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Development of 9kWp solar system to enhance smoked shrimp (*sesar unjur*) production at Igan, Sarawak, Malaysia

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ABSTRACT

This paper presents a reliable stand-alone solar Photovoltaic (SAPV) system to supply the electricity needs of the *sesar unjur* production, which is mainly to operate the 5 kW smoked machine. At the present time, the production is merely traditional by burning white mangrove wood to smoke fresh shrimp and give a unique taste to the *sesar unjur*. The traditional technique leads to low quantity production making it hard to penetrate a wider market. Therefore, a more automatised and modern technique should be adopted to increase the yield to production time ratio. The activities that were carried out during this work include load demand profile, a study of resource availability, sizing of PV panels and dimensioning of the hybrid solar PV inverter. The activities englobe the common steps of designing a stand-alone solar PV system. The detailed calculation of the sizing of the components mainly based on the Malaysia Sustainable Energy Development Authorities (SEDA) and MS standards. As a result, a SAPV system with total capacity of 9kWp from 20 solar PV panels, which is used to power up a 5 kW drying and smoking machine, is designed and installed at the targeted location where it agreed by the community. Based on the outcomes, the smoked solar machine (OGsAnuh) can produce 40 kg *sesar unjur* per day, which requires around 400 kg of fresh shrimp or known as *payak*, by the local people. This is carried out in 4 cycles of production, with each cycle process about 100 kg fresh shrimp, which results in 10 kg *sesar unjur*. Furthermore, the dense of smoked taste can be controlled, which significant to market demand and environmental sustainability, simultaneously.

Introduction

The location of Igan, situated near the confluence of the Igan River and the South China Sea, holds significance in the culinary world due to its reputation for seafood delicacies, which include seafood cuisine, salted fish, smoked fish, umai, and the highly prized smoked shrimp, known locally as "*sesar unjur*" or "kupah." *Sesar unjur* is a distinctive Sarawakian delicacy primarily found in Melanau areas, including Mukah, Matu, Sarikei, and Igan. Its unique taste commands a high market value, often reaching up to Ringgit Malaysia (RM) 200 per kilogram. Traditionally, the production of *sesar unjur* has relied on the use of white mangrove wood for smoking, imparting a characteristic flavor to the shrimp. However, the traditional method has faced limitations, including low production capacity and environmental concerns. As a result, there is a pressing need for modernization to increase production efficiency and reduce environmental impact in the *sesar unjur* industry.

The traditional production process involves a smoking period that varies from 5 to 24 h, depending on the region, to prevent overcooking and maintain the shrimp's quality. However, prolonged exposure to smoke, particularly for 5 to 6 h, poses health risks, including respiratory issues and impaired lung function [1]. Moreover, the traditional method's reliance on mangrove wood as a fuel source has far-reaching consequences mangrove ecosystem and contributes to air pollution [2] & [3].

To address these challenges, there is a compelling need to explore alternative methods of *sesar unjur* production. Modernization efforts entail the development of a smoke machine capable of efficiently processing shrimp while minimizing adverse health effects associated with traditional smoking techniques. However, modern machines often have high electricity requirements for optimal operation. Fig. 1

The integration of solar photovoltaic (PV) systems in food processing operations has gained prominence for several reasons. Firstly, it offers a

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solution to mitigate rising energy costs, providing long-term fixed energy expenses and shielding food processing businesses from market volatility. Secondly, it aligns with environmental sustainability goals by reducing CO2 emissions associated with conventional energy sources. Solar PV systems also have the potential to improve food quality, enhancing attributes such as color, aroma, taste, and hygiene.

Applications of solar PV in food processing extend to various aspects of the industry, including cleaning, drying, and milling. For instance, solar PV systems have been employed for automatic vegetable washing in the field, resulting in reduced water usage, elimination of human intervention, and enhanced monitoring of vegetable weight. Solar-based drying methods have proven effective in reducing post-harvest food losses, particularly for vegetables and fruits, due to their cost-effectiveness.

In the context of seafood processing, solar PV technology has been harnessed to enhance fish drying processes. A solar dryer with a direct solar heat radiation absorber and integrated solar PV as an energy source has been developed, reducing drying times significantly compared to traditional methods.

Therefore, this study draws inspiration from the successes of previous research efforts and applies solar PV technology to support the operation of a smoke machine for *sesar unjur* processing. The installation of 20 solar PV panels, generating 9 kW of power, powers a 5 kW smoke machine, thereby increasing *sesar unjur* productivity while simultaneously reducing operational costs.. 1 illustrates the incorporation of solar PV technology into the *sesar unjur* production process, setting the stage for an innovative approach that enhances production efficiency and reduces environmental impact. The subsequent sections of this study delve into the development procedures and methodologies employed in this solar PV-powered *sesar unjur* processing system. The use of solar PV in food processing operations has increased significantly as integrating solar PV, could secure lower energy costs. The price of electricity from the grid might climb, sometimes erratically. While solar provides long-term fixed energy costs, protecting the food processing business from market volatility and allowing it to grow sustainably [4].

Besides, utilising solar PV in food industries help in reducing the emission of CO_2 energy that leads to global climate change [5]. Hence, it is benefitted in preserving the environment. Furthermore, in terms of the food quality, it can be improved, especially food colour, aroma, taste and hygiene.

In food processing industries, solar PV is frequently used for food cleaning, drying, and milling. For example, study in [6] used solar PV to automatically wash the vegetables in the field. This solar PV vegetable cleaning system provided some advantages, such as the usage of water was reduced by comparing the existing method., human requirements and interference were eliminated, the weight of vegetables was monitored, losses could be easily analysed, and no external supply was needed other than solar energy.

Furthermore, Ekka and Kumar mentioned in 2023 that in the current food processing industry, the problem of food losses caused by improper post-harvesting methods are about 50 % for vegetables and fruits. While solar-based drying is one of the primitive methods to reduce post-harvesting food losses due to the cost-effective advantage [7].

Meanwhile, in 2016, A. Noor Iskandar and M. E. Ya'acob used solar PV for food drying processing [8]. The construction of the PV dryer is designed with 0.66 $m \times$ 0.66 $m \times$ 0.8 m dimensions, comprising three trays with an effective area of 0.61 $m \times$ 0.61 m and can hold approximately 6 kg of fresh leafy herbs or fruits at one time. This system has significantly increased in power supply, which then increased the surrounding chamber temperature and, thus, increased the rate of the drying process.

Then, current research by Sangari A et al. and Ya'acob et al. introduced solar PV for water purification and rainwater harvesting, respectively [9] & [10]. In [9], the proposed work is to supply drinking water continuously without any interruption and minimise the cost of water purification. On the other hand, [10] presented a conceptual idea of utilising the existing large-scale solar PV farms as a rainwater runoff surface. This project was mainly to support the national agenda on Alternative Water Resources, Water Innovation and Stormwater Flood Risk Management.

In addition, solar PV also designed as food dryer machine in various agriculture products [11–16]. Specifically used for drying tomatoes [14], herbs [15] and turmeric [16].

For food dryer study in seafood product, Hantoro et al. designed a solar dryer that combined with solar absorber with direct solar heat radiation and solar PV as energy sources to enhance the fish drying process. In their research, the drying periods needed by fish dryer machine is 4 h lesser than using traditional method to achieve under 10 % of final moisture content [17]. Songli et al. also designed a fish dryer based on exhaust system of solar-based refrigerator system in year 2021 and obtained the exhaust heat from the condenser can until 65.3°C [18].

In conjunction with all the previous works, solar PV food processing has contributed many advantages, especially for cost energy saving. Thus, in this study, it used solar PV to support the operation of the smoked machine to process *sesar unjur*. 20 solar PV panels are installed to generate 9 kW power that required operating the 5 kW smoked machine to increase the *sesar unjur* productivity, while reduce the operation costs.

In terms of the solar PV system, if compared to the previous studies, the uniqueness is mainly on the selection of solar panel, solar battery, solar inverter and the rest of solar PV system components, which to well-suit the main application, ensuring the reliable and efficient operation of the off-grid solar PV system to process the *sesar unjur,* and at the same time it is easy to be used by the local people.

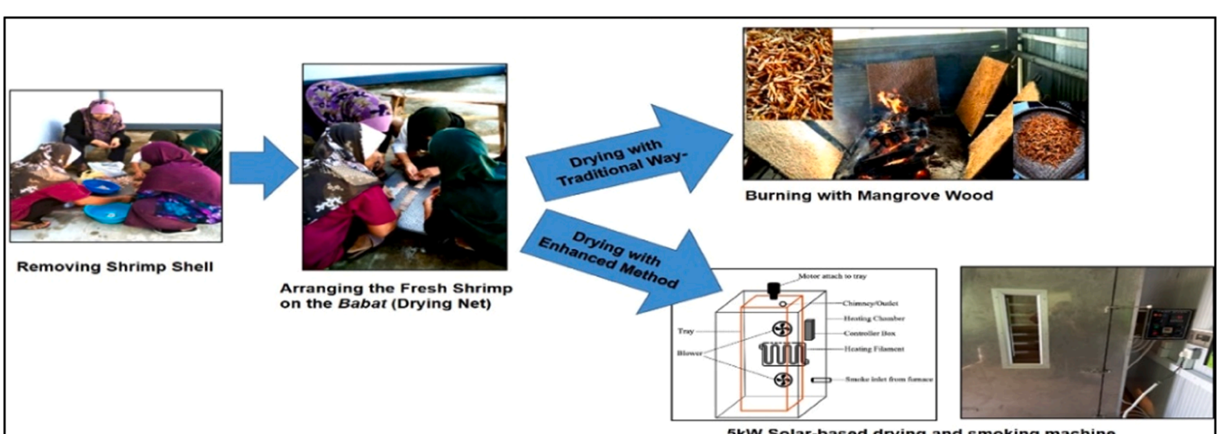

Fig. 1. Enhanced Smoked Shrimp Production.