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Development of Functional Aromatherapy Candles from Banana Peel Extract: A Techno-Economic Study for Green Tourism Products Based on Collaborative Governance

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ABSTRACT

This study evaluates the economic feasibility of developing innovative and eco-friendly tourism products in Ciletuh Geopark through collaborative governance, namely functional aromatherapy candles made from banana peel extract. The research applies content analysis and economic evaluation using principles such as profit margin, payback period, and net present value. Data on materials and tools were collected from credible e-commerce sources officially recognized by local government, ensuring complete specifications. The analysis included calculating all relevant data and simulating production over 20 years. Results indicate the project is economically viable, with strong profit potential and positive outcomes across all parameters, especially with massive marketing through collaborative governance. This research contributes to sustainable tourism by promoting waste-based green products, generating socio-economic benefits for stakeholders, and supporting the achievement of SDGs.

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1. INTRODUCTION

Agricultural waste has become a pressing environmental challenge due to its growing volume and poor management practices. Many reports regarding the way how to solve current issues in waste have been well-documented [1-13]. Strategies on how to solve this issue must be taken. Especially, in agrarian countries such as Indonesia, large amounts of agricultural by-products are generated but remain underutilized, often ending up in landfills or open dumping sites that contribute to pollution and ecological imbalance. Among these wastes, banana peels are produced in considerable quantities because bananas are one of the most widely consumed fruits [14-18]. Instead of being processed, the peels are frequently discarded, leading to issues such as water contamination and organic overload in waste systems [19]. This condition is paradoxical, as banana peels actually contain bioactive compounds including antioxidants, flavonoids, and antimicrobial agents that possess both functional and economic potential [20].

Recognizing this potential, banana peels can be repositioned within a circular economy framework as raw materials for value-added products. One innovative application is their use in developing functional aromatherapy candles. These candles not only release natural aromas derived from volatile compounds such as isoamyl acetate, but also provide additional benefits, including relaxation, antimicrobial properties, and ecological value [21,22]. As wellness tourism grows globally, such eco-friendly products have increasing relevance for destinations like Ciletuh Geopark, which emphasize sustainability and the integration of local resources. The transformation of banana peel waste into aromatherapy candles thus represents a strategic approach to reducing environmental burdens while supporting the development of green tourism products.

Previous research has highlighted the importance of *waste-to-product* initiatives guided by techno-economic studies to ensure process efficiency, financial feasibility, and long-term sustainability [23-25]. Studies show that banana peels can be utilized for functional foods, cosmetics, natural dyes, and aromatherapy products due to their rich chemical composition [26-30]. Furthermore, the growing demand for natural and eco-friendly commodities in tourism underscores the necessity of evaluating new products not only from a technological perspective but also from an economic standpoint. Feasibility analyses such as return on investment (ROI), payback period (PBP), and break-even point (BEP) are essential to determine whether such innovations can be scaled and sustained in competitive markets [26,31].

However, technological innovation alone is not sufficient for the successful integration of eco-friendly products into the tourism sector. Collaborative governance plays a crucial role in aligning the interests of stakeholders, overcoming coordination challenges, and embedding local wisdom into sustainable tourism development [32,33]. Active partnerships among government, private industry, MSMEs, local communities, and academics are vital to ensuring that green tourism products are accepted, supported, and expanded [34-36].

Based on this perspective, the present study aims to develop functional aromatherapy candles from banana peel extract as sustainable tourism products. The research focuses on a techno-economic analysis to evaluate the feasibility and potential profitability of producing such materials on a practical scale, as reported elsewhere (**Table 1**). The novelty of this study lies in integrating techno-economic feasibility assessment with a collaborative governance framework, an approach that has not been explored in previous research. The expected outcome is to provide a practical model for transforming organic waste into value-added tourism products, thereby contributing to SDG 12 (responsible consumption and production),

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SDG 8 (inclusive economic growth), and SDG 17 (partnerships for sustainable development), while simultaneously strengthening the creative economy in the Ciletuh Geopark area.

Table 1. Previous studies on techno-economic analysis.

No	Title	Ref
1	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	[37]
2	Techno-economic feasibility of educational board game production from agro-industrial waste in support of Sustainable Development Goals (SDGs) through science and technology integration	[38]
3	Resin-based brake pad from rice husk particles: From literature review of brake pad from agricultural waste to the techno-economic analysis	[39]
4	Techno-economic evaluation of biodiesel production from edible oil waste via supercritical methyl acetate transesterification	[40]
5	Techno-economic analysis for the production of silica particles from agricultural wastes	[41]
6	Techno-economic analysis for the production of LaNi5 particles	[42]
7	Computational bibliometric analysis on publication of techno-economic education	[43]
8	Optimal design and techno-economic analysis for corncob particles briquettes: A literature review of the utilization of agricultural waste and analysis calculation	[44]
9	Techno-economic feasibility and bibliometric literature review of integrated waste processing installations for sustainable plastic waste management	[45]
10	Production of wet organic waste ecoenzymes as an alternative solution for environmental conservation supporting sustainable development goals (SDGs): A techno-economic and bibliometric analysis	[46]
11	Techno-economic analysis of production ecobrick from plastic waste to support sustainable development goals (SDGs)	[47]
12	Techno-economic evaluation of the production of resin-based brake pads using agricultural wastes: Comparison of eggshells/banana peels brake pads and commercial asbestos brake pads	[48]
13	Techno-economic analysis of sawdust-based trash cans and their contribution to Indonesia's green tourism policy and the sustainable development goals (SDGs)	[49]
14	Techno-economic analysis of the business potential of recycling lithium-ion batteries using hydrometallurgical methods	[50]
15	Techno-economic evaluation of hyaluronic acid production through extraction method using yellowfin tuna eyeball	[51]
16	Techno-economic analysis on the production of zinc sulfide nanoparticles by microwave irradiation method	[52]

2. METHODS

This study employed a content analysis approach, focusing on charts, curves, and tables that contained relevant data. The analysis emphasized linking the obtained results with findings from previous studies to ensure contextual accuracy. The data source was an economic evaluation conducted through a feasibility study that considered several financial parameters: Gross Profit Margin (GPM), Internal Rate of Return (IRR), Payback Period (PBP), Cumulative Net Present Value (CNPV), Break-Even Point (BEP), and the sales-to-investment ratio. The overall systematic process applied in this study is illustrated in **Figure 1**. To support accurate economic evaluation, data on raw materials and equipment prices were collected from government-licensed and credible e-commerce platforms. Each financial calculation was simulated based on production predictions projected for the next 20 years, under the

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assumption of stable and ideal conditions. Additionally, it was assumed that no inflation, deflation, or monetary crisis occurred during this period. As shown in **Figure 1**, the process of making functional aromatherapy candles from banana peel extract begins with raw material collection, including banana peels, paraffin wax, essential oil, candle wicks, and natural dyes. Since the core innovation lies in the use of banana peel extract, special attention was given to its processing. The banana peels were first cleaned, dried in an oven to a moisture content of 8–12%, ground using a milling machine, and then subjected to extraction. The extract underwent filtration and solvent evaporation before being stored in a dark, airtight glass container.

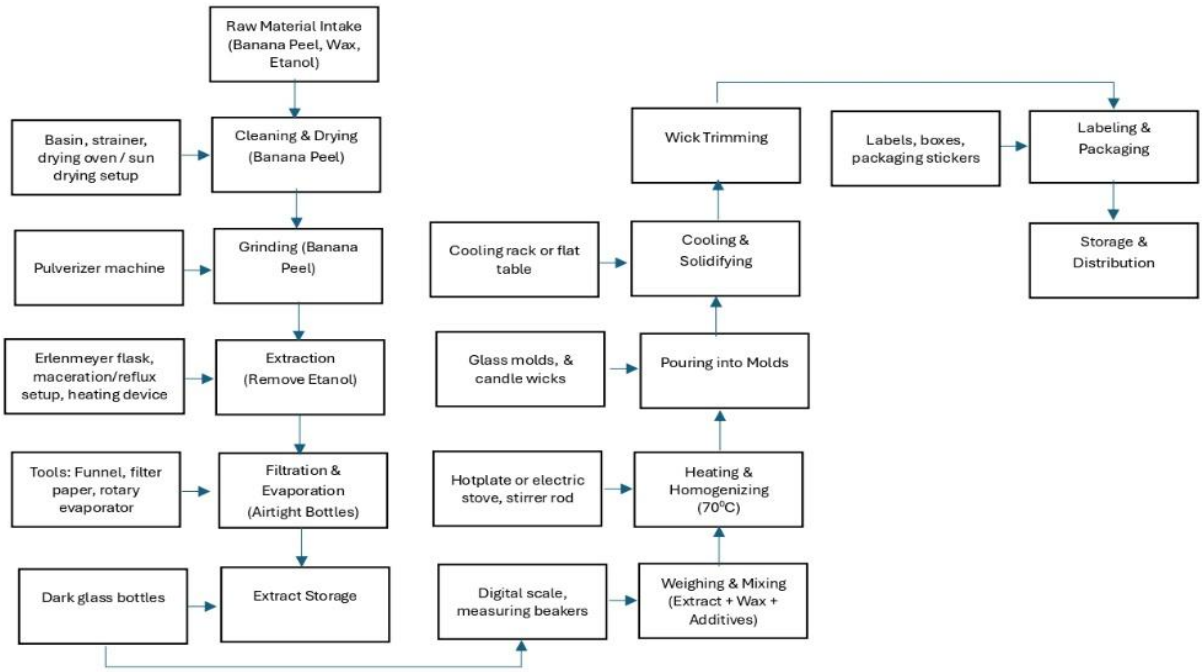

Figure 1. Flowchart for making aromatherapy candles with banana peel extract.

Once the extract was prepared, the next stage involved weighing and mixing it with other raw materials, such as wax and additives (aroma and dye). The mixture was homogenized at 70 °C using a hotplate, followed by pouring into molds with pre-set wicks. After natural cooling and solidification, the final stage consisted of labeling and packaging to ensure proper storage and distribution of the finished product.

3. RESULTS AND DISCUSSION

Table 2 shows the sales capacity of this product when it was first established, it was able to produce a capacity of 1000 products in one day, assuming there were no obstacles in production if multiplied by 300 working days, the annual capacity could reach 300,000 products because this candle is quite premium sold in natural tourism places as a characteristic of the tourist area souvenirs and the price is following the price in the market, the unit selling price is USD 4.06; Thus, the gross income per year can reach USD1,218,750.

Table 3 shows the results of the techno-economic simulation that the production of functional aromatherapy candles from banana peel extract is projected to reach 300,000 units per year, with an estimated gross income of USD 1,218,750 and a total production cost of USD 1,130,906.82. This production cost is dominated by raw materials worth USD 975,000, followed by labour, marketing, and utility costs as part of the total variable cost of USD 1,082,668.74. Meanwhile, annual fixed costs are recorded at USD 52,291.94, which includes

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depreciation of USD 4,053.86 from the total initial investment of USD 43,451.86. Operating profit is estimated at around 7% of total sales, with a profit margin on sales of 7.21%. The break-even point was achieved at a production volume of 115,281 units (around 38% of maximum capacity), with a return on investment (ROI) of 216.69% and a payback period of only 0.44 years or around 5-6 months. This finding indicates high financial feasibility. This success can be further strengthened through a collaborative governance approach based on the penta helix, which involves elements of government, business actors, communities, academics, and the media in the supply chain, production, and promotion. This approach is believed to be able to reduce costs, ensure continuity of supply, empower communities, and ensure economic and ecological sustainability within the framework of green tourism development.

Table 2. Estimated selling price.

Sale	Estimate	Unit
Capacity	1,000	Unit/Day
Capacity	300,000	Unit/Year
Selling price	4.06	USD
Income per year	1,218,750	USD

Table 3. Parameters of economic evaluation results.

Parameter	Mark
Loan interest	
Capital-related cost	USD 48,238.08
Fixed cost + depreciation	
Depreciation	USD 4,053.86
Fixed cost less depreciation	
Total fixed cost	USD 52,291.94
Raw material	USD 975,000.00
Utilities	USD 1,393.74
Operating labor	USD 16,125.00
Labour-related cost	USD 4,837.50
Sales-related cost	USD 85,312.50
Total variable cost	USD 1,082,668.74
Sales	USD 1,218,750.00
Manufacturing cost	USD 1,130,906.82
Investment	USD 43,451.86
Profit	7%
Profit to sales	202%
Unit	300000 Unit
Fixed cost	USD 52,291.94
Variable cost	USD 1,082,668.74
Variable cost	USD 0.00
Sales	USD 1,218,750.00
Sales	USD 0.00
BEP	115.281 Unit
Percent profit on sales	7.21%
Return on investment	216.69%
Payout time	0.44 Years

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Figure 2 shows the CNPV curve, which is the accumulation of Net Present Value values over time that are used to see the development of project feasibility or profitability sustainably. The curve is estimated for the next 20 years with the assumption that the economic conditions in the world and locally are stable, meaning that they are not affected by inflation or deflation, including the monetary crisis. This curve shows that the CNPV value in the first and second years is negative or a loss; this is due to significant initial costs related to factory construction, procurement of tools and materials, and product marketing, which require quite large capital costs. However, in the following year, with an increase in production capacity, the CNPV value began to show a significant increase in business profits, and this continued to grow over the next 20 years.

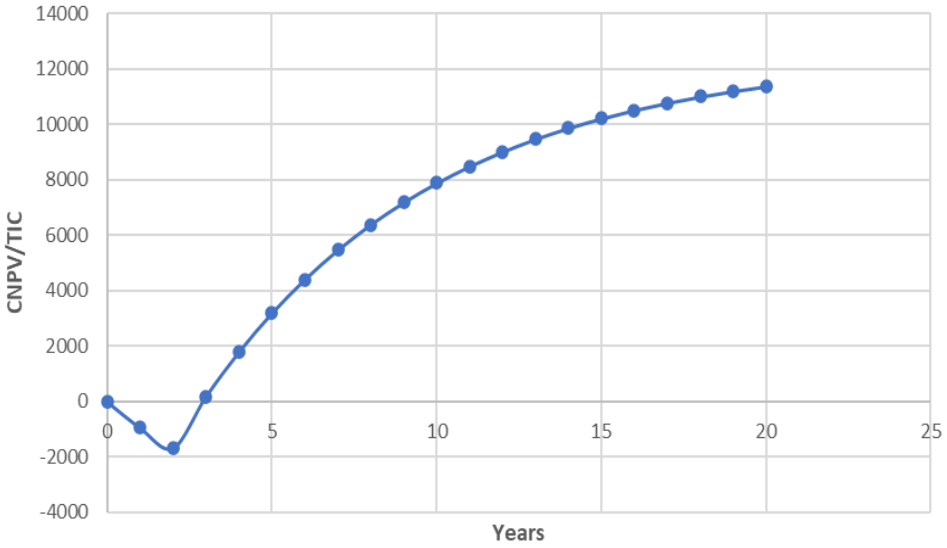

Figure 2. CNPV/TIC curve.

4. CONCLUSION

The feasibility study calculation of the production of functional aromatherapy candles from banana peel extract shows that this project is very feasible to be developed economically, with a production capacity of 300,000 units per year, gross revenue reaching IDR 19.5 billion, and annual operating profit of around IDR 1.4 billion. Financial parameters such as an ROI of 216.7%, a payback period of only 5-6 months, and a break-even point at 38% of production capacity indicate high profitability and low business risk. Although the value in the first two years was negative due to development and marketing costs, the growth trend over the next 20 years continues to show consistent positive results. Therefore, to realize this potential sustainably, an approach of collaborative governance between government, private sector, academics, communities, and media is essential to ensure raw material supply, production efficiency, wide distribution, and local community economic empowerment. This collaboration model is in line with the principles of green tourism and supports the achievement of SDGs, making banana peel waste management a creative solution that has economic, social, and environmental impacts.

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6. AUTHORS' NOTE

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

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