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Short Communication

Microwave Drying of Onion Slices

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Abstract

White onion slices were dried using microwave drying technique. The effect of process parameters during microwave dehydration such as effect of various power levels (0.25, 1.00, 1.50 and 2.25 kW) on mass reduction, water loss and diffusivity were studied. It was found that the mass reduction and water loss increased with increase of power level. The moisture diffusivity varied in the range of 6.491 × 10^{-09} to 6.491 ×10^{-08} m²/s. The drying times of onions slices by microwave drying at 0.25, 1.00, 1.50 and 2.25 kW level were 15.86, 6.78, 5.3 and 3.2 hrs. Quality of dried product in respect to colour, rehydration and water activity was superior.

Keywords: Microwave drying, colour value, Onion dehydration.

Introduction

India (21%) and China (19.3%) is the largest producer of onion (*Allium cepa L.*) by area as well as by total production. Onions compared with other fresh vegetable are relatively high in food energy, intermediate in protein content and rich in calcium and riboflavin. The post harvest losses of this vegetable are quite serious in our country so drying or dehydration should be carried out to increase its shelf life but challenge in fruits and vegetables drying are to reduce the moisture content of the product to a level where microbiological growth will not occur and simultaneously keep the high nutritive value.

Onions are dried from initial moisture content of about 82 per cent to 6 per cent or less sufficient for storage and processing[1]. V-12 is the special variety of white onion which is used for dehydration purpose due to its high solid content (17-18 per cent). Tray drying brings the product to undesirable changes in colour, texture, flavor and loss in nutritive value[2]. Hence, a new method of drying in combination of osmosis (in which partial dehydration of the fruit is brought about by immersing them in osmotic solution using controlled heat transfer applications and then drying) could be a good solution[3].

Osmosis of onion is done in salt solution because the reconstitution factor for salt-treated samples is greater than that for sugar-treated product[4]. Osmotic dehydration is effective even at ambient temperature, so that damage of texture, color, and flavor of food from heat are minimized[5]. Microwave drying has been shown to have low energy consumption[6]. Heating is more rapid because the surface-to-centre conduction stage is largely eliminated[7]. Microwaves have been shown to result in faster drying of materials and satisfying certain quality constraints of product for corn[8] and raisins[9].

Material and Methods

Materials: The good quality white onions (cultivar V-12) were selected and cut with a sharp stainless steel knife into circular slices of approximate 4 mm $\pm$ 0.1 mm thickness.

Measurement of initial Moisture Content: The moisture content of the fresh as well as osmotically dehydrated onion samples was determined by using AOAC (1984) method.

$$\text{Percent moisture content (db)} = \frac{W_1 - W_2}{W_2} \times 100$$

Microwave Drying Characteristics: Water loss: The water loss (WL) is defined as the net weight loss of the fruit on initial weight basis and will be estimated as

$$WL = \frac{W_i . X_i - W_\theta . X_\theta}{W_i}$$

Mass reduction: The weight reduction (WR) can be defined as the net weight loss of the fruit on initial weight basis.

$$WR = \frac{W_i - W_\theta}{W_i}$$

Microwave drying of onion: Main switch control put at ON condition which gives the power to blower for cooling the magnetron and then switched ON the filament switch of the magnetron which gives 100 per cent voltage to filaments after a delay of 120 seconds then known percentage of initial moisture content and known weighed sample of onion were taken and uniformly spread on the turntable inside the microwave cavity, for an even absorption of microwave energy. Now power level and time were pre-set through a control panel provided on front side of dryer.

Moisture Diffusivity: The moisture diffusivity of the samples was estimated by using the simplified mathematical Fick's diffusion model.

$$\frac{\delta M}{\delta t} = D\frac{\delta^2 M}{\delta X^2}$$

$$\ln[MR] = \ln\left(\frac{M - M_e}{M_0 - M_e}\right) = \ln\frac{8}{\pi^2} - \left(\frac{-\pi^2 D_{eff} t}{L^2}\right)$$

A general form of above eq^n could be written in semi-logarithmic form, as follows.

$\ln(M_R) = A - Bt$

Experimental values of the effective diffusivity are typically calculated by plotting experimental drying data in terms of ln (M_R) versus drying time and the slope of the curve was a measure of the moisture diffusivity.

$$Slope = \frac{\pi^2 D_{eff}}{L^2}$$

Quality evaluation: In order to determine quality of osmotic dehydrated onion samples had been evaluated on the basis several parameters such as, colour, rehydration and water activity.

Colour measurement: The most common technique to assess the colour is Hunter lab colorimeter used in the present.

Water activity: A digital water activity meter was used for measuring water activity of dehydrated onion samples.

Rehydration ratio: The rehydration ratio of dried onion samples was determined by putting 10 g of samples with 1000 ml of distilled water in beaker. It was allowed to rehydrate for 5 h at 20 ^{0}C temperature.

$$rehydrationratio = \frac{Mass\ of\ rehydrated\ \ samples(g)}{Mass\ of\ dried\ \ samples(g)}$$

Specific energy consumption

$$SEC = \frac{P \times t_{on}(100 - M_f)}{m(M_i - M_f)}$$

Results and Discussion

Microwave drying of onion slices: The weight of the onion samples was taken after every 15 min intervals for the first one hour of the experiments. Afterwards the weight was noted after 30 min intervals till the sample attained constant weight. The drying times of onions slices by microwave drying at 0.25, 1.00, 1.50 and 2.25 kW power level were 15.86, 6.78, 5.3 and 3.2 hrs respectively. Graph plotted as moisture content v/s drying time (figure 1).

Moisture Diffusivity of onion slices: Moisture ratio plotted as ln (MR) v/s drying time (figure 2). The variation in (MR) with drying time for each case was found to be linear. The slope became steeper with increase in microwave power level. Moisture diffusivities were calculated from the slopes of these straight lines[10,11]. It was observed that moisture diffusivity increased with microwave power level in microwave drying processes .The moisture diffusivity varied in the range of 6.491 × 10^{-09} to 6.491 ×10^{-08} m²/s during microwave drying of onion samples.

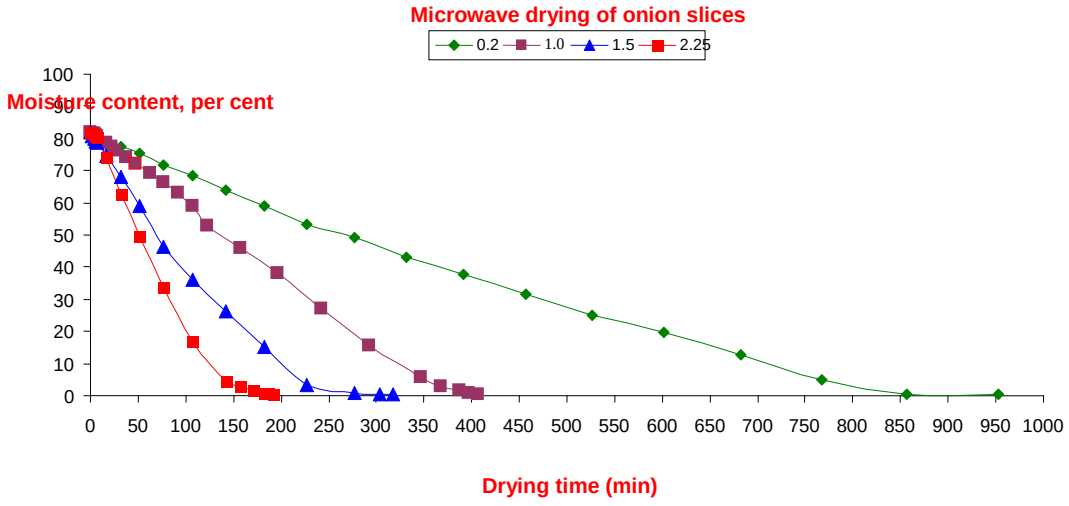

Figure-1
Drying curve for fresh onion slices by microwave drying

Effect of process parameter on quality: The quality of dehydrated onion slices was evaluated on the basis of colour as well as water activity. The L* (lightness) increased for the onion slices when power level was increased from 0.25 kW to 1.50 kW, meaning that sample became lighter in colour, However, L-value reduced further at 2.25 kW level possibly due to exposure of product to high temperature result in darkening of dried product (table 2).

Water activity: Water activity was determined as a measure of storage stability using a Hygrolab-3 water activity meter for all samples. The water activity of all samples were around 0.46-0.61 which is recommended to avoid microbial growth and enzymatic reactions[12].

Specific Energy Consumption: Specific energy consumption was determined using equation and the data are summarized in table 5.

The specific energy consumption was found more at 1.50 kW (35.39) power level.

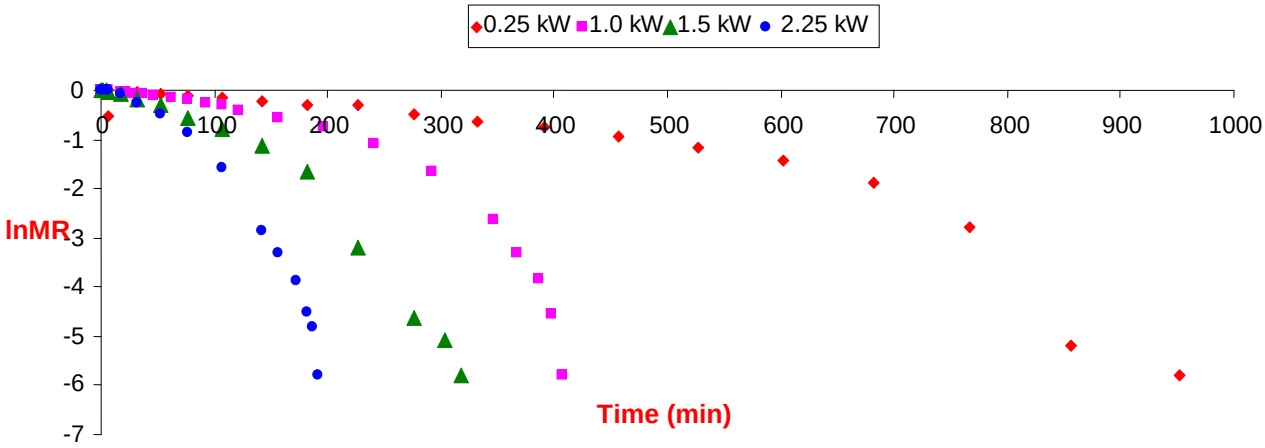

Figure-2
Variation in ln (MR) with drying time at different power levels for microwave drying of onion slices

Table-1
Effective moisture diffusivity of onion slices during microwave drying

Sr. no	Microwave Level	Diffusivity (m^2/s)	R^2
1	0.25	6.49114×10^{-09}	0.9112
2	1.00	1.29823×10^{-08}	0.946
3	1.50	4.86835×10^{-08}	0.9374
4	2.25	6.49114×10^{-08}	0.9409

Table-2
Lightness (L* values) of microwave dried onion slices

Drying method	Mw Density	L*	a*	b*
Microwave Drying	0.25	33.11	7.23	3.97
	1.00	41.53	6.82	4.71
	1.50	41.61	7.15	5.95
	2.25	38.48	8.54	6.30

Table-3
Rehydrational characteristics of microwave dried onion slices

Sr.no	Drying Techniques	Microwave Level (kW)	Rehydration ratio (RR)	Coefficient of rehydration (COR)
1	**Microwave Drying**	0.25	3.74	0.71
2		1.00	3.94	0.75
3		1.50	4.18	0.80
4		2.25	4.21	0.80

Table-4
Water activity (a_w) of microwave dried onion slices

Sr. No	Drying Technique	Power Level (%)	Water activity (a_w)
1	Microwave Drying	0.25	0.616
2		1.00	0.536
3		1.50	0.595
4		2.25	0.610

Table-5
Specific energy consumption of Osmo-microwave and microwave dried onion slices at different power levels

Sr. No	Microwave Level	Drying Time (min)	SEC (MJ/Kg $_{water}$)
1	0.25	952	17.66
2	1.00	407	23.20
3	1.50	318	35.39
4	2.25	192	32.05

Conclusion

Based on the results of the investigation, the following conclusions were drawn: The moisture diffusivity varied in the range of 6.491×10^{-09} to 6.491×10^{-08} m²/s during microwave drying of onion samples. Microwave drying efficiency of onion was in the range of 17.43 to 34.93 (MJ/Kg $_{water}$) at different power levels The values of rehydration ratio of microwave dried sample ranged from 3.74 to 4.21. Microwave power level had a significant effect on the rehydration ratio, colour and water activity of dried samples.

Notations Used: W_θ = mass of slices after time θ, g**,** W_i = initial mass of slices, g **,** WR = weight reduction**,** W_θ = mass of slices after time θ, g **,** W_i = initial mass of slices, g**,** X_θ = water content as a fraction of mass of slices at time θ., X_i =water content as a fraction of initial mass of slices, D = diffusion coefficient, M = moisture content g water per g dry matter**,** X= characteristic dimension i.e. distance from the center of the line and**,** T= time elapsed during the drying **,** SEC = Sp. energy consumption (J/kg water)**,** ton = total power-on time (s)**,** P = microwave power input (W)**,** m = initial mass (kg)**,** Mi = initial moisture content (ratio, wet basis)**,** Mf = final moisture content (ratio, wet basis)

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