

# Yield, Weight Loss, and Frying Time of Jackfruit and Papaya Chips Produced by Vacuum Frying

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## ARTICLE INFO

### Article history

Received May 16, 2026

Revised June 19, 2026

Accepted July 09, 2026

### Keywords

Fruit Processing;

Jackfruit;

Papaya;

Vacuum Frying;

Weight Loss

## ABSTRACT

Jackfruit and papaya are highly perishable fruits that require appropriate processing to extend shelf life and increase their economic value. Vacuum frying is commonly used to produce fruit chips with reduced moisture content while preserving product quality. This study contributes to evaluated the yield, weight loss, and frying time of jackfruit and papaya chips produced under commercial vacuum-frying conditions. Data were collected through direct observation and production records from 11 processing batches ( $n = 11$ ). The process was conducted at a frying temperature of 85°C and a vacuum pressure of -65 cmHg. No process parameters were intentionally varied; therefore, the study represents the performance of a single operating condition. The average yield of jackfruit and papaya chips was 23.3% and 11.6% respectively while the respective weight losses were 76.7% and 88.4%. The average frying times were 119 min for jackfruit chips and 129 min for papaya chips. The lower yield, higher weight loss and longer frying time observed in papaya chips indicates a higher moisture removal requirement than jackfruit chips. These findings provide baseline performance data for vacuum-fried fruit chip production and suggest that differences in raw material characteristics, particularly moisture content, strongly influence processing efficiency and product recovery.

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## 1. Introduction

Jackfruit (*Artocarpus heterophyllus*) and papaya (*Carica papaya* L.) are widely cultivated tropical fruits with high moisture contents and limited postharvest shelf life. The more mature the fruit, the greater the moisture content [1][2]. The abundance of jackfruit and papaya, together with its perishable nature, need adequate processing methods. One method is to turn them into chips to reduce moisture content and so improve the shelf life and economic value [3].

Vacuum frying is a highly recommended procedure for the production of fruit chips. Vacuum frying has become a preferred technology for producing high-quality fruit chips because it operates

under reduced pressure, allowing water to evaporate at lower temperatures than conventional atmospheric frying [4][5]. This pressure reduces the temperature of vacuum frying relative to conventional frying, enabling the boiling point of water in substances that typically evaporate at 100°C to evaporate more rapidly at temperatures below 100°C [6][7]. Fruits and vegetables possess a significant water content and are susceptible to harm at elevated temperatures. The condition of vacuum frying helps preserve the natural color, flavor, texture, and nutritional quality of fruits while reducing thermal degradation. Previous studies have demonstrated that vacuum frying can improve the overall quality of fruit-based snack products and provide better retention of desirable sensory attributes compared with conventional frying methods [8]–[10].

During frying, the fruit will experience shrinkage until it transforms into fruit chips with reduced moisture content [11]. The weight prior to frying and after to frying will vary due to material shrinkage. Weight loss transpires due to the substantial evaporation of water from the substance during the drying process, together with the loss of certain volatile constituents. This occurs due to the transfer of substantial thermal energy to the substance, prompting the evaporation of water from it [12]. Jackfruit and papaya had different water contents. The initial weights before frying and the final weights after frying were recorded in order to determine the yield and weight loss values of the materials during the frying process [13][14].

Yield and weight loss are important indicators for the performance of a frying process, because they directly affect product recovery, raw-material utilization and the economics of production [15]. Yield is defined as the fraction of final product obtained from the initial raw material, while weight loss is the mass reduction during processing, mainly by evaporation of moisture. Moreover, frying time is a practical operational parameter, which affects production capacity and energy consumption. Yield statistics are useful to assess the efficiency of the frying process [11],[16][17].

The evaluation of chip product yield and the calculation of yield in the frying process are important for assessing the effectiveness of frying, ensuring the consistency of product quality, optimizing the frying process, and identifying potential areas for improvement to obtain high-quality chips [17][18]. Most previous vacuum-frying studies have focused on process optimization, product quality attributes, oil uptake, or mass-transfer phenomena. However, quantitative information regarding yield, weight loss, and frying time under routine industrial production conditions is rarely reported, particularly for tropical fruits such as jackfruit and papaya. Furthermore, comparative baseline data generated from commercial-scale processing lines are limited despite their importance for production planning, process benchmarking, and future optimization studies.

Therefore, this study does not investigate the effects of varying processing parameters but instead provides baseline industrial performance data for vacuum-fried jackfruit and papaya chips produced under a fixed operating condition. The novelty of this work lies in reporting and comparing yield, weight loss, and frying time obtained from multiple production batches in a commercial vacuum-frying process. The findings provide practical benchmark information that can be used by the industry and researchers to evaluate process efficiency and to support future studies involving process optimization and scale-up of vacuum-fried fruit chips.

The present study presents industrial baseline data for yield, weight loss and frying time of jackfruit and papaya chips produced under commercial vacuum-frying conditions. The resulting benchmark values are expected to support process evaluation, production planning, and future optimization studies.

## 2. Method

### 2.1. Studi Design and Processing Conditions

This study was conducted as an observational assessment of a commercial vacuum-frying operation. No experimental factors were intentionally manipulated, and all observations were performed under the standard operating conditions routinely applied in the production facility. The

objective was to find out the baseline industrial data for yield, weight loss and frying time during the production of jackfruit and papaya chips.

Data were collected by directly observing the production process and by analyzing production records from the frying unit. A total of 11 production batches were observed for each fruit type. Vacuum frying was performed at a fixed temperature of 85°C and a vacuum pressure of -65 cmHg. Because operating conditions were not varied, the study characterized process performance under a single commercial processing condition rather than investigating the effects of process parameters.

## 2.2. Preparation of Jackfruit and Papaya Chips

The jackfruit flesh was chosen for its solid, unblemished texture and it was divided into two parts. The white center was subsequently removed and the seeds are separate. The papaya fruit was peeled at the base and tip. The peeled papaya was seeded and then washed to remove any dirt. After washing, the papaya was cut horizontally into sections approximately 6 cm long. These sections were then cut vertically at each corner of the seed cavity to ensure a neat and tidy cut. The sections were grouped according to fruit color and placed in separate baskets.

The fruit sample were frozen at -15 to -20°C for a duration of 24 hours. The frying procedure involves placing the raw material into a vacuum fryer basket and adjusting the temperature to 85°C. Make sure the frying tube and all the valves were tight. The vacuum pump was turned on and monitored until a pressure of -65 cmHg was reached. The frying process takes around 120 to 180 minutes. Temperature and pressure variations were monitored and documented every 15 minutes. Upon completion of frying, the basket was taken out from the oil and secured to drain for two minutes. Then, the air valve was opened, and a gradual flow of air was allowed to preserve the quality of fruit chips [19][20].

The prepared fruit chips were relocated to a stainless-steel baking pan utilizing a scoop and/or scraper. Any aggregated or stuck fragments were separated. This was executed promptly after positioning the chips on the pan to enable effortless separation. They were subsequently drained using a spinner for 2 minutes and it was continued for 1 minute. The chips were subsequently weighed to ascertain their final weight post-frying.

## 2.3. Yield Analysis of the Chips

An examination of the yield of jackfruit and papaya chips was performed by measuring both the initial and final mass of the samples post-frying. Mass observations were performed on 11 processing batches of each fruit type. Yield was calculated using equation (1)[7].

$$\text{Yield (\%)} = \frac{\text{Weight of fruit after frying (g)}}{\text{Weight of fruit before frying (g)}} \times 100 \% \quad (1)$$

## 2.4. Weight Loss Analysis of the Chips

Weight loss assessments were conducted gravimetrically by measuring the original and final mass of the substance. Weight loss observations were performed on 11 processing batches. Weight loss was calculated using equation (2)[14].

$$\text{Weight loss (\%)} = \frac{\text{Initial weight (g)} - \text{Final weight (g)}}{\text{Initial weight (g)}} \times 100 \% \quad (2)$$

## 2.5. Frying Time Analysis of the Chips

Frying duration was observed to assess consistency and its impact on the final chip outcomes. The frying duration was observed from the time the sample was placed in the vacuum fryer until it was taken out. Observations were conducted 11 times during the production process.

Because this study was performed under commercial operating conditions, batch sizes were not standardized and reflected normal industrial production practices. Initial batch weights ranged from 16.0–25.1 kg for jackfruit and 3.0–20.0 kg for papaya. Therefore, differences in batch load may have contributed to variations in frying time, yield, and weight loss. The results should consequently be interpreted as representative industrial performance data rather than controlled experimental comparisons between fruit types.

### 3. Results and Discussion

#### 3.1. Yield of the Chips

During the frying process, the yield is influenced by frying efficiency, including frying time, water evaporation, oil absorption, and the draining process [7]. Furthermore, the type of fruit or the quality of the fresh ingredients, such as the thickness of the flesh and the degree of ripeness, also play a role [21]. Table 1 describes the weight and yield changes in jackfruit chips, while Table 2 describes the papaya chips. The average initial and final weights of jackfruit chips were 20.2 and 4.7 kg, respectively, while those of papaya chips were 9.9 and 1.1 kg. These results indicate that during frying, the cut fruit will experience weight loss. During the frying process, the yield value is influenced by the effectiveness of the frying and the draining process. In vacuum frying, the water content contained in the fruit in the form of ice crystals will evaporate and cause the final weight of the fried fruit chips to decrease [11],[22].

**Table 1.** The data of jackfruit chips

| Data               | Initial weight (kg) | Final weight (kg) | Frying time (minutes) | Yield (%) | Weight loss (%) |
|--------------------|---------------------|-------------------|-----------------------|-----------|-----------------|
| 1                  | 16.0                | 3.8               | 115                   | 23.8      | 76.3            |
| 2                  | 22.5                | 6.1               | 120                   | 27.1      | 72.9            |
| 3                  | 16.0                | 3.9               | 92                    | 24.4      | 75.6            |
| 4                  | 21.6                | 4.9               | 120                   | 22.7      | 77.3            |
| 5                  | 24.0                | 5.6               | 123                   | 23.3      | 76.7            |
| 6                  | 22.0                | 4.7               | 118                   | 21.4      | 78.6            |
| 7                  | 20.0                | 5.1               | 120                   | 25.5      | 74.5            |
| 8                  | 17.4                | 4.4               | 170                   | 25.3      | 74.7            |
| 9                  | 18.2                | 4.0               | 100                   | 22.0      | 78.0            |
| 10                 | 19.6                | 3.5               | 110                   | 17.9      | 82.1            |
| 11                 | 25.1                | 5.7               | 129                   | 22.7      | 77.3            |
| Average            | 20.2                | 4.7               | 119                   | 23.3      | 76.7            |
| Standard Deviation | 3.1                 | 0.9               | 21                    | 2.5       | 2.4             |

The yield of jackfruit chips ranges from 17.9 to 27.1%, with an average of 23.3%. Meanwhile, papaya chips range from 8.8 to 14.3%, with an average of 11.6%. Jackfruit and papaya chips have different yields value. Jackfruit chips have a much higher yield than papaya chips, twice the value. The higher the yield, the higher the weight of the resulting product. The difference in yield between the two types of chips indicates that the type of fruit affects the yield. The process of water evaporation and the total dissolved solids present in the material are also factors that affect the amount of yield in the material after processing [7],[23].

Because weight loss is mathematically complementary to yield, yield was used as the primary indicator of process performance. The corresponding weight-loss values were therefore presented as supporting information rather than as an independent response variable.

The yield values obtained in this study were similar to those reported for other vacuum-fried fruits, with final yields generally between 10 and 30%, depending on fruit type, maturity stage and moisture content. Moisture removal during vacuum frying had a significant effect on the yield and texture of fruit-based snacks. Differences in initial moisture content and fruit structure affected mass reduction and final product recovery [24]. Fruits with higher initial moisture content generally resulted in lower yields due to greater water loss during processing [25]. The yield of jackfruit chips was

23.3%, falling within the upper part of this range, whereas papaya chips were closer to the lower end, reflecting greater moisture removal during processing.

It should be noted that the production batches were not standardized in size. Initial batch weights ranged from 16.0–25.1 kg for jackfruit and 3.0–20.0 kg for papaya. Consequently, part of the observed variation may have been associated with batch load differences in addition to differences in fruit characteristics.

**Table 2.** The data of papaya chips

| Data               | Initial weight (kg) | Final weight (kg) | Frying time (minutes) | Yield (%) | Weight loss (%) |
|--------------------|---------------------|-------------------|-----------------------|-----------|-----------------|
| 1                  | 16.0                | 1.8               | 144                   | 11.3      | 88.8            |
| 2                  | 4.0                 | 0.5               | 87                    | 12.5      | 87.5            |
| 3                  | 20.0                | 2.4               | 150                   | 12.0      | 88.0            |
| 4                  | 12.0                | 1.3               | 130                   | 10.8      | 89.2            |
| 5                  | 8.2                 | 0.8               | 115                   | 9.8       | 90.2            |
| 6                  | 8.0                 | 0.7               | 110                   | 8.8       | 91.3            |
| 7                  | 3.0                 | 0.4               | 110                   | 13.3      | 86.7            |
| 8                  | 8.2                 | 1.1               | 139                   | 13.4      | 86.6            |
| 9                  | 16.0                | 1.5               | 145                   | 9.4       | 90.6            |
| 10                 | 4.0                 | 0.6               | 130                   | 14.3      | 85.7            |
| 11                 | 9.0                 | 1.1               | 160                   | 12.2      | 87.8            |
| Average            | 9.9                 | 1.1               | 129                   | 11.6      | 88.4            |
| Standard Deviation | 5.5                 | 0.6               | 22                    | 1.8       | 1.8             |

### 3.2. Weight Loss of the Chips

Shrinkage is the loss of weight or mass of raw materials during the production process. Shrinkage can occur when rotten, damaged, or dirty parts are removed, or water evaporates from the material [26]. In vacuum frying, shrinkage can be caused by the evaporation of water from the material. The water content in fruit evaporates when it reaches boiling point under vacuum conditions [27]. Table 1 and Table 2 show the weight loss values for jackfruit and papaya chips. Weight-loss values were complementary to yield values and averaged 76.7% for jackfruit chips and 88.4% for papaya chips. These values primarily reflected moisture removal during vacuum frying. Because weight loss was calculated directly from the same mass measurements used for yield determination, the trends observed were identical but inverse to those of yield. Therefore, weight-loss data should be interpreted as supporting evidence of moisture removal rather than as an independent performance indicator.

Shrinkage during processing is influenced by several factors, including the type of fruit, the initial water content before frying, the frying conditions, and oil absorption [28]. The type of fruit and the composition of the raw materials influence the physiology of fruit chips. Fruit types with a denser structure and lower water content will experience less shrinkage than fruit with a more water-rich cell structure. Water loss is the primary factor in the shrinkage of raw fruit during frying [29].

Vacuum frying conditions, such as temperature and pressure, also affect the shrinkage of the final product. Low temperatures and pressure lower the boiling point of water, allowing the ingredients to evaporate more quickly. Higher pressure, longer frying times, and temperatures that reach the boiling point of water cause the water in the ingredients to evaporate and decrease [30][31]. During frying, fruit chips come into direct contact with oil, potentially absorbing it. As the water evaporates, the area becomes filled with oil. The amount of oil in the chips affects the final weight of the fruit chips [32][33].

### 3.3. Frying Time of the Chips

Based on the data in Table 1 and Table 2, it is known that the frying process time varies. This difference is caused by the type of raw material and its water content. The frying method for fruit chips depends on the type of fruit and its water content. In addition, the amount of raw material, temperature, and pressure in the vacuum fryer also affect the frying process time [24][34]. The average

frying time of jackfruit chips was  $119 \pm 21$  min and of papaya chips it was  $129 \pm 22$  min. There was a small difference (about 10 min) in frying time of the two fruits although the moisture content of papaya is generally higher than that of jackfruit.

This observation suggests that the duration of frying was not solely dependent on the initial moisture content of the raw material. Other factors associated with commercial production conditions may have also influenced process variability, such as variations in batch load size, fruit geometry, tissue structure, and operational decisions made during production.

Furthermore, the large variation in batch sizes in this study may have partially obscured the effect of moisture content on frying time. Because the study was conducted under routine industrial conditions and batch loads were not standardized, direct comparisons between fruit types should be interpreted with caution. Therefore, although papaya required a slightly longer frying period on average, the available data do not support the conclusion that fruit type alone determined frying duration under the conditions evaluated.

#### 4. Conclusion

This study provides baseline industrial performance data for vacuum-fried jackfruit and papaya chips produced under commercial operating conditions ( $85^{\circ}\text{C}$  and  $-65$  cmHg). Jackfruit chips had a higher average yield than papaya chips, although both products needed similar frying times. Yield is influenced by raw-material characteristics, such as moisture content and fruit structure, and potential differences in batch size. For industrial application, process control should be based on a measurable endpoint (e.g. a target final moisture content) rather than a fixed frying time to improve product consistency and optimize yield. Future studies should include direct moisture measurements and standardized batch loads to develop more reliable process-control parameters.

**Author Contribution:** All authors contributed equally to the main contributor to this paper. All authors read and approved the final paper.

**Conflicts of Interest:** The authors declare no conflict of interest.

#### References

- [1] P. Mukherjee, I. Hoque Mondal, L. Rangan, and R. Uppaluri, "RSM based optimal drying-parameters of unripe-papaya (*Carica papaya* L.)," *Mater. Today Proc.*, vol. 68, pp. 854–861, 2022, <https://doi.org/10.1016/j.matpr.2022.06.350>.
- [2] N. C. Kha, T. H. Quan, N. T. Y. Nhi, B. L. Giang, and T. T. Truc, "A comparison of the morphological characteristics, physiochemical, nutrients, and antioxidative activities of four genotypes of jackfruits (*Artocarpus heterophyllus*) located in Mekong Delta, Vietnam," *Appl. Food Res.*, vol. 5, no. 1, p. 100847, Jun. 2025, <https://doi.org/10.1016/j.afres.2025.100847>.
- [3] A. Teshome Ayele, M. R. Ismail-Fitry, Y. Desta Bizualem, P. Kumar, E. Mirete Deresa, and N. C. Stanley, "Deep-fried sweetpotato chip production: A review on pretreatment, frying conditions, and quality parameters," *J. Agric. Food Res.*, vol. 24, p. 102406, Dec. 2025, <https://doi.org/10.1016/j.jafr.2025.102406>.
- [4] T. Kourimsky, A. S. Tsagkaris, K. Bechynska, M. Koudela, J. Hajslova, and B. Hradecka, "Potential of vacuum frying on the preparation of carrot crisps and a non-destructive technique for rapid acrylamide detection," *Food Chem.*, vol. 517, p. 149459, Jul. 2026, <https://doi.org/10.1016/j.foodchem.2026.149459>.
- [5] R. L. Monteiro, J. O. de Moraes, J. D. Domingos, B. A. M. Carciofi, and J. B. Laurindo, "Evolution of the physicochemical properties of oil-free sweet potato chips during microwave vacuum drying," *Innov. Food Sci. Emerg. Technol.*, vol. 63, p. 102317, Jul. 2020, <https://doi.org/10.1016/j.ifset.2020.102317>.
- [6] B. K. H. H. Batuwita, J. M. J. K. Jayasinghe, R. A. U. J. Marapana, C. V. L. Jayasinghe, and B. K. K. K. Jinadasa, "Reduction of asparagine and reducing sugar content, and utilization of alternative food

- processing strategies in mitigating acrylamide formation—A review,” *Food Bioprocess Technol.*, vol. 18, no. 3, pp. 2101–2144, Mar. 2025, <https://doi.org/10.1007/s11947-024-03565-z>.
- [7] W. Y. Díaz-Ávila, F. Vaillant, F. J. Castellanos-Galeano, and P. Rodríguez, “Design and evaluation of a semi-continuous vacuum frying system to produce high-quality chips from ripened fruits: Application to plantain,” *J. Food Eng.*, vol. 408, p. 112867, Apr. 2026, <https://doi.org/10.1016/j.jfoodeng.2025.112867>.
- [8] R. Wang, M. Xu, Q. Han, Y. Liu, and K. Chen, “Effect of coating pretreatment on sensory quality of vacuum low temperature fried crisp jujube,” *Int. J. Gastron. Food Sci.*, vol. 42, p. 101338, Dec. 2025, <https://doi.org/10.1016/j.ijgfs.2025.101338>.
- [9] Y. Yuan *et al.*, “Innovative Food Processing Technologies Promoting Efficient Utilization of Nutrients in Staple Food Crops,” *Engineering*, vol. 50, pp. 229–244, Jul. 2025, <https://doi.org/10.1016/j.eng.2025.04.014>.
- [10] D. Ramappa *et al.*, “Standardization of vacuum frying techniques for the development of low-fat beetroot finger chips,” *Food Humanit.*, vol. 3, p. 100424, Dec. 2024, <https://doi.org/10.1016/j.foohum.2024.100424>.
- [11] A. Al Faruq, M. H. A. Khatun, S. M. R. Azam, M. S. H. Sarker, M. S. Mahomud, and X. Jin, “Recent advances in frying processes for plant-based foods,” *Food Chem. Adv.*, vol. 1, p. 100086, Oct. 2022, <https://doi.org/10.1016/j.focha.2022.100086>.
- [12] W. Treesuwan, K. Treesuwan, and K. Pipithsanchan, “Impact of low-cost drying methods on the formulation and physicochemical properties of functional snack derived from fruits of *Solanum torvum* Swartz,” *Appl. Food Res.*, vol. 6, no. 1, p. 102178, Jun. 2026, <https://doi.org/10.1016/j.afres.2026.102178>.
- [13] X. Zhang, M. Zhang, and B. Adhikari, “Recent developments in frying technologies applied to fresh foods,” *Trends Food Sci. Technol.*, vol. 98, pp. 68–81, Apr. 2020, <https://doi.org/10.1016/j.tifs.2020.02.007>.
- [14] Y. He, B. Lu, X. Huang, and C. Feng, “A mathematical model for predicting the weight loss of packaged fruits,” *Appl. Food Res.*, vol. 4, no. 2, p. 100642, Dec. 2024, <https://doi.org/10.1016/j.afres.2024.100642>.
- [15] H. S. Chua *et al.*, “Sustainable bio-oil production from municipal solid waste: Optimising pyrolysis parameters for superior yield and quality,” *Results Eng.*, vol. 26, p. 105445, Jun. 2025, <https://doi.org/10.1016/j.rineng.2025.105445>.
- [16] A. T. Omidiran, O. J. Odukoya, O. O. Akinbule, and O. P. Sobukola, “Effect of microwave-assisted pre-drying and deep-fat-frying conditions on some quality attributes of orange fleshed sweetpotato chips,” *Food Chem. Adv.*, vol. 3, p. 100534, Dec. 2023, <https://doi.org/10.1016/j.focha.2023.100534>.
- [17] S. P. S. R. Sivaranjani, J. Joshi, S. S. Mukta, and P. S. Rao, “A comprehensive review of the mechanism, changes, and effect of deep fat frying on the characteristics of restructured foods,” *Food Chem.*, vol. 450, p. 139393, Aug. 2024, <https://doi.org/10.1016/j.foodchem.2024.139393>.
- [18] L. Huang, S. Liu, Y. Wang, H. Li, J. Cao, and X. Liu, “Effect of cooking methods and polysaccharide addition on the cooking performance of cubic fat substitutes,” *LWT*, vol. 181, p. 114741, May 2023, <https://doi.org/10.1016/j.lwt.2023.114741>.
- [19] W. Liu, M. M. Nasiru, J. Xu, and C. Li, “Vacuum frying of low-fat hairtail: process optimization, physicochemical dynamics, and volatile compounds characterization,” *Food Chem.*, vol. 501, p. 147647, Feb. 2026, <https://doi.org/10.1016/j.foodchem.2025.147647>.
- [20] P. M. M. Castillo, L. T. Díaz, S. T. Díaz, D. A. Correa, and R. J. Martelo Gómez, “Mass Transfer during Atmospheric and Vacuum Frying of Chorizo,” *Int. J. Food Sci.*, vol. 2021, pp. 1–9, May 2021, <https://doi.org/10.1155/2021/9142412>.
- [21] L. Fuentes, S. Rivera, and C. Contreras, “Potential negative impacts of rising temperatures on fruit ripening and quality in raspberries, blackberries, and blueberries,” *Sci. Hortic. (Amsterdam)*, vol. 358, p. 114692, Feb. 2026, <https://doi.org/10.1016/j.scienta.2026.114692>.
- [22] F. Ayustaningwarno, E. van Ginkel, J. Vitorino, M. Dekker, V. Fogliano, and R. Verkerk, “Nutritional and Physicochemical Quality of Vacuum-Fried Mango Chips Is Affected by Ripening Stage, Frying Temperature, and Time,” *Front. Nutr.*, vol. 7, Jul. 2020, <https://doi.org/10.3389/fnut.2020.00095>.

- [23] A. Arslan and İ. Alibaş, "Assessing the effects of different drying methods and minimal processing on the sustainability of the organic food quality," *Innov. Food Sci. Emerg. Technol.*, vol. 94, p. 103681, Jun. 2024, <https://doi.org/10.1016/j.ifset.2024.103681>.
- [24] J. Wichaphon, J. Judphol, W. Tochampa, and R. Singanusong, "Effect of frying conditions on properties of vacuum fried banana bracts," *LWT*, vol. 184, p. 115022, Jul. 2023, <https://doi.org/10.1016/j.lwt.2023.115022>.
- [25] M. J. Gidado, A. A. N. Gunny, S. C. B. Gopinath, A. Ali, C. Wongs-Aree, and N. H. M. Salleh, "Challenges of postharvest water loss in fruits: Mechanisms, influencing factors, and effective control strategies – A comprehensive review," *J. Agric. Food Res.*, vol. 17, p. 101249, Sep. 2024, <https://doi.org/10.1016/j.jafr.2024.101249>.
- [26] K. A. Taiwo and O. D. Baik, "Effects of pre-treatments on the shrinkage and textural properties of fried sweet potatoes," *LWT - Food Sci. Technol.*, vol. 40, no. 4, pp. 661–668, May 2007, <https://doi.org/10.1016/j.lwt.2006.03.005>.
- [27] T. M. Oyinloye and W. B. Yoon, "Analysis of Mass Transfer and Shrinkage Characteristics of Chinese Cabbage (*Brassica rapa* L. ssp. *pekinensis*) Leaves during Osmotic Dehydration," *Foods*, vol. 13, no. 2, p. 332, Jan. 2024, <https://doi.org/10.3390/foods13020332>.
- [28] M. Aguirre-García, O. Cortés-Zavaleta, H. Ruiz-Espinosa, C. E. Ochoa-Velasco, and I. I. Ruiz-López, "The role of coupled water and solute diffusion and product shrinkage during osmotic dehydration," *J. Food Eng.*, vol. 331, p. 111121, Oct. 2022, <https://doi.org/10.1016/j.jfoodeng.2022.111121>.
- [29] Z. Xu, S. Y. Leong, M. Farid, P. Silcock, P. Bremer, and I. Oey, "Understanding the Frying Process of Plant-Based Foods Pretreated with Pulsed Electric Fields Using Frying Models," *Foods*, vol. 9, no. 7, p. 949, Jul. 2020, <https://doi.org/10.3390/foods9070949>.
- [30] H.-I. Chien *et al.*, "Determining the Optimal Vacuum Frying Conditions for Silver Herring (*Spratelloides gracilis*) Using the Response Surface Methodology," *Foods*, vol. 12, no. 19, p. 3533, Sep. 2023, <https://doi.org/10.3390/foods12193533>.
- [31] N. Morakabati, S.-A. Shahidi, L. Roozbeh Nasiraie, A. Ghorbani-HasanSaraei, and S. Naghizadeh Raeisi, "Vacuum frying of parsnip slices: Optimization by taguchi and response surface methodology and modeling the kinetics of water loss," *Alexandria Eng. J.*, vol. 100, pp. 312–321, Aug. 2024, <https://doi.org/10.1016/j.aej.2024.05.052>.
- [32] N. Mahmud, J. Islam, W. Oyom, K. Adrah, S. C. Adegoke, and R. Tahergorabi, "A review of different frying oils and oleogels as alternative frying media for fat-uptake reduction in deep-fat fried foods," *Heliyon*, vol. 9, no. 11, p. 23, 2023, <https://doi.org/10.1016/j.heliyon.2023.e21500>.
- [33] Y. Li *et al.*, "Monitoring the Changes in Heat Transfer and Water Evaporation of French Fries during Frying to Analyze Its Oil Uptake and Quality," *Foods*, vol. 11, no. 21, p. 3473, Nov. 2022, <https://doi.org/10.3390/foods11213473>.
- [34] S. Manzoor, F. A. Masoodi, R. Rashid, and T. A. Ganaie, "Quality changes of edible oils during vacuum and atmospheric frying of potato chips," *Innov. Food Sci. Emerg. Technol.*, vol. 82, p. 103185, Dec. 2022, <https://doi.org/10.1016/j.ifset.2022.103185>.