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Design and Development of Oil Drying Machine for Domestic User

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Abstract

This study presents the design and development of a compact oil drying machine for domestic users. Conventional oil drying machines are typically designed for industrial applications, making them bulky, costly, and unsuitable for domestic use. Therefore, this project aims to develop a lightweight, portable, and user-friendly device capable of efficiently removing excess oil from fried food. The machine was developed through systematic design, material selection, and prototype fabrication. Performance evaluation was conducted using fried food samples at different operating speeds (3000, 6000, and 9000 rpm) and processing times (3, 6 and 9 s). Results show that the machine removes up to 24 g and 29 g of oil from 200 g and 400 g samples, respectively, with higher speeds and longer durations improving oil separation efficiency. Noise levels increased with speed, ranging from 88.5 dBA to 96.8 dBA without a rubber seal, and were reduced to 82.0 – 90.4 dBA with the addition of rubber seal. Overall, the developed machine demonstrates effective oil removal, improved food quality, and practical usability. The compact design and stable low-speed operation (3000 rpm) make it suitable for household applications, supporting healthier food preparation.

1. Introduction

Frying is a common cooking method used worldwide to improve the taste, texture, and shelf life of food products [1]. The process produces a crispy texture and good flavour, which makes fried food popular in many countries. However, fried food usually absorbs a high amount of oil during the frying process, especially on the food surface and within the porous structure [2], [3]. High intake of oily food is related to several health problems such as obesity and cardiovascular diseases [4]. In Malaysia, the number of obesity cases among adults and children has increased significantly in recent years, making it an important public health issue [5]. Therefore, reducing the oil content in fried food is important to promote healthier eating habits. In addition, the Ministry of Health Malaysia reported that obesity and non-communicable diseases remain major health concerns among

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Malaysians [6]. Therefore, reducing the oil content in fried food is important to support healthier eating habits and improve public health.

Oil drying machines are commonly used to remove excess oil from fried food after frying. These machines operate using centrifugal force, where the food is rotated at high speed to separate oil from the surface [7]. This method is widely applied in industrial food processing because it is effective, fast, and improves product quality. Higher rotational speed generally increases oil separation efficiency, although excessive speed may affect food texture and physical quality [8], [9].

Currently, there is a lack of compact and user-friendly oil drying machines designed for domestic users [10]. To the best of the authors' knowledge, no oil drying machines specifically designed for household use have been reported. Most existing machines are developed for industrial applications and do not consider the specific requirements of household environments, such as limited space, ease of cleaning, simple operation, and user safety. Domestic users require machines that are simple to use, space-saving, and practical for daily food preparation [11]. As a result, there is a need to develop a small-scale oil drying machine that is suitable for home use.

Therefore, this study aims to design and develop a compact oil drying machine for household users. The machine is designed to be lightweight, easy to operate, and effective in removing excess oil from fried food. The design also focuses on ease of cleaning and maintenance. This study is expected to provide a practical solution to reduce oil content in fried food and support healthier food preparation at home.

2. Methodology

The development of the oil drying machine was carried out using a systematic approach to ensure that the design meets the required performance and usability. The methodology consists of several main stages, including problem identification, concept development, design, fabrication, and testing. The overall process is illustrated in Fig. 1.

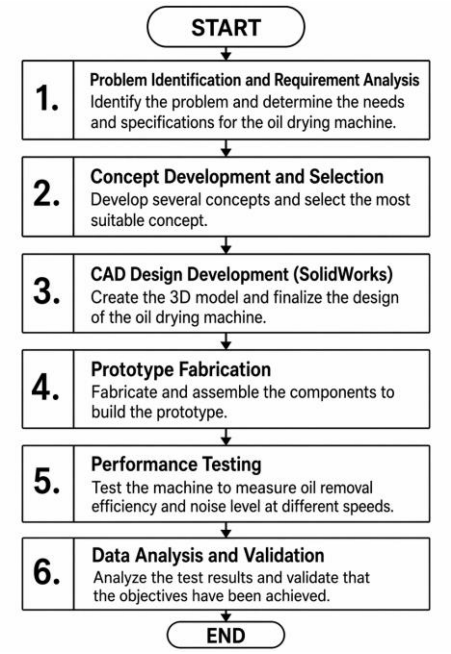

Fig. 1 *Methodology flowchart for the development of the oil drying machine*

2.1 Requirement Analysis and Concept Development

The study began with the identification of user requirements for a household oil drying machine. The main design criteria include compact size, ease of operation, low noise level, safety, and effective oil removal performance. In addition, the machine must be easy to clean and suitable for frequent domestic use.

The concept of the oil drying machine was developed based on the principle of centrifugal separation, where excess oil is removed from fried food through high-speed rotation. The design aims to produce a compact, safe, and user-friendly machine suitable for household applications. Several conceptual designs were generated to achieve the required performance and usability. Each concept applies the same working principle but differs in terms of structure, component arrangement, and overall configuration. The conceptual design sketches are presented in Fig. 2.

Concept 1 adopts a box-type structure with a transparent viewing panel, allowing users to observe the drying process during operation. Concept 2 utilises a cylindrical structure with a top-mounted motor, resulting in a more compact and balanced design. Concept 3 presents a simplified vertical configuration with fewer components, focusing on ease of operation and portability. To evaluate the suitability of each design, a comparison was conducted based on several criteria, including structural stability, size, ease of fabrication, safety, and cost. The comparison of the conceptual designs is summarised in Table 1.

Based on the evaluation, Concept 2 was selected for further development. This concept provides a better balance between performance, stability, and compactness. The cylindrical structure allows more uniform distribution of centrifugal force, which improves oil separation efficiency while reducing vibration during operation. In addition, the design is more suitable for household use due to its smaller footprint and improved structural stability.

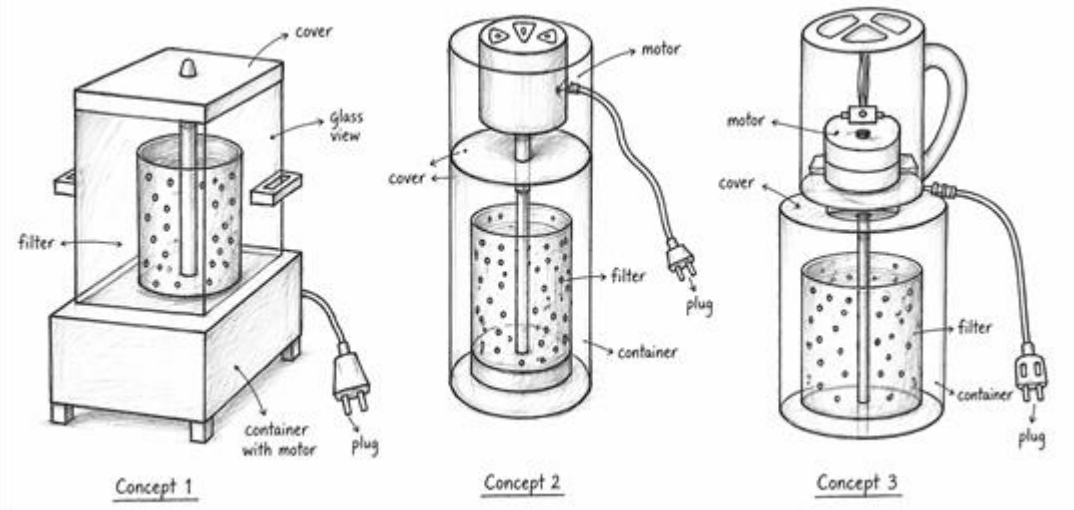

Fig. 2 C*onceptual design sketches of the oil drying machine*

Table 1 *Comparison of conceptual designs of the oil drying machine*

Item	Concept 1	Concept 2	Concept 3
Structure	Box-type structure with transparent viewing panel. Motor at bottom.	Cylindrical structure with top-mounted motor. Compact and balanced.	Vertical compact design with top motor and short shaft.
Working Configuration	Rotation in rectangular enclosure. Oil collects at base.	Rotation in cylindrical container for uniform centrifugal force.	Simplified structure with reduced height.
Advantages	Stable, allows visual monitoring.	Better balance, efficient oil flow, compact.	Simple, portable, low cost.
Disadvantages	Bulky, heavier, higher cost.	More complex assembly and cleaning.	Higher vibration, lower stability at high speed.
Suitability	Users rioritizing visibility and stability.	Best balance of performance and compactness.	Users rioritizing portability and low cost.

Table 1 compares three proposed design concepts based on their structure, working configuration, advantages, disadvantages, and suitability. Concept 1 uses a box-type structure with a transparent viewing panel, providing good stability and easy visual monitoring, but it is relatively bulky and costly. Concept 2 features a cylindrical structure with a top-mounted motor, offering better balance, efficient oil flow, and a compact design, although its assembly and cleaning are more complex. Concept 3 has a compact vertical design with a top-mounted motor and short shaft, making it simple, portable, and low-cost, but it may experience higher vibration and lower stability at high speed. Overall, each concept provides different benefits depending on the design priorities, such as visibility, performance, compactness, portability, and cost.

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2.2 Detailed Design and CAD Modelling

The selected concept was further developed into a detailed design using computer-aided design (CAD) software. The CAD modelling process was used to define the geometry, dimensions, and assembly of all components to ensure proper fit and alignment. The design includes a rotating inner filter, a stationary outer container, a shaft, bearings, and a motor-driven system. The structure was designed to be compact and stable, with a removable cover to enhance safety and ease of cleaning. The final CAD model of the oil drying machine is presented in Fig. 3.



Fig. 3 *CAD assembly design of the oil drying machine*

2.3 Prototype Fabrication and Assembly

The prototype was fabricated based on the finalised design using selected materials and components. The fabrication process involved machining, assembly, and alignment of the rotating system. Proper alignment of the shaft and filter was ensured to minimise vibration during operation. The structural frame was designed to provide stability, while the cover was incorporated as a safety feature to prevent oil splashing and accidental contact with rotating parts.

2.4 Experimental Setup and Performance Evaluation

The performance of the developed oil drying machine was evaluated through experimental testing to determine its effectiveness in removing excess oil from fried food. The evaluation focused on oil removal performance, noise level, and the condition of the food after the drying process.

French fries were used as the test sample because they are commonly consumed fried food and contain a noticeable amount of surface oil after frying. The experiment was carried out using three rotational speeds, which were 3000 rpm, 6000 rpm, and 9000 rpm. Two sample masses were used, namely 200 g and 400 g, while three drying times of 3 s, 6 s, and 9 s were applied for each test.

Before the drying process, the fried food samples were weighed to obtain the initial mass after frying. The samples were then placed inside the rotating filter basket and the machine was operated according to the selected speed and drying time. After the drying process, the samples were weighed again to obtain the final mass. The difference between the initial mass and final mass was used to determine the amount of oil removed.

For noise level testing, the machine was operated at the same three speed levels using a 200 g sample for 10 s. The sound level was measured using a sound pressure level meter in decibel A (dBA) under two conditions, which were with and without a rubber seal between the cover and the container. This test was conducted to evaluate the effect of the rubber seal in reducing noise during operation.

Visual observation was also carried out to evaluate the condition of the French fries after the drying process. Parameters such as crispiness, breakage, greasiness, and overall appearance were observed. The collected data were analysed to determine the most suitable operating condition that gives effective oil removal, reduced noise level, and good food quality for household applications.

3. Results and Discussion

The performance of the developed oil drying machine was evaluated based on oil removal performance, noise level, and food quality after the drying process. These factors are important to determine whether the machine is suitable for household applications. The experimental results were analysed to study the effect of rotational speed, drying time, and sample mass on machine performance. Different operating conditions were used to observe changes in oil separation efficiency and machine stability. The findings were used to identify the most suitable operating condition that provides effective oil removal, low noise, and good food quality for domestic use.

3.1 Oil Removal Performance

This section evaluates the oil removal performance of the developed machine under different operating conditions. The experiment was conducted by varying the sample mass, rotational speed, and drying time to observe their effects on the amount of oil separated from the French fries. The amount of separated oil was calculated based on the difference between the mass of the French fries before and after the drying process.

Table 2 *Amount of oil separated from French fries*

Mass (g)	Speed (rpm)	Time (s)	Mass French fries before drying (g)	Mass French fries after drying (g)	Mass of separated Oil (g)
200	3000	3	130	120	10
		6	130	116	14
		9	140	122	18
	6000	3	130	117	13
		6	140	124	16
		9	120	100	20
	9000	3	130	115	15
		6	120	101	19
		9	130	96	24
400	3000	3	320	308	12
		6	320	304	16
		9	320	299	21
	6000	3	330	315	15
		6	320	301	19
		9	330	305	25
	9000	3	340	323	17
		6	330	307	23
		9	340	311	29

Table 2 shows the oil removal performance of the machine under different operating conditions. The amount of oil removed was determined from the difference between the mass before and after the drying process for different speeds, drying times, and sample masses.

The results show that oil removal increased when the rotational speed and drying time increased. For the 200 g sample, the oil removed increased from 10 g at 3000 rpm for 3 s to 24 g at 9000 rpm for 9 s. For the 400 g sample, the oil removed increased from 12 g to 29 g under the same operating conditions. This shows that higher speed produces stronger centrifugal force, which helps to remove more oil from the food surface. A longer drying time also improves oil separation because the food remains under centrifugal action for a longer period. At each speed level, the amount of oil removed increased steadily from 3 s to 9 s. However, operating at very high speed for a longer time may affect the food structure and cause breakage, especially for soft fried products. Therefore, the operating condition should consider both oil removal performance and food quality.

Fig. 4 (a) and Fig. 4(b) show that oil removal performance improves as the speed and drying time increase. This confirms that both speed and time are important factors in the effectiveness of the oil drying machine.

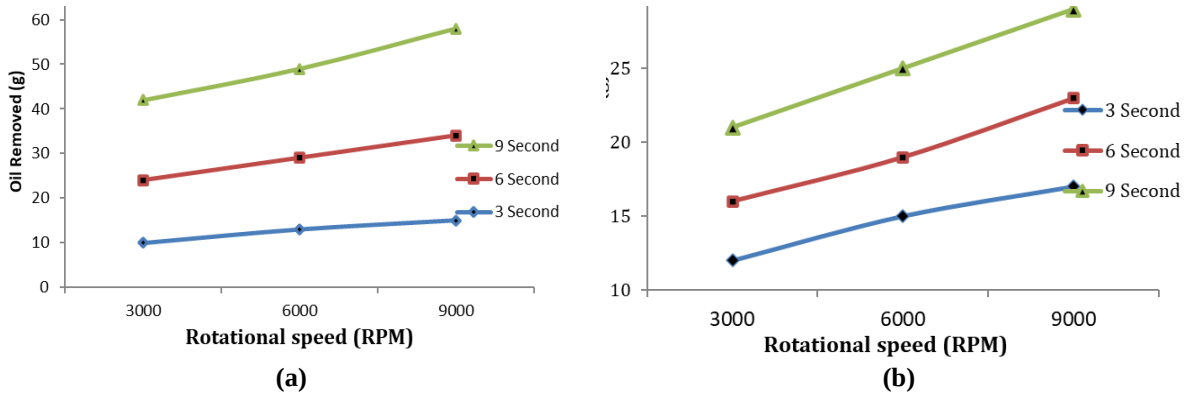

Fig. 4 *Effect of rotational speed and drying time on oil removal performance: (a) 200 g sample; (b) 400 g sample*

3.2 Noise Level Analysis

Noise level testing was carried out to evaluate the suitability of the machine for household use. High noise during operation may reduce user comfort and make the machine less practical for domestic environments.

Table 3 Noise level of the oil drying machine with and without rubber seal

Rotational speed (rpm)	Noise level without rubber seal (dBA)	Noise level with rubber seal (dBA)
3000	88.5	82
6000	92.3	86.7
9000	96.8	90.4

Table 3 shows the noise levels of the oil drying machine with and without the rubber seal at different rotational speeds. Without the rubber seal, the recorded noise levels were 88.5 dBA, 92.3 dBA, and 96.8 dBA for 3000 rpm, 6000 rpm, and 9000 rpm, respectively. The results show that the noise level increased as the rotational speed increased due to stronger vibration and motor movement at higher speed. To reduce vibration and improve machine stability, a rubber seal was installed between the cover and the container.

After adding the rubber seal, the noise levels were reduced to 82.0 dBA, 86.7 dBA, and 90.4 dBA, respectively. The highest noise reduction was observed at 3000 rpm. This shows that the rubber seal is effective in reducing vibration and improving operational comfort. Fig. 5 shows the comparison of noise levels before and after using the rubber seal. The results confirm that the use of a rubber seal improves machine performance and supports safer household operation.

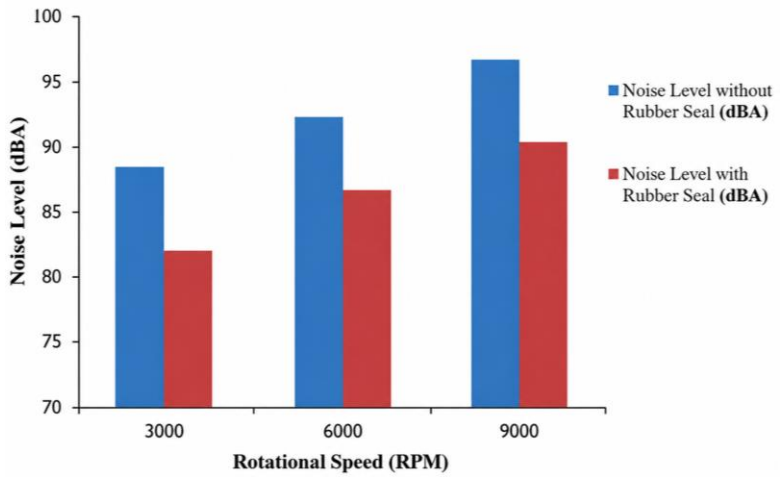

Fig. 5 *Noise level of the oil drying machine with and without rubber seal at different rotational speeds*

3.3 Food Quality Observation

The condition of the French fries after the drying process was also observed because food quality is important for household applications. Removing excess oil should not damage the food structure or reduce consumer acceptance. At 3000 rpm, the fries maintained a good shape with a less greasy surface and acceptable crispiness. The fries appeared lighter and remained crispy for a longer time after drying. This condition is suitable for normal household use because the food quality was maintained while excess oil was successfully reduced.

At 6000 rpm, the fries showed better oil removal performance compared to the lower speed. The fries were less greasy and crispier, but some small cracks and minor breakage were observed. This indicates that the higher centrifugal force started to affect the food structure. At 9000 rpm, the amount of oil removed was the highest, but more visible damage occurred. Some fries broke into smaller pieces and the physical appearance was affected. Although the fries were less greasy and crispier, excessive speed reduced the overall food quality.

These observations show that higher rotational speed improves oil removal performance, but it may also reduce food quality if the speed is too high. Therefore, a balance between oil removal efficiency and food quality is needed to ensure the machine is suitable for household applications.

4. Conclusion

A compact oil drying machine for household applications was successfully designed, developed, and evaluated in this study. The machine uses the principle of centrifugal force to remove excess oil from fried food effectively while maintaining a simple structure, compact size, and user-friendly operation suitable for domestic use.

The experimental results showed that oil removal performance increased with higher rotational speed and longer drying time. The maximum oil removed was 24 g for the 200 g sample and 29 g for the 400 g sample at the highest speed and longest drying duration. However, excessive speed also caused more food breakage and higher noise during operation. Noise level analysis showed that the use of a rubber seal helped to reduce vibration and operational noise, making the machine more comfortable and practical for household use. In addition, food quality observation showed that lower and medium speed provided better balance between oil removal performance and food condition compared to the highest speed.

Based on the overall findings, the speed range of 3000 rpm to 6000 rpm is considered the most suitable operating condition for household applications. The developed oil drying machine provides an effective, low-cost, and practical solution for reducing oil content in fried food while supporting healthier food preparation at home.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design:*** *Abdullah Wagiman, Chye Zhuan En, Kee Jia Le, Loh Jia Qi;* ***data collection:*** *Abdullah Wagiman, Chye Zhuan En, Kee Jia Le, Loh Jia Qi;* ***analysis and interpretation of results:*** *Abdullah Wagiman, Chye Zhuan En, Kee Jia Le, Loh Jia Qi;* ***draft manuscript preparation:*** *Abdullah Wagiman, Chye Zhuan En, Kee Jia Le, Loh Jia Qi, Mohd Shahir Yahya, Nurmina Abdullah. All authors reviewed the results and approved the final version of the manuscript.*

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