Nanotechnology Perceptions
ISSN 1660-6795
www.nano-ntp.com

Simple Mathematical Modelling of Thai Glutinous Rice, Khao Tan Rice Cracker

Mali Sarobol[1], Wanida Pharanat[1], Suminya Teeta[2], Preedok Sarobol[2], Chuchat Pharanat[3]

[1]Program of Physics, Faculty of Education, Rajabhat Maha Sarakham University, Maha Sarakham province, Thailand
[2]Program of Physics, Faculty of Science and Technology, Rajabhat Maha Sarakham University, Maha Sarakham province, Thailand
[3]Electrical Technology, Faculty of Engineering, Rajabhat Mahasarakham University, Maha Sarakham province, Thailand
Email: mali.sa@rmu.ac.th

Rice is a major cash crop which is important both for consumption and export, as a major agricultural export product of Thailand. This study aimed to examine the drying behavior of crackers using the thin-layer GIR-HAD method at temperatures of 60, 70, and 80oC. This article presents the mathematical modeling of drying curves, provides an initial way to determine moisture diffusivity values, and evaluates the activation energy of the cracker. This study explores the utilization of the GIR-HAD drying technique on crackers to enhance the efficiency of thermal processing. Non-linear regression techniques are employed to calculate drying coefficients using mathematical models. The findings suggest that the Midilli Kucuk model is the most optimal model for all GIR-HAD drying processes. The drying rate was positively correlated with the intensity of gas-fired infrared, resulting in a decrease in the overall drying time. The range of the total color difference (ΔE) was between 21.38 and 25.89. As the gas-fired infrared intensity increased, the hardness, chewiness, and fracturability of the product decreased. The moisture diffusivity was significantly enhanced when using the GIR-HAD drying method, ranging from 1.37x10-11 to 3.64×10-10 m2/s. The link between the effective diffusivity coefficient and temperature was described using an Arrhenius-type equation. The activation energy for the diffusion of moisture was calculated to be 19.27 kJ/mol. The energy consumption per unit of water removed at a temperature of 80oC was 2.93 kWh/kg, which led to a 79% reduction in energy usage compared to a temperature of 60oC. This study presents a method for preparing rice crackers that could be an advantageous choice for the industry.

Keywords: Mathematical modelling, Khao tan rice cracker, Effective moisture diffusivity

1. Introduction

Cracker is a well-liked Thai traditional food that holds economic significance for local business owners in Mahasarakham province, Thailand. Many recipes, especially those that follow the Northern Thai culinary tradition, frequently use Khao Tan rice crackers. In Thailand, Thunya-Siring lutinous rice (broad spectrum blast resistant varieties) were used as raw materials for khao tan, it was granted registration by Rice Department in 2012 [1]. It's the product of the local wisdom in Maha Sarakham province. Considering that rice is the main source of food for every household, it is projected that each family must cultivate rice on around 5 rai (8,000 square meters) of land to have a sufficient supply for year-round use, thereby avoiding the need to purchase it at a high cost. Additionally, new innovations, products, and technologies to enhance rice production capabilities and develop products on a local wisdom base to lead to good management and quality of life for Thai farmers, including consumers and prosperity progress of the country in a sustainable manner. Noting the advantages of solar energy dryer assisted drying process over sun drying alone and concerned with maintaining the health of rice consumers, The drying process is a key stage in achieving high quality final products[2][3]. Solar thermal systems in agriculture can help conserve post-harvest technology since every agricultural product retains a specific quantity of water in its natural form, known as the moisture percentage.

Reducing the moisture content of the product to a safe level is a realistic, cost-effective, and responsible method for preserving its quality and storage life, as demonstrated by research[4][5]. Drying is an essential step for controlling the moisture content of the product. In developed areas, mechanical dryers, which include air heating burners and high-speed fans, have supplanted the traditional method of sun drying by forcing hot air over the article to be dried. Solar thermal systems have proven to be feasible, cost-effective, and ecologically beneficial for preserving post-harvest in the agricultural industry in numerous nations. Solar heating systems utilized for food drying can enhance product quality and minimize waste, thereby enhancing the overall quality of life. However, in numerous nations where solar-based food processing systems would be highly beneficial or essential, there is a lack of credible information regarding these technologies. There are numerous drying techniques at one's destruction, including fluidized bed impinging stream drying, far-infrared drying, and hot air vacuum microwave freeze drying. Hot air, presently the prevailing drying method, is characterized by its established technology and economical character. Nevertheless, it engenders significant particulate pollution, demanding a substantial amount of energy, and fails to provide assurance of optimal drying quality. Far-infrared drying is characterized by its rapid drying process and negligible energy usage. From the above limitation of traditional drying methods, an alternative method to reduce operating cost and conserve qualities of dried khao tan rice cracker is needed. In this work, the objectives of the research were to reduce the operational cost of the drying process, develop a simple mathematical model of Thai glutinous rice cracker, and to evaluate the physical properties.

2. Methodology

2.1 Material preparation

Thunya-Sirin glutinous rice was purchased from organic farm harvested at Ban Don Toom, Maha Sarakham province in northeastern Thailand. After soaking the rice in water at room temperature (about 25–30 degrees Celsius) for twenty-four hours, with water being replaced every six hours, the rice was then placed in a closed container for four hours and allowed to incubate.[4], to get rid of any dust particles, they were washed and rinsed in water for a period of time. After soaking the raw rice in watermelon juice or adding some watermelon juice to the cooked rice, the glutinous rice was cooked in a steam cabinet under atmospheric pressure for 15 minutes at a time. It is believed that this causes the rice to become slightly sweeter and crispier, and it also causes the rice to take on an excellent brownish or reddish color when it is fried if it is done correctly. Khao tan rice cracker process as shown in Figure 1a, Figure 1b, Figure 1c

Figure 1a. Khao Tan before drying.

Figure 1b. Rice cracker production process.

Figure 1c. Rice cracker produced.

2.2 Drying procedure

Figure 2 illustrates a schematic diagram of a GIR-HAD (combined gas-fired infrared and air convection drying) system utilized for experimental purposes. The drying process was carried out at an air velocity of 1 m/s and using gas-fired infrared burners with intensities set at 60, 70, and 80°C. The Rajabhat Maha Sarakham University in Thailand utilized the Modified GIR-HAD.

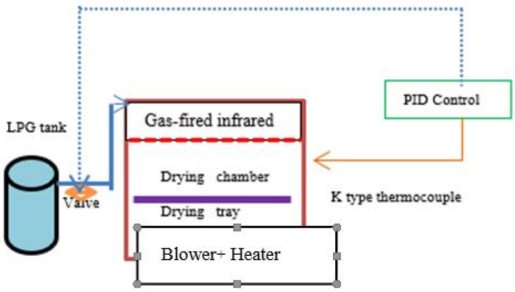

Figure 2. Schematic diagram of combined gas-fired infrared burner and air convection dryer

2.3 Experimental measurements

The parameters utilized in our present investigation include the precise determination of accuracies and uncertainties. The electromagnetic flow meter has undergone testing and calibration, resulting in a flow meter accuracy of ± 5 ml/min. The T-type thermocouples have an accuracy of ± 5 C. In each drying condition, an amount of 1000 g of freshly made crackers was evenly distributed on a tray made of stainless-steel wire mesh, which was then placed inside the drying chamber. GIR-HAD experiments were conducted at different drying temperatures with a sample thickness of 3 mm. The moisture contents of the samples were determined using the AOAC method [6]. The samples, which had a final moisture content of around 4-6% (dry basis), were stored in polypropylene bags in cold storage at a temperature of 4°C for further assessment of their quality. The moisture ratio was determined utilizing

Equation (1).

$$MR = \frac{M - M_0}{M_e - M_0} \ldots\ldots\ldots\ldots\ldots (1)$$

where M = moisture content at time

Me = equilibrium moisture content

Mo = initial moisture content (%dry basis)

2.4 Effective moisture diffusivity

As shown in Equation (2), Fick's second law of diffusion can characterize the drying characteristics of biological products throughout the decreasing rate period.

$$\frac{\partial M}{\partial t} = \nabla.(D_{eff}\nabla M) \ldots\ldots\ldots \quad (2)$$

where D_{eff} is effective moisture diffusivity (m^2/s) and M is moisture content (g water/g dry matter)

To calculate effective moisture diffusivity, crackers were assumed to be spherical. Equation (3) expresses an analytical solution to Fick's second law for a spherical shape.

$$MR = \frac{6}{\pi^2}\sum_{n=1}^{\infty}\frac{1}{n^2}\exp\left(-n^2\pi^2\frac{D_{eff}t}{r^2}\right) \ldots\ldots\ldots \quad (3)$$

where r is the radius of rice kernel (1.09 mm), n is the number of terms taken into consideration (n = 1, 2, 3,.). For a long drying period ($D_{eff}t/r^2$ is greater than 0.1), only the first term of the expansion needs to be considered, thus simplifying Equation (3) to Equation (4)

$$1n(MR) = 1n\frac{6}{\pi^2} - \frac{\pi^2 D_{eff} t}{r^2} \ldots\ldots\ldots\ldots\ldots \quad (4)$$

The effective moisture diffusivity of the sample at each moisture content can be calculated using Equation (5)

$$D_{eff} = \frac{-0.1011n(MR) - 0.0504}{(t/r^2)} \ldots\ldots\ldots\ldots \quad (5)$$

We determine the activation energy by modifying the updated Arrhenius equation, as we cannot accurately measure the temperature within the GIR-HAD drier. This technique assumes that the effective moisture diffusion and the ratio of GIR-HAD output power to sample weight (m/p) are more relevant than air temperature. Then Equation (6) can be effectively used as follows

$$D_{eff} = D_0 \exp\left(-\frac{E_a}{RT}\right) \ldots\ldots\ldots \quad (6)$$

where E_a is the activation energy (kJ/mol), R is the ideal gas constant (8.3143 kJ/mol), T is the absolute temperature (K), and D_0 is the pre-exponential factor (m^2/s).

2.5 Specific energy consumption

The specific energy consumption (SEC) of the cracker during GIR-HAD drying was quantified using a Clamp-On Power Meter (YOGOGAWA; CW 140; kWh). The term "energy" referred to in this context is the amount of energy needed to extract one unit of mass of water from an initial moisture content of 296±35% d.b. to a final moisture level of 4-6% d.b. The total energy was determined by adding together the energy consumed by the gas-fired infrared radiation source (Egas-fired IR), blower (E_{blower}), and electrical heater (E_{heater}). This calculation did not consider any heat recovery from the exhaust air. The specific energy consumption was determined as followed by Equation (7)

$$SEC = \left(\frac{E_{blower} + E_{gas-fired\ infrared} + E_{heater}}{M_{ims} - M_{fms}}\right) \ldots\ldots\ldots\ldots \quad (7)$$

where M_{ims} and M_{fms} refer to initial and final moisture content (d.b.), ms mass of dry solid (kg). ($E_{gas\text{-}fired\ IR}$) was gas-fired infrared radiation source, blower (E_{blower}) and electrical heater (E_{heater}),

2.6 Modeling drying data

Each experiment had three replications, with a preset GIR-HAD and drying time. The presented data is an average of these values. Non-linear regression studies were conducted using statistical computer software to determine each model's parameter values. Table 1. summarizes the statistical data obtained from the models. The model constants are k, n, a, and b.

Table 1. Mathematical models given for drying curves.

No.	Model name	Model	References
1	Newton	MR = exp (-kt)	[7]
2	Page	MR = exp(-kt^n)	[7]
3	Modified page	MR = exp(-(kt)^n)	[7]
4	Wang and Singh	MR = 1 + a.t + bt^2	[8]
5	Henderson and Pabis	MR = a*exp (-kt)	[8]
6	Logarithmic	MR = a*exp (-kt)+c	[8]
7	Midili et al.	MR = a*exp(-kt^n)+b.t	[7]

2.7 Error analyses

The accuracy of the fit was evaluated using correlation coefficients (R^2) and root mean square error (RMSE). The greater R^2 and lower RMSE indicate a strong fit to the model. The parameters were computed as follows: Equation (8)- Equation (9)

$$R^2 = 1 - \frac{\sum_{i=1}^{N}\left(X_{pre,i} - X_{exp,i}\right)^2}{\sum_{i=1}^{N}\left(X_{pre,ave} - X_{pre,i}\right)^2} \ldots\ldots\ldots\ldots\ldots\ldots \ (8)$$

$$RMSE = \sqrt{\frac{1}{N}\sum_{i=1}^{N}\left(X_{pre,i} - X_{exp,i}\right)^2} \ldots\ldots\ldots\ldots\ldots\ldots \ (9)$$

where $X_{exp,i}$ is the ith experimental values, $X_{pre,i}$ is the ith predicted values, $X_{exp,ave}$ is the ith experimental average values, N is the number of observations and z is the number of constants.

2.8 Color measurement

A Hunter Lab colorimeter (MiniScan XE Plus, Hunter Associates Laboratory, Inc., USA) was used to measure the lightness (L*), redness (a*), and yellowness (b*) of newly manufactured and fried crackers. Each sample was tested three times in different positions, with 30 samples utilized to get the average value. Another relevant color metric is the total color difference (E). It is possible to calculate it using Equation (10).

$$\Delta E = \sqrt{(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2}$$

$\Delta L = L - L_{0,} \Delta a = a - a_{0,} \Delta b = b - b_{0,} \ldots\ldots\ldots$ (10)

2.9 Texture analysis

Cracker hardness and fractur abilities were measured using a texture analyzer (Stable Micro System, TA.XT.Plus, Surrey, UK) with a 1 kg load cell, 50 mm cylindrical probe diameter, and 1 mm/s cross-head speed.

2.10 Sensory evaluation

30 participants, who had been checked for basic taster perception, evaluated their satisfaction with the crackers' color, odor, flavor, texture, and overall acceptability. The voluntary customers washed their lips with water, tasted samples, and assessed their level of happiness. A nine-point hedonic scale (1 = dislike exceedingly, 2 = dislike very much, 3 = dislike moderately, 4 = dislike slightly, 5 = neither like nor dislike, 6 = like slightly, 7 = like moderately, 8 = like very much, and 9 = like extremely) was employed as an instrument for sensory evaluation.

2.11 Statistical analysis

The experimental data was analyzed using ANOVA. Duncan's new multiple range test was used to determine multiple comparisons of mean values at a 95% confidence level.

3. Results and discussion

3.1 Drying characteristics

The graphs showed that the moisture ratio declined significantly during the first stage of drying and then gradually decreased to equilibrium levels. We found that higher gas-fired infrared intensities enhanced the moisture removal from the product. This was most likely because the higher gas-fired infrared intensity caused a rapid increase in temperature at the product's surface, resulting in an increase in water vapor pressure inside the product, as illustrated in Figure 3.

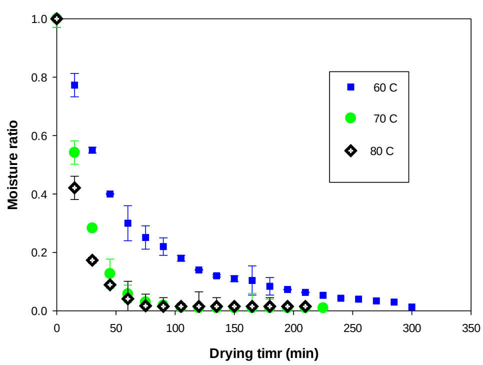

Figure 3. Drying characteristics of crackers versus drying temperature.

3.2 Effective moisture diffusivity

The moisture diffusivities of the samples under various GIR-HAD drying settings were determined by applying Equation (5). Variations in the effective moisture diffusivities occur due to distinct methods of moisture transport throughout the drying process. During the initial phase, the cracker's surface becomes nearly saturated with moisture, and the moisture from the interior replaces the moisture on the surface. As the drying process continues, the surface experiences the formation of a porous structure. In this stage, the transport of moisture will typically take the form of vapor. As the temperature increased, the effective moisture diffusivity rose across the board for all treatments and thicknesses. An increase in infrared intensities resulted in an increase in the crackers' effective moisture diffusivity. The results of this investigation indicate that the effective moisture diffusivity of dried crackers, when subjected to different drying process settings, varied from $1.37\text{x}10^{-11}$ to 3.64×10^{-10} m^2/s. This information is presented in Table 2. When it comes to the normal value range of D_{eff} in typical food drying procedures, which is between 10^{-12} and 10^{-6} m^2/s, this result falls within the normal range. In this work, used the Arrhenius type connection to express the temperature dependence of the effective diffusivity coefficient. The data found that the activation energy for the moisture diffusion was 19.27 kilojoules per mole.

3.3 Specific energy consumption

The increase in gas-fired infrared intensities generated a rapid rise in temperature at the product's surface, resulting in an increase in water vapor pressure inside the product and, hence, an increased drying rate. Using various gas-fired infrared intensities, we investigated the energy and time required to dry crackers to a final moisture content of 4-6% (d.b.). The results revealed a 150 minute reduction in drying time and 2.93 kWh/kg of water removed, for a 79% energy savings compared to drying at 60°C.

3.4 Modeling drying

One of the most significant parts of drying technology is the straightforward mathematical modeling of the drying procedure. In this study, the experimental drying data of crackers at various GIR-HAD were fitted into seven generally used thin-layer drying models, as shown in Table 1. Seven thin-layer drying models were fitted to the experimental data of crackers. The Midilli Kucuk model was revealed to be the best model for all GIR-HAD drying. The value of R^2 was 0.999, indicating good fit and RMSE were also good 0.004.

Table 2. Result of analyses on the modelling

Drying temperature	Model	Coefficients				Statistics	
						R^2	RMSE
60°C	Newton	k =0.00011				0.996	0.018
70°C		k =0.00016				0.993	0.020
80°C		k =0.00018				0.995	0.009
60°C	Page	k =0.00023	n=1.1002			0.991	0.025
70°C		k =0.00031	n=1.0761			0.997	0.004
80°C		k =0.00036	n=1.1095			0.998	0.001
60°C	Modified page	k =0.00035	n=1.0981			0.992	0.019
70°C		k =0.00042	n=1.1033			0.991	0.011
80°C		k =0.00590	n=1.1057			0.995	0.015

60°C	Wang and Singh	a=-0.00020	b=0.0001			0.990	0.023
70°C		a=-0.00018	b=0.0001			0.991	0.014
80°C		a=-0.00016	b=0.0001			0.993	0.026
60°C	Henderson and Pabis	a=1.02350	k=0.0002			0.996	0.012
70°C		a=1.02011	k=0.0001			0.998	0.017
80°C		a=1.02009	k=0.0001			0.990	0.010
60°C	Logarithmic	a=1.04338	k=0.0003	c=-0.0198		0.997	0.008
70°C		a=1.04326	k=0.0002	c=-0.0993		0.996	0.014
80°C		a=1.04310	k=0.0002	c=-0.0990		0.995	0.010
60°C	Midili et al.	a=0.99121	k=0.0001	n=1.0967	b=-4.10x10^{-7}	0.999	0.008
70°C		a=0.98533	k=0.0002	n=1.0979	b=-5.50x10^{-6}	0.998	0.015
80°C		a=0.98817	k=0.0002	n=1.0973	b=-1.13x10^{-6}	0.999	0.004

3.5 Color measurement

Color quality of the product It will have an impact on consumers' purchase[9][10]. The lightness (L*), redness (a*), and yellowness (b*) values of the commercial cracker and the overall color difference (ΔE) of dried cracker values range from 21.38 to 25.89. The results indicate that the color value of the cracker increased as the intensity of the gas-fired infrared increased[11]. The color of the cracker decreased as its brightness heightened. The reduction in lightness was evident at increased drying temperatures. High gas-fired infrared radiation levels and air convection drying may result in low-quality rice.

3.6 Texture analysis

The hardness values range from 950.13±83.64 to 1,112±70.01 g, whereas the fractur ability values range from 1,590.31±102.51 to 1,834.20±80.13 g. Cappellotto et al. (2021) found that heating led to an increase in filler hardness through the inclusion of protein aggregates and gelatinized starch domains into the interconnected structure[12]. While flavor and taste take center stage when describing cuisine, texture is just as important. As with flavor and aroma, people have different preferences when it comes to the texture of the food they eat.

3.7 Sensory evaluation

In this research, it was found that overall acceptances for most of the samples were reportedly in the range of "7 = like moderately, 8 = like very much." A higher drying temperature resulted in decreased acceptance rates for all sensory attributes[13][14]. The concentration reduction of odor components damaged by the heat treatment may be the cause of the reduced acceptance of odor. The sensory data were examined statistically and shown Table 3.

Table 3 Satisfaction with the items' quality after sensory evaluation.

Drying conditions	color	order	favor	texture	overall acceptances
Commercial	8.11±0.76^{a}	8.97±1.60^{a}	8.83±1.25^{a}	8.43±0.96^{a}	8.73±0.96^{a}
60°C	7.45±1.20^{b}	6.23±1.27b^{c}	8.45±1.04^{a}	8.57±1.12^{a}	8.77±0.85^{a}
70°C	7.58±1.06^{b}	8.77±1.19^{a}	8.81±1.18^{a}	8.40±1.56^{a}	8.90±1.09^{a}
80°C	8.23±1.45^{a}	8.83±1.11^{a}	8.82±1.23^{a}	8.67±1.34^{a}	8.66±1.04^{a}

4. Conclusion

The simple mathematical modelling of Thai glutinous rice, khao tan rice cracker results showed that drying temperatures resulted in higher drying rates and increased levels. To investigate the thin layer GIR-HAD drying behavior of crackers at drying temperatures 60 70 80°C. In this work, the experimental drying data of crackers at different GIR-HAD were fitted into 7 commonly used thin-layer drying models, listed in Table 1. Seven common thin-layer drying models were fitted to the experimental data of crackers. The Midilli Kucuk model was revealed to be the best model for all GIR-HAD drying. The value of R^2 was 0.999, indicating good fit and RMSE were also good 0.004. The total color difference (ΔE) varied from 21.38 to 25.89 and increasing gas-fired infrared intensity decreased in hardness, chewiness and fractur ability of product. The effective moisture diffusivity increased with the GIR-HAD drying varying from 1.37×10^{-11} to 3.64×10^{-10} m^2/s. The temperature dependence of the effective diffusivity coefficient was expressed by an Arrhenius type relationship. Activation energy for the moisture diffusion was determined as 19.27 kJ/mol. The specific energy consumption at 80°C was 2.93 kWh/kg of water removed resulting in a 79% energy saving when compared to 60°C. The hardness values range from 950.13±83.64 to 1,112±70.01 g, whereas the fractur ability values range from 1,590.31±102.51 to 1,834.20±80.13 g. Overall acceptances for most of the samples were reportedly in the range of like moderately and like very much.

Acknowledgment

The authors would like to gratefully acknowledge the Thailand Science Research and Innovation (TSRI), Rajabhat Maha Sarakham Universitying (RMU, Thailand) for the financial support.

References

1. “The impacts of climate change factors on rice production and climate-smart agriculture in the watershed areas of central Thailand | RMUTSB ACADEMIC JOURNAL (HUMANITIES AND SOCIAL SCIENCES).” https://so05.tci-thaijo.org/index.php/rmutsb-hs/article/view/225035 (accessed Feb. 24, 2024).
2. K. Chojnacka et al., “Improvements in drying technologies - Efficient solutions for cleaner production with higher energy efficiency and reduced emission,” J. Clean. Prod., vol. 320, 2021, doi: 10.1016/j.jclepro.2021.128706.
3. S. Mehran, M. Nikian, M. Ghazi, H. Zareiforoush, and I. Bagheri, “Experimental investigation and energy analysis of a solar-assisted fluidized-bed dryer including solar water heater and solar-powered infrared lamp for paddy grains drying,” Sol. Energy, vol. 190, 2019, doi: 10.1016/j.solener.2019.08.002.
4. N. Sakai and T. Hanzawa, “Applications and advances in far-infrared heating in Japan,” Trends Food Sci. Technol., vol. 5, no. 11, pp. 357–362, Nov. 1994, doi: 10.1016/0924-2244(94)90213-5.
5. T. V. L. Nguyen, M. D. Nguyen, D. C. Nguyen, L. G. Bach, and T. D. Lam, “Model for thin layer drying of lemongrass (Cymbopogon citratus) by hot air,” Processes, vol. 7, no. 1, 2019, doi: 10.3390/pr7010021.
6. E. de C. Tobaruela, A. de O. Santos, L. B. d. Almeida-Muradian, E. da S. Araujo, F. M. Lajolo, and E. W. Menezes, “Application of dietary fiber method AOAC 2011.25 in fruit and

comparison with AOAC 991.43 method," Food Chem., vol. 238, 2018, doi: 10.1016/j.foodchem.2016.12.068.
7. A. Daliran, M. Taki, A. Marzban, M. Rahnama, and R. Farhadi, "Kinetic analysis, mathematical modeling and quality evaluation of mint drying in greenhouse solar dryer," Therm. Sci. Eng. Prog., vol. 46, no. July, p. 102252, 2023, doi: 10.1016/j.tsep.2023.102252.
8. M. Sarobol, P. Thammapat, W. Pharanat, S. Ruttanasuriyakorn, A. Inta, and P. Sarobol, "Mathematical Model Suitability for Thin-Layer Drying of Chiangda Herbal Tea (Gymnema inodorum Lour) under Modified Greenhouse Dryer," J. Phys. Conf. Ser., vol. 1144, no. 1, 2018, doi: 10.1088/1742-6596/1144/1/012061.
9. S. L. Talebzadeh et al., "Interaction of Different Drying Methods and Storage on Appearance, Surface Structure, Energy, and Quality of Berberis vulgaris var. asperma," Foods, vol. 11, no. 19, 2022, doi: 10.3390/foods11193003.
10. M. Li, Y. Chen, X. Wang, S. Cheng, F. Liu, and L. Huang, "Determination of drying kinetics and quality changes of Panax quinquefolium L. dried in hot-blast air," LWT, vol. 116, Dec. 2019, doi: 10.1016/j.lwt.2019.108563.
11. I. Alibas, A. Yilmaz, B. B. Asik, and H. Erdoğan, "Influence of drying methods on the nutrients, protein content and vitamin profile of basil leaves," J. Food Compos. Anal., vol. 96, Mar. 2021, doi: 10.1016/j.jfca.2020.103758.
12. M. Kamei, M. Nishibe, R. Araki, K. Kohyama, and Y. Kusakabe, "Effect of texture preference on food texture perception: Exploring the role of matching food texture and preference," Appetite, vol. 192, no. October 2023, p. 107078, 2024, doi: 10.1016/j.appet.2023.107078.
13. C. Niamnuy, M. Nachaisin, J. Laohavanich, and S. Devahastin, "Evaluation of bioactive compounds and bioactivities of soybean dried by different methods and conditions," Food Chem., vol. 129, no. 3, 2011, doi: 10.1016/j.foodchem.2011.05.042.
14. J. K. Korese and S. K. Chikpah, "Understanding infrared drying behavior of shea (Vitellaria paradoxa) fruit by-product for the production of value-added products," Biomass Convers. Biorefinery, vol. 13, no. 16, pp. 15001–15015, Nov. 2023, doi: 10.1007/S13399-022-03494-X.