# Effect of blanching-brine-calcium pretreatment on red chili pepper drying

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**Abstract.** The red chili pepper drying aims to remove moisture content up to 11% (wet basis). Dried chilies can be easy to distribute and have longer shelf life because it can be protected from decaying by enzymatic and microbial activity. Pretreatment in drying is one of alternative to decrease drying time. This present study was carried out on effect of blanching-brine-calcium pretreatment toward drying kinetics in chili. In this case, chili provided from the local market was pretreated with blanching, dehydrated osmotic with brine, calcium dipping pretreatment and combination of them. The chili products were dried in tray dryer at 40°C, 50°C, 60°C and 70°C for 8 hours afterward. Result showed that Lewis model is suitable drying model. The blanching-brine-calcium pretreated chili can be well and faster dried with activation energy was 36.4290 kJ/mol and $k_0$ was 7.8712. At 70°C, red chili pepper needed 6.467 hours to dry. Thus, the blanching-brine-calcium pretreatment can be potential to reduce the energy cost for drying as well as retain the quality.

## 1 Introduction

Red chili pepper (*Capsicum frutescens*) is one of the most tropical agricultural crop widely used food flavouring or food seasoning. It is the most abundantly consumed spice because of its hot sensation [1]. It is important commodity and highly commercial demanded by the food industry, not only based on its economic value, but also for the combination of aromatic, colour, flavour, hotness properties and nutritional values [2, 3]. The post-harvest red chili pepper has high moisture content ranging 70-80% (wet basis) [4]. So, it is one of perishable vegetable due to decay easily and very susceptible by organisms, enzymes, fungal and insect attack during storage. Drying may be an alternative method in order to prevent deterioration of food and agricultural products [5].

Drying is one of the agricultural preservation to prevent decay and spoilage [6]. Drying aims to reduce microbiological activity and to improve the stability of moist materials with removal of moisture content until desired level by introduction of heat [7, 8, 9]. So, it can provide longer shelf-life, easy to storage and distribution [5]. However, physicochemical quality degradation of products is major challenges during drying process. The longer drying time result the higher quality degradation. As a result, pretreatments have been

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applied prior to drying fruits and vegetables to control the physicochemical quality changes [10].

Pretreatment is an essential step in the processing of food materials such as drying. Pretreatment can speed up drying rate, improve the quality of dried product, prevent browning, keep texture and help retain volatile compounds [11]. There are various pretreatments in drying which includes chemical pretreatment, blanching, and osmotic dehydration [12]. Blanching and osmotic dehydration can increase the drying rate by removal moisture content before drying. Chemical pretreatments such as calcium chloride dipping can increase the drying rate by removing the surface resistance of fruits or vegetables and retain firmness [12]. Thus, it is important to predict and simulate the drying behaviour. Drying kinetics model is one of ways that can be used to estimate drying time to reach desired level moisture content of materials at various temperatures for retaining quality of product [11]

The objective of this research was to investigate the effect of blanching-brine-calcium pretreatment on red chili pepper drying kinetics at various temperatures. It is also used to estimate drying time for red chili pepper drying. The information obtained could be usefull to finding proper drying condition in order to minimize the quality degradation.

# 2 Materials and Methods

## 2.1 Materials

Fresh red chili peppers (ghost chili) with moisture content 78.08 % (wet basis) or 3.56 gram water $gram^{-1}$ dry basis (db), were purchased from a local market in Semarang, Central Java, Indonesia. They were sorted and cleaned. Calcium chloride (food grade with purity 94.0%, Merck Germany) and sodium chloride (purity 97.99%, UniChemCandi Indonesia) were used for pretreatment chili drying.

## 2.2 Methods

### *2.2.1 Pretreatment drying of red chili pepper*

Three pretreatments before drying for red chili pepper were blanching, osmotic dehydration with brine dipping and calcium solution dipping. Blanching was done by immersing red chili peppers in hot water (distilled water) at 90°C for 3 minutes [13]. They were cooled in cold water and removed the excess water with tissue paper before drying [10]. The chilies were osmotically pretreated by brine solutions dipping in 10% (w/v) NaCl solution at room temperature for 30 minutes. Sodium chloride was chosen as osmotic dehydration agent because it has high osmotic pressure [10, 14]. The chilies were chemical dipped in 1% $CaCl_2$ solution process to remove surface resistance and retain firmness in chili, afterwards [15]. The last sample was pretreated by combination of blanching-brine-calcium pretreatment. So, the red chili peppers with various pretreatments have been ready to dry.

### *2.2.2 Red chili pepper drying*

The red chili pepper drying was conducted in a laboratory tray dryer. The non pretreated and pretreated red chili pepper was dried under 40°C, 50°C, 60°C and 70°C for 8 hours. The constant air flow rate was operated equal to 0.22 $ms^{-1}$. As the responses, the total moisture contents were observed every 30 minutes by gravimetric method.

#### *2.2.3 Drying kinetics model development*

Drying kinetics model is one of alternative to predict and simulate the drying behaviour. It can be proposed to evaluate the rate of moisture with time. So, drying time needed to reach desired level moisture content of materials can be estimated. There have been several drying models to describe moisture removal in food materials presented in literatures [5]. In this research, to select a suitable drying model for describing the drying process of chili, drying curves were fitted in drying models as in Table 1. The correlation between temperature and constant of drying rate is described by Arrhenius equation. In these models, the values of the equilibrium moisture content (Me) to calculate moisture ratio were obtained from sorption isotherm of dried chili under various temperature that is affected by relative humidity. The equilibrium moisture content in chili was assumed refer to Modified Oswin equation as derived by [16]

$$HR = 1/[\{(a + bT)]/Me\}c + 1] \quad (1)$$

Where, HR is the equilibrium relative humidity in decimal; Me is the equilibrium moisture content in % (dry basis); T is the temperature in Celsius. a, b and c are parameter constants. The value of parameter constants are a = 19.299; b = -0.19499 and c = 1.517 [16]. The parameter values used to determine other indefinite variables such as equilibrium moisture content at various temperatures and relative humidity.

## 3 Results and Discussion

### 3.1 Drying kinetics at various pretreatments

Pretreatment is one of alternatives to increase drying rate of products. In this research, the various pretreatments in red chili pepper drying were fitted on drying curves. Moisture ratio and drying time are fitted as drying curve to determine drying kinetics of red chili pepper. Effect of various pretreatments on drying kinetics can be seen in Fig. 1.

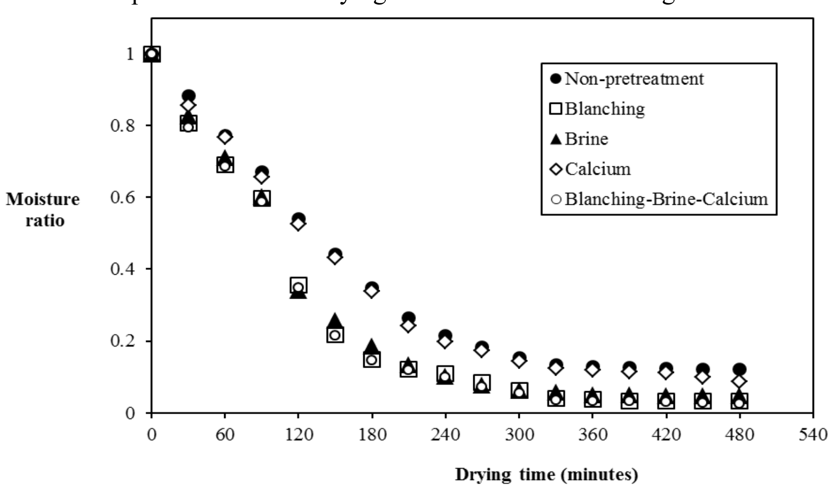


**Fig. 1.** Effect of various pretreatments on drying kinetics red chili pepper at 70°C

Based on Fig.1, the blanching-brine-calcium pretreated samples showed the faster drying rate. It is apparent that moisture ratio decreases significantly with drying time. On the other hand, unpretreated chili has slower drying rate. Blanching-brine-calcium pretreatment for red chili pepper drying can be well and faster dried. Tunde-Akintunde [12] also reported that blanching and osmotic dehydration can increase the drying rate by removal moisture content before drying. Blanching can made soften tissues and enhance mass transfer during drying. Osmotic pretreatment is achieved by dipping the product in a brine solution prior to drying [10]. In addition, chemical pretreatments such as calcium chloride dipping can increase the drying rate by removing the surface resistance [15].

The drying model can be used to predict drying behaviour and the drying time to reach desired level moisture content of material. The moisture ratio and drying time were fitted in drying curve. Several models in exponential regression can be used to obtain parameter value and statistical result of the drying model such as constant of drying rate (k) and coefficient of determination ($R^2$) values. Table 1 shows values of the drying constants and drying coefficients of the several models.

**Table 1.** The values of the drying constants and drying coefficients of the several models.

| Kinetics Model | Pretreated | Drying Constants | $R^2$ |
|---|---|---|---|
| Lewis<br>MR = exp(-kt) | Non | k = 0.0055 | 0.9836 |
| | *Blanching* | k = 0.0084 | 0.9750 |
| | *Brine* | k = 0.0081 | 0.9759 |
| | *Calcium* | k = 0.0058 | 0.9866 |
| | BBC | k = 0.0087 | 0.9763 |
| Page<br>MR = exp($-kt^n$) | Non | k = 0.0032; n = 1.1050 | 0.9866 |
| | *Blanching* | k = 0.0019; n = 1.2987 | 0.9874 |
| | *Brine* | k = 0.0020; n = 1.2800 | 0.9874 |
| | *Calcium* | k = 0.0031; n = 1.1209 | 0.9903 |
| | BBC | k = 0.0020; n = 1.3014 | 0.9888 |
| Modified Page<br>MR = exp[$-(kt)^n$] | Non | k = 0.0055; n = 1.1057 | 0.9866 |
| | *Blanching* | k = 0.0082; n = 1.3016 | 0.9874 |
| | *Brine* | k = 0.0079; n = 1.2834 | 0.9874 |
| | *Calcium* | k = 0.0057; n = 1.1216 | 0.9903 |
| | BBC | k = 0.0083; n = 1.3039 | 0.9888 |
| Handerson and Pabis<br>MR = a exp(-kt) | Non | k = 0.0059; a = 1.0414 | 0.9861 |
| | *Blanching* | k = 0.0089; a = 1.0551 | 0.9780 |
| | *Brine* | k = 0.0086; a = 1.0582 | 0.9794 |
| | *Calcium* | k = 0.0060; a = 1.0382 | 0.9885 |
| | BBC | k = 0.0091; a = 1.0521 | 0.9790 |
| Logarithmic<br>MR = a exp(-kt) + c | Non | k = 0.0062; a = 1.0226; c = 0.0288 | 0.9868 |
| | *Blanching* | k = 0.0085; a = 1.0650; c = -0.0159 | 0.9786 |
| | *Brine* | k = 0.0084; a = 1.0613; c = -0.0052 | 0.9794 |
| | *Calcium* | k = 0.0062; a = 1.0328; c = 0.0083 | 0.9886 |
| | BBC | k = 0.0086; a = 1.0644; c = -0.0196 | 0.9800 |
| Two term model<br>MR = a exp($-k_0t$) + a exp($-k_1t$) | Non | $k_0$ = 0.0056; $k_1$ = -0.0178; a = 1.0522; b = 1.351 x $10^{-5}$ | 0.9907 |
| | *Blanching* | $k_0$ = 0.0089; $k_1$ = 0.0089; a = 0.9970; b = 0.0580 | 0.9780 |
| | *Brine* | $k_0$ = 0.0086; $k_1$ = 0.0086; a = 1.0129; b = 0.0452 | 0.9794 |
| | *Calcium* | $k_0$ = 0.0060; $k_1$ = 0.0060; a = 0.8290; b = 0.2092 | 0.9885 |
| | BBC | $k_0$ = 0.0066; $k_1$ = -0.0057; a = 3.1122; b = -2.0723 | 0.9815 |
| Approximation of diffusion<br>MR = a exp(-kt) + (1-a) exp(-kbt) | Non | k = 0.0419; a = -0.1239; b = 0.1488 | 0.9890 |
| | *Blanching* | k = 0.0220; a = -0.9810; b = 0.5659 | 0.9881 |
| | *Brine* | k = 0.0187; a = -1.6418; b = 0.6858 | 0.9884 |
| | *Calcium* | k = 0.0309; a = -0.1560; b = 0.2153 | 0.9919 |
| | BBC | k = 0.0062; a = 3.2412; b = -0.8644 | 0.9800 |
| Wang and Singh<br>MR = 1 + at + $bt^2$ | Non | a = -0.0046; b = 5.820 x $10^{-6}$ | 0.9956 |
| | *Blanching* | a = -0.0057; b = 8.100 x $10^{-6}$ | 0.9707 |
| | *Brine* | a = -0.0057; b = 7.986 x $10^{-6}$ | 0.9762 |
| | *Calcium* | a = -0.0046; b = 5.882 x $10^{-6}$ | 0.9942 |
| | BBC | a = -0.0058; b = 8.218 x $10^{-6}$ | 0.9707 |
| Midilli<br>MR = a exp[$-k(t)^n$] + bt | Non | k = 0.0007; n = 1.4297; a = 0.9840; b = 0.0002 | 0.0002 |
| | *Blanching* | k = 0.0009; n = 1.4674; a = 0.9771; b = 8.192 x $10^{-5}$ | 0.9909 |
| | *Brine* | k = 0.0008; n = 1.4815; a = 0.9818; b = 0.0001 | 0.9936 |
| | *Calcium* | k = 0.0009; n = 1.3855; a = 0.9801; b = 0.0002 | 0.9976 |
| | BBC | k = 0.0009; n = 1.4551; a = 0.9739; b = 6.843 x $10^{-5}$ | 0.9914 |

These values show that the tested drying models predict drying behaviour of red chili pepper adequately. In all cases, the $R^2$ value of the model was maximum, indicating a good fit [17]. Generally, Midilli model gave a higher $R^2$. Thus, in the empirical case the Midilli model may be assumed to represent the drying behaviour of red chili pepper.

The model was validated for estimating drying time in laboratory experiment. It is aimed to find out the model that suitable with the real condition of red chili drying process. The result of experimental validation that is compared the Lewis and Midilli model to know suitable model can be seen in Table 2.

**Table 2.** Drying Time to Dry Red Chili Pepper until 11% Dry Basis at 70°C and Various pretreatments using Lewis and Midilli Models

| Pretreatment | Drying Time (hours) | | |
|---|---|---|---|
| | Lewis Model | Midilli Model | Experimental Validation |
| Non | 10.39 | 7.06 | 10.67 |
| Blanching | 6.81 | 6.47 | 6.83 |
| Brine | 7.10 | 6.27 | 7.63 |
| Calcium | 9.91 | 7.51 | 9.45 |
| BBC | 6.66 | 5.99 | 6.47 |

Based on Table 2, we can know that the analysis results using the lewis model shows closer to the experimental validation result. This suggests that Lewis model is more accurate than the Midilli model although the $R^2$ value of the Midilli kinetics model is higher. In addition, Lewis model is a basic and simple kinetics model so it is easy to calculate and manual analysis. Whereas, the Midilli model is a complex model and requires relatively complex calculations.

## 3.2 Drying time estimation at blanching-brine-calcium pretreatment under various temperatures

The moisture ratio was influenced by temperature and drying time. The higher temperature and the longer drying time, resulted the lower of moisture ratio in chili. Based on experiment under various temperatures, the relative humidity can be determined by psychometric chart. Thus, equilibrium moisture content of red chili pepper in experiment can be determined based on sorption isotherm. Additionally, the drying time when moisture content decreased from 78.08 % to 11% (wet basis) also can be calculated. The value of constant of drying rate (k), relative humidity, equilibrium moisture content and drying time estimation of red chili pepper under various temperatures using Lewis Model analyses were summarized in Table 3.

**Table 3.** Parameter Value and Drying Time Estimation of Drying Red Chili Pepper

| Temperature (°C) | $H_R$ | Me | k (minutes$^{-1}$) | Drying Time (hours) |
|---|---|---|---|---|
| 30 | 0.80 | 0.0907 | 0.0013756 | 56.44 |
| 40 | 0.45 | 0.0714 | 0.0024916 | 28.11 |
| 50 | 0.28 | 0.0563 | 0.0029622 | 22.25 |
| 60 | 0.17 | 0.0236 | 0.0043249 | 13.74 |
| 70 | 0.12 | 0.0117 | 0.0086579 | 6.65 |
| 80 | 0.07 | 0.0042 | 0.0106660 | 5.30 |
| 90 | 0.048 | 0.0013 | 0.0150140 | 3.74 |

The result showed that the higher temperature caused the higher constant of drying rate and shorter drying time. Based on Table 3 we can know that drying was greatly affected by the drying temperature. The drying rate constant (k) increased with the drying air temperature. The dependence of the rate constant on drying air temperature was correlated by the Arrhenius. The plot depicting the relationship between k and 1/T was found to be exponential regression in the range of temperatures investigated. Here, the activation energy (Ea) was about 36.4290 kJ/mol and value of $k_0$ was 7.8712. The activation energy value of red chili pepper drying is in the range to the values reported (15–40 kJ/mol) by Rizvi [18] for various foods. Higher activation energy values signify greater temperature sensitiveness [19]. Thus, the drying rate constant on blanching-brine-calcium pretreatment chili can be estimation at various temperatures.

## 4 Conclusions

The red chili pepper was dried at various pretreatments and temperatures to reach 11% (wet basis) moisture content. The Lewis model is suitable drying model to estimate drying time in chili drying. The blanching-brine-calcium pretreated chili can be well and faster dried with activation energy was about 36.4290 kJ/ mol and value of $k_0$ was 7.8712. The temperature dependence of drying was correlated by Arrhenius. Thus, blanching-brine-calcium pretreatment under high temperatures can be potential to reduce the time for drying as well as energy cost.

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