

# Techno-economic analysis of sea cucumber tortilla chips in Madurese, Indonesia

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**Abstract.** Fortified sea cucumber tortilla chips aim not only to diversify their utilization but also to address pressing sustainability issues related to local resource management and environmental impact. This study assesses the feasibility and sustainability of producing sea cucumber-based tortilla chips in Madurese, Indonesia. The research focuses on promoting sustainable production practices by evaluating the energy consumption, resource efficiency, and environmental footprint of the entire production process. The techno-economic analysis covers the production process, considering factors like processing technologies, market demand, resource availability, and environmental impact. The electrical power demand for the plant is delineated as 138.86 kW per batch for primary operations. The project also explores potential economic benefits for local communities by promoting the use of local resources, supporting rural development, and contributing to long-term sustainability. Results show an NPV of IDR 694,159,220 at an 18% interest rate, an IRR of 27.44% exceeding the prevailing rate, and a net B/C ratio greater than 1.43. The calculated PBP is 3.56 years, with a BEP of 9,611 packs annually. Integrating this innovative product into the market could diversify the local economy, reduce environmental strain, and enhance socio-economic well-being in Madurese, Indonesia.

## 1 Introduction

The techno-economic analysis of sea cucumber tortilla chips in Madurese, Indonesia, offers a compelling avenue for research due to its potential to bridge the realms of technology, economics, and culinary innovation. Sea cucumbers, abundant in the coastal waters of Indonesia, represent a valuable marine resource with diverse applications beyond traditional seafood markets [1,2]. By employing technological advancements in food processing and manufacturing, coupled with rigorous economic analysis, this study seeks to unlock insights into the feasibility, profitability, and sustainability of producing sea cucumber tortilla chips. Such insights hold significance for stakeholders ranging from local

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entrepreneurs and seafood processors to policymakers and conservationists, as they offer a nuanced understanding of how innovation can drive economic growth while promoting environmental stewardship in coastal regions.

Recent literature underscores the growing interest in leveraging technology to enhance the economic value of marine resources and diversify local economies in Indonesia. Studies by researchers emphasize the role of innovative food processing techniques in adding value to seafood products and creating new market opportunities. Additionally, research by Purwanti et.al highlights the importance of techno-economic analysis in evaluating the feasibility of food processing ventures, particularly in resource-rich but economically marginalized regions like Madurese, Indonesia [3]. By building upon these insights, the present study aims to contribute to the discourse on sustainable development, technological innovation, and economic empowerment in coastal communities reliant on marine resources.

The main research problem revolves around assessing the techno-economic feasibility of producing sea cucumber tortilla chips in Madurese, Indonesia, considering factors such as production costs, market demand, technological capabilities, and environmental sustainability. The study seeks to address this problem by conducting a comprehensive analysis that integrates techno-economic modeling, market research, and sustainability assessments. By identifying optimal production processes, pricing strategies, and market channels, the research aims to provide stakeholders with actionable insights to capitalize on the economic potential of sea cucumber tortilla chips while fostering sustainable utilization of marine resources and supporting local livelihoods in the Madurese community.

Based on the scientific literature, the specific solution for exploring the potential of sea cucumber tortilla chips lies in leveraging the high-value components and bioactive present in sea cucumbers, as elucidated by [4]. These studies underscore the diverse biological and pharmacological activities of sea cucumbers, highlighting their suitability as functional foods with various health benefits, including anti-cancer, anti-hypertensive, and antioxidant properties. Tortilla chips were fortified sea cucumbers, there is an opportunity to create innovative snack products that not only cater to consumer demand for healthier options but also capitalize on the nutritional richness of sea cucumbers.

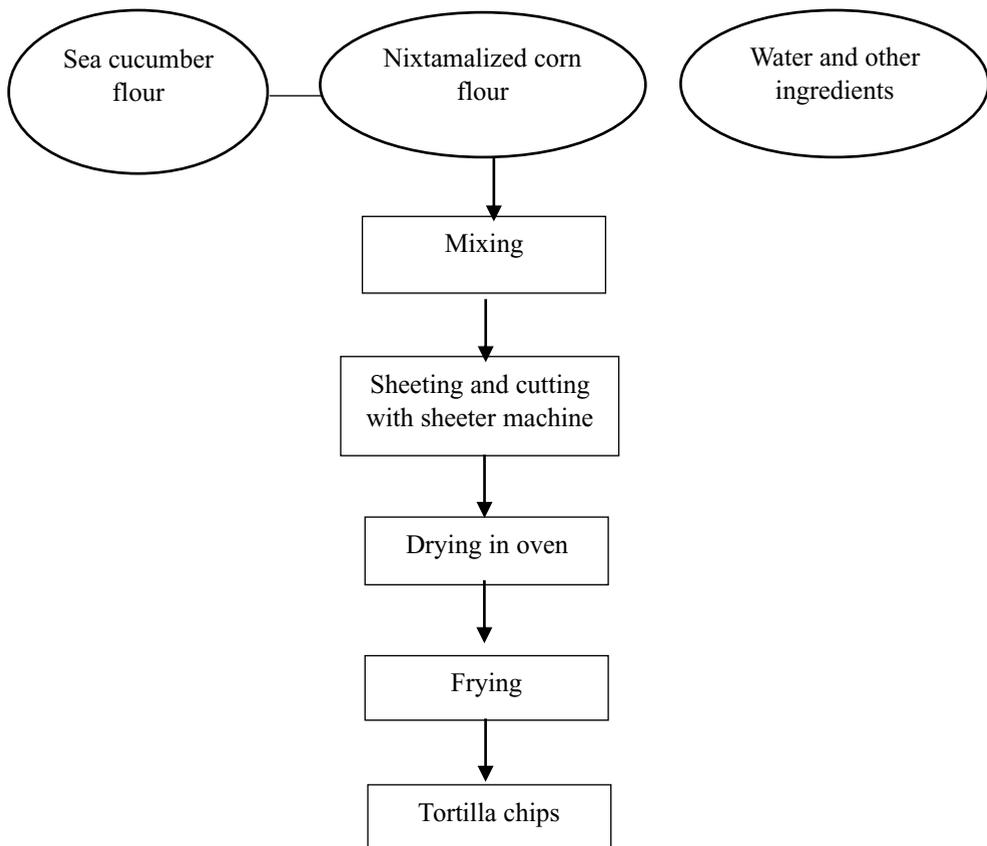
Moreover, insights from economic studies such as [2,5] indicate the high economic value and promising market demand for sea cucumbers, laying the groundwork for exploring sea cucumber-based products from a techno-economic perspective. By conducting comprehensive techno-economic analysis, including cost-benefit assessments, market projections, and production feasibility studies, stakeholders can gain valuable insights into the economic viability of producing sea cucumber tortilla chips. Additionally, the integration of sea cucumbers into aquaculture systems for nutrient recycling and waste processing, as discussed by [6], offers a sustainable and cost-effective approach to sea cucumber production, further supporting the economic feasibility of sea cucumber-based snack products like tortilla chips.

## **2 Methods**

### **2.1 Technical feasibility analysis**

The methodology employed in this study of the techno-economic analysis of cucumber sea tortilla chips, encompasses several key factors crucial in process parameters and economic parameters to evaluate the feasibility of this innovative product. Assessment of processing technologies relevant to the addition of sea cucumbers into tortilla chip production was conducted. The tortilla chips processed has described by previous study [7,8] in process

flow diagram (Figure 1). This involved exploring various methodologies such as dehydration, slicing, and seasoning, aimed at optimizing the incorporation of sea cucumber slices into the chip-making process while maintaining high standards of product quality and safety. Additionally, market demand was thoroughly scrutinized using a combination of research methodologies including surveys, interviews, and secondary data analysis [9]. This comprehensive investigation sought to understand consumer preferences, emerging market trends, and potential demand projections for sea cucumber tortilla chips. Moreover, the methodology incorporated evaluations of resource availability and environmental impact to ascertain the feasibility of sustainable production practices. Life cycle assessments were employed to quantify the environmental footprints associated with the production process, while assessments of raw material availability and infrastructure requirements were conducted to ensure project viability.



**Fig. 1.** Tortilla chips process flow diagram

## 2. 2 Financial feasibility analysis

Furthermore, the study delved into the socio-economic dynamics of local communities engaged in the sea cucumber value chain, exploring potential income generation and employment opportunities. These considerations were integral in assessing the feasibility and potential socio-economic benefits of the innovative product [10]. The investment feasibility criteria utilized, including Net Present Value (NPV), Internal Rate of Return (IRR), Net Benefit/Cost Ratio (Net B/C), and Pay Back Period (PBP), served as pivotal

metrics in the analysis, providing a comprehensive framework for evaluating the economic viability of cucumber sea tortilla chips.

### 3 Results and discussion

#### 3.1 Technical feasibility analysis

The production process of sea cucumber tortilla chips begins with the preparation of sea cucumbers, which are meticulously cleaned and sliced into uniform pieces, dried, and grinded. Sea cucumber flour as a fortifier to improve the taste and nutritional content of tortilla chips. At the same time, a dough consisting of nixtamalized corn flour, water, salt and additive had been prepared, and sea cucumber flour had added, formed into a chip with 2 mm of thickness using sheeter machine. Chips were dried in gas oven at 50 °C for 90 minutes then cooked by frying in vegetable oil until it reaches the desired level of crispiness. After cooking, it is followed by a cooling period, mixed with flavorings then packaged in metalized plastic pouch (Figure 1).

Enrichment is the addition of nutrients to one or several food ingredients in order to increase the nutritional value of food ingredients, such as to achieve the higher protein content of snacks [11]. Sea cucumber has a high protein content, tortilla chips with the incorporation of indigenous protein or mineral supplements, have the potential to become a signature snack in corn-producing areas of Indonesia [12].

This study makes use of local resources like *Holothuria* sea cucumbers from Madura, known for their high protein content, with some species containing up to 79% protein, such as *H. leucospilata*. Traditionally used in cooking and medicine, these sea cucumbers are now being added to tortilla chips to improve their nutritional value while introducing a distinct savory, oceanic flavor. In addition, local Madurese corn, through the nixtamalization process, enhances the texture and nutrition of the final product. This approach not only boosts the health benefits of the tortillas but also supports sustainability by utilizing abundant local resources and helping the local economy through product diversification [13].

**Table 1.** Details of machines for tortilla chips production

No	Machines	Quantity	Capacity (kg/h)	Power (Watt)	Time (Hour)	Energy (kWh)
1	Sheeter machine	1	30	1500	1	4.2
2	Mixer	2	3	125	2.5	0.63
3	Oven (gas)	2	3	-	2.5	-
4	Grinder	1	75	2200	1.7	3.74
5	Weight balance	1	10	8	1.3	0.01
6	Sealer machine	1	300	500	3.6	1.8

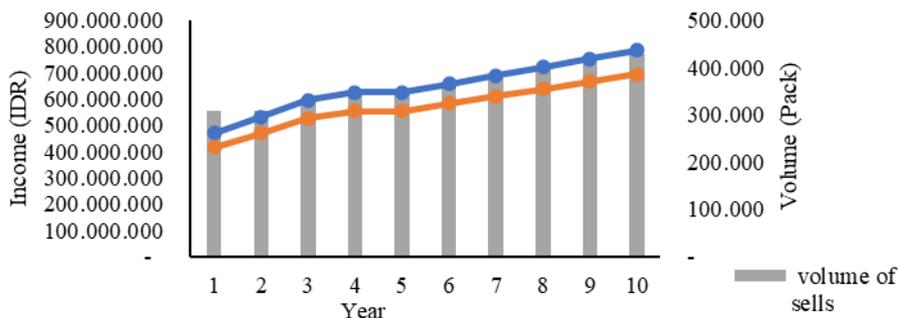
On Table 1 described the equipment necessary for manufacturing tortilla chips plays a vital role in facilitating the production process and ensuring product quality. An analysis of energy requirements is imperative for accurately estimating the usage of electricity and gas essential for production purposes, directly influencing incurred expenses related to energy consumption [14]. The indispensable equipment comprises a sheeter machine, weight balance, mixer, deep fryer, and gas oven, each serving specific functions such as flattening dough, precise ingredient measurement, thorough ingredient blending, frying for crispiness, and potential additional processing for oil removal or flavor enhancement. These equipment components collectively contribute to maintaining uniformity and quality throughout the

tortilla chip manufacturing process, thus meeting consumer expectations and industry standards.

In assessing the utility needs of the facility, we conduct computations to determine the electricity. The computation of the electricity demand entails aggregating the power requirements of individual pieces of equipment. Specifically, the electrical power demand for the plant is delineated to 138.86 kW per batch for primary operations, in addition to 54.2 kW per day allocated for office and ancillary facility operations. Given an operational schedule of 11 batches per day, the resulting daily energy consumption translates to a total cost of IDR 2,320,770 in Indonesian Rupiah.

### 3.2 Financial feasibility analysis

Financial projections, encompassing cash inflows, financing, and outflows, are essential for assessing a business's profitability, commonly referred to as profit and loss projection in academic contexts [15]. This projection signifies the variance between the net sales of products over a specific timeframe and the total costs incurred within the same period. It is assumed that all produced products (adjusted for production losses) are sold. The net profit, represented by earnings after tax (EAT), denotes the operational profit before tax (EBT), diminished by tax payments. The anticipated profit and loss are delineated through the EBT and EAT figures, as illustrated in Figure 2. Taxation is computed as a fixed 11.5% value-added tax (VAT) for a presumed tool lifespan of 10 years, commencing the year subsequent to the attainment of positive EBT values in cash flows. The projected total cash inflow for a decade with volume production amount 3,603,600 packs is estimated at IDR 21,498,048,000 while the total capital (comprising total production costs) amounts to IDR 15,046,633,000 resulting in a total EBT of IDR 6,451,415,000 and a cumulative net profit of IDR 5,709,502,275 will be realized over the course of 10 years.



**Fig. 2.** Predicted income and volume of annual sales

According to various studies, the global tortilla chips market was valued at USD 20.28 billion in 2018 and is expected to grow to USD 27.43 billion by 2025, at a CAGR of 4.41% [16]. Sustainable production practices, like using energy-efficient methods and sourcing local ingredients, play a key role in reducing environmental impact. In Indonesia, the snack food market is projected to reach USD 6.92 billion by 2024, driven by the rising demand for affordable, healthier options [17]. By focusing on sustainable raw materials and optimizing production, companies can meet consumer demands while also reducing their environmental footprint [16,18]. Additionally, these practices are aligned with the United Nations' Sustainable Development Goals (SDGs), contributing to food security and minimizing environmental strain [13].

Daily production is 11 batches and 24 days for a month produced 288 packs of tortilla chips in a year. The price offered (IDR 5,700) is around half the market price of tortillas, which is affordable and attracts consumers to consume tortillas with better nutritional content. Based on the table of Production Costs above, the total fixed and variable production cost is IDR 1,296,549,925. The composition of production costs in order of composition from the largest, namely production support materials (46%), raw materials (38%), labor (14%) and utilities (1.89%) (Table 2).

**Table 2.** Calculation for Business Analysis

<b>Production Capacity</b>	<b>Values</b>
Production per mount (packs per month)	26,400
Production per year (packs per year)	343,200
Batch number per year (batches per year)	288
Product selling price per pack (IDR per pack)	5,700
<b>Production costs per year</b>	<b>1,272,480,000</b>
Raw materials costs per year (IDR per year)	483,840,000
Production support materials per year (IDR per year)	584,640,000
Labor costs per year (IDR per year)	180,000,000
Utilities per year (IDR per year)	24,000,000
<b>Investment costs</b>	<b>67,265,000</b>
Machines (IDR)	19,925,000
Equipment (IDR)	37,340,000

Table 3 described the payback period for the sale of sea cucumber tortilla chips is determined to be 3.56 years. If the investment fulfills this criterion, it qualifies for acceptance. Furthermore, the calculated Net Present Value (NPV) exceeds zero, meeting the assessment criteria for investment acceptance when NPV is positive [19]. Subsequently, a positive discount factor of 18% is derived. Considering the Internal Rate of Return (IRR) (56.76%) surpasses the benchmark interest rate of 10%, the investment proposal is deemed acceptable. Consequently, based on the assessment of the four investment appraisal techniques, the financial analysis concludes that the project is financially viable, warranting acceptance. This signifies that business expansion initiatives aimed at enhancing production can proceed smoothly.

**Table 3.** Financial Criteria of feasibility analysis

<b>Feasibility Criteria</b>	<b>Values</b>
BEP	9,611
NPV	694,159,220
IRR	27.44%
Net B/C	1.43
Payback period	3.56

By utilizing local resources such as sea cucumbers and Madurese corn, the production process not only contributes to the local economy but also reduces environmental impact. This is achieved by minimizing the need for long-distance transportation and using renewable, locally sourced ingredients. Energy consumption is calculated to manage production costs, ensuring efficiency throughout the production process. These practices support the project's commitment to sustainability, aligning with global efforts to reduce environmental impact while ensuring long-term food security.

## 4 Conclusion

The essential equipment required for tortilla chip production plays a critical role in ensuring process efficiency and product quality, while energy requirements are carefully calculated to manage consumption expenses. Financial projections, including profit and loss estimates, show promising returns over a 10-year period, with positive Net Present Value (NPV) and Internal Rate of Return (IRR) indicating strong financial viability. The affordable pricing further enhances market appeal, ensuring consumer demand is met. Moreover, the determined payback period and positive financial metrics support the project's feasibility, enabling smooth expansion to enhance production and meet consumer demand. In addition to financial feasibility, the project promotes sustainability by utilizing local resources, such as sea cucumbers and Madurese corn, which reduce environmental impact by minimizing transportation emissions and using renewable, local ingredients. These efforts align with global sustainability goals, contributing to long-term environmental and economic sustainability.

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