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Convective-cum-Microwave Drying Characteristics of Ginger *(Zingiber officinale)*

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Abstract

Investigations were carried out to study the effect of drying parameters viz. exposure time, pause time and power level on convective-cum-microwave drying of ginger. Multilayer drying of ginger was carried out at 3 levels each of exposure time (5-25s), pause time (10-100s) and microwave power levels (270–1350W). Drying air temperature, relative humidity, air velocity, moisture content, moisture ratio and drying rate were measured. Quality attributes included rehydration ratio, shrinkage ratio, colour change, oil content and overall acceptability. Multilayer drying of ginger with an initial moisture content of 89% wb was carried out at 60°C, air velocity of 3.5 m/s and loading density of 44.66 kg/m^2 in a mechanical drier till the moisture content reached 35% (wb) followed by drying in microwave oven to a final moisture content of 6% (db). The drying rateincreased with the increase in exposure time and power level whereas it decreased with the increase in pause times. The increase in exposure time resulted in increased rehydration ratio, colour change and decrease in shrinkage ratio, oil content and overall acceptability. Pause time had little effect on quality parameters. The increase in power level resulted in increase in rehydration ratio, colour change and decrease in shrinkage ratio, oil content and overall acceptability. The optimum conditions were found to be 8.6s exposure time, 55s pause time and 810W power level. During storage the maximum variation in quality was observed in LDPE package and the results were comparable for HDPE and Laminate packages.

Keywords: Drying-kinetics, ginger, optimization, microwave, multilayer drying, storage.

1. Introduction

Ginger, the rhizome of *Zingiber* species, has long been used both in medicine and in spice form (Sagar and Kumar, 2009). *Zingiber officinale* belongs to the botanical family of the *Zingiberaceae.* Ginger is a perennial plant with upright reddish stem, looking like leaves, and grows from one to three or four feet in height. It originated in India and is grown in almost all the states. It is rich in nutrients as it contains proteins, essential fats and vitamins B and C. It is rich in antioxidants. It contains up to 85-91% moisture, 3–8% proteins, 2–6% fat, and 3-6% fibre. Ginger has been widely used all over the world as a safe herbal medicine for treatment of arthritis, rheumatism, muscular aches, sore throats, cramps, hypertension, dementia etc (Tanira et al., 2008). The characteristic flavor and aroma of ginger is due presence of 3% essential oil.

A 5% solution of essential oil of ginger, *Zingiber officinale*, is used as post-operative treatment for nausea and vomiting caused by motion sickness or other illness. It also clears congestion in the body and detoxifies it by promoting elimination of wastes through the skin, mainly through sweating. It is also said that ginger acts as a catalyst to improve the absorption and effectiveness of other herbs (Anonymous 2010). It has antioxidant effect that can control the generation of free radicals. Free radical level has been reported to be high in cancer cells (Norliza et al., 2006).

Dried foods can be stored for long periods without deterioration. Drying brings about substantial reduction in weight and volume; thereby lowering packaging, transportation and storage costs and enables storability of the product under ambient temperatures.

The product may be dried in single or multiple layers. Drying in thin layers has proved to be expensive and energy inefficient. However, multilayer drying has not been found suitable for products having high moisture content.

Use of microwave energy in drying offers reduced drying times and complements conventional drying in later stages by specifically targeting the internal residual moisture. Because waves can penetrate directly into the material, heating is volumetric (from inside out) and provides fast and uniform heating throughout the entire product. The quick energy absorption by water molecules causes rapid water evaporation (resulting in higher drying rates of food), creating an outward flux of rapidly escaping vapour. Many conventional thermal methods including airflow drying, vacuum drying, and freeze-drying, result in low drying rates in the falling rate period of drying (Clary et al., 2005). Combined drying of hot air and microwave-vacuum resulted in a dried product of superior quality (Argyropoulos et al., 2011). Also, in comparison to conventional drying, the microwave assisted drying shows more stability of macro and micronutrients present in the product (Camacho et al., 2012).

Most of the research work on combined microwave-convective drying of agricultural commodities has been reported for low-moisture foods such as grains (Mosqueda and Tabil, 2011). This necessitates developing an efficient drying technique that reduces the drying time, energy consumption and produce good quality dehydrated product. Thus, the present study has been planned to study the drying kinetics of microwave drying of ginger, to study the effect of microwave process parameters on the quality of dried ginger, to optimize the microwave dehydration process parameters, to study the quality of dehydrated ginger during storage.

2. Materials and Methods

2.1. Raw materials

The fresh ginger was procured from local market, Ludhiana; the sample was prepared in the food engineering laboratory. Ginger was peeled manually with the help of knives and peelers, and then sliced within a thickness of 2.5 mm with the help of cutter. The colour and moisture content of fresh ginger was noted. The initial moisture content of ginger was 89% (wb) and having l, a and b value were 58.6, 6.4 and 22.7 respectively.The samples were pretreated as per procedure reported by Schweiggert et al. (2008). Ginger was blanched by tying the sample in muslin cloth and dipped for 5 min in hot water at 90 °C and subsequently dipped in cold water for 1 min to minimize losses of valuable compounds.

2.2. Experimental procedure

Multilayer drying was carried out in satake dryer and microwave drying was carried out in a microwave. The ginger was put into the drying boxes according to the desired loading density to get the required bed depth. The temperature and relative humidity of the ambient, incoming and exhaust air were determined with the help of thermo-hygrometer placed on the surface of the sample. All these parameters were recorded at regular intervals. The sample was dried to a final moisture content of 35% (wb) in multilayer drying and thereafter the sample was shifted to the microwave oven till the final moisture content 6% (db). For each experiment, the known weight of dried ginger was formulated as per experimental combinations by varying exposure time (s), pause time (s) and power level (W) (Table 1) and quality attributes (color, rehydration ratio, shrinkage ratio, oil content and overall acceptability) were measured by standard procedures. The samples were allowed to come to room temperature, packed and stored. Three replications were taken for each experiment to get an average values.

2.3. Statistical analysis of multilayer-cum-microwave data

The data were statistically analyzed by using SPSS 16.0 computer software package.

Table 1: Experimental structure with coded and actual levels of the process variables for the dried ginger using Box-Behnken Design

E/S	Pause time (X_1)		Exposure time (X_2)		Power level (X_3)	
	Actual	Coded	Actual	Coded	Actual	Coded
1.	55	0	15	0	810	0
2.	10	-1	15	0	270	-1
3.	55	0	15	0	810	0
4.	100	1	15	0	270	-1
5.	55	0	15	0	810	0
6.	10	-1	15	0	1350	1
7.	10	-1	5	-1	810	0
8.	55	0	25	1	270	-1
9.	100	1	25	1	810	0
10.	100	1	5	-1	810	0
11.	10	-1	25	1	810	0
12.	55	0	25	1	1350	1
13.	55	0	5	-1	1350	1
14.	55	0	5	-1	270	-1
15.	100	1	15	0	1350	1
16.	55	0	15	0	810	0
17.	55	0	15	0	810	0

E/S: Experiment/ sample no.

2.4. Optimization of multilayer-cum-microwave drying for ginger

The Response surface methodology (Box-Behnken Design) was applied to the experimental data using a commercial statistical package, Design-Expert trail version 9.0.4 (Statease Inc., Minneapolis, USA) for getting optimal values.

2.5. Effective moisture diffiusivity

During drying, it can be assumed that diffusivity, explained with Fick's diffusion equation, is the only physical mechanism to transfer the water to surface (Dadali et al., 2007; Dincer and Dost, 1995; Wang et al., 2007). Effective moisture diffusivity, which is affected by composition, moisture content, temperature and porosity of the material, is used due to the limited information on the mechanism of moisture movement during drying and complexity of the process (Abe and Afzal, 1997).

2.6. Statistical evaluation of the models

Linear and nonlinear regression models are important tools to find the relationship between different variables, especially for which no established empirical relationship exists. The validity of the above empirical models as shown in Table 2 was checked by non-linear regression technique using SPSS (Statistical package for social science version 16.0), in order to predict the mass kinetics of convective-cum-microwave

Table 2: List of microwave drying models

Sl. No.	Name of model	Model equation	Reference
1.	Newton's model	MR=Exp (-kt)	Lewis (1921)
2.	Logarithmic model	MR=b+a Exp (-kt)	Yagcioglu (1999)
3.	Henderson and Pabis model	MR=a Exp (-kt)	Henderson (1974)
4.	Two term exponential	MR=a exp(-kt)+(1–a) exp (-kat)	Sharaf-Eldeen et al. (1980)
5.	Wang & Singh model	MR=1+at+bt2	Wang and Singh (1978)
6.	Page model	MR=Exp (-ktn)	Page (1949)
7.	Midilli model	MR=a Exp (-ktn)+bt	Midilli et al. (2002)

drying of ginger.

The various statistical parameters such as coefficient of determination (R^2), reduced chi-square (χ^2) and root mean square error (RMSE) were used as primary criterion to select the best model. Therefore, the best model or the goodness of fit was determined by choosing one with the highest R^2, and the least χ^2, RMSE and P% and were defined by the following equations. (1)

$$R^2=\frac{\sum_{i=1}^{n}(MR_i-MR_{pre,i}).\sum_{i=1}^{n}(MR_i-MR_{exp,i})}{\sqrt{\left[\sum_{i=1}^{n}(MR_i-MR_{pre,i})^2\right].\left[\sum_{i=1}^{n}(MR_i-MR_{exp,i})^2\right]}} \quad (2)$$

$$\chi^2=\frac{\sum_{i=1}^{n}(MR_{exp,i}-MR_{pre,i})^2}{N-n} \quad (3)$$

$$MBE=\frac{1}{N}\sum_{i=1}^{N}(MR_{pre,i}-MR_{exp,i}) \quad (4)$$

$$RMBE=\left[\frac{1}{N}\sum_{i=1}^{N}(MR_{pre,i}-MR_{exp,i})^2\right]^{\frac{1}{2}}$$

$$P\,(\%)=\frac{100}{N}\sum_{i=1}^{N}\left|\frac{\text{Experimental value-predicted value}}{\text{Experimental value}}\right|$$

Where, $MR_{exp,i}$ and $MR_{pre,i}$ are experimental and predicted dimensionless moisture ratios, respectively, N is no. of observations and z is number of constants.

2.7. Storage of dried ginger flakes

Dried garlic flakes were packed in high density polyethene (HDPE), low density polyethene (LDPE) and laminate packages and samples were stored at ambient condition for six months. The quality parameters studied were rehydration ratio (RR), Shrinkage ratio (SR), Colour change (CC), Oil content (OC) and overall acceptability (OA).The statistical analysis of data was done by using uni-variateanalyses of variance (UNI-ANOVA) in general linear model using Statistical Package for Social Science (SPSS, 16.0). Means were computed and tested at 5% level of significance.

3. Results and Discussion

3.1. The effect of exposure time, pause time and power level on moisture content and drying rate

Study on convective-cum-microwave drying of ginger was carried out in session 2013–2014 to evaluate the effect of exposure time, pause time and microwave power level on drying kinetics and quality attributes. The ginger slices were dried using multilayer drying at an air temperature of 60 °C at air velocity of 3.5 m/s and loading density of 44.66 kg m^{-2} upto a moisture content of ≈35% wb (the point where drying rate became slow) followed by microwave drying to a moisture content of ≈6% db (bone dry conditions) to overcome the slow removal of moisture at the end (Andres et al., 2004). The drying process parameters viz; exposure time, pause time and microwave power level were optimized using 'Response Surface Methodology 'where 3-Factor Box–Behnken Design was used for responses, namely; color, rehydration ratio, shrinkage ratio, oil content and overall acceptability. In addition, the impact of various parameters on quality of ginger was also investigated. The microwave drying of ginger was carried out at 3 levels of exposure time ranging between 5–25 s and 3 levels of pause time ranging between 10–100 s and microwave drying was carried out at 3 power levels ranging between 270–1350W.

It was observed that moisture content decreased with increase in exposure time irrespective of the pause time and Power level. However the effect was least pronounced at lower ET because of lower drying rate. Moisture content values were closer at 15 and 25s ET.e.g. at 10s PT and 810W PL, the moisture content after 10 min of microwave drying was 20.00, 21.81 and 53.00 (% db) at 25, 15 and 5s exposure time respectively (Figure 1). Similar trends were found in other combinations as well.

There was a significant effect of pause time on decrease in moisture content in microwave drying at different exposure

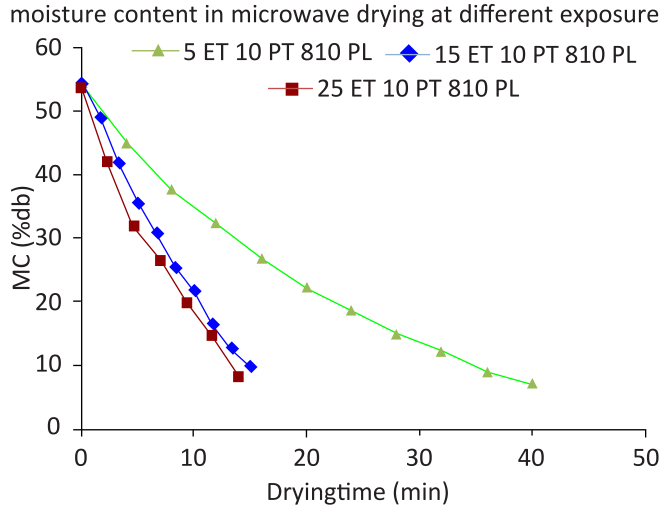


Figure 1: Effect of exposure time on moisture content

time and power levels. Decrease in moisture content decreased with increase in pause time due to lower moisture diffusion. Moisture content removal was gradual at all pause times. For e.g. at 15s ET and 270W PL, the moisture content after 15 min of microwave drying was 29.55, 39.00 and 44.50 (% db) at pause time of 10, 55 and 100 s respectively (Figure 2).

It was also observed that the decrease in moisture content increased with increase in power level irrespective of exposure time and pause time. However the effect was least pronounced at lower PL. The moisture content values were closer at 810 and 1350W PL. But the effect of PL was more at 25s ET. For e.g.at 25s ET, the moisture content after 7 min of

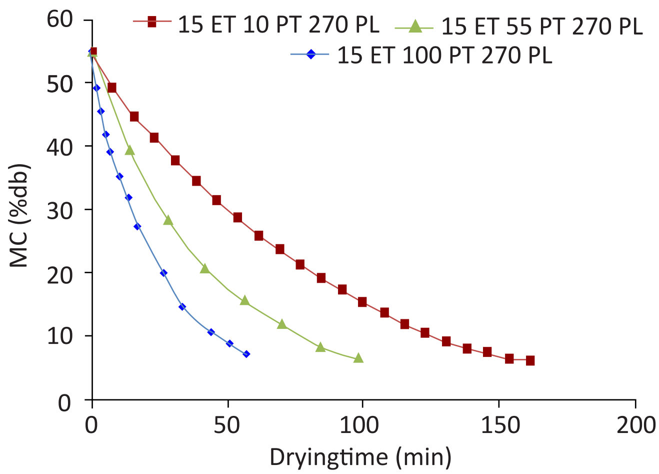


Figure 2: Effect of pause time on moisture content

microwave drying was 38.18, 26.36, 11.81% at 270, 810 and 1350 W respectively and the corresponding values at 15 s exposure were 39.09, 30.80, 17.20 (% db) (Figure 3).

The initial drying rates were different for all the combinations of exposure time and pause time. The initial drying rate was highest (77.92 g min^{-1} kg) for sample with 25s ET, 10s PT and 1350W PL and was lowest (1.95 g min^{-1} kg) for sample with 5s

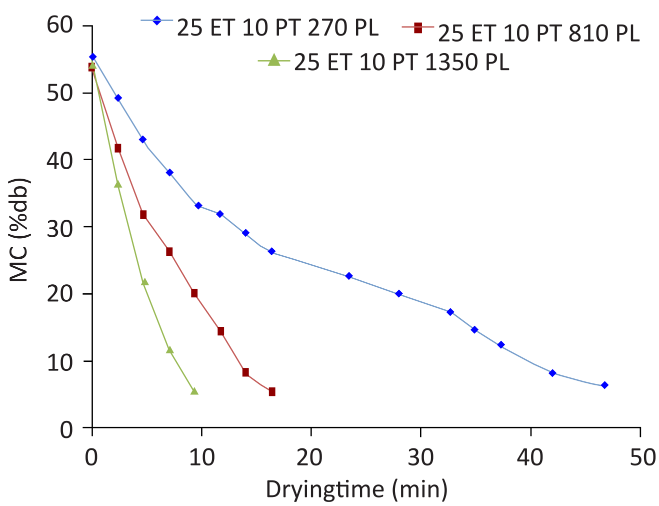


Figure 3: Effect of power level on moisture content

ET, 100s PT and 270W PL. The effect of exposure time, pause time and power level on drying rate in microwave drying are presented in Figure 4, Figure 5 and Figure 6 respectively. It

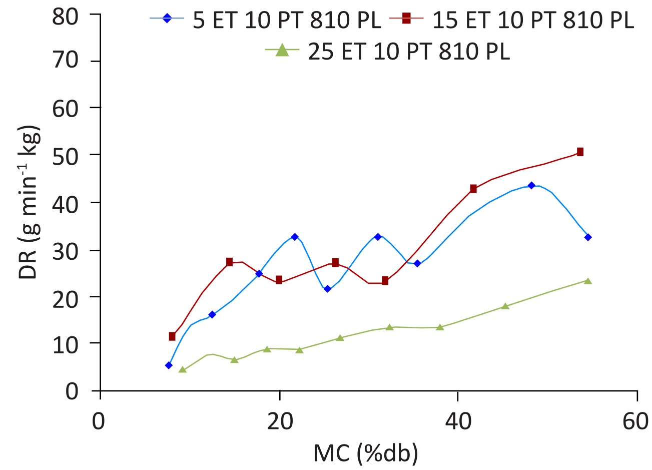


Figure 4: Effect of exposure time on drying rate

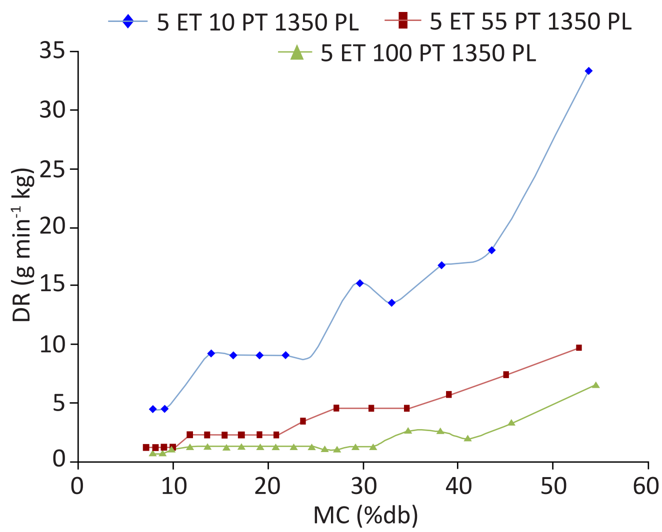


Figure 5: Effect of pause time on drying rate

was visualized from the plots that, as the drying progressed, both, moisture available as well as drying rate declined. The drying rate decreased with decrease in available free moisture owing to lower driving force and lower moisture diffusion from centre to the surface of the dried product. Most of the samples dried in falling rate periods. Few odd samples showed slightlyconstant rate period at the beginning of drying that too lasted for a few seconds in MWD. Generally, more than one falling rate period was observed.

It was clear that drying rate increased with increase in exposure time irrespective of the pause time and power level. However the effect was least pronounced at lower ET because of lower moisture removal. Drying rate values were quite closer at 15 and 25s ET e.g. at 10s PT and 810W PL, the drying rate after 5 min of microwave drying was 42.86, 38.18 and 22.73 (g min^{-1} kg) at 25, 15 and 5s ET respectively (Figure

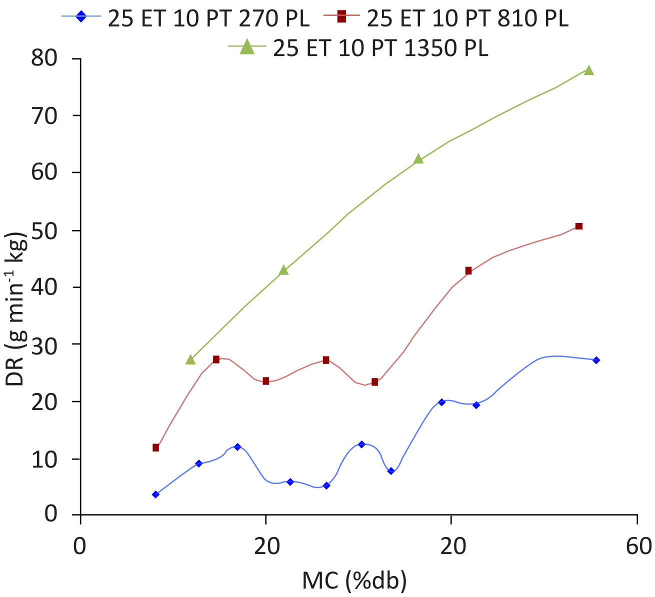


Figure 6: Effect of power level on drying rate

4). Similar trends were found in other combinations as well.

Drying rate decreased with increase in pause time due to decrease in moisture diffusion within the material owing to the cooling effect during prolonged pause time. Drying rate values were closer at 55 and 100s PT. For e.g. at 5 ET and 1350 PL, the drying rate after 7 min of microwave drying was 13.64, 9.00, 7.79 (g min^{-1} kg) at 10, 55 and 100s PT respectively (Figure 5). Similar tends were found in other combinations as well. It was clear that the drying rate increased with the increase in power level. However the effect was more pronounced at higher exposure times. Similar results were observed for microwave assisted convective drying of onion slices (Sahoo and Mohanty 2011). When the interior of the ginger reached the boiling point of water, free moisture evaporated inside the product, which caused a vapour pressure gradient that expelled moisture from the sample. The vapour pressure developed within the food sample led to an increase in pore size, which is known as the puffing effect. The increased pore size provides easy diffusion of moisture throughout the sample (Mudgett, 1989). For e.g. at 25s ET and 10s PT, the drying rate after 7 min of microwave drying was 19.48, 23.38, 42.86 (g min^{-1} kg) at 270, 810 and 1350W PL respectively. Similar trends were shown in other combinations as well. There were exceptions like in certain treatments (5 ET 10 PT 810 PL, 15 ET 10 PT 810 PL, 25 ET 10 PT 810 PL; 5 ET 10 PT 1350 PL, 15 ET 10 PT 1350 PL; 5 ET 55 PT 810 PL, 15 ET 55 PT 810 PL, 25 ET 55 PT 810 PL; 5 ET 100 PT 270 PL, 15 ET 100 PT 270 PL, 25 ET 100 PT 270 PL; 5 ET 10 PT 270 PL, 5 ET 55 PT 270 PL, 5 ET 100 PT 270 PL; 15 ET 55 PT 270 PL, 15 ET 55 PT 810 PL, 15 ET 55 PT 1350 PL) where the values of DR were quite closer at two power levels compared to the third. However an erratic trend was also observed in certain combinations (5 ET 100 PT 270 PL, 5 ET 100 PT 810 PL, 5 ET 100 PT 1350 PL).

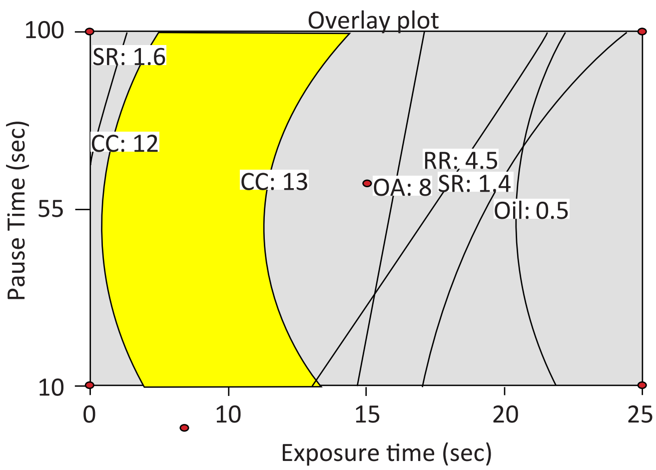
3.2. Optimization of multilayer cum microwave drying of ginger

The optimum values of process parameters and responses are presented in Table 3. The process conditions for microwave drying of ginger were optimized using numerical optimization technique. The main criteria for constraints optimization were maximum possible rehydration ratio, volatile oil, overall acceptability and minimum possible shrinkage ratio, color change (Themelin et al., 1997; Ade-Omowaye et al., 2002). The contour plots for each response were generated for different interaction of any two independent variables. In order to optimize the process conditions for microwave drying of ginger by numerical optimization technique, equal importance of '3' was given to three process parameters (*viz.* exposure time, pause time and microwave power level) and responses (i.e. rehydration ratio, shrinkage ratio, color, volatile oil, overall acceptability and total drying time). The conditions were experimentally verified with deviation of +0.10%. The optimum operating conditions for exposure time, pause time and microwave power level was 8.6s and 55s and 810W respectively. Corresponding to these values

Table 3: Optimum values of process parameters and responses

Process parameters	Goal	Lower limit	Upper limit	Importance	Optimization level
A: exposure time (s)	In range	5	25	3	8.6
B: pause time (s)	In range	10	100	3	55
C: Power level (W)	In range	270	1350	3	810
Responses					Predicted value
Rehydration ratio	Maximize	3.1	4.94	3	4.24
Shrinkage ratio	Minimize	1.14	1.71	3	1.54
Color change	Minimize	8.71	17.66	3	12.58
Volatile oil	Maximize	0.38	0.74	3	1.21
Drying time	Minimize	7	287	3	90
Overall acceptability	Maximize	6.8	8.7	3	8.31

of process variables, the value of rehydration ratio, shrinkage ratio, volatile oil, colour change, drying time and overall acceptability were 4.24, 1.54, 1.21, 12.58, 90, 8.31 respectively (Figure 7). The overall desirability was 0.69.



RR: 4.23541; SR: 1.53655; CC: 12.5788; Oil: 0.607039; OA: 8.30671; X1: 8.60; X2: 55.00

Figure 7: Superimposed contour plot of different responses for optimization of convective cum microwave dehydration of ginger

3.3. *Effective moisture diffusivity during microwave drying of ginger*

The experimental data for effective moisture diffusivity has been given in the Table 4. The exposure time and power level have a pronounced influence on the drying rate and as a consequence, markedly affects the value of the diffusion coefficient. With increase in exposure time and power level, the effective diffusivity increased due to the increase in the vapor pressure inside the sample. The highest D_{eff} value of 73.03×10^{-9} m^2/s was recorded for treatment (15 ET 10 PT 1350 PL) and lowest value of 1.01×10^{-9} m^2/ s was recorded for treatment (5 ET 100 PT 270 PL).

3.4. *Validation of empirical models for microwave drying*

In order to evaluate the performance of microwave models that fit into ginger drying, the values of statistical parameters for all the experimental runs were compared and model coefficients were calculated using non-linear regression techniques of SPSS version 16. Seven drying models were fitted to experimental data using Σ-Plot. Out of seven, only five were compatible with the experimental data .The fitness of drying models was tested in terms of coefficient of determination (R^2), Chi-square (χ^2) and root mean square error (RMSE). The best model chosen was one having the highest R^2 and the least χ^2 and RMSE. These models coefficients

Table 4: Effective moisture diffusivity (m^2/s) for microwave drying of ginger

Treatment	Layer thickness 25×10^-6 m							
	R2	Deff× 10-9	Treatment	R2	Deff× 10-9	Treatment	R2	Deff× 10-9
5ET 10 PT 270 PL	0.8686	9.13	5 ET 55 PT 270 PL	0.8766	3.04	5 ET 100 PT 270 PL	0.8595	1.01
15 ET 10 PT 270 PL	0.9516	12.17	15 ET 55 PT 270 PL	0.9272	7.10	15 ET 100 PT 270 PL	0.9051	5.07
25 ET 10 PT 270 PL	0.9815	8.11	25 ET 55 PT 270 PL	0.8501	8.11	25 ET 100 PT 270 PL	0.9326	4.06
5 ET 10 PT 810 PL	0.872	16.23	5 ET 55 PT 810 PL	0.8845	4.06	5 ET 100 PT 810 PL	0.8014	2.03
15 ET 10 PT 810PL	0.8894	38.54	15 ET 55 PT 810 PL	0.8659	22.31	15 ET 100PT 810 PL	0.9598	9.13
25 ET 10 PT 810 PL	0.9316	32.46	25 ET 55PT 810 PL	0.9544	16.23	25 ET 100 PT 810 PL	0.979	10.14
5 ET 10 PT 1350 PL	0.8958	17.24	5 ET 55 PT 1350 PL	0.9234	5.07	5 ET 100 PT 1350PL	0.8471	2.03
15 ET 10 PT 1350 PL	0.8701	73.03	15 ET 55 PT 1350 PL	0.9626	14.20	15 ET 100 PT 1350 PL	0.9703	10.14
25 ET 10 PT 1350 PL	0.9681	43.61	25 ET 55 PT 1350 PL	0.9718	14.20	25 ET 100 PT 1350 PL	0.9717	9.13

and the results of statistical analysis are presented in Table 4. The lowest R^2 value of 0.907 was obtained for Newton model fitted to drying condition: 15s ET, 55s PT, 810W PL; while the highest value of 1.00 was obtained for logarithmic and Wang and Singh model fitted to drying condition:25s ET, 55s PT, 810W PL;15s ET, 55s PT, 1350W PL;25s ET, 55s PT, 1350W PL and15s ET, 100s PT, 1350W PL. The lowest value 0.000327 was obtained for page model fitted to drying condition: 15s ET, 55s PT, 270W PL; while the highest value 47.148 was obtained for logarithmic model fitted to drying condition: 15s ET, 55s PT, 270W PL. The lowest RMSE value 0.01768 was for page model fitted to drying condition: 15s ET, 55s PT, 270W PL; while the highest value 6.708 was for logarithmic model fitted to drying condition: 15s ET, 55s PT, 270W PL. It is clear that the Page model showed the highest adequacy of fit between experimental and predicted data for constant pause time, exposure time and power level.

3.5. *Storage of dried ginger flakes*

3.5.1. *Effect of storage period on rehydration ratio, shrinkage ratio, colour change, oil content, flavor and overall acceptability*

The rehydration ratio of the stored product decreased with the increase in storage period. The maximum variation (3.82

to 4.45) in rehydration ratio with storage period was observed in LDPE packed sample and minimum in HDPE (4.45−4.00) and laminate (4.45−4.01). The shrinkage ratio of the stored product increased with the increase in storage period. The maximum variation (1.40 to 1.57) in shrinkage ratio with storage period was observed in LDPE packed sample and minimum in HDPE (1.40−1.49) and laminate (1.40−1.52). The colour change of the stored product increased with the increase in storage period. The maximum variation (13.20 to 14.53) in colour change with storage period was observed in LDPE packed sample and minimum in HDPE (13.20−14.42) and laminate (13.20−14.50).The oil content of the stored product decreased with the increase in storage period. The maximum variation (0.92 to 1.32%) in oil content with storage period was observed in LDPE packed sample and minimum in HDPE (1.10-1.32%) and laminate (1.08-1.32%).The flavour of the stored product decreased with the increase in storage period. The maximum variation (7.50−8.30) in flavour with storage period was observed in LDPE packed sample and minimum in HDPE (7.70−8.30) and laminate (7.60−8.30). The overall acceptability of the stored product decreased with the increase in storage period. The maximum variation (7.30−8.30) in OA with storage period was observed in LDPE packed sample and the minimum variation in OA was observed in HDPE (7.50−8.30) and laminate (7.40−8.30).The univariate ANOVA also corroborated the results showing that the storage period and packaging material has significant effect on rehydration ratio, shrinkage ratio, colour change, oil content, flavor and overall acceptability at 5% level of significance.

4. Conclusion

Higher values of exposure time and power level resulted in faster moisture removal and vice-versa. Also the drying rate increased with increase in exposure time and power level but the drying rate decreased with decrease in available free moisture. The page model showed higher adequacy of fit. The best quality of ginger was measured under optimum operating conditions of 8.6s exposure time, 55s pause time and 810W power level.

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