Original Article
Journal of Biosystems Engineering
J. of Biosystems Eng. 42(3):190-198. (2017. 9)
https://doi.org/10.5307/JBE.2017.42.3.190
eISSN : 2234-1862
pISSN : 1738-1266

# Predictive Thin Layer Drying Model for White and Black Beans

**Hoon Kim[1], Jae-Woong Han[2]***

[1]*Research Group of Smart Food distribution system, Korea Food Research Institute, Sungnam 13539, Korea*
[2]*Division of Bio-Industry Engineering, Koungju National University, Yesan 32439, Korea*

Received: 1st August, 2017; Revised: 21st August, 2017; Accepted: 23rd August, 2017

## Abstract

**Purpose:** A thin-layer drying equation was developed to analyze the drying processes of soybeans (white and black beans) and investigate drying conditions by verifying the suitability of existing grain drying equations. **Methods:** The drying rates of domestic soybeans were measured in a drying experiment using air at a constant temperature and humidity. The drying rate of soybeans was measured at two temperatures, 50 and 60℃, and three relative humidities, 30, 40 and 50%. Experimental constants were determined for the selected thin layer drying models (Lewis, Page, Thompson, and moisture diffusion models), which are widely used for predicting the moisture contents of grains, and the suitability of these models was compared. The suitability of each of the four drying equations was verified using their predicted values for white beans as well as the determination coefficient ($R^2$) and the root mean square error (RMSE) of the experiment results. **Results:** It was found that the Thompson model was the most suitable for white beans with a $R^2$ of 0.97 or greater and RMSE of 0.0508 or less. The Thompson model was also found to be the most suitable for black beans, with a $R^2$ of 0.97 or greater and an RMSE of 0.0308 or less. **Conclusions:** The Thompson model was the most appropriate prediction drying model for white and black beans. Empirical constants for the Thompson model were developed in accordance with the conditions of drying temperature and relative humidity.

**Keywords:** Black bean, Grain dryer, Simulation, Thin-layer drying model, White bean

## Introduction

Soybeans are rich in vegetable protein as well as a variety of functional ingredients, and contribute to the prevention of adult diseases. While eating habits have become more westernized, including higher meat consumption, public interest in soybeans is increasing as they can improve dietary health (Cho, 2012). Although soybean consumption in South Korea has experienced steady growth, the cultivation area of soybeans has continuously decreased from 10,000 ha in 1995 to 8,000 ha in 2013. Soybean importation has been on the rise, costing USD 644.9 million in 2009 and USD 883.3 million in 2013 (Ministry of Agriculture, Food and Rural Affairs, 2016).

Soybeans undergo a drying process for long-term storage, timely harvest, and quality improvement. This process aims to maximize moisture removal while minimizing quality degradation (Keum et al., 2002).

High-temperature drying procedures for rapid moisture removal may increase stress by creating imbalances in the internal temperature and moisture content of beans, and these increased stresses may result in grain cracking, and thus quality degradation, if extended beyond the limits of the material (Yamaguchi et al., 1980). The quality of all grains varies significantly depending on their drying conditions; as such, determining the optimal drying conditions for grains by analyzing the drying process is important for maintaining the quality of grains (Keum et al., 1997).

In order to determine optimal drying conditions, the

***Corresponding author:** Jae-Woong Han
**Tel:** +82-42-330-1283; **Fax:** +82-41-330-1289
**E-mail:** hanwoong@kongju.ac.kr

thin layer drying model is considered a basic component for the development of the deep bed drying simulation, including the development of the dryer and determination of the drying conditions (Basunia and Abe, 1998; Han et al., 2006). Kim et al. (2004) conducted rice drying experiments at low temperature and low relative humidity, and reported that the Page model best suited to rice drying. Kim et al. (2016) evaluated the suitability of the Lewis, Page, Thompson and reduced moisture diffusion models (thin layer drying models generally used for sorghum) at three drying temperatures between 30 and 50°C as well as three levels of relative humidity between 30 and 50%. They reported that the reduced moisture diffusion model was the most suitable. Most thin layer drying models concentrate on major grains such as rice; however, studies on other miscellaneous grains are lacking. Other models have been used due to the lack of domestic studies. However, foreign and domestic grains differ in their physical properties and thus require different drying conditions. This study was conducted to identify the drying characteristics of domestically popular soybeans (white and black beans) and develop a suitable thin layer drying model from the four widely used thin layer models (Lewis, Page, Thompson, and moisture diffusion model).

## Materials and Methods

### Sample

Samples produced in 2015 from Yeongwol, Gangwon-do were used for this experiment. The samples were threshed, sealed, and stored in a low-temperature storage tank at 2°C to reduce the overall moisture deviation. They were left at room temperature while sealed one day before the beginning of the experiment to reach equilibrium with the external atmosphere. Threshing was delayed until the pods had dried because separating the pods was difficult at the time of harvesting; this resulted in their low initial moisture content. The moisture content of the soybeans was measured using the atmospheric-pressure constant-temperature measurement method conditions in accordance with 103°C-15 g-72 h (ASAE standard, 2004). The initial moisture content of the white beans was 14.9%, w.b.; however, that of the black beans was 14.7%, w.b.

### Thin layer drying apparatus

The equilibrium moisture content was measured using the dynamic measurement method, and an air conditioner (MTH4100, SANYO, UK) was used to generate air at a constant temperature and humidity. The air conditioner produced dry air in a 20-70°C (±0.3°C) temperature range and a 30-98% (±2.5%) relative humidity range (Fig. 1). The equilibrium moisture content of soybeans (white and black beans) was measured at drying temperatures of 50 and 60°C and relative humidities of 30, 40, and 50% for a combined total of six drying conditions. The air generated under each drying condition was transferred to the air filling and drying chambers by the air blower, and the air that passed through the drying chamber was returned to the air conditioner. The drying chamber was cylindrical with a 250 mm diameter and 400 mm height, and a rectifying grid was installed at the bottom to ensure constant air distribution. The wind velocity in the thin layer drying chamber was measured with an anemometer (VELCICALC-PLUS, TSI, USA) at 10 points, and found to be 0.60±0.05 m/s. Soybeans were arranged in a thin layer on a 250 mm-diameter round wicker sample tray installed in the thin layer drying chamber, and weight changes were measured at 10 min intervals using an electronic scale (GF-4000, AND, Japan)

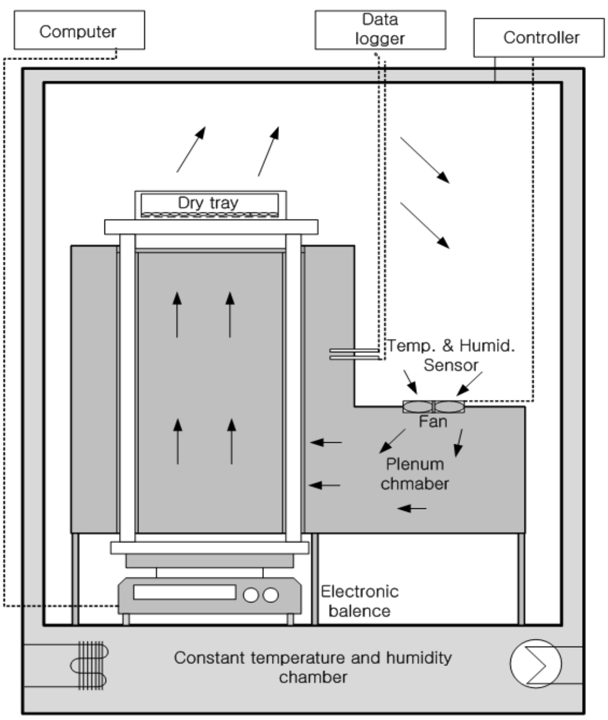


**Figure 1.** Schematic diagram of experimental apparatus for drying.

to track changes in the moisture content. Drying was performed until the equilibrium moisture content was reached in the drying conditions. Experiments were repeated three times under each drying condition. The first and second experiments were averaged and used to identify the drying model, and the third experiment was used to verify the developed model.

## Thin layer drying models

To determine the model and parameters of the soybean thin layer drying equations, existing agricultural product thin layer drying models were used. Four drying models that have been shown to produce accurate results with convenient calculations were selected and compared (Keum et al., 1997).

Verification was performed using the Lewis model based on Newton's law of cooling, the Page model based on the thin layer drying model of corn, the Thompson model using corn, and Henderson's drying model using the solutions of the moisture diffusion law (Kim, 2004). The four models are shown in the following equations (1)-(4):

- Lewis (Lewis, 1921):

$$MR = \exp(-k_1 \cdot t), \quad (1)$$

- Page (Page, 1949):

$$MR = \exp(-P \cdot t^Q) \quad (2)$$

- Moisture diffusion (Henderson, 1952):

$$MR = A \cdot \exp(-k_2 \cdot t), \quad (3)$$

- Thompson (Thompson, 1967):

$$t = A \cdot \ln(MR) + B \cdot (MR)^2, \quad (4)$$

where $MR = \frac{M_t - M_e}{M_o - M_e}$,

$MR$ : Moisture ratio (dimensionless),
$M_t$ : Moisture content (%, d.b.),
$M_e$ : Equilibrium moisture content (dec., d.b.),
$M_o$ : Initial moisture content (dec., d.b.),
t : Drying time (h),
$A, B, k_1, k_2, P, Q$ : Empirical constants.

The moisture ratio represents the degree of drying for an assigned initial moisture content of 1. The moisture ratio becomes zero when the soybeans reach their equilibrium moisture content. The measured moisture ratio then underwent nonlinear regression analysis using SAS 9.4 (SAS institute, Cary NC) to determine the parameters. The parameters of the drying model were $A, B, k_1, k_2, P, Q$, which were determined by the drying temperature ($T_0$) and relative humidity ($RH_0$) (equation (5)).

$$A, B, k_1, k_2, P, Q = a_0 + a_1(T_0) + a_2(RH_0) + a_3(RH_0)^2 + a_4(T_0 \cdot RH_0), \quad (5)$$

where, $a_0, a_1, a_2, a_3, a_4$ : Empirical constants,
$T_0$ : Temperature (°C),
$RH_0$ : Relative humidity (dec.).

The experimental constants were determined using the PROC STEPWISE of SAS 9.4 (SAS institute, Cary NC). The accuracy was obtained using the $R^2$ and RMSE between the measured moisture ratio and the predicted moisture ratio.

# Result and Discussion

## Drying rate

Figures 2 and 3 represent the drying rates of white and black beans at relative humidity levels of 30, 40, and 50% for both drying temperature as the changes in moisture ratios. As shown in the figures, the drying rates of both white and black beans changed exponentially. The half-drying time (time to reach MR=0.5), generally considered to be an indicator of the drying rate,

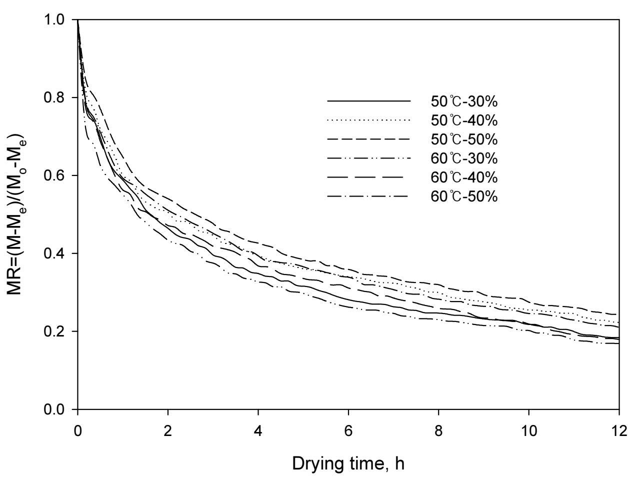


**Figure 2.** Drying curves of white beans at various air temperatures and relative humidity.

decreased in the first two hours after drying began and then tapered to a more gradual decline. The drying rates of white and black beans were similar; however, the drying rate of white beans was slightly faster. The drying rate was faster with lower relative humidity and higher drying temperature, and showed significant variations depending on the drying temperature.

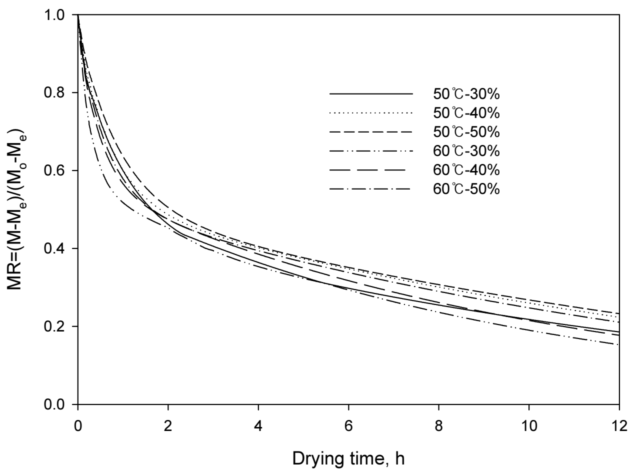


**Figure 3.** During curves of black beans at various air temperatures and relative humidity.

## Thin drying model

Table 1 shows the parameter values of the Lewis, Page, Thompson, and moisture diffusion models for white and black beans, where $T_0$ and $RH_0$ are, respectively, the drying temperature and relative humidity for each condition. The determination coefficient (P) was high for white beans in the Page model, and the k value was high for black beans in the Lewis model. The determination coefficient (A) was 0.7727 in the moisture diffusion model for white beans; however, it decreased to 0.6979 for black beans in the Thompson model. While these coefficients of determination were low due to differences in the graphed starting points, the coefficients of determination for all other models were greater than 0.94, showing relatively good agreement.

To verify the suitability of the four proposed drying equations, the $R^2$ and RMSE values between the measured and predicted moisture ratio for each temperature are shown in Table 2. For white beans, $R^2$ was 0.91 or greater and RMSE was 0.1099 or less for the Lewis model, $R^2$ was 0.94 or greater and RMSE was 0.2067 or less for the Page model, and $R^2$ was 0.86 or greater and RMSE was 0.0432 or less for the reduced moisture diffusion model. For the Thompson model, $R^2$ was 0.97 or greater and RMSE was

**Table 1.** Estimated values of experimental coefficients for drying model

| Type | Model | Experiment coefficients | $R^2$ |
|---|---|---|---|
| White beans | Lewis | $k=0.28658-0.00615T_o-0.89RH_o+0.8975RH_o^2-0.00205T_o \cdot RH_o$ | 0.9773 |
| | Page | $P=0.31797-0.00667T_o-0.026RH_o-0.195RH_o^2-0.0069T_o \cdot RH_o$ | 0.9954 |
| | | $Q=1.67112-0.00714T_o-2.6655RH_o+2.285RH_o^2+0.00665T_o \cdot RH_o$ | 0.9137 |
| | Thompson | $A=-18.78631-0.28517T_o-41.4735RH_o+28.8RH_o^2+0.42686T_o \cdot RH_o$ | 0.9233 |
| | | $B=15.59923-0.26386T_o-4.0325RH_o+1.77RH_o^2+0.2488T_o \cdot RH_o$ | 0.9426 |
| | Simplified diffusion | $A=0.91202-0.00596T_o+0.0165RH_o-0.383RH_o^2+0.00735T_o \cdot RH_o$ | 0.7727 |
| | | $k_2=0.23357+0.00007333T_o-0.545RH_o+0.46RH_o^2+0.0012T_o \cdot RH_o$ | 0.8343 |
| Black beans | Lewis | $k=0.2758-0.00278T_o-0.822RH_o+0.925RH_o^2-0.0022T_o \cdot RH_o$ | 0.9906 |
| | Page | $P=0.01935+0.01617T_o+0.277RH_o+0.416RH_o^2-0.01655T_o \cdot RH_o$ | 0.9432 |
| | | $Q=2.79042-0.06284T_o-5.2645RH_o+2.9875RH_o^2+0.0722T_o \cdot RH_o$ | 0.8187 |
| | Thompson | $A=-5.69675+0.05556T_o-21.863RH_o+42.6RH_o^2-0.7935T_o \cdot RH_o$ | 0.6979 |
| | | $B=-2.82265+0.05581T_o+16.165RH_o+19.6325RH_o^2-0.46445T_o \cdot RH_o$ | 0.8788 |
| | Simplified diffusion | $A=0.87093-0.00477T_o-0.1365RH_o+14.0RH_o^2+0.0051T_o \cdot RH_o$ | 0.9607 |
| | | $k_2=0.2571-0.00015T_o-0.1365RH_o-0.505RH_o^2+0.0025T_o \cdot RH_o$ | 0.9484 |

$T_0$ : Drying temperature
$RH_0$ : Relative humidity
$A, B, k_1, k_2, P, Q$ : Empirical constants

**Table 2.** Estimated coefficients of determination and root mean square errors between measured and predicted of moisture ratios for each temperature and relative humidity

| Type | Drying condition | $R^2$ | RMSE | $R^2$ | RMSE | $R^2$ | RMSE | $R^2$ | RMSE |
|---|---|---|---|---|---|---|---|---|---|
| | Model | Lewis | | Page | | Thompson | | Moisture diffusion | |
| White beans | 50°C-30% | 0.9304 | 0.094 | 0.9715 | 0.2067 | 0.9799 | 0.0144 | 0.8819 | 0.0408 |
| | 50°C-40% | 0.9109 | 0.1015 | 0.9595 | 0.2497 | 0.9734 | 0.0176 | 0.8683 | 0.0408 |
| | 50°C-50% | 0.9121 | 0.0992 | 0.9576 | 0.2778 | 0.9827 | 0.0104 | 0.8663 | 0.0389 |
| | 60°C-30% | 0.9296 | 0.1021 | 0.9886 | 0.2067 | 0.9979 | 0.0236 | 0.8688 | 0.0374 |
| | 60°C-40% | 0.9093 | 0.1099 | 0.9564 | 0.2647 | 0.993 | 0.0172 | 0.8612 | 0.0432 |
| | 60°C-50% | 0.9139 | 0.1049 | 0.9476 | 0.2922 | 0.9981 | 0.0508 | 0.8629 | 0.0387 |
| Black beans | 50°C-30% | 0.9602 | 0.0961 | 0.9966 | 0.0963 | 0.9829 | 0.0109 | 0.8755 | 0.0391 |
| | 50°C-40% | 0.9164 | 0.0993 | 0.9928 | 0.0741 | 0.9709 | 0.0199 | 0.8725 | 0.0486 |
| | 50°C-50% | 0.9282 | 0.0923 | 0.9972 | 0.0952 | 0.9725 | 0.0062 | 0.8891 | 0.0352 |
| | 60°C-30% | 0.9251 | 0.0981 | 0.9946 | 0.0767 | 0.9924 | 0.0259 | 0.8668 | 0.0367 |
| | 60°C-40% | 0.9289 | 0.0915 | 0.9933 | 0.0682 | 0.9869 | 0.0308 | 0.8901 | 0.0288 |
| | 60°C-50% | 0.9359 | 0.0913 | 0.9973 | 0.0741 | 0.9791 | 0.0208 | 0.8990 | 0.0316 |

0.0508 or less. Of the four models, the Thompson model was thus determined to be the most suitable for representing the drying rate of white beans.

In the case of black beans, $R^2$ was 0.91 or greater and RMSE was 0.0993 or less for the Lewis model, and $R^2$ was 0.87 or greater and RMSE was 0.0486 or less for the reduced moisture diffusion model. For the Page model, the $R^2$ value was 0.99 or greater; however, the RMSE was 0.0963. Results therefore indicated this model is unsuitable for black beans because of the high RMSE, even though the determination coefficient was high. For the Thompson model, $R^2$ was 0.97 or greater and RMSE was 0.0308 or less; thus, the Thompson model was found to be the most suitable of the four models to represent the drying rate of black beans because of its high determination coefficient ($R^2$) and low RMSE. The Thompson model was found the most suitable for both white and black beans, followed by the reduced moisture diffusion model.

Figures. 4-9 show the moisture ratios measured in the experiment as well as those predicted by the four models using white beans at temperatures of 50 and 60°C and relative humidities of 30, 40, and 50%. At a drying temperature of 50°C, the Thompson model show good agreement for the overall drying process. The moisture diffusion model had poor accuracy at the beginning of drying but showed good agreement after the halfway point in the drying. Similar trends were seen at a drying temperature of 60°C: at the beginning of drying, the Page model showed good agreement, but after two hours of drying, the results of the Thompson and reduced moisture diffusion models were relatively accurate. However, although the reduced moisture diffusion model had a small moisture ratio error, the slope of its graph was not aligned. The Lewis model was found to be unsuitable as a drying model because it showed significant differences from the beginning of drying. The Thompson model exhibited good agreement between the predicted and measured moisture ratio throughout the drying process except at the start of drying.

Figures. 10-15 show the moisture ratios measured in the experiment as well as those predicted by the four models using black beans at temperature of 50 and 60°C and relative humidities of 30, 40, and 50%. The Thompson model and the reduced moisture diffusion model showed relatively good agreement, as in the case of white beans. However, the reduced moisture diffusion model had a relatively small moisture ratio error but notably different graphed slope. The Lewis and Page models were found to be unsuitable as drying models because they showed significant differences from the beginning of the drying process. As in the case of white beans, the Thompson model exhibited good agreement between the predicted and measured moisture ratios throughout the drying process, with an exception at the beginning of drying.

Figures. 16 and 17 compare the predicted values of the thin layer drying process for soybeans presented by Overhults (1973) to those of white and black beans

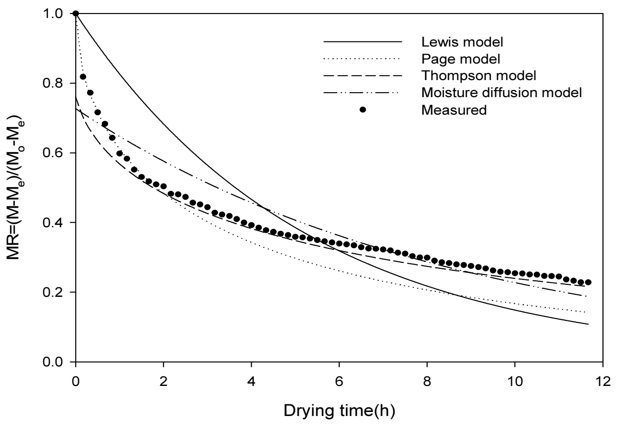


**Figure 4.** Comparison of measured and predicted white bean moisture ratios from four different drying models at 50℃ and 30% relative humidityhoutdlhe were seen at aoving this portion or including further explanation.rmaton.

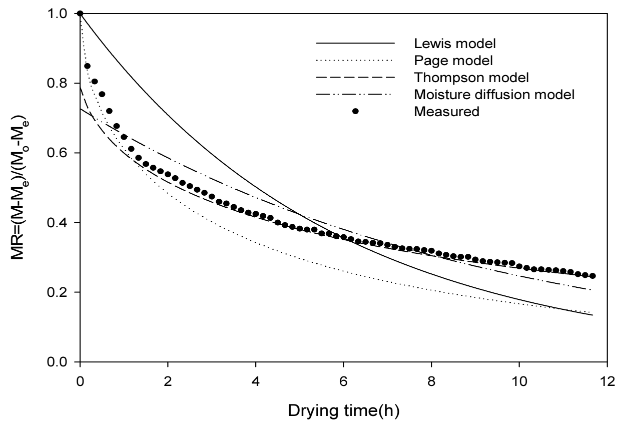


**Figure 5.** Comparison of measured and predicted white bean moisture ratios from four different drying models at 50℃ and 40% relative humidity.

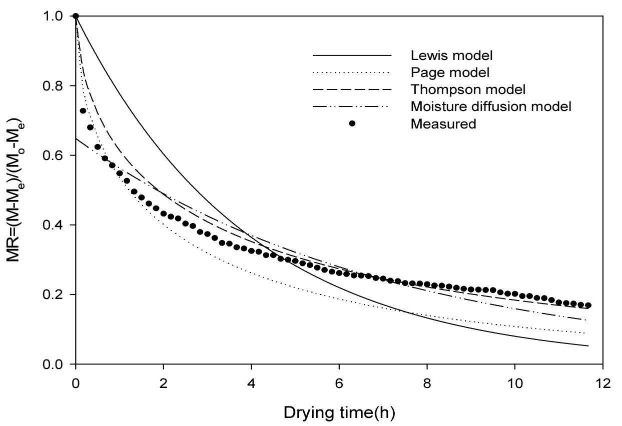


**Figure 6.** Comparison of measured and predicted white bean moisture ratios from four different drying models at 50℃ and 50% relative humidity.

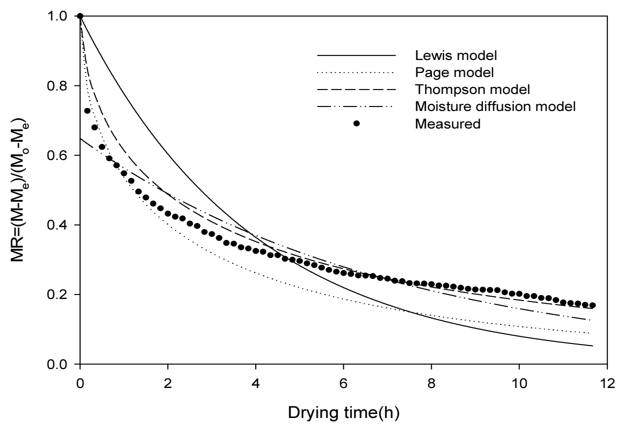


**Figure 7.** Comparison of measured and predicted white bean moisture ratios from four different drying models at 60℃ and 30% relative humidity.

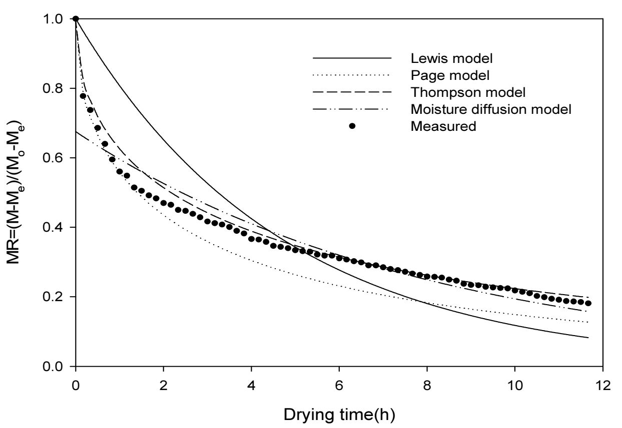


**Figure 8.** Comparison of measured and predicted white bean moisture ratios from four different drying models at 60℃ and 40% relative humidity.

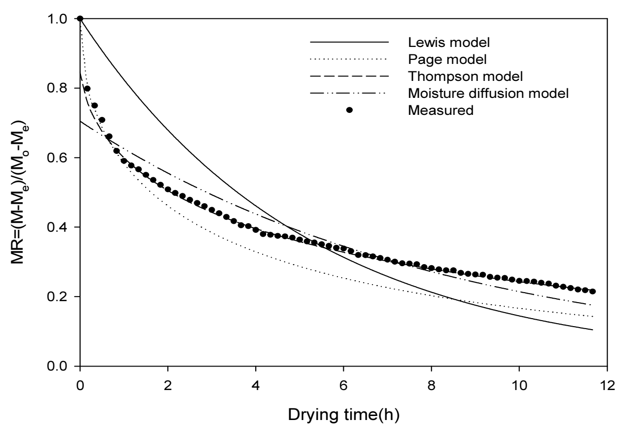


**Figure 9.** Comparison of measured and predicted white bean moisture ratios from four different drying models at 60℃ and 50% relative humidity.

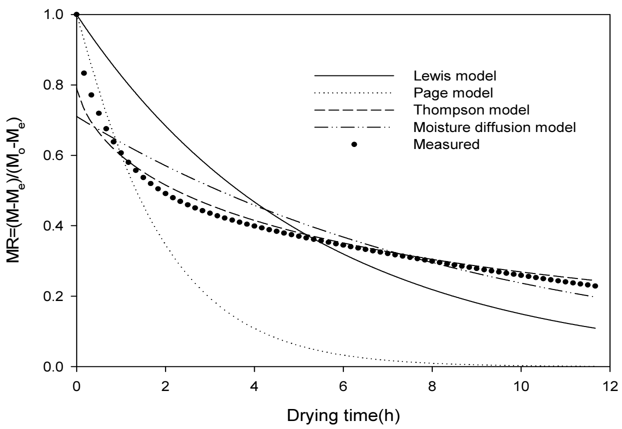


**Figure 10.** Comparison of measured and predicted black bean moisture ratios from four different drying models at 50℃ and 30% relative humidity.

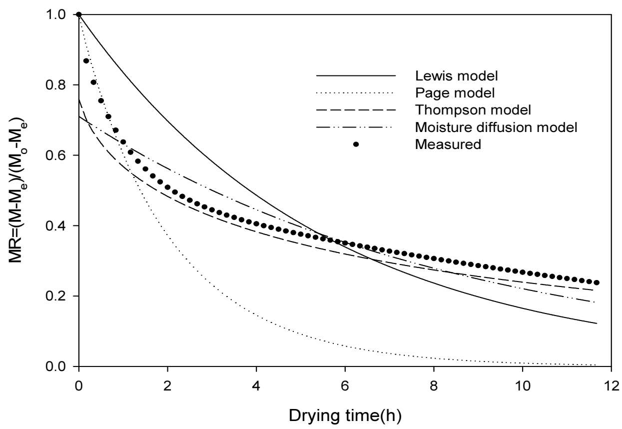


**Figure 11.** Comparison of measured and predicted black bean moisture ratios from four different drying models at 50℃ and 40% relative humidity.

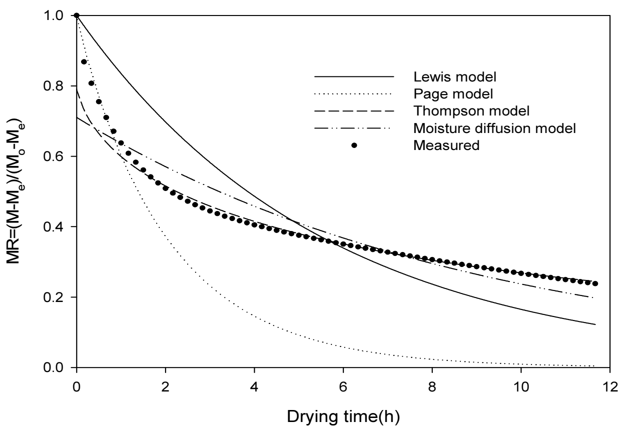


**Figure 12.** Comparison of measured and predicted black bean moisture ratios from four different drying models at 50℃ and 50% relative humidity.

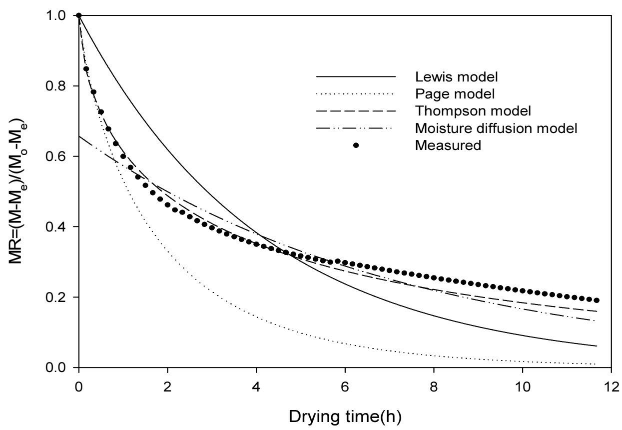


**Figure 13.** Comparison of measured and predicted black bean moisture ratios from four different drying models at 60℃ and 30% relative humidity.

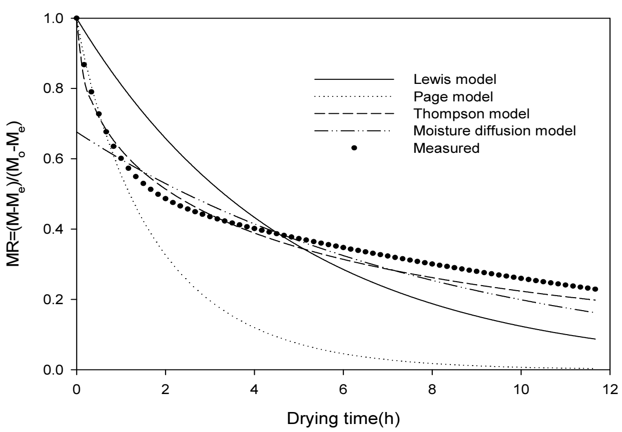


**Figure 14.** Comparison of measured and predicted black bean moisture ratios from four different drying models at 60℃ and 40% relative humidity.

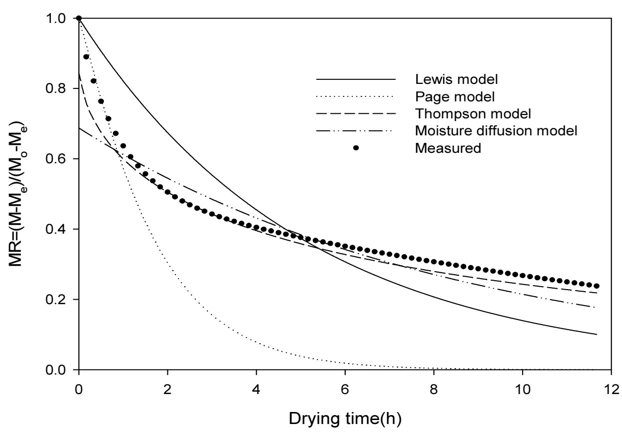


**Figure 15.** Comparison of measured and predicted black bean moisture ratios from four different drying models at 60℃ and 50% relative humidity.

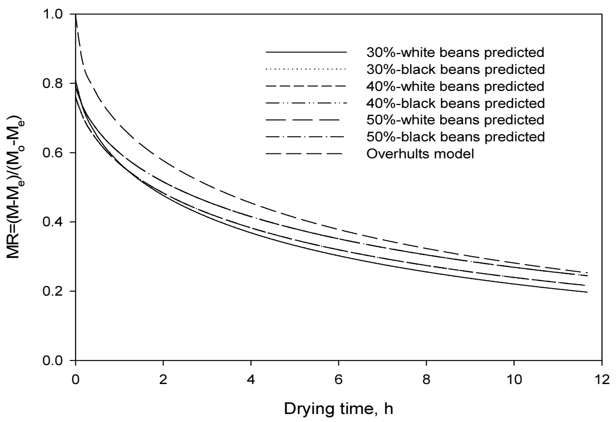


**Figure 16.** Comparison of the drying model developed in this study and the existing soybean drying model (Overhults, 1973) at a drying air temperature of 50℃.

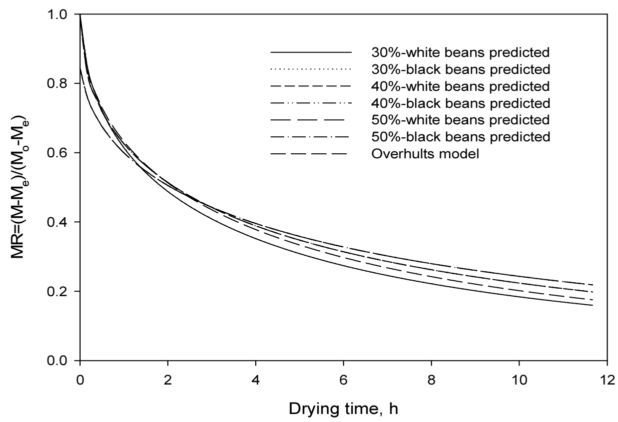


**Figure 17.** Comparison of the drying model developed in this study and the existing soybean drying model (Overhults, 1973) at a drying air temperature of 60℃

presented by the developed drying model. There was no difference in the drying model between white and black beans at a drying temperature of 50°C. The developed model showed differences from the Overhults model at all relative humidity conditions. The drying temperature of 60°C showed a similar tendency to that of 50°C, but the error grew larger as drying continued. A comparison of the predicted values of the three models showed the moisture ratios were different in all temperature ranges, but the slopes of moisture ratios showed similar tendencies.

## Conclusions

This study was conducted to develop a thin layer drying model for domestic white and black beans under drying conditions at 50 and 60°C and relative humidities of 30, 40, and 50%. The suitability of the developed drying model was verified using four thin layer drying models (Lewis, Page, Thompson, and moisture diffusion models) which are widely used for predicting the moisture content of grains, and the parameters were expressed as functions of drying temperature and relative humidity. The relative suitabilities of the four drying equations were verified using their predicted values for white beans as well as their $R^2$ and RMSE from the experiment results. It was found that the Thompson model was the most suitable for white beans with a $R^2$ of 0.97 or greater and an RMSE of 0.0508 or less. For black beans, the Thompson model was also found to be the most suitable with a $R^2$ of 0.97 or greater and an RMSE of 0.0308 or less. A comparison between the predicted values of the thin layer drying equation proposed by Overhults (1973), which depended only on the drying temperature, and the developed thin layer drying equation for white and black beans revealed that both drying temperature and relative humidity are required for accuracy in soybean thin layer drying models. As there were no significant differences between the predicted values for white and black beans using the developed thin layer drying model, the same model can be applied regardless of the soybean type.

## Conflict of Interest

The authors have no conflicting financial or other interests.

## Acknowledgments

This work was supported by a grant from Korea Institute of Planning and Evaluation for Technology in Food, Agriculture, Forestry and Fisheries (IPET) in Gyeonggi-Do, Korea (315036-3).

## References

ASAE Standards. 2004. Moisture measurement-unground grain and seeds. 582 .

ASAE Standards. 2004. Moisture relationships of plant-based agricultural product. 528-544.

Basunia, M. A. and T. Abe. 1998. Thin-layer drying characteristics of rough rice at low and high temperatures. Drying Technology. 16(3-5):579-595.

Cho, J. H. 2012. Preparation and Characteristics of Soybean Meats Prepared by Different Soybean Cultivars. MS thesis. Kyoungpook National University, Department of applied biosciences (In Korean, with English abstract).

Han, J. W., D. H. Keum, H. Kim and S. E. Lee. 2006. Thin Layer Drying Model of Green Rice. Journal of Biosystems Engineering. 31(5): 410-415 (In Korean, with English abstract).

Henderson, S. M. 1952. A basic concept of equilibrium moisture. Agricultural Engineering. 33:29-32.

Keum, D. H. and C. W. Park. 1997. Equilibrium Moisture Contents and Thin Layer Drying Equations of Cereal Grains and Mushrooms (I) - Thin Layer Drying Equations of Short Grain Rough Rice. Journal of the Korean Society for Agricultural Machinery. 22(1): 11-20 (In Korean, with English abstract).

Keum, D. H., H. Kim and S. J. Hong. 2002. Far-Infrared Ray Drying Characteristics of Rough Rice (I) -Thin layer drying equation-. Journal of the Korean Society for Agricultural Machinery. 27(1): 45-50 (In Korean, with English abstract).

Kim, H. S, O. W. Kim, H. Kim, H. J. Lee and J. W. Han. 2016. Thin Layer Drying Model of Sorghum. Journal of Biosystems Engineering. 41(4):357-364 (In Korean, with English abstract).

Kim, H., D. H. Keum and O. W. Kim. 2004. Low Temperature Thin Layer Drying Model of Rough Rice. Journal of Biosystems Engineering. 29(6):495-500 (In Korean, with English abstract).

Lewis, W. K. 1921. The rate of drying of solid materials. Industrial Engineering Chemistry. 13:427-432.

Ministry of Agriculture, Food and Rural Affairs Republic of Korea (In Korean). 2016. Agriculture, Food and Rural Affairs Statistics Yearbook.

Page, G. 1949. Factors influencing the maximum rates of air drying shelled corn in thin layers. M. S. Thesis, Purdue University.

Thompson, T. L. 1967. Predicted performances and optimal designs of convection grain dryers. University Microfilms.

Yamaguchi, S., S. Yamazawa, K. Wakabayashi and T. Shibata. 1980. Experimental study on the internal stress cracking of rice kernel(part1). Journal of the Japanese Society of Agricultural Machinery. 42(1): 91-96.