Drying Characteristics of Banana Powder

Publication History
Received: 10 November 2015
Accepted: 24 December 2015
Published: 1 January 2016

Citation
Nimesh Chauhan, Jethva KR. Drying Characteristics of Banana Powder. Indian Journal of Science, 2016, 23(77), 75-88
Drying Characteristics of Banana Powder

Nimesh Chauhan¹  K. R. Jethva²

¹ Ex. Student, College of Agricultural Engg. & Tech., AAU, Godhra-389001, Gujarat, India.
² Assistant Professor, Department of Processing & Food Engineering, College of Agricultural Engg. & Tech., AAU, Dahod Raod, Dholakuva, Godhra-389001, Gujarat, India. E-mail: kamaljethva@gmail.com, Mobile: 09408582415

ABSTRACT

Banana is one of the most consumed fruits in tropical and subtropical regions of Southeast Asia, belongs to family Musaceae and class Liliopsida. Banana is the fourth largest fruit crop of the world. India is the largest producer of banana and ranks first in the banana production in the world during the year 2012-13. The total world production of banana is 10.53 million tons in the year 2012-13, and having market value equivalent to 55,000 crores. The Gujarat account for 17.10 % of banana fruits produced in India and ranks second in the production of banana fruit after Tamil Nadu in 2012-13.

The weight of selected banana fruits ranged between 98 to 120 gm. The maximum and minimum diameter of banana fruits ranged from 35.00 to 41.00 mm and 31.00 to 35.00 mm. The pulp to peel ratio for banana fruits was ranges from 1.27 to 1.43. Carbohydrate content of dehydrate the banana powder after dehydration in Tray dryer with perforated plates possessed significantly higher amount (78%) at 80°C temperature for 7mm slices. The fat content was highest in the Tray dryer with solid plates at 80°C temp. for 7mm Slices. Ash content of the eighteen samples was in the range of 4.1 to 5.12 %.The ash content was highest in the oven at 80°C for 7mm slices and tray dried at 75°C for 7mm slices samples. The 7-mm slices dried at 75 °C in Multi-purpose tray dryer have obtained the highest sensory score within the experimental range of different dryers. It can be concluded from the study that multi-purpose tray dryer best suitable for drying of banana slices to get good quality powder.

Keywords: Drying, Dehydration, Banana, Dryers

INTRODUCTION

Banana is one of the most consumed fruits in tropical and subtropical regions of Southeast Asia, belongs to family Musaceae and class Liliopsida. Banana is the fourth largest fruit crop of the world. India is the largest producer of banana and ranks first in the banana production in the world during the year 2012-13 (Deshmukh et al., 2013). The total world production of banana is 10.53 million tons in the year 2012-13, and having market value equivalent to 55,000 crores. The four leading Banana exporting countries i.e., Ecuador, Costa Rica, Guatemala, and Colombia account 84 % of international trading. The wastage of banana was estimated to be 12 to 14 percent, equivalent to ₹ 7,500 crores.

The Gujarat account for 17.10 % of banana fruits produced in India, and ranks second in the production of banana fruit after Tamil Nadu in 2012-13 (Anon., 2014). In Gujarat, the area under banana cultivation was about 551.7 metric hectares and produced about 4.52 million tons of bananas during the year 2012-13 (Anon., 2014). The wide variety of banana fruits grown is the main reason for this first position of India in production of banana in the world. Though India
is the largest producer of banana, but the processing of banana is less than 2% and the post harvest losses of banana are estimated to be more than 25%. As banana is available throughout the year in tropical countries, like India, there is a vast need to utilize for proper processing techniques. It could be processed into different value added products like powder, chips, wine and fig etc. Normally bananas contain significantly higher amount of potassium, i.e., 400 mg/100 g pulp and trace amount of sodium, i.e., 1mg and iron (Stover and Simmonds, 1987).

Banana fruit is having high initial moisture content of about 72 to 77% (wb), there are more chances of the fruit getting spoiled or deteriorated. Also, banana is a highly perishable fruit, it has comparative short shelf life and marketing of fresh fruits to different places is very difficult. Therefore, it is necessary to convert it into value added products which retain its colour, flavour and nutrients with longer shelf life. So to increase the shelf life of banana, the fruit is converted into various processed products like powder, dried slices, pulp, juice, RTS, beverages, etc. Banana powder is used in cake, bread, cookies, baby food, ice-cream, flavoured milk, shrikhand, chocolates etc (Mhaske Ashvini, 2014).

A possible alternative solution to this problem is the storage and the transport in powder form. There are many drying techniques available to dry banana, such as tray dryer, hot air oven dryer, multi tray dryer, sun and solar drying, microwave drying, osmotic dehydration, freeze drying, and convective air drying. The process of dehydration results in changes in the quality specially the concentration of nutrients, sensory changes like color, texture and aroma. It is essential to test the quality of processed produce to ensure the utilizability for nutritional benefit.

Banana powder is prepared by different drying methods (tray drying, oven and multi-purpose tray dryer) is a very interesting alternative to recompose the fruit with practically all the properties of the natural product. Preparation of good quality banana powder by giving pretreatment of dipping in lemon solution (1:1) will retains the colour, flavour, aroma, texture and taste in the final product. Dehydration prior to hot air drying will also reduce the moisture content, drying time and energy consumption. Subsequent hot air drying will give the dried product of an excellent quality. Banana powder by different drying methods will be checked for nutrients, colour, flavour, and texture often indistinguishable from the original product.

A process for the comparative drying of banana fruit will be developed. The best operational conditions will be identified, so that high performance is achieved both in terms of operation time and quality of the dried banana powder. Finally, the dried banana powder will be packed by vacuum packaging in a flexible plastic material to extend the shelf life of the products as well as to prevent the deterioration of the product during the long term storage. In view of the above facts, the present investigation was focused on drying characteristics of banana powder in hot air oven and tray dryer and multi-purpose tray dryer at temperature range at 70, 75 & 80°C.

MATERIALS AND METHODS

Experiments were carried out in the Department of Processing and Food Engineering, College of Agricultural Engineering & Technology, Anand Agricultural University, Godhra.
Selection of Variety
There are different varieties of banana grown in Panchmahal or nearby Godhra region. Locally available variety of banana was selected for its sweet taste, whitish pulp as well as higher pulp to peel ratio.

Physical Parameters of Fresh Banana Fruit
Various physical parameters of the fresh banana fruit such as fruit weight, maximum and minimum diameter of fruit with and without peel, length, skin thickness, puncture operation, and pulp to peel ratio were recorded.

Experimental Parameter
Raw material
Ripe banana fruits and lemon were procured from the Godhra local fruit market and taken for the preparation of banana powder in the experimental laboratory of APE department of CAET, Godhra. The freshly collected banana fruits and lemon were washed, peeled, cut and sliced, dipped, soaking and then kept for drying processes.

Pre-treatment Methods
Washing
The fresh banana fruits and lemon were thoroughly washed with copious quantity of tap water to remove impurities such as surface dirt, dusts or any other foreign particles.
Peeling
Fresh banana fruits were procured from wholesaler markets of Godhra city was manually peeling to remove unnecessary portion say the peel to have useful portion of fruit.
Cutting and slicing.
After proper trimming of fresh banana fruits, they were manually sliced to a 5 mm and 7mm thickness with the help of stainless steel knife and also cut the lemon for preparing a solution. Uniform thicknesses of slices were maintained by manual slicing, uneven shaped as well as non uniform slices were removed carefully.

Dipping in the solution of lemon
The slices of banana fruits were dipped in the solution of lemon and water with the proportion 1:1 for 10 mins to minimize the enzymatic browning. After proper dipping of banana slices, they were kept out and placed into the filter paper for soaking up to the 10minute.

Methods for Drying
Weight accurately 100gm of the banana slice for drying in tray dryer with perforated tray, tray dryer with solid plates and multi-purpose tray dryer.

Perforated Tray Drying
In order to remove the moisture from dehydrated banana slices, further perforated tray drying of banana slices is necessary to achieve the equilibrium moisture content. The slices of 5mm and 7mm thickness were loaded in the perforated tray dryer. The drying was carried out at i.e. 75° C air temperature. The observations of weight loss of banana slices were recorded placed in the
hot-air oven at interval of one hour. The drying was continued till the equilibrium moisture content of the slices was obtained.

**Tray drying with solid plates**

It is similar to that perforated tray drying. In this dryer the steel tray are used instead of perforated tray as like in tray dryer. In cabinet tray drying method, sample is placed into the tray dryer at 75° C for 17hours.

**Multi-Purpose Tray Drying**

Drying experiments were performed at temperatures of 70, 75 and 80 °C at constant air velocities 0.7 m/s in the multi purpose tray dryer. The thickness of the sample was about 5 to 7 mm which loaded in tray. The weight of sieve with the sample was measured with a digital balance and recorded at 1 hours interval for all temperature and velocity ranges selected for the study. For measuring the weight of the sample during experimentation, the sieve with sample was taken out of the drying chamber, weighed on the digital top pan balance and placed back into the chamber. The digital top pan balance was kept very close to the drying unit. Each process of weight measurement lasted about 8.25 ±0.25 s. The drying procedure was continued till the moisture content of the sample reduced to about 18-22%.

**Effect of Dehydration on Nutrient Composition**

Dehydration is the process of removal of moisture by the application of artificial heat under controlled conditions of temperature, humidity and air flow. Uniform quality of product can be obtained when dried under controlled conditions. Less time is required for drying in multipurpose tray dryer as compare drying in cabinet driers and microwave ovens. Pre-treatment prior to drying is essential to maintain quality and prevent spoilage during storage. The materials used and methodology employed for carrying out the investigation on effect of dehydration on nutrient qualities of banana powder like carbohydrate, Fat, Ph and moisture content.

**Packaging Material**

The dehydrated drum banana slices by various driers were grind, screened and packed in high density polypropylene pouches (250 micron), heat sealed vacuum packed and placed in normal closed area at ambient conditions.

**Organoleptic Quality Evaluation**

Sensory analysis was conducted on all samples. 15panelist were asked to assess the expanded powder for taste, aroma, color, texture and over all acceptability and to mark on Hedonic Rating Test (1-dislike extremely, 5-neither like nor dislike and 9-like extremely) in accordance with their opinion. The panelist score were compiled and checked for standard deviation and the percentage of dislike for every dryer (Kroll,1998).Every dried sample from different dryer of 25gm sample was served to the panel evaluation.
EXPERIMENTAL PROCEDURE
Drying experimental was performed at temperature of 70, 75 and 80°C. The temperature range was selected according to previous research work reported by Abano E. E. and Sam-Amoah L. K.(2011) and preliminary trials. The thickness of the sample was about 5mm and 7mm. The weight of tray with the sample was measured with a digital balance and recorded at 1 hours interval for all temperature selected for the study. For measuring the weight of the sample during experimentation, the tray with sample was taken out of the drying chamber, weighed on the digital top pan balance and placed back into the chamber. The digital top pan balance was kept very close to the drying unit. Each process of weight measurement lasted about 10s. The drying procedure was continued till the moisture content of the sample reduced to about 7- 8% (dry basis).

RESULT AND DISCUSSIONS

PHYSICAL PARAMETERS OF FRESH BANANA FRUIT

Fruit Weight
The weight of selected banana fruits ranged between 98 to 120 g. The mean value of fruit weight with their standard deviation was 111.24 ± 1.78 g.

Maximum and Minimum Diameter
The maximum and minimum diameter of banana fruits ranged from 35.00 to 41.00 mm and 31.00 to 35.00 mm, respectively for whole fruit (with peel) and the maximum and minimum diameter of banana fruits ranged from 26.00 to 31.00 mm and 21.00 to 28.00 mm (without peel). The mean values of maximum and minimum diameter of banana fruits with the standard deviation were 37.14 ± 1.47 mm and 33.19 ± 0.97 mm for whole fruit with peel and 27.99 ± 1.47 mm and 25.40 ± 0.97 mm for the fruits after peeling, respectively.

Length of banana fruits samples
It can be observed from the data that the length for small, medium and large samples varied from 113.42, 126.78 and 134.96. However, overall length of whole lot varied from 113.42 to 134.96 mm with an average value of 126.41mm.

Hardness of banana fruits
Puncture test represents hardness of the banana fruits. It can be observed the pressure from center, top and bottom portion of the banana fruits, and its varied from 4.00 to 7.8 lb, 4.0 to 10.85 lb and 4.25 to 10 lb, with an average value of 5.064, 5.32 and 6.3 lb respectively.

Pulp to peel ratio
The pulp to peel ratio for banana fruits was ranges from 1.27 to 1.43 and mean value of pulp to peel ratio with their standard deviation was 1.35 ± 0.22.
EFFECT OF DEHYDRATION ON NUTRIENT COMPOSITION

Carbohydrate Content of the dehydrated banana powder

Carbohydrate content of dehydrate banana powder as shown in the table indicate that the banana powder after dehydration in oven dryer possessed significantly higher amount (78%) at 80°C temperature for 7mm slices samples ,as compared to other, it was about more than fresh banana fruits. The carbohydrate content was highest amount (75%) in tray dryer at70 °C for 5mm slices and multi-purpose tray dryer (68%) at 75°C for5mm slices.

<table>
<thead>
<tr>
<th>Carbohydrate in fresh banana(gm)</th>
<th>Tray dryer with perforated plates</th>
<th>Tray dryer with solid plates</th>
<th>Multi-purpose tray dryer</th>
</tr>
</thead>
<tbody>
<tr>
<td>27.2</td>
<td>78</td>
<td>75</td>
<td>68</td>
</tr>
</tbody>
</table>

Fat Content of the dehydrated banana powder

Fat content of the twenty two samples was in the range of 1.6 to 12 %.The fat content was highest in the, and Tray dryer with solid plates at 80°C, 65°C & 75°C,andtemperature for 7mm,7mm,5mm slices samples respectively. The fresh sample of banana fruits contains 1.2 gm per 100gm of the fat. This tray dryer sample was the least one the fat content was about 2.5 times more than in fresh banana fruits.

<table>
<thead>
<tr>
<th>Fat in fresh banana(gm)</th>
<th>Tray dryer with perforated plates</th>
<th>Tray dryer with solid plates</th>
<th>Multi-purpose tray dryer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2</td>
<td>5.6</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>

Ash Content of the dehydrated banana powder

Ash content of the twenty two samples was in the range of 2.5 to 5.12 %.The ash content was highest in the oven at 80°C for 7mm slices and tray dried at 75°C for 7mm slices samples. In multi-purpose tray dried sample highest amount of ash at 75°C for 7mm slices samples. The fresh sample of banana fruits contains 2.5gm per 100gm of the ash. Multi-purpose tray dryer sample was the least one the ash content was about 50% more than in fresh banana fruits.
Table 3: Ash composition of dehydrated banana powder (per 100gm powder)
(All the parameters are in %)

<table>
<thead>
<tr>
<th>Ash in fresh banana(gm)</th>
<th>Tray dryer with perforated plates</th>
<th>Tray dryer with solid plates</th>
<th>Multi-purpose tray dryer</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5</td>
<td>5.12</td>
<td>5.12</td>
<td>5</td>
</tr>
</tbody>
</table>

pH Content of the dehydrated banana powder

pH content of the twenty two samples was in the range of 4.4 to 4.7 %. The pH content was highest in the multi-purpose tray dried samples at 75°C for 7mm slices and in oven and tray dried sample at 80°C and 75°C temperature for 7mm and 7mm slices respectively. The fresh banana fruits samples recorded 4.9 pH.

Table 4: pH of dehydrated banana powder

<table>
<thead>
<tr>
<th>pH in fresh banana</th>
<th>Tray dryer with perforated plates</th>
<th>Tray dryer with solid plates</th>
<th>Multi-purpose tray dryer</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.9</td>
<td>4.4</td>
<td>4.5</td>
<td>4.7</td>
</tr>
</tbody>
</table>

Moisture Content of the dehydrated banana powder

Moisture content of the twenty two samples was in the range of 70-80.95 %. Maximum moisture content was in oven, tray, and multipurpose tray dryer at temperature 80°C, 80°C & 80°C for 7mm, 5mm & 7mm slices respectively. It can be seen that the moisture was reduced to the 74-77% of banana fruits. It was observed that the fat level is increased by drying of banana slices in oven dryer rather than in other dryers, whereas carbohydrate level was increased by drying in oven dryer. The removal of moisture was best in the multi-purpose tray dryer.

SENSORY EVALUATION

It was observed from the fig. that the slices dried in Multi-purpose tray dryer have obtained the highest sensory score within the experimental range of different dryers. This may be due to the different drying capabilities of dryers.

Table 5: Overall Evaluation of Banana Powder

<table>
<thead>
<tr>
<th>Qualities</th>
<th>Tray dryer with perforated plates</th>
<th>Tray dryer with solid plates</th>
<th>Multi-purpose tray drying</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taste</td>
<td>6.36</td>
<td>7.00</td>
<td>8.18</td>
</tr>
<tr>
<td>Color</td>
<td>5.83</td>
<td>6.58</td>
<td>8.33</td>
</tr>
<tr>
<td>Aroma</td>
<td>7.00</td>
<td>7.00</td>
<td>7.82</td>
</tr>
<tr>
<td>Texture</td>
<td>7.17</td>
<td>7.17</td>
<td>7.83</td>
</tr>
<tr>
<td>Overall acceptability</td>
<td>6.59</td>
<td>6.93</td>
<td>8.04</td>
</tr>
</tbody>
</table>
Drying rate of banana slices dried with different dryers

Drying rate indicated the extent of removal of moisture periodically from the fruits. When the slices dried in multi-purpose tray dryer, the removal of moisture was maximum in first 1 hour of exposure which reduced to a constant weight by 8 hour 30 minute for 5mm banana slices and 9 hour for 7mm slices at 70°C temperature in multi tray dryer. Whereas the drying time taken by tray was 23 hour for 7mm slices and 20 hour for 5mm slices, and in oven dryer 22 hour for 7mm slices and 20 hour for 5mm slices. The other three temperature data (at 65, 75 & 80°C) are shown in table below:

**Table 6: Drying Rate of banana slices at 70°C, 75°C & 80°C in Tray dryer with perforated plates, Tray dryer with solid plates and Multi-purpose tray dryer**

<table>
<thead>
<tr>
<th>Name of dryer</th>
<th>Temperature(°C)</th>
<th>Drying time(5mm)</th>
<th>Drying time(7mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tray dryer with perforated plates</td>
<td>70</td>
<td>20</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>75</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>80</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>Tray dryer with solid plates</td>
<td>70</td>
<td>20</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>75</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>80</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>Multi-purpose tray dryer</td>
<td>70</td>
<td>11</td>
<td>12</td>
</tr>
</tbody>
</table>
Variation of Moisture Content with Time

The banana slices dried at temperature of 65, 70, 75 & 80°C in the Tray dryer with solid plates, Tray dryer with perforated plates and multipurpose tray dryer with thickness of about 5mm to 7mm. The initial M.C of banana slices was 82.2 % (w.b). In drying experiment, the moisture content of banana slice reduced with the drying duration due to conversion of slices water in vapor through increase in the energy. The M.C variation with drying time for banana slice is presented graphically below;

Fig. 2: Variation of M.C(Kg water/Kg dry matter) with Respect to Drying Time in Banana slices (5mm) in tray dryer with perforated plates

Fig. 3: Variation of M.C (Kg water/Kg dry matter) with Respect to Drying Time in Banana slices (7mm) in tray dryer with perforated plates

Fig. 4: Variation of M.C. (Kg water/Kg dry matter) with Respect to Drying Time in Banana slices (5mm) in tray dryer with solids plates.

Fig. 5: Variation of M.C. (Kg water/Kg dry matter) with Respect to Drying Time in Banana slices (7mm) in tray dryer with solids plates.
It can be observed from the data that the drying time to reach the equilibrium moisture content for the 5mm & 7mm banana slices varied from 20, 25, 20, 22, 17, 17 & 12, 12 hour in oven dryer at temperature of 65, 70, 75 & 80 °C respectively. Similarly the other eight temperature data are shown in table. Fig. 2 & 3 shows that the moisture content dropped faster in the starting, whereas it become slow in the last phase at all the temperatures considered in the study. It was also observed that within a certain temperature range (75-80 °C), increasing drying temperature speeds up the drying process, thus shortening the drying time. Similar findings have been reported for fruit and vegetable products drying (Kumar et al., 2012; Fenton and Kennedy, 1998; Ramaswamy and Nieuwenhuijzen, 2002; Wang and Chao, 2002; Dhobi and Chothani, 2012).

**Variation of Moisture Ratio with Time**

The curves in Fig. 4 & 5 indicate that moisture ratio decreases continuously as the drying progresses. It took 3 to 4 hour to remove the first half moisture from 5mm and 7mm banana slices at 65, 70, 75 & 80 °C in Oven dryer. The time required to reduce first half moisture was 30 & 50 % of total time in banana slices. The same condition was observed for drying of banana slices in tray dryer and multi-purpose tray dryer. They taken 3 hour and 2 hour respectively, to remove the first half moisture (moisture ratio = 0.5) at 65, 70, 75 & 80 °C, which shows the 18-15% and 18-30 % of total time was in banana slices.
Fig. 8: Variation of Moisture Ratio (M/Mo) with Respect to Drying Time in (5mm) Banana slices in tray dryer with perforated plates

Fig. 9: Variation of Moisture Ratio (M/Mo) with Respect to Drying Time in (7mm) Banana slices in tray dryer with perforated plates

Fig. 10: Variation of Moisture Ratio (M/Mo) with Respect to Drying Time in (5mm) Banana slices in tray dryer with solids plates

Fig. 11: Variation of Moisture Ratio (M/Mo) with Respect to Drying Time in (7mm) Banana slices in tray dryer with solid plates

Fig. 12: Variation of Moisture Ratio (M/Mo) with Respect to Drying Time in (5mm) Banana slices in Multi-purpose Tray Dryer

Fig. 13: Variation of Moisture Ratio (M/Mo) with Respect to Drying Time in (7mm) Banana slices in Multi-purpose Tray Dryer
CONCLUSIONS

The weight of selected banana fruits ranged between 98 to 120 gm and the mean value of fruit weight was 111.24 gm. The maximum and minimum diameter of banana fruits ranged from 35.00 to 41.00 mm and 31.00 to 35.00 mm, and the mean values of maximum and minimum diameter of banana fruits were 37.14 mm and 33.19 mm for whole fruit with peel and 27.99 mm and 25.40 for the fruits after peeling. It can be observed the pressure at center top and bottom portion of the banana fruits were varied from 4.00 to 7.8lb, 4.0 to 10.85lb and 4.25 to 10lb, with an average value of 5.06, 5.32 and 6.3 respectively. The pulp to peel ratio for banana fruits was ranges from 1.27 to 1.43. The mean value of pulp to peel ratio was found 1.35.

Carbohydrate content of dehydrated banana powder in Tray dryer with perforated plates possessed significantly higher amount (78%) at 80˚C temperature for 7mm. The fat content was highest in the Tray dryer with solid plates at 80˚C temp. for 7mm slice thickness. Ash content of the twenty two samples was in the range of 4.1 to 5.12 %. The ash content was highest in the oven at 80˚C for 7mm slices and tray dried at 75˚C for 7mm slices samples. The 7-mm slices dried at 75 ˚C in Multi-purpose tray dryer have obtained the highest sensory score within the experimental range of different dryers. It can be concluded from the study that multi-purpose tray dryer suits the best for drying the banana slices among the three dryer.

REFERENCES


