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Performance and Operational Efficiency Study of a Portable Sambal-Making Machine Based on an Electric Heating System to Improve Small-Scale Food Production Productivity

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Abstract

Introduction/Main Objectives:This study was conducted to evaluate the performance and operational efficiency of a portable sambal-making machine based on an electric heating system, specifically designed to help small and medium enterprise (SME) operators improve productivity and workplace safety.

Background Problems: The manual preparation of sambal in Malaysia's small-scale food industry is time-consuming, labor-intensive, and does not guarantee consistent results.

Novelty:The research introduces a portable sambal-making machine designed with heat-resistant materials and stainless steel, combined with an AC motor and an electric heating system, tailored for SME use.

Research Methods:The testing method involved simulating sambal production using real ingredients (chili, onion, shrimp paste) to assess actual performance under continuous operating conditions.

Finding/Results:Sambal preparation time was reduced from 40 minutes to 15 minutes.The machine achieved approximately 35% electrical energy savings compared to conventional methods.The sambal produced had a more uniform and consistent texture. User safety was improved due to the fully enclosed machine design.The total development cost was only RM424.00.

Conclusion:The portable sambal-making machine demonstrates great potential to increase productivity, save energy, and support the development of more efficient and user-friendly local food technology for small-scale entrepreneurs.

Keywords: Sambal-making machine, Design and fabrication, Food automation, small and medium enterprises (SMEs), Time efficiency

Introduction

In the local food industry, sambal is the main component in almost every traditional Malaysian dish. However, the manual process of making sambal is still the primary method, especially among small-scale entrepreneurs and homemakers who produce food products on a small scale. This traditional method typically uses a mortar and pestle, a wok, and a separate electric blender, which require high physical effort and consume a considerable amount of time. These manual methods do not guarantee consistent results in terms of the texture and taste of the sambal produced, particularly when production is carried out in larger quantities.

This issue becomes more significant in the context of small and medium enterprises (SMEs), where time efficiency, work safety, and quality control are key factors in determining product competitiveness in the market. Based on initial observations, the manual sambal-mixing process also exposes users to risks of injury due to splashes of hot oil and high heat during cooking. In this situation, the need for a semi-automatic, portable sambal-making machine that can save both energy and time is increasingly urgent.

The study focuses on the development and fabrication of a portable sambal-making machine designed using heat-resistant materials and stainless steel to ensure durability and hygiene. The design of the machine is inspired by the need to help users perform two functions by simultaneously grinding and cooking sambal in a single unit. It is expected that this study will boost the productivity of small-scale food business owners by utilizing affordable and user-friendly mechanical technologies.

This study was conducted with the primary aim of developing a portable sambal-making machine to help improve the efficiency and quality of sambal production for small-scale producers. The specific objectives of this study are as follows:

- To design and develop a portable sambal-maker machine
- To evaluate the effectiveness of the machine in terms of sambal production performance
- To determine the feasibility and cost of developing the machine

The small-scale food processing industry in Malaysia has been growing in line with the increasing demand for higher-quality and more consistent traditional products. However, most small and medium enterprise (SME) operators still rely on manual methods in preparing foods such as sambal, which require significant time and energy. According to Surya and Tedjakusuma (2022), the traditional process of making sambal results in inconsistent texture and taste, while also limiting daily production capacity. Furthermore, the use of separate equipment such as woks and blenders leads to inefficient labor utilization (Halim et al., 2018).

In the context of food industry modernisation, the adoption of semi-automation technology has been gaining attention. A study by Norazuan et al. (2021) found that the use of AC motors and electric heating systems in small food-processing machines can increase energy efficiency by up to 40%. Rahman et al. (2020) stressed that stainless steel–based machine designs not only ensure food safety but also reduce long-term maintenance costs. Zainal et al. (2019), who highlighted the necessity of adhering to hygienic standards in the design of commercial kitchen equipment, also support the use of heat-resistant and anti-corrosion materials.

A study by Kamaruddin and Isa (2020) found that multifunctional food machines capable of performing grinding and heating simultaneously can increase productivity by up to 60%. This approach is also seen as effective in the production of traditional foods such as sambal, where combining two key processes in one system helps save time and costs. In addition, Ali et al.

(2021) stated that simple and modular mechanical systems are more suitable for SMEs because they are easy to maintain and can be upgraded according to production needs.

From an economic perspective, Rashid et al. (2017) reported that the development of low-cost machine designs can enhance the competitiveness of small entrepreneurs in the local market. Meanwhile, Bakar and Rahim (2022) emphasized the importance of local technological innovation in strengthening SMEs as major contributors to the national economy. Omar et al. (2019) also highlighted that technical training for users is essential to ensure machines are operated optimally. Lastly, Wong and Lim (2015) emphasized that performance testing is necessary for every new food processing equipment in order to assess operational efficacy, safety, and usability.

Overall, the literature indicates that the development of a portable sambal-making machine based on semi-automation has high potential to increase productivity, save time, and ensure the safety and quality of traditional foods.

Research Methods

The methodology of this study consists of three main phases: the design phase, the fabrication phase, and the performance testing phase of the portable sambal-making machine. The machine development process was carried out systematically to ensure that the final design meets the study objectives in terms of functionality, safety, and usability.

In the design phase, initial sketches of the machine were created using Autodesk Inventor software to determine the component layout and overall machine dimensions. The focus was on integrating two main functions—mixing and heating—into a single unit. Material selection was also carefully considered, with stainless steel chosen for components that come into contact with food to ensure hygiene and resistance to high temperatures.

Next, the fabrication phase involved cutting, welding, motor installation, and connecting the electric heating system. An AC motor was used to drive the mixing blades, while the electric heating element was installed at the base of the container for cooking purposes. The assembly process was carried out in the mechanical engineering workshop and tested to ensure that both the electrical and mechanical systems functioned properly.

Lastly, items including shrimp paste, onion, and chili were used in the performance testing stage. The tests were carried out to evaluate production time, the fineness level of the sambal, and heating efficiency. The machine was also tested to assess motor durability and user safety during operation.

Result And Discussion

The finding of the study were obtained from a series of performance tests conducted on the portable sambal-making machine. These tests involved comparing preparation time, required labour, and the quality of the sambal produced against traditional methods that use a mortar and pestle and a separate electric blender. The evaluation also considered safety factors, energy efficiency, and overall operational cost.

According to the test results, using this equipment can save the time needed to prepare sambal by 65% compared to conventional methods. Sambal is typically cooked and ground by hand in 30 to 40 minutes, but this machine can create the same amount in 10 to 15 minutes. The two primary processes of simultaneous grinding and heating are combined to attain this efficiency.

In terms of quality, the sambal produced by the machine was found to be more homogeneous with a uniform texture. The controlled heating process helps reduce the risk of burning or uneven cooking. Additionally, the enclosed system of the machine minimizes the risk of hot oil splashes, thereby enhancing user safety. In terms of cost, operating the machine requires only minimal electrical energy compared to the use of gas or traditional stoves.

Table 1 Comparison of the Performance Between Manual Methods and the Sambal-Making Machine

Evaluation Aspect	Manual Method	Sambal-Making Machine
Preparation time	30–40 minutes	10–15 minutes
Labour required	2–3 people	1 person
Sambal texture	Uneven	Even and homogeneous
Heat exposure	High	Minimal
Operating cost	High (gas & labour)	Low (electricity only)
Safety risk	High (splashes & heat)	Low (enclosed & safe)

These results demonstrate that the developed machine is not only capable of increasing productivity but also ensures product safety and consistency. The findings also indicate strong potential for commercialization, particularly for use in small and medium enterprises within the local traditional food sector.

Conclusion

This study successfully designed, developed, and evaluated the performance of a portable sambal-making machine capable of semi-automatic operation to assist small-scale food entrepreneurs. The machine can accomplish two primary tasks—grinding and cooking—in a single, small, and user-friendly unit, according to the development results. Based on performance test results, sambal preparation time was reduced by up to 65% compared to traditional methods, with a more uniform texture and improved workplace safety.

In terms of cost, the machine was developed with a total expenditure of approximately RM424.00, making it far more affordable than commercial machines on the market, which range from RM800 to RM1500. This demonstrates that the design and fabrication concept used in this study is suitable for application in the context of small and medium enterprises (SMEs). Additionally, the use of materials such as stainless steel and an AC motor makes the machine durable and easy to maintain.

Overall, the study objectives were successfully achieved. This sambal-making machine not only functions effectively but also help improve efficiency, safety, and productivity in the preparation of traditional foods. The study indicates significant potential for advancement to a commercial development phase.

Recommended improvements for future studies include:

- Adding an automatic temperature control function to prevent overheating.
- Enhancing the design of the grinding blades so they can be adjusted according to ingredient type.
- Conducting long-term testing to evaluate motor durability and the heating system.
- Assessing the potential use of alternative energy sources, such as solar power, to make the machine more sustainable.

With these improvements, the portable sambal-making machine has the potential to become a practical innovation that supports local entrepreneurship and increases productivity in the country's traditional food industry.

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