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Original Article

Design and Development of an Automated Wrapper Machine for Roasted Glutinous Rice

M.F. Basar[1], N.I.B.M. Farriz[2], N. Hasim[3], N.A. Aliteh[4]

[1,2,3]Faculty of Electrical Technology and Engineering, Universiti Teknikal Malaysia Melaka (UTeM), Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia.
[4]Research and Development Division, Hioki E.E. Corporation, Koizumi Ueda, Nagano, Japan.

[2]Corresponding Author : mfarriz@utem.edu.my

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Abstract *- This paper presents the design and development of an automated wrapper machine for roasted glutinous rice, locally known as pulut panggang, which is traditionally wrapped in banana leaves. Manual wrapping of pulut panggang is highly time-consuming, labor-intensive, and inconsistent in shape and tightness, especially when carried out in large batches. Small and medium enterprises face challenges in maintaining uniform quality, controlling labor costs, and meeting growing demand. The proposed machine focuses on automating the rolling process, enabling the glutinous rice to be packed efficiently in banana leaf rolls. This addresses the main problems of the traditional method by reducing manual handling, improving speed, and ensuring consistent product results. The system was developed not only to improve productivity but also to evaluate the relationship between load (kg) and electrical current (A) drawn during operation. The machine operates on a rectified DC voltage supply. Users place the glutinous rice with a banana leaf in the designated holder and activate the switch to initiate the rolling mechanism. Experimental results demonstrated an average time saving of 4.22s per piece compared to manual wrapping. Electrical performance measurements recorded an average supply voltage of 12V, average rated current of 0.138A, and average power consumption of 1.67W. It was also observed that the current increased proportionally with load due to the higher torque requirement. Overall, the automated packing machine proved effective in reducing wrapping time, ensuring consistent results, and maintaining low energy consumption, making it suitable for small-scale food processing applications.*

Keywords *- Banana leaf wrapping, Food processing automation, Small-scale packaging machine, Energy consumption.*

1. Introduction

Convenience and efficiency have become key aspects of modern food processing systems, where automation can significantly improve productivity and consistency. Consumers increasingly demand products that are prepared in a faster and more reliable manner, while food producers seek methods that reduce labor requirements and maintain quality. In the context of Southeast Asia, Malay cuisine in Malaysia, Indonesia, Singapore, and Brunei shares many traditional dishes rooted in common cultural practices [1]. One such dish is roasted glutinous rice, locally known as *pulut panggang*, which consists of glutinous rice filled with ingredients such as desiccated coconut, beef floss, or shrimp floss. Traditionally, this delicacy is wrapped in banana leaves and grilled over a charcoal stove [2]. The wrapping process, however, is time-consuming and requires skilled manual handling. This creates challenges for large-scale preparation, especially for small and medium enterprises that aim to meet increasing demand. To address this limitation, an automated packing machine was developed to simplify and accelerate the wrapping process. The primary function of the machine is to roll glutinous rice into banana leaves efficiently while reducing the time required compared to manual wrapping. The operation of the machine is designed to be simple and user-friendly. Users place the glutinous rice with a banana leaf on the designated holder and activate the process using a Double Pole Double Throw (DPDT) switch. Once engaged, the system initiates the rolling mechanism, driven by a powered steel component that completes the wrapping motion. Previous studies on food automation have highlighted the importance of mechanized systems in improving efficiency, hygiene, and product uniformity [3]. Automated wrapping and packaging technologies have been widely applied in industries such as confectionery, bakery, and snack production, where rolling, sealing, and portioning processes are mechanized to reduce manual labor [2, 4-6]. In traditional food contexts, however, fewer studies have focused on developing machines tailored to local delicacies such as banana leaf-wrapped rice products. Some research has explored semi-automated devices for rolling or pressing glutinous rice-based foods, but these are typically large, factory-scale systems that are expensive, making them unsuitable for small enterprises [7, 8].

Furthermore, most prior works emphasize mass-production packaging, with limited attention to preserving the authenticity and cultural preparation of traditional Malay cuisine. Therefore, a gap remains in the design of affordable, small-scale, and user-friendly machines capable of replicating the manual wrapping process while significantly reducing preparation time.

This research explicitly addresses that gap by proposing an automated wrapping machine uniquely designed for roasted glutinous rice (*pulut panggang*), a traditional Southeast Asian delicacy. Unlike previous automation works that focus mainly on confectionery or bakery products, the proposed system adapts rolling mechanics inspired by automated sushi machines and applies them to banana-leaf wrapping, which presents distinct mechanical challenges such as leaf fragility, uneven surface, and moisture sensitivity. This research presents a small-scale, reasonably priced solution for regional Small and Medium Enterprises (SMEs) that enhances operational effectiveness while maintaining cultural authenticity. Additionally, it contrasts earlier food automation projects and shows how the suggested method fills both the contextual and technological gaps left by huge industrial systems. All things considered, the study encourages sustainable, culturally sensitive automation that boosts competitiveness and productivity without sacrificing tradition by incorporating technology into traditional food preparation.

Theoretically, food processing automation aims to reduce reliance on humans by standardising repetitive processes, including packing, sealing, and portioning. To guarantee constant product quality and cleanliness, it depends on mechanical accuracy and process-control principles. The current wrapping system, which applies automation concepts to the material and cultural components of traditional food preparation, was designed using this conceptual framework as a guide. The automated wrapping machine, designed and developed using SolidWorks 2016 and built with useful hardware, is described in this article. After describing the machine's working mechanism, performance testing is done to assess how well it works. The effectiveness of the system and its potential for small-scale food production are highlighted in the findings, discussion, and conclusion sections.

2. Literature Review

2.1. Roasted Glutinous Rice in Traditional Food Culture

A classic Malay food, *pulut panggang*, or roasted glutinous rice, is often made in Brunei, Malaysia, Indonesia, and Singapore [9]. It is made of steamed glutinous rice that has been stuffed with shrimp, meat, or spicy sambal, wrapped in banana leaves, and roasted over charcoal. In addition to maintaining the rice's solid cylindrical form, the banana leaf provides it with a unique scent while it is grilling. Traditionally consumed at teatime, this food is highly valued for its cultural and celebratory significance.

Fig. 1 Roasted glutinous rice [10]

Pulut panggang is hard to make because it takes a lot of work. The sticky rice needs to soak overnight before it can be boiled. The other items are being made at the same time as the banana leaves are being cut and pressed. Stick the tape around each part really well so it does not tear or leak [10]. In order to maintain standards and order, skilled people are required. Some problems with manual wrapping are that it is not always the right size or tightness, it takes more time, and you cannot make as many. When the need for local foods grows because of growth and marketing, it is hard to increase output because of these factors. It requires talent to wrap *pulut panggang* because the banana leaves must be handled carefully to avoid damaging them. Because of this, production is not only more expensive, but roll size and thickness change, which makes the end product less consistent and of lower quality. These issues make it clear that we need a cheap, automated way to pack that does not require people to do it all by hand but still does a good job every time.

Automation has worked well in the businesses that make bread, candy, drinks in bottles, and snacks in boxes. There are many benefits to using mechanised systems [11], such as higher output, less user tiredness, better cleanliness, and uniform product quality. Also, technology has cut down on the need for skilled workers in large-scale manufacturing, which has helped businesses better meet their customers' growing needs [11, 12].

Despite these advancements, relatively little attention has been paid to the automation of traditional Southeast Asian foods wrapped in natural materials, such as banana leaves. Because of their thickness, varying size, and fragility, banana leaves present special issues when compared to ordinary packaging films used in confections or snacks. The creation of automated systems especially made for regional specialities like *pulut panggang* has been hampered by this. Current studies often concentrate on either generic packaging options that do not maintain the authenticity of traditional food preparation or large-scale industrial wrapping equipment that is expensive and unsuitable for small businesses [13].

2.2. Lesson from Automated Sushi Rollers

Sushi preparation is one of the closest comparisons to wrapping *pulut panggang*. In traditional sushi rolling, cooked rice and other ingredients are spread out on a nori (laver) sheet, which is then physically rolled into a cylindrical shape, pressed to create a consistent shape, and then sliced into smaller pieces. Despite cultural differences, the technical problem is the same: employing a wrapper to turn a soft, sticky food substance into a uniform cylindrical roll.

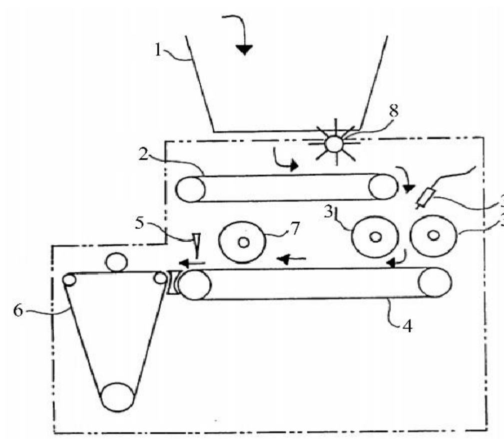


Fig. 2 Structural overview of a sushi roller [14]

Similar to *pulut panggang*, making sushi by hand takes a lot of time, effort, and is prone to errors. Commercial-scale operations have difficulties as a result of worker tiredness and human capacity limitations that limit the quantity of sushi rolls that can be produced in a given amount of time. Numerous automated sushi rolling devices have been created in response to this [14-16]. A rice hopper, a conveyor system for portioning and moving rice, and a shaping mechanism with synchronised rollers that simulates the hand rolling process are the usual components of these machines. By guaranteeing consistent component sizes, a cutting mechanism enhances productivity and product appearance.

The sushi rolling machine serves as an example of how traditional meal preparation may be automated without sacrificing cultural authenticity. Its accurate cutting, synchronised rolling, regulated rice distribution, and engineering concepts are all closely related to the automation of roasted glutinous rice wrapping. But there are still significant distinctions. Banana leaves are stiffer and thicker than nori sheets. They are also more likely to tear when they are stressed. They can be different sizes and shapes depending on how they are made. This needs a number of different mechanical handling methods, such as power control, moving wheels, and systems that keep leaves from getting damaged.

2.3. Research Gap and Contribution of This Study

There is a lot of evidence in the literature that automatic rolling and packing technologies have been used successfully in restaurants, candy shops, and sushi factories. These methods cut down on the need for workers, improve speed, and ensure that the quality of the product stays the same. But traditional Southeast Asian foods like *pulut panggang* have not gotten much attention. These foods are hard to make because they are cooked in a certain way and use natural wrapping.

The thickness, pliability, and durability of banana leaves differ from those of normal packaging films or nori sheets used in other items. Additionally, they are more delicate and need to be handled carefully to avoid ripping or deforming when being wrapped. Because of these qualities, the traditional packing equipment now in use is inappropriate for this delicate product.

The scope and price of the available solutions represent still another constraint. Small and medium-sized businesses (SMEs), which are the primary manufacturers of *pulut panggang*, are unable to afford the bulky, costly, and mass-production-oriented industrial wrapping machinery. These companies usually work in local markets where product quality, affordability, and cultural authenticity are more significant factors than high volume.

An economical, easy-to-use, and effective wrapping machine made especially for roasted glutinous rice is thus obviously needed. By creating an automated packaging machine that incorporates banana leaves and is modelled after current rolling technologies, including sushi machines, the current study fills this gap. The suggested approach is appropriate for small-scale applications as it minimises labour reliance, guarantees constant product quality, cuts down on wrapping time per item, and uses less energy.

In positioning this work within the broader field of food processing automation, the proposed system extends industrial automation principles into a culturally specific context. Unlike existing industrial designs that focus on mass production and uniformity, this study emphasizes sustainable, small-scale innovation suited for traditional foods using natural wrapping materials. This approach highlights the contribution of the present work as a bridge between modern engineering practices and community-based food processing applications.

3. Methodology

The methodology for this study, as shown in Figure 3, was divided into three main stages: design, fabrication, and testing.

3.1. Research and Design

To choose the best design for the automated packaging machine, the first step was to collect information and carry out a study. It was discovered that hand wrapping was labour-intensive, time-consuming, and often produced unequal wrapping quality. Reviews of the literature and conversations with specialists in food processing and mechanical design were used to investigate potential solutions. SolidWorks was used to create the final design, which centred on a straightforward, easy-to-use framework ideal for small food enterprises.

3.2. Fabrication

The SolidWorks model was used to create the machine components after the design was complete. The primary body was made out of sturdy frames made from meticulously soldered metal plates. In order to guarantee the structure's strength and endurance and lessen the possibility of bending or damage over time, appropriate welding techniques were used.

After the body was completed, every component was put together to make a functional prototype. At this stage, the machine's electrical power source, DPDT switch, and rolling mechanism were linked to enable complete functioning. This stage was crucial to turning the design concept into a useful instrument that could effectively complete automatic wrapping.

3.3. Testing and Evaluation

After being made, the equipment was put through performance tests to make sure it would work. As part of the test, glutinous rice wrapped in banana leaves was put in the right holder, and the DPDT switch was used to start the rolling mechanism. Observations were made to ensure that the rolling and wrapping process went smoothly.

The machine's performance was evaluated with three main goals in mind: (i) finding out how much time the machine would save wrapping compared to doing it by hand; (ii) seeing how well the machine rolled glutinous rice without damaging the banana leaves; and (iii) exploring on how the load affects the current the machine draws while it is running.

To depict the sequential technique, from data collecting to design, manufacture, and testing, a flowchart was created, as shown in Figure 3. In order to accomplish the goals of creating an effective automated packaging machine for roasted glutinous rice, this ensured that every phase of the project was carried out methodically.

The operator put the banana leaf and sticky rice on the rolling tray and then turned on the motorised rollers by pressing the DPDT switch. The machine went through one full run of wrapping in about 15seconds. The motor then stopped by itself. To make it look like different amounts of filling, the load on the rolling surface was varied from 0.01 kg to 0.028 kg. At each load point, a digital voltmeter was used to record the current and voltage values. A clock was used to record the time. Five trials were used for time-saving analysis, and ten trials were used for load-current analysis to make sure that the data were consistent and reliable.

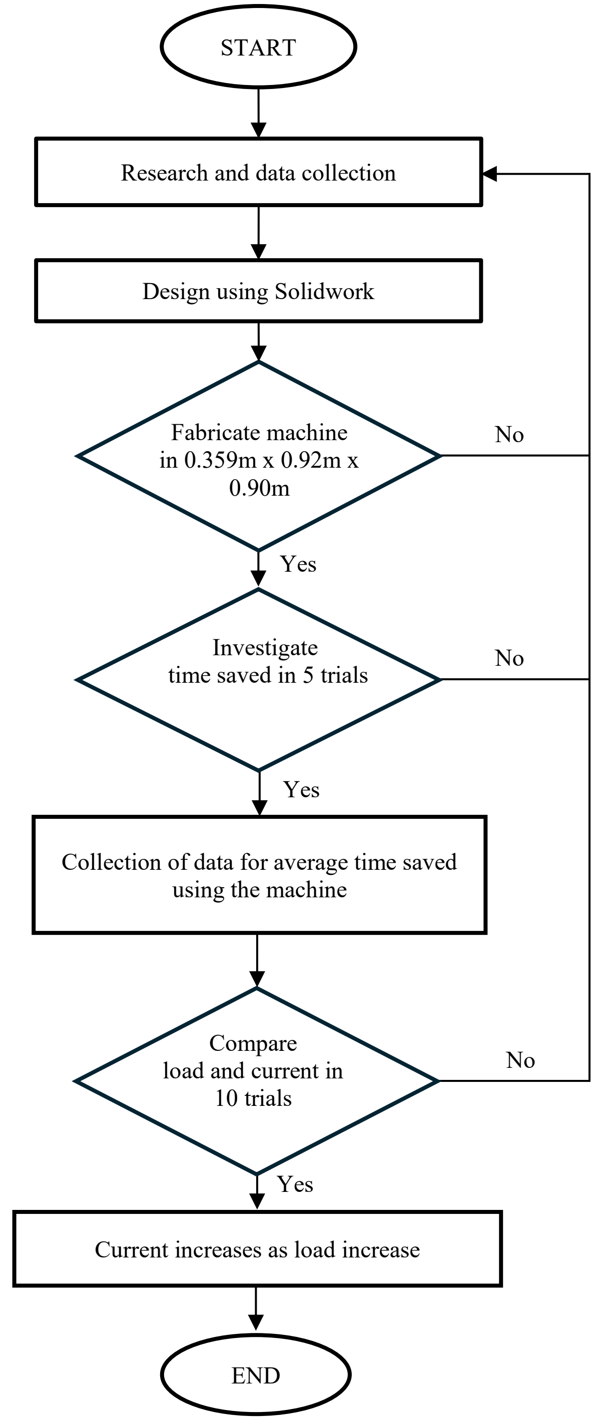


Fig. 3 Project flowchart

4. Design and Development

4.1. Project Design

Figure 4 shows that SolidWorks software was used to create the mechanical parts of the automatic packing machine. The whole setup of the system was made by drawing each part separately and then putting them together. Once the assembly was complete, it was checked to make sure that the plan worked well and was built well enough for the job.

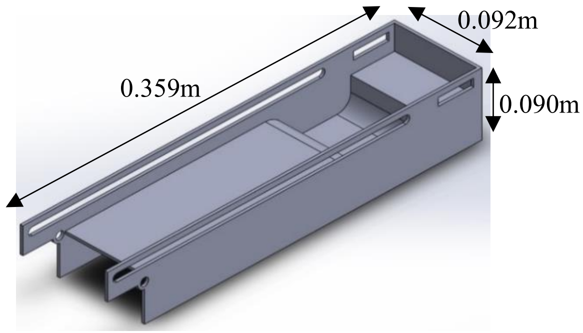


Fig. 4 Hardware design using SolidWorks

The curved part of the design is essential because it holds the glutinous rice covered in banana leaves as it is being rolled. For the rice rolls to have a cylindrical form, this curved contour is necessary. The design of this component was carefully selected to minimise the chance of damaging the banana leaves, prevent slippage, and enable a smooth rolling action. If any part of the design was judged unsuitable, iterative adjustments were made until the dimensions and functionality were perfect. This process ensured that the design adhered to the intended purpose while also taking into account practical production constraints. After the final design was confirmed in SolidWorks, the prototype was created utilising the finalised dimensions.

4.2. Hardware Development

In order to construct the automated packaging machine's hardware, components that provide adequate torque, stability, and reliability for the rolling process were carefully selected and integrated [17]. The components were chosen based on their torque capacity, affordability, local availability, and compatibility with a 12V DC system to ensure safe, low-cost, and reliable operation suitable for small-scale food enterprises. The iron rods used to roll the glutinous rice covered in banana leaves were powered by a 12V DC gear motor (ZYTD 520), as shown in Figure 5. This motor was chosen because it was affordable, readily available in the community, and suitable for low-voltage operation. It may be supplied directly by the power unit used in this project, which has a rated voltage of 12V. By increasing torque output, the gear motor design maintains excellent operating efficiency and durability while handling the resistance faced throughout the rolling process.

Fig. 5 12V DC Gear motor (ZYTD 520)

As shown in Figure 6, the system is powered by a 12V, 5A regulated DC power supply (QT_12VPSU). This device ensures the dependable operation of delicate parts, such as the DC gear motor and limit switch, by converting the AC mains input into a steady DC output with minimal ripple voltage. Providing voltages higher than the motor's rated value may cause damage or overheating. Voltage control was thus essential for device protection.

Fig. 6 12V, 5A Power supply unit (QT_12VPSU)

Cotton cloth was used as the rotating element for the rolling surface, as shown in Figure 7. Cotton was selected because of its affordability, simplicity of procurement, and ability to absorb moisture. Its durability and hypoallergenic qualities allow it to be used repeatedly in contact with food-wrapping materials while still being strong and hygienic.

Fig. 7 Cotton fabric as a rotating element

To control the metal rod's motion both forward and backward, a steel rail was added, as shown in Figure 8. As motion is transferred from the motor via the belting system, the rail ensures linear stability, allowing the rod to go straight forward. This part is necessary to keep alignment and rolling performance constant throughout the wrapping operation.

Fig. 8 Steel rail (CYTRON Linear Guide Set)

4.3. System Assembly and Operation

The automated packaging equipment for roasted glutinous rice that was created after the design stage is seen in Figure 9. To show where they fit into the system and how they contribute to the packing process, the main parts have been labelled. A DPDT switch, belt drive, cotton fabric roller, steel rail, limit switch, 12V DC gear motor, and a 12V, 5A regulated power supply unit are among the components included in the machine. The machine's functioning is seen in Figure 10. The first step is to wrap the sticky rice in banana leaves (Step 1) and place it in the machine's curved holding section (Step 2). The rolling process is then started when the user flips on the DPDT switch (Step 3), which supplies power to the DC gear motor. The rice roll is moved forward along the steel rail by the motor driving the metal rod via the belt system (Step 4). The rice keeps rolling until it reaches the machine's conclusion (Step 5), at which time the wrapped product is ready to be picked up (Step 6). This step-by-step method makes sure that every piece of roasted sticky rice is rolled out the same way, which saves time and effort and increases speed and stability. The curved holder gives the rod the right shape when rolling, and the electrical and mechanical components work together to provide for smooth forward motion.

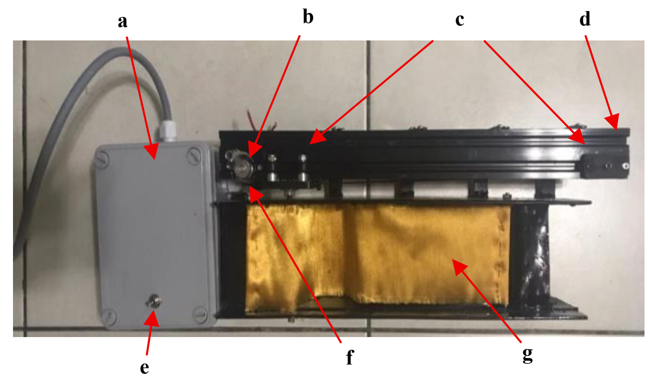
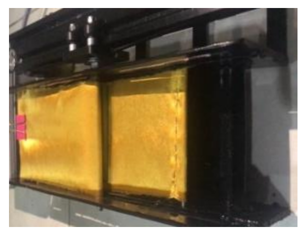


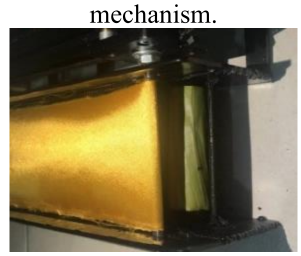
Fig. 9 Mechanized packing solution: (a) Power supply unit, (b) 12V DC gear motor, (c) Limit switch, (d) Steel rail, (e) DPDT switch, (f) Belt drive, and (g) Cotton fabric.

Step 1: Wrap the glutinous rice with banana leaves.



Step 4: The metal rod advances, driving the rolling mechanism.

Step 2: Position the wrapped rice on the designated holder.



Step 5: Allow the rice roll to travel to the end of the machine.

Step 3: Activate the switch to begin the rolling process.

Step 6: Retrieve the completed glutinous rice roll.

Fig. 10 Step-by-step rolling process using the machine

5. Result and Analysis

The automated packaging machine's performance statistics for roasted glutinous rice are shown in Tables 1 through 4. The research compared the machine's capacity, operating time, power consumption, and rolling with manual wrapping. Overall, the findings demonstrate that the automated equipment consumes less energy and is much more efficient than hand rolling. It operates dependably, maintaining constant voltage, current, and rolling time. All things considered, the machine benefits conventional food firms by decreasing the need for human labour and increasing production, with packing efficiency increasing by around

25%. The operation of the machine's electrical system under various loads is shown in Table 1. As the load became greater, the current increased from 0.130A at 0.010kg to 0.147A at 0.028kg, but the voltage remained constant at about 12V. As a result, the power consumption increased from 1.557W to 1.786W. Since the DC gear motor could instantly adjust its torque to accommodate the extra weight without suffering a voltage drop, this shows that the system is reliable and strong.

Table 1. Voltage and current with various loads

No. of trial	Load (kg)	Voltage (V)	Current (A)	Power (W)
1	0.010	11.98	0.130	1.557
2	0.012	12.02	0.132	1.587
3	0.014	12.04	0.134	1.613
4	0.016	12.06	0.135	1.628
5	0.018	12.07	0.137	1.654
6	0.020	12.08	0.138	1.667
7	0.022	12.09	0.139	1.681
8	0.024	12.12	0.143	1.733
9	0.026	12.13	0.145	1.759
10	0.028	12.15	0.147	1.786

Table 2 compares the amount of time needed for automated and manual wrapping. Compared to 19.5s for human rolling, the automated procedure took an average of 15.3 seconds for each piece. As a result, the machine saved around 4 to 4.5 seconds for each item, proving that it can work faster and demand less labour from people while still generating high-quality wrapping. In Table 3, electrical efficiency and time evaluations are shown together. Even though the load was gradually increased, the rolling time stayed about the same, between 14.60s and 15.73s. This stability shows that the extra current needed for heavy loads more than made up for the higher power demand, ensuring smooth and reliable operation. The machine uses between 1.55W and 1.81W of power, which is a relatively low range.

This makes it energy-efficient for small-scale food handling. Table 4, which shows the percentage drop in rolling time, shows the advantages of being efficient. The machine was about 23% to 26% more efficient than hand wrapping, with a gain of 26.06% being the largest. These steady time savings show how stable the system is at growing output, even for small businesses with limited work hours.

Table 2. Automated rolling against manual rolling

No. of trials	Automated Rolling time(s)	Manual Rolling time(s)	Time difference (s)
1	15.22	19.32	4.10
2	15.31	19.54	4.23
3	15.42	19.43	4.01
4	15.12	19.65	4.53
5	15.23	19.45	4.22

Table 3. Voltage and current with various loads against time

No. of trials	Load (kg)	Voltage (V)	Current (A)	Power (W)	Time Taken (s)
1	0.010	11.97	0.130	1.556	14.60
2	0.012	12.01	0.133	1.597	14.55
3	0.014	12.03	0.136	1.636	14.88
4	0.016	12.06	0.139	1.676	14.93
5	0.018	12.08	0.141	1.703	15.01
6	0.020	12.09	0.143	1.729	15.06
7	0.022	12.11	0.145	1.756	15.25
8	0.024	12.13	0.146	1.771	15.60
9	0.026	12.15	0.148	1.798	15.62
10	0.028	12.16	0.149	1.812	15.73

Table 4. Percentage difference of automated rolling versus manual rolling

No. of trials	Automated Rolling time (s)	Manual Rolling time (s)	Time difference (s)	Percentage of Difference (%)
1	15.22	19.32	4.10	23.74
2	15.31	19.54	4.23	24.28
3	15.42	19.43	4.01	23.01
4	15.12	19.65	4.53	26.06
5	15.23	19.45	4.22	24.34

Figure 11 shows how voltage and current change when different loads are put on them. According to the data, the current slowly rose as the load rose. However, the voltage stayed about 12V throughout all of the tests.

The DC gear motor reacted quickly and effectively by drawing more current to provide the higher power needed for heavy loads. The power supply's capacity to operate reliably is shown by the stable voltage. Figure 12 displays five human-manual and automated rolling time trials. With rolling durations ranging from 15.1s to 15.5s as opposed to 19.3s to 19.6s for a human, the automated procedure consistently outperformed the conventional approach. With an average time reduction of 4.2s per item, more than 25% more work was completed in the same amount of time.

These results demonstrate that machines can do wrapping tasks more quickly and precisely than humans. To provide a clearer validation of the experimental results, the statistical summary of the time-saving and energy-consumption measurements is presented in Table 5.

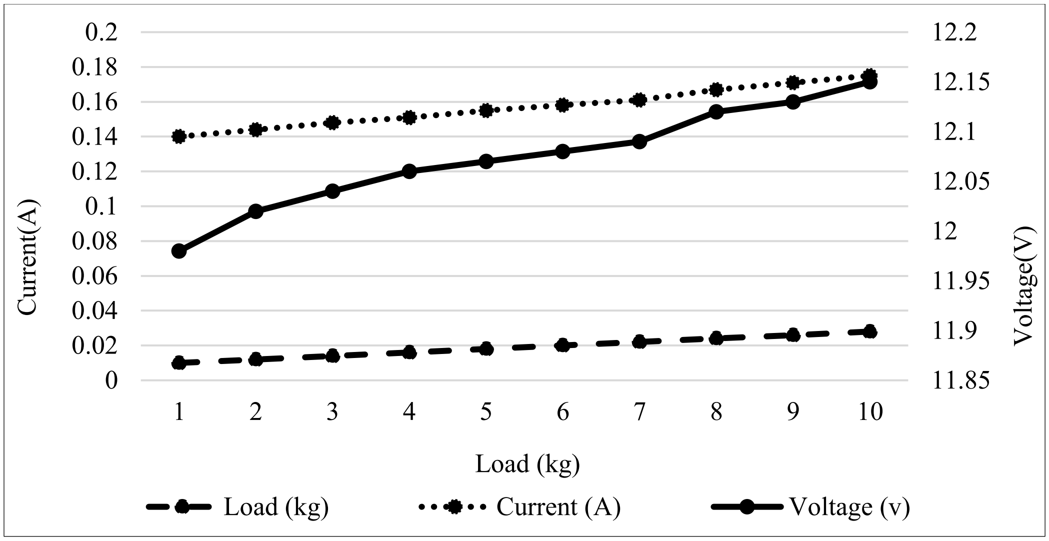


Fig. 11 Voltage and current with various loads

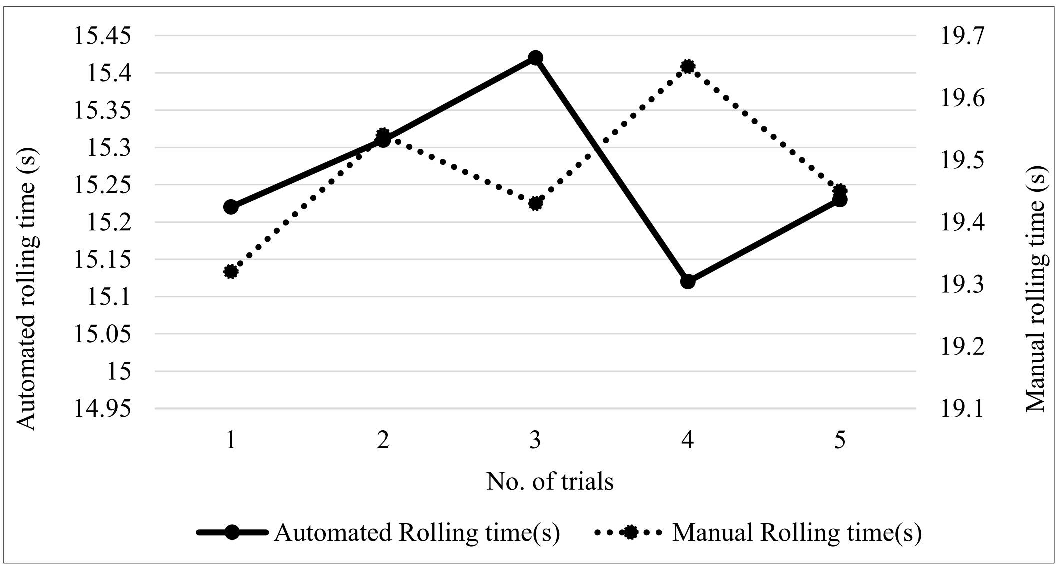


Fig. 12 Time taken of automated rolling against manual rolling

The table shows the averages and ranges of values from several tests, demonstrating that the automatic wrapping machine's mechanical and electrical performance factors are stable and consistent. The low standard deviation numbers show that the automatic wrapping system worked well and consistently during tests. From n = 5 paired trials, the automated wrapping averaged 15.26 ± 0.11s, while manual wrapping took 19.48 ± 0.12s, giving a mean saving of 4.22 ± 0.20s (≈ 24.29% ± 1.13%). An average power of 1.70 ± 0.09W was obtained for electrical performance throughout n = 10 load sites. The voltage stayed constant at 12.08 ± 0.06 V, and the current increased with load to 0.141 ± 0.006A.

The suggested machine's dependability for small-scale food production is validated by the little variations, which verify steady energy performance and constant efficiency.

Table 5. Statistical summary for time and energy measurements

Parameter	Mean	± Standard Deviation (SD)
Time-saving Measurement (n = 5)		
Manual wrapping time	19.48s	± 0.12s
Automated wrapping time	15.26s	± 0.11s
Time saving	4.22s	± 0.20s
Percentage improvement	24.29%	± 1.13%
Energy Measurement (n = 10)		
Voltage	12.08V	± 0.06V
Current	0.141A	± 0.006A
Power	1.70W	± 0.09W

***n denotes the number of trials*

6. Discussion

The automated packaging machine's ability to reduce wrapping time while using little energy is shown by the experimental results displayed in Tables 1 through 4. In keeping with findings from past food automation studies where mechanisation resulted in time savings of up to 30% for repetitive operations, the system consistently shortened the rolling length by 23% to 26% when compared to hand wrapping [18, 19]. These results show that, without sacrificing product quality, automation may greatly boost the efficiency of traditional meal preparation.

The suggested machine's simpler but torque-balanced roller layout allowed it to attain greater efficiency when compared to current automated wrapping systems documented in earlier research. The majority of the food industry's most advanced automation systems, such as sushi-rolling machines and confectionery, are designed for large-scale production and require sophisticated feeding mechanisms and high-power motors. In contrast, this system can function efficiently with only 12V DC, delivering a constant wrapping time of around 15s per piece and a steady power usage of 2W. This is a 23% to 26% savings when compared to hand wrapping. This performance shows that the suggested design may approach or surpass industrial automation performance inside a low-cost, small-enterprise framework by striking a favourable balance between mechanical stability, energy efficiency, and cultural flexibility.

The voltage was constant at around 12V during every experiment, as shown in Tables 1 and 3, suggesting that the electrical system was built correctly to function reliably. With higher loads, an increase in current is anticipated because more torque is required to overcome resistance during rolling. Importantly, the rolling time remained almost constant between 14.6 seconds and 15.7 seconds, suggesting that machine performance was unaffected by the increase. This suggests that there was enough power margin in the motor and mechanical design to accommodate load changes. For small businesses, where dependability has a direct influence on everyday productivity, this kind of constancy is essential.

The system's energy efficiency is further shown by the use of a low-power 12V DC gear motor, which uses less than 2W even at the greatest load [20]. Other automated food processing equipment, including semi-automated wrapping machines or dough mixers, usually uses a lot more energy [21]. Therefore, the suggested design provides an economical and ecologically beneficial solution that is especially appropriate for SMEs with constrained energy resources.

This work's adoption of automation concepts from sushi-rolling machines to *pulut panggang*, a culturally particular culinary item, is one of its distinctive contributions. Banana leaves are more difficult to work with because of their thickness and fragility than nori sheets, which are used in sushi. The machine's curved shape and rolling mechanism are suitable for handling such natural wrappers, as shown by the constant performance over many trials. The automation of Southeast Asian traditional cuisines has received little attention in the literature, which is a significant vacuum that this fills.

However, there are still a few constraints. The present prototype underwent careful testing on a small sample size. Future research should examine the machine's long-term durability, capacity to process larger quantities, and usability for small company owners. To boost productivity even further, semi-automated feeding systems, force-measuring sensors, and rollers that can be adapted for various leaf shapes may be introduced in the future.

The results show that packing packages by hand is hard and costs a lot, especially for small and medium-sized businesses. Labour costs are still high because the machines need to be run by trained people. The goods are also less uniform and easier to sell because the rolls are not all the same thickness or shape. Using technology to solve these problems not only boosts output but also makes it easier to maintain the quality of standard food production.

Automation could make things more efficient and cut down on physical work, but it could also change how people normally work. It is not meant to replace staff; the planned method is meant to help them. The work will be easier for them, and they will have more time to focus on quality control and overseeing the process. This method blends new technology with the needs in the community to help small food businesses use robotics in a fair way.

Finally, the results show that the automated packing machine is both technically feasible and useful for small-scale applications. By combining modern efficiency with cultural identity, it drastically changes how traditional food production is mechanised.

7. Conclusion

An automated packaging machine for *pulut panggang*, a traditional Malay dish composed of roasted sticky rice, was successfully designed, constructed, and tested in this research. The concept was inspired by the sluggish and exhausting nature of physical wrapping, which restricts small food enterprises. Reliability, affordability, and ease of use were the prototype's main objectives. The SolidWorks-created plan makes use of readily available local resources. Tests revealed that the machine functioned properly with varying dosages. The voltage remained constant at about 12V, but the current increased to provide sufficient power for rolling when the load was added. Since the machine used less than 2W of power, small firms with limited electrical resources might utilise it. The automated process was, above all, roughly 25% quicker than hand wrapping, saving 4s to 5s every item. More consistent output, less worker fatigue, and increased overall productivity are all benefits of this development for big batches. The results demonstrate the usefulness of automating traditional meal preparation without sacrificing cultural authenticity. This project has addressed items wrapped in natural materials like banana leaves, filling a gap in the literature by using ideas from other rolling devices, such as sushi machines. The goal of future development is to increase the system's functionality and optimise it even further. The development of a semi-automated feeding mechanism to reduce human handling, sensors to measure torque and identify process problems, and adjustable rollers to handle varying banana leaf sizes are some of the main advancements.

To assess long-term dependability and user acceptability, field tests with small company owners and durability testing over lengthy periods of time are also crucial. These actions will facilitate the technology's expansion while maintaining its affordability, effectiveness, and suitability for conserving *pulut panggang*'s cultural significance.

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