Drying Kinetics of Garlic Slices by Hybrid Drying Technique

Jaspreet Singh Grewal
Processing & Food Engineering, Agriculture University, Ludhiana

Mohammed Shafiq Alam
Processing & Food Engineering, Agriculture University, Ludhiana

Usman Ahmed
Department of Food Tech. BGIET
Sangrur, Punjab

ABSTRACT
Studies were carried out to evaluate the drying behaviour of garlic slices (Avg. 3mm) which were dried with fluidized bed cum microwave hybrid drying technique. Combined drying experiments were carried out with 0.1 % to 0.5 % KMS pre-treated garlic slices (250g) at 55°C to 75°C and microwave power level from 810 W to 1350 W. The results showed that the moisture content decreasing trend with drying time irrespective drying air temperature & microwave power level where as no remarkable effect of KMS concentration was observed on drying time. The drying rates were observed to increase with increase in drying air temperature in fluidized bed drying almost showing a falling rate drying. The drying rate first increased then decreased trend irrespective of microwave power levels and KMS concentrations.

Keywords
Garlic slices, KMS concentration, Hybrid drying, Power level, Moisture content

1. INTRODUCTION
Garlic (*Allium sativum* L.) is a bulbous perennial plant of the lily family lilliaceae. Garlic is a rich source of carbohydrates, proteins and phosphorous. The fresh peeled garlic cloves contains 60-65 % (wb) moisture, 6.30 % protein, 0.10% fat, 1% mineral matter, 0.80% fiber, 29 % carbohydrates, 0.03 % calcium, 0.31 % phosphorous, 0.001 % iron, 0.40 mg/100g nicotinic acid and 13 mg/100g vitamin C [1]. Hard neck, Soft neck and Creole varieties of garlic are grown worldwide. Hard neck varieties have fewer cloves and have little or no papery outer wrapper protecting the cloves. Soft neck varieties are white, papery skins and multiple cloves that are easily separated. There are two types of soft neck varieties: artichoke and silver skin. Creole variety has eight to twelve cloves per bulb arranged in a circular configuration. Garlic has been used ‘time memorial, for the treatment of a wide variety of ailments, including hypertension, headache, bites worms, tumours etc. Hippocrates, Aristotle and Pliny cited numerous therapeutic uses for garlic. Although garlic have wide range of well-documented pharmacological effects; it’s most important clinical uses are in the area infections, cancer prevention and cardiovascular disease [2].

Presently convective, fluidized bed and sun drying of garlic is in practice, which damages the sensory characteristics and nutritional properties due to the surface case hardening and the long drying duration. Main disadvantages of convective drying are long drying duration, damage to sensory characteristics and nutritional properties of foods and solute migration from interior of the food to the surface causing case hardening. Severe shrinkage during drying also reduces the rehydration capacity of the dehydrated products [3]. Fluidized bed drying of garlic cloves has also been attempted but it was not effective in reducing the drying time and energy consumption appreciably in comparison to convective drying process.

Use of Microwave is considered as the fourth generation drying technology. 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, creating an outward flux of rapidly escaping vapour. Microwaves penetrate the food from all direction. This facilitates steam escape and speed heating. In addition to improving the drying rate, this outward flux can help to prevent the shrinkage of tissue structure, which prevails in most conventional air drying techniques. Hence better rehydration characteristics may be expected in microwave dried products [4, 5]. Microwave processes offer a lot of advantages such as less start up time, faster heating, energy efficiency (most of the electromagnetic energy is converted to heat), space savings, precise process control and food product with better nutritional quality. Hybrid drying technique is the combination of different drying methods used for drying which is best suitable method of drying in reduced time with maintain its nutritional quality of product [6]. Keeping in view the above aspects, the present study has been planned to study the drying kinetics of garlic slices by using hybrid drying technique (Fluidized bed- cum-microwave) viz. KMS concentration, drying air temperature and microwave power level.

2. MATERIALS AND METHODS
The fresh garlic was procured from local market, Ludhiana. The garlic bulbs were sorted for its uniform size and were peeled manually with the help of knives and then uniformly sliced (Avg. 3mm) with the help of garlic slicer .The colour and moisture content of fresh garlic slices was noted. The samples were pre-treated with different concentrations of KMS as per the procedure reported by [7].

The experiment on drying characteristics of garlic slices for the hybrid drying technique fluidized-cum-microwave drying; the experiments were planed according to completely randomized design (CRD). Each sample was replicated thrice. The range of process parameters selected for the study of drying characteristics was:

KMS Concentration: 0.1% to 0.5%

Process temperature: 550C to 750C

Microwave power level: 810 W to 1350 W

Twenty seven experiments for the study of drying characteristics of garlic slices (FCM) were selected and each experiment has three replicates.

The experimental set up for fluidized bed drying of garlic slices (Fluidized bed drying at constant velocity of 3.5 m/s [10]) consists of three basic parts: a system for provision of air, a section for heating the air and a drying chamber. A 0.75 KW, 3 phase electric motor controlled by a simple general-purpose AC Drive (Model: VFD007L21A, Delta electronics, Inc. Taiwan) was used to drive the blower. Air flow can be controlled by varying the frequency of AC supply to motor. Circuit diagram of AC Drive, PID 518 temperature controller, temperature sensor, heaters and contactors.

The experimental set up for microwave drying of garlic slices by microwave dryer (Power range 0-1350 W and frequency 2450 MHz).It consists of a high voltage power source, transformer and a cooking chamber. The transformer passes the energy to the magnetron which converts high voltage electric energy to microwave radiations. The magnetron usually controls the direction of the microwaves with the help of microcontroller.

The fluidized bed dryer were started half an hour before keeping the sample to achieve steady state conditions. For each experimental combination as mentioned above for fluidized bed drying, 250 g of garlic slices were put into the drying trays/bucket. All the samples were recorded for their change in weight throughout drying process. The moisture content of each sample was reduced to 39 ±1 % (wb) by fluidized bed drying. The fluidized bed dried samples were further dried to 6 to 7 % (wb) by using microwave drying. Three replications were taken for each experiment to get an average values.

2.1 Drying parameters

2.1.1 Moisture content

The moisture content of garlic was determined by standard oven method (AOAC 2000). 5 gm of sample was weighed and dried at 103 ± 2°C in hot air oven till the weight became constant. The moisture content was calculated, using the relationship as in equation no.1.

$$M.C.(\%\ wb) = \frac{W_1 - W_2}{W_1} x100 \qquad (1)$$

Where,

W1 = Initial moisture content of the sample (g)

W2 = Final moisture content of the sample (g)

The determination of the moisture content (MC) was made on a three sample basis. The moisture content obtained in% wb was converted into% db by using the following formula as in equation no.2.

$$M.C.(\%\ db) = \frac{100 \times MC\ (\%\ wb)}{100 - MC\ (\%\ wb)} \times 100 \qquad (2)$$

2.1.2 Equilibrium moisture content

The samples were allowed to dry till the weight of the samples became constant at the set drying conditions and the moisture content of that dried samples was assumed to be the equilibrium moisture content for the selected environment [8].

2.1.3 Moisture ratio

Moisture ratio was calculated as given by equation no.3 [8].

$$MR = \frac{M - Me}{Mo - Me} \qquad (3)$$

Where,

M = Moisture Content of sample at any time (%, db)

Me = Equilibrium Moisture Content (%, db)

Mo = Initial Moisture Content (%, db)

2.1.4 Drying rate

Drying rate was determined by moisture content (%, db) decrease of the sample per unit time (min) as given by equation no.4 [8].

$$\frac{dM}{dT} = \frac{(M_i - M_{i+1})}{(t_{i+1} - t_i)} \qquad (4)$$

Where,

dM/dT = drying rate, moisture loss per min (%db/min)

Mi = Moisture content

3. RESULTS AND DISCUSSION

The drying characteristics of garlic slices in fluidized bed-cum-microwave combination were studied for different concentration of KMS, fluidized bed drying air temperature and microwave power level. The data recorded during drying of garlic slices were used to study drying curves as given below

M.C. (% db) v/s drying time

Drying rate (%/min) v/s moisture content (% db)

3.1 M.C. (% db) v/s drying time

The trends for moisture content w.r.t drying time for different combination of KMS concentration, fluidized bed drying (FBD) temperature and microwave power level are shown in fig. 3.1.The drying behaviour of garlic slices exposed to fluidized bed-cum-microwave drying revealed that the moisture content showed decreasing trend with the drying time [9] irrespective of the drying air temperature, KMS concentration & microwave power level. No remarkable effect of KMS concentration was observed on drying time. For reducing the moisture content from 222.58 % db to 6(±1) % db, the reduction in the moisture content with drying time was slowest for the sample dried at 550C drying air temperature followed by 810 W microwave power level and fastest for the sample dried at 750C drying air temperature followed by 1350 W irrespective for KMS concentrations, witnessing average drying time of 72.17 min; 440 sec and 48 min; 300 sec respectively.

3.2 Drying rate (%db/min) v/s moisture content (% db)

The trends for drying rate (%db/min) with moisture content for different combinations of KMS concentration, fluidized bed dried temperature and microwave power level are shown in Fig 3.2 and Fig.3.3. The drying rates were observed to increase with increase in drying air temperature Table 3.1); recording average drying rates 2.33, 2.75 & 3.34 (%db/min) for 550C, 650C & 750C irrespective of KMS concentrations. Highest average drying rate (3.35 %db/min) for 750C and 0.5 %; lowest average drying rate (2.33 %db/min) for 550C and 0.1% as shown in table 3.1. The drying rate showed continuously decreasing trend irrespective of the drying air temperature and KMS concentration. Since during fluidized bed drying the moisture content was reduced from 222.58 % db to 63 (±1) % db; the free moisture was available; showing almost a falling rate drying with the advance in drying time as by [10].However, 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. In comparison to KMS concentrations, the drying air temperature showed remarkably higher variations in drying rate with the advance in drying time (Figs. 3.2 and 3.3).

The effect of power level on drying rate has been presented in table 3.1 and trend shows in Figs. 3.2. & 3.3.It was clear from these figures that the drying rate increased with increase in power level irrespective KMS concentrations and no remarkably effect with increase in KMS concentration for same power level, recording average drying rates 0.10, 0.13& 0.17 (%db/sec) for 810, 1080 &1350 W microwave power levels irrespective of KMS concentrations. Highest average drying rate (0.18 %db/sec) for 1350 W and 0.5 %; lowest average drying rate (0.10 %db/sec) for 810 W and 0.1% as shown in table 3.1. Since during microwave drying the moisture content was reduced from 63 (±1) % db to 6 (±1) % db; the bound moisture was available; showing first increase in drying rate then continuously decreasing with the advance in drying time. The drying rate showed first increased then decreased trend irrespective of microwave power levels and KMS concentrations.

Table3.1. Average drying rates for Fluidized bed -cum-microwave drying process

Hybrid technique	**Fluidized bed drying air temperature (^{0}C)**	**KMS concentrations (%)**		
		0.1	**0.3**	**0.5**
Fluidized bed drying	55	2.33	2.33	2.33
	65	2.75	2.75	2.75
	75	3.34	3.35	3.35
	Microwave power level (W)			
Microwave drying	810	0.10	0.11	0.11
	1080	0.13	0.12	0.13
	1350	0.17	0.17	0.17

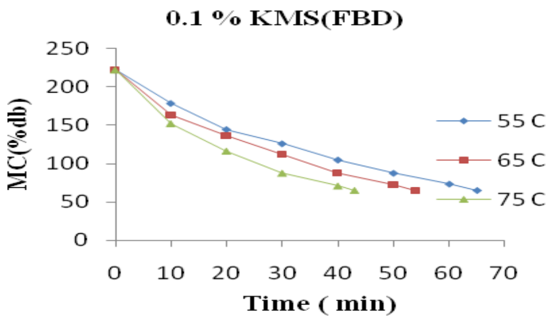


Fig 3.1 a

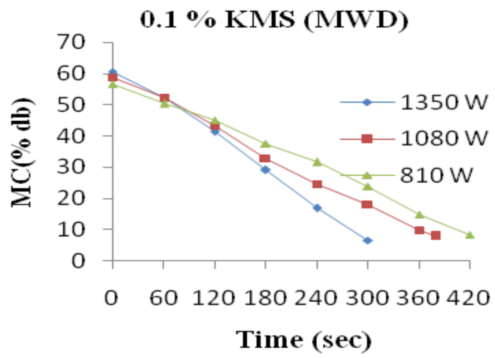


Fig 3.1 b

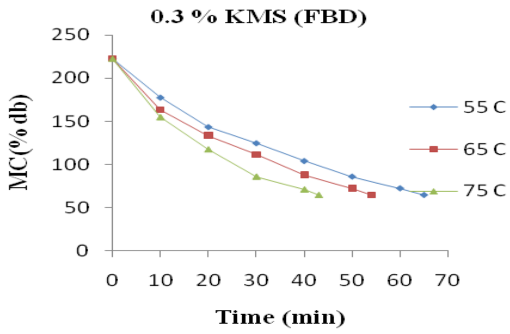


Fig 3.1 c

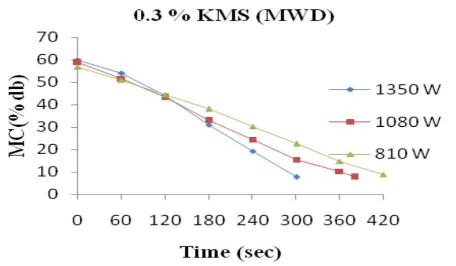


Fig 3.1 d

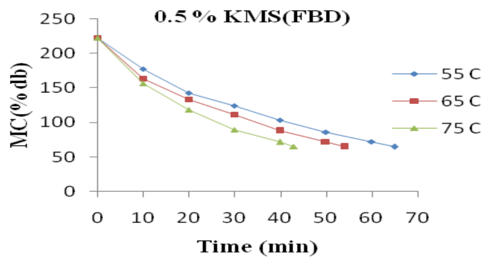


Fig 3.1 e

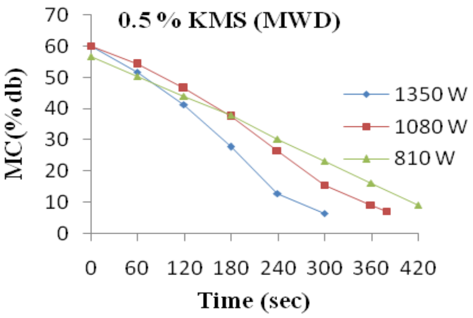


Fig 3.1 f

Fig 3.1: Variation of moisture content (%db) with KMS concentration and drying time.

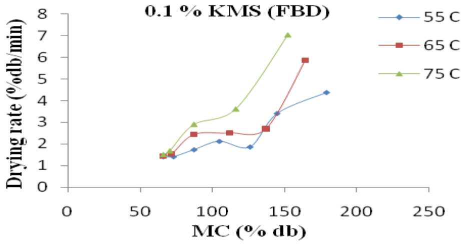


Fig 3.2 a

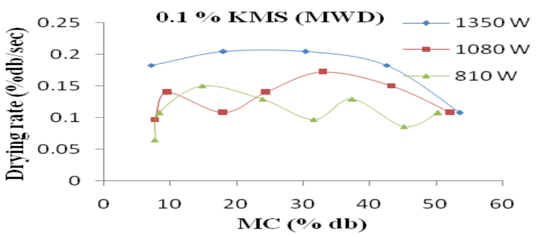


Fig 3.2 b

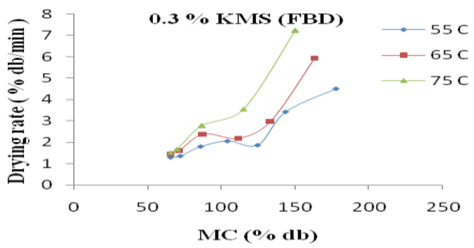


Fig 3.2 c

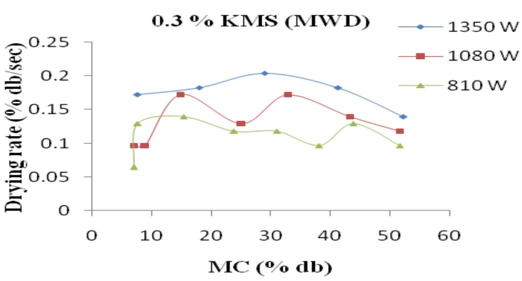


Fig 3.2 d

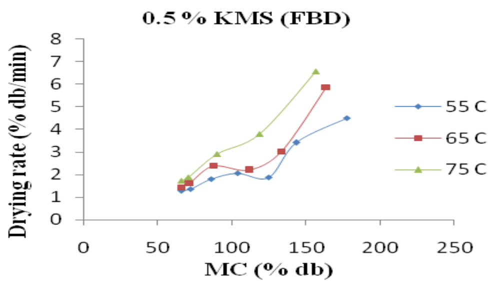


Fig 3.2 e

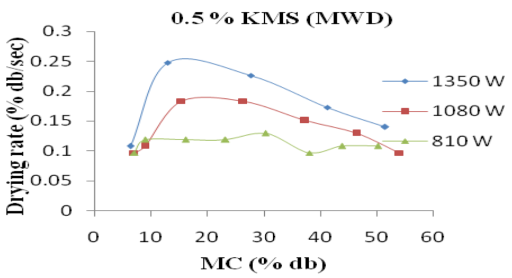


Fig 3.2 f

Fig 3.2 : Variation of drying rate Vs moisture content with KMS concentration & microwave power level.

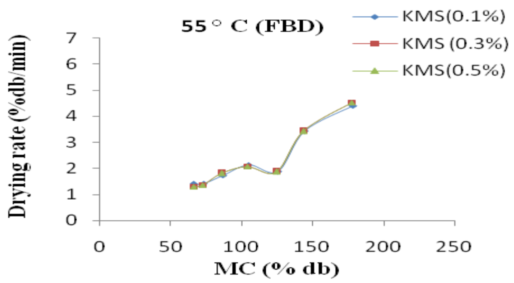


Fig 3.3 a

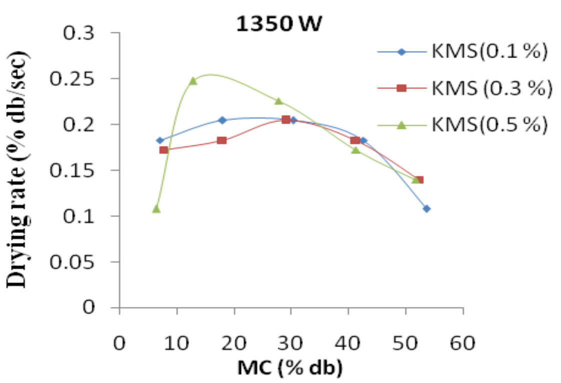
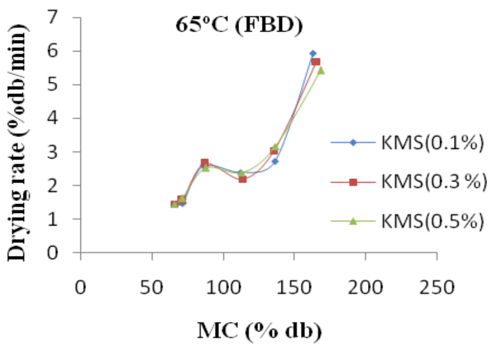


Fig 3.3 b



Fie 3.3 c

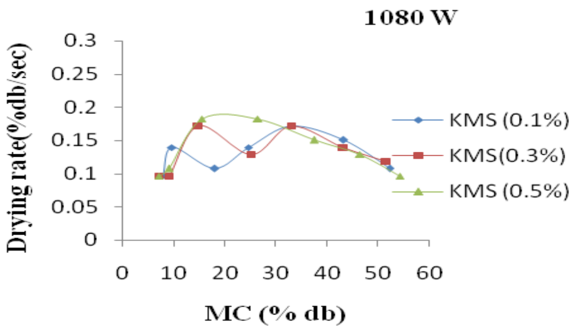


Fig 3.3 d

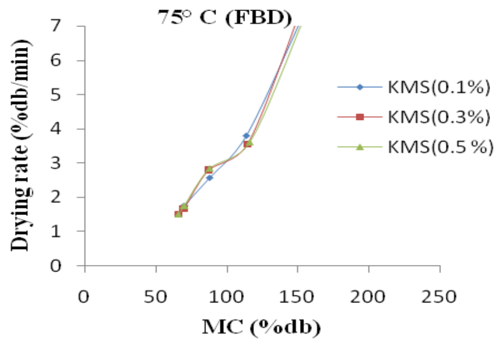
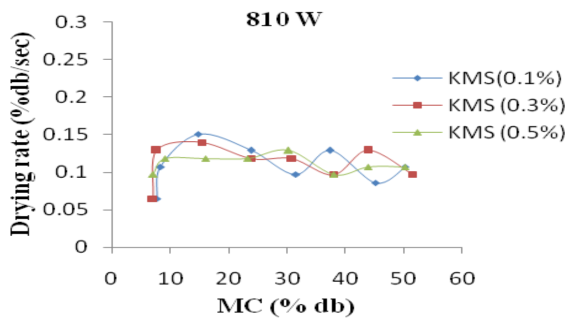


Fig 3.3 e



Fige 3.3 f

Fig 3.3 Variation of drying rate Vs moisture content (%db) with KMS concentration

4. CONCLUSIONS

From the present investigation it can be concluded that drying behaviour of garlic slices exposed to fluidized bed-cum-microwave drying showed decreasing moisture content trend with the drying time irrespective of the drying air temperature, KMS concentration & microwave power level. No remarkable effect of KMS concentration was observed on drying time. The drying rates were observed to increase with increase in drying air temperature in fluidized bed drying. The free moisture was available; showing almost a falling rate drying with the advance in drying time. The drying rate showed first increased then decreased trend irrespective of microwave power levels and KMS concentrations. Further researcher can improve the quality of garlic slices with addition of other drying technique in to this process.

5. REFERENCES

[1] M Brondnitz, J Pascale and L Van, Flavour component of garlic extract. J. Agric. Fd. Chem., 19: 273-75, (1971).

[2] H.S. Laul, M.S. Padma and J.M. Tosk, Allium sativum (Garlic) and cancer prevention. J. Nutr. Res. 10: 937:48, (1990).

[3] W.M.A. McMinn and T.R.A Magee, Principles, methods and applications of the convective drying of foodstuffs. Fd. Bioprod. Proc. 77: 175-93, (1999).

[4] M.A.M. Khraisheh, T.R. Cooper and T.A. Magee, Shrinkage characteristic of potatoes dehydrated under combined microwave and convective air conditions. Drying Technol. Int. 15:1003-22, (1997).

[5] D.G. Prabhanjan H.S. Ramaswamy and G.S.V. Raghavan, Microwave assisted convective air drying of thin layer carrots. J. Fd. Engg. 25:283-93, (1995).

[6] C. Zheng-Wei, X. Sbi-Ying and S. Da-Wen, Dehydration of garlic slices by combined microwave-Vacuum and Air Drying. Drying Technol. 21: 1173-84 (2003).

[7] E E Abano, W Effects of Pretreatments on the drying characteristics and Chemical Composition of Garlic Slices in a Convective Hot Air Dryer. J. Agric. Fd. Technol., 5: 50-58, (2011).

[8] D Brooker, F Bakker and C.W. Hall, Drying and storage of grains and oilseeds. CBS Publishers and Distributers, New Delhi, India, (1997).

[9] S Abbasi, S Mousavi, M Mohebbi and S Kiani, Effect of Time and Temperature on Moisture Content, Shrinkage, and Rehydration of Dried Onion. Iranian J. Chemical Engg. 6:57-70, (2009).

[10] S. Shoba, P.S. Champawt, V.D. Mudgal and S.K. Jain (2012) Dehydration kinetics of garlic flakes in fluidized bed dryer. J. Agric. Engg. 49: 51-62, (2012).