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Fluidized Bed Drying of Beetroots and Determination of Effect on Drying Parameters

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ABSTRACT

As we know the drying is very effective unit operation for food preservation. It also overcome the drawback of natural drying in terms of drying time, temperature and qualities of the final products. Experiments were conducted to study the effect of drying time on moisture content of beetroots in fluidized bed drying system. The drying parameters likewise inlet air temperature, inlet air velocity and outlet air humidity were observed. Drying of beetroots was carried out in a fluidized bed drying at 60 ºC, 67.50 ºC and 75 ºC temperature.

Key words: *Drying, Moisture content, Fluidized bed drying, Beetroot and Effect on drying time.*

INTRODUCTION

Beetroot (*Beta vulgaris L.*) is crop belonging to the Chenopodiaceae family having, bright crimson color. It is famous for its juice value and medicinal properties; and known by several common names like beet, chard, spinach beet, sea beet, garden beet, white beet and *Chukander* (in hindi). Beetroot gives the best value from June to November, and for storing, the beetroot leaves should be cut 50 mm above the root. They will keep for 4-5 days when refrigerated in the vegetable crisper[4].

Drying or dehydration is, by definition, the heat and mass transfer process for removal of water by application of heat, from a solid or liquid food, with the purpose of obtaining a solid product sufficiently low in water content[7]. Drying is the oldest method of preserving food. Compared with other methods, drying is quite simple. Dried foods keep well because the moisture content is so low that spoilage organisms cannot grow. Drying will never replace canning and freezing because these methods do a better job of retaining the taste, appearance, and nutritive value of fresh food. But drying is an excellent way to preserve foods that can add variety to meals and provide delicious & nutritious food. One of the biggest advantages of dried foods is that they take much less storage space than canned or frozen foods. Although solar drying is a popular and very inexpensive method.

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Dependable solar dehydration of foods requires 3 to 5 consecutive days when the temperature is 95 ºF (35 ºC) and the humidity is very low hence solar drying is thus not feasible (www.aces.uiuc.edu). Fluidized bed dryer are found throughout all industries, from heavy mining through food, fine chemicals and pharmaceuticals. They provide an effective method of drying relatively free flowing particles with a reasonable narrow particles size distribution. The feed may take the form of powders, granules, crystals, seed, pre-forms and non-friable agglomerates[4].

In, fluidized bed drying process, the drying completed mostly in falling rate period that can be subdivided into unsaturated surface drying region and internal movement of moisture-control region. The research conducted to determine the effect of various drying parameters during fluidized bed drying of beetroot[5].

Fluidized bed drying has been recognized as a smooth, uniform drying method, capable of lowering down to very low residual moisture content with a high degree of efficiency[1]. This process is characterized by high moisture and heat transfer rates and excellent thermal control capacity compared with conventional drying processes[12,3]. It is also a very convenient method especially for heat sensitive food materials as it prevents them from overheating due to mixing[2].

The present study was carried out with the objective to determine the effect of drying time on moisture content during fluidized bed drying of beetroot.

MATERIAL AND METHODS

Materials

The fresh beetroot vegetables were procured from local market. The beetroot vegetables were washed and graded manually to select good quality vegetables, free from blemishes, injuries, of optimum maturity. The beetroot vegetables were sliced into size (LxWxT) was 7 mm x 7 mm x 1 mm respectively. After slicing and cutting, for each experiment, 500 g accurately weighed samples were taken in fluidized bed drying chamber; then the drying chambers were placed in dryer for drying at the selected value of temperature and velocity combinations. After drying, dried samples were packed in LDPE pouches.

Methods

Experiments were carried out to study the effect of drying time on moisture content during fluidized bed drying of beetroot (*Beta vulgaris L.*) pieces in an experimental fluidized bed drying (FBD) system. A batch type fluidized bed dryer was used for this purpose. The entire experimental studies were conducted in the Department of Post Harvest Engineering and Technology, Faculty of Agricultural Sciences, A.M.U. Aligarh. Details of experimental design, experimental setup and procedure are reported in following sections -

Experimental plan

Beetroot are cleaned, washed, peeled and sliced. Then FBD system was used for drying of beetroot. The entire experimental studies were conducted in the laboratories of A.M.U. Aligarh where well-established facilities are available. The equipments and instruments available in the department e.g. fluidized bed dryer, electronic weighing balance, data logger, digital temperature meter, hot air oven, Anemometer, knife, desiccator, heat sealer, beetroot slicer and beetroot dresser were used. Experimental variables/ parameters and their levels and description are given in following –

Fig. 1: Fluidized bed drying system[7]

Table 1: Details of variables / parameters and their levels and description

S. No.	Variables/parameters	Level	Description
1	Independent dryer parameters • Inlet air temperature. • Inlet air velocity.	 3 3	 60, 67.50 and 75 ºC 9, 10.5 and 12 m/s
2	Measuring parameters	3	Outlet air temperature. Humidity of outlet air. Sample weight in every 5 min interval.

Experimental set up

Fluidized bed dryer

This is a dryer in which moisture removal takes place by fluidization of solids with hot air. This setup fitted with specially designed vertical polycarbonate glass column. The lower conical portion of the column is fitted with fluidizing material. The materials are supported on the screen mesh held between two flanges. Air from a compressor is heated in the heater box and passed through the column. Flow control and by pass valve are fitted to regulate the airflow.

Specifications

Utilities required : Electricity supply; 1 phase, 220 volt AC, 3 kW
Free flow solids (beetroot particles)
Technical details :
Column : Polycarbonate glass
Dia. 80 mm, Total length 500 mm with one end conical
Air supply : Compatible system (9 m/s, 10.50 m/s & 12 m/s)
Heating chamber : Compatible capacity fitted with nichrome wire heater
Temperature controller: 0-300 ºC
Inlet temperature range: 40-120 °C
Outlet temperature range: 40-120 °C
Timer : 0-60 min
Capacity : 350-1500 g
Drying chamber specifications
Top dia. : 20 cm
Total height : 34.5 cm (14 + 20.5 from top)
Angle of taperness from bottom = 45°

Determination of experimental parameters

Initial moisture content

Initial moisture content of beetroot was determined by hot air oven method as recommended by Ranganna[11]. A brief description of method is presented below:-

Procedure

Moisture content of beetroot was determined by hot air oven method. 5 g each of samples were weighed in lower flat-bottom petridishes. These petridishes containing the samples were placed into hot air oven and maintained the temperature of oven at 60-80 ºC. The cover was removed before placing into hot air oven. After 6-8 hrs, petridishes were taken out from the oven, covered with its lid and put into desiccator. The Petridishes were cooled and weighed. Moisture content of samples was determined using following formula:

$$\text{Moisture content (\%, db)} = \frac{\text{Loss in weight of samples}}{\text{Final (bone dry) weight of samples}} \times 100$$

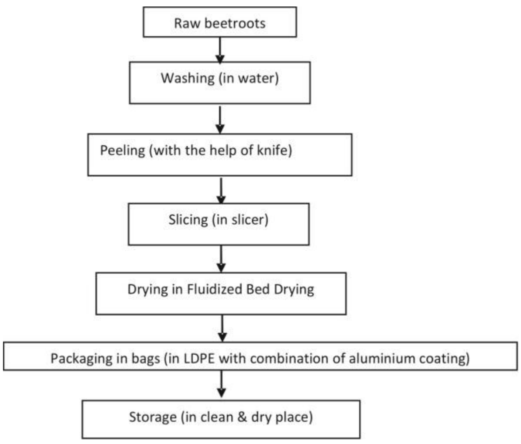

Fig. 2: Process flow chart for dying beets in fluidized bed dryer[8]

RESULTS AND DISCUSSION

The initial moisture content of the beetroots was 483.772-654.717 (%, db). At 60 °C air temperature and air velocity of 9 m/s, the moisture content of beetroots was reduced to 5.663 % (db) at the end of 105 minutes drying, but at the same temperature when air velocities were 10.50 m/s and 12 m/s, the moisture content values were 5.332 and 4.151 % (db) at the end of 95 minutes in both sample.

At 67.50 °C drying air temperature and air velocity of 9 m/s, the moisture content of beetroots was reduced to 5.485 % (db) at the end of 90 minutes drying but at the same temperature when air velocities were 10.50 m/s and 12 m/s, the moisture content values were 5.133 and 3.75 % (db) at the end of 95 minutes for both samples.

At 75 °C for air velocity 9 m/s, the moisture content of beetroot was reduced to 5.417 % (db) at the end of 80 min drying and at the same temperature when air velocities were 10.50 m/s and 12 m/s, the moisture content values were respectively 4.618 and 3.517 % (db) at the end of 80 and 95 min drying.

Thus at 12 m/s air velocity the equilibrium moisture content was the least as compared to those at other air velocities and at same temperature. The Fig 3 to 5 shows the plots between moisture content and drying time at all air temperatures and air velocities combinations. At initial stage of drying (up to 40-50 min) the moisture content of sample decreased rapidly with increase in drying time. Thereafter, the moisture content of samples decreased slowly with increase in drying time and attained final equilibrium moisture content. This may be due to the partial vapor-pressure of moisture present in sample initially being more in comparison to that of the external environment (surrounding of the sample). At the initial stage of drying moisture starts migrating rapidly from the sample to the external environment because of higher partial vapor pressure difference between sample and environment. As a result, the partial vapor pressure difference between the product and environment decreases rapidly, which leads to slower removal of moisture from the product and becomes constant at the end of drying.

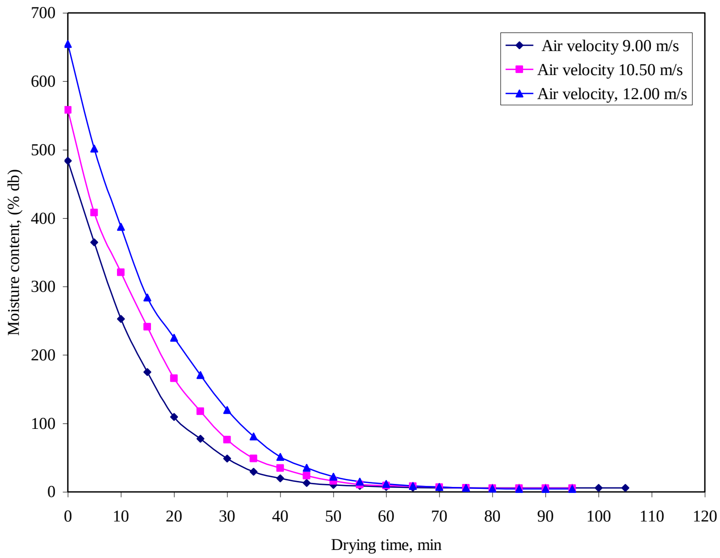

Fig. 3: Effect of air velocity on moisture content of beetroots during drying at inlet air temperature 60 ºC during FBD

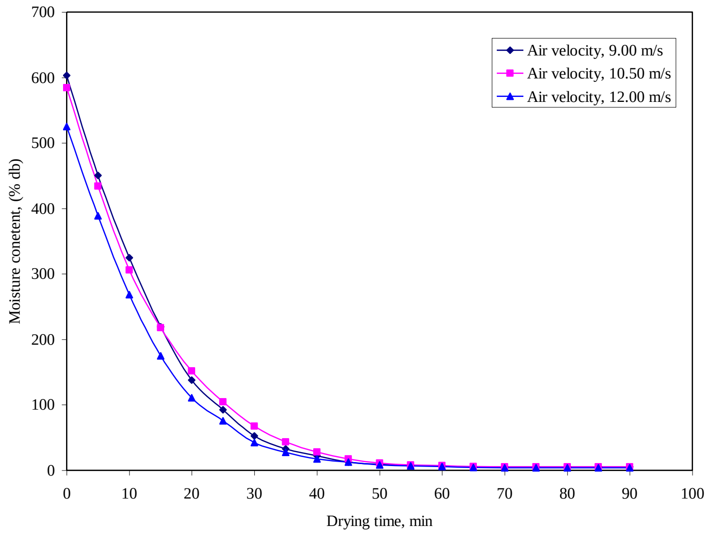

Fig. 4: Effect of air velocity on moisture content of beetroots during drying at inlet air temperature 67.50 ºC during FBD

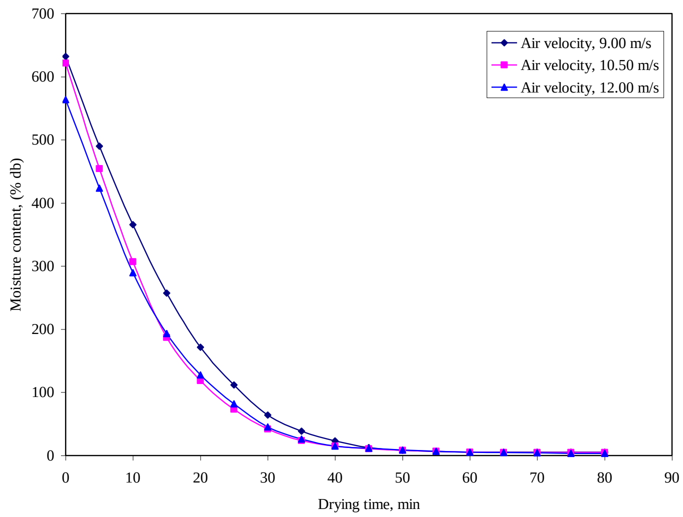

Fig. 5: Effect of air velocity on moisture content of beetroots during drying at inlet air temperature 75 ºC during FBD

The equilibrium moisture content values were higher for sample dried at 60 °C as compared to those dried at 67.50 and 75 °C. For the same temperature, if air velocity will increase then drying rate will increase as perKumar *et al*.[6]. In that case faster drying rate will reduce the drying time.

CONCLUSION

The experiments were conducted to study the effect of drying time on moisture content during fluidized bed drying of beetroot (*Beta vulgaris L.*) pieces in fluidized bed drying. The results obtained from these drying system was compared in different inlet air temperature levels selected were 60, 67.50 and 75 °C and inlet air velocity levels were 9, 10.50, 12 m/s.

The experiment results could be concluded as follows –The final moisture content in elevated temperature (75 ºC) and air velocity (12 m/s) combination found lower 3.517 (%, db) as compared lower temperature (60 ºC) and air velocity (9 m/s) combination 4.151 % (db); The data are useful in design and development of dryer and improvement in processing techniques of beetroot.

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