International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2018; 6(1): 1435-1437

Received: 25-11-2017
Accepted: 26-12-2017

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# Effect of drying temperature and slice size on physical properties of dried okra

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**Abstract**
An experiment was conducted to see the effect of drying temperature and slice size on physical properties of drying okra was conducted at Department of Plant Breeding and Genetics, K.N.K College of Horticulture Mandsaur, RVSKVV Gwalior during March 2008 to last May 2008. The maximum bulk density (0.23g/ml) was found in combination of 50 ºC and 1 cm slice size whereas, minimum true density (0.31g/ml) was found under 60 ºC and 2 cm slice size. The minimum shrinkage ratio of dried okra (0.17) was found under 70 ºC and 1 cm slice size. The maximum rehydration ratio (6.75) was found under 50 ºC and 1 cm slice size.

**Keywords:** Bulk density, true density, shrinkage ratio, rehydration ratio, okra

## 1. Introduction
Okra (*Abelmoschus esculentus* L.) is an annual herb, belongs to the family Malvaceae. Okra is an important constituent of Indian food/curries. The demand of okra is very high so that it is very important for us. The price of okra is also very sensitive issue. At the same time due to poor post-harvest handling of okra losses are about 20-40%. Moreover, the processing of okra is very limited. Okra tender pods are used as vegetable and are eaten boiled or in the forms of sliced and fried pieces. It is also used as snacks and it is excellent thickener for gravies and soups because of their high mucilage content. Some time they are sliced and sun dried for off-season use. Dried slice are reported to be produced in Turkey on a large scale (Anon, 1951) [1]. It is a good source of vitamins A and B, protein, calcium, potassium and other mineral matters. It is also excellent source of iodine and useful for the treatment of goiter. Eating fresh raw okra fruits empty stomach every morning nourishes the body and increases the semen content. The powdered root of okra is given with sugar for leucorrhoea backache. Okra acts as a tonic for both man and woman and enables them to increase their vitality and vigour. The post-harvest handling of okra through drying i.e. partial removal of water to enhance their keeping quality has been practiced other than sun drying technique. All drying technologies require large amount of energy for removal of water from vegetables and are less energy efficient. Okra also contain large amount of water, which needs to be removed by drying. A need was felt to process the local okra cultivar through low cost drying technology in the form of slices to help reduce the post-harvest losses of okra as well as to increase off-season use.

## 2. Material and Methods
The present investigation was carried out at Department of Plant Breeding and Genetics, K.N.K., College of Horticulture, Mandsaur, R.V.S.K.V.V. Gwalior during March 2008 to last May 2008. The experimental material is okra *cv.* Mahyco-10 used in this study was collected from a local farmer Mr. Modi Ram Patidar in Mandsaur (M.P.). The experiment laid out into sixteen treatment combinations which consisted four treatments of drying temperature *i.e.* 50, 60, 70, and 80 ºC and four slice size *i.e.* 1, 2, 3, and 4 cm were replicated two times in a factorial complete randomized design. Tails and butts of the cleaned pods were removed by a stainless steel knife. Okra samples were cut in to different slice sizes of 1 cm, 2 cm, 3 cm and 4 cm by using cut and chop board. For getting desired size of slices markings were made on the cut and chop board and the samples were fixed to the board with the help of wooden sticks. Samples were blanched in NaCl solution (0.5%) at 95 $^0$C for 5 min. The blanched samples were immediately cooled by immersing in cold water. Then blanched samples were spread on a stainless steel sieves to drain excess water (Shivhare *et al*., 2000) [8]. Drying time was noted down by calculating the total time taken in drying with the help of a digital clock.

### 2.1 Bulk density (g/ml)
Bulk density used to specify the quality of product, was measured by pouring a known mass of the sample into a 1000 ml cylinder and reading the volume after gently tapping the cylinder twice (Shivhare *et al*., 2000) [8]. The bulk density may be expressed as below:

$$\text{Bulk density (g/ml)} = \frac{M}{V}$$

Where, M = Mass of sample, g
V = Volume of the sample, ml

### 2.2 True density (g/ml)
True density is an important factor for heat and mass transfer analysis through products. For determination of true density, known volume of water was taken in a measuring cylinder of 1000 ml capacity. The samples were dipped in the water containing measuring cylinder. The rise in the level of water is noted and true density is obtained by dividing the mass of the sample by increase in the water volume.

$$\text{True density (g/ml)} = \frac{M}{V_2 - V_1}$$

Where, M = Mass of sample, g
$V_1$= Volume of water after dipping the sample, ml
$V_2$= Volume of water before dipping the sample, ml

### 2.3 Shrinkage ratio (%)
Shrinkage ratio is specify the quality of okra was measured by pouring a know volume of the sample into 500 ml cylinder and reading the volume after gently tapping the cylinder twice (Ranganna *et al.*, 1986) [7]. Shrinkage ratio of any material may be expressed as below:

$$\text{Shrinkage ratio (\%)} = \frac{V_d}{V_f}$$

Where, $V_d$ = Volume of dried sample, ml
$V_f$ = Volume of fresh sample, ml

### 2.4 Rehydration ratio (%)
Rehydration ratio was obtained by dividing mass of the rehydrated sample by mass of the dried sample. Rehydration of the dried sample was carried out by adding 80 ml distilled water to 5 g dried okra slices contained in a 500 ml beaker. The beaker was covered with aluminum plate and the contents were brought to boiling point within 3 min. and the boiling was continued for 10 min (Shivhare *et al*., 2000) [8]. Excess water was removed by placing the sample on a stainless steel sieve and mass of the rehydrated sample was determined.

## 3. Results and Discussion
### 3.1 Bulk density
The results of bulk density for dried okra at different temperature and slice size are presented in Table 1 which shows that the maximum bulk density (0.23g/ml) were observed under drying temperature 50 ºC and 1 cm slice size. This is due to the fact that bulk density decreases at low moisture content. These changes could be due to the structural properties of the produce. Similar results have been reported during the air-drying of carrot, potato and fresh apple by (Zogzas *et al*., 1994) [10].

### 3.2 True density
The results of true density for dried okra at different temperature and slice size are presented in Table 2. It shows that lowest true density (0.31g/ml) was recorded under 60 ºC drying temperature and 2 cm slice size whereas, highest (0.40 g/ml) was found at 50 ºC and 1 cm slice size. True density and moisture content relationship is a linear function which shows that the true density decreases linearly with the increase in moisture content. Similar results have been suggested by (Pandey, 1998) [6].

### 3.3 Shrinkage ratio
The results of the shrinkage ratio for dried okra at different temperature and slice size are presented in Table 3. Minimum shrinkage ratio (0.17) is observed under 70 ºC and 1 cm slice size and maximum in 1 cm slice size drying at 50 ºC and 60 ºC temperature. Shrinkage is not linearly depending on the moisture reduction. Similar results have been reported by (Boyce, 1966) [4], (Nellist, 1974) [5] and (Spencer, 1972) [9]. When a produce is dried very high moisture content to very low moisture content, the shrinkage is not linear function of moisture reduction, but the rate of shrinkage decreases with the increase in moisture reduction. Similar results have been reported in malt by (Bala, 1983) [3].

### 3.4 Rehydration ratio
Values of rehydration ratio for dried okra at different temperature and slice size are presented in Table 4. Maximum rehydration (6.75) was found in combination of drying temperature 50 ºC and slice size 1 cm and minimum (4.16) at 50 ºC with slice size 4 cm. Dried okra sliced rehydrated by hot water, the volume and mass was increased ranging from 60-65%. This is due to water absorption by dried okra slices. Similar results have been reported by (Asota, 1996) [2] in okra and tomato as 63%, 75% respectively.

**Table 1:** Effect of drying temperature and slice size on bulk density of dried okra

| Slice size (cm) | Temperature (⁰C) | | | | Mean |
|---|---|---|---|---|---|
| | **50 ⁰C ($T_1$)** | **60 ⁰C ($T_2$)** | **70 ⁰C ($T_3$)** | **80 ⁰C ($T_4$)** | |
| 1cm ($S_1$) | 0.23 | 0.17 | 0.17 | 0.22 | 0.19 |
| 2cm ($S_2$) | 0.18 | 0.16 | 0.18 | 0.21 | 0.18 |
| 3cm ($S_3$) | 0.17 | 0.20 | 0.17 | 0.19 | 0.18 |
| 4cm ($S_4$) | 0.18 | 0.21 | 0.21 | 0.18 | 0.20 |
| Mean | 0.19 | 0.18 | 0.18 | 0.20 | |
| Treatment | S.Em± | C.D. at 5% level | | | |
| T | 0.0049 | 0.01463 | | | |
| S | 0.0049 | NS | | | |
| T X S | 0.0098 | 0.02927 | | | |

**Table 2:** Effect of drying temperature and slice size on true density of dried okra

| Slice size (cm) | Temperature (⁰C) | | | | Mean |
|---|---|---|---|---|---|
| | **50 ⁰C ($T_1$)** | **60 ⁰C ($T_2$)** | **70 ⁰C ($T_3$)** | **80 ⁰C ($T_4$)** | |
| 1cm ($S_1$) | 0.40 | 0.35 | 0.34 | 0.33 | 0.36 |
| 2cm ($S_2$) | 0.33 | 0.31 | 0.36 | 0.32 | 0.33 |
| 3cm ($S_3$) | 0.33 | 0.39 | 0.35 | 0.33 | 0.35 |
| 4cm ($S_4$) | 0.34 | 0.37 | 0.37 | 0.32 | 0.34 |
| Mean | 0.35 | 0.36 | 0.36 | 0.32 | |
| Treatment | S.Em± | C.D. at 5% level | | | |
| T | 0.0087 | 0.026 | | | |
| S | 0.0087 | NS | | | |
| T X S | 0.0174 | Ns | | | |

**Table 3:** Effect of drying temperature and slice size on shrinkage ratio of dried okra

| Slice size (cm) | Temperature ($^0$C) | | | | Mean |
|---|---|---|---|---|---|
| | 50 $^0$C ($T_1$) | 60 $^0$C ($T_2$) | 70 $^0$C ($T_3$) | 80 $^0$C ($T_4$) | |
| 1cm ($S_1$) | 0.26 | 0.26 | 0.19 | 0.20 | 0.23 |
| 2cm ($S_2$) | 0.21 | 0.19 | 0.17 | 0.19 | 0.19 |
| 3cm ($S_3$) | 0.25 | 0.23 | 0.19 | 0.19 | 0.22 |
| 4cm ($S_4$) | 0.19 | 0.22 | 0.22 | 0.17 | 0.20 |
| Mean | 0.23 | 0.23 | 0.19 | 0.19 | |

| Treatment | S.Em± | C.D. at 5% level |
|---|---|---|
| T | 0.008 | 0.026 |
| S | 0.008 | 0.026 |
| T X S | 0.017 | NS |

**Table 4:** Effect of drying temperature and slice size on rehydration ratio of dried okra

| Slice size (cm) | Temperature ($^0$C) | | | | Mean |
|---|---|---|---|---|---|
| | 50 $^0$C ($T_1$) | 60 $^0$C ($T_2$) | 70 $^0$C ($T_3$) | 80 $^0$C ($T_4$) | |
| 1cm ($S_1$) | 6.75 | 6.55 | 6.39 | 6.68 | 6.59 |
| 2cm ($S_2$) | 5.87 | 6.34 | 5.05 | 5.55 | 5.70 |
| 3cm ($S_3$) | 5.07 | 6.22 | 4.61 | 5.07 | 5.24 |
| 4cm ($S_4$) | 4.16 | 4.48 | 4.55 | 4.62 | 4.95 |
| Mean | 5.46 | 5.89 | 5.15 | 5.48 | |

| Treatment | S.Em± | C.D. at 5% level |
|---|---|---|
| T | 0.109 | NS |
| S | 0.109 | 0.327 |
| T X S | 0.218 | NS |

## 4. Conclusion
On the basis of present investigation, it can be concluded that drying temperature 50 $^o$C and slice size 1 cm give maximum value for bulk density, true density, shrinkage ratio and rehydration ratio.

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