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Cost Analysis and Economic Evaluation for the Fabrication of Hard Candy with the Addition of Black Cumin Seed Extract and Honey

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ABSTRACT

This study evaluated the economic feasibility of fabricating functional hard candy made with black cumin extract and honey. We compiled investment, operating, and sales data, then applied standard financial criteria, including gross profit margin, internal rate of return, break-even analysis, payback period, and present value. A theoretical production line and formulation were specified, and costs were estimated from market prices and equipment lists. Findings indicated that the process was technically feasible and financially promising under baseline assumptions. Profitability remained sensitive to ingredient prices and capacity, because raw materials, especially honey and black cumin, dominate total costs. The evaluation also considered labor, utilities, and overhead to capture manufacturing conditions. The results support commercialization when pricing and procurement strategies prioritize stable supply and efficiency. This work contributes a structured techno-economic framework for functional confectionery and demonstrates that locally sourced ingredients can underpin viable products with nutritional appeal and potential public health value.

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1. INTRODUCTION

Candy is a widely accepted food product enjoyed across all age groups [1]. In Indonesia, the daily consumption of hard candy is estimated at 8 grams per person. Hard candy is a solid confectionery product typically made from a combination of sucrose, glucose syrup, and permitted additives. It has a shiny appearance and a firm texture that does not soften during consumption. Recent developments in the food industry have introduced functional candy products containing bioactive compounds, including those derived from spices. Among these, Nigella sativa (black cumin or habbatussauda) has gained attention for its potential health benefits due to its rich composition of carbohydrates, fats, proteins, vitamins, minerals, and essential oils (particularly thymoquinone) [4]. However, the characteristic bitter and spicy taste of Nigella sativa [see https://hellosehat.com/hidup-sehat/fakta-unik/manfaat-habbatussauda-untuk-kesehatan/] necessitates the addition of sweeteners to enhance its acceptability.

Honey, a natural sweetener composed of fructose, glucose, sucrose, and other oligosaccharides, is also rich in vitamins and minerals [2,3]. It is traditionally used to treat digestive and respiratory infections and to improve general health [4 and see https://perkebunan.sariagri.id/57468/enam-pemanis-alami-ini-bisa-digunakan-sebagai-pengganti-gula]. Combining black cumin and honey provides a dual-function formulation that is not only palatable but also nutritionally advantageous. While previous studies have explored the antioxidant and therapeutic properties of Nigella sativa and honey in food applications [5-9], industrial-scale production remains limited, particularly due to the absence of comprehensive techno-economic feasibility assessments. The challenges in scaling up production and addressing cost-related constraints highlight a significant gap between laboratory research and commercial viability [10,11].

This study addresses that gap by evaluating the technical and financial feasibility of producing functional hard candy enriched with Nigella sativa extract and honey. The novelty of this research lies in integrating a dual-functional ingredient formulation with a detailed economic viability analysis. Unlike prior works that focused solely on sensory or chemical evaluations, this study bridges the gap between product development and commercialization through a structured financial modeling approach. The goal is to provide a feasible framework for producing functional confectionery products based on locally sourced, health-promoting ingredients.

2. METHODS

This study employed a techno-economic analysis (TEA) approach to evaluate the financial feasibility of fabricating functional hard candy enriched with Nigella sativa extract and honey. Detailed information regarding this method is explained elsewhere [12,13]. Data for this analysis were gathered from current market prices of commercially available ingredients, obtained through reputable online shopping platforms. These data provided the basis for estimating raw material requirements, production costs, and capital investment.

The production process began with the theoretical formulation of hard candy, followed by cost calculations using simple mathematical modeling. Investment components included fixed capital costs (such as equipment purchase, installation, building, and utilities), as well as working capital for operational readiness. The main production equipment comprised an electric syrup cooker, batch roller, hard candy forming machine, and packaging system.

To ensure a comprehensive financial assessment, several economic indicators were calculated: Payback Period (PBP), Return on Investment (ROI), Gross Profit Margin (GPM), Break-Even Point (BEP), and Cumulative Net Present Value (CNPV). A project lifespan of 20 years was assumed for the simulation, during which fixed and variable costs were analyzed, including depreciation, labor, maintenance, and utilities.

Figure 1 shows the overall production process flow, including seventeen sequential steps: beginning with warm water extraction of black cumin powder, filtration, and ending with molding, cooling, and packaging of the hard candy. The extract was incorporated alongside honey in the cooking stage to ensure the preservation of bioactive compounds.

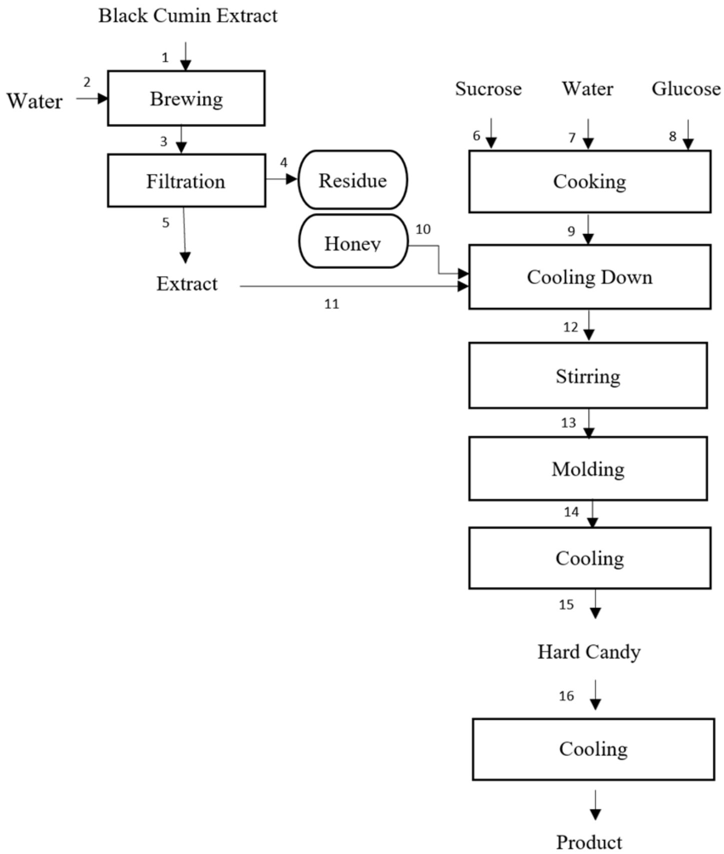

Figure 1. Production of hard candy from black cumin seed extract and honey.

To evaluate business resilience, sensitivity analyses were also conducted. These assessed how fluctuations in raw material prices, production capacity, and external economic variables (such as taxes and discount rates) could affect profitability. This methodological approach ensures a holistic evaluation of technical operations and financial outcomes, supporting the development of a sustainable and scalable functional candy product.

3. RESULTS AND DISCUSSION

3.1. Cost Structure of Raw Materials

The economic evaluation begins with an analysis of raw material costs, which play a critical role in determining the financial feasibility of functional hard candy production. As shown in **Table 1**, the ingredients used include black cumin, honey, sucrose, glucose syrup, and water. While sucrose, glucose, and water are low in price and widely available, *Nigella sativa* extract and honey constitute a significant portion of the total raw material cost.

The high cost of *Nigella sativa* extract is primarily due to its status as a premium herbal component and the complex extraction process involved. Though used in small quantities, its price per kilogram elevates the overall material expenditure. Honey, another major

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contributor, has a high market price, especially when purity and quality suitable for functional foods are ensured. These two ingredients collectively dominate the raw material cost structure, with honey alone contributing up to 38.1% of the daily production cost.

Table 1. Raw Material

No	Raw Material	Requirement (kg/h)	Price (Rp)	Total (Rp)
1	Black Cumin	2	75,000	150,000
2	Honey	30	80,000	2,400,000
3	Sucrose	140	12,500	1,750,000
4	Glucose	60	25,000	1,500,000
5	Water	100 liters	5,000	500,000
	Daily Cost			6,300,000
	Annual Cost			1,890,000,000

The composition of inputs remains consistent across production scales, demonstrating a linear formulation model. This consistency simplifies scaling but also increases vulnerability to market price volatility, particularly for dominant inputs. Effective supply chain management, including price negotiation, source diversification, and usage optimization, is essential to enhance cost-efficiency without compromising quality.

3.2. Equipment Investment and Cost Allocation

The next component in the cost structure involves production equipment. **Table 2** lists the necessary machinery for small-scale production. These include an electric syrup cooker, cooling table, batch roller and rope sizer, hard candy forming machine, cooling sifter, and an automatic pillow-type packing machine. The total cost of equipment is Rp30,013,800, with the hard candy forming machine being the most expensive single item, accounting for 26.6% of the equipment investment.

Table 2. Equipment Calculation.

No	Equipment	Unit Price (Rp)	Quantity	Total Price (Rp)
1	Electric syrup cooker	5,000,000	1	5,000,000
2	Cooling table	2,000,000	1	2,000,000
3	Batch roller and rope sizer	5,000,000	1	5,000,000
4	Hard candy forming machine	8,000,000	1	8,000,000
5	Cooling sifter	6,000,000	1	6,000,000
6	Automatic pillow-type packer	4,013,800	1	4,013,800
	Total			30,013,800

This distribution indicates that forming and cooling stages are the most equipment-intensive, requiring both technical precision and material robustness. Though the syrup cooker is critical in the early phase, its cost is relatively modest, suggesting lower complexity in the heating process. The high cost of the packing machine, while necessary for precision and hygiene, also necessitates ongoing maintenance planning to protect the investment.

3.3. Utility Consumption and Energy Efficiency

Energy consumption is another variable cost component assessed in this study. As presented in **Table 3**, the electric syrup cooker consumes the most power, representing 61.4% of total annual utility expenses. This is followed by the cooling table and forming machine. Despite their importance, supporting tools like the cooling sifter and packing machine show relatively low energy use, which is beneficial for overall energy efficiency.

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Table 3. Utilities.

No	Equipment	Power (kW)	Usage (h/day)	Price/kWh (Rp)	Daily Cost (Rp)	Annual Cost (Rp)
1	Electric syrup cooker	0.16	8	5,000	6,400	1,920,000
2	Cooling table	0.05	8	5,000	2,000	600,000
3	Batch roller and rope sizer	0.012	8	5,000	480	144,000
4	Hard candy forming machine	0.03	8	5,000	1,280	384,000
5	Cooling sifter	0.006	8	5,000	240	40,000
6	Automatic pillow-type packer	0.028	8	5,000	1,120	40,000
	Total					3,128,000

The data reveal a need for verifying certain entries, such as the identical utility costs assigned to devices with different power ratings and usages. Nonetheless, the overall trend suggests prioritizing efficiency improvements in the most energy-consuming stages to reduce overhead.

3.4. Fixed Capital Investment (FCI) and Structure

A complete breakdown of fixed capital investment is shown in **Table 4**. The total FCI amounts to Rp179,860,548.60, with the bulk (79.5%) classified as direct costs. These include equipment purchase, transportation, installation, utilities, building, and environmental considerations. Indirect costs such as contractor fees and contingencies are relatively minor.

This structure reflects a capital-intensive industry where investment in physical infrastructure is a prerequisite for scaling production. Effective financial planning is needed to manage startup burdens and maintain long-term operational stability.

Table 4. Fixed Capital Investment.

No	Component Direct Cost	Factor	Cost (Rp)
1	Equipment	1	33,141,800
2	Transportation	0.1	3,314,180
3	Insurance	0.007	231,993
4	Delivery	0.05	1,657,090
5	Installation	0.55	18,227,990
6	Instrumentation	0.3	9,942,540
7	Piping	0.5	16,570,900
8	Electrical	0.5	16,570,900
9	Utilities	0.4	13,256,720
10	Building	0.7	23,199,260
11	Insulation	0.06	1,988,508
12	Fireproofing & Safety	0.05	1,657,090
13	Yard Improvement	0.08	2,651,344
14	Environmental	0.7	23,199,260
15	Land	0.08	2,651,344
	Subtotal (Direct Cost)		168,260,919
	Indirect Cost		
16	Technicians & Supervision	0.1	3,314,180
17	Contractor Fees	0.15	4,971,270
18	Contingency	0.1	3,314,180

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Table 4 (continue). Fixed Capital Investment.

No	Component Direct Cost	Factor	Cost (Rp)
	Subtotal (Indirect Cost)		11,599,630
	Startup & Working Capital		
19	Off-site Facilities	0.2	6,628,360
20	Plant Startup	0.07	2,319,926
21	Working Capital Investment (WCI)	0.2	31,740,097
	Total Capital Investment (TCI)		211,600,645.41

3.5. Total Manufacturing Cost and Operational Structure

The comprehensive cost structure for manufacturing the functional hard candy is detailed in **Table 5**, which summarizes both variable and fixed costs. The raw material cost, totaling Rp1,890,000,000 per year, is the most dominant component, accounting for approximately 78% of the Total Product Cost (TPC). This reinforces earlier observations regarding the cost burden of black cumin extract and honey.

Operational labor costs are estimated at Rp102,000,000 per year, with associated labor-related overheads including payroll (30%), maintenance (6%), and plant overhead (100% of labor costs). Sales-related expenses such as packaging, marketing, administration, and R&D collectively account for a small percentage of projected revenue but must still be managed efficiently to protect profitability.

This data illustrates the concentration of costs in materials and labor, suggesting that profit margins are highly susceptible to increases in ingredient prices or wage inflation. Depreciation and tax-related costs form smaller portions but still require financial allocation for sustainability.

Table 5. Total Manufacturing Cost.

No	Item	Cost (Rp)
1	Raw Materials	1,890,000,000
2	Utilities	3,128,000
3	Operating Labor	102,000,000
4	Payroll Overhead (30%)	30,600,000
5	Maintenance (6%)	6,120,000
6	Operating Supplies (15%)	918,000
7	Environmental (15%)	4,502,070
8	Depreciation (10%)	17,986,055
9	Local Taxes & Insurance	7,194,422
10	Plant Overhead	102,000,000
11	Packaging (1% of sales)	25,920,000
12	Administration (2%)	51,840,000
13	Distribution & Marketing	51,840,000
14	Research and Development	25,920,000
15	Patents and Royalties	25,920,000
	Total Product Cost	**2,423,749,095.40**

3.6. Sales Performance and Revenue Projection

The sales structure and expected revenue are outlined in **Table 6**. The product is priced at Rp180 per unit, while the estimated minimum viable price is Rp168.32 per unit. This slight margin allows for modest profit generation. With a production capacity of 14.4 million pieces

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per year, the projected revenue reaches Rp2,592,000,000 annually. Packaging is arranged in units of 10 candies per pack, enhancing perceived value while simplifying distribution.

Although the profit margin is narrow, the business model is scalable. Market factors such as demand elasticity, consumer perception, and competitor pricing must be continually monitored to ensure the price point remains viable and appealing.

Table 6. Sales breakdown details.

Parameter	Value
Minimum Selling Price	Rp168.32/piece
Selling Price Set	Rp180/piece
Packaged Price (10 pcs/pack)	Rp1,800
Daily Production Capacity	300,000 pieces
Annual Production Capacity	14,400,000 pieces
Annual Revenue	Rp2,592,000,000

3.7. Investment Profitability and Break-Even Analysis

The detailed techno-economic calculation is compiled in **Table 7**, where all variable and fixed costs are reconciled with investment and revenue figures. The Break-Even Point (BEP) is calculated at 8,777,251 units/year, equivalent to 61% of full production capacity. Despite a relatively low profit-to-sales ratio (6.4%), the project demonstrates robust financial performance based on key indicators: a Return on Investment (ROI) of 93.55% and a Payback Period (PBP) of less than one year.

This structure suggests the business is highly responsive to economies of scale. Once production exceeds BEP levels, profits accumulate rapidly. However, this advantage depends heavily on maintaining supply and market conditions. Any decline in production or price could jeopardize return timelines.

Table 7. Results of Techno-Economic Calculations.

Component	Value (Rp)
Total Fixed Cost	234,567,150.26
Total Variable Cost	2,207,168,000.00
Total Manufacturing Cost	2,423,749,095.40
Sales	2,592,000,000.00
Estimated Profit Margin	6.4%
Break-Even Output	8,777,251 units
Profit-to-Sales Ratio	0.0649
ROI	93.55%
Payback Period	0.97ears

3.8. CNPV/TIC Evaluation Over Project Lifecycle

Long-term financial viability is illustrated through the Cumulative Net Present Value/Total Investment Cost (CNPV/TIC) analysis. The financial behavior over the 20-year project timeline is visualized in **Figure 2**. In the first three years, the CNPV remains negative, driven by high capital investments, especially for equipment and infrastructure. In year 4, the Payback Point is achieved, after which profitability grows steadily. From years 5 to 20, the CNPV continues to rise, surpassing 1000, signaling a positive net gain and project sustainability.

This analysis confirms that although the project carries initial financial strain, particularly due to high upfront fixed costs (FCI and WCI), it becomes profitable relatively quickly. The

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CNPV/TIC model also reflects the importance of maintaining full or near-full production capacity, as output volume directly affects revenue and cost absorption.

When the unit price increases beyond Rp 180 or raw material costs decrease through procurement strategies, the slope of the CNPV curve could become even steeper. Conversely, any disruption in operations or demand would flatten the curve, delaying returns.

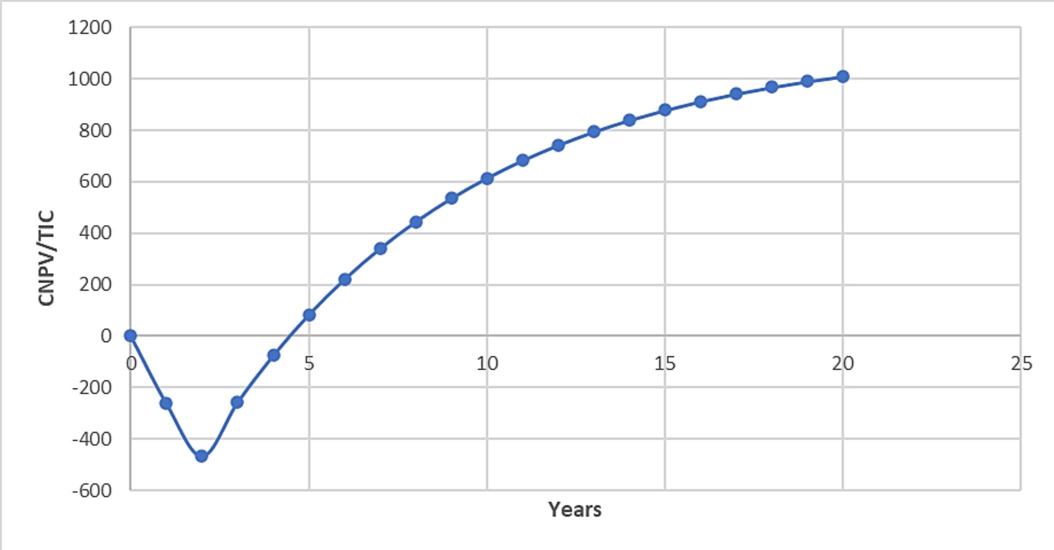

Figure 2. CNPV Curve Across Production Years.

From the above results, several points are as follows:

(i) Integration of Local Resources and Functional Food: The findings demonstrate that the use of local ingredients such as black cumin and honey not only adds functional value to food products but also supports local agricultural empowerment and agro-industrial diversification. This approach aligns with SDG 2 (Zero Hunger) and SDG 12 (Responsible Consumption and Production).

(ii) Investment Feasibility Analysis: Although the profit margin remains relatively low at 6.4%, the high ROI (93.5%) and short payback period (0.97 years) indicate strong investment potential, particularly for small and medium enterprises in the functional food sector.

(iii) Operational Efficiency and Risk: The heavy reliance on honey as a raw material introduces cost structure vulnerabilities. Therefore, strategies such as sourcing diversification or partial substitution with other natural sweeteners could be explored to mitigate financial risk.

(iv) Scalability and Market Expansion Potential: With an annual production capacity of 14.4 million units and a break-even point at only 61% capacity, there is significant potential to scale up production and expand into broader functional food markets, both domestically and internationally, especially through health-oriented branding.

(v) Contribution to Food Science and Technology: This study contributes to the growing body of techno-economic analysis (TEA) applications in functional food production (a field that remains underexplored in Indonesia), offering a valuable model for future research and industry development.

(vi) Recommendations for Further Development: Future studies are encouraged to explore alternative formulations, such as increasing thymoquinone content or incorporating other bioactive compounds, as well as adopting low-energy production technologies to reduce utility costs and enhance operational efficiency.

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Finally, this study adds new information regarding cost analysis in the industry, as reported elsewhere (**Table 8**).

Table 8. Previous studies on economic evaluation.

No	Title	Ref
1	Integrating learning media for language and literacy development: Educational impact and economic evaluation of recycled paper production	[14]
2	Techno-economic analysis of sawdust-based trash cans and their contribution to Indonesia's green tourism policy and the SDGs	[15]
3	Techno-economic analysis of solar panel production from recycled plastic waste as a sustainable energy source for supporting digital learning in schools based on Sustainable Development Goals (SDGs) and science-technology integration	[16]
4	Techno-economic evaluation of gold nanoparticles using banana peel (*Musa Paradisiaca*)	[17]
5	Techno-economic feasibility of educational board game production from agro-industrial waste	[18]
6	Optimal design and techno-economic analysis for corncob particles briquettes	[19]
7	Economic evaluation of different fuels in the production of La_2NiO_4 particles using a sol-gel combustion	[20]
8	Techno-economic evaluation of biodiesel production from edible oil waste	[21]
9	Techno-economic evaluation of dysprosium-doped cobalt ferrites nanoparticles	[22]
10	Techno-economic analysis of the business potential of recycling lithium-ion batteries	[23]
11	Computational bibliometric analysis on publication of techno-economic education	[24]
12	Techno-economic feasibility and bibliometric review of integrated waste processing installations	[25]
13	Techno-economic and bibliometric analysis of wet organic waste ecoenzymes production	[26]
14	Techno-economic analysis of production ecobrick from plastic waste	[27]
15	Alternative energy options for a Thai durian farm: Feasibility study and experiments for the combination of solar photovoltaics and repurposed lithium-ion batteries	[28]

4. CONCLUSION

Based on the results of the techno-economic analysis, the production of functional hard candy enriched with Nigella sativa extract and honey is proven to be both technically and economically feasible. Despite the relatively low profit margin of 6.4%, the project demonstrates strong financial indicators, including a Return on Investment (ROI) of 93.55%, a Payback Period (PBP) of 0.97 years, and a Break-Even Point (BEP) achieved at 61% of production capacity. The largest component of production cost arises from raw materials, particularly honey and black cumin, underscoring the need for supply chain efficiency and cost-control strategies. Nevertheless, the business model shows resilience under varying market conditions and offers a viable approach to value-added food innovation using local resources. To enhance sustainability and scalability, additional support from government initiatives and industrial partnerships is recommended, particularly in optimizing input costs and marketing efforts. This project contributes to the development of functional food products in agricultural economies through evidence-based investment analysis.

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6. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

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