A comparative study on drying of basil leaves

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Abstract: Basil is a popular aromatic and annual herb growing in many regions of the world. Immediately after its harvesting, the highly perishable raw material, i.e. leaves, have to be preserved against deterioration and spoilage. More often, during peak period, most of the crop is lost/wasted due to lack of proper post-harvest processing techniques. Drying is by far the most widely used treatment, which needs to be performed very carefully and preciously so as to preserve the aroma and color of the leaves. Various drying treatments and experimental methods viz., solar drying, tray drying, vacuum drying and fluidized bed drying were carried out at the temperatures of 45 ℃, 55 ℃ and 65 ℃ to find and suggest the optimum drying condition for acquiring quality dried basil leaves. Results have revealed that 'total drying time' is considerably reduced with the increase in drying air temperatures from 45 ℃ to 65 ℃. It could be recommended that for the best drying of basil leaves, the drying operation needs to be carried out in the fluidized bed dryer at 45 ℃ for 30 s steam blanched sample ensuring the best results in quality of basil leaves as compared to other methods and treatments whatever considered during present study.

Keywords: drying, drying characteristics, basil leaves, solar drying, tray drying, vacuum drying and fluidized bed drying

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1 Introduction

Basil (Ocimum viride) happens to be an important tender-growing aromatic annual herb indigenous to West Africa, but vastly cultivated in India.

The use of basil and other spicy herbs in food preparations are not just only for flavoring from their strong spicy aroma, but also for other purposes such as their medicinal, antioxidant, anti-inflammatory, antiviral or antimicrobial properties (Risch, 1997).

In spite of being extremely important, this vital plant is scarce during off-seasons, which necessitates good preservation. Also, the plant is highly perishable, and has to be preserved against deterioration and spoilage, which makes its drying a most imperative deed.

Historically, basil has a very rich history bearing several names, derivations and beliefs associated with it, that ultimately made it 'king of the herbs'. Indeed, the common name '*basil'* was believed to be derived from the Greek word *basileus* that actually means a "king". Alternatively the word *basilikon* too means a "royal" (called Herb royale in French). Also the Latin word *basiliscus*, refers to "basilisk"- a mythical 'fire-breathing dragon' that could kill with just a glance. It is the antidote to their venom, according to Roman legend. Similarly, the genus *Ocimum* name was derived from Greek to be fragrant. For Indian conditions the species name are often popular as *sanctum*, because it used to be one of the two most sacred plants in India which are widely grown near houses and temples. Also it is called Common or Sweet or Holy Basil in Common English and *Tulsi* in Hindi, Sanskrit and Gujarati languages (Gupta, 2007). Proper drying of this important crop happens to be the most common and effective method that could vastly increases the shelf life of such spicy herbs by inhibiting the growth of microorganisms and preventing the onset of some biochemical reactions. It ultimately may alter the organoleptic and nutritional characteristics of dried leaves.

Basil crops stored at high moisture content generally get deteriorated because of microbiological growth. One of the most common preservation methods to avoid such conditions or scenarios for herbs and spices remains

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drying. Proper drying of basil leaves or any such material, is not only improving the quality of product, but also reducing various costs involved in its processing, marketing and other in tangible means. For situations like India, the transport and storage costs are amply high, which could be significantly lowered after proper drying operations of such crops. It happens because of the reason that weight and volume gets drastically reduced to facilitate the storage and transport of leaves at lower costs. This altogether established the importance of drying for basil and alike medicinal crops. Since this process consists simultaneous heat and moisture transfers which inevitably requires various kinds of systems, crops and their varieties have different structures, shapes and characteristics and therefore, they have altogether different drying behaviors. Understanding these drying behaviors and their proper planning and conductance undoubtedly remained one of the biggest needs for the growers and accordingly a big challenge for the researchers. The major focus for drying such leaves often remained centered around a point where its aroma needs to be preserved beside the appearance and nutritional characteristics. Researchers (Diaz-Marotoet al., 2002; Brophy et al., 1986; Fleisher, 1981) have reported that improper drying may cause losses in volatilities or formation of new volatilities as a result of oxidation and esterification reactions. The volatile composition of basil is found to be dependent on the variety and/or geographical cultivation of the basil plant depending upon main components (Linalool, methyl cinnamate, eugenol, methyl eugenol, and etc.) of this precious herb. The majority of findings have revealed this fact where the drying is reported to influence changes in the volatile compounds present in basil.

If we look from quantitative points of view, these decreases in the total amounts of essential oils have been reported to varied tune, say being 36% to 45% for sweet basil during drying at ambient temperature (Nykanen and Nykanen, 1987; 1989). A study by Yousif et al. (1999) showed significant difference in concentrations of linalool and methyl chavicol in air-dried basil samples compared to those present in fresh samples, while that of vacuum dried samples showed substantial increase of about 2.5 fold for linalool and 1.5 fold for methyl chavicol, compared to that present in air-dried samples. Di Cesare et al. (1994; 2000; 2001; 2002; 2003) found microwave drying to retain high percentages of characteristic volatile compounds (eucalyptol, linalool, eugenol, and methyl eugenol) in basil (*Ocimum basilicum* L.) compared to samples dried by air-drying and freeze-drying with blanching, except freeze-dried unblanched leaves. Other studies on drying methods on volatilities of leaf (Diaz-Maroto et al., 2002), and spearmint (Diaz-Maroto et al., 2003) too have given such logical variability.

In general type, variety and production practices of the crop, its chemical composition and susceptibility to heat treatment, pretreatment given, method and conditions of drying and climatic conditions are important factors affecting drying. Consumers prefer processed products that keep more of their original characteristics. For that a comparative study for drying of basil leaves was carried out and found out most suitable techniques. The estimated annual basil consumption in some major markets of the world as: USA-600 to 700 tonnes, Germany-100-150 tonnes, U.K.-100-150 tonnes, Netherland-10-20 tonnes, Switzerland - 10-20 tonnes and Japan 10-20 tonnes (Pruthi, 1993). In Indian market the price of *Ocimum sanctum* leaves oscillates between Rs. 200 to 250 per kg, while their another valuable byproduct 'oil of basil' is also remains in great demand with tremendous potential to fetch considerable profits for the growers. The process of this important product are equally realized and established at global scale too. In all it is estimated that about 50% of such herb plants as traded are used for the food industry, 25% in cosmetics, 20% for medicinal and 5% for other uses such as insecticides (Svoboda et al., 1993).

Taherigaravand et al. (2013) conducted certain drying experiments at varied air temperatures and offered a Genetic Algorithm which could find the best Feed-Forward Neural Network (FFNN) structure to model the moisture content of dried Basil in most of the conditions. This ultimately facilitated better predictions of moisture content of dried basil leaves, which in turn has direct impacts on drying of basil leaves. Yuparat et al.

(2014) utilized some of the predictive models to evaluate the performances as well as influences of certain parameters towards drying of leaves and other similar materials by fitting prevailing moisture versus time data to five different crop drying models. The drying constants were well related to the drying temperatures. The ultimate findings of Abdollah et al. (2014) reflected the facts that (1) drying temperatures can decrease essential oil contents of basil, (2) drying methods can change the chemical profile of essential oil of basil, and (3) oven drying at 40 ℃ had the least effect on essential oil.

Aromatic plants and EOs have been used since ancient times and are still widely used for their biological properties and their applications in various industries: food, cosmetics, perfumery, and pharmacy. Mohammed et al (2016) adopted solvent-free microwave extraction (SFME) and conventional hydro-distillation (HD) for the extraction of essential oils (EOs) from Egyptian sweet basil (*Ocimum basilicum* L.) leaves and pair of two resulting EOs were compared with regards to their chemical composition, antioxidant, and antimicrobial activities, achieving compounds constituting even 99% or more total oils with many better alternatives for the extraction of EO from O. basilicum for providing a richer source of natural antioxidants, as well as strong antimicrobial agents for food preservation.

Looking into plethora of such studies and their findings towards drying effects on volatile components of basil leaf, present research was conceived and conducted in India whose preliminary results are reported herein. The major aim of the work was to examine the influence of various drying methods on a couple of crop varieties as cultivated in India, in particularly its western part nearing state of Gujarat. At least two varieties of *Ocimum sanctum* are mostly found in cultivation, out of which the green type (Sri Tulsi) is the most widespread. The other one known as Krishna Tulsi, bears purple leaves and has equal importance and considerations in the region. The results of this study have provided ample food for thought for visualizing and adopting most effective drying method for basil leaves cultivated in this specific region of India, to promote its market/utility and also to maintain its nutritional value and other qualitative parameters in an optimum manner.

2 Materials and methods

2.1 Experimental material

Experiments were conducted to dry the basil leaves using different drying methods for quality produce. Basil plants were grown in the backyard of P.G. Institute of Food Processing of Technology and Bio-Energy, Anand Agricultural University, Anand. The plant leaves were manually nibbed from the basil plant and cleaned with water spray at evenings so as to remove dust and other impurities. Soft stems were separated from the leaves manually if left during nibbing. Care was taken to avoid bruised and discolored leaves. In preliminary experiment hot water blanching was carried out using the method described by Ranganna (1986) for catalase and peroxidase analysis.

2.2 Experimental apparatus

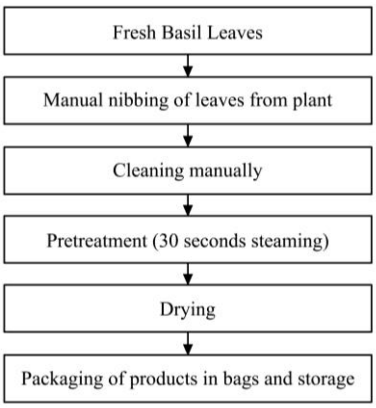
Drying experiments were performed in a cabinet type laboratory hot air tray dryer manufactured by Navrang Scientific Works Pvt. Ltd., New Delhi and fitted with manually controlled digital thermostat, PT-100 thermocouple, a blower driven by 0.5 hp motor and electric finned heaters of 3×1 kW. The dryer was adjusted to the selected temperature (45 ℃, 55 ℃, 65 ℃) for about half an hour before the start of the experiment to achieve the steady state condition. Air velocity was set at 1.0 m s^{-1} and maintained by adjustable flap throughout drying time and measured by digital anemometer. Then 100 g of pretreated and untreated samples of basil leaves were uniformly spread in the tray.

The solar drying studies of basil leaves were carried out in the commercial solar dryer. The modular size of the solar dryer was 1000 mm × 2000 mm. Total modules were two having loading capacity up to 10 kg per batch. The tray size and numbers were 500 mm × 425 mm × 25 mm and eight numbers respectively. The trays were made of stainless steel with SS wire mesh. Inlet, outlet and ambient temperatures were recorded. Each 100 g blanched and unblanched samples were uniformly spread in single layer on a perforated stainless steel wire mess tray and dried at the desired temperature. An electrically heated laboratory vacuum dryer manufactured by

Gansons Ltd., Mumbai and externally fitted with rotary vacuum pump and thermostat was used. The dryer was pre-adjusted to the selected temperature (45 ℃, 55 ℃, 65 ℃) for about half an hour before starting of the experiment to achieve the steady state. Each 100 g blanched and unblanched samples were uniformly spread in single layer on a perforated stainless steel tray and dried at the desired temperature with a constant vacuum of 700 mm Hg.

The drying experiments were performed in laboratory fluidized bed dryer Plenum chamber of dryer consists of a truncated conical base having bottom diameter of 0.21 m and top diameter of 0.30 m. The height of cylindrical column is 0.73 m. An air supply unit to fluidize the sample is provided at the bottom with centrifugal blower coupled with three phase 1 hp electric motor and a flow regulating device to regulate the air flow rate. Air is heated with two electric heaters of 1 kW each to regulate the temperature of hot air. The blanched and un-blanched basil leaves samples (100 g) each were dried by spreading them in single layer in the perforated wire basket placed in the plenum chamber. The hot air was supplied through the bottom of the plenum chamber at the specified temperature (45 ℃, 55 ℃, 65 ℃) and at 2 m s^{-1} air velocity. This air velocity was maintained using adjustable flab at the air inlet and measured with digital anemometer.

The exact flow chart as conceived and utilized for drying of basil leaves remained as follows:



2.2.1 Drying of basil leaves

The fresh blanched and unblanched basil leaves samples (100 g) were dried by employing different drying methods such as hot air drying at 45 ℃, 55 ℃ and 65 ℃, solar drying, vacuum drying at 45 ℃, 55 ℃ and 65 ℃ and fludized bed drying at 45 ℃, 55 ℃ and 65 ℃ and 2 m s^{-1} air velocity. The drying of flowers was done with the pre-decided drying parameters. Before putting the samples in drying unit, the dryer was started to attain the preset temperature. The reduction in weight was taken regularly with increase of time period with the help of electronic digital weight balance of 0.1 g accuracy. The drying process was stopped when the moisture content reached to about 4%-6% (d.b.). The product was then cooled for 10 min after drying and packed in LDPE bags.

2.2.2 Drying characteristics of basil leaves

The drying characteristics of basil leaves in terms of variation in moisture content, weight loss, drying time, drying rate and moisture ratio with respect to time were studied for different methods of drying, considered for the study. The effects of drying temperature on the drying behavior were also studied.

Moisture content

The method described in AOAC (1990) was used to determine the moisture content. A metallic dish was dried in oven at 110 ℃ for one hour. It was quickly covered, cooled in desiccator and weighed (W_1). A 5 g sample was kept in thin layer on the metallic dish and weighed as quickly as possible to avoid loss of moisture (W_2). The sample was kept in hot air oven maintained at 100 ± 5 ℃. The sample was dried for about 4 h until two to three consecutive weights remained constant and final weight was recorded (W_3). The moisture content was calculated using the following equation:

$$\%\ \text{Moisture content} = \frac{\left[(W_2 - W_1) - (W_3 - W_1)\right] \times 100}{(W_3 - W_1)} \quad (1)$$

where, W_1 = Weight of empty metallic dish, g; W_2 = Weight of metallic dish with sample, g; W_3 = Weight of metallic dish with dried sample, g.

Equilibrium moisture content

The final moisture content at the end of drying period was approximated as equilibrium moisture content at respective drying temperature for calculation of moisture ratio (Abhay and Jain, 2006)

Moisture ratio

Moisture Ratio (MR) is defined as follows

$$MR = \frac{M - M_e}{M_o - M_e} \quad (2)$$

where, M = Moisture content, % (d.b.) at time t (min) during drying; M_o = Moisture content, % (d.b.) at the initiation of drying i.e. at zero time; M_e = Equilibrium moisture content, % (d.b.).

The moisture ratios at different time intervals were calculated by using Equation (2) to study the drying characteristics of basil leaves.

3 Results and discussion

Average initial moisture content of 24 samples of the fresh basil leaves was 81.68% (w.b.) at the time of harvest. The range of moisture content varied from 81.00%-83.00% (w.b.), which shows that the basil leaves can be considered under highly perishable group. The drying characteristics of basil leaves were analyzed using the experimental data on moisture of product at various time intervals for different drying conditions. The experimental data of the drying behavior of basil leaves in relation to moisture content, moisture ratio and drying rate were recorded and summarized. After pretreatment, the samples were dried up to the safe moisture content level of 4% to 6% (d.b.).

Relation of time, temperature, moisture content (% d.b.) and drying rate (% d.b. min^{-1}) were attempted to characterize the drying behavior of basil leaves. The moisture content, moisture ratio and drying rate were compared for the blanched and unblanched samples with different time, temperature for different dryers.

The basil leaves were steamed and thus had some condensed moisture on the surface, which contributed to higher moisture content than actual.

3.1 Drying behavior of basil leaves

3.1.1 Hot air tray drying

The basil leaves were dried in the drying chamber of hot air tray dryer that had set to pre-decided temperature. The drying in hot air dryer was done at 45℃, 55℃ and 65℃ till the final weight reached to predecided level, according to the final moisture content of dried product. Figures 1 to 3 illustrate variation in the moisture content with respect to drying time for blanched and unblanched samples of basil leaves at 45℃, 55℃, and 65℃ temperatures respectively in the hot air tray dryer. From the figures it can be seen that the total drying time decreased with the increase of drying temperature. The effect on drying time was found more prominent with blanched than unblanched samples for the temperature 45℃ and 55℃. However, at air temperature of 65℃, the effect of blanching on drying time was comparatively less. It was also observed that moisture reduced rapidly at initial level, which decreased with time in both blanched and unblanched samples for all three temperatures.

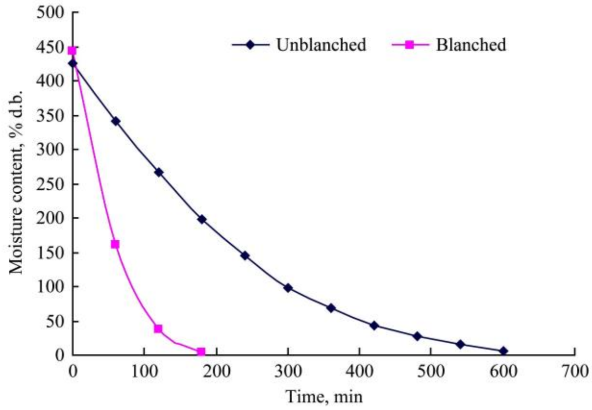


Figure 1 Variation in moisture content of basil leaves with drying time for hot air tray drying at 45℃

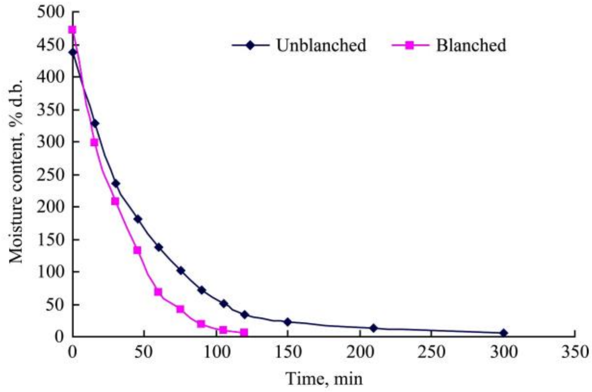


Figure 2 Variation in moisture content of basil leaves with drying time for hot air tray drying at 55℃

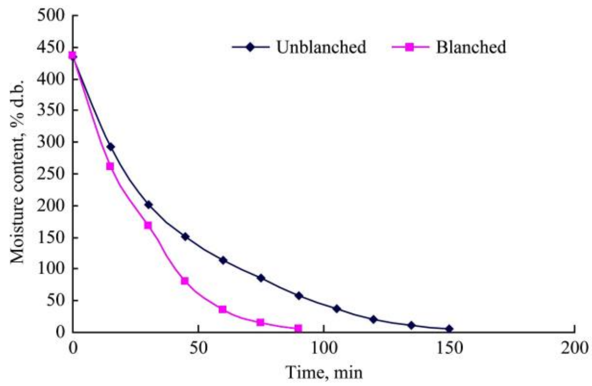


Figure 3 Variation in moisture content of basil leaves with drying time for hot air tray drying at 65℃

The effect of temperature on drying time was found more prominent for blanched basil leaves. The initial moisture content of 442.55%, 472.22% and 436.84% (d.b.) were reduced to final moisture content of 4.61%, 5.56% and 5.26% (d.b.) in 180, 120, and 90 min for 45℃, 55℃ and 65℃ temperatures, respectively. In case of unblanched samples, the initial moisture 426.32%, 437.63% and 434.76% (d.b.) were reduced to final moisture content 5.26%, 5.74% and 5.17% (d.b.) in 600, 300 and 150 min for 45℃, 55℃ and 65℃, respectively.

The basil leaves dried at 45℃ took a considerably long time to reduce the moisture content from about 442.55% to 4.61% (d.b.), while at higher temperature 65℃ took less time in unblanched samples. Obliviously, at higher temperature the movement of drying front was fast as compared to lower temperature that resulted into rapid evaporation of water from the vegetative parts of leaves, resulted in higher moisture loss and less time required for drying. The similar types of results were obtained in blanched samples.

3.1.2 Solar drying

Freshly harvested leaves of the basil were dried in the forced convection type solar dryer at 45℃, 55℃, 65℃. The temperature in the dryer was varied from 50℃ to 70℃ during the sun light hours. The temperature inside the dryer was kept at 45℃, 55℃ and 65℃ by covering the white cloth over the glass of the dryer depending on the temperature needed. The observations on the weight loss were recorded at an interval of 60 min. The observations of the moisture loss data were taken under solar drying converted into the % d.b.

The drying of basil leaves in solar dryer was slower at the 45℃ which might be due to the condensation effect during drying. Due to the moderate temperature inside the dryer, the rate of evaporation was slow. Moreover, the lower rate of evaporation was further diminishing due to the condensation of vapour accumulated in the free space inside the dryer. From the Figures 4, 5 and 6, it can be seen that the total drying time for the unblanched samples were found more than the blanched samples for each drying temperatures. Thus the effect was found more prominent for the blanched samples than the unblanched samples at each temperature. At the 45℃, the time required for drying was much more in comparison to that at 55℃ and 65℃ temperatures in case of unblanched samples. The effect on drying time on unblanched and blanched samples was higher in the case of 45℃ and 55℃ comparison to 65℃. The effect of solar drying on blanched and unblanched basil leaves samples indicates that as drying air temperature increased, the rate of moisture reduction also increased. The effect of temperature was found more prominent for blanched basil leaves. The initial moisture content 436.84%, 451.35% and 448.39% (d.b.) were reduced to final moisture content of 5.26%, 4.51% and 5.74% (d.b.) in 360, 240, and 150 min for 45℃, 55℃ and 65℃ temperatures, respectively. In case of unblanched samples, the initial moisture content 431.92%, 426.32%, and 426.32% (d.b.) were reduced to final moisture content of 4.61%, 5.26% and 5.26% (d.b.) at 1860, 420, 240 min for 45℃, 55℃ and 65℃ temperature, respectively.

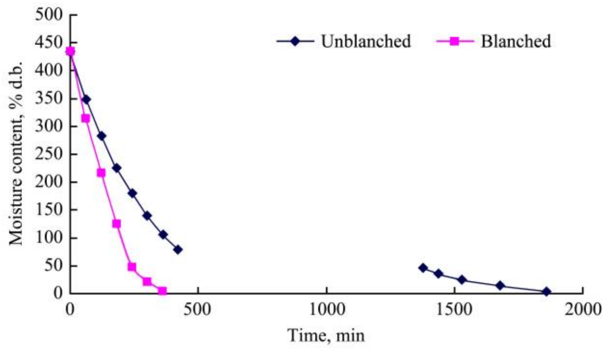


Figure 4 Variation in moisture content of basil leaves with drying time for solar drying at 45 ℃

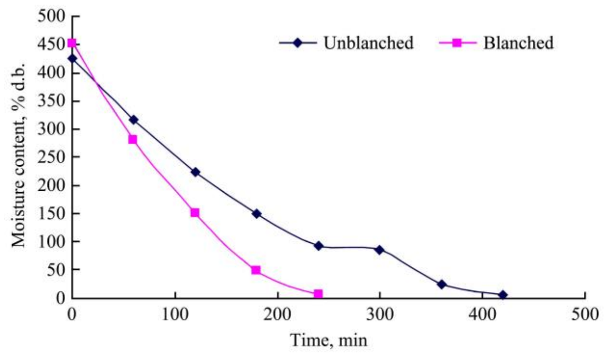


Figure 5 Variation in moisture content of basil leaves with drying time for solar drying at 55℃

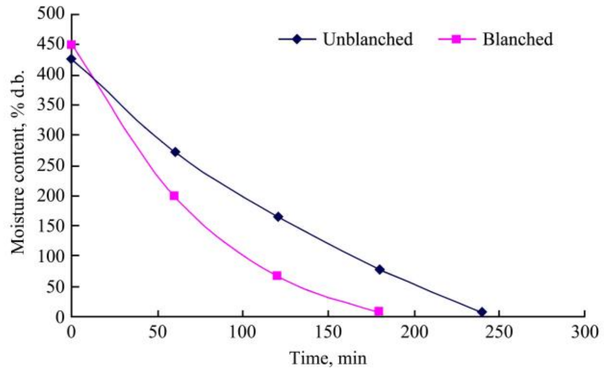


Figure 6 Variation in moisture content of basil leaves with drying time for solar drying at 65℃

3.1.3 Vacuum drying

The freshly harvested basil leaves were placed over stainless steel tray, which was kept over the platform for drying in vacuum oven at 45℃, 55℃ and 55℃ and 700 mm of Hg vacuum. The drying in vacuum oven was done at each till the final weight reached to predecided level. The observations in regards to weight loss were noted during each drying run at an interval of 60 min.

In vacuum drying, moisture loss was more in the blanched basil leaves samples than the unblanched samples at 45℃, 55℃ and 65℃ drying temperatures. From the Figures 7, 8 and 9, it was observed that the moisture loss was less in case of blanched samples at 55℃. The effect of blanching at 55℃ was comparatively lower than the 45℃ and 65℃ drying temperatures, which was not similar to the trend observed for hot air tray drying and solar drying. The initial moisture loss was rapidly increasing at 45℃ in the unblanched sample compared to the hot air and solar drying. This was due to the effect of the vacuum in 45℃ temperature in unblanched sample. No constant rate drying period was observed during drying. Complete drying took place only in falling rate period.

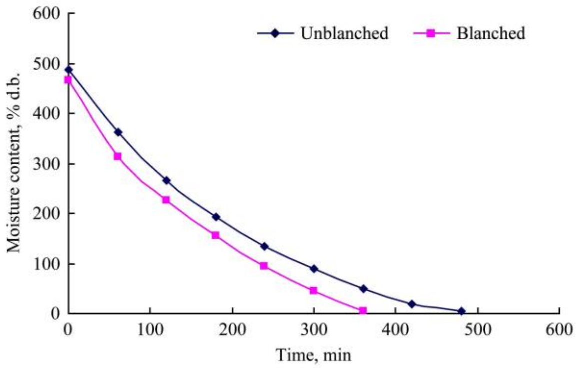


Figure 7 Variation in moisture content of basil leaves with drying time for vacuum drying at 45℃

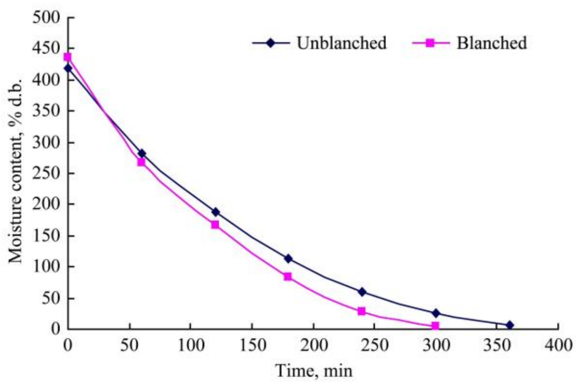


Figure 8 Variation in moisture content of basil leaves with drying time for vacuum drying at 55℃

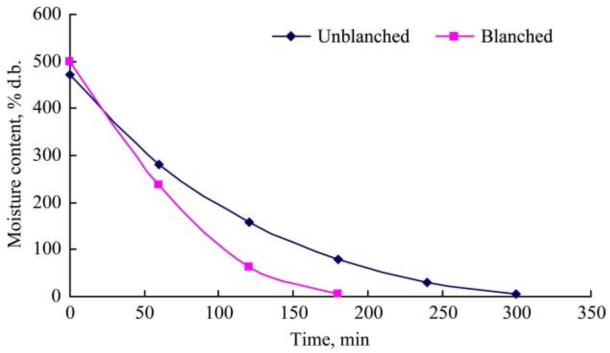


Figure 9 Variation in moisture content of basil leaves with drying time for vacuum drying at 65℃

The effect of drying air temperature on drying behavior of basil leaves for blanched and unblanched samples indicate that as inlet temperature increased, the rate of moisture reduction was increased. The effect of temperature was found more prominent for blanched basil leaves. The initial moisture content 466.67%, 436.84% and 500.00% (d.b.) were reduced to final moisture content of 5.56%, 5.26% and 5.88% (d.b.) in 360, 300, and 180 min at 45℃, 55℃ and 65℃, respectively. In case of unblanched samples, the initial moisture content 488.24%, 417.95% and 471.43% (d.b.) were reduced to final moisture content of 5.88%, 5.98% and 4.76% (d.b.) in 480, 360 and 300 min at 45℃, 55℃ and 65℃, respectively.

3.1.4 Fluidized bed drying

It was found from the Figures 10, 11 and 12 that the fluidized bed drying took less time in the blanched and un-blanched samples at the temperatures of 45℃, 55℃ and 65℃ in comparison to hot air tray, solar and vacuum drying. This was due to the effect of increase in the total surface area contact to the air. It was also observed that the moisture reduction was more in the blanched leaves than the un-blanched leaves drying for all the temperatures. The effect on drying time was found more prominent with blanched than the un-blanched samples at 45℃ and 55℃. However, at higher drying air temperature of 65℃, the effect of blanching on drying time was comparatively less. It was also observed that moisture reduction was rapid initially, which decreased with time in later part of drying for both blanched and un-blanched samples to all the temperatures.

The effect of drying air temperature on drying behavior of basil leaves for blanched and un-blanched samples indicate that as inlet temperature increased, the rate of moisture reduction also increased. It was observed that the effect of temperature was found more prominent for blanched basil leaves in case of fluidized bed drying. The initial moisture content 476.27%, 473.03%, and 473.03% (d.b.) were reduced to final moisture content of 5.46%, 4.87% and 4.87% (d.b.) in 120, 75, and 60 min at 45 ℃, 55 ℃ and 65 ℃ respectively. In the case of un-blanched samples, the initial moisture 437.63%, 426.32% and 449.45% (d.b.) were reduced to final moisture content of 5.74%, 5.26% and 4.37% (d.b.) in 240, 135 and 75 min at 45 ℃, 55 ℃ and 65 ℃, respectively.

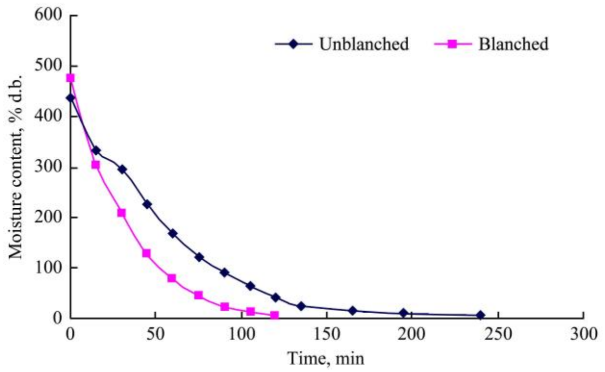


Figure 10 Variation in moisture content of basil leaves with drying time for fluidized bed drying at 45 ℃

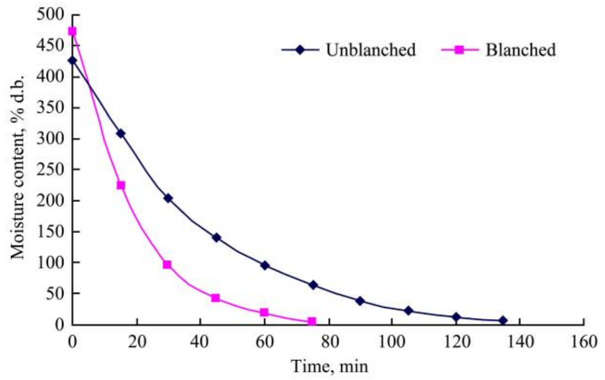


Figure 11 Variation in moisture content of basil leaves with drying time for fluidized bed drying at 55 ℃

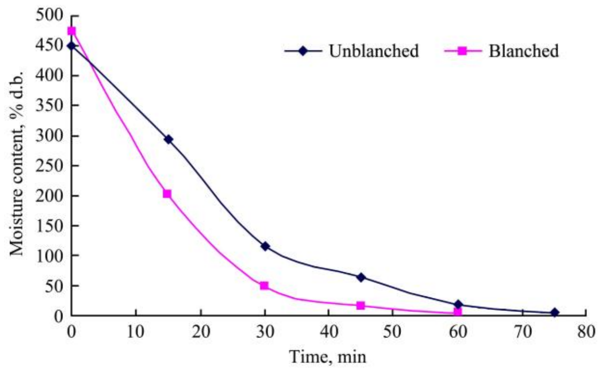


Figure 12 Variation in moisture content of basil leaves with drying time for fluidized bed drying at 65 ℃

4 Conclusions

The investigation on drying of basil leaves was carried out to develop dried basil leaves / powder so as to enhance the availability of basil leaves/powder in lean period. Basil leaves were steam blanched for 30 seconds for pretreatment. The blanched and unblanched samples of 100 g weight were loaded in the various dryers viz. hot air tray dyer, solar dryer, vacuum dryer and in the wire basket in the fluidized bed dryer at constant air velocity at 2 m s^{-1} at 45 ℃, 55 ℃ and 65 ℃. On the basis of experimental results and data analysis the following conclusions are drawn given as follows:

1) Total drying time considerably reduced with the increase in drying air temperature from 45 ℃ to 65 ℃.

2) Blanched sample took less time for drying compared to unblanched samples in each dryer at every temperature from 45 ℃, 55 ℃ and 65 ℃.

3) Fluidized bed dryer had taken less time to dry the basil leaves at each temperature than all other dryers. It was observed that for 45 ℃, the initial moisture content 437.63% (d.b.) was reduced to 5.74% (d.b.) in 240 min and initial moisture content 476.27% (d.b.) reduced to 5.46% (d.b.) in 120 min for unblanched and blanched basil samples, respectively, whereas for temperature 55 ℃, the initial moisture content 426.32% (d.b.) was reduced to final moisture content to 5.26% (d.b.) in 135 min and initial moisture content 473.03% (d.b.) reduced to 4.87% (d.b.) in 75 min for unblanched and blanched on drying behavior of basil leaves. The effect of temperature was found more prominent for blanched basil leaves. The initial moisture content 476.27%, 473.03%, and 473.03% (d.b.) were reduced to final moisture content of 5.46%, 4.87% and 4.87% (d.b.) in 120, 75, and 60 min for 45 ℃, 55 ℃ and 65 ℃ respectively. In the case of unblanched samples, the initial moisture 437.63%, 426.32% and 449.45% (d.b.) were reduced to final moisture content of 5.74%, 5.26% and 4.37% (d.b.) in 240, 135 and 75 min for 45 ℃, 55 ℃ and 65 ℃ temperatures, respectively.

Looking into the growing demands as well as the markets of medicinal and aromatics plants, there exists vast scope to commercialize the drying operations and its futuristic interventions where by utilizing the smart means of engineering and sciences, the draying operations could be further refined and standardized at micro scales.

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