SSRG International Journal of Recent Engineering Science
ISSN: 2349–7157 / https://doi.org/10.14445/23497157/IJRES-V11I5P122

Volume 11 Issue 5, 220-226, Sep-Oct 2024

Original Article

Engineering Design of Technology Innovation and its Application for Salai Fish Processing Using Biomass Energy

Juandi Muhammad[1], Gimin[2], Saberina Hasibuan[3]

[1]*Department of Physics, Universitas Riau, Pekanbaru, Indonesia*
[2] *School of Economics Education, Faculty of Teaching and Education, Universitas Riau, Pekanbaru, Riau, Indonesia*
[3]*Department of Aquaculture, Faculty of Fisheries and Marine Science, Riau University, Pekanbaru Indonesia*

[1]*Corresponding Author : juandi@lecturer.unri.ac.id*

Received: 29 August 2024 Revised: 01 October 2024 Accepted: 19 October 2024 Published: 30 October 2024

Abstract *- Biomass Energy is energy derived from plants that can be used as a source to generate heat in the fish processing room. Biomass Energy is needed by the community for cooking and heating something. To meet the needs of use for processing smoked fish, the utilization of biomass energy is carried out. This study is an initial study of the design of technological innovation engineering and its application to the processing of smoked fish in industrial businesses in the cold water village, Bukit Raya District, Pekanbaru City. This study aims to analyze the optimal design for the utilization of biomass energy. The biomass energy source comes from types of plants, especially rambutan tree trunks because rambutan tree trunks provide a good aroma for the smoked fish products produced. The research method is a direct experimental method to design and apply to industrial businesses in the cold water village, Bukit Raya District, Pekanbaru City, with the raw materials used being catfish and patin fish. The composition of patin fish and catfish is 30 kg, = and 40 kg. The heat energy generated from the combustion of rambutan tree trunks is visible in the combustion chamber. Based on the results of the observations, the results of the smoked fish will be obtained after the process has been going on for 1 day (24 hours), which is quite efficient in terms of fast processing time. So, the results of the analysis of the smoked fish have the potential to be marketed because the color is bright and fragrant.*

Keywords *- Design, innovation, Technology, Smoked fish, Biomass.*

1. Introduction

The gaps in previous research can be identified as follows: there has been no discussion of the Specific Physical Process stating that biomass can produce heat energy through a physical process, but the technological process has not been explained. Further research is needed to identify and analyze the most efficient specific methods. Social and Economic Aspects: The development of biomass as an energy source also needs to consider social and economic aspects, such as its impact on local communities and the labor market, so this research is still needed to find the latest Technological Innovation in smoked fish processing to increase energy conversion efficiency. This gap requires further exploration to find out existing innovations and untapped potential. Biomass is an abundant energy source on this earth, and it comes from plants. In the future, biomass will be increasingly considered as the population of living things will increase. Biomass is one of the most important energies for survival because its availability as an energy source never runs out. One of the energy sources that is being developed is an abundant energy source on this earth, namely biomass, to produce heat energy after going through a physical process [1,2,3]. The physical process that underlies the use of biomass energy is the mechanism of heat transfer, both conduction, convection and radiation. Through the radiation mechanism, heat energy from biomass can be transferred to the combustion chamber and through the convection mechanism, the air in the chamber will become hot; there will be air flow accompanied by heating, while through the conduction process, the metals as the walls of the tool in this technology will be able to absorb heat and store heat. Heat transfer will occur into the technology chamber for lighting smoked fish [4,5,6]. The engineering design applied to this smoked fish processing tool uses materials from metal plates that will easily occur a multiple reflection system mechanism, meaning an increase in heat in the room so that this can save biomass materials to be less. The design of the space where the biomass is made in the form of a parabola will be able to maximize biomass energy so that it can minimize the use of rambutan trees as an energy source [7,8,9]. The method used in the research is experimental, meaning that first, the engineering design of the technological tool was carried out. Then, this technological tool was tested

in the industry for processing smoked fish. The quality of the smoked fish obtained is characterized by its red color and aroma, and this shows that the engineering design that was carried out has worked well and succeeded in producing a quality product [10,11]. Technological innovation in fish processing, especially the smoked method, has become the focus of research to improve efficiency and product quality; efficient smoked fish processing depends on smoking techniques and adequate tool design to ensure optimal processes.

Good tool design can improve energy utilization and reduce emissions generated during the processing process [12]. The use of biomass as a renewable energy source has gained significant attention in recent years. Biomass can be processed into energy that can be used for a variety of applications, including food processing. Biomass offers significant environmental benefits compared to fossil fuels, as it reduces carbon emissions and supports sustainability [13]. The application of biomass energy in the fish processing industry, especially in the smoking process, can provide a sustainable solution. Research shows that the use of biomass can increase energy efficiency and reduce operational costs. With the appropriate tool design, the smoking process of smoked fish can be carried out more efficiently, producing high-quality products with lower environmental impact [14].

Engineering design in technological innovation for fish processing needs to consider various aspects, including technical, economic, and environmental aspects. A systematic approach in engineering design can help identify the most effective solutions to improve the processing process. Integrating appropriate technology with renewable energy sources such as biomass can be the key to creating a sustainable and efficient fish processing system [15]. The novelty of this research is in the design of the Parabolic Room; the concept of using a parabolic design for biomass space is an innovation that is not yet common in biomass energy research. This design can potentially increase the efficiency of energy collection and conversion from biomass, which could be a breakthrough in biomass technology.

Energy Optimization: This work offers a more systematic and efficient approach than traditional methods by focusing on designs that maximise biomass energy. This could lead to the developing of more effective systems for generating energy from biomass.

2. Materials and Methods

2.1. Material

The materials used in this study are raw materials of catfish and patin fish. Samples of catfish and patin fish were taken from the community around the activities that cultivate catfish and patin fish. For the engineering design of the technological innovation tool, zinc plate metal plates and iron anchors were used to make the tool frame.

2.2. Experimental Equipment

The experimental setup includes the following: Preparation of Materials and Tools

2.2.1. Materials

- Fresh fish (smoked fish)
- Biomass source (Agricultural waste, especially rambutan tree trunks)

2.2.2. Tools

- Smoking technology or tools specifically designed to use biomass as an energy source (Figure 1).
- A thermometer and temperature measuring device are used to monitor conditions during the smoking process.

2.2.3. Experimental Procedure

- Fish Preparation: Clean and prepare the smoked fish according to processing standards.
- Biomass Energy System Setup: Design and build a smoking system using biomass. Make sure the system can control temperature and airflow.

2.2.4. Smoking Process

- Smoke the fish.
- Observe the condition of the smoked fish during the process.

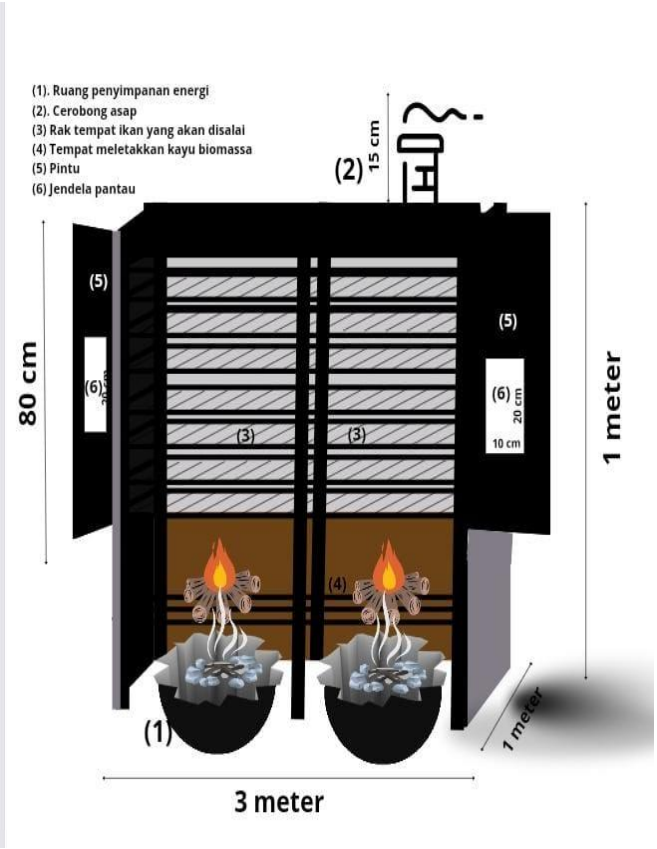

Fig. 1 Engineering Design of Research Tools

3. Results and Discussion

3.1. Engineering Design Making Technology

The technology for lighting raw materials of fish is an important innovation to improve the productivity and quality aspects of good smoked fish. The final productivity of making Smoked Fish depends on the lighting technology used. The engineering design process for making smoked fish technology tools can be seen in Figure 2. Figure 2 shows the working part of the technological tool for preparing the seat frame in the tool for the seat of the fire retardant that comes loose on the raw fish material being served so that the production quality remains guaranteed. Furthermore, the engineering design is to increase the efficiency of the tool so that heat is not lost in the combustion furnace, so the tool is designed with a parabolic system in the biomass combustion chamber, at the same time so that there is no loss of energy, the design section of the tool for the part where the mass is located can be seen in Figure 3.

3.2. Application of Engineering Equipment Technology in Industry

Engineering technology tools for processing smoked fish are then applied to the industry. In its application, the raw materials of catfish and patin fish are placed on shelves in the ignition room, as shown in Figure 4. Biomass, as an energy source, is placed on the bottom and has been designed in such a way as to produce maximum performance, meaning there is no energy loss. This ignition process lasts for 24 hours, and the result is smoked fish that is red in color and has a fragrant aroma, as shown in Figure 5. Based on the experiments that have been carried out by implementing the proposed engineering design for smoked fish processing, it can be seen that the performance of the designed tool has been successful; the indicator of success is that it can increase the efficiency of working time to only 24 hours or 1 working day, whereas so far the business actor has needed 72 hours or 3 days.

Fig. 2 Engineering Design Process for making innovative technology tools for fish lighting

Fig. 3 Engineering the creation of a biomass space

Fig. 4 Fish are placed on shelves in the tool according to the Engineering design

Fig. 5 Production of smoked fish produced using technological equipment made according to engineering design

The technological innovation tool has worked well, as can be seen from the observation results shown in Figures 6 to 8 below. Figure 6 shows a graph showing the time required to process smoked fish in both methods without technological innovation. The processing time is longer because this method is traditional because the unfocused biomass chamber system produces heat energy. Figure 7 shows a comparison of the amount of biomass produced with and without the application of technological innovation. The use of modern technological innovation, a parabolic combustion chamber can increase efficiency, including the use of less biomass, a more efficient system, and processing techniques will be more environmentally friendly because they use less biomass. The application of technological innovations, such as the use of parabolic combustion chambers, shows several important advantages:

- Increased Efficiency: Parabolic combustion chambers are designed to maximize energy conversion from biomass. With an optimal design, more energy can be produced from less biomass, reducing the need for raw materials.
- Redued Biomass Use: With a more efficient system, the amount of biomass required to achieve the same energy yield is reduced. This not only saves costs but also reduces pressure on natural resources. Environmentally Friendly Processing Techniques: Innovations in biomass processing can result in lower emissions and less waste. By using more sustainable methods, negative impacts on the environment can be minimized.

Figure 8 shows a comparison between the amount of smoked fish production produced without equipment innovation and with the use of equipment innovation. In the first part, smoked fish production without equipment innovation shows a lower number, reflecting the limitations of traditional methods that are less efficient and less than optimal techniques can affect production results.

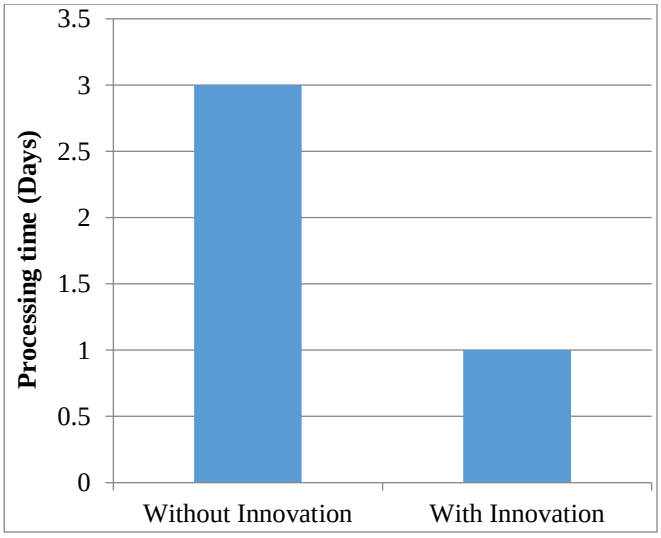

Fig. 6 Comparison of processing time for smoked fish with and without technological tool innovation

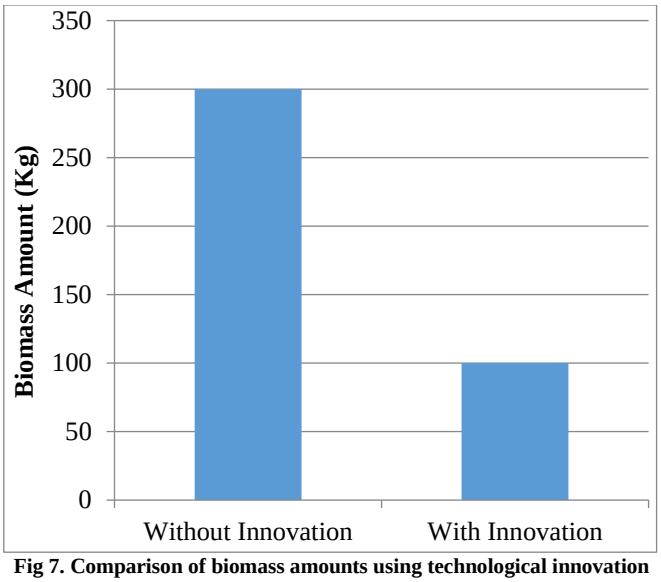

Fig 7. Comparison of biomass amounts using technological innovation and without using technological innovation

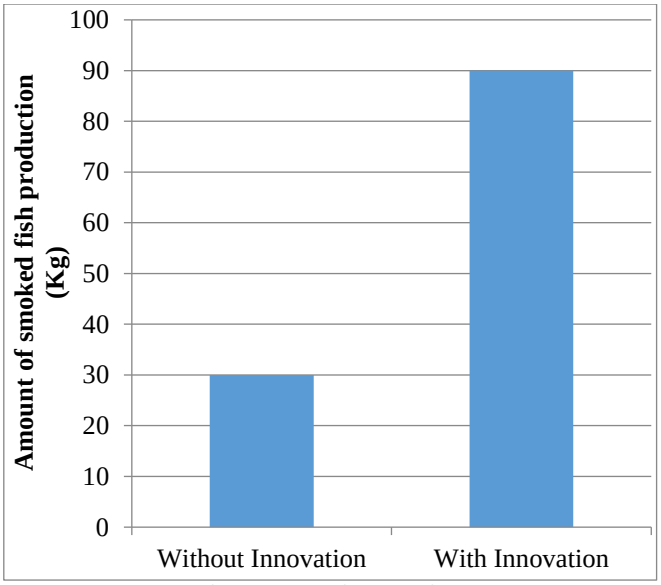

Fig. 8 Comparison of the amount of smoked fish production without using tool innovation and with using tool innovation

In contrst, in the second part of the graph, it can be seen that smoked fish production using equipment innovation has increased significantly. This innovative equipment includes more modern smoking technology, which uses a better parabolic biomass combustion chamber, increasing process efficiency and producing more products. This can also reduce losses during the production process and increase overall production capacity.

3.3. Assess the Environmental Impact of Biomass Source

The use of biomass in this technological tool innovation as an energy source in the processing of smoked fish has a significant environmental impact and can be assessed from several aspects.

- Reducing Carbon Emissions

The use of less biomass, in this case waste from rambutan tree trunks, as fuel for the fish smoking process can reduce carbon emissions compared to the use of more Biomass fuel.

- Waste Management

Using biomass waste as an energy source helps reduce the accumulation of waste in the environment. This can reduce soil and water pollution, often caused by poorly managed biomass waste.

- Sustainability of Energy Sources

Biomass is a renewable energy source that uses well-managed biomass. By relying on less biomass, the smoked fish processing industry can create a more sustainable energy system, which reduces dependence on non-renewable energy sources.

- Air Quality

Although biomass is cleaner than fossil fuels, biomass combustion can still produce particles and other pollutants that affect air quality. Therefore, efficient and clean smoked fish processing technology is very important to minimize this impact.

3.4. Include an Economic Analysis of the Biomass-based Method

Processing smoked fish using biomass energy technology offers a sustainable and efficient alternative in the fisheries industry. The process of processing smoked fish requires energy sources for grilling and smoking, which often rely on large amounts of biomass. From an economic perspective, biomass-based methods in processing smoked fish show significant potential. First, operational costs can be reduced because less biomass is used, and the price will be cheaper compared to other smoked fish processing equipment that requires a lot of biomass. In addition, using biomass waste as an energy source creates added value, which can increase income for smoked fish processing industry players and fishermen. With an initial investment in biomass-based processing technology, producers can gain long-term efficiency. The overall economic feasibility analysis, including operational costs, initial investment for biomass technology and supporting infrastructure, can be explained in Table 1. The cost components in Table 1 must be taken into account. So, with proper management and a clear business strategy, biomass-based methods in processing smoked fish can provide economic benefits while supporting environmental sustainability (Table 1 part C). The formula used to calculate the profit aspect for one production is stated in equation (1). The profit result is obtained because for every 4 kg of raw patin fish material, one kg of smoked fish will be produced, so from 90 kg of raw patin fish material, 22.5 kg of smoked patin fish will be produced.

$$\text{Profit} = (B\text{-}A) = \text{Rp } 855.000 \quad (1)$$

3.5. Case Studies and Future Research Directions

Smoked fish processing is a culinary tradition rich in nutritional and economic value but often faces challenges in terms of efficiency and sustainability. With the advancement of technology, the use of biomass energy in the process of processing smoked fish has become an attractive alternative. Biomass energy, which comes from rambutan tree trunks, offers an environmentally friendly solution and can reduce dependence on fossil fuel sources. The case study in this research that applies biomass-based technology to smoked fish processing can provide insight into how the process of processing smoked fish can be carried out more efficiently and sustainably.

Future research in the application of biomass technology, future research can be focused on developing a system that integrates renewable energy sources with the process of processing smoked fish. For example, using an integrated Internet of Things system to process smoked fish can increase the efficiency of the work of the tool and can be controlled remotely. In addition, research can also explore new technologies, such as biomass-based heaters, that are more effective and environmentally friendly. With this approach, the smoked fish processing industry can not only increase productivity but also have a positive impact on the environment.

The direction of future research should consider aspects of sustainability, energy efficiency, and technological innovation. Through collaboration between academics, industry, and government, more in-depth research on the processing of smoked fish using biomass energy can be produced. This will improve product quality, open up new opportunities for business actors, support food security, and contribute to reducing the carbon footprint in the fisheries sector. Thus, the use of technology in the processing of smoked fish based on biomass energy can be a solution that is beneficial for society and the environment.

3.6. Ethical Considerations Regarding the Use of Biomass

Using biomass from rambutan tree trunks as an energy source for processing smoked fish requires serious attention to resource sustainability. It is important to ensure that the extraction of raw materials is not excessive so that the regeneration of rambutan trees and environmental sustainability are maintained. This reflects the ethics in using natural resources, where the ecosystem balance must be maintained to be used sustainably. The impact on local communities is an ethical aspect that should not be overlooked. Many communities depend on rambutan trees for their livelihoods. If biomass processing interferes with their access to these resources, this can create conflict and injustice. By involving local communities in the decision-making process, we can ensure that they receive fair benefits and access to the resources available. Environmental health should also be a major focus in the biomass processing process. This

process should be designed to minimize negative impacts, such as air pollution, soil pollution, and water pollution. Using environmentally friendly technologies is essential to reduce the ecological footprint of biomass processing. This way, we can maintain environmental health and protect the community from possible negative effects. Ethical considerations also include the comparison between biomass and other energy sources. If biomass from rambutan trees is proven more sustainable than fossil fuels, then its choice can be considered positive. However, we must ensure that the use of this biomass does not harm sustainable agricultural or forestry practices and does not threaten biodiversity. This is essential to ensure that the energy solution chosen does not negatively impact the environment and society. In the context of smoked fish processing, animal welfare must be considered. The fishing methods used must not harm the fish population, and it is better if the raw fish is obtained from responsible farming.

In this way, we protect fish resources and fulfill the ethical principles underlying sustainable food processing. Public education and awareness also play an important role. Communities need to be empowered and informed about sustainable smoked fish processing practices and the benefits and risks of biomass use. A good education will raise awareness of the importance of ethical resource management and encourage communities to participate in preserving the environment.

Ultimately, discussions about the ethics of biomass use must involve a wide range of stakeholders, including local communities, scientists, and policymakers. Involving multiple perspectives in decision-making is essential to ensuring that solutions are equitable and sustainable. With a collaborative approach, we can create biomass uses that are not only efficient but also environmentally and socially responsible.

Table 1. Economic analysis of smoked fish processing business

A. Production Cost Aspects

No	Description	Variable Costs (Rp)	Fixed Costs (Rp)
1	Cost of technological innovation tools		15.000.000,-
2	Cost of raw materials for catfish (90) Kg @ Rp. 18.000	1.620.000,-	
3	Biomass waste wood from rambutan stems. @Rp.500/kg smoked fish raw material	45.000,-	
4	Labor cost per person @Rp.2000/kg	180.000	
	Total Production Costs	1.845.000	

B. Sales result aspects

No	Description	Sales results (Rp)
1	Smoked fish 22,5 Kg, @ Rp. 120.000	2.700.000

C. Profit result aspect

No	Profit (B-A)/day Rp.	Profit per month (10 times) Rp.	Profit per year Rp.
1	855.000	8.055.000	96.660.000

4. Conclusion

In the initial study stage of this research, it can be concluded that the engineering design of technology for processing smoked fish has succeeded in utilizing maximum biomass energy with a minimum amount of biomass of up to 1/3 of the previous one.

The results of smoked fish products produced can increase up to 3 times. The processing time of smoked fish has become efficient within 24 hours, whereas previously, it took 72 hours. The smoked fish products produced are also of high quality with a red color and a fragrant smell.

Acknowledgments

The author would like to thank the Directorate of Research, Technology, and Community Service, Directorate General of Higher Education, Research, and Technology, Ministry of Education, Culture, Research, and Technology, which has funded this community service activity in the 2024 budget year and would also like to thank LPPM Universitas Riau, UKM MINA SALAI KUARAN, and students who have participated in the MBKM Program.

References

[1] Juandi Muhammad, Joko Risnto, and Gimin, "Biomass-Based Dryer Technology Innovation in the Agrotechnology Industry with the Internet of Things System," *Proceedings of the 4th Green Development International Conference (GDIC 2022)*, pp. 1-7, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[2] Juandi Muhammad, Joko Risnto, and Gimin, "Technological Innovation based on Biomass Waste with Controlled Features for Cassava Drying Agrotechnology," *BIO Web of Conferences*, vol. 99, pp. 1-7, 2024. [CrossRef] [Google Scholar] [Publisher Link]

[3] Juandi Muhammad, Joko Risnto, and Gimin, "Drying Fresh Cassava Chip using Biomass Energy with IoT Monitoring System," *Agricultural Engineering International: CIGR Journal*, vol. 24, no. 3, 2022. [Google Scholar] [Publisher Link]

[4] Florin Popescu et al., "A Mathematical Model of Biomass Combustion Physical and Chemical Processes," *Energies*, vol. 13, no. 23, pp. 1-36, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[5] Gbeminiyi M. Sobamowo et al., "Analysis of Heat Transfer in the Pyrolysis of Differently Shaped Biomass Particles Subjected to Different Boundary Conditions: Integral Transform Methods," *Journal of Heat and Mass Transfer Research*, vol. 4, no. 1, pp. 21-34, 2017. [CrossRef] [Google Scholar] [Publisher Link]

[6] M. Brennan Pecha et al., "Progress in Understanding the Four Dominant Intra-particle Phenomena of Lignocellulose Pyrolysis: Chemical Reactions, Heat Transfer, Mass Transfer, and Phase Change," *Green Chemistry*, vol. 21, pp. 2868-2898, 2019. [CrossRef] [Google Scholar] [Publisher Link]

[7] Ratna Purwaningsih et al., "Product-service System Method to Measure Sustainability Level of Traditional Smoked Fish Processing Industries," *MATEC Web of Conferences*, vol. 154, pp. 1-5, 2018. [CrossRef] [Google Scholar] [Publisher Link]

[8] Samuel Ayofemi Olalekan Adeyeye, "Smoking of Fish: A Critical Review," *Journal of Culinary Science & Technology*, vol. 17, no. 6, pp. 559-575, 2019. [CrossRef] [Google Scholar] [Publisher Link]

[9] Sitnah Aisyah Marasabessy, "Strategic Process Design for Fish–Based SMEs," *Proceeding 7th International Seminar on Industrial Engineering and Management*, pp. 1-8, 2014. [Google Scholar] [Publisher Link]

[10] A. Fuentes et al., "Physicochemical Characterization of Some Smoked and Marinated Fish Products," *Journal of Food Processing and Preservation*, vol. 34, no. 1, pp. 83-103, 2010. [CrossRef] [Google Scholar] [Publisher Link]

[11] Hua Feng et al., "Insight into the Characterization of Volatile Compounds in Smoke-flavored Sea B0ass (Lateolabrax Maculatus) During Processing via HS-SPME-GC-MS and HS-GC-IMS," *Foods*, vol. 11, no. 17, pp. 1-14, 2022. [CrossRef] [Google Scholar] [Publisher Link]

[12] Abdo Hassoun et al., "Seafood Processing, Preservation, and Analytical Techniques in the Age of Industry 4.0," *Applied Sciences*, vol. 12, no. 3, pp. 1-28, 2022. [**CrossRef**] [**Google Scholar**] [**Publisher Link**]

[13] Miguel-Angel Perea-Moreno, Esther Samerón-Manzano, and Alberto-Jesus Perea-Moreno, "Biomass as Renewable Energy: Worldwide Research Trends," *Sustainability*, vol. 11, no. 3, pp. 1-21, 2019. [CrossRef] [Google Scholar] [Publisher Link]

[14] Nahid Taherzadeh-Shalmaei et al., "Evaluating the Energy Use, Economic and Environmental Sustainability for Smoked Fish Production from Life Cycle Assessment Point of View (Case Study: Guilan Province, Iran)," *Environmental Science and Pollution Research*, vol. 28, pp. 53833-53846, 2021. [CrossRef] [Google Scholar] [Publisher Link]

[15] M. Shainee et al., "Design Theory in Offshore Fish Cage Designing," *Aquaculture*, vol. 392-395, pp. 134-141, 2013. [CrossRef] [Google Scholar] [Publisher Link]