Effect of drying temperature and slice size on quality of dried okra (*Abelmoschus esculentus* (L.) Moench)

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Abstract Okra (*Abelmoschus esculentus* (L.) Moench) is an important vegetable crop of India. Dried okra pods have wide use in snacks and are in great demand for domestic as well as export market. Hence, effect of four slice sizes (1, 2, 3 and 4 cm) and four drying temperatures (50, 60, 70 and 80 °C) on quality of hot air dried okra were studied. Okra pods were dried in the form of slices cut across the length at different temperatures. Quality assessment of okra was done on the basis of protein, ascorbic acid and fibre content. Okra slice sizes and drying temperatures affected all the quality parameters significantly ($p < 0.05$). Maximum retention of protein, ascorbic acid and fibre content were found in 2 cm long slices dried at 60 °C temperature.

Keywords Okra • Drying • Protein • Ascorbic acid • Fibre

Introduction

Okra (*Abelmoschus esculentus* (L.) Moench) is an annual vegetable crop, belongs to the family Malvaceae. It occupies fifth position, next to tomato in terms of production, in India. It was cultivated over an area about 432 thousand ha with production of 4528 thousand MT and productivity 10.5 MT/ha in the year 2008–09, (Indian Horticulture Database 2009).

Tender pods of okra are mainly used as vegetable. They are also used as snacks and are sliced and sun dried for off-season use. Dried slices are reported to be produced in Turkey on large scale (Anon. 1959). Applications of modern technologies in vegetable cultivation have significantly contributed to improve vegetable production. The losses also increase cumulatively as the produce moves down the pipe line from harvesting to its consumption by the consumer. It is estimated that the total losses of vegetables in India due to inadequate post-harvest handling, transportation and storage are about 20–40% (Chadha 2005; Singh 2006). Vegetables are characterized by high metabolic activities and known to have short shelf life. About 10–15% fresh vegetables shrivel and stale, lowering their market value and consumer acceptability. Okra is a good source of carbohydrate, protein, dietary fibre, calcium, magnesium, potassium, vitamins A and C (Nahry et al. 1978; Adom et al. 1996; 1997; Sobukola 2009). Okra contains glycans, a substance responsible for the viscosity of aqueous suspension (Owoeye et al. 1990) and the stringy, gum like consistency that is desired in good quality soups (Falade and Omojola 2010). It is also an excellent source of iodine, which is useful for the treatment of goiter. The powdered root of okra is consumed along with sugar as a treatment for leucorrhoea backache. Okra acts as a tonic for both man and woman and enables them to increase their vitality and vigour. Mucilage from the stem and roots is used for clarifying sugarcane juice in gur or Jaggery manufacturing in India. Fully ripened fruits and stem containing crude fibre are used in the paper industry. Okra gum obtained from seedpods of *Hibiscus esculentus* is an anionic polysaccharide, which can be used as flocculant for removal of solid wastes from tannery effluent (Agarwal et al. 2003).

Okra is highly perishable because of its high moisture content and respiratory activities, thus it is necessary to dry

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them for prolong use (Falade and Omojola 2010). The demand of okra is so high that at times okra has to be imported. On the other hand, due to poor post harvest management okra losses are quite high. Moreover the processing of okra is also very limited. The traditional method for preserving okra (Kordylas 1991) involves slicing and sun drying of the fruit until they become brittle, followed by milling into powder for further use. Since it is an important constituent of Indian food/curries, drying of okra to enhance its keeping quality has been practiced since time immemorial. Sun drying is inexpensive drying technique, but has many drawbacks (Doymaz 2005). Therefore, to overcome these problems okra is dried in solar or hot air driers more effectively (Doymaz and Pala 2002). Microwave drying of okra has also been done (Dadali et al. 2007). Raghavan et al. (2005) indicated that about 34% of the world produce requires artificial drying. The drying characteristics of okra has been reported by research workers (Gögus and Maskan 1999; Doymaz 2005; Dadali et al. 2007). Extra source of heating besides solar energy can also be provided by specially designed container which increases the temperature and air current to speed up drying. The okra pods in the form of slices when dried in a hot air dryer will not only reduce the post harvest losses but also minimize packaging, storage and transport cost. Therefore, the experiment was under taken with specific objectives to study the effect of different temperatures and slice sizes on quality of final product.

Materials and methods

Fresh and mature fruits (edible stage) of okra cv. Mahyco-10 were obtained from a local farmer's field in Mandsaur district of MP, India and stored at 3–4 °C for about a day (Doymaz 2004). Okra pods were taken out and kept at ambient condition one hour before the commencement of experiment. Samples were blanched in NaCl solution (0.5%) at 95 °C for 5 min. The blanched samples were immediately cooled by immersing in cold water and spread on a stainless steel sieves to drain excess water (Shivhare et al. 2000). Okra pods were cut manually using cut & chop board into four sizes across the length. Both the ends of okra pods were rejected. The sliced sample (200 g) was spread uniformly in a single layer on drying tray (30 cm×20 cm) and then trays were kept in a convective hot air dryer with drying air velocity of 1.5 ± 0.1 m/s. The drying system was run for about 30mins to bring it to steady conditions before the start of the drying experiment. Drying was carried out until the final moisture content reaches to a level less than 10% (wb). Sixteen treatment combinations consisting of four drying temperature i.e. 50, 60, 70, and 80 °C and four slice sizes i.e. 1,

2, 3, and 4 cm were replicated twice in a factorial complete randomized design. The observations on the moisture loss were recorded at every half an hour interval as suggested by Shivhare et al. (2000) and Doymaz (2004).

Analysis was carried out for estimation of protein, ascorbic acid and fibre content in dried okra samples. The protein content was calculated by multiplying per cent nitrogen content in okra with the factor 6.25 (Sadashivam and Manickam 1992). Dried sample (5 g) was digested with sulphuric acid using hydrogen peroxide for removing black colour, then estimation of nitrogen in percent was done by colorimetric method using UV–VIS spectrophotometer ELICO BL-198 after the development of colour with Nessler's reagent. The ascorbic acid content of okra was determined by titration method, using 2,6-dichlorophenol indophenol dye (Harris and Ray 1935). Fibre content was determined according to the method described by Pearson (1970). Crude fibre was determined by acid and subsequent alkali treatment, oxidative hydrolytic degradation of the native cellulose and considerable degradation of lignin. The residue obtained after final filtration is weighed, incinerated, cooled and weighed again. The loss in weight gives crude fibre content. Moisture content of okra was determined as per AOAC (1965) method. For this purpose the sample was dried in a hot air oven for 24 h at 105 °C and weight loss was expressed as moisture content. The experimental data was statistically analysed.

Results and discussion

The protein content, ascorbic acid and fibre content of fresh okra cv. Mahyco- 10 were determined and found to be 2.05 g/100 g, 14.81 mg/100 g and 6.9 g/100 g respectively. These properties of dried okra were observed for different slice sizes and drying temperature as discussed in the following sections.

Protein content Protein content of okra pods cut in different size and dried at different temperature are presented in Table 1. The maximum average protein content in dried okra was found to be 18.0 g/100 g at 60 °C (T_2), which was significantly higher than those dried at other temperatures. The minimum average protein content of 15.8 g/100 g was noted for 80 °C (T_4) drying temperature. In case of slice size, the maximum average protein content in dried okra was found to be 17.6 g/100 g with 2 cm (S_2) slice size, which was significantly higher than other sizes of slice. The minimum average protein content of 16.8 g/100 g was noted for 1 cm (S_1) slice size. Combined effect of drying temperature and slice size showed that the maximum protein content of dried okra was 19.1 g/100 g under 60 °

Table 1 Effect of drying temperatures and slice sizes on protein, ascorbic acid and fibre content in dried okra pods

Slice Size (cm)	Protein Content (g/100 g)				Mean
	50 °C (T ₁)	60 °C (T ₂)	70 °C (T ₃)	80 °C (T ₄)	
1 cm (S ₁)	16.9	18.2	16.7	15.3	16.8
2 cm (S ₂)	18.0	19.1	17.3	16.1	17.6
3 cm (S ₃)	17.6	17.8	16.5	15.7	16.9
4 cm (S ₄)	18.2	16.7	16.7	16.1	16.9
Mean	17.7	18.0	16.8	15.8	
Treatment	S.Em±		CD _{5%}		
T	0.166		0.499		
S	0.166		0.499		
T x S	0.333		0.998		
Ascorbic Acid Content (mg/100 g)					
1 cm (S ₁)	7.0	8.0	9.0	6.5	7.6
2 cm (S ₂)	8.0	10.0	8.0	6.7	8.2
3 cm (S ₃)	8.0	9.0	7.0	6.4	7.6
4 cm (S ₄)	8.0	7.0	6.5	6.3	7.0
Mean	7.8	8.5	7.6	6.5	
Treatment	S.Em±		CD _{5%}		
T	0.165		0.496		
S	0.165		0.496		
T x S	0.330		0.991		
Fibre Content (g/100 g)					
1 cm (S ₁)	22.0	22.0	20.1	19.0	20.8
2 cm (S ₂)	23.0	24.0	21.0	21.1	22.3
3 cm (S ₃)	21.0	23.0	22.0	19.2	21.3
4 cm (S ₄)	20.0	20.0	21.5	19.0	20.1
Mean	21.5	22.3	21.2	19.6	
Treatment	S.Em±		CD _{5%}		
T	0.179		0.539		
S	0.179		0.539		
T x S	0.359		1.078		

C and 2 cm slice size (T₂S₂), which is significantly higher than any other combination. The minimum protein content 15.3 g/100 g was recorded under combination of 80 °C temperature and 1 cm slice size (T₄S₁). Drying causes loss of protein which increased with drying temperature. Reduction of slice size increased the cut surface area which might be more vulnerable to protein loss, whereas bigger slice size required more time/prolonged exposure to higher temperature for desired level drying resulting in more loss of protein. Nahri et al. (1978) has also found the protein content of sundried (20 days) okra slices as 15.17–19.82% for three Egyptian varieties.

Ascorbic acid content Values of ascorbic acid content of dried okra as recorded under different temperature and slice

size are presented in Table 1. The maximum average ascorbic acid of dried okra was found to be 8.5 mg/100 g at 60 °C (T₂), which is significantly higher than that of okra dried at other temperatures. The minimum average ascorbic acid content of 6.5 mg/100 g was noted with 80 °C (T₄) drying temperature. In case of slice size the maximum average ascorbic acid of dried okra was found to be 8.2 mg/100 g at 2 cm (S₂) slice size, which is significantly higher than other levels of slice size. The minimum average ascorbic acid content of 7.0 mg/100 g was determined for 4 cm (S₄) slice size. Adom et al. (1997) observed that slice thicknesses (0.5, 1.0 and 1.5 cm) of okra had a non-significant effect ($P<0.01$) on vitamin C content of final product at five drying times (0, 24, 48, 72 and 96 h) in a solar dryer. Amongst different combination of drying temperature and slice size, the maximum ascorbic acid content of dried okra was 10 mg/100 g under 60 °C and 2 cm slice size (T₂S₂), which was significantly higher than any other combination. The minimum ascorbic acid 6.3 mg/100 g was recorded under combination of 80 °C and 4 cm slice size (T₄S₄). In general under all the treatments the ascorbic acid found to be low as compared to the fresh okra. The losses of ascorbic acid were recorded ranging from 46–52%. The variable losses of ascorbic acid under different sizes and drying temperatures in dried okra are due to sensitivity to high temperature. Similar results for ascorbic acid contents have been reported by Osunde and Musa Makama (2007) in okra, tomato and sweet pepper as 46.5%, 69.67% and 74% respectively. Sablani (2006) reported that microwave and vacuum drying methods can reduce the loss of ascorbic acid due to low levels of oxygen. Falade and Omojola (2010) also found 10 and 20 mg/100 g of ascorbic acid in sun- and solar-dried okra pods respectively.

Fibre content Fibre contents for dried okra at different temperature and slice size (Table 1) reveals that the maximum average fibre content in dried okra was found to be 22.3 g/100 g at 60 °C (T₂), which was significantly higher than the samples dried at other temperatures. The minimum average fibre content of 19.6 g/100 g was observed with the sample dried at 80 °C (T₄). For slice size, the maximum average fibre content of dried okra was found to be 22.3 g/100 g at 2 cm (S₂) slice size, which is significantly higher than okra pods dried at other slice sizes. The minimum average fibre content of 20.1 g/100 g was observed in case of 4 cm (S₄) slice size. Among different combinations of drying temperature and slice size, the maximum fibre content in dried okra pods was 24.0 g/100 g under 60 °C and 2 cm slice size (T₂S₂), which was significantly greater than any other combination. The minimum fibre content 19.0 g/100 g was recorded under combination of 1 cm and 4 cm slice sizes at 80 °C drying

temperature (T_{4S_1} and T_{4S_4}). Nahri et al. (1978) has also found fibre content as 8.32–14.60% in sundried (20 days) okra of three varieties in Cairo (Egypt).

Conclusion

Okra (*Abelmoschus esculentus* (L.) Moench) is a potential vegetable crop with wide scope of export both in fresh as well as in dried form. Size reduction and drying of okra pods will facilitate easy packaging, storage and transport. Thus, okra pods were dried in the form of slices cut across the length at different temperatures. Effect of four slice sizes (1, 2, 3 and 4 cm) and four drying temperatures (50, 60, 70 and 80 °C) on quality of okra were studied. Quality assessment of okra was done on the basis of protein, ascorbic acid and fibre content. Okra slice sizes and drying temperatures were found to affect all the quality parameters significantly. Maximum protein, ascorbic acid and fibre content retention were found in 2 cm slice size dried at 60 °C temperature.

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