-3 days as compared to 5 – 6days in open sun drying with an effective drying period of 10:00 AM to 17:00 PM.
2. Performance of dryer was very good as the maximum temperature difference between inside and outside the solar cabinet dryer was found to be 23^0C.
3. Pre- treatment of Bael samples with potassium meta bisulphite (0.2 %) has affected the drying rate and drying time. It was reduced to 2 days as compared to 3 days for raw samples.
4. Sensory evaluation of the pretreated reconstituted sample was best but reconstituted sample of raw sample was also very good.
5. All the samples could be stored safely for 6-7 months in polythene bags without any change in quality.

In general, it could be concluded that the solar cabinet dryer is suitable for Bael drying.

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