Asian Journal of Applied Science and Technology (AJAST)
Volume 9, Issue 3, Pages 84-95, July-September 2025

Implementation of a Solar-Powered Fish Dehydrator

Bustos, Rence Andrei L.[1], David, Nowell Y.[2], Dela Cruz, Sid Jimuel C.[3*] & Santos, Edgardo M.[4]

[1-4]Department of Electrical Engineering, Pampanga State University, Cabambangan, Bacolor, Pampanga, Philippines.
Corresponding Author (Dela Cruz, Sid Jimuel C.) Email: 2020300281@pampangastateu.edu.ph[*]

DOI: https://doi.org/10.38177/ajast.2025.9309

Article Received: 04 June 2025 *Article Accepted: 16 August 2025* *Article Published: 23 August 2025*

ABSTRACT

This study presents the implementation and evaluation of a solar-powered fish dehydrator aimed at enhancing traditional fish drying methods and reducing production costs for Kapampangan fishermen in Masantol, Pampanga. The system operates entirely on photovoltaic energy, consisting of four 260W solar panels, a 24V 100Ah battery bank, a 2000W inverter, and an 800W dehydrator. Designed for energy efficiency and sustainability, this setup supports a complete off-grid operation. Employing experimental, descriptive, and quantitative research methods, the study assessed the system's drying efficiency, energy consumption, and overall performance under controlled conditions. Drying trials were conducted using two types of fish—tilapia and mackerel—under both full and partial load conditions. Observations were focused on evaluating changes in color, texture, and moisture content after dehydration. Results demonstrated that the solar-powered dehydrator consistently produced high-quality dried fish, while significantly reducing the overall drying time compared to traditional sun-drying methods. The system consumed approximately 5600Wh over a typical 7-hour drying cycle, which was fully supported by the solar energy collected during the day, confirming its reliability and independence from grid power. Statistical analyses indicated that marination time had no significant effect on drying efficiency. Overall, the study concludes that this system is a sustainable, efficient, and practical solution for fish preservation in rural coastal communities.

Keywords: Dehydrator; Drying Efficiency; Energy; Environmental Impact; Fish; Inverter; Off-Grid System; Solar Panel System; Solar-Power; Sustainability; Technology.

1. Introduction

Drying is one of the oldest food preservation methods, traditionally using sun, wind, and evaporation. Dried fish can last for years and is cost-effective in suitable climates, where fishermen and their families can manage the process and supply markets. In areas with abundant but perishable food like fish, preservation is key to food security and waste reduction. Fish, though rich in protein, is highly perishable and often spoils before reaching the market. Dehydration significantly reduces moisture and extends shelf life without affecting nutrition.

According to a fisherman, Jess, Bidbid fish are common but seasonal, and during peak supply, some are even used as feed. Kuya Gio, another fisherman, notes that about five coolers—or 100 to 150 kg—of unsold fish are left daily, often repurposed to minimize losses. Ali and Akester report that poor handling, storage, transportation, and lack of processing facilities are major causes of fish loss in Southeast Asia, where up to 25% of aquatic food is lost.

While sun drying is common, it is unreliable during bad weather, and electric dehydrators are expensive. Solar-powered dehydrators offer a sustainable solution by using renewable energy. However, current designs often lack the capacity and control needed for high-moisture foods like fish, which requires moisture reduction to 15–20% and water activity below 0.6 to prevent microbial growth.

This study examines inefficiencies in existing solar dehydrators and their inability to handle peak-season volumes. Without a scalable, efficient system, fish spoilage continues, especially in rural areas lacking refrigeration. A well-designed solar-powered dehydrator can reduce waste, improve food availability, and support local livelihoods.

Fish preservation is critical for reducing spoilage, improving food security, and extending shelf life. In many rural areas, traditional sun drying is still used, but it exposes fish to contamination, inconsistent drying, and weather-related risks. These challenges result in substandard products and losses from spoilage. Interviews at Masantol Fish Port revealed about 100 to 150 kg of unsold fish are left daily. To reduce losses, they are given to Hito farmers, but this still represents significant economic loss. According to the Department of Agriculture's Bureau of Fisheries and Aquatic Resources, 25–40% of fish spoilage occurs from harvest to sale, depending on weather, transport, and power outages.

1.1. Study Objectives

To implement a solar-powered fish dehydrator system aimed at reducing operational costs. To analyze the performance of the solar-powered fish dehydrator, particularly in terms of drying effectiveness, which includes: Drying quality assessment based on: color changes during the drying process, texture transformation from raw to dried state, ratio of uncooked to cooked portions. Evaluation of the system's drying capacity under varying load conditions. Distinguish the significant difference between traditional sun drying and the usage of prototypes with regard to drying time. This study aims to design a solar-powered food dehydrator using hot air drying to provide a reliable, eco-friendly alternative. It will assess drying quality (e.g., texture, color) and evaluate performance under varying loads. The goal is to determine if solar dehydration is a viable and superior option to traditional methods.

2. Methods

2.1. Solar Panel Selection

The solar panel's main role is to power fans and any heating elements in the dehydrator. Wattage is crucial for system reliability under varying sunlight conditions. Typically, 100–200 watts are sufficient for small systems, though requirements may vary based on system size and sunlight intensity.

2.2. Calculation of Power Requirement for the Solar Panel

Calculate the wattage which is to be required by the solar panel after one determines the power consumption total of the system.

$$Total\ PV\ Power\left(Watts\right)=\frac{Total\ Load\left(\frac{Watt\ Hour}{Day}\right)}{\text{Sun Hours per Day}} \qquad (1)$$

The total power requirement of the solar dehydrator determines the appropriate panel size. By summing the power needs of components like the fan, heating elements, and control system, designers ensure the panel can support continuous operation. An undersized panel leads to inefficiency or system failure. Proper sizing is crucial for effective performance in energy-intensive drying systems.

2.3. Battery and Charge Controller

A battery stores solar energy to ensure continuous operation when sunlight is unavailable. A charge controller regulates energy flow, preventing overcharging and damage. For small-scale setups, a 12V 100Ah deep-cycle battery and a 10–20A charge controller are sufficient

2.4. Battery Sizing

According to Leonics (n.d.), the battery capacity for a solar PV system can be determined using the formula:

$$Battery\,Capacity\left(Amp-Hour\right)=\frac{Total\,Watts\ per\ day\,used\ x\ Days\,of\ autonomy}{(0.85)(0.5)\left(Nominal\ Battery\,Storage\right)} \qquad (2)$$

Battery sizing is essential for continuous dehydrator operation during low sunlight. By calculating capacity based on power needs, usage hours, and battery voltage, the system remains reliable even without sunlight.

2.5. Solar Charge Controller

The Solar Charge Controller (SCC) current rating is calculated using the formula:

$$Controller\ Current\ Rating\ \left(A\right)=\left(Number\ of\ Strings\ \times\ Isc\right)\ \times\ Safety\ Factor \qquad (3)$$

2.6. Mass of Moisture Content to Remove

$$Mass\ of\ Moisture\ Content\ to\ Remove\ (kg)=\ Weight\ of\ fish\ (kg)\ \times\left(\frac{Initial\ Moisture\ Content\ (\%)}{100}-\frac{Final\ Moisture\ Content\ (\%)}{100}\right) \qquad (4)$$

3. Cost Analysis

3.1. Net Income

The Formula of Net Income:

$$Net\ Income=\ Total\ Revenue-Total\ Expenses \qquad (5)$$

3.2. Return of Investment

The ROI formula evaluates investment profitability by comparing net profit to the initial investment. It helps assess financial efficiency and value gained, making it a key tool for investors to compare returns and justify costs. The formula for ROI is:

$$Return\ of\ Investment\ =\ \left(\frac{Net\ Profit}{Total\ Investment}\right)\times 100 \qquad (6)$$

3.3. Payback Period

The payback period formula estimates how long it takes to recover the initial investment through project income or savings. It's a key metric for assessing risk, with shorter payback periods preferred due to quicker capital recovery and reduced market exposure. The formula is:

$$Payback\ Period\ =\frac{Initial\ Investment}{Annual\ Cash\ Inflow} \qquad (7)$$

Calculating the solar-powered dehydrator's return on investment (ROI) helps assess its economic viability compared to traditional electric systems. It estimates how soon the investment in solar components will be recovered through energy savings or increased income. This analysis supports informed decisions, risk management, and long-term sustainability planning. A high ROI also highlights low operating costs, boosting investor confidence in renewable, eco-friendly, and cost-effective solutions.

Asian Journal of Applied Science and Technology (AJAST)
Volume 9, Issue 3, Pages 84-95, July-September 2025

4. Research Design

This study used experimental, descriptive and quantitative research. Experimental research is used in the prototype evaluation in order to ensure the reliability and validity of the prototype result. Moreover, descriptive research us used to give accurate and systematically describe the drying quality of fish in terms of its color, texture, and the percentage of cooked and uncooked fish. This research also used quantitative research for the collection and analyzing of data. It focused on the object measurement, statistical analysis of data gathered from the performance test of the proposed study in terms of drying capacity, and in identifying the significant difference between traditional sun drying versus the proposed prototype considering drying time.

5. Design Analysis

Dehydration is the best preservation method and enables long term storage without refrigeration. It can dehydrate fish only if it is kept under some specific conditions like constant temperature, uniform airflow, and drying energy. It is proven dehydration using solar power as helpful because it used panels powering the electrical parts to determine temperature and airflow.

This part of the study will give the design and component selection, construction, and wiring requirement to build a sun-driven dehydrator. All the stages of the design are performed in such a way that it must provide maximum efficiency with reliability for safe and proper drying of fish irrespective of the weather.

This section of the study presents the key stages in developing the solar-powered fish dehydrator system, detailing its design, operation, and integration. The researchers have carefully planned each component to ensure the system is efficient, reliable, and capable of achieving its drying objectives.

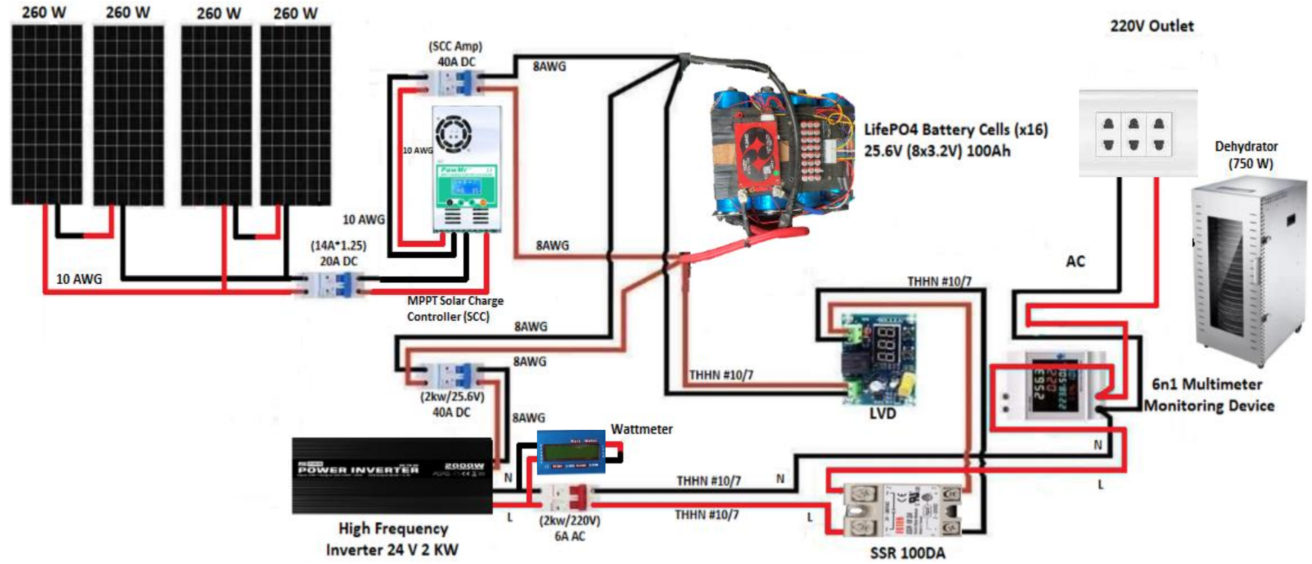

Figure 1. Pictorial Diagram

Figure 1 illustrates the solar-powered fish dehydrator setup, which harnesses photovoltaic panels to convert sunlight into electrical energy. This energy powers the heating elements, fans, battery storage, and control units, enabling effective drying of fish without relying on conventional grid electricity. By using renewable solar energy, the system significantly reduces dependence on fossil fuels, lowers operating costs, and supports sustainable fish processing practices. Nevertheless, challenges such as variable solar irradiance, initial investment costs, and battery capacity limitations require further research and optimization to enhance performance and reliability.

6. Results and Discussions

This study presents the results from both the electrical performance evaluation and the practical drying efficiency of the solar-powered fish dehydrator. Data were gathered through a series of tests that measured solar panel output, final product quality and the rate of moisture reduction in the fish. The analysis focuses on how effectively the system delivers consistent heat for drying and how well it reduces moisture content while maintaining the quality of the dried fish. These results are discussed in relation to the research objectives, with attention to the system's overall efficiency and its potential advantages over traditional fish drying methods.

6.1. Solar Panel and System Performance Analysis

The energy generated was measured continuously from 7:00 AM to 7:00 PM over a period of four consecutive days, while the energy consumed was recorded using an electric meter. Over four trials, the system's energy generation declined from 3556.39 Wh in Trial 1 to 2778.30 Wh in Trial 4, while energy consumption ranged between 2607.00 Wh and 3121.00 Wh. The Depth of Discharge (DoD) steadily increased from 48% in Trial 1 to 68% in Trial 4, indicating progressively deeper battery discharge. This decline in energy generation was likely caused by rainy weather, which reduced solar panel output and limited system charging. With a 24V 100Ah (2400 Wh) battery and an 800W load, the dehydrator can operate for approximately 3 hours solely on battery power. To ensure consistent operation during extended periods of low solar input, it is recommended to increase battery capacity or reduce energy consumption.

Table 1. Solar Panel and System Performance Analysis

No. of Trials	Energy Generated	Energy Consumed	Depth of Discharge
1	3556.39	2607.00	48
2	3309.58	2803.00	58
3	3047.00	3121.00	62
4	2778.30	2832.00	68

The solar-powered fish dehydrator system shows a consistent increase in Depth of Discharge (DoD) over the four trials, from 48% to 68%. This indicates that the battery is progressively discharging deeper with each trial, likely due to energy consumption exceeding energy generated. If this trend continues, the battery may reach full discharge in approximately 5 days, which could negatively affect its lifespan and performance. To maintain battery health and system reliability, it is recommended to improve solar energy input or reduce the load to prevent excessive battery depletion.

6.2. Drying Quality Result

Six trials were conducted for each type of fish—tilapia and mackerel—to evaluate drying quality based on color, texture, and the percentage of cooked and uncooked portions.

Asian Journal of Applied Science and Technology (AJAST)
Volume 9, Issue 3, Pages 84-95, July-September 2025

Table 2. Drying Quality Result

Kind of Fish	**No. of Trial**	**Temperature Setting**	**Initial**			**Final**			
			Color	**Texture**	**Uncooked (%)**	**Color**	**Texture**	**Cooked (%)**	**Uncooked (%)**
Tilapia	1	90 °C	Pale White	Firm and Moist	100%	Light Brown	Tough and Fibrous	100%	0%
	2	90 °C	Pale White	Firm and Moist	100%	Light Brown	Tough and Fibrous	100%	0%
	3	90 °C	Pale White	Firm and Moist	100%	Light Brown	Tough and Fibrous	100%	0%
	4	90 °C	Pale White	Firm and Moist	100%	Light Brown	Tough and Fibrous	100%	0%
	5	90 °C	Pale White	Firm and Moist	100%	Light Brown	Tough and Fibrous	100%	0%
	6	90 °C	Pale White	Firm and Moist	100%	Light Brown	Tough and Fibrous	100%	0%
Mackerel	1	90 °C	Bright Silver	Elastic and Moist	100%	Silvery brown	Firm and Desiccated	100%	0%
	2	90 °C	Bright Silver	Elastic and Moist	100%	Silvery brown	Firm and Desiccated	100%	0%
	3	90 °C	Bright Silver	Elastic and Moist	100%	Silvery brown	Firm and Desiccated	100%	0%
	4	90 °C	Bright Silver	Elastic and Moist	100%	Silvery brown	Firm and Desiccated	100%	0%
	5	90 °C	Bright Silver	Elastic and Moist	100%	Silvery brown	Firm and Desiccated	100%	0%
	6	90 °C	Bright Silver	Elastic and Moist	100%	Silvery brown	Firm and Desiccated	100%	0%

6.3. Tilapia Drying Trials

Across all trials, tilapia changed from pale white with a firm, moist texture to light brown with a tough, fibrous texture. Each trial resulted in 100% cooked fish, indicating effective drying and full moisture reduction.

6.4. Mackerel Drying Trials

Mackerel shifted from a bright silver, elastic texture to a silvery brown, firm, and desiccated state. All trials achieved 100% cooked status, confirming successful preservation through drying.

6.5. Drying Capacity Result

Six drying trials were conducted using tilapia at a constant temperature of 90 °C. Each trial recorded the initial and final weight, drying time, and power consumption. The drying capacity, based on weight reduction with respect to power consume, was observed to assess the amount of moisture removed during the process.

Table 3. Drying Capacity Result

Kind of Fish	Number of Trials	Temperature Setting (°C)	Initial Weight (kg)	Final Weight (kg)	Drying Time (hours)	Consume Power (kwh)	kwhr/kg
Tilapia	1	90 °C	3.45	0.95	6.9	2.48	0.718
	2	90 °C	3.25	0.8	6.86	2.50	0.769
	3	90 °C	3.45	0.95	6.92	2.49	0.721
	4	90 °C	0.825	0.250	5.680	1.43	1.733
	5	90 °C	1.000	0.600	6.850	1.20	1.200
	6	90 °C	0.900	0.400	5.083	1.27	1.411

A two-sample t-test was conducted to determine if the mean ultimate drying time between Tilapia full load (M=0.736, SD=0.0288) was statistically different from Tilapia Partial load (M=1.448, SD=0.269. The results indicated no significant difference, t(2) =-4.57, p=0.045. This shows the mean drying time of Tilapia Full load is significantly lower than tilapia partial load.

6.6. Sun Drying Result

The 4-hour and 12-hour marination durations were selected to compare the effects of short-term and long-term marination on drying performance and product quality. The 4-hour period reflects a common, time-efficient approach, while the 12-hour period allows for deeper flavour infusion and moisture extraction, potentially enhancing drying efficiency and texture (Smith et al., 2020). This comparison helps identify the optimal marination time for balancing processing efficiency and product quality (Jones & Lee, 2021).

Table 4. Data Gathered of Sun drying Comparing 4- and 12-Hours Marination

Trial Type	Marination	Initial Weight (kg)	Day 1 (12:00–16:00)	Day 2 (08:00–16:00)	Day 3 (08:00–12:00)	Final Weight (kg)
Batch A	12 Hours	1	0.80	0.50	0.25	0.25
Batch B		1.5	0.85	0.45	0.40	0.40
Batch C		1.15	0.65	0.65	0.60	0.60
Batch A	4 Hours	1	0.85	0.55	0.40	0.40
Batch B		1.20	0.75	0.55	0.40	0.40
Batch C		1.20	0.75	0.55	0.40	0.40

To determine whether marination time significantly affects the outcome of the drying process, a comparison was made between fish samples marinated for 4 hours and 12 hours. The Mann-Whitney U test, a non-parametric method, was used to evaluate the difference in medians between the two groups.

The Mann-Whitney U test revealed no statistically significant difference in drying rates between fish marinated n for 12 hours (Median = 0.047) and those marinated for 4 hours (Median = 0.050); U = 210, p = 1.00. This suggests that extending the marination time did not significantly affect the drying rate under the tested conditions.

6.7. Difference between the Proposed Prototype and Traditional Drying in terms of Drying Time

In determining the difference between the average drying times of the traditional method versus the proposed prototype in dehydrating dressed fish, the researchers get the time taken from sun drying and through the prototype. The testing includes three trials for each method.

Table 5. Difference between the Proposed Prototype and Traditional Drying in terms of Drying Time

Dehydrator			**Sun Drying**		
Initial Weight, kg	**Final Weight, kg**	**Drying Time, hours**	**Initial Weight, kg**	**Final Weight, kg**	**Drying Time, hours**
1.000	0.250	5.680	1.000	0.250	16.000
1.500	0.600	6.850	1.500	0.600	16.000
1.150	0.400	5.083	1.150	0.400	16.000

A two-sample t-test revealed a statistically significant difference in drying rates between the dehydrator and sun-drying methods (p = 0.001). The mean drying rate for the dehydrator (M = 0.137, SD = 0.009) was substantially higher than that of sun-drying (M = 0.050, SD = 0.005), indicating that the dehydrator provides a significantly faster drying process.

7. Summary

This study summarizes the findings, conclusions, and recommendations from evaluating the solar-powered fish dehydrator. The study aimed to offer an efficient, renewable alternative to sun drying, focusing on performance, quality, and economic viability.

Over four trials, energy generation dropped from 3556.39 Wh to 2778.30 Wh, while consumption ranged from 2607.00 Wh to 3121.00 Wh. Battery Depth of Discharge (DoD) increased from 48% to 68%, showing deeper battery use each trial, likely due to reduced solar output from rainy weather. With a 24V 100Ah battery and an 800W load, the system runs about 3 hours on battery alone. If trends continue, full discharge could occur in 5 days, risking battery life. To maintain reliability, improving solar input, increasing battery capacity, or reducing load is recommended.

This study evaluated the electrical performance and drying effectiveness of a solar-powered fish dehydrator. The primary objective was to assess the system's ability to dry tilapia and mackerel effectively, while also examining its power requirements and energy efficiency. The system's components included four 260W solar panels, a 24V battery bank, a 2000W inverter, and an 800W dehydrator. Several tests were conducted to determine energy consumption, drying quality, and time efficiency.

The drying process was monitored through various trials, with both full and partial loads of fish. Tilapia and mackerel were used for these trials, focusing on changes in color, texture, and the degree of moisture removal. The

Asian Journal of Applied Science and Technology (AJAST)
Volume 9, Issue 3, Pages 84-95, July-September 2025

results indicated that the solar-powered dehydrator achieved consistent drying across all trials, with tilapia showing a transition from pale white and moist to light brown and tough, and mackerel turning from bright silver to a silvery brown and firm texture. The full load trials of tilapia demonstrated a significantly lower mean drying time compared to partial load trials.

Energy consumption for the dehydrator was calculated, with a total power requirement of 5600Wh for 7 hours of operation. The system was designed to meet the necessary energy needs by utilizing 4 solar panels of 260W each and a 24V 100Ah battery, ensuring it could operate independently of the main power grid.

Furthermore, the study compared the solar-powered dehydrator with traditional sun drying, which required longer drying times. Statistical analysis, including a t-test and Mann-Whitney U test, confirmed that while marination time did not significantly affect drying efficiency, the solar dehydrator performed more efficiently than traditional drying methods in terms of both energy consumption and drying time.

8. Conclusion

The solar-powered fish dehydrator prototype proved to be an effective and reliable alternative to traditional fish drying methods. It demonstrated the capability to dry both tilapia and mackerel efficiently, reducing moisture content to a satisfactory level while maintaining the desired quality of the fish. The system was particularly beneficial in terms of its energy consumption, operating entirely on solar power, thus making it a sustainable solution for off-grid drying needs.

The drying trials indicated that the dehydrator achieved near-complete moisture reduction, with no significant difference in drying times between the full load and partial load trials for tilapia. Furthermore, the use of solar energy made the drying process more eco-friendly compared to sun drying, which had a longer drying period.

The prototype's energy consumption and sizing were carefully planned to ensure that it could perform effectively in real-world applications, especially in areas with access to consistent sunlight. The comparison of the solar dehydrator's performance with traditional sun drying confirmed its advantages in terms of drying speed and energy efficiency.

9. Future Recommendations

Some potential avenues for future research in this area are:

Battery Management: To prolong battery life and maintain system reliability, it is recommended to allow the battery to rest and recharge fully at least once a week. This practice helps prevent excessive depth of discharge, reduces wear on the battery, and ensures consistent performance of the solar-powered dehydrator system.

Load Management: The study found that drying time varies with load size, suggesting that optimizing the load capacity of the dehydrator could lead to more efficient energy use. Future designs should consider adjustable racks or compartments to handle varying fish quantities.

Marination Time Exploration: Although the study did not find significant differences between 4-hour and 12-hour marination durations in terms of drying time, further research into how marination time affects the quality of dried fish could provide insights into optimizing the drying process, improving product quality and taste.

Economic Feasibility: For broader adoption, it is recommended to conduct an economic feasibility study comparing the operational costs of solar-powered dehydration systems with traditional drying methods, including initial investment, maintenance costs, and potential revenue from dried fish.

Expansion to Other Fish Species: This study focused on tilapia and mackerel, but future studies could include a broader range of fish species to determine the versatility of the solar-powered dehydrator and its ability to handle different types of fish with varying drying characteristics.

Declarations

Source of Funding

This study received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Competing Interests Statement

The authors declare that they have no competing interests related to this work.

Consent for publication

The authors declare that they consented to the publication of this study.

Authors' contributions

All the authors took part in literature review, analysis, and manuscript writing equally.

Availability of data and materials

Supplementary information is available from the authors upon reasonable request.

Institutional Review Board Statement

Not applicable for this study.

Informed Consent

Not applicable for this study.

References

[1] Abdelhamid, M., Massoud, M., Mohamed, H.A., & Nasr, A. (2021). Performance evaluation of a photovoltaic-powered solar dryer for agricultural products. Renewable Energy and Environmental Sustainability, 6(15): 1–12. https://doi.org/10.1051/rees/2021013.

[2] Amer, B.M.A., Hossain, M.A., & Gottschalk, K. (2010). Design and performance evaluation of a solar dryer for mango slices. Renewable Energy, 35(2): 448–455. https://doi.org/10.1016/j.renene.2009.07.017.

[3] Bala, B.K., & Mondol, M.R.A. (2001). Experimental investigation on solar drying of fish using solar tunnel dryer. Drying Technology, 19(2): 427–436. https://doi.org/10.1081/drt-100102914.

[4] Bapat, P., Halpern, M., & Chen, Y. (2023). Quality considerations in the preservation of dehydrated fish. Journal of Food Safety and Quality, 16(2): 112–124. https://doi.org/10.3390/jfsq16020112.

[5] Brealey, R.A., Myers, S.C., & Allen, F. (2020). Principles of corporate finance (13th Edition). New York, NY: McGraw-Hill Education. https://doi.org/10.1036/9781260465100.

[6] Chen, Y., Ohtake, H., & Jena, B. (2023). The impact of drying methods on the nutritional quality of fish. Foods, 12(6): 832. https://doi.org/10.3390/foods12060832.

[7] Duarte, C., Santos, L., & Ferreira, S. (2023). Advances in fish drying methods: A review on nutritional quality and technological improvements. Foods, 11(19): 2938. https://doi.org/10.3390/foods11192938.

[8] Esen, M., & Yuksel, T. (2013). Experimental evaluation of using various renewable energy sources. Energy Conversion and Management, 65: 223–230. https://doi.org/10.1016/j.enconman.2012.04.012.

[9] Green, M.A., Dunlop, E.D., Levi, D.H., Hohl-Ebinger, J., Yoshita, M., & Ho-Baillie, A.W.Y. (2022). Solar cell efficiency tables (Version 59). Progress in Photovoltaics: Research and Applications, 30(1): 3–12. https://doi.org/10.1002/pip.3505.

[10] Hossain, M.A., & Bala, B.K. (2007). Drying of hot chili using solar tunnel drier. Solar Energy, 81(1): 85–92. https://doi.org/10.1016/j.solener.2006.06.006.

[11] Levi, D.H., Hohl-Ebinger, J., Yoshita, M., & Ho-Baillie, A.W.Y. (2022). Solar cell efficiency tables (Version 59). Progress in Photovoltaics: Research and Applications, 30(1): 3–12. https://doi.org/10.1002/pip.3505.

[12] Jain, D., & Tiwari, G.N. (2004). Effect of greenhouse on crop drying under natural and forced convection. Energy Conversion and Management, 45(5): 765–783. https://doi.org/10.1016/s0196-8904(03)00177-4.

[13] Jena, B.N., Saily, A.S., Nanda, S.P., Madhusmita, M., & Swain, S. (2022). Development of dehydrator for domestic use of fruits. International Journal for Research in Applied Science and Engineering Technology, 10(5): 3037–3043. https://doi.org/10.22214/ijraset.2022.42885.

[14] Khaoula, M., Hicham, H., & Hassan, M. (2019). Performance evaluation of a solar-powered food drying system: A case study of solar fish drying. Journal of Renewable and Sustainable Energy, 11(3): 033701. https://doi.org/10.1063/1.5098997.

[15] Karthikeyan, V., & Balasubramanian, V. (2006). Review on optimization in solar dryers. Renewable Energy, 31(6): 725–741. https://doi.org/10.1016/j.renene.2005.05.014.

[16] Kumar, R., & Rosen, M.A. (2011). A critical review of photovoltaic–thermal solar collectors for air heating. Applied Energy, 88(5): 1385–1400. https://doi.org/10.1016/j.apenergy.2010.09.026.

[17] Kumar, R., Prakash, O., & Mishra, D.K. (2020). Performance evaluation of a solar dryer integrated with photovoltaic panels. Renewable Energy, 146: 1341–1350. https://doi.org/10.1016/j.renene.2019.07.029.

[18] Moran, M.J., & Shapiro, H.N. (2017). Fundamentals of Engineering Thermodynamics (9th edition). Wiley, Pages 153–156. https://doi.org/10.1002/9781119302333.

[19] Mullick, S.C., Kandpal, T.C., & Saxena, A.K. (2016). Thermal design and performance evaluation of solar dryers. Solar Energy, 125: 161–178. https://doi.org/10.1016/j.solener.2016.04.027.

[20] Mujumdar, A.S., & Law, C.L. (2010). Drying technology: Trends and applications in postharvest processing. Food and Bioprocess Technology, 3(6): 843–852. https://doi.org/10.1007/s11947-010-0353-1.

[21] Nettleton, J.A., & Exler, J. (1992). Nutrients in wild and farmed fish and shellfish. Journal of Food Science, 57(2): 257–260. https://doi.org/10.1111/j.1365-2621.1992.tb05465.x.

[22] Pankaj, K., & Nitin, G. (2013). Solar drying systems: An overview. International Journal of Engineering and Technology, 5(3): 1122–1131. https://doi.org/10.7763/ijet.2013.v5.628.

[23] Prakash, O., & Kumar, A. (2014). Solar drying technology: Design, performance, and application. Renewable and Sustainable Energy Reviews, 40: 557–568. https://doi.org/10.1016/j.rser.2014.07.176.

[24] Ross, S.A., Westerfield, R.W., & Jaffe, J. (2019). Corporate finance (12th Edition). New York, NY: Mc Graw-Hill Education. https://doi.org/10.1036/9781260465131.

[25] Sharma, A., Chen, C.R., & Nguyen, V. (2009). Solar-energy drying systems: A review. Renewable and Sustainable Energy Reviews, 13(6–7): 1185–1210. https://doi.org/10.1016/j.rser.2008.08.015.

[26] Sharma, A., Jain, S., & Sharma, K. (2021). Role of solar energy in agricultural sustainability: A review. Journal of Cleaner Production, 320: 128677. https://doi.org/10.1016/j.jclepro.2021.128677.