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IoT-Enabled Purification System for Kerisik to Coconut Oil Production

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Abstract

The increasing demand for high-quality and sustainable cooking oil has led to innovations in coconut oil production technology. This study presents the development of an Internet of Things (IoT)-embedded purification machine, the S-PMK (Sistem Penulenan Minyak Kelapa), designed to convert traditionally discarded kerisik oil, a roasted coconut by-product of small and medium scale enterprises (SMEs) in Sabak Bernam, Selangor into high-quality Coconut Cooking Oil (CCO). The system integrates a two-stage purification process that combines chemical/adsorption treatment with mechanical separation. From mechanical separation, three filtration stages were implemented to ensure fffective waste separation (Marina et al., 2009): Pre-Filter, Microfilter, and Membrane Filter. It incorporates a smart IoT framework utilizing the WECON V-Net 2.0 cloud platform for real-time temperature monitoring and automation. Experimental evaluations demonstrated outstanding operational efficiency: processing 20 L of crude kerisik oil over 120 minutes yielded 19.8 L of treated oil, reflecting a 99% recovery rate. The embedded temperature sensor exhibited high accuracy with a minimal deviation of only 1–4°C compared to a reference thermometer. Post-treatment chemical analysis showed that Free Fatty Acids (FFA) decreased by 27% from 0.484% to 0.354% (well below the APCC standard of <0.5%), moisture fell to 0.152%, and peroxide value remained extremely low (<0.1 mEq/kg). Additionally, the dark golden-brown colour was successfully purified into a clear light yellowish hue, and the strong roasted odour was minimized. This innovation effectively supports the circular economy by transforming agricultural waste into a high-value commercial product, paving the way for smart, scalable food processing systems in the industry 4.0 era.

Keywords: Kerisik Oil; filtration; Internet of Things (IoT); purification

Introduction

Coconut production in Sabak Bernam, Selangor, represents a major agricultural sector in Malaysia, yet it faces systemic challenges in ensuring the sustainability of its production systems (Rahman et al., 2025). As an agropolitan area heavily reliant on coconut processing, Sabak Bernam's small and medium-sized enterprises (SMEs) produce a significant amount of kerisik oil as a traditional by-product of grated and roasted coconut processing. However, this kerisik oil is routinely discarded as waste because local producers lack the technical knowledge required to purify it. Although laboratory-scale research and development have shown that this raw by-product has high potential to be converted into high-value products, adapting these chemical and physical treatments into a scalable industrial machine requires further study (Sunartono et al., 2025).

Currently, the extraction and processing of oil from roasted coconut in Sabak Bernam are carried out on a small scale using traditional methods that are highly inefficient, labor-intensive, and time-consuming. These traditional techniques result in highly inconsistent oil quantity and quality. While the raw kerisik oil exhibits excellent chemical freshness and minimal hydrolytic rancidity (indicated by a low Peroxide Value of <0.1 mEq/kg and a Free Fatty Acid value of 0.484%), its dark golden-brown color and strong roasted odor negatively impact consumer acceptance and lower its commercial value.

In modern oil refining, bleaching and multi-stage filtration are critical steps utilized to remove unwanted pigments, trace metals, and odor-causing volatile compounds (Makhoukhi et al., 2009; Chen et al., 2024). Industrial bleaching processes typically deploy 0.5% to 4% bleaching clay at temperatures between 90°C and 120°C for 20 to 30 minutes to optimize purity without causing thermal degradation (Gharby, 2022). Integrating these refining principles with an automated control framework is crucial to developing a highly efficient, consistent, and smart food processing system (Boukerroui & Ouali, 2002).

To resolve these systematic inefficiencies and support a sustainable local circular economy, this study proposes the development of an IoT-enabled purification machine called S-PMK *(Sistem Penulenan Minyak Kelapa)*. This machine transforms underutilized agricultural waste into refined Coconut Cooking Oil (CCO). To guide this research, three specific objectives were established:

1. To design a coconut cooking oil (CCO) processing machine using the kerisik oil by-product from the kerisik processing industry.
2. To produce a functioning machine prototype for operational field testing among smallholders in Sabak Bernam.

3. To evaluate the performance of the developed machine based on the chemical and physical quality of the treated oil produced.

Methodology

The S-PMK machine development framework is built on the integration of mechanical engineering and digital automation to create a coherent purification system in Figure 1. Integrated System Design: The main components of this machine are made of food-grade stainless steel to guarantee product safety and ensure efficient heat conduction during the heating phase. The Mixer Tank is equipped with an automatic heating system that maintains an operating temperature between 60-90°C. This temperature is critical to ensure optimal reaction between the kerisik oil and bentonite clay, which acts as an adsorbent for impurities and pigments.

Staged Filtration Stage: The filtration system is designed with a planned waste path to maintain the demands of green technology in real machine on Figure 2 (Huda et al., 2024). The oil is flowed in the following sequence:

- Pre-filter: Removes large particles and kerisik solid waste, where this solid waste is flowed directly to a dedicated waste management unit.
- Microfilter: Separates fine suspended particles to improve liquid clarity.
- Membrane Filter: Ultra-fine purification process to separate residual water and micromolecules to produce stable Treated Oil.

IoT (Internet of Things) Integration: The machine uses the WECON V-Net 2.0 platform which provides SCADA-like capabilities. This integration allows for real-time monitoring of operational status through a visual dashboard accessible via a smartphone app. The temperature sensor (TE) acts as the primary data input connected to the IoT controller to automate the operation of the pump and heating system, thus minimizing manual intervention and the risk of human error.

The effectiveness of the purification system was evaluated using physical and chemical indicators, including peroxide value, free fatty acid content, and moisture content, as reported in Table 1. Oil Quality Analysis: Laboratory results demonstrate the effectiveness of the purification process compared with the Asian and Pacific Coconut Community (APCC) standards as shown in table 1:

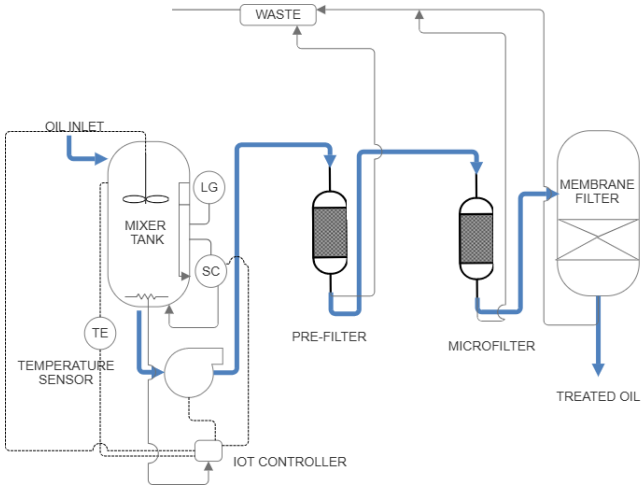


Figure 1: Schematic Diagram of S-PMK machine

Table 1: Oil-quality indicators before and after purification

Parameters	Before Purification	After Purification	APCC Standard
Free Fatty Acids (FFA) (%)	0.484%	0.354%	< 0.5%
Moisture Content (%)	0.154%	0.152%	0.1 - 0.5%
Peroxide Value (mEq/kg)	< 0.1	< 0.1	< 3



Figure 2: S-PMK machine

Results and Discussion

Experimental data indicate the operational potential of the S-PMK prototype. As shown in Table 2, operational performance was assessed by the recovery of treated oil from the crude-oil input. The treatment machine processed 20.0 L of crude oil and successfully recovered 19.8 L of purified oil within 120 minutes. This indicates an excellent oil recovery efficiency of 99%, with only 0.2 L (1%) of oil loss during processing. The small loss may be attributed to residual oil remaining inside the equipment and pipelines, oil retained in filter media or treatment components and minor evaporation or handling losses during operation.

Table 2: Operational parameters of the S-PMK machine

Parameters	Result
Initial Amount of Crude Oil (L)	20.0
Treated Oil Amount (L)	19.8
Processing Time (Minutes)	120
Oil Recovery Rate (%)	99

The 99% recovery rate indicates limited oil loss under the reported test conditions. Profitability for SME operators was not directly evaluated.

IoT System Validation: Confidence in smart automation is supported by the accuracy of the sensors. Comparisons between IoT sensors and reference thermometers show a marginal error of only 1–4°C as shown in Table 3. A visual digital dashboard allows operators to monitor these parameters remotely, supporting remote monitoring of operating conditions.

Table 3 : Comparison of reference temperature readings and IoT sensor readings

No. of test	Reference temperature (°C)	IoT sensor readings (°C)	Differences (°C)
Test 1	60	61	1
Test 2	70	72	2
Test 3	80	84	4

Figure 3 presents a three-dimensional scatter plot illustrating the relationship between FFA content, amount of absorbent, and speed. The observed improvements include an approximately 27% reduction in FFA and a change in colour. The original moisture content (0.154%) is indeed within the APCC limit, but the vacuum heat treatment process is still important for long-term stability.

Physical Analysis: The physical change from golden brown to clear yellow is a visual validation of the efficacy of bentonite clay in adsorbing pigments. Technically, the original brown color and slightly high palmitic acid content (10.5 g/100g) are the chemical "signature" of the Maillard reaction that occurs during traditional kerisik roasting. Although this lipid profile is slightly different from virgin coconut oil, it still complies with food safety standards for cooking use, suggesting potential for value-added processing, subject to further product and food-safety verification.

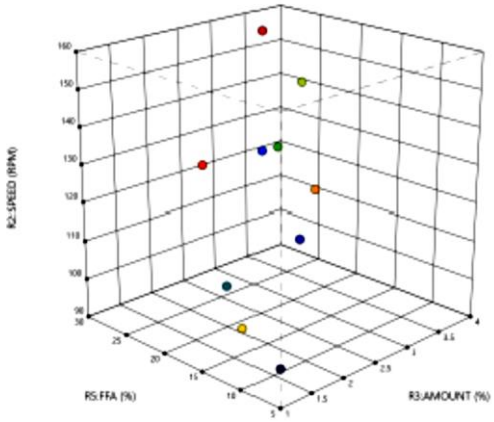


Figure 3. Experimental data based on three variables

Conclusion

The S-PMK prototype demonstrates the technical feasibility of transforming discarded kerisik oil into refined cooking coconut oil through an integrated multi-stage purification and IoT temperature monitoring framework. In pilot batch testing (20.0 L), the system achieved a 99% oil recovery rate and successfully purified the oil to comply with APCC standards, reducing Free Fatty Acids (FFA) by 27% (from 0.484% to 0.354%) while maintaining low peroxide levels. However, because the raw kerisik oil already satisfied baseline APCC chemical safety thresholds prior to treatment, the machine's primary function is physical polishing and aesthetic improvement. While these findings validate the pilot-scale prototype, full commercial application will require further refinement of colour and roasted aroma, alongside future evaluations of long-term oxidative shelf-life, filter maintenance cycles, and economic ROI for SME operators.

References

Abd Rahman, D. N., Ahmad, N., & Hawari, N. N. (2025). Systemic challenges in Malaysia's sustainable coconut production system: Rich picture and causal loop analysis. International Journal on Food System Dynamics, 1–18. https://doi.org/10.1163/18696945-bja00011

Boukerroui, A., & Ouali, M.-S. (2002). Edible oil bleaching with a bentonite activated by microwave irradiation. Annales de Chimie Science des Matériaux, 27(4).

Chen, Z., Shen, R., Xie, J., Zeng, Y., Wang, K., Zhao, L., Liu, X., & Hu, Z. (2024). Multi-frequency ultrasonic-assisted enzymatic extraction of coconut paring oil from coconut by-products: Impact on the yield, physicochemical properties, and emulsion stability. Ultrasonics Sonochemistry, 109. https://doi.org/10.1016/j.ultsonch.2024.106996

Gharby, S. (2022). Refining vegetable oils: Chemical and physical refining. Scientific World Journal, 2022. https://doi.org/10.1155/2022/6627013

Huda, M. S., Wilson, P., Sarker, N. C., & Monono, E. (2024). Optimizing bleaching process parameters of distillers corn oil for edible applications using a response surface methodology. LWT, 212. https://doi.org/10.1016/j.lwt.2024.116991

Makhoukhi, B., Didi, M. A., Villemin, D., & Azzouz, A. (2009). Acid activation of bentonite for use as a vegetable oil bleaching agent. Grasas y Aceites, 60(4), 343–349. https://doi.org/10.3989/gya.108408

Marina, A. M., Che Man, Y. B., & Amin, I. (2009). Virgin coconut oil: Emerging functional food oil. Trends in Food Science and Technology, 20(10), 481–487. https://doi.org/10.1016/j.tifs.2009.06.003

Sunartono, Lenggogeni, Handayani, I., Setiawan, H., Adiarso, A., Nelly, A., Hermawan, E., Wijono, R. A., Wicaksana, D., Marsudi, A., Setiyadi, E., Saparudin, Setiadi, S., Ferabianie, A., & Dewi, Y. (2025). Assessing competitiveness and sustainability of the cooking oil industry through the valuation of eco-efficiency on the utilization of spent bleaching earth. Case Studies in Chemical and Environmental Engineering, 11, Article 101176.