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Characteristics of Okra under Different Process Pretreatments and Different Drying Conditions

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Abstract

Okra (*Abelmoschus caillei*) is a vegetable crop that is popular in the tropical region because of its easy cultivation, dependable yield, adaptability to varying weather conditions and resistance to diseases and pests. Apart from its high vitamin B and folic acid contents, okra is said to be very useful against genito-urinary disorders, spermatorrhoea and chronic dysentery while also used in curing ulcers and hemorrhoids. This vegetable crop is seasonal and highly perishable in its natural state after harvest resulting in huge postharvest losses during the production season and extreme scarcity in the off-season. According to past research, drying has demonstrated promising results in preventing postharvest losses and prolonging shelf lives of fruits and vegetables. This study was conducted to investigate the effects of osmotic dehydration process pretreatment and drying temperature on drying rate and quality attributes of okra. A 2 x 3 x 4 factorial experiment under a randomized complete block design was used for the experimental design and the drying process was carried out using a temperature-controlled dryer that has been designed and built prior to this study. Two levels of osmotic solution concentration (40 and 60°Brix of sucrose), three levels of osmotic process duration (60, 120 and 180 min) and four levels of drying temperature (50, 60, 70 and 80°C) were considered with each trial being carried out in triplicates. The quality attributes investigated included: ash content, crude fibre, crude fat, crude protein, bulk density, least gelation concentration and water absorption capacity. Results showed that drying rate, crude fibre, crude fat, crude protein, bulk density and least gelation concentration increased while ash content and water absorption capacity decreased with increase in drying temperature and osmotic solution concentration. However, drying rate and all the quality parameters increased with increase in drying temperature, osmotic solution concentration and osmotic process duration.

Keywords: Drying conditions; Drying rate; Osmotic dehydration; Okra (*abelmoschus caillei*); Process pretreatments; Quality parameters

Introduction

Okra is a vegetable crop that belongs to the genus *Abelmoschus*, family *Malvaceae* and has two main species: *Abelmoschus esculentus* (L.) Moench and *Abelmoschus caillei* (A. Chev.) Stevels [1]. Okra (Figure 1) has been a popular vegetable crop in the tropics because of its ease of cultivation, dependable yield, adaptability to varying moisture conditions and resistance to diseases and pests. The crop is suitable for cultivation as a garden crop as well as on large commercial farms. Okra is the most important fruit vegetable crop and a source of calorie (4550 kcal/kg) for human consumption. It ranks first before other vegetable crops [2]. As an annual crop, it is one of the most commonly grown vegetable crops in the tropics. Okra is among the most heat and drought-tolerant vegetable species, but severe frost can damage the pods. Okra cultivation and production has been widely practiced because of its importance to the economic development and can be found in almost every market in Africa.

Basically, drying process is a heat and mass transfer phenomenon where water migrates from the interior of the drying product to the surface from where it evaporates. In this process, according to Mohammed et al. [3], the microorganisms that destroy food require moisture to live. In addition to preservation, dehydration reduces product weight and volume by significant amounts and improves the efficiency of product transportation and storage. Mohammed et al. [3] studied the drying characteristics of Okra under different solar dryers in order to evaluate the drying efficiency and qualities of dried okra. In the study, okra was treated by 1.0% sodium carbonate at boiling point for 3 min under different drying systems and flow rates of air of 0.075, 0.149 and 0.249 m^3/s at the same time. The result obtained showed that the best quality was achieved by using indirect dryer for drying okra at air flow rate of 0.075 m^3/s. Result also showed that the drying efficiency was decreased as the moisture content of okra was reduced.

Roman & Hensel [4] investigated the effect of air temperature and relative humidity on the thin-layer drying of celery leaves (*Apium graveolens var secalinum*). In the investigation, thin-layer drying of celery leaves was studied under different conditions of air temperature and relative humidity ranging from 20-50°C and 10-60% respectively

Figure 1: Freshly harvested okra fruits.

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using a through-flow laboratory dryer. Result showed that both air temperature and relative humidity had effect on the drying time with the effect of the former being more pronounced while that of the latter was practically negligible at 50°C. Result also showed that the color of the dried leaves did not significantly change at temperatures between 20 and 40°C but the color was negatively affected at 50°C.

Agarry and Owabor [5] studied the effects of temperature, solute concentration, size diameter and process time on osmotic dehydration of okra in sucrose solution. They used Response Surface Methodology (RSM) under Central Composite Rotatable Design (CCRD) for the experimentation while optimizing the osmotic dehydration process for water loss and solutes gain. Results showed predicted optimized water loss and solute gain of 39.78% and 10.16% respectively at solute concentration, solution temperature, sample size diameter and process time of 49.28 (% w/w), 40.79°C, 15 mm and 4.49 h respectively. Result also showed that at the predicted optimum condition, the corresponding observed water loss and solute gain were 38.87 and 10.65 (g/100 g initial sample) respectively.

Taiwo et al. [6] studied the influence of osmotic agents and pretreatment methods on mass transfer and product characteristics of strawberry. The investigation included the impact of different pretreatment methods, osmotic solutions and osmotic conditions on some physical characteristics of strawberry. Result showed that highest water loss was obtained in samples treated under vacuum, in a salt-sucrose mix or in a high-intensity electric field or under high pressure treatments. Further results showed that the increases in solid gain relative to untreated samples were 96-270, 40-160 and 50-62% for pre-frozen treatment, high pressure treatment and high-intensity electric field treatment respectively.

Singh et al. [7] studied osmotic dehydration kinetics of carrot cubes in sodium chloride solution of concentrations 5, 10 and 15% (w/v), solution temperatures of 35, 45 and 55°C, sample-to-solution ratio of 1:4, 1:5 and 1:6 within 240 min duration. Penetration model, Magee model and Azura model were applied to experimental data with Azura model being the best fitted to the experimental data for water loss and solute gain during osmotic dehydration. By interactive technique with a computer programme, effective diffusivities of water and solute were computed with the aid of the analytical solution of Fick's unsteady state law of diffusion. Results showed that the effective diffusivity of water was in the range of 2.6323×10^{-9} and 6.2397×10^{-9} m^2/s while that of solute ranged between 3.1522×10^{-9} and 4.6400×10^{-9} m^2/s.

Moreira et al. [8] mathematically modeled the drying kinetics of chestnut (*Castanea sativa mill*). The drying kinetics were experimentally determined using a pilot-plant scale dryer with a closed air circuit assisted by a heat pump. Experimental conditions such as drying temperature, relative humidity, air velocity and different states of chestnuts were investigated while measured parameters included weight, size and color of the dried product. The results of the experiment showed that higher driving force led to higher drying kinetics when the physical conditions were eliminated. Results also showed that the color of cut dried chestnuts were preserved better and the quality attributes depended on the moisture content of chestnut.

Chenlo et al. [9] studied the mass transfer during osmotic dehydration of chestnut using sodium chloride solutions. Working at three different temperatures of 25, 35 and 45°C, aqueous solution of sodium chloride of concentrations 17.0, 22.0 and 26.5% w/w were used as osmotic media. The output parameters determined included total mass, solids gain, water loss and moisture content while color was determined as a quality parameter for each sample. Empirical model based on Logistic Dose Response (LDR) curves with a diffusion model were employed to achieve the experimental data modelling; the result showed that the LDR model successfully fits the experimental data. Result also revealed that the optimal values of experimental conditions were obtained when a temperature of 25°C and a sodium chloride concentration of 22.0% w/w were used.

The demand for okra by the growing population has not been met despite the increase in the production of okra. This is as a result of wastes that come from biological and biochemical activities taking place in this fresh product, inefficient handling and transportation, unfavorable storage conditions, inadequate postharvest handling and poor market outlet. Okra (moisture content 86% wb) is highly perishable in its natural state after harvest; it is seasonal - available during the production season but very scarce and unaffordable during the off-season. This crop contains valuable nutrients to the extent that it should be made available all the year round in a very good postharvest condition.

Drying is the most efficient, reliable and practically feasible methods of postharvest preservation of okra and other highly-perishable fruits and vegetables. Therefore, the main objective of this study was to investigate the effects of some processing parameters on the drying rate and post-drying quality attributes of okra. The specific objectives are: (i) to investigate the effects of osmotic dehydration process as a pre-treatment method on drying rate and post-drying quality attributes of okra and; (ii) to investigate the effects of drying temperatures on the drying rate and the post-drying qualities.

Materials and Methods

Experimental equipment

The equipment used for this study is an experimental dryer which was designed and built prior to this study. Other apparatus included a refractometer (Model 300002), infrared moisture meter (Model AD-4714A), okra slicer, sensitive weighing balance, grinder (Polymix - PX-MFC90D), stainless steel knife, thermo-hygrometer, desiccators, sucrose and distil water.

As shown in figures 2 and 3, the dryer consists of heating chamber having three electrical heating coils of 1.8 kW each, connected directly

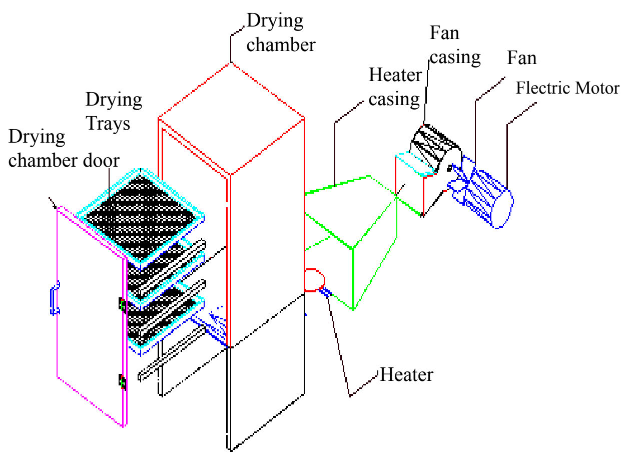

Figure 2: Exploded view of the dryer showing the component parts.

Figure 3: Pictorial side view of the dryer showing the temperature regulator.

to a centrifugal fan of 0.5 hp and drying chamber. The heating coils are connected in series and the whole unit connected to the temperature regulator (0-400°C) which controls the temperature of the heaters. The drying cabinet measures 50 cm long, 50 cm wide and 80 cm high (with external dimension of 56 cm x 56 cm x 86 cm) consisting of three set of trays separated by 15 cm clearance. The drying chamber is double walled insulated with fiber glass with a thickness of 3 cm. The drying trays having an area of 50 cm x 50 cm are made from one inch square pipe with expanded metal having an aperture wide enough to allow free flow of heated air.

The heating chamber is trapezoidal in shape with the length of the side touching the drying chamber 60 cm while the opposite side touching the fan is 20 cm. The length of the chamber is 50 cm in order to accommodate the heating elements. To ensure that the hot air touches all the products simultaneously the heating chamber opened directly into the drying chamber. To avoid moisture condensation at the top of the dryer vents are provided with the aid of two galvanized pipes of four inch diameter. This was achieved by drilling holes of about 5 mm diameter for discharge of moisture laden air and for the placement of the thermo-hygrometer probe.

Experimental design

In order to investigate the effects of the processing parameters on the drying rate and post-drying quality attributes of okra, a 2 × 3 × 4 factorial experiment under randomized complete block design (RCBD) was used for the study. The design included two levels of osmotic solution concentration (40 and 60 °Brix), three levels of osmotic process duration (60, 120 and 180 min) and four levels of drying temperature (50, 60, 70 and 80°C). All tests were carried out in triplicates making a total of 72 experimental runs that were individually tested and measured.

Experimental procedure

Sample pretreatment: Green, mature and freshly-harvested okra pods that were healthy and free from mechanical injuries were purchased from a local farmer within Ilorin metropolis. The okra variety used for this study is known as "*Yaya*" or "*Kogboye*" and is commonly grown among farmers in the South-West Zone of Nigeria. Samples were weighed using a top loading balance - Snowrex Counting Scale (Model SRC 5001, Saint Engineering Ltd., London, UK) with an accuracy of 1 g and range 0 - 5000 g.

Okra pods were rinsed in clean water at room temperature and cut with the okra slicer to a thickness of 7 mm. 100 g of the sample were weighed and immersed in a hypertonic solution of sucrose of two different concentrations (40 and 60 °Brix - mass ratio of fruit to sucrose was 1:1) for two simultaneous counter-current flows - an exit of water from the product to the solution and a migration of natural solids into the product. Samples were removed from the sucrose solution after separately subjecting them to the three different osmotic process durations (60, 120 and 180 min). All samples were drained, weighed and checked for sample weight, moisture content and dry solids mass after osmotic dehydration pretreatment.

Drying procedure: The dryer was pre-heated to a temperature of 40°C by the means of temperature regulator while the samples were being prepared to ensure stability of the condition of the drying chamber. After arranging the trays in the dryer, the fan was switched on and set to a velocity of 0.5 m/s using the fan regulator with the speed measured with the anemometer. The initial condition of the environment and the drying chamber was recorded immediately after loading. 100 g of samples of okra pretreated with two levels of osmotic solution concentration (40 and 60 °Brix) for three levels of osmotic dehydration process duration (60, 120 and 180 min) were weighed and dried at four levels of drying temperature (50, 60, 70 and 80°C) with each experiment carried out in triplicates. The temperature of the exhaust air from the dryer was also measured and recorded. The drying samples were weighed at intervals of 1 h and drying continued until the desirable moisture contentment of 10% (wb) was reached.

Output parameters

Drying rate: Drying rate is the rate of change in moisture with drying time during the drying process. In this study, drying rate was determined by using equation 1 below as:

$$R = \left(\frac{dM}{dt} \right) = \frac{m_i - m_f}{t} \quad (1)$$

where; R is the drying rate in g/h; *dM* is change in mass of okra in g; *dt* change in time in h; t is the total time of drying in h; m_i and m_f are the initial and final mass of okra samples respectively in g.

Post-drying qualities: The post-drying qualities of okra were determined at the Biochemistry Laboratory of the Nigerian Stored Products Research Institute (NSPRI), Ilorin, using the AOAC [10] standards and Ogungbenle et al. [11] method. The post-drying qualities determined included: crude protein content, crude fat content, crude fibre content, ash content, bulk density, least gelation concentration (LGC) and water absorption capacity (WAC).

Statistical analysis: The data obtained from the experiments for drying rate and post-drying qualities were subjected to the statistical Analysis of Variance (ANOVA) at 95 % confidence level ($p \leq 0.05$) using the SPSS computer software package. Further analysis by Duncan New Multiple Range Test (DNMRT) was used to compare the means among different levels of each experimental factors.

Results and Discussion

ANOVA of process variables on drying rate and post-drying qualities

The result of the statistical analysis of variance (ANOVA) of the data obtained from the experiment is presented in table 1. From the

SV	DF	SS	MS	F	P>F
Drying rate					
C	1	8.473	8.473	15.643*	0.000
T	3	381.657	127.219	234.866*	0.000
D	2	1.090	0.545	1.006	0.373
C X T	3	0.514	0.710	0.316	0.814
C X D	2	1.194	0.597	1.102	0.341
T X D	6	3.351	0.558	1.031	0.417
C X T X D	6	3.094	0.516	0.952	0.467
Error	48	28.000	0.542		
Total	71	425.373			
Crude ash					
C	1	8.167	8.161	2.821E03*	0.000
T	3	17.271	5.757	1.990E03*	0.000
D	2	5.414	2.707	935.607*	0.000
C X T	3	0.513	0.171	59.070*	0.000
C X D	2	0.150	0.075	25.900*	0.000
T X D	6	0.450	0.075	25.923*	0.000
C X T X D	6	0.269	0.045	15.524*	0.000
Error	48	0.139	0.003		
Total	71	32.365			
Crude fibre					
C	1	16.321	16.321	3.957	0.052
T	3	555.959	85.320	44.931	0.000
D	2	80.667	40.334	9.779	0.000
C X T	3	1.695	0.565	0.137	0.937
C X D	2	1.118	0.559	0.136	0.874
T X D	6	9.652	1.609	0.390	0.882
C X T X D	6	1.932	0.322	0.078	0.998
Error	48	197.976	4.125		
Total	71	865.320			
Crude fat					
C	1	0.226	0.226	7.164*	0.010
T	3	5.658	1.886	59.895*	0.000
D	2	0.234	0.117	3.708*	0.032
C X T	3	0.007	0.002	0.078	0.972
C X D	2	0.005	0.002	0.078	0.925
T X D	6	0.260	0.043	1.377	0.243
C X T X D	6	0.027	0.004	0.143	0.990
Error	48	1.511	0.310		
Total	71	7.928			
Crude protein					
C	1	11.155	11.155	5.710*	0.021
T	3	22.154	7.385	3.780*	0.016
D	2	23.875	11.937	6.111*	0.004
C X T	3	0.276	0.092	0.047	0.986
C X D	2	0.106	0.053	0.027	0.973
T X D	6	0.568	0.094	0.048	0.999
C X T X D	6	0.043	0.007	0.004	1.000
Error	48	93.767	1.953		
Total	71	151.943			
Bulk density					
C	1	0.003	0.003	1.084*	0.303
T	3	0.070	0.023	9.825*	0.000
D	2	0.006	0.003	1.285*	0.286
C X T	3	0.003	0.001	0.422	0.738
C X D	2	0.005	0.003	1.074	0.350
T X D	6	0.044	0.007	3.049	0.013
C X T X D	6	0.004	0.001	0.282	0.943
Error	48	0.114	0.002		
Total	71	0.249			
LGC					
C	1	23.347	23.347	3.452	0.069
T	3	181.375	60.458	8.938*	0.000
D	2	87.250	43.625	6.450*	0.003
C X T	3	16.708	5.569	0.823	0.487
C X D	2	4.694	2.347	0.347	0.709
T X D	6	47.750	7.958	1.177	0.335
C X T X D	6	16.083	2.681	0.396	0.878
Error	48	324.667	6.764		
Total	71	701.875			
WAC					
C	1	0.113	0.113	2.608	0.113
T	3	2.846	0.949	21.927*	0.000
D	2	0.968	0.484	11.189*	0.000
C X T	3	0.063	0.021	0.482	0.696
C X D	2	0.028	0.014	0.320	0.728
T X D	6	0.134	0.022	0.518	0.792
C X T X D	6	0.056	0.009	0.217	0.969
Error	48	2.077	0.043		
Total	71	6.285			

*Significantly different at P≤0.05.

Table 1: Analysis of variance (ANOVA) of the effect of process variables on drying rate and post-drying qualities of okra: C - osmotic solution concentration; T - drying temperature; D - osmotic process duration; LGC - least gelation concentration; WAC - water absorption capacity.

analysis table, it is clear that the drying temperature was significant on drying rate and all the post-drying quality parameters; osmotic solution concentration was significant on the drying rate and post-drying qualities except crude fiber, least gelation concentrations (LGC) and water absorption capacity (WAC); osmotic process duration was significant on all the post-drying qualities but not on drying rate; no interaction of the process variables was significant on any of the output parameters except crude ash on which all the process variables and their interactions were significant, all at $p \leq 0.05$. This implies that osmotic solution concentration, osmotic process duration and drying temperature had appreciable effects on the drying rate and post-drying quality attributes of okra. Therefore, while drying okra, these factors must be carefully controlled.

Effect of osmotic solution concentration on drying rate and post-drying qualities

The effect of osmotic solution concentration on drying rate is shown in figure 4. The figure showed that, generally, osmotic solution concentration had no appreciable effect on drying rate. However, for drying temperature of 50°C, drying rate at osmotic solution concentration of 40 °Brix was higher than that 60 °Brix. As shown in figure 5, increase in osmotic solution concentration decreased the ash content at all levels of osmotic process duration and drying temperature. Crude fibre slightly increased with increased with increasing osmotic solution concentration from 40 to 60 °Brix (Figure 6) at all drying temperatures and osmotic process duration.

As indicated by figure 7, values of crude fat obtained at osmotic solution concentration of 40 °Brix were not different those at 60 °Brix Implying that osmotic solution concentration did not have effect on the crude fat content of dried okra. Crude protein increased with increasing osmotic solution concentration for all osmotic process duration and drying temperature (Figure 8). Bulk density increased with increasing osmotic solution concentration from 40 to 60 °Brix for drying temperatures of 50, 60 and 80°C but decreased with increasing osmotic solution concentration for drying temperature of 70°C (Figure

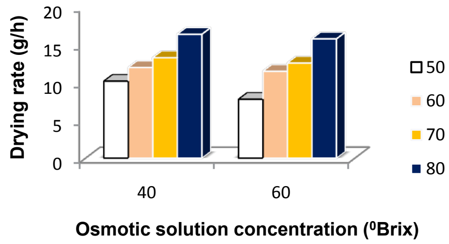

Figure 4: Effect of osmotic solution concentration on drying rate at different drying temperature for 60 min.

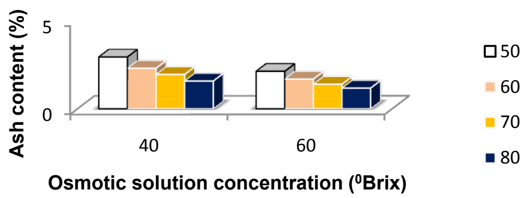

Figure 5: Effect of osmotic solution concentration on ash content at different drying temperature for 60 min.

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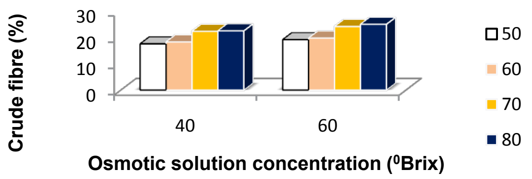

Figure 6: Effect of osmotic solution concentration on crude fibre at different drying temperature for 60 min.

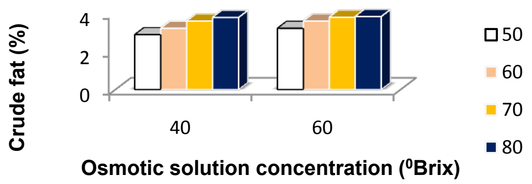

Figure 7: Effect of osmotic solution concentration on crude fat at different drying temperature for 60 min.

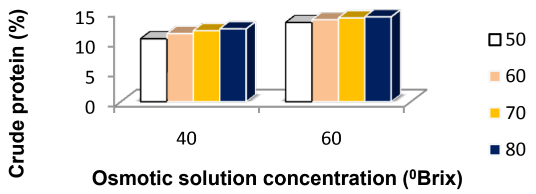

Figure 8: Effect of osmotic solution concentration on crude protein at different drying temperature for 60 min.

9). As seen from figure 10, LGC at 60 °Brix was higher, when compared with that of 40 °Brix. From figure 11, it is obvious that increase in osmotic solution concentration from 40 - 60 °Brix led to increase in WAC.

Effect of drying temperature on drying rate and post-drying qualities

From table 2, it is obvious that drying rate increased as the drying temperature increased from 50 to 80°C at all levels of osmotic dehydration concentration and osmotic dehydration time. This is in agreement with the findings of past researchers such as Mohamed et al. [3]. Duncan's New Multiple Range Test (Table 2) showed that, all levels of drying temperature had effect on drying rate (at $P \le 0.05$). This implies that increase in the drying temperature from 50 to 80°C showed a progressive increase in the drying rate. Ash content decreased as the drying temperature increased from 50 to 80°C at all levels of osmotic dehydration concentration and osmotic dehydration time. Furthermore, all levels of drying temperature had effect on ash content (at $P \le 0.05$). This implies that increase in the drying temperature from 50 to 80°C resulted in a progressive decrease in the ash content.

Crude fiber increased with increasing drying temperature for all levels of osmotic dehydration concentration and osmotic dehydration time. Further analysis showed that crude fiber between 50 and 70°C, 50 and 80°C, 60 and 70°C, 60 and 80°C were significantly different but, between 50 and 60°C, 70 and 80°C were not significantly different. From the data, the highest value of crude fiber was recorded at 80°C. Crude fat increased as the drying temperature increased from 50 to 80°C. Crude fat at 70 and 80°C were not significantly different from each other but values at other levels of drying temperature were significantly different with value of crude fat at 80°C being the highest. Crude protein and bulk density increased with increasing drying temperature from 50 to 80°C. The lowest LGC was obtained at 60°C which implies that dry okra will get better at 60°C. The lower the LGC, the better the gelling ability [11]. As the drying temperature increased from 50 to 80°C, WAC of the dried okra decreased to the minimum value.

Effect of osmotic process duration on drying rate and post-drying qualities

All discussions on the effect of osmotic process duration on drying rate and post-drying qualities are based on table 3 below. Drying rate showed progressive increase (though not statistically significant) with increasing osmotic process duration. Ash content and crude fiber increased as the osmotic process duration increased from 60 to 180 min at different temperature and for all osmotic solution concentration. Crude fat content was almost the same for all osmotic process durations. Values of crude fat 60 and 120 min were not significantly different, while the values at 60 and 180 min, 120 and 180 min were significantly different.

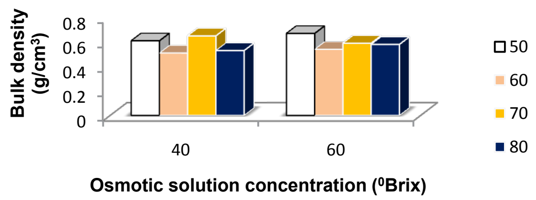

Figure 9: Effect of osmotic solution concentration on bulk density at different drying temperature for 60 min.

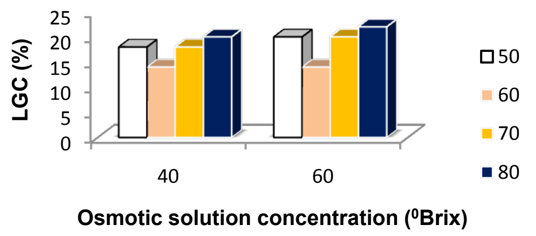

Figure 10: Effect of osmotic solution concentration on LGC at different drying temperature for 60 min.

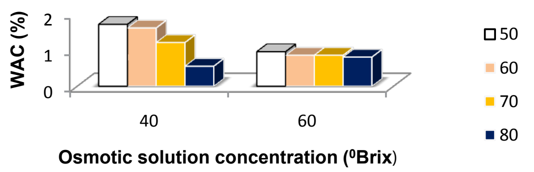

Figure 11: Effect of osmotic solution concentration on WAC at different drying temperature for 60 min.

Drying Temperature (°C)	50	60	70	80
Drying rate (g/h)	9.7000[d]	11.7778[c]	12.9167[b]	16.0667[a]
Crude ash (%)	2.9122[a]	2.5050[b]	2.0006[c]	1.6222[d]
Crude fibre (%)	18.9267[b]	20.2500[b]	24.6728[a]	25.4106[a]
Crude fat (%)	3.1089[c]	3.5650[b]	3.7339[a]	3.8439[a]
Crude protein (%)	11.1022[b]	11.6572[a]	12.1878[a]	12.5739[a]
Bulk density (g/cm³)	0.5929[a]	0.5362[b]	0.6111[a]	0.5466[b]
Least gelation concentration, LGC (%)	20.0000[a]	17.1667[b]	20.6667[a]	21.3333[a]
Water absorption capacity, WAC (%)	1.2583[a]	1.1750[a]	0.9833[b]	0.7417[c]

*Means with the same letter are not significantly different but means with different letters are significantly different (at P ≤ 0.05) using Duncan's New Multiple Range Test

Table 2: Effect of drying temperature on drying rate and post-drying qualities of okra*.

Osmotic process duration (min)	60	120	180
Drying rate (g/h)	12.4417[a]	12.6917[a]	12.7125[a]
Crude ash (%)	1.8854[c]	2.3604[b]	2.5342[a]
Crude fibre (%)	21.0571[c]	22.2412[b]	23.6467[a]
Crude fat (%)	3.5042[b]	3.5446[b]	3.6400[a]
Crude protein (%)	12.5671[a]	11.9158[a]	11.1579[b]
Bulk density (g/cm³)	0.5846[a]	0.5638[a]	0.5668[a]
Least gelation concentration, LGC (%)	18.2500[b]	20.3750[a]	20.7500[a]
Water absorption capacity, WAC (%)	1.0625[a]	1.1687[a]	0.8875[b]

*Means with the same letter are not significantly different but means with different letters are significantly different (at P ≤ 0.05) using Duncan's New Multiple Range Test.

Table 3: Effect of osmotic process duration on drying rate and post-drying qualities of okra*.

Crude protein decreased as the osmotic process duration increased from 60 to 180 min. Values of crude protein at 60 and 120 min were not significantly different from each other but significantly different from that at that at 180 min. Osmotic process duration had no appreciable effect on bulk density. LGC increased as the osmotic process duration increased from 60 to 180 min. Values of LGC at 120 and 180 min were not significantly different but significantly different from the value at 60 min which gave the lowest value of LGC. WAC increased with increasing osmotic process duration from 60 to 180 min with the highest value being at 120 min. WAC is an indication of the dried okra being used as a thickener in liquid and semi-liquids foods as dried okra has the ability to absorb water and swell for improved consistency in food.

Conclusion

Okra dries faster at a higher temperature as compared to a lower temperature. Osmotic dehydration pretreatment increases the rubbery nature of materials. LGC had the lowest value at 60°C implying that dried okra will get better at 60°C compared with higher drying temperatures. Ash content can be best preserved in okra by drying at a lower temperature of 50°C, osmotic solution concentration of 40 °Brix and osmotic process duration of 180 min. Based on the result of this study, crude protein, crude fiber and crude fat in dried okra can be maximized by drying at 80°C after pretreatment with osmotic solution concentration of 60 °Brix and osmotic process duration of 180 min. WAC was higher at a drying temperature of 50°C, osmotic solution concentration of 40 °Brix and osmotic process duration of 120 min. Further studies should be carried out on the factors that affect the storability of dried okra for long-time storage and preservation. Further studies should also be carried out to investigate the use of sucrose for osmotic dehydration pretreatment vis-à-vis the palatability of dried okra.

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