J. of Soil Sciences and Agricultural Engineering, Mansoura Univ., Vol 12 (5):391 - 395, 2021

Journal of Soil Sciences and Agricultural Engineering

Journal homepage: www.jssae.mans.edu.eg
Available online at: www.jssae.journals.ekb.eg

Influence of Microwave Drying on Some Characteristics of Onion Quality

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ABSTRACT

The experiments were carried out at ABED*, FAMU** and connecting with ARI, ARC*** Dokki, Giza, Egypt to study effect of microwave drying on onion quality and properties at 2018. The following points will be considered: microwave power levels and onion slices thickness, fitting the mathematical models (Lewis's model) which describe the microwave drying curves. At 640W and thickness of 6mm are consider the olmost good treatment for dryer using microwave at 19°of Hue angle(H),considered the best method of drying onion because it was given the lowest value of total color change.

Keywards: onion slices ,microwave and solar drying.

INTRODUCTION

Onion ranks third world highest vegetable production. Fresh and dried forms of onion were used in the world market. The main important product of them are considered the falked, minced, chopped and powdered (Anonymous 2001 and Anonymous 2002). The average production of onion is 15.248 ton/ feddan. The total cultivated area for onion is about 194010 feddan and total production is estimated at 1549500 ton/year. Onion slices (*Allium cepa* L) is one of the most export product of Egypt (FAO 2018).

Water removal from agricultural and food materials is very energy intensive. The efficiency of drying with respect to both energy and time is an important economic consideration (Hebbar *et al.*, 2004).

Akpinar *et al.*, (2003) stated that drying of foods has been widely used throughout the history of man allowing flexibility in availability of these products regardless of season. Today the dehydrated food industry occupies an important place within general food industries throughout the world.

. Wang and Sheng (2006) showed that microwave is more rapid, more uniform and more energy efficient than hot-air convection and infrared radiation drying. The removal of moisture is accelerated and the rate of heat transfer from the surface into the interior of the solid material is significantly decreased due to the absence of convection.

Lewicki and Jakubczyk (2004) said that as a result of water removal, destruction of natural structures and loss of semi permeability of the membranes occurs, hence rheological properties also change. The outer layers of drying material become rigid and acquire considerable mechanical strength. One of the main physical changes influencing the structure of plant tissue during drying is shrinkage, which starts at the very beginning of the drying process. The shrinkage upon drying depends on tissue structure of the product subjected to drying, and for fruits and vegetables are almost linearly related to moisture content.

Kalse *et al.*, (2012) mentioned that 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 diffusive 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 color, rehydration and water activity was superior.

Sorour and ELmasery (2014) studied two medods for drying onion slices (weighing 100 g with a moisture content of 7.3 g water/g dry matter), using microwave and infrared radiation methods to a moisture content of 7% (wet basis). Three different output power levels of 200, 300 and 400 W were used for microwave drying, whereas the infrared drying treatment involved three intensity levels that were 3000, 4000 and 5000 W/m^{2}a drying air temperature of 35 C and air velocity of 0.5 m/s. They revealed that microwave drying was more effective in shortening drying time when compared with infrared drying. Microwave dried onion slices were lighter in color and had higher rehydration ratios meanwhile, onion slices were darker in color and had lower rehydration ratios when infrared drying method was employed. To evaluate the drying kinetics of onion slices.

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DOI: 10.21608/jssae.2021.179967

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The present study amied to evaluate and identifed the new techenic of drying slices of onion for decrement time of drying and enchancing product quallity.

MATERIALS AND METHODS

The experiments were carried out at ABED*, FAMU**and ARI, ARC*** Dokki, Giza, Egypt, to study effect of microwave drying on quality and properties of onion slices at 2018.

The onion Giza 20 was cultivated in the period from January to May at farm of Agricultural Research Center – Gemeiza Research station (2018).

Microwave oven

Microwave oven dryer of SHARP Company, 20 Liter volume is used for all experimental work.

Drying trails were carried out at three microwave generation power levels 320, 480and 640W. The average values from these trials were obtained and drying parameters were determined.

Lewis model

This model is used to evaluate the drying process. The model is presented in equation 1 and 2:

$$MR = \exp(-K_L t) \quad \text{..........(equ: 1)}$$

$$MR = \frac{Mi - Mf}{M - Mf} \quad \text{..........(equ: 2)}$$

Where;MR; Moisture ratio, %
Mi; M.Cof instantaneousof onion slices, %(db).
M; M.C of Initial of onion slices. % (db).
Mf; M.C Final moisture content of onion samples, % (db).
K_L; drying constant
T;Time of drying, min

Experimental procedures

Onions were hand peeled, cut into slices of approximately 2.0, 4.0, 6.0 ±0.1mmthickness with a sharp stainless steel knife. The simples of about 100g were used per each treatment of onion slices. The thickness of the onion slices was measured using venire caliper and their average values were identified. At the beginning of each experimental, three different masses of each representative samples were used to determine the average initial moisture content of onions at different onion slices thickness layers. The obtained results show that the average initial moisture content was 86%wb (733% db.).

The samples mass were indentifed by German Manufactured digital balance (Sartorius GP 4100) with accuracy of 0.01g.

Surface color measurements

The protable color analyzer is used to evaluate the samples surface color for each of dried and wet samples.Lutron, Model RGB-1002 equipped with an external sensor probe having a 45°/0° color measuring geometry. The color value of each sample was shown by color indices (RGB and HSL). "H" (hue angle) index for different samples varies in the range 0-360° that is describing a set of colors, "S" (saturation) shows purity and color saturation.

The device measures the intensity of color from 0% (neutral gray) to 100% (fully saturated or pure hue) which L (luminance) is the amount of illumination (luminosity) from 0.0% (no light) to 100% (full light).

Rehydration ratio

The rehydration ratio of dried onion slices was determined by dunking dried sample 10 g in 50 ml of water at room temperature and after 5 h; the water was drained and weighed. The rehydration ratio was calculated as the ratio of the mass of the rehydrated sample to that of dry sample using:

$$Rr = Mr \backslash Mb \qquad \text{(equ: 3)}$$

Which:
Mr =mass after rehydration
Mb= mass before rehydration

RESULTS AND DISCUSSION

Slices onion moisture content

Figure 1 (a, b and c) illustrates differences at moisture content of onion slices are fuction of drying time for all onion slices thickness and microwave power levels. The onion moisture content is decreased at increase of microwave power and decrease of the onion slices thickness.

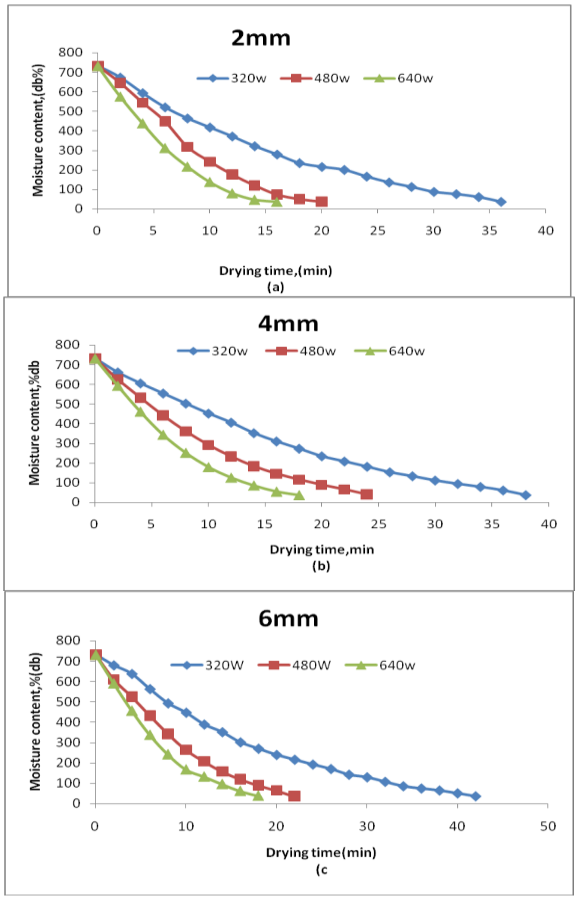

Figure (1 a, b and c) The moisture constant of onion via drying time at slices thickness and microwave power.

As shown in figure 1 (a, b, c) thickness of onion slices 2, 4 and 6mm reach the safe level of moisture content for storage after 16, 17and 18 minute respectively at microwave power level 640 watt, after 20, 24 and 22 minute respectively at microwave power 480 watt and after 36, 38 and 42 minute receptively at microwave power 320 watt.

Calculation of drying constant (kL) for Lewis's equation

The KL values at Lewis model (1) are determined as a function of moisture ratio (MR) with tested samples during time (t). Figure 2 (a, b and c), 3(a, b and c) and 4 (a, b and c) present this exponential relationship at the microwave power levels (320, 480 and 640 W) and onion slices thickness of 2, 4 and 6 mm,respectivly. Table (1) included the calculated drying values constant.

Table 1. KL values of lewis eguation under microwave power and slices thickness.

Microwave power (W)	Drying constant (KL) Thickness (mm)		
	2	4	6
320	0.08	0.074	0.075
480	0.168	0.125	0.135
640	0.232	0.187	0.18

As shown in Table (1) the drying constant (K_L), for each slices thickness increased greatly with increasing microwave power, and for each microwave power tend to decreased with increasing slice thickness.

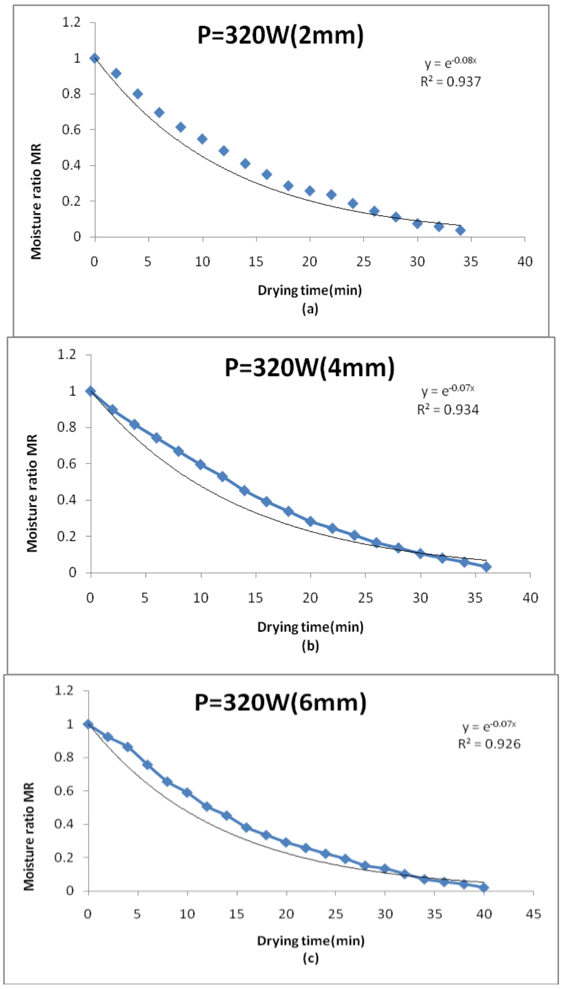

Figure (2 a, b and c): The relationship between time (min) and MR to determination the (KL) constant of Lewis equation at the maximum power of 320 W and different slices thickness.

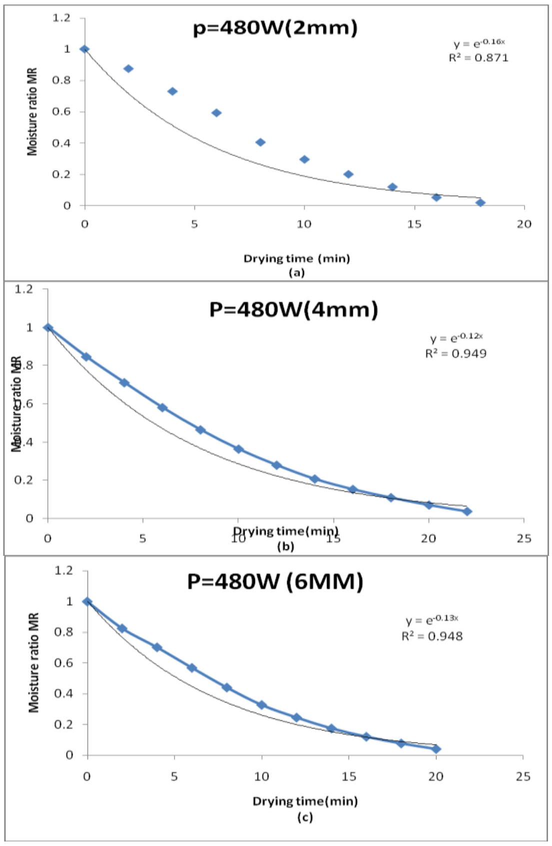

Figure (3 a, b and c): The relationship between time (min) and MR to determination the (KL) constant of Lewis equation at the maximum power of 480W and different slices thickness

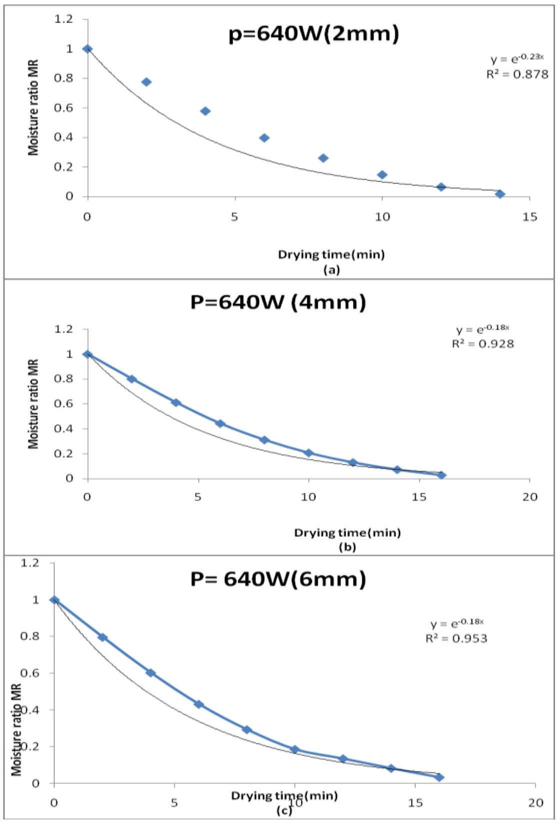

Figure (4 a, b and c): The relationship between time (min) and MR to determination the (KL) constant of Lewis equation at the maximum power of 640and different thickness of slices

The regression of samples was conformed to identife the drying parameters (power , slices thickness) and KL constant).The analysis indicated a direct linear relationship between KL constant and studied paramters (power and slices thickness), as shown as in figure 5 and equation 4.

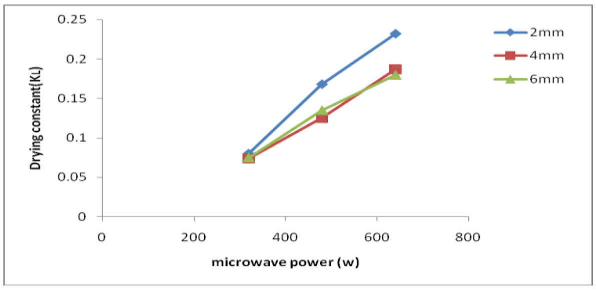

Figure 5. Relationship between (p) and "KL" at different (Th)

The relation between the microwave power (P) and KL constant under differentslices thickness were conformed in equ.4.

KL= a+ b (P) (Equ: 4)

Where;

KL; Drying constant **min^{-1}**
a ;Constant of equation **min^{-1}**
b ; Constant of equation **min^{-1}.W**
p ; Microwave power **W**

The value of R^2 which indicate the best treatment for the dried onion using lewis model is illustrated in table 3.

Table 2.Constants of equation and the coefficient of determination of equation (4)

Slices of thickness (mm)	a	b	R^2
2	-0.068	0.0005	0.9918
4	-0.0408	0.0004	0.9969
6	-0.0275	0.0003	0.9932

The relation between slices thickness and KL constant for microwave power as shown as in figure 6 and equation 5. A linear relationship KL constant and slices thickness identified at all microwave power'.

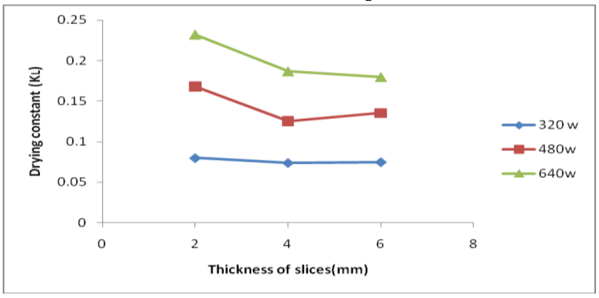

Figure 6. Relationship between "Th" and "KL" at different (p)

kL = c + d (Th) (equ: 5)

Where:

kL = Drying constant **min^{-1}**
c= Constants of equation **min^{-1}**
d = Constants of equation **min^{-1}.mm**
Th = Slices of thickness **mm**

Table 3. Constants of equation and the coefficient of determination of equation (5)

Power (W)	C	d	R^2
320	0.0813	-0.0012	0.6048
480	0.1757	-0.0083	0.5377
640	0.2517	-0.013	0.8489

Fitting curve simulation of Lewis model Figure 7and8 shows the measure and predicted values of moisture content at levels of drying slices thickness and power.

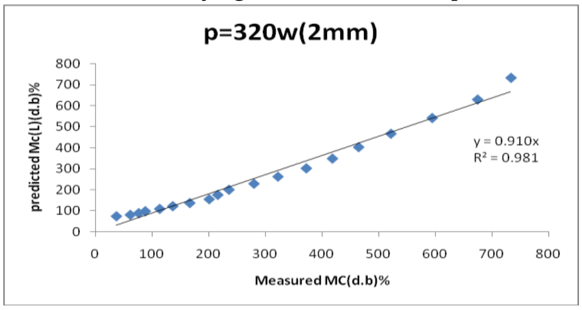

Figure 7. Measured and predicted values Lewis model at thickness (2mm) and power (320w)

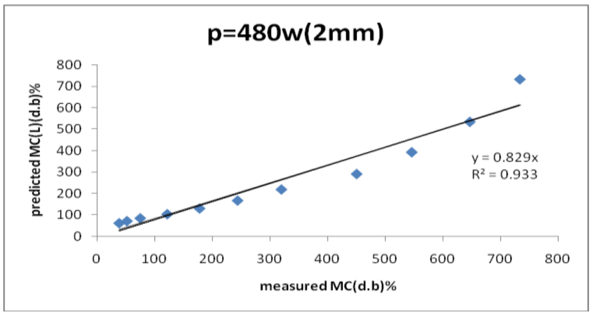

Figure 8. Measured and predicted values using Lewis model at thickness (2mm) and power (480w)

Color of onion drying

The data recorded in Table (4) cleared that there were significant differences between HSL color parameters for the fresh and dried onion samples. Demonstrably, the value of (H°) for fresh onion was 17° comparing with color map of the color measurement model HSL.

Table 4. Color analysis for fresh and dried onion slices samples

Drying method	Thickness	H° Range	Average	S (%) Range	Average	L (%) Range	Average
Fresh sample		15-20	17	80-95	88	75-85	80
Microwave dryer (640W)	2mm	18- 25	21	80-85	82	66-90	81
	4mm	18-21	20	85-88	86	78-93	83
	6mm	18-20	19	88-90	89	72-90	85
Microwave dryer (480W)	2mm	18-27	22	87-88	88	78-93	83
	4mm	18-23	21	86-89	88	62-90	72
	6mm	18-22	20	86-88	87	66-78	71
Microwave dryer (320W)	2mm	21-27	24	85-88	86	60-79	70
	4mm	17-26	22	85-88	86	60-79	70
	6mm	19-20	20	66-91	82	73-76	74

While, the best value of (H°) was 22° for direct solar dryer at slices thickness 2mm. These results may be due to the highest value of saturation (S) 80% and lightness value 80%. Similarly, the best treatment for microwave dryer was identified at treatment of 640W (6mm), where; (H°) value was 19° with saturation value 89% and 85% lightness.

Figure (9) show that the effect of different slices thickness and levels of microwave power on the hue angle of the onion slices dried by microwave oven. The hue angle decreased by the increasing of slices thickness and levels of microwave power.

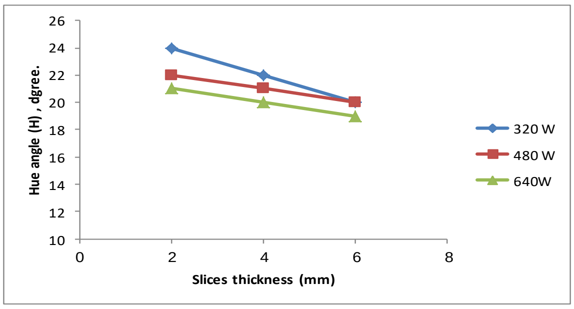

Figure 9. Effect of different slices thickness on the hue angle at levels of microwave power by microwave oven.

Rehydration of onion drying

Figure (10) shows the effect of different slices thickness on the rehydration ratio of onion slices dried by the microwave oven as indicators of quality. The rehydration ratio increased by the increase microwave power levels and onion slices thickness upto 640 W.

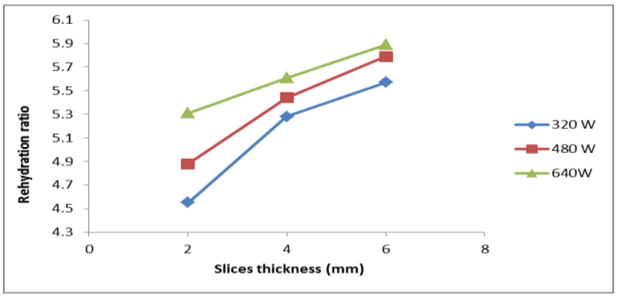

Figure 10. Effect of different slices thickness on the rehydration ratio by microwave oven.

Changing the slices thickness from 2 to 6 mm at the minimum microwave power level 320W increased the rehydration ratio from 4.55 to 5.57. On the other hand, at the maximum microwave power level of 640 W increased the rehydration ratio from 5.31 to 5.89.The increase of microwave power levels and onion slices thickness may be due to less shrinkage of the onion slices.

Recommendations:

1. Microwave oven can be used in drying onion slices.
2. At 640W and thickness of 6mm are consider the olmost good treatment for dryer using microwave at 19°of Hue angle(H),considered the best method of drying onion because it was given the lowest value of total color change.

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تأثير التجفيف بالميكروويف على بعض خصائص جودة البصل

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أجريت التجارب في قسم الهندسة الزراعية والنظم الحيوية – كلية الزراعة – جامعة المنوفية والمعمل المركزي بمعهد بحوث الهندسة الزراعية – مركز البحوث الزراعية – الدقي – الجيزة لدراسة تأثير التجفيف علي خواص الجودة للبصل بالميكروويف. وقد تم دراسة تأثير مستويات مختلفة من الطاقة وأسماك مختلفة من شرائح البصل علي خصائص التجفيف باستخدام فرن الميكروويف. واستخدام نموذج Lewis's model في توفيق منحنيات تجفيف الميكروويف. ودراسة خواص الجودة للمنتج النهائي. وكان من أهم توصيات الدراسة يفضل تجفيف شرائح البصل بالميكروويف عند مستوى الطاقة 640 وات وسمك6مم لان ذلك يعطى أقل قيمة لزاوية(Ho) وهى 19 درجة.