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Solar Powered Putu Mayam Machine: Design and Development of a Prototype Machine

Mohamad Alif Hakimi Mohd Rizal[1], Muhammad Akhtar Zulkifli[1], Mahmod Abd Hakim Mohamad[1,2*], Nurfarahin Onn[3]

[1] *Department of Mechanical Engineering, Centre for Diploma Studies, Universiti Tun Hussein Onn Malaysia, Pagoh Higher Education Hub, 84600 Pagoh, Johor, MALAYSIA*
[2] *Sustainable Product Development (S-Proud), Department of Mechanical Engineering, Centre for Diploma Studies, Universiti Tun Hussein Onn Malaysia, Pagoh Higher Education Hub, 84600 Pagoh, Johor, MALAYSIA*
[3] *Koperasi RT Johor Zon Selatan Berhad, Jabatan Perpaduan Negara dan Integrasi Nasional Johor, Tingkat 20, Bangunan KWSP, Jalan Dato' Dalam, 80000 Johor Bahru, Johor, MALAYSIA*

*Corresponding Author: hakim@uthm.edu.my
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Abstract

This paper presents the design and development of a solar-powered machine to automate putu mayam production, a staple Malaysian kuih dish. Traditional manual methods are labor-intensive, especially for small-scale street vendors, leading to limited production capacity. To address this, a prototype was developed using SolidWorks 2023, featuring aluminum components, a 24V DC motor, and a solar panel system for sustainability. During testing, the machine demonstrated the capability to produce 8 putu mayam units in 10 seconds, a significant improvement over manual production speeds, which averaged 3 seconds per unit. This innovation reduces labor needs by an estimated 67%, enhancing efficiency and providing an affordable solution for small vendors. The solar-powered machine's integration of mechanical and electrical components represents a step forward in sustainable food processing technology, with the potential to increase production capacity and maintain traditional quality standards.

1. Introduction

Putu Mayam, sometimes called idiyappam or string hoppers is a well-liked traditional treat in Malaysia. This delicious dish has a special place in Malaysian cuisine [1]. Putu mayam goes by a lot of names. Putu mayam is referred to by several names in India and Sri Lanka, its place of origin, including putu mayam, idiyappam, string hoppers, sevai, and chomai. In Sri Lanka and India, it is a well-liked breakfast. They are referred to as putu mayam in Malaysia and Singapore. In Indonesia, it is called putu mayang or mayong. The main ingredients are rice flour, water, salt, and a small amount of oil. After combining the ingredients into a dough, the mixture is fed through an idiyappam or murukku press to create vermicelli rice noodles, which are then steam- cooked [2].

Malaysia's putu mayam industry has a long history and still thrives today. The foundation of this sector is made up of small-scale companies and local vendors, who are frequently located in busy food stalls and street markets around the nation, especially in Pulau Pinang. Putu Mayam is made by steaming a mixture of rice flour and water in cylindrical moulds, which produces delicate noodles that resemble threads. After that, these noodles are served with sugar and grated coconut, making for a tasty and fragrant treat. Many Malaysians rely on the putu

mayam industry for their livelihood, but it also preserves the nation's culinary legacy and acts as a cultural symbol [3].

One of the challenges in the putu mayam sector, mainly food carts and Small and Medium-Sized Enterprises (SMEs), is that many have found limited capacity due to manual production with traditional tools. The other problem is that human power cannot do it quickly and consistently after some period because theyare tired [4].

To solve the problems of the limitation of capacity and the consistency of production, several companies have already innovated their machines to solve this problem because many of the sellers have come after them to solve it. These two companies use the same approaches to solve this problem: a semi-automatic machine that is easy to handle and improves the consistency of production so it can be flawless. However, one of these machines is still in the research and development phase. The putu mayam vendor has created and tested the other one, but it hasn't been released for sale yet. To solve this problem, a machine that is well equipped needs to be made to help all the putu mayam sellers, whether it is a fully automated machine or a semi-automatic machine. The objective is to make a machine that is easy to handle and makes production faster and more consistent.

The scope of this project encompasses several key aspects. Firstly, it involves conducting Q&A sessions and interviews with street vendors and small- to medium-sized businesses (SMEs) to gather insights and requirements. Participation is limited to street vendors and SMEs to ensure relevance and practicality. The machine targeted for development is designed to handle putu mayam dough weighing up to 2 kg and achieve a production quantity of approximately 8 units per 10 seconds. SolidWorks software will be utilised for the product design phase. Solar energy is identified as the power source for this device, aligning with green technology objectives. Furthermore, all design and circuit work for the solar-powered Mayam machine must be completed before fabrication and testing. The effectiveness of this solar-powered Mayam machine will be confirmed through rigorous testing procedures, ensuring its functionality and efficiency in real-world applications.

The project aims to revolutionize manufacturing by integrating solar technologies into a machine, aimingto simplify operation, reduce production time, and mitigate pollution. By adoption of environmentally friendly practices, the machine is expected to enhance efficiency, making it easier for operators to use while contributing to a shorter production cycle. The focus on reducing pollution underscores a commitment to sustainable manufacturing. Anticipated benefits include expanded output for vendors due to increased efficiency and the potential for the machine to impart a unique flavour and consistency, setting it apart from traditional processes.
The project focuses on the traditional Malaysian treat, Putu Mayam, and its significance in the local culinary landscape. Acknowledging the challenges faced by small-scale businesses and vendors in the manual production of Putu Mayam, the project aims to address capacity limitations and consistency issues by developing an innovative machine. Two companies have already ventured into semi-automatic solutions, and the project seeks to design a well-equipped prototype, either fully automated or semi-automatic, to benefit all Putu Mayam sellers.

1.1 Literature Review

The development of a putu mayam machine necessitates a review of past research on automating traditional food processes, particularly for putu mayam, a popular delicacy in Southeast Asia and South India [1]. The review begins with an overview of manual preparation techniques, highlighting the cultural significance and challenges, such as labor intensity and inconsistencies in product quality [1]. Existing automation in the food industry, especially for similar products like noodles, demonstrates improvements in efficiency but struggles to retain the artisanal quality central to traditional foods. This tension between automation and cultural authenticity is a key consideration [2]. Additionally, a comparison of the traditional extruder materials used—wood, plastic, and stainless steel offers insight into their respective advantages and limitations. Plastic is more Affordable and lightweight but raises safety concerns and is less durable [4]. Stainless Steel are Durable, hygienic, and produces consistent results but requires manual labor [5]. The proposed automation aims to merge stainless steel's durability with the precision and efficiency of modern machinery. While automation enhances production speed and consistency, there’s a challenge in preserving the artisanal touch and cultural integrity of the final product [2]. In summary, while traditional methods carry cultural importance, they are not scalable for large-scale production. Automation offers improved efficiency and consistency but must balance these gains with the preservation of traditional craftsmanship [2][5].

1.2 Plastic

Fig. 1 is a tool that was created because the stainless-steel tools that were created are often damaged. Therefore, plastic mold is a better solution. The plastic mold has several advantages, including good, thick material, and a wide dough space, avoiding the problem of damage as often happens with stainless-steel tools [6]. Ease of use of plastic molds, both with rotation and straight pressure, is also emphasized. In addition, these tools are manufactured in Malaysia, and can be found in certain stores, such as TBK Ny Liem [6]. The disassembly factor on the print, like the cookie print, is also explained. This mold is equipped with 8 shapes of mold holes that can be replaced according to use. Finally, the size of the putu mayam spiral is suitable and beautiful [6].

Fig. 1 *Putu Mayam Plastic Tool* [5]

1.3 Modern Methods

The culinary scene has changed recently because of the incorporation of contemporary technologies with time-honored food preparation techniques. The invention of the contemporary putu mayam machine, a technical marvel intended to optimize and boost putu mayam manufacturing efficiency, is one such example. This machine is a break from the traditional manual methods; it introduces automated procedures that guarantee uniformity and accuracy in the preparation of this cherished Southeast Asian and South Indian treat, while also saving time. Modern putu mayam machines are innovative creations that come from advances in food processing and engineering. In contrast to its conventional equivalents, this machine frequently has features like user-friendly interfaces, finely calibrated steam controls, and automated extrusion systems. Together, these components provide a high degree of efficiency that permits higher production levels without sacrificing the true flavour and texture that distinguish putu mayam.

1.4 Zull Design Autotronic

In 2020, Zull Design Autotronic Company successfully produced an innovative machine that brought the name "PUTU MAYAM MACHINE" into the market. Fig. 2 is a machine that not only steals attention with its modern design, but also with specifications that provide added value to the food industry [7]. There are several interesting features in this product, one of which is the construction material made of stainless steel, guaranteeing the durability and stability of the machine [7]. These advantages make it a very suitable choice for commercial use such as in the sales business. Not only that, "PUTU MAYAM MACHINE" is also powered with power around 220V to 240V, providing enough capacity to operate the putu mayam production process efficiently [7]. This machine is categorized as a semi-automatic machine, which allows it to be easily integrated with other machines in the food production series. This flexibility gives the user freedom to combine this technology with other tools in their food industry kitchen [7].

Another feature that needs to be emphasized is the capacity of the dough storage area, capable of holding up to 2 kg of dough. This capacity, of course, depends on the efficiency of the operator. Overall, the "PUTU MAYAM MACHINE" machine by Zull Design Autotronic Company is a revolution in the commercial production of putu mayam, providing efficiency and reliability to meet the growing demands of the modern food market [7].

Fig. 2 *Zull Design Putu Mayam machine* [7]

1.5 KueMue

Fig. 3 is an innovation that has been brought by the KueMue Company, an entity that has just appeared in the industry arena in Malaysia [8]. By highlighting the latest machines they produce, it not only focuses on the production of putu mayam, but also presents a holistic approach by providing the ability to produce a wide variety of traditional and modern sweets [8]. This machine created by KueMue Company, apart from being an effective tool for making putu mayam, is also designed to open opportunities for creativity in producing tarts, noodles, laksa, and biscuits. The uniqueness of this machine is its ability to meet the needs of various types of cakes, giving it a significant competitive advantage in this industry.

One advantage that needs to be emphasized is the use of a 2000 mAh x 2 batteries that facilitates the operation process of this machine [8]. With the ability to move without following the needs of the electricity source, this machine provides flexibility to users, especially those operating in areas that may have limited energy sources. In addition, the variety of molds available to change allows users to easily create a variety of dishes and customize the cake according to taste and market demand [8]. In accordance with the variety of cakes that can be produced by this machine, the size of the mold which ranges from 26 cm to 37 cm provides greater opportunities for experimentation and variation in cake design [8]. This not only covers the practical dimension of various types of kuih, but also opens the door to creativity in producing unique and interesting kuih dishes. Overall, by combining the uniqueness of the production of various cakes, the practical use of batteries, and various mold equipment, this machine made by KueMue Company promises a new era in the cake industry by providing a versatile tool to achieve customer satisfaction and meet the challenges of market dynamics [8].

Fig. 3 *KueMue machine* [8]

2. Methodology

The study focuses on solving the problem of the time used to make putu mayam. By adding a DC motor to the machine, it will increase the production rate per minute. In the meantime, it also decreases the time needed for the seller to operate the machine. Putu mayam vendors can provide insightful feedback and help identify areas for improvement by using Google Forms to address driver challenges. The feedback obtained yields significant information for improved operational efficiency and decision-making, with a respondent value of 10. The discussion is about the project framework, influencing factors, conceptual design, materials, project costs, and the types of sensors that work best.

2.1 Design Identification

This machine is constructed with the parts where two of it are for store and extrude it through the nozzle and the other one is the frame which made by 20mm x 20mm steel. The dough storage has a cylindrical shape that is built with a 3mm aluminium plate. The dough extruder system is just an enhanced version of the syringe. It is built with a 24 V 150W DC Motor that is connected rack and pinion gear which push the piston that pushes the dough. Fig. 4 shows the drawing of the Solar Energy Mayam Machine using 3D Design using SolidWorks.

Table 1 *Prototype dimensions*

Part	Dimensions (mm)
Dough storage	100 x 400
Frame	800 x 400 x 300
Electrical Box	130 x 200 x 130

Table 1 shows that the prototype consists of three main parts, each with specific dimensions that ensure functionality and compact design. The dough storage unit measures 100 mm × 400 mm, providing adequate space

for holding dough before processing. Supporting the structure is the frame, which has dimensions of 800 mm × 400 mm × 300 mm, offering stability and accommodating the main components of the system. Additionally, the electrical box measures 130 mm × 200 mm × 130 mm, serving as the enclosure for the control and power supply elements.

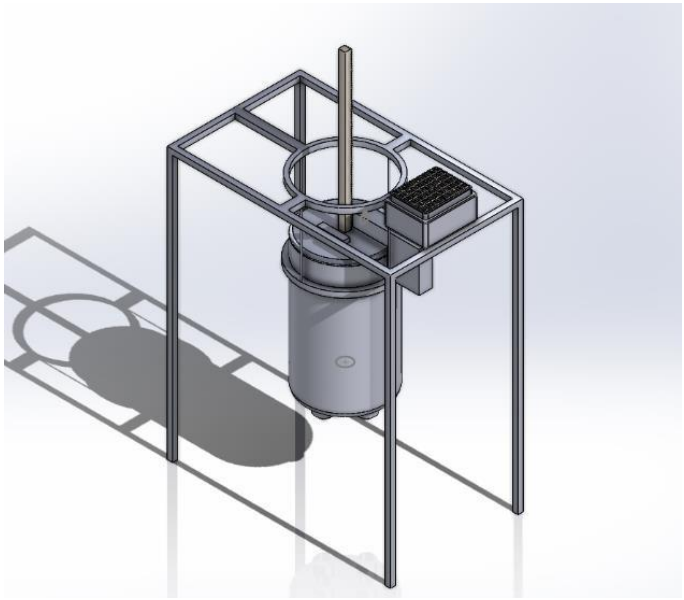

Fig. 4 *Drawing of Solar Energy Mayam machine using 3D design using SolidWorks*

2.2 Characteristic of Solar Energy Mayam Machine

The Solar Energy Putu Mayam Machine is a semi-automatic device designed to assist in producing putu mayam efficiently. It operates using solar energy harvested from sunlight, making it an eco-friendly and sustainable solution. In terms of performance, the machine can accelerate the production process, allowing users to prepare putu mayam faster compared to traditional methods. Despite being relatively large, it is still portable and manageable for transportation, making it practical for both small businesses and mobile food operators. From an economic perspective, the machine is cost-effective, offering affordable pricing with low maintenance costs, which increases its suitability for small-scale entrepreneurs. Furthermore, the choice of aluminium as the main construction material enhances its durability and resistance to rust, ensuring long-lasting performance. Aluminium is also a safe and hygienic material, making it highly suitable for use in the food industry. Overall, this machine combines functionality, sustainability, and affordability, making it an innovative solution for modern food production.

2.3 Putu Mayam Machine Fabrication

This study focuses on constructing a Putu Mayam machine to aid sellers in efficiently making Putu Mayam. The design prioritizes stability and functionality, dividing the fabrication process into key stages for smoother assembly. The process begins with metal cutting, ensuring components are sized accurately for proper arrangement. Precision tools are used to avoid errors that could impact subsequent stages. Next, welding and grinding assemble the machine's frame, emphasizing strength and stability.

The grinding process smooths welded surfaces, giving the frame a professional finish. The dough storage component is made from lightweight but sturdy aluminum. Aluminum sheets are cut, rolled in the lab, and riveted together for secure assembly. A protective top cover is added to maintain hygiene. The nozzle, crucial for dough extrusion, is created by drilling precise holes in a drink can, ensuring smooth and consistent output. The dough pressing mechanism uses a 12V motor and a custom iron design to press the dough through the nozzle. Wiring connects the motor to the control system, ensuring reliable operation with a stable power supply. This comprehensive process results in an efficient and user-friendly Putu Mayam machine.

2.4 Circuit Connection

The study focuses on solving the problem of the time used to make putu mayam. SolidWorks 2023 makes it easier to plan and create forms and sizes for design projects. It also makes it possible to modify current parts and designs to meet specific needs. The Smart Solar Grass Cutter needs a circuit connection to function. A program called Fritzing is used to design connections. Software is required to make wire connections to protect electrical equipment from harm. To avoid circuit failure, it needs to be mimicked after that.

Fig. 5 shows the circuit where the power supply, consisting of solar panels and batteries, ensures continuous power for the system. Powering the Arduino, motor drives, and other parts are solar panels and batteries. To regulate the movement of the motor shuttle and guarantee a smooth dough-pressing operation, the Arduino Uno central microcontroller is connected to the motor's 12 V DC motor via a designated connection. When producing putu mayam consistently, this motor comes in quite handy. The linked DC motor is driven by control signals that the Arduino also transmits to the motor driver that runs on batteries. This motor is controlled by a signal from the Arduino via a motor driver, and it may move the press to force dough out of the nozzle, for example. Circuit functionality includes power management, control logic and motor control. Solar panels and batteries that power the Arduino, motor drivers and motors ensure continuous operation. The motor driver then controls the speed and direction of the DC motor according to these instructions. This integrated system, powered by a combination of solar energy and batteries, is ideal for applications such as mobile robots that require precise distance measurement and motor control.

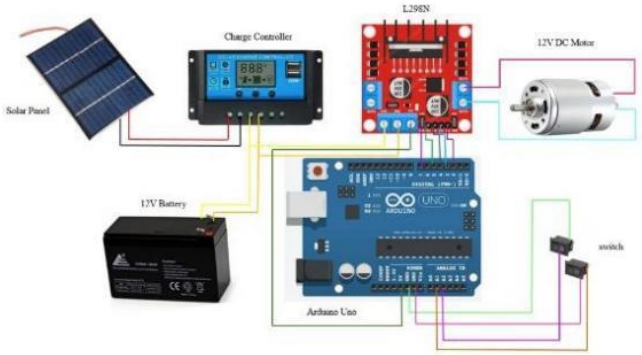

Fig. 5 *Solar Energy Mayam machine circuit*

3. Results and Discussion

The purpose of data collecting is to determine if the project's goal is to ascertain the sellers' conditions when selling putu mayam. A google form has been conducted to collect all the data from putu mayam sellers. This Google form is meant for all Malaysian sellers of putu mayam. This is because they are industry professionals who have seen ups and downs in the putu mayam sales. This will make it easier for them to make putu mayam quickly and with less labour demands.

3.1 Final Product of Solar Energy Mayam Machine

Fig. 6 illustrates the fabricated Putu Mayam machine, showcasing its key components and functional design. The structural frame, constructed from welded iron, provides robust support and ensures stability during operation, allowing for the secure mounting of all essential parts. A cylindrical aluminum dough storage container is prominently featured at the center of the machine. Aluminum is chosen for its lightweight, durable, and corrosion-resistant properties, making it suitable for food-grade applications and ensuring hygiene standards are met. The motor and control system housing, highlighted in red, is positioned at the top of the machine, which contains a 12V motor responsible for powering the dough pressing mechanism. This housing protects the motor and electrical components from external damage, ensuring reliable and safe operation. Surrounding the dough container is the pressing mechanism mount, designed to provide stable support for the mechanism, enabling precise and efficient dough extrusion through the nozzle. Overall, the machine integrates a durable frame, hygienic materials, and an efficient pressing system to facilitate the production of Putu Mayam.

(a) **(b)**

Fig. 6 *Final product of Solar Energy Mayam machine (a) Side view (b) front view*

3.2 Testing Results for Solar Energy Mayam Machine

The Solar Energy Mayam Machine represents a significant advance in semi-automated putu mayam machines that integrate solar power to improve sustainability and efficiency. This innovative device combines a motor with a dough extruder that uses an environmentally friendly energy source, promising a cost-effective and environmentally friendly solution for all of the putu mayam sellers. The test will demonstrate the time taken to complete 1 round of extruding the dough.

3.3 Limitations

The study demonstrates a promising market potential for the putu mayam industry, particularly for small and medium-sized traders who aim to expand their business sustainably. The findings highlight that by addressing key challenges faced by these traders, a tailored machine can be developed to streamline their production processes, thus enabling steady daily income and financial stability. This potential aligns with the need for economic resilience, benefiting not only individual traders but also their families. Future research and development efforts could focus on enhancing machine efficiency and cost-effectiveness, which would further support small-scale operators in maximizing their productivity and market reach.

4. Conclusion

The Putu Mayam machine has several drawbacks. Iron and aluminium are durable, but they might not hold up well in harsh conditions or under high pressure. Because of its limited production capacity, the 12V motor is not appropriate for large-scale operations. Dough loading and nozzle alignment are examples of manual tasks that decrease automation efficiency. Additionally, the design is specific to Putu Mayam, which limits its versatility. While consistency may be impacted by precision problems in manual fabrication, routine maintenance is essential for performance and hygiene. Furthermore, the machine would need a major redesign for industrial-scale applications and is better suited for small- to medium-scale production.

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Conflict of Interest

This publication has no conflicts or issues regarding the data, as it relies on references from the internet and research.

Author Contribution

The authors confirm their contribution to the paper as follows: ***problem, conception, and design study:*** *Mohamad Alif Hakimi Mohd Rizal, Muhammad Akhtar Zulkifli;* ***prototype manufacturing and data collection:*** *Mohamad Alif Hakimi Mohd Rizal, Muhammad Akhtar Zulkifli, Mahmod Abd Hakim Mohamad;* ***analysis and interpretation of results:*** *Mohamad Alif Hakimi Mohd Rizal, Muhammad Akhtar Zulkifli, Mahmod Abd Hakim Mohamad, Nurfarahin Onn;* ***draft manuscript preparation:*** *Mohamad Alif Hakimi Mohd Riza1, Muhammad Akhtar Zulkifli Mahmod Abd Hakim. All authors reviewed the results and approved the final version of the manuscript.*

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