International Journal of Progressive Sciences and Technologies (IJPSAT)
ISSN: 2509-0119.
© 2022 Scholar AI LLC.
Vol. 36 No. 2 January 2023, pp. 161-171

Techno-Economic Analysis Of Industrial-Scale Dried Skipjack Tuna Production In West Aceh District, Indonesia

Iing Pamungkas[1], Heri Tri Irawan[1]

[1]Industrial Engineering Department, Engineering Faculty
Universitas Teuku Umar
Indonesia
iingpamungkas@utu.ac.id

Abstract – Abstract— Dried skipjack tuna is a processed fish product that is produced traditionally and is a processed product from various regions in Indonesia, including Aceh. Dried skipjack tuna is used as a food ingredient in people's daily lives so that the demand is relatively stable. West Aceh has good fishery resource potential, but currently does not yet have an industrial-scale fish processing industry, especially the production of skipjack tuna-based dried fish. As a basic initiation, it is necessary to carry out a techno-economic study for an initial study in setting up various types of businesses or industries. The purpose of this study was to determine the production capacity, production process, location and layout of the dried skipjack tuna processing factory facilities, as well as determine the feasibility of investment in terms of the economic assessment of the operation of the dried skipjack tuna processing industry. The results of the research that has been carried out, the planned production target per day is 600 kilograms of raw skipjack tuna which will be processed into 600 packs of dried skipjack tuna with a packaging weight of 500 grams. Determining the location of the factory using scoring method, the location of Suak Raya, West Aceh Regency was chosen as the location for the establishment of the dried skipjact tuna industry. The layout design is based on the corelap algorithm with several production spaces such as storage area, bone extraction area, cutting area, sorting area, drying area, fish separation area, weighing area, and packing area. Based on economic analysis, the dried skipjack tuna production industry is considered feasible to operate with an investment value of Rp. 773,795,000 and a total cost of Rp. 5,877,604,900. The cost of production (HPP) is Rp. 26,087 per package and a predetermined selling price of Rp. 36,522 per package or 40% of the HPP. Other economic analyzes that have been carried out obtained a Break-Even Point (BEP) value of 468,000 packages per year, a Pay Back Period (PBP) for 3 years, a Net Present Value (NPV) of Rp. 3,328,686,033.29, the Net Benefit Cost (Net B/C) is 56 and the Internal Rate of Return (IRR) is 67%.

Keywords – dried skipjack tuna; techno-economic; industry

I. INTRODUCTION

Skipjack tuna (*Katsuwonus pelamis L.*) is classified as an important pelagic fishery resource and is an export commodity [1]. Skipjack tuna is found in almost all Indonesian waters and one of them is found in Aceh waters, Indonesia. Skipjack tuna can be used as a dried fish that has a high selling value and export value if it is processed properly and hygienically and packaged like a product on the market. Dried skipjack tuna in Japan is known as Katsuobushi, which is a product of processed smoked fish or dried fish produced from a combination of boiling and drying processes. Dried skipjack tuna is a traditional processed fish product, and is a processed product from various regions in Indonesia, especially in North Sulawesi, South Sulawesi, Aceh, and several other areas [2].

From an economic perspective, dried skipjack tuna production is a potential business that can benefit the community, with domestic and foreign market opportunities that are still very open. Dried skipjack tuna is used as a food ingredient in people's daily lives so that the demand is relatively stable. Meanwhile, from a technological point of view, the dried skipjack tuna

production process does not require high technology, but requires results that meet consumption standards. In addition, improvement in terms of production quality is something that deserves attention [3-4]. Dried skipjack tuna or better known as Katsuo-bushi is included in processed products that are dried in stages. Dried skipjack tuna weighs about 20–30% of the raw material, with a moisture content of 15–17% due to the drying process [5].

West Aceh has good fishery resource potential, but currently does not yet have an industrial-scale fish processing industry, especially the production of skipjack tuna-based dried fish. As a basic initiation, it is necessary to carry out a techno-economic study for an initial study in setting up various types of businesses or industries. Studies in terms of supporting technology that are commonly carried out are production analysis in the form of specifications and availability of raw materials, capacity planning and production process technology, machinery and equipment, mass balance, factory location determination and layout design. Engineering economics is a discipline commonly used in assessing the feasibility of a proposed new business or new investment. It is also used by management in decision making. While the investment criteria is one way that was developed to find a comprehensive measure as a basis for accepting or rejecting a business. Several methods used to assess the feasibility of a business or industry are grouped based on value for money, namely Net Present Value (NPV), Net Benefit Cost Ratio (Net B/C), Internal Rate of Return (IRR); and based on time values, namely Payback of Period (PBP), Break Event Point (BEP), and Sensitivity Analysis.

Techno-economic research has many applications such as the production of hydochar and biochar [6], biomass supply chain [7], agrophotovoltaics [8], and cellulosic ethanol [9]. Several previous studies related to this research were the use of biomass stoves in dried fish production [10], management of dried fish processing businesses [11], and the effect of liquid smoke concentration and soaking time on the organoleptic quality of dried fish [12].

The purpose of this study was to determine the production capacity, production process, location and layout of the dried skipjack tuna processing factory facilities, as well as determine the feasibility of investment in terms of the economic assessment of the operation of the dried skipjack tuna processing industry.

II. Research Methods

Data collection was carried out through interviews and direct observation with related parties such as dried skipjack tuna businesses that have been operating for a long time, fish traders to find out the catch and fluctuations in fish prices. In addition, a literature study was conducted to collect relevant research data to be used as a research reference [13-16].

Data processing is divided into two aspects of study, namely technology and economics. The two aspects of the study are then classified into five analyses, namely production analysis (specification of raw materials, availability of raw materials, production capacity planning, production process technology, mass balance, machinery and equipment, factory location, layout design and factory space requirements), financial analysis (NPV, Net B/C Ratio, IRR, PBP, and BEP), sensitivity analysis. The general research procedure is shown in Figure 1.

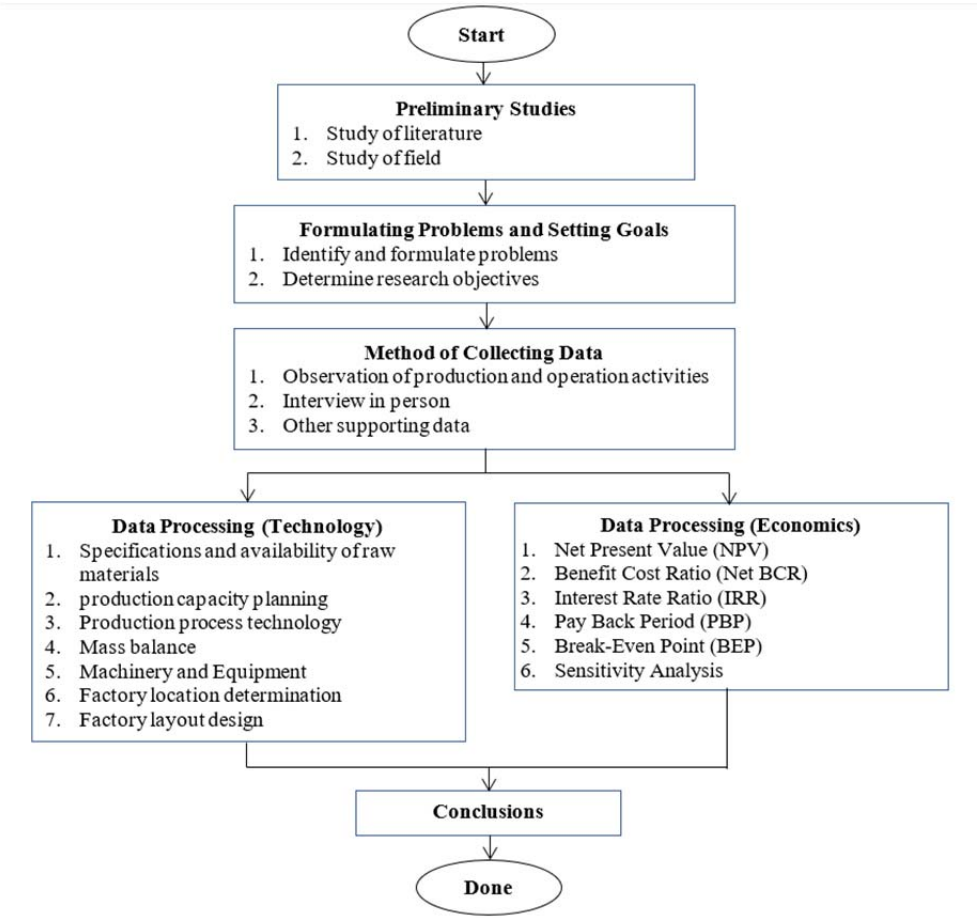

Fig. 1. Research procedure

III. Result And Discussion

A. Specifications, Availability of Raw Materials, and Production Capacity

The raw material used for making dried skipjack tuna comes from skipjack tuna, where skipjack tuna is still commonly found in West Aceh District and its surroundings. Skipjack tuna in the market or port must have different sizes, such as small, medium and large sizes. This will complicate the process of drying the fish because it does not have a uniform size so that the fish cooked will vary. Therefore, the raw materials must be sorted first before the fish enter the drying process.

The availability of raw materials for processing dried skipjack tuna in West Aceh District still depends on the fishermen in the vicinity. Based on data from the West Aceh Fisheries Service, the total production of skipjack tuna in West Aceh Regency in the second semester of 2021 was 77,918 kilograms. In the rainy season, raw materials are difficult to obtain so that it is still not sufficient for skipjack tuna raw materials. Based on these problems, the availability of materials in a business must always be sufficient for each production even during the rainy season. As an alternative, if skipjack tuna is difficult to find, mackerel tuna can be used as a substitute, where this mackerel tuna has a shape or texture that is almost the same as skipjack tuna. Procurement of mackerel tuna can be obtained from fishermen in other areas whose locations are still accessible so that dried skipjack production can take place continuously.

The production capacity is planned to be a medium scale dried skipjack tuna industry. The factory is planned to have an installed capacity of 1,200 kg per day, meaning that the factory is capable of processing 1,200 kg of raw skipjack tuna. Based on the availability of raw materials, the dried skipjack industry is targeted to produce 600 kg of raw skipjack tuna which will be processed into 600 packages of dried skipjack tuna with a content weight of 500 grams per pack. Products will be marketed to the surrounding community and sold online. The market potential for dried skipjack tuna products is very large, but the dried skipjack tuna processing industry is still very limited, especially in West Aceh District.

B. Production Process Technology, Mass Balance, and Equipment

The dried skipjack tuna production process already uses a fish drying oven, of course this has a positive impact because the production process does not depend on weather factors. The oven holds 30 skipjack tuna with a mass of 100 kg and is processed into 60 sticks. Drying is done for 1.5 hours which is the maximum drying time. This is done so that the water content in the fish is reduced by up to 50% and the meat in the fish is cooked evenly. Even cooking will produce optimal fish meat texture, tasty and reddish brown color of fish meat. The dried skipjack tuna that has been cooked is packaged using plastic packaging. The mass balance of dried skipjack tuna processing is presented in Figure 2.

Machines and equipment used in the dried skipjack tuna processing industry are still relatively simple, where the tools used are cutting tools such as knives, then fish bone extractors, dryers, scales and vacuum sealers.

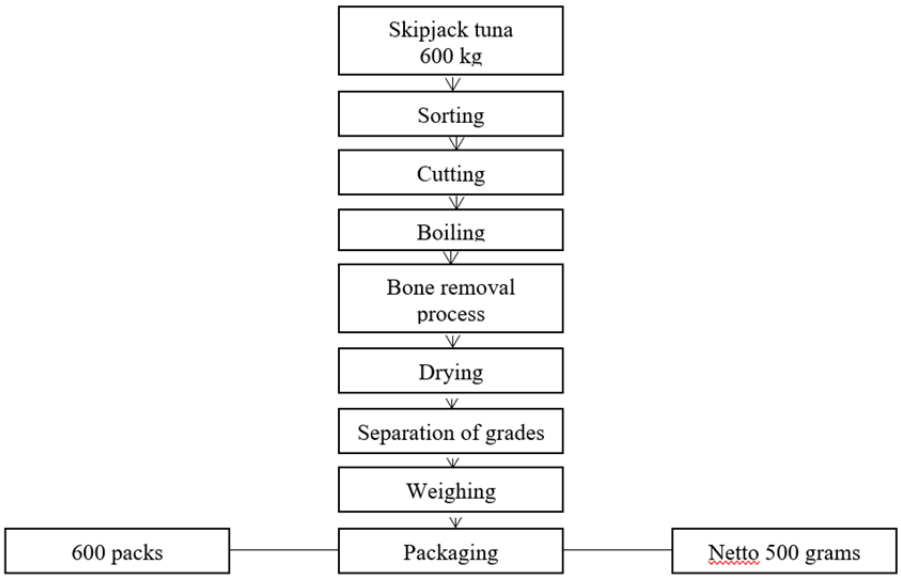

Fig. 2. Mass balance

C. Factory Location

The dried skipjack tuna that will be established in West Aceh Regency has 3 alternative locations, namely Kuala Bubon, Suak Raya, and Ujong Karang. Determining the location of the factory is carried out in several stages, including determining the area of the location, determining the community environment to be studied and selecting the best location. There are several factors that need to be considered in determining the location of a factory, namely market location, sources of raw materials, transportation, sources of energy or electricity, climate, level of labor or wages, legal and taxation systems, community attitudes, water, and industrial waste disposal. The following is a location assessment by considering the factors to be assessed related to the factory construction plan, including:

1. Source of raw materials
2. Rent a place
3. Means of transportation
4. Labor availability
5. Environmental aspects related to environmental impacts

Before choosing the best location, a factor score will be determined first. The following factor scores will be assessed with a score description, including:

1 = Less

2 = Moderate

3 = Good

4 = Very Good

The next step is to determine the weight of the factors to be assessed, including:

1. Source of raw materials = 20
2. Rent a place = 25
3. Means of transportation = 10
4. Labor = 15
5. Waste = 30

The following is the scoring based on the location of each region in West Aceh District.

Table 1. Factory location determination scoring table

Factors assessed	**Potential Location**		
	Kuala Bubon	***Suak Raya***	***Ujong Karang***
Source of raw materials	3	4	3
Rent a place	2	4	1
Means of transportation	4	3	4
Labor	3	4	2
Waste	3	4	1

The next step is to calculate the load score for each location.

Table 2. Factory Location Score Load

Factors assessed	**Weight**	**Score**			**Weight x Score**		
		Kuala Bubon	***Suak Raya***	***Ujong Karang***	***Kuala Bubon***	***Suak Raya***	***Ujong Karang***
Source of raw materials	20	3	4	3	60	80	60
Rent a place	25	2	4	1	50	100	25
Means of transportation	10	4	3	4	40	30	40
Labor	15	3	4	2	45	60	30
Waste	30	3	4	1	90	120	30
Total Load Score					**285**	**390**	**185**

The results of determining the alternative location for the establishment of the selected dried skipjack tuna industry location is the location that gives the highest score weight, namely in the Suak Raya area.

D. Factory Layout Design

The design of the factory layout begins with the stage of making an Activity Relationship Chart (ARC) which aims to determine the level of relationship between activities that occur in each area one with another area in pairs. This relationship is seen from several aspects, including departmental linkages, material flows, equipment used, people working, information and the environment. Based on the relationship between these activities and their reasons, the ARC for all available areas in the dried skipjack tuna industry is presented in the following table and figure.

Table 3. Letters and Meanings in ARC

No.	Interest Level	Code	Color
1	Very important	A	Red
2	Of Certain Importance	E	Yellow
3	Iportant	I	Green
4	Normal	O	Blue
5	Not important	U	White
6	Undesirable	X	Brown

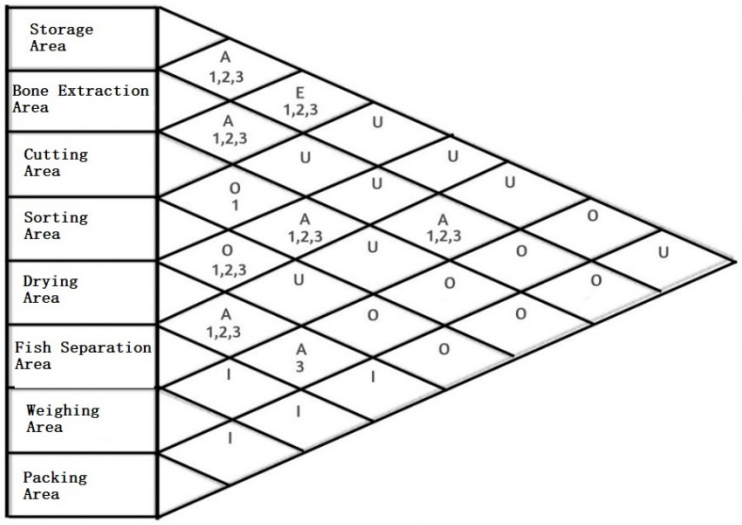

Fig. 3. Linkages between activities in the dried skipjack tuna industry

Table 4. Reason Code in ARC

No	Reason
1	Using the same workforce
2	Sequence of workflow processes
3	Job relatedness

The proximity value of each code in ARC

A : 15

E : 10

I : 5

O : 1

U : 0

X : -10

Tabulation is done for the Total Closeness Rating (TCR) value, namely in Table 5.

Table 5. Total Closeness Rating (TCR)

D/D	A 1	A 2	A 3	A 4	A 5	A 6	A 7	A 8	A	E	I	O	U	X	TC R	*Orde r*
Storage area (A1)	-	A	E	U	U	U	O	U	1	1	-	1	4	-	26	6
Bone extraction area (A2)	A	-	A	U	U	A	O	O	3	-	-	2	2	-	47	2
Cutting area (A3)	E	A	-	O	A	U	O	O	2	1	-	3	1	-	28	5
Sorting area (A4)	U	U	O	-	O	U	O	O	-	-	-	4	3	-	4	8
Drying area (A5)	U	U	A	O	-	A	A	I	3	-	1	1	2	-	51	1
Fish Separatio n Area (A6)	U	A	U	U	A	-	I	I	2	-	2	-	3	-	40	3
Weighing area (A7)	O	O	O	O	A	I	-	I	1	-	2	4	-	-	29	4
Packing area (A8)	U	O	O	O	I	I	I	-	-	-	3	3	1	-	18	7

Determining the layout of the facility based on the corelap algorithm, namely in Figure 4.

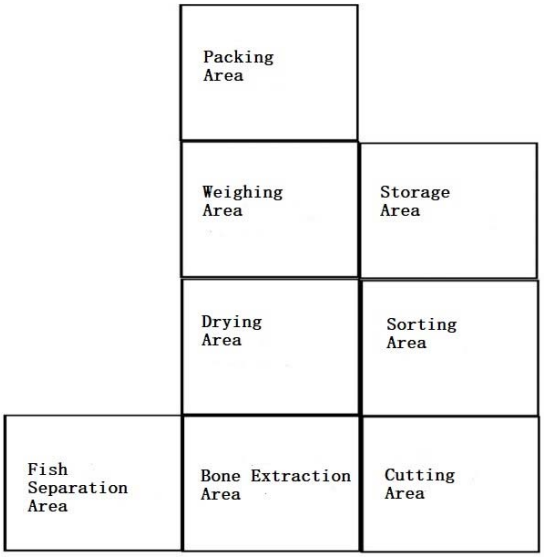

Fig. 4. Facility layout based on corelap algorithm

Based on the facility layout design using the corelap algorithm for the dried skipjack tuna industry, the next step is to make a design proposal based on the initial design that has been made. Facility layout based on the corelap algorithm is presented in Figure 5.

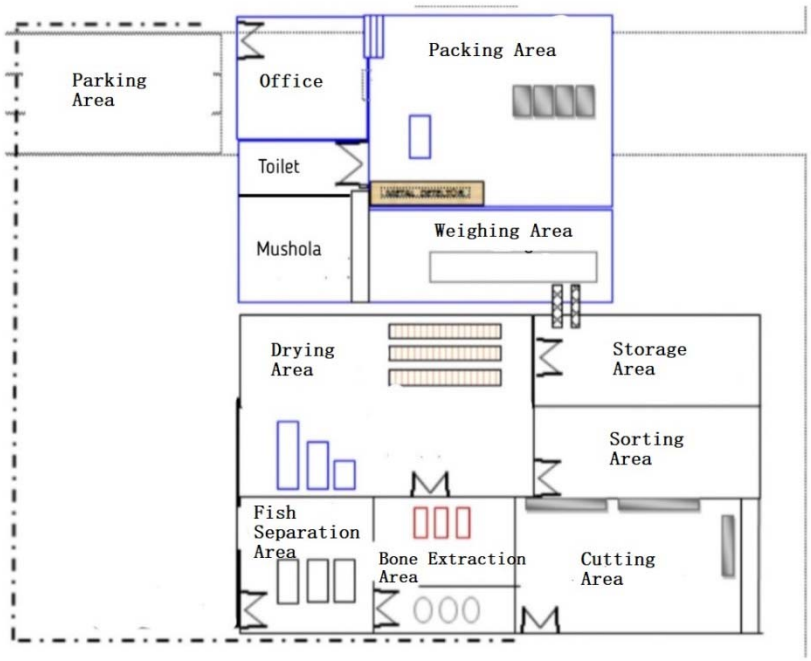

Fig. 5. Proposed layout design

E. Financial Analysis

Financial analysis aims to calculate the amount of funds needed in planning an industry by calculating the expected costs and benefits by comparing costs and revenues. Financial analysis requires several assumptions that are adjusted to the conditions at the time the study was conducted and are based on the results of calculations that have been carried out on analysis of other aspects, business establishment standards and applicable regulations. The basic assumptions that become the calculations in the financial analysis are used to determine the feasibility of the dried skipjack tuna industry. The assumptions used are as follows.

1. This financial analysis is carried out with investment costs for the establishment of a new business.
2. The economic life of the industry is assumed to be 10 years, adjusted to the economic life of the machines and equipment.
3. The remaining value of the building at the end of the project is 50% of the initial value, the residual value of machinery and equipment is 5% of the initial value, and the residual value of vehicles is 20% of the initial value.
4. Machinery and equipment maintenance costs are 2% of the price of the machine and equipment.
5. The production capacity of dried skipjack tuna is 360-600 packs per day with 600 kg of skipjack tuna per day.
6. The number of working days per year is 312 days, assuming 26 working days in a month and 12 months in a year.
7. Capital interest is assumed to be 15%
8. Taxes are calculated based on Law no. 36 of 2008 for corporate tax of 28%.
9. Initial operation is calculated based on the first 1 month in the first year of operation which is only 60% of production capacity.
10. The production capacity in the first year is 60%, the production capacity in the second year is 80%, while the production capacity in the third year and so on is 100%.
11. The project starts in year 0, while the first production begins in year 1.

Complete assumptions for the financial analysis of the dried skipjack tuna industry are presented in Table 6.

Table 6. Assumptions of Financial Analysis of the Dried Skipjack Tuna Industry

No.	Assumption Variable	Unit	Value
1	Project age	Years	10
2	Working days per month	Days	26
3	Months of work per year	Months	12
4	Number of working days per year	Days	312
5	Residual value of the building from its initial value	%	50%
6	Residual value of land from initial value	%	100%
7	Residual value of machinery and equipment from initial value	%	10%
8	Vehicle residual value	%	20%
9	The economic life of office equipment, machinery and equipment, and vehicles	Years	5
10	The cost of maintaining machines and equipment from the price	%	2%
11	Production capacity	Packs per day	600
12	Production capacity a. First year b. Second year c. Third year and so on	 % % %	 60% 80% 100%
13	Raw material requirements a. Skipjack Tuna b. Salt	 Kg per day Packs per month	 600 50
14	Price of raw materials per Kg a. Skipjack Tuna b. Salt	 Rupiahs Rupiahs	 20.000 8.000
16	discount factor	%	15%
17	Fuel requirement per month	Rupiahs	1,500,000
18	Contingency	%	10%
19	The number of packages needed per day	Packs	600
20	Price of plastic packaging	Packs	1000
21	Tax	%	28%

The results of the financial analysis and feasibility indicators for the dried skipjack tuna industry are presented in Table 7.

Table 7. Results of the financial analysis and feasibility indicators for the dried skipjack tuna industry

Financial analysis	Value
Investments + Contingencies	Rp. 773,795,000
Total cost	Rp. 5,877,604,900
Total Production per Year (Package)	112,320-187,200
Cost of goods sold (HPP)	Rp. 26,087
Package Selling Price	Rp. 36,522
Profit per Pack (+40%)	Rp. 10,435

Income per Year	Rp. 4,102,148,316 – Rp. 6,836,913,860
Profit per Year	Rp. 273,567,580 – Rp. 1,406,450,851
Business Feasibility Indicators	**Value**
NPV	Rp3,328,686,033.29
IRR	67%
Net B/C	56
Payback Period (year)	3
BEP (package)	468,000

F. Sensitivity Analysis

Sensitivity analysis aims to find out whether an industry is still feasible to run when experiencing an increase in production costs or a decrease in the amount of production at a certain time. The assumption of changes made is if the total cost of production increases by 20% in raw materials and other utilities that affect the cost and amount of production. The recapitulation of the results of the sensitivity analysis in the dried skipjack tuna industry is presented in Table 8.

Table 8. Sensitivity analysis with 20% contingency

Criteria	Value
NPV	Rp. 872,748,934.49
IRR	31%
Net B/C	6
Payback Period (year)	4

IV. Conclusion

The results of the research that has been carried out, the planned production target per day is 600 kilograms of raw skipjack tuna which will be processed into 600 packs of dried skipjack tuna with a packaging weight of 500 grams. Determining the location of the factory using scoring method, the location of Suak Raya, West Aceh Regency was chosen as the location for the establishment of the dried skipjact tuna industry. The layout design is based on the corelap algorithm with several production spaces such as storage area, bone extraction area, cutting area, sorting area, drying area, fish separation area, weighing area, and packing area. Based on economic analysis, the dried skipjack tuna production industry is considered feasible to operate with an investment value of Rp. 773,795,000 and a total cost of Rp. 5,877,604,900. The cost of production (HPP) is Rp. 26,087 per package and a predetermined selling price of Rp. 36,522 per package or 40% of the HPP. Other economic analyzes that have been carried out obtained a Break-Even Point (BEP) value of 468,000 packages per year, a Pay Back Period (PBP) for 3 years, a Net Present Value (NPV) of Rp. 3,328,686,033.29, the Net Benefit Cost (Net B/C) is 56 and the Internal Rate of Return (IRR) is 67%.

Acknowledgment

This research was funded by Universitas Teuku Umar (Kemendikbud) in accordance with the Letter of Agreement Assignment Asisten Ahli for Research Implementation for the 2022 Fiscal Year Number: 120/UN59.7/SPK-PPK/2022.

References

[1] Sitepu, Agape Isak, et al. "Kajian Mutu Ikan Kayu Serut Yang Dikemas Plastik Dengan Nitrogen Dan Tanpa Nitrogen." *Media Teknologi Hasil Perikanan* 9.1 (2020): 8-13.

[2] Iqlima, Annisa, et al. " Pengujian Kapang dan Bakteri Patogen pada Ikan Kayu (Katsuobushi) Asap Cair Selama Penyimpanan." *Media Teknologi Hasil Perikanan* 7.2 (2019): 46-51.

[3] Pamungkas, Iing, Heri Tri Irawan, and Lian Arkanullah. "Implementasi Statistical Process Control Untuk Pengendalian Kualitas Garam Tradisional Di Kabupaten Pidie." *Jurnal Optimalisasi* 4.2 (2020): 108-118.

[4] Muzakir, Fitriadi, et al. "Penerapan Mesin Pengasapan Ikan untuk Nelayan Desa Langkak Kecamatan Kuala Pesisir Kabupaten Nagan Raya." *Jurnal Pengabdian Masyarakat: Darma Bakti Teuku Umar* 2.1 (2020): 34-42.

[5] Tinuwo, Greace, et al. "Isotermi Sorpsi Air Ikan Kayu (Katsuo-Bushi) Yang Dibuat Dengan Konsentrasi Asap Cair Dan Lama Perendaman Yang Berbeda." *Media Teknologi Hasil Perikanan* 7.2 (2019): 36-40.

[6] Kumar, Adarsh, Komal Saini, and Thallada Bhaskar. "Hydochar and biochar: production, physicochemical properties and techno-economic analysis." *Bioresource technology* 310 (2020): 123442.

[7] Lo, Shirleen Lee Yuen, et al. "Techno-economic analysis for biomass supply chain: A state-of-the-art review." *Renewable and Sustainable Energy Reviews* 135 (2021): 110164.

[8] Schindele, Stephan, et al. "Implementation of agrophotovoltaics: Techno-economic analysis of the price-performance ratio and its policy implications." *Applied Energy* 265 (2020): 114737.

[9] Aui, A., Y. Wang, and M. Mba-Wright. "Evaluating the economic feasibility of cellulosic ethanol: A meta-analysis of techno-economic analysis studies." *Renewable and Sustainable Energy Reviews* 145 (2021): 111098.

[10] Hasan, Hafidh, and Sri Haryani Anwar. " Pengenalan dan Pemanfaatan Tungku Biomassa dengan Pembakaran Bersih BAgi Pengusahan Ikan Kayu (Keumamah) di Kota Banda Aceh." *JUARA: Jurnal Wahana Abdimas Sejahtera* (2020): 43-54.

[11] Hasan, H., & Anwar, S. H. (2021). Pengenalan dan Pemanfaatan Tungku Biomassa dengan Pembakaran Bersih BAgi Pengusahan Ikan Kayu (Keumamah) di Kota Banda Aceh. *JUARA: Jurnal Wahana Abdimas Sejahtera*, *2*(1), 43-54.

[12] Bakri, M., and Nasir Nasir. "Manajemen usaha pengolahan ikan kayu (keumamah) masyarakat Lampulo Banda Aceh." *Jurnal Serambi Akademica* 6.2 (2018): 1-8.

[13] Katiandagho, Yisia, Siegfried Berhimpon, and Albert Royke Reo. "Pengaruh konsentrasi asap cair dan lama perendaman terhadap mutu organoleptik ikan kayu (Katsuo-Bushi)." *Media Teknologi Hasil Perikanan* 5.1 (2017): 1-7.

[14] Irawan, Heri Tri, and Iing Pamungkas. "Studi Kelayakan Investasi Perkebunan Kelapa Sawit PT. Agro Sinergi Nusantara (ASN) Kabupaten Aceh Selatan." *Jurnal Optimalisasi* 6.1 (2020): 40-46.

[15] Irawan, Heri Tri, et al. "Penentuan Posisi dan Strategi Usaha Produksi Paving Block di Kabupaten Aceh Besar." *Jurnal Optimalisasi* 8.1 (2022): 55-61.

[16] Irawan, H. T., I. Pamungkas, and A. Saputra. "Determination of the cost of patchouli oil production in South Aceh using break-even analysis." *IOP Conference Series: Materials Science and Engineering*. Vol. 1003. No. 1. IOP Publishing, 2020.

[17] [16] Pamungkas, Iing, and Heri Tri Irawan. "Analisis Break-Even Point pada Usaha Produksi Minyak Nilam di Kabupaten Aceh Selatan." *Journal Industrial Servicess* 6.2 (2021): 112-116.