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Microwave Drying Characteristics of Green Peas and its Quality Evaluation

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Abstract

The drying characteristics of green peas were examined in a microwave dryer for power level of 20,40 and 60W. The green peas were pretreated with citric acid solutions and blanched with hot water at 85^{0}C before drying. The drying process was continued until sample moisture fell to equilibrium moisture content. The blanched samples dried faster than those in other pretreatments and control conditions. Moreover, rehydration capacities of the pretreatments were higher than control samples. The drying rate curve contained no constant rate drying period but the drying process took place in the falling rate period. Drying data were fitted to two thin-layer drying models; namely Page and exponential model. The performance of the models was evaluated by comparing the coefficient of determination (R^2), and root mean square error (RMSE). The models that best represented green pea drying was Page model.. All the sensory attributes like colour, taste, texture, flavor, appearance and overall acceptability are acceptable in hot water blanched sample dried at 40W.

Keywords: Green pea, Microwave, Pretreatments, Drying characteristics.

1. Introduction

Pea (Pisum sativum L.) is one of the most commonly grown food legumes in the world and it has been widely used in the human diet for a long time because it is an excellent source of protein, vitamins, minerals and other nutrients and is low in fat, high in contains fiber, and no cholesterol. Worldwide pea production in 2007 was 8, 240, 469 tons. The major producer countries include China, India, the United States, France, and

Egypt. Due to their seasonal and perishable nature, peas must be subjected to some form of preservation such as canning, freezing, or cold storage in order to make them available for later consumption (Lin *et al.*,2005, Pardeshi *et al.*,2009).

Drying is an alternative method of pea preservation. Dried peas are gaining popularity because they offer the advantage of longer shelf life, palatability, and convenience during transport and handling. In addition to preservation, drying lowers the cost of packaging, storage, and transportation by reducing both of the weight and volume of the final product (Chauhan & Srivastava, 2009).

Higher temperature and longer drying time in conventional drying may cause serious damage to the quality parameters of the product such as colour, nutritional value and taste. The heat generated at a particular location in the material is depended on the distance from the surface on which microwave incident (Lambert's microwave absorption relationship). Since the diameter of green peas is much smaller than the penetration depth of the microwave field, a uniform electric field strength distribution and thus a uniform microwave heating within the material could be considered (Chen *et al.*, 2001). Microwave drying results in a high thermal efficiency, uniform heating, shorter drying time and improved product quality compared to conventional hot air drying. The influences of pretreatments and microwave power on the drying kinetics, physico-chemical characteristics and sensory attributes were experimentally investigated. In addition, a semi theoretical model that best describes the green pea drying process was selected from two most commonly used thin-layer models.

2. Materials and Methods

Materials: Good quality fresh green peas (Pisum sativum) were purchased from a local market in Allahabad, U.P. The initial moisture content of green peas was determined by hot air oven at 105-110ºC for 4-6 h. This was repeated three times to obtain a reasonable average. The average initial moisture content was found to be 76% on wet basis.

Drying procedure:

Drying experiments were performed in a microwave dryer with technical features of 230V, with a frequency of 2450 MHz. Drying trial was carried out at three different microwave generation power being 20, 40 and 60W. Pretreatments were applied to the peas before drying, and an untreated sample was used as a control. After pretreatment, samples were placed on a plate inside the oven. Then the samples were dried at power of 20, 40, and 60W. Moisture losses were recorded at 1 min intervals during the drying process using an electronics balance with an accuracy of 0.1 g. The dried product was cooled to normal temperature in a desiccators containing silica gel and then packed in polyethylene bags, which were then heat-sealed and stored at room temperature. The experiments were repeated twice and the average of the moisture ratio at each value was used to draw the drying curves.

3. Mathematical Modeling of Drying Kinetics

The moisture ratio (MR) of the green peas was calculated using the following equation:

$$MR = \frac{Mt - Me}{Mo - Me}$$

Where Mt, M0, and Me are the moisture content at any time during drying (kg water=kg dm), initial moisture content (kg water=kg dm), and equilibrium moisture content (kg water=kg dm), respectively.

The drying curves were fitted by means of two moisture ratio models that are widely used in most food and biological materials (Simal *et al.*, 1996) ; namely Page and exponential models. These models are generally derived by simplifying the general series solution of Fick's second law. The model was used to predict the drying characteristics of corn.

$$MR = A \exp(-kt) \quad (1)$$

The exponential model, equation (1) is a simple lumped model is often used to describe mass transfer in drying process (Wang *et al*., 2007). Because of its simplicity and high correlation to most drying data it was mostly used.

$$MR = \exp(-kt^n) \quad (2)$$

The Page model is an empirical modification of Lewis model to overcome its shortcomings. It has been successfully used to describe the drying characteristics of some agricultural products (Singh *et al*., 2006, Alibas *et al,* 2007) .

4. Data Analysis:

Regression analysis was performed. The coefficient of determination (R^2) and root mean square error (RMSE) were used in this study to evaluate the goodness of fit. These parameters can be calculated by using the following equations:

$$RMSE = \sqrt{\frac{\sum_{i=1}^{N}\left(MR_{exp,i} - MR_{cal,i}\right)^2}{N}} \quad (3)$$

N is the number of observations, MRexpand MRpre are the experimental and predicted moisture ratios, respectively. Higher values of R^2 and lower values of RMSE indicate better goodness of fit (Sobukola, 2009).

Sensory evaluation: The rehydrated dried carrot slices were used for preparing carrot soup and cooked curried carrot, which were subjected to sensory evaluation by the trained panel of 10 judges on a 9-point Hedonic scale (Amerine *et al*., 1965).

Statistical analysis: The experiments were conducted with 3 replicates and two level full factorial ANOVA was adopted to calculate the statistical significance (Snedecor and Cochran, 1968).

5. Results and Discussion

5.1 Drying Curve: Variation of moisture content versus drying time for different sample of green peas is shown in Fig. 1. As it can be observed in this figure, with increasing drying power the amount of moisture removed from green peas increased and the time to achieve final moisture content in finished products was reduced. The pretreated samples had shorter drying time as compare to control onces. Variation of drying rate versus drying time for different samples of green peas is shown in Fig.2-4. Drying rate decreases continuously with time. In these curves, increasing the microwave power increases the drying rate and there was not constant-rate period but it seen to occur the falling-rate period. This shows that diffusion is dominant physical mechanism governing moisture movement in the green peas. These results are in good agreement as compared to the earlier studies of various vegetables (Akpinar & Bicer., 2004)

5.2 Modelling drying data

The constants of models for microwave drying of green peas in microwave powers are presented in table 1. The best model to describe drying behaviour of green peas was selected on the basis of high (R^2) value. It is observed from table 2 that the high values of coefficient of determination (R^2) are indicative of good fitness of the empirical relationship to represent the variation in moisture ratio with drying time. Thus, the Page model may be assumed to represent the thin layer drying of green peas in a microwave dryer. Page model for hot water blanched sample dried at 20 W power and exponential model for citric acid blanched sample dried at 60 W power are closely banding around at a 45° straight line - a very good agreement between calculated and experimental data, which indicates that these models could adequately describe the drying behavior of green peas.

5.3 Sensory Characteristics of green peas

The blanching before drying is the destruction or inactivation of enzymes that can affect the colour, texture, flavour and nutritive value of foods during storage. The mean score for colour varied from 6.4 to 7.7. The highest value for colour was 7.7 for the hot water blanched sample dried at 40W. The highest value for taste was 7.7 for the hot water blanched sample dried at 40W. The green peas with citric acid blanched treatment had low scores when compared with control and hot water blanched samples which may be because of slightly salty taste in citric acid blanched samples. The highest value for texture was 8.0 for the hot water blanched sample dried at 40W. The green peas dried at 60W received low scores, because the hard texture of green peas achieved due to high power of microwave during drying. The highest value for flavour as 7.5 for the hot water blanched sample dried at 40W. The sample prepared at 60W microwave power had lost its flavour due to high heat and the citric acid blanched samples had achieved salty flavour making both of them less appreciable. The highest value for appearance as 8.1 for control sample dried at 40W. Fig. 10 shows the bar graph of mean scores of different treatments. The mean score for overall acceptability varied from 6.0 to 7.9. The highest value for overall acceptability as 7.9 for the hot water blanched sample dried at 40W, it may be because the mentioned sample was better in parameters like colour, taste, texture, flavour when compared with other samples giving it more acceptability. Similar results were also discussed by (Kanwade and Narain, 1990). Fig.5 shows the bar graph of mean scores of different treatments.

6. Conclusion

Based on the experimental results the blanched samples had shorter drying times than other pretreated and control samples. Microwave power was an important factor in drying of green peas. High microwave power resulted in a shorter drying time. Page models gave excellent fits for pretreated and control samples. The sensory quality of dried green pea was highly acceptable for hot water blanched sample dried at 40W.

Table1: Results of nonlinear regression analyses for thin layer drying curve fitting for citric acid blanched samples.

Power (W)	Page Model				Exponential Model			
	R^2	RMSE	N	k	R^2	RMSE	a	k
20	0.9868	0.0699	0.926	0.2097	0.9629	0.092	0.127	0.285
40	0.9861	0.0694	0.970	1.978	0.9486	0.116	0.166	0.352
60	0.9891	0.0686	0.9348	1.826	0.9604	0.105	0.173	0.319

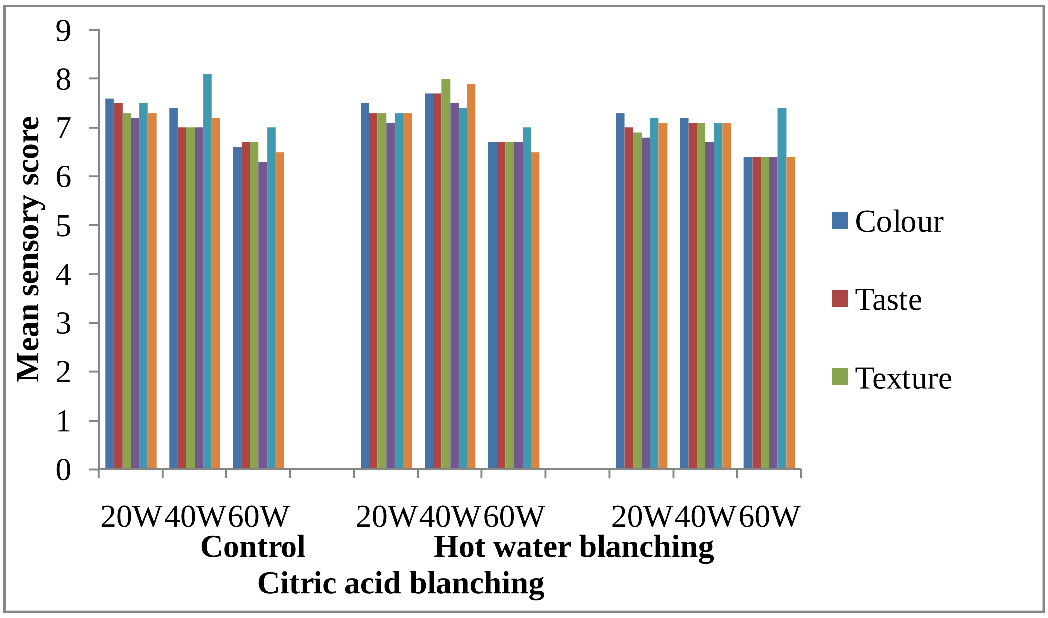

Fig. 4: Effect of pretreatment and Microwave power on sensory characteristics of dried green peas.

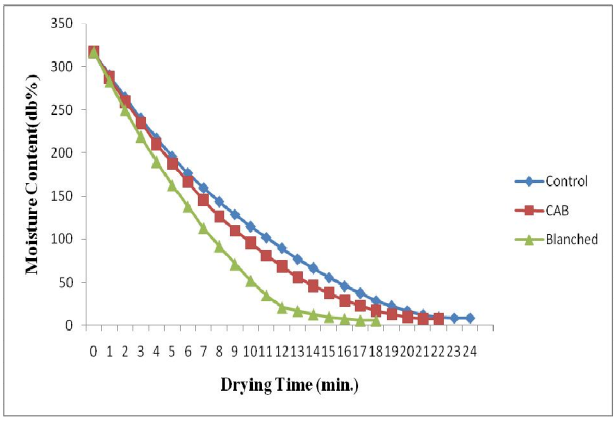

Fig. 1: Effect of pre treatment on moisture content of green peas at 60W.

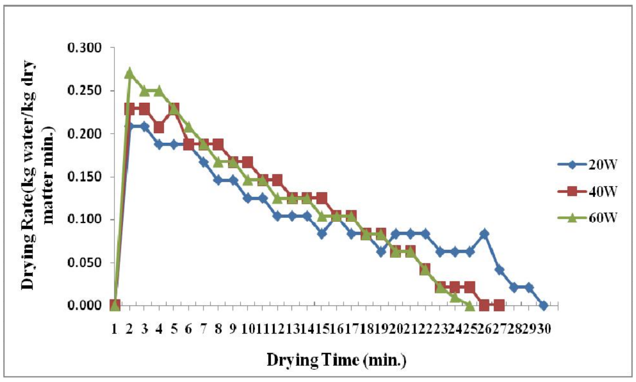

Fig. 2: Effect of microwave power on drying rate of green peas for control samples.

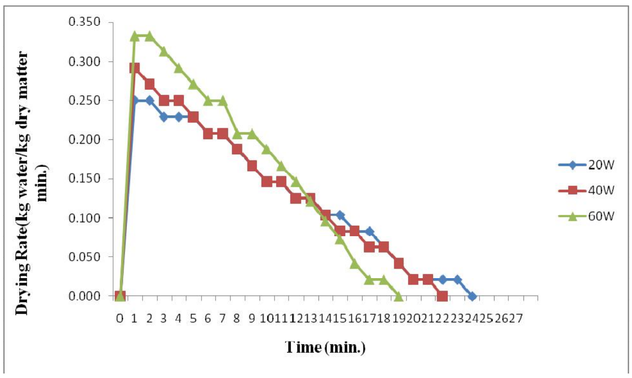

Fig. 3: Effect of microwave power on drying rate of green peas for blanched samples.

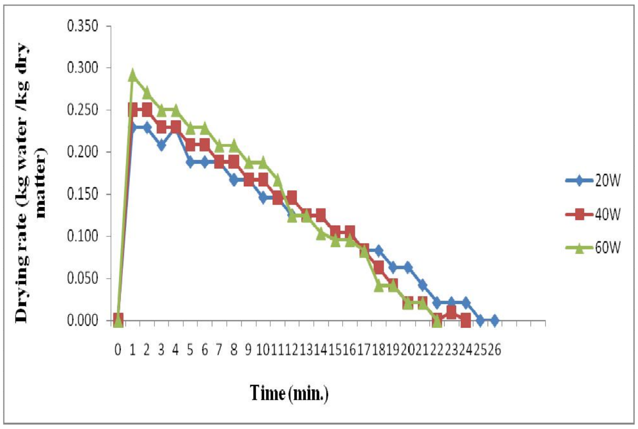

Fig. 4: Effect of microwave power on drying rate of green peas for citric acid blanched samples.

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