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SHORT COMMUNICATION

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COMPARATIVE STUDY ON DRYING CHARACTERISTICS AND QUALITY CHANGES OF GREEN CHILI

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ABSTRACT

In this study, green chili was dried by a pilot scale microwave-convective dryer. This work presents experimental study of the drying kinetics and modeling of green chili under different blanching pretreatments and drying conditions. The effects of water blanching and microwave blanching followed by microwave convective and hot air drying treatments respectively on drying rate, effective moisture diffusivity, and color change of green pepper were studied in comparison with un blanched samples at constant microwave power level, hot air temperature and air velocity .Results indicated that drying rate was found to be affected by pretreatments. Chili samples with microwave blanching pretreatment followed by microwave convective treatment dried faster and had higher Hunter L (lightness), a (redness) and þ(yellowness) values than the untreated and hot air dried chilies. The drying data were fitted to the seven thin-layer drying models. The Midilli model was found to be the best fit for the microwave drying behavior of chili with R2> 0.995, RMSE< 0.019 and χ^2< 0.031.This study shows that the microwave convective drying technique can be used to achieve better quality end product

I. INTRODUCTION

For the preservation of vegetables, drying is one of the oldest methods known . The basic objective in drying food products is the removal of water in the solids up to a certain level, at which microbial spoilage and deterioration chemical reactions are greatly minimized. [1].

India has produced around 1 million tonnes of chilli and export different types of chillies required to various markets around the world. Green chili (Capsicum frutescens) is consumed as both a raw and cooked vegetable, as well as being commonly used in making powders, paste, pickles and sauce [2]. Chili has high vitamin content (C, B and E), flavanoids, capsaicin and minerals [3]. Traditional methods of processing such as sun drying take many days to produce, which leads to low production rate [4]. Hot air-drying is the most widely used drying operation in food and chemical industry. Although it is used because of simplicity of construction and operation, there is a concern for nutritional quality loss, color change, shrinkage and long drying time [5].

Microwave drying of food materials has been identified as a potential means for reducing the total drying time. [6, 7, 8, 9]. Some strategies used to improve dried product quality include combination of microwave and conventional hot air drying, pulsed or intermittent drying, and microwave-vacuum drying [10]. Utilizing microwave (MW) energy in drying offers reduced drying times and complements conventional drying in later stages by specifically targeting the internal residual moisture [11]. Generally the first step in fruit and vegetable processing is blanching in order to avoid the production of unpleasant flavors and browning. The blanching of peppers is usually performed using hot water or steam. Microwave blanching reduces heating time, as well as the loss of water soluble nutrients that are leached into the water [5]

Therefore, the objective of this study was to investigate the suitability of various drying models to describe the microwave convective drying behavior of green chili after MW blanching. A comparison study was also conducted to compare the colour and drying characteristics of conventional hot air drying process combined with water blanching.

II. PROCEDURE

A schematic diagram of the microwave convective drier is shown in Fig. 1. Drying treatment was performed in a industrial microwave oven (customized) with technical features of 220 V, 50 Hz and 1.2 kW, at the frequency of 2450 MHz, The adjustment of microwave output power and processing time was done with the aid of a digital control facility located on the microwave oven. Each sample was placed at the centre of the oven during drying experiments.

Fresh green chilis were divided into 3 groups. First group contains two control samples treated by hot air and microwave convective treatment (130 W) respectively. Second group sample was pretreated by water blanching at 100°C for 3 minutes followed by hot air treatment. Third group sample was pretreated by microwave blanching at 6.3 W/g for 3 min followed by microwave convective treatment (130 W).

Drying trials were carried out at constant air velocity (2.2 m/s), constant hot air temperature (60°C). During drying experiments, each sample was put on the rotating glass of microwave and is placed at the centre of the oven cavity. Moisture loss was measured by taking out the rotating glass and periodically weighing on the digital balance with a precision of 0.01 g. Drying trial was carried out until the weight of the chili sample reduced to a level corresponding to moisture content of about 0.1 kg water/kg dry base. All the experiments were done in two replications.

For quality evaluation, moisture content and colour of samples were measured using the methods described by Ranganna [12] and Hunter Lab Colorflex colorimeter (Hunter Associates Laboratory, Reston, Va., U.S.A.) respectively. The color values were expressed as L*(lightness), a*(redness /greenness) and b*(yellowness/blueness). total color difference (ΔE) were calculated in comparison with unbranched chili (control).

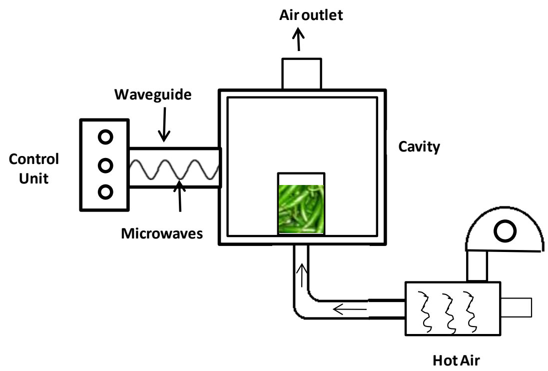

Fig. 1. Schematic diagram of microwave- convective dryer

A. Mathematical modelling

It is important to model the drying behaviour effectively for knowing the drying characteristics of green chilli. In this study, the experimental drying data of green chilli by using different pretrements at constant microwave power and hot air temperature were fitted into seven commonly used thin-layer drying models, listed in Table 1.

Moisture ratio of chilli samples during drying is calculated by the following equation:

$$MR = \frac{M_t - M_e}{M_0 - M_e} \qquad (1)$$

where M_t, M_0 and M_e are moisture content at any time of drying (kg water/kg dm), initial moisture content (kg water/ kg dm) and equilibrium moisture content (kg water/kg dm),respectively [13, 7].

B. Correlation coefficients and error analysis

To represent the experimental data for various treatments, the ability of the tested mathematical model was evaluated through three parameters; the correlation coefficient (R^2), the reduced ($\boldsymbol{x}^2$) and the root mean square error (RMSE). The higher the R^2 and lower the $\boldsymbol{x}^2$ and RMSE values, the accurate are the fitting procedure [14, 15].

C. Drying rate

The drying rate of samples was calculated using Equation:

$$DR = \frac{M_{t+\Delta t} - M_t}{\Delta t} \qquad (2)$$

where $M_{\Delta t+t}$ is moisture content at t+ Δt (kg water/kg dm), t is time (min) and DR is the drying rate (kg water/kg dm min).

TABLE I: MATHEMATICAL MODELS FOR THE DRYING CURVES

Model No.	Name	Model equation	References
1	Lewis	MR= $exp(-kt)$	[16]
2	Page	MR = $exp(-kt^n)$	[17]
3	Modified Page	MR = $exp(-(kt)^n)$	[18]
4	Henderson and Pabis	MR = $a\cdot exp(-kt)$	[19]
5	Logarithmic	MR = $a\cdot exp(-kt) + c$	[20]
6	Midilli	MR = $a\cdot exp(-kt^n) + bt$	[21]
7	Wang and Singh	MR = $1 + at + bt^2$	[14]

III. RESULTS AND DISCUSSION

A. Drying models

The statistical results from models are summarized in Table II. The values of mentioned tests were in the range of 0.969–0.999 for R^2, 0.003–0.835 for $\boldsymbol{x}^2$, and 0.011– 0.118 for RMSE. The model of Midilli was found to be the most suitable model to represent the thin-layer drying behavior of green chili samples based on the highest R^2 and the lowest RMSE, and lowest $\boldsymbol{x}^2$. The experimental data with those predicted with the Midilli model were similar for chilli samples at different treatments.

B. Drying rate

Figure 2 shows the drying curves of green chilli during microwave convective and hot air with different treatments. The microwave convective drying with microwave blanching treatment is the fastest drying method followed by microwave convective with no blanching, hot air with water blanching, hot air with no blanching. The drying process took place in the falling rate period [22]. The drying rate increases initially and then starts to decrease as the process continues. The moisture of the product reduced over time. Similar results have been observed in the drying of different fruits and vegetables: banana [23], kiwifruit [24[, parsley [7]; carrot pomace [25]; pineapple, mango, guava and papaya [26] and apple pomace [14].The average drying rate (Table III) was found to be low for hot air treatment without blanching and high for microwave convective treatment followed by microwave blanching.

C. Color analysis

Lightness (L*), greenness (-a*) and yellowness (+b*) of fresh dill leaves were 46.853 ± 2.461, -5.36 ± 1.542 and 23.23 ± 0.674, respectively. All the treatments resulted in increase of lightness, greenness and yellowness of the dried green chilli. It has been reported that the microwave-convective drying followed by microwave blanching resulted in lighter product colour compared to other treatments. Similar results have been observed in the drying of red chilli [27]. The colour change value was also least in the microwave blanched sample followed by water blanching, microwave hot air drying and hot air drying.

TABLE III VALUES OF THE DRYING CONSTANTS AND COEFFICIENTS OF DIFFERENT MODELS DETERMINED THROUGH REGRESSION METHOD FOR ALL DRYING METHODS

Model	Group	Hot air Temperature (°C)	Microwave power (W)	Constants and coefficients	R^2	x^2	RMSE
Lewis	GICI	60		k= 2.775.10^{-3}	0.984	0.313	0.058
	GICII	60	130	k= 5.995.10^{-3}	0.991	0.052	0.038
	GII	60		k= 4.158.10^{-3}	0.983	0.229	0.053
	GIII	60	130	k= 9.258.10^{-3}	0.977	0.16	0.066
Wang and Singh	GICI	60		a= -1.2.10^{-3} b=- 7.191.10^{-8}	0.969	0.835	0.118
	GICII	60	130	a= -4.124.10^{-3} b= 3.698.10^{-6}	0.996	0.017	0.031
	GII	60		a= -2976.10^{-3} b= 2.237.10^{-6}	0.998	0.065	0.026
	GIII	60	130	a= -5.916.10^{-3} b= 8.01.10^{-6}	0.993	0.089	0.05
Logarithmic	GICI	60		a= 1.497; k=0.15; b=-0.47	0.997	0.148	0.016
	GICII	60	130	a= 1.333; k=0.379; b=-0.328	0.999	0.003	0.011
	GII	60		a= 1.361; k=0.25; b=-0.353	0.996	0.156	0.02
	GIII	60	130	a= 1.413; k=0.528; b=-0.395	0.993	0.635	0.028
Modified Page	GICI	60		k= 1.453.10^{-4} n= 24	0.997	0.02	0.015
	GICII	60	130	k= 1.671.10^{-3} n= 9	0.997	0.011	0.016
	GII	60		k= 3.498.10^{-4} n= 18	0.995	0.027	0.019
	GIII	60	130	k= 9.859.10^{-4} n= 8	0.994	0.026	0.027
Midilli	GICI	60		a=0.99; k=4.092.10^{-4} ; b=-1.113.10^{-4}; n=24	0.999	0.025	0.011
	GICII	60	130	a=1; k=3.464.10^{-3} ; b=-3.83.10^{-4};	0.999	0.003	0.011

				n=9			
	GII	60		a=0.979; $k=9.678.10^{-4}$; $b=-1.654.10^{-4}$; n=18	0.997	0.051	0.017
	GIII	60	130	a=0.994; $k=1.998.10^{-3}$; $b=-3.215.10^{-4}$; n=8	0.995	0.044	0.024
Page	GICI	60		$k= 2.52.10^{-4}$; n= 24	0.997	0.031	0.019
	GICII	60	130	$k= 1.936.10^{-3}$; n= 9	0.997	0.011	0.017
	GII	60		$k= 6.856.10^{-4}$; n= 18	0.994	0.041	0.025
	GIII	60	130	$k= 1.247.10^{-3}$; n= 8	0.993	0.029	0.029
Henderson and Pabis	GICI	60		a=1.088; $k=2.997.10^{-3}$	0.978	0.227	0.045
	GICII	60	130	a=1.039; $k=6.277.10^{-3}$	0.989	0.041	0.032
	GII	60		a=1.062; $k=4.461.10^{-3}$	0.979	0.179	0.045
	GIII	60	130	a=1.061; $k=9.813.10^{-3}$	0.97	0.136	0.057

TABLE II: VARIOUS PARAMETERS WITH DIFFERENT DRYING TREATMENTS

Sl.No	**Parameters**	**Group I (No blanching)**		**Group II (Water blanching)**	**Group III (MW blanching)**
		Control 1 Hot air at 60°C	Control 2 MW+hot air at 60°C	Hot air at 60°C	MW+hot air at 60°C
1	Drying time (min)	750	300	525	240
2	Average drying rate (Kg water/kg dm.min)	0.444	0.977	0.631	1.329
3.	L^*	62.72 ± 0.23	60.28 ±2.32	57.45 ±1.55	54.73 ±2.19
4.	a^*	3.01 ±1.46	3.44 ±1.04	3.51 ±1.04	4.19 ± 1.41
5	b^*	22.1 ±1.22	21.79 ±1.25	21.08 ±1.61	17.99 ±1.37
6	Color change (ΔE)	17.94 ±0.78	16.06 ±0.33	13.87 ± 1.33	13.08 ±1.85

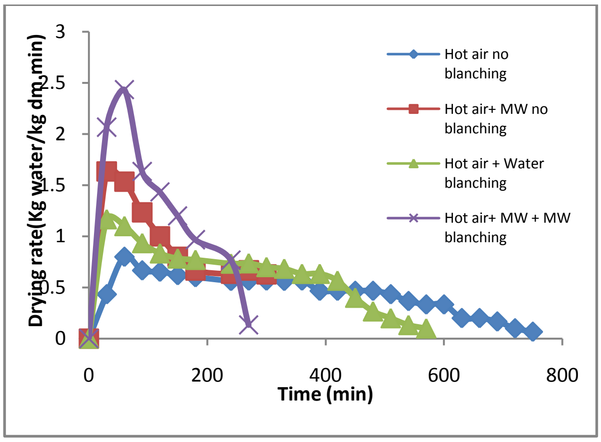

Fig2. Relationship between the drying rate and the drying time during various drying methods

IV. CONCLUSIONS

Microwave convective drying with 130 W followed by microwave blanching reduced the drying time from 750 min to 240 minutes and increased the average drying rate from 0.44 to 1.32 Kg water/kg dm.min. and could also maintain color of dried chili as the color change value is less. However, the work has to be further carried out at different microwave power levels.

REFERENCES

[1]. M.K. Krokida , , V.T. Karathanos, , Z.B. Maroulis and D. Marinos-Kouris, "Drying kinetics of some vegetables," *Journal of Food Engineering*, Vol 59, pp. 391–403, Oct, 2003.

[2]. T. Jyothirmayi, G .Narsing Rao and D.Govardhana Rao, "Physicochemical changes during processing and storage of green chili (Capsicum Annum) powders," *Journal of Food Processing and Preservation*" Vol 32, pp 868-880, 2008.

[3]. USDA National Nutrient Database for Standard Reference

[4]. W. Szulmayer, " From Sun-Drying to Solar Dehydration I and II," Food Technology in Australia, September, pp: 440-501, 1971.

[5]. L. Dorantes- Alvarez L., L Parada-Dorantes L. *Blanching using microwave processing. In: The Microwave Processing of Foods*. H. Schubert and M. Regier .,Eds. Woodhead Pub Lim. England, 2005.

[6]. A. Sarimeseli, " Microwave drying characteristics of coriander (Coriandrum sativum L.) leaves," *Energy Convers. Manag*., 52 ,pp. 1449–1453, 2011.

[7]. A.Soysal., S. Oztekin,., O. Eren, . " Microwave drying of parsley: modelling, kinetics, and energy aspects.," *Biosyst. Eng*. Vol 93, pp. 403–413, 2006.

[8]. Z.H. Duan, M. Zhang, J. Hao. "Preparation of crispy bighead carp slices," *Sci. Technol. Food Int*., Vol 2, pp. 44–47, 2003.

[9]. M. Al-Harahsheh, A.H. Al-Muhtaseb, T.R.A. Magee, "Microwave drying kinetics of tomato pomace: effect of osmotic dehydration," *Chem. Eng. Process*, Vol 48, pp. 524–531, 2009.

[10]. S. Gunasekaran, " Pulsed microwave – vaccum drying of food materials," *Drying Technology: An International Journal, vol 17, pp. 395-412, 1999.*

[11]. M. *John* Osepchuk., *Microwave Power Applications IEEE transactions on microwave theory and techniques, Vol 50, pp. 975, March 2002.*

[12]. S. Ranganna, S. Handbook of Analysis and Quality Control for Fruit and Vegetable Products. McGraw-Hill Book Company, New Delhi, 1986.

[13]. A. Evin, "Thin layer drying kinetics of Gundelia tournefortii L.," Food Bioprod. Process , Vol 90, pp. 323–332, 2011.

[14].] Z. Wang., J. Sun, J., F. Chen., X. Liao., X. Hu. "Mathematical modelling on thin layer microwave drying of apple pomace with and without hot air pre-drying." *J. Food Eng*., Vol 80, pp 536–544, 2007.

[15]. B. Ozbek, G. Dadali.. " Thin-layer drying characteristics and modelling of mint leaves undergoing microwave treatment." . *J. Food Eng, Vol.* 83, pp 541–549, 2007.

[16]. I. Doymaz and O. Ismail. " Drying characteristics of sweet cherry." *Food Bioprod. Process*, Vol 89, pp. 31–38, 2011.

[17]. S.V. Jangam, V.S. Joshi, A.S. Mujumdar, B.N. Thorat. "Studies of dehydration of sapota

(Achras zapota)." *Drying Technol*., Vol 26, pp. 369–377, 2008.

[18]. D. Arslana and M.M. Ozcan, " Study the effect of sun, oven and microwave drying on quality of onion slices," *LWT – Food Sci. Technol*., Vol 43 , pp. 1121–1127, 2010.

[19]. A. Figiel. " Drying kinetics and quality of beetroots dehydrated by combination of convective and vacuum-microwave methods." *J. Food Eng*., Vol 98, pp. 461–470, 2010

[20]. R.P. Kingsly, R.K. Goyal, M.R. Manikantan, S.M. Ilyas " Effects of pretreatments and drying air temperature on drying behavior of peach slice." *Int. J. Food Sci. Technol*., Vol 42 , pp. 65–69, 2007.

[21]. A. Midilli, H. Kucuk, Z. Yapar. " A new model for single layer drying." *Drying Technol*., Vol 20, pp. 1503–1513, 2002.

[22]. H. Feng , J. Tang and R.P Cavalieri. " Dielectric properties of dehydrated apples as affected by moisture and temperature," *Transactions of the ASAE 45*." Vol 1, pp 129-135, 2002.

[23]. M. Maskan M . " Microwave/air and microwave finish drying of banana.," *Journal of Food Engineering* Vol, 44, pp. 71-78, 2000.

[24]. A. Femenia, G. Sastre-Serrano, S. Simal, M.C. Garau, V.S. Eim, C. Rossello, 'Effects of air-drying temperature on the cell walls of kiwifruit processed at different stages of ripening ," *LWT – Food Sci. Technol*., Vol 42, pp. 106–112, 2009.

[25]. N. Kumar, B.C. Sarkar, H.K. Sharma, " Effect of air velocity on kinetics of thin layer carrot pomace drying," *Food Sci. Technol. Int*. Vol 7, pp. 439–447, 2011.

[26]. L.G. Marques, M.M. Prado and J.T. Freire. "Rehydration characteristics of freeze-dried tropical fruits" , *LWT – Food Sci. Technol*., Vol 42, pp. 1232–1237, 2009.

[27]. S. Tontand and N. Therdthai, "Preliminary study of chili drying using microwave assisted vacuum drying technology," 1.As. J. Food Ag-Ind, Vol 2, pp 80-86, 2009.

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Sameera Nayani is working as Research Analyst in Enerzi Microwave Systems Pvt. Ltd. , where she has been working on various applications of Microwave heating in food industries. Her recent activities include drying of chilies and pasteurization of juices. With the Master's degree in Biotechnology from Andhra University, she has more than 3 years experience in Research Work in Microwave food Applications, quality analysis, estimation of nutritional value. Microwave applications include drying, disinfections, pressurization / sterilization, extraction of bio molecule, frying, puffing, tempering, extrusion. The current work will be continued for the further improvement of process, to investigate the drying and other quality characteristics of chili using combined microwave-convection drying and design to address the issues of alternative drying methods and the existing knowledge gap. Her future work will be focused on waste utilization by microwave extraction.

Vivekanand Hiremath is working in Enerzi Microwave Systems Pvt. Ltd. as R&D engineer, where he has devoted his time in exploring new applications of Microwave heating in Ceramics, Polymers and food industries. His recent activities in Iron Ore industries and Iron oxides. With the Bachelors degree in Mechanical Engineering from Visvesvaryya Technological University, Belgavi, he has more than 3 years experience in Research Work in Microwave Applications, Design of Microwave systems, Analysis and manufacturing of Electromagnetic systems. With the diverse experience in Joint research work with many organizations he shoulders Quality Assurance and Project Planning and implementation in Organization.