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TECHNO-ECONOMIC ANALYSIS OF CHILI SAUCE PRODUCTION USING FERMENTED CASSAVA FLOUR

ANALISIS TEKNO-EKONOMI PRODUK OLAHAN SAUS CABAI BERBAHAN BAKU TEPUNG UBI KAYU FERMENTASI

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ABSTRAK

Penelitian ini menganalisis kelayakan produk olahan baru pada saus cabai dengan memanfaatkan bahan baku pangan lokal berupa tepung ubi kayu yang sudah di fermentasi. Tujuan untuk mengetahui kelayakan produk olahan saus cabai dengan bahan baku tepung ubi Kayu fermentasi berdasarkan aspek teknis/teknologi dan aspek ekonomi. Metode yang digunakan analisis tekno-ekonomi yaitu NPV, IRR, B/C Ratio, dan PP. Berdasarkan aspek teknologi, yaitu analisis organoleptik, kadar air rata-rata 72% dan pH rata-rata 4,01. Kualitas saus cabai berbahan baku tepung ubi kayu fermentasi sangat baik dan layak di kembangkan. Aspek finansial menunjukkan nilai NPV adalah Rp. 40.138.730 IRR sebesar 34,53% nilai B/C Ratio 2,25%, PP 2 tahun 1 bulan. Hasil analisis tekno ekonomi produk saus cabai berbahan baku tepung ubi kayu fermentasi layak di kembangkan serta memiliki potensi besar untuk meningkatkan nilai tambah, membuka peluang usaha baru, dan mendukung ketahanan pangan berbasis bahan lokal berkelanjutan di masyarakat.

Kata kunci: Saus Cabai, Tekno-ekonom, Ubi Kayu

ABSTRACT

This study performs a techno-economic analysis to assess the feasibility of developing chili sauce products incorporating fermented cassava flour as a local food ingredient. The evaluation covers both technical/technological and economic aspects. Technologically, the product exhibits favorable characteristics with a mean moisture content of 72% and pH of 4.01, supported by positive organoleptic test results. Economically, financial analysis indicates strong viability, with a Net Present Value (NPV) of IDR 40,138,730 an Internal Rate of Return (IRR) of 34.53%, a Benefit-Cost (B/C) Ratio of 2.25, and a Payback Period (PP) of 2 years and 1 months. The integrated findings from both technical and economic evaluations confirm that chili sauce formulated with fermented cassava flour is technically sound and economically feasible for commercial development. This product has significant potential to enhance added value, create new business opportunities, and support sustainable local food security.

keywords: chili sauce, techno-economic, cassava

INTRODUCTION

Chili sauce is a very popular spicy food ingredient in the world, including in Indonesia, with a spicy taste that can stimulate and increase appetite (Anggraini *et al*., 2023). The spicy sensation in chilies is caused by the compound capsaicin (Mansyur *et al*., 2021). Chilies, as a good source of vitamin C, contain large amounts of antioxidants such as vitamin A; group B vitamin complexes such as niacin, pyridoxine (vitamin B6), riboflavin, and thiamin (vitamin B1); flavonoids such as α-carotene, β-carotene, lutein, zeaxanthin, and cryptoxanthin; and high bioactive compounds such as capsaicinoids, phenols, and flavonoids (Chakrabarty *et al*., 2017; Liu *et al*., 2024; Kusnadi *et al*., 2019). Processing cassava through the fermentation process is one of the efforts to increase the protein content in cassava. Fermented cassava flour has the advantage of higher protein content than ordinary cassava flour (Bolaji *et al*., 2021; Kusumaningrum, 2016). Fermented cassava can increase protein with an increase ($P<0.05$) in protein (21.02%). Fe (52.69%). Zn (69.46%). ascorbate (125.71%) and protein digestibility (62.42%) (Anyiam *et al*. 2023). Previous research, the development of a chili sauce formula by adding fermented cassava flour so that it has 76.66% moisture content, 5.47% ash, 0.48% fiber, 19233.33 cp viscosity, and 21.20% total soluble solids Brixabu 5.47% protein, 0.48% fiber, 19233.33 cp viscosity, and 21.20% total soluble solids Brix. Product shelf life is very important in the processing of chili sauce products because a good shelf life greatly affects the quality and economic value of the product. Chili sauce with fermented cassava as a raw material has the potential to be developed in Southeast Sulawesi

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because raw materials are very available. The area of cayenne pepper land is 1.266 ha, and the area of cassava land is 2,044 ha (BPS Sultra, 2022). The chili sauce can be used by MSME businesses in restaurants and households in Southeast Sulawesi. The selection of techno-economic analysis by combining technical/technological aspects and economic aspects, because techno-economic analysis is a method to justify the feasibility of the shelf life of chili sauce products made from fermented cassava flour from a technical/technological aspect and marketing and financial feasibility from an economic aspect (Sucipto *et al*., 2020). Furthermore, a techno-economic analysis is essential to determine production process efficiency, cost-benefit ratios, and potential for industrial-scale development. From a technical standpoint, this analysis encompasses the quality assessment of raw materials, the evaluation of the product's physical and chemical characteristics, and its stability during storage. Economically, it entails a thorough examination of production costs, profit potential, and market prospects to ascertain the long-term viability of the chili sauce venture. Through this integrated techno-economic approach, the development of fermented cassava flour-based chili sauce can be transformed into a highly competitive local food innovation. Such a product is anticipated to offer enhanced nutritional value and contribute to regional food self-sufficiency. This initiative aligns with community empowerment objectives in Southeast Sulawesi and supports national programs aimed at increasing the added value of agricultural products through appropriate technology and sustainable innovation. Consequently, this research is positioned to make a substantive contribution to local economic development while reinforcing food security through the valorization of regional resources.

RESEARCH METHODS

This research will analyze the feasibility of processed chili sauce products with the addition of fermented cassava flour based on techno-economy. To analyze the shelf life of processed chili sauce products, it was carried out at the Food Science and Technology Laboratory, Halu Oleo University, Southeast Sulawesi. The research flowchart can be seen in Figure 1.

Data Analysis

This study examines three key aspects: technical/technological, marketing, and financial. The technical aspect, managed by Member 1, focuses on product shelf-life and ensuring adherence to the research schedule. The marketing aspect assesses market feasibility and opportunities, while the financial aspect evaluates the project's economic viability.

Technical Aspect: Shelf-Life Determination of Chili Sauce

The technical aspect of this research aims to determine the shelf life of chili sauce products packaged in plastic. The study will be conducted in three stages: (1) production of fermented cassava flour, (2) formulation of chili sauce with substituted fermented cassava flour, and (3) shelf-life estimation. Shelf life was estimated using the Accelerated Shelf-Life Testing (ASLT) method. The samples were stored at three different temperatures (30°C, 40°C, and 50°C) for 25 days. Quality parameters were analyzed at 5-day intervals. The evaluated parameters included viscosity, moisture content, pH, total mold and bacterial count, and organoleptic properties (Asnani *et al*., 2022; Adelina *et al*., 2024; Affandi *et al*., 2020; Setiarto, 2018; Muflihati and Amalia, 2022).

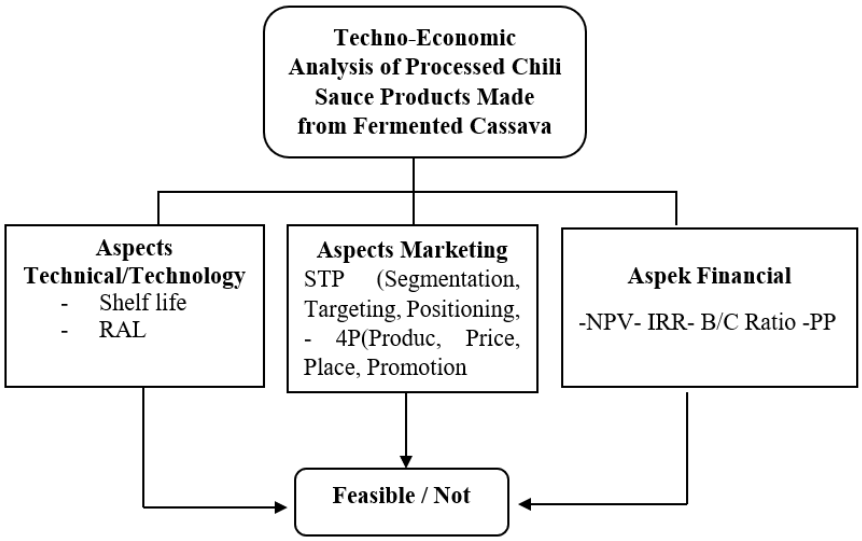

Figure 1. Flowchart of research techno-economic analysis of processed chili sauce products made from fermented cassava flour

Marketing Analysis

To assess market feasibility and opportunities, this study adopted a two-stage analytical framework. First, the STP (Segmentation, Targeting, Positioning) model was applied to segment the potential market, select the target consumer base, and establish a distinct product positioning (Kasmir and Jakfar, 2012; Santoso *et al*., 2023). Subsequently, the marketing mix (4Ps)—encompassing Product, Price, Place, and Promotion—was formulated to design a strategic market entry plan based on the STP findings (Fitriani *et al*., 2021; Niu *et al*., 2020).

Financial Aspect

The financial feasibility of the project will be evaluated based on key investment criteria (Table 1), including the Net Present Value (NPV), Internal Rate of Return (IRR), Benefit-Cost Ratio (B/C Ratio), Payback Period (PP), and Profitability Index (PI) (Kasmir and Jakfar, 2012; Rahim *et al*., 2020).

RESULTS AND DISCUSSION

Technical/Technological Aspect

The technical analysis aims to establish an optimal production scale and select appropriate processes and equipment to ensure the technology is both effective and fully utilized. Specifically for this study, the technological aspect focuses on evaluating the feasibility of the fermented cassava flour processing method for chili sauce production.

Production Process of Chili Sauce with Fermented Cassava Flour

The production of chili sauce incorporating fermented cassava flour comprises several sequential stages, from raw material preparation to final packaging. The general procedure is outlined below:

1) Raw Material Preparation
   Fermented cassava flour, characterized by its high carbohydrate content, serves as the base ingredient. This flour is typically derived from cassava that has undergone a fermentation process, which enhances its distinctive flavor and nutritional profile. Fresh chilies, selected based on the desired spiciness level, function as the primary ingredient. Supplementary ingredients, including garlic, sugar, salt, and vinegar, are also prepared. Vinegar is added to impart a sour taste and act as a natural preservative.
2) Fermented Cassava Flour Preparation
   Cassava undergoes a fermentation process by soaking for 72 hours. This step facilitates the bioconversion of carbohydrates into lactic acid and other metabolites, improving the flour's functional properties and developing a characteristic umami and slightly sour flavor profile suitable for sauce applications.
3) Chili Processing
   Fresh chilies are thoroughly washed and subsequently ground into a paste or fine powder. The comminuted chilies are then heated to develop their pungency and eliminate undesirable volatile compounds
4) Cooking and Homogenization
   All ingredients are mixed and heated for approximately 45 minutes until fully incorporated and a characteristic aroma develops. This thermal processing also serves to eliminate pathogenic microorganisms and extend product shelf life. During this stage, any sediment or separated oil is removed through filtration to achieve a smooth, uniform consistency.
5) Filtration and Packaging
   The cooked sauce is filtered to remove residual solids such as chili skins or other coarse particles. The refined product is aseptically packaged in sterile containers under hygienic conditions to prevent contamination and maintain product quality. The incorporation of fermented cassava flour yields a chili sauce with enhanced viscosity, unique flavor characteristics, and potentially improved nutritional value due to the presence of fermentation-derived compoundincluding probiotics and lactic acid. The detailed production flowchart is presented in Figure 2.

Hedonic Evaluation

A hedonic test was conducted to assess consumer preference for the prepared chili sauce formulations. The evaluation employed a 5-point hedonic scale, where higher scores indicate greater acceptability of the product's sensory characteristics. The mean preference scores for chili sauce with fermented cassava flour supplementation are presented in Table 2. Kruskal-Wallis test results revealed that the incorporation of fermented cassava flour significantly influenced color and texture preference ($p < 0.05$).

Color

The mean hedonic scores for color ranged from 3.40 (somewhat like) to 5.00 (like). The highest preference was observed in the sauce with a 4% flour concentration. However, a further increase to 5% resulted in a significant decrease in color acceptability (Table 2). This decline is likely attributable to the dilution of the sauce's characteristic red hue at higher flour concentrations, making it less visually appealing.

Aroma

Aroma acceptability scores ranged from 3.00 (like) to 4.60 (very like). As shown in Table 2, panelists' preference for the aroma increased with higher concentrations of fermented cassava flour, peaking at 5%. The highest score at the 5% concentration suggests that this formulation imparted a more favorable aromatic profile, potentially derived from the fermentation metabolites in the cassava flour.

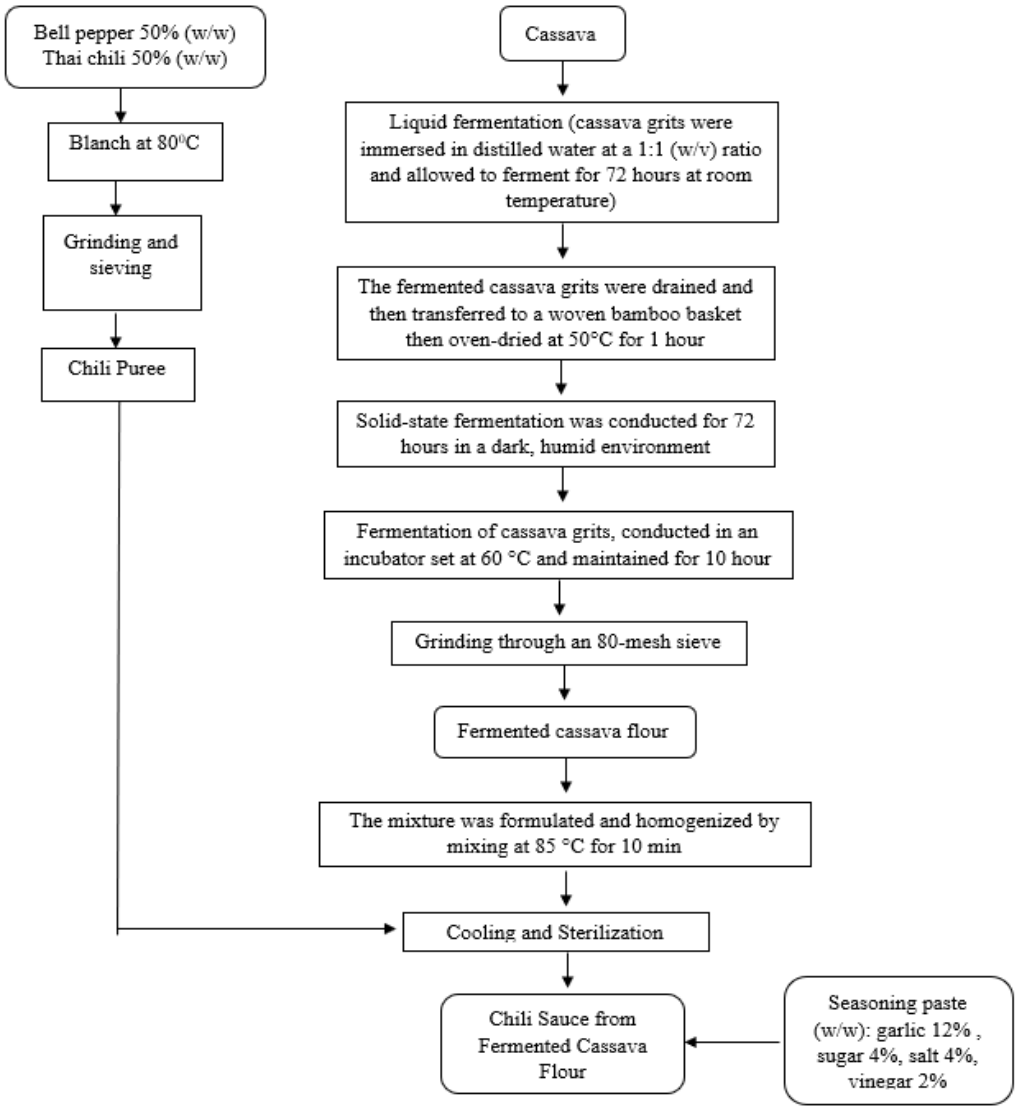

Figure 2. Process flow of making chili sauce made from fermented cassava flour

Table 2. Mean value of chili sauce hedonic test mean hedonic scores of the chili sauce formulations

Parameters	**Mean Hedonic Scores of the Chili Sauce Formulations Mean Value of Hedonic Test for Chili Sauce**				
	M0	**M1**	**M2**	**M3**	**M4**
Colour	4.60 ±0.55abc	5.00 ± 0.00a	5.00 ± 0.00a	4.40 ±0.55bc	3.40±1.14c
Aroma	4.60 ±0.55a	4.20 ±0.84a	4.40 ±0.55a	4.20 ±0.45a	3.00±0.00b
Flavour	4.20 ±0.45a	4.20 ±0.45a	4.00 ±0.00a	3.80 ±0.45a	2.60±0.55b
Texture	5.00±0.00ab	4.40 ±0.55bcd	4.60 ±0.55bd	4.20 ±0.45d	2.80 ±1.30c

Data source: Primary 2025

The Kruskal-Wallis test revealed significant differences ($p < 0.05$) in the sensory attributes—color, texture, aroma, and taste—of chili sauce with varying concentrations of fermented cassava flour.

Taste

The taste acceptability scores ranged from 2.60 (like) to 4.20 (very like). Preference for the taste increased progressively with the concentration of fermented cassava flour, reaching an optimum at 4% (Table 2). This indicates that a 4% addition optimally enhances the umami or other desirable flavor notes without introducing off-flavors.

Texture

Hedonic scores for texture spanned from 2.80 (dislike) to 5.00 (like). The most preferred texture was achieved at a 4% flour concentration. The significant drop in acceptability at 5% (Table 2) suggests that this higher concentration resulted in a sauce that was perceived as overly thick or pasty, negatively impacting its sensory appeal. A desirable chili sauce

texture is characteristically viscous yet pourable, ensuring even distribution. The study determined that a 4% concentration of fermented cassava flour yielded an optimal sensory profile, producing the most preferred color, aroma, taste, and texture among panelists. These findings indicate that incorporating fermented cassava flour at an optimal level significantly enhances the product's overall sensory quality and consumer acceptability.

Moisture Content and pH Analysis

Moisture content is a critical parameter in food products, significantly influencing their stability, shelf life, and sensory attributes (taste, color, and aroma) (Rahman, 2009). Similarly, pH indicates the acidity or alkalinity of a solution. A lower pH value corresponds to a higher acid concentration, which can inhibit microbial growth, whereas a higher pH indicates lower acidity. The measured values of moisture content and pH for the chili sauce samples across all treatments, analyzed on a weekly basis, are presented in Table 3.

The moisture content and pH of the chili sauce formulations are presented in Table 3. Moisture content varied significantly across treatments ($p = 0.04$), with the highest value (74.90%) observed in the M4 treatment and the lowest (70.35%) in the M0 treatment. All samples exhibited moisture contents below the maximum limit of 83% stipulated by the SNI 01-2976-2006 standard, with an overall mean of 72%. The average pH across all treatments was 4.01, which falls within the acceptable range ($pH \leq 4.0$) mandated by the same standard.

The significant effect ($p < 0.05$) of fermented cassava flour addition on moisture content is attributed to the high-temperature cooking process (800°C - 1000°C), which drives off water and causes the sauce to thicken. Consequently, the inverse relationship between flour concentration and moisture content suggests that lower moisture levels, as seen in the M0 treatment, could potentially contribute to a longer product shelf life.

The observed pH (mean 4.01) confirms the acidic nature of the product, a key factor for microbial stability. All formulations complied with the SNI quality requirement ($pH \leq 4.0$). The slight variations around the mean (4.00 - 4.02) are not statistically significant, indicating that the addition of fermented cassava flour did not substantially alter the product's acidity under the conditions of this study. As supported by Jannah (2018), the stability of this pH level is crucial, as any significant increase in moisture during storage could potentially solubilize acidic compounds and lead to a further decrease in pH. Therefore, the application of fermented cassava flour as a thickening agent not only determines the textural and viscous properties but also influences critical parameters such as water activity and pH stability, thereby enhancing the overall quality and extending the shelf life of the chili sauce.

Market Analysis and Strategy

A viable business strategy requires a clearly defined and potential market for product introduction and distribution (Kasmir and Jakfar, 2012; Udayana *et al*., 2022). The market for chili sauce in Kolaka Regency, Southeast Sulawesi, was analyzed using the STP (Segmentation, Targeting, Positioning) framework.

Segmentation and Targeting

The consumer market was segmented based on geographical and behavioral factors. The primary target market comprises the residents of Kolaka Regency and the broader Southeast Sulawesi province, a region with a demonstrated high consumption frequency of chili sauce, indicating a strong product-market fit. This product holds significant market potential due to its complementary nature with popular food items. The primary consumer base encompasses households, restaurants, food stalls, and large-scale culinary industries. Effective market segmentation can be further pursued based on demographic and psychographic variables, including age, lifestyle, and income level. A profound understanding of these segment characteristics enables producers to formulate differentiated marketing strategies. These may include tailored packaging, unique flavor profiles, and tiered pricing structures aligned with the respective purchasing power of each target group.

Positioning and Opportunity

The product is positioned as a novel food item leveraging local ingredients (fermented cassava flour), differentiating it from conventional sauces. The high affinity for chili sauce consumption within the local population presents a significant market opportunity (Karamoy, 2013; Majid, 2014). Chili sauce holds significant market potential due to its status as a daily-consumed food condiment. The primary target markets encompass households, food vendors, and the local culinary industry.

Table 3. Mean values of water content and pH test of chili sauce

Parameters	Mean values of water content and pH test of chili sauce				
	M0	M1	M2	M3	M4
Water content (%bk)	70.35 ±0.11ab	70.49 ± 0.03bc	71.59 ± 0.04c	72.88 ±0.02d	74.90±0.20a
pH	4.02 ±0.09a	4.02 ±0.04a	4.01 ±0.00a	4.01 ±0,00a	4.00±0.00a

Data source: Primary 2025

Pricing Strategy

Pricing is a critical determinant of commercial success, directly influencing sales volume and profitability (Swastha, 2006). The selling price was established at IDR 6.000 per bottle, determined through a cost-plus pricing model based on the calculated Cost of Goods Sold (COGS) to ensure business sustainability and optimal net profit (Setiadi *et al*., 2014). The cost structure encompasses primary and secondary raw materials, labor, energy, packaging, and distribution. In determining the selling price, producers must balance the purchasing power of consumers in Kolaka Regency with targeted profit margins to ensure affordability. A competitive pricing strategy is crucial for market penetration and rivalry against both local and national brands. Furthermore, integrating value-added features—such as the use of natural ingredients (fermented cassava flour), unique flavor profiles, and attractive packaging—serves as a key product differentiator, thereby supporting a value-based pricing approach.

Pricing strategy incorporates considerations for potential market expansion, including penetration into the food stall, household, and retail store segments. A price point of IDR.6,000, coupled with a proportional profit margin, is strategically set to balance product quality with market accessibility. Furthermore, promotional tactics—such as volume-based discounts and partnerships with culinary enterprises—can be leveraged to enhance sales performance and fortify the product's position within local and regional markets.

Capital Investment and Assumptions

The initial capital requirement for fixed assets and working capital is IDR 10.000.000. The financial projection is based on the following key assumptions:

1. The project's economic life is estimated at 5 years.
2. A loan interest rate of 7% per annum is applied, based on BRI's Micro Business Credit (KUR) terms for a 5-year tenure (PT. BRI Persero, 2024).
3. The income tax rate is 0.5%, in accordance with Article 2 of Law No. 23 of 2018 for businesses with an annual taxable income below IDR 4,800.000.000.

Revenue Projection

Revenue refers to the total income generated from sales before the deduction of investment costs (Kasmir and Jakfar, 2012). The projected revenue for the chili sauce business, based on target sales volumes, is detailed in Table 4, The consistent month-on-month sales growth demonstrates substantial market demand for the chili sauce produced from fermented cassava flour. This upward revenue trend is attributed to strategic marketing initiatives, consistent product quality, and strong consumer loyalty driven by the product's unique taste profile.

Cash Flow Projection

A projected cash flow statement was constructed, detailing operational inflows, investment outflows, and financing activities based on the methodology of Kasmir and Jakfar (2012). The comprehensive cash flow projection for the chili sauce business is shown in Table 5, The cash flow statement, which details cash inflows and outflows over a specific period, serves as a key indicator of a business's financial management efficacy. A consistent positive cash flow, signifying that operational income surpasses expenditures, enables business owners to fund investments, expand production capacity, and ensure the long-term sustainability of the chili sauce enterprise.

Table 4. Chili Sauce Business Income.

Sales	Year 1 (IDR)	Year 2 (IDR)	Year 3 (IDR)	Year 4 (IDR)	Year 5 (IDR)
Selling chili sauce	10.671.150	21.068.010	28.263.870	32.858.610	40.245.450

Data source: Primary 2025

Table 5. Cash flow of chili sauce business

Description	Year1 (IDR)	Year 2 (IDR)	Year 3 (IDR)	Year 4 (IDR)	Year 5 (IDR)
Revenue	45.064.750	50.267.130	60.607.860	65.356.830	80.464.730
Expenses/costs	35.642.100	36.758.000	36.874.000	38.000.000	40.176.000
Net profit Before interest (EBT)					
Bank interest 3%	9.422.650	13.509.130	23.733.860	27.356.830	40.288.730
	150.000	150.000	150.000	150.000	150.000
Net Profit	9.272.650	13.359.130	23.583.860	27.206.830	40.138.730

Data source: Primary 2025

Table 6. Financial feasibility of chili sauce business

No	Criteria	Unit	Criteria Feasible	Results	Conclusion
1.	NPV	IDR	>1	40.138.730	Feasible
2.	IRR	Percent (%)	>DF	34.53	Feasible
3.	B/C Ratio	Percent (%)	>1	2.25	Feasible
4.	PP	Year	< Year	2.1	Feasible

Data source: Primary 2025

Financial Feasibility Analysis

The financial viability of the chili sauce business was evaluated using standard capital budgeting metrics, including Net Present Value (NPV), Internal Rate of Return (IRR), Benefit-Cost Ratio (B/C Ratio), and Payback Period (PP) (Kasmir and Jakfar, 2012). The results of this analysis are summarized in Table 6.

1. Net Present Value (NPV)
   The calculated NPV is IDR 40,138,730. As this value is positive (NPV > 0), the proposed business is considered financially feasible and is expected to generate value beyond the cost of capital.
2. Internal Rate Return (IRR)
   The IRR was determined to be 34.53%. This return significantly exceeds the prevailing interest rate of 7% (used as the discount rate), further confirming the project's financial attractiveness.
3. Benefit Cost Ratio (B/C Ratio)
4. The B/C Ratio of 2.25 indicates that for every unit of currency invested, the project returns 2.25 units in present value terms. Since this ratio is greater than 1.0, the business is deemed economically viable.

The analysis shows a Payback Period of 2 years and 1 month. As this duration is substantially shorter than the projected 5-year economic life of the project, the investment carries a low risk of capital loss and is considered acceptable.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

This study demonstrates the comprehensive feasibility of developing chili sauce utilizing fermented cassava flour. From a technical and technological standpoint, the product formulation proved viable. The incorporation of fermented cassava flour significantly influenced key sensory attributes ($p < 0.05$ for taste, aroma, color, and texture), while the physicochemical properties, including a moisture content of 70.90% and a pH range of 4.00–4.02, were within acceptable standards for product quality and stability. From a commercial perspective, the marketing analysis indicates a strong market potential and a high likelihood of acceptance, particularly within the Kolaka Regency. Financially, the venture is highly viable. The capital budgeting analysis over a 5-year projection yielded a positive Net Present Value (NPV) of IDR 40,138,730, an Internal Rate of Return (IRR) of 34.53% exceeding the discount factor, a Benefit-Cost Ratio (B/C) of 2.25, and a Payback Period (PP) of 2 years and 1 month, which is less than the project's economic life. All financial indicators confirm that the business is feasible to implement. Leveraging appropriate technology, local raw material availability, and effective marketing strategies, the fermented chili sauce venture possesses significant potential to emerge as a leading regional product and enhance local economic development.

Recommendations

The abundant availability of chili and cassava in Kolaka Regency offers a compelling opportunity to establish a commercially viable chili sauce business utilizing fermented cassava flour, leveraging local resources for economic development.

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