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The Comparative Study of Mathematical Models and Chlorophyll Retention in The Drying of Green Peas

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ABSTRACT

The objectives of this study were to determine a suitable drying model and drying conditions for green peas. The drying of green peas in a hot air oven was done by treating fresh green peas using different blanching methods prior to drying in the oven using a thin layer technique at three temperatures of 50, 60 and 70°C. Drying data were fitted to the Page model which gave two empirical drying parameters namely drying constant (K) and drying exponent (N). The K increased with increased the drying temperatures as well as the blanching treatments. Blanching inboiling chemical solution and drying at 50°C displayed the highest chlorophyll retention. Moreover, blanching in boiling water and drying at 50°C was also a suitable drying condition for this experiment.

Keywords: green peas, hot air drying, chlorophyll, drying model

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Introduction

Peas are considered to be a vegetable to which science and technology have been applied in several ways; they can be eaten as two quite different foods; this is, as green peas or as dried peas.Chlorophylls are found in plants as well as green peas. Chlorophyll is an antioxidant and functions as a prooxidant under light [1] and a chemo-preservative phytochemical [2]. Substantially increased yields will require imaginative new method of processing with minimum cost to village level processors. This is the reason that corresponds to the important of development of a system for small scale farmers to preserve their excess production which may include drying techniques.Drying of green peas has not shared the success of the canned and frozen products. The drying process for the green peas was long regarded as obstinate and difficult due to the hardening of the outer tissues.The green peas dry very slowly toward the end of the process.Potisate and Phoungchandang [3] reported that quality evaluation by chlorophyll retention showed that the best quality for ivy gourd leaves resulted from pretreated by blanching with a mixture of 0.1% sodium hydrogen carbonate, 0.1% magnesium oxide and 0.5% sodium metabisulfite and drying at 50°C in heat pump-assisted dehumidified air dryer.

Drying models

The relationship analogous to the Newton's law of cooling is often used in drying analysis in order to describe the falling rate period which is called the Newton model (Equation 1). The Newton model is suitable for drying of agricultural products which their drying curves follow exponential curve [4] .

$$\frac{X - X_e}{X_0 - X_e} = \exp(-Kt) \qquad (1)$$

Page's drying model [5] was successfully employed to describe the experimental data of most agricultural products (Equation 2).

$$\frac{X - X_e}{X_0 - X_e} = \exp(-Kt^N) \qquad (2)$$

where: $\frac{X - X_e}{X_0 - X_e}$ = Moisture ratio

X = Moisture content (% dry basis)

X_e = Equilibrium moisture content (% dry basis)

X_0 = Initial moisture content (% dry basis)

K = Drying constant (hr^{-1})

N = Drying exponent

t = Drying time (hr)

The objectives of this study were to determine the suitable drying model and drying conditions for green peas. The effects of pre-drying treatments and drying temperatures on chlorophyll retention were performed.

Research methodology

1. Peas

Mature green peas of variety *Pisumsativum* L. grown in Chiangmai area (Northern Thailand) was used in this study. Before drying,fresh green peas were cleaned and manually peeled.Initial moisture content of the green peas was determined as described in AOAC method [6].

2. Hot air drying

A Gallenkamp oven (2370 CS2M, Loughborough, Leicestershire) of 70.6 x 60.5 45.5 cm. in dimension was used to study the drying characteristics of the green peas. The interior of the oven was of corrosion resistant EN58B stainless steel. The temperature was accurately and reliably controlled by a COMPENSTAT solid state thermostat which had a direct reading scale calibrated from 40 to 250°C. An indicator lamp lighted when the oven reached a set temperature.

3. Pre-drying treatment

Three pre-drying treatments were conducted in the study as follow.

3.1 No pre-drying treatment

3.2 Blanching in boiling water at 100°C for 2 minutes

3.3 Blanching in boiling chemical solution which was a mixture of 0.1% sodium hydrogencarbonate,0.1% magnesium oxide and 0.5% sodium metabisulfite followed the method of Potisate and Phoungchandang [3]. The green peas were blanched in the boiling chemical solution at 100°C for 2 minutes.

4. Drying of green peas

A small wire mesh tray with a load of 150 g of green peas were placed and spread properly into a thin layer on the tray using the hot air drying and the moisture content was regular determined to monitor the moisture content loss. Each pre-drying treatment of the green peas was dried at three different drying temperatures of 50, 60 and 70°C in order to study the effect of drying temperatures on the chlorophyll retention of the green peas. The drying experiments were terminated when the moisture content of dried green peas was 13 % wet basis (15 % dry basis).

5. Total chlorophyll

The total chlorophyll of the fresh and dried green peas was determined by spectrophotometric method based on the method as described in AOAC method [6]. The chlorophyll study was made to determine the color changes due to the pre-drying treatments and the drying temperatures.

6. Statistical analysis

A completely randomized 3 X 3 factorial experiment was used to study the main factors of the drying process: pre-drying treatments and drying temperatures and interaction between the main factors. Three replications were used to determine each parameter. The SPSS 16 for Windows was used to calculate analysis of variance (ANOVA). Duncan's multiple range tests was used to determine the significant treatments at a 95% confidence interval.

Results

1. Drying of green peas

Three pre-drying treatments were conducted in the study including no pre-drying treatment (as control), blanching in boiling water and blanching in boiling chemical solution. A small wire mesh tray with a load of 150 g of the green peas was placed and spread into a thin layer. The initial moisture content of the green peas was 73.88% wet basis (282.93% dry basis). Three different drying temperatures of 50, 60 and 70°C were used. The conditions of ambient air during the experiment varied between temperature of 27 - 30°C and a relative humidity of 40 – 50%.

1.1 Equilibrium moisture content (EMC or X_e)

The X_e was determined to calculate moisture ratio. The moisture content of the green peas was monitored every hour until the moisture content was reduced to a constant value. The green peas were dried at 50, 60 and 70°C within 24 hours until the moisture of the dried green peas was equalized with the relative humidity of the drying air. The X_e's of the green peas at different temperatures and for the different pre-drying treatments are shown in Table 1. The X_e of green peas at each drying temperature and drying condition in Table 1 was used in Equation 1 and 2 to determine K and N.

Table 1 Equilibrium moisture content (EMC or X_e) at the three different pre-drying treatments and three different drying temperatures.

Temperature (°C)	X_e (% dry basis)		
	No pre-drying	Blanching in boiling water	Blanching in boiling chemical solution
50	8.40	5.93	5.82
60	4.29	3.57	3.48
70	2.96	2.82	2.76

1.2 Drying of green peas

Figure 1 and 2 illustrate the plots of moisture ratio and drying times for the prediction and observed values for the drying at 70°C to determine the K in equation 1 (Figure 1) and the K and N in equation 2 (Figure 2). The X_e in Table 1 was used to determine the K and N. From Figure 1 and 2, it was found that constant rate drying was not found. In addition, the high coefficients of determination (R^2) were obtained from the Page model (Figure 2). The K and N values of the Page model are shown in Table 2. The K and N in Equation 2 can be used to predict the drying time at the specific drying temperature of the green peas.

Table 2 Drying constant (K) and drying exponent (N) of dried green peas at three different pre-drying treatments and three different drying temperatures from the Page model.

Temperature (°C)	No pre-drying treatment		Blanching in boiling water		Blanching inboiling chemical solution	
	K (hr^{-1})	N	K(hr^{-1})	N	K (hr^{-1})	N
50	0.52530	0.69831	0.62828	0.93308	0.63532	0.91336
60	0.81008	0.66808	0.83768	0.90667	0.87748	0.87298
70	0.82758	0.87689	1.23475	0.71272	1.24028	0.67699

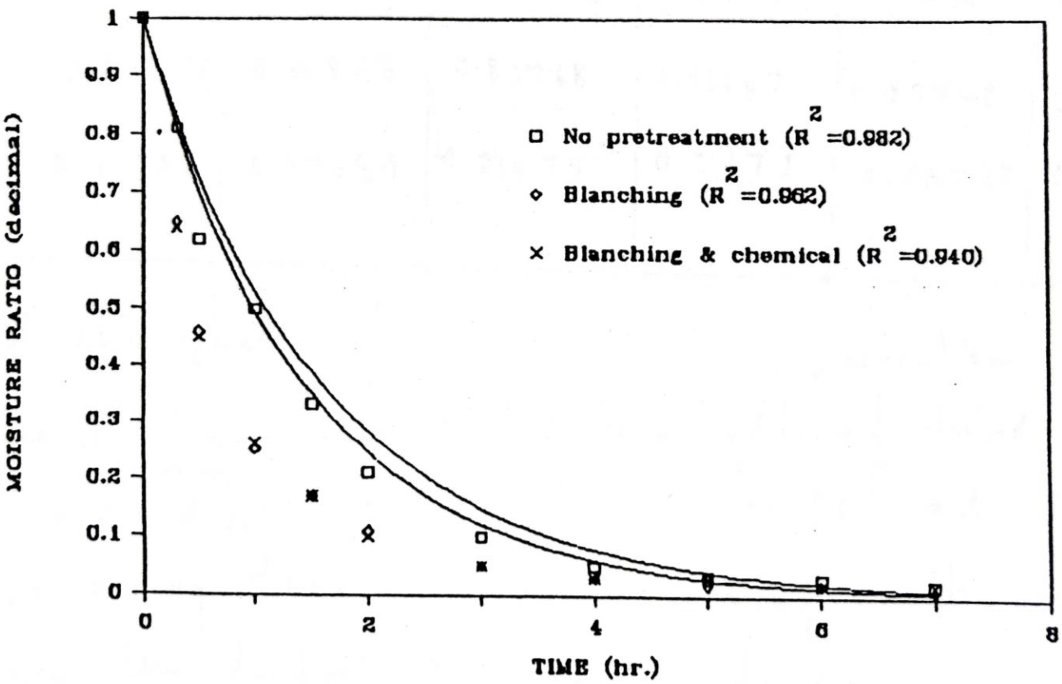

Figure 1 Predicted and observed drying results for 70°C drying temperature and three pre-drying treatments with drying constant, K for the Newton model

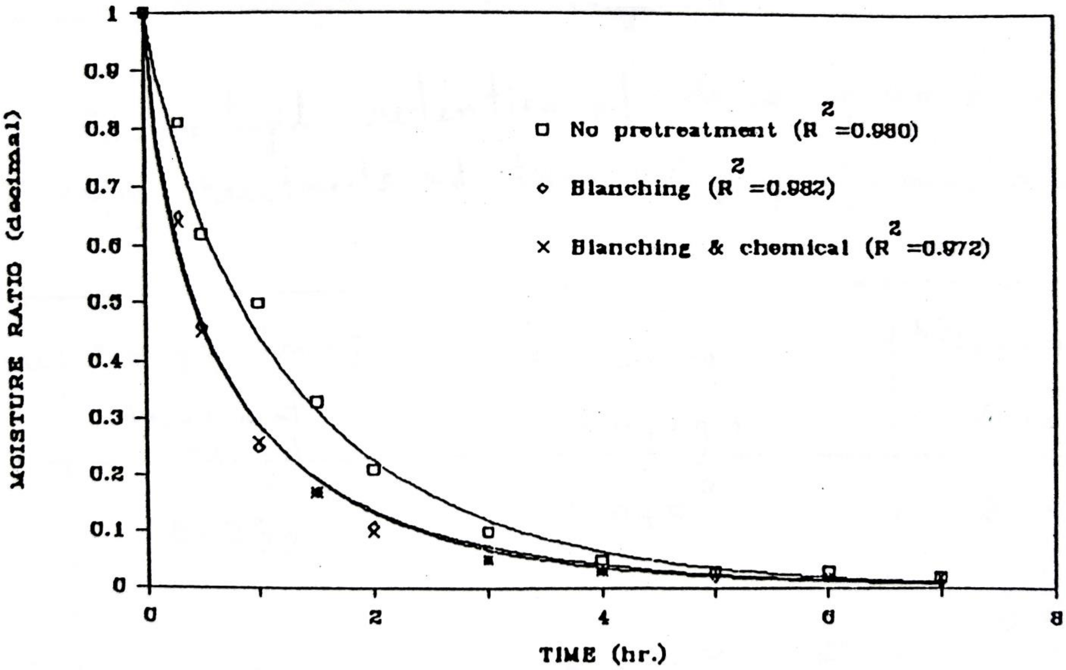

Figure 2 Predicted and observed drying results for 70°C drying temperature and three pre-drying treatments with drying constant, K and drying exponent, N for the Page model

2. Total chlorophyll

Table 3 illustrates the total chlorophyll retention of dried green peas with three different pre-drying treatments and three different drying temperatures. The blanching in boiling chemical solution displayed the highest chlorophyll retention.

Table 3 Chlorophyll retention of dried green peas after pre-drying treatments and three different drying temperatures

Temperature (°C)	No pre-drying treatment (mg/g)	Blanching in boiling water (mg/g)	Blanching inboiling chemical solution (mg/g)
50	0.033^{c}	0.045^{b}	0.056^{a}
60	0.020^{e}	0.036^{c}	0.038^{c}
70	0.012^{f}	0.021^{e}	0.029^{d}

Different superscripts mean that the values are significantly different ($P \leq 0.05$)

Remarks: Total chlorophyll of fresh green peas was 0.065 mg/g.

Discussion and Conclusion

Discussion

The plot of moisture ratio with time (only at 70°C) deceased with time and decreased rapidly at the beginning of drying and then gradually decreased at the end of drying (Figure 1 and 2). The drying data obtained was the best analyzed using the Page model (Equation 2). The values for X, X_0 and t for each test were obtained from the experimental drying data. The values of X_e were taken from Table 1 to determine the K and N values (Table 2). The Page model was suitable for many agricultural products due to their exponential drying curve [5, 7]. The increase of drying temperatures increased the K values (Table 2). For the drying constants in Table 2, with blanching treatment an increasing 10°C drying temperature from 50 to 60°C increased the drying constant by 25.0% and an increasing 10°C drying temperature from 60 to 70°C increased the drying constant by 32.2%.

The drying constant increased with the blanching treatments. However, the drying constant of the blanching in boiling water and blanching inboiling chemical solution were in similar trend. The results agreed with Potisate and Phoungchandang[3] for the drying of Ivy gourd leaves.

The total chlorophyll retention increased with decreasing the drying temperatures. The blanching in boiling chemical solution displayed the highest chlorophyll retention and the blanching methods provided higher chlorophyll retention than no pre-drying treatment (Table 3) due to the inhibition of enzymatic browning reaction and the results agreed with Ivy gourd leaf drying [3]. In addition, the blanching in boiling water and drying at 50°C was also a suitable drying condition because this treatment refrained from using any chemical treatment.

Conclusions

The blanching in boiling water and blanching in boiling chemical solution influenced the drying constant and total chlorophyll retention of the dried green peas. Drying data has been successfully fitted to the Page model with two empirical drying parameters (K and N).The obtained K and N in Equation 2 can be used to predict the drying time at the specific drying temperature of the green peas.

The drying constant increased with increased the drying temperatures as well as the blanching treatments. The blanching in boiling chemical solution and drying at 50°C displayed the highest chlorophyll retention. Moreover, the blanching in boiling water and drying at 50°C was also a suitable drying condition because this treatment refrained from using any chemical treatment.

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