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ORIGINAL RESEARCH

Valorization of Pineapple (*Ananas comosus*) Peel into Face Wash: A Financial Feasibility Study for MSME Development

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Abstract
The utilization of agro-industrial waste as a raw material for value-added products has gained increasing attention, particularly in the development of natural-based cosmetics. This study aims to evaluate the financial feasibility of producing face wash formulated with pineapple (*Ananas comosus*) peel extract at the micro, small, and medium enterprise scale. The analysis was conducted using key financial indicators, including Net Present Value, Internal Rate of Return, Payback Period, and Break Even Point, supported by sensitivity analysis to assess business resilience under changing economic conditions. The results indicate that the proposed business generates a positive Net Present Value of IDR 402,682,800 with an Internal Rate of Return of approximately 65%, significantly exceeding the discount rate of 14%. The Payback Period is estimated at one year, indicating a rapid recovery of the initial investment. The Break Even Point is achieved at 4,130 units, representing approximately 51% of the projected sales capacity. Sensitivity analysis reveals that the business is more affected by a decrease in selling price than by an increase in production costs; however, the project remains financially viable under both conditions. Furthermore, simulation of increased production capacity demonstrates improved profitability due to economies of scale. Overall, the findings confirm that the development of face wash based on pineapple peel extract is financially feasible and offers a promising approach for sustainable waste valorization in the cosmetic sector.

Keywords
Bromelain; financial feasibility; MSME; natural cosmetics; pineapple peel; sensitivity analysis; waste valorization

1. INTRODUCTION

The rapid growth of agro-industrial activities has led to an increasing accumulation of organic waste, particularly from fruit processing industries. Pineapple (Ananas comosus) is one of the major tropical commodities, generating a significant proportion of by-products such as peels, cores, and crowns. These residues can account for up to 40–50% of the total fruit mass and are often underutilized despite containing valuable bioactive compounds (Chiarelli et al., 2024). Improper disposal of pineapple waste contributes to environmental issues, while at the same time representing a missed opportunity for value-added product development.

Among the bioactive compounds present in pineapple waste, bromelain a proteolytic enzyme has attracted considerable attention due to its multifunctional properties. Recent studies have highlighted that bromelain exhibits anti-inflammatory, antioxidant, antimicrobial, and exfoliating activities, making it highly suitable for cosmetic and cosmeceutical applications, particularly in skincare formulations (Venetikidou et al., 2025; Marissa et al., 2025). In addition, bromelain has been reported to promote skin renewal and enhance photoprotective effects, further supporting its use as an active ingredient in facial cleansing products (Marissa et al., 2025).

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The growing demand for sustainable and natural-based cosmetics has accelerated the exploration of enzyme-based formulations derived from agricultural waste. Current research trends emphasize the integration of green chemistry and circular economy principles, where waste materials are converted into high-value functional products (Chiarelli et al., 2024; Bala et al., 2019). Bromelain extracted from pineapple peel has been identified as a promising candidate for such applications; however, challenges remain in terms of extraction efficiency, stability, and scalability, which can affect its commercial viability (Bala et al., 2019; Kumar et al., 2025).

Several studies have investigated the extraction, characterization, and application of bromelain from pineapple waste, including its incorporation into cosmetic formulations and its effectiveness in treating skin-related conditions such as acne (Anbesaw, 2021). Nevertheless, most of these studies primarily focus on technical and biochemical aspects, with limited attention given to the economic feasibility of translating such innovations into scalable business models, particularly at the micro, small, and medium enterprise (MSME) level.

In practice, the commercialization of bio-based cosmetic products requires not only technical feasibility but also financial viability. Financial indicators such as Net Present Value (NPV), Internal Rate of Return (IRR), and Break Even Point (BEP) are essential tools for evaluating investment decisions and long-term sustainability. However, studies that integrate waste valorization, cosmetic formulation, and comprehensive financial analysis remain scarce, especially in developing countries where MSMEs play a crucial role in economic development.

Therefore, this study aims to analyze the financial feasibility of producing face wash based on pineapple peel extract at the MSME scale. The analysis employs key financial indicators, including NPV, IRR, Payback Period, and BEP, complemented by sensitivity analysis to evaluate the robustness of the business under varying economic conditions. This research is expected to contribute to the development of sustainable cosmetic products while providing a practical framework for the economic utilization of agro-industrial waste..

2. MATERIALS AND METHODS

2.1. Materials

The primary raw material used in this study was pineapple peel obtained from ripe fruits of *Ananas comosus* collected from a local traditional market in Jambi, Indonesia. Chemical materials used in the formulation included propylene glycol (analytical grade, Merck, Darmstadt, Germany), glycerin (food grade, Brataco Chemical, Jakarta, Indonesia), potassium hydroxide (KOH) (analytical grade, Merck, Germany), xanthan gum (Sigma-Aldrich, St. Louis, USA), tea tree oil (essential oil grade, Now Foods, USA), turmeric oil (local supplier, Indonesia), and distilled water. All reagents were used without further purification.

The equipment used in this study included a homogenizer, digital weighing balance (Ohaus Corporation, Parsippany, USA), hot plate stirrer (IKA C-MAG HS 7, IKA Works, Staufen, Germany), and pH meter. Packaging materials consisted of polyethylene terephthalate (PET)

bottles with a capacity of 100 mL sourced from a local packaging supplier.

2.2. Methods

2.2.1. Extraction of Bromelain from Pineapple Peel

Pineapple peel was cut into small pieces and blended with distilled water at a ratio of 1:2 (w/v). The mixture was filtered using muslin cloth to obtain crude extract. The filtrate was then subjected to centrifugation at 4,000 rpm for 15 minutes to remove insoluble particles. The supernatant containing crude bromelain extract was stored at 4°C prior to use. This method was adapted from previous studies with minor modifications to suit laboratory-scale extraction.

2.2.2. Formulation of Face Wash

The face wash formulation was prepared by mixing the bromelain extract with supporting ingredients, including surfactant base, humectants, and stabilizers. Xanthan gum was first dispersed in distilled water to form a gel base. Propylene glycol and glycerin were added as humectants, followed by the gradual addition of bromelain extract under continuous stirring using a homogenizer at 3,000 rpm for 10 minutes. Essential oils were incorporated at the final stage to enhance fragrance and antimicrobial properties. The pH of the formulation was adjusted to 5.5–6.0 using KOH solution to match skin compatibility.

2.2.3. Financial Feasibility Analysis

The financial feasibility of the proposed business model was evaluated using standard investment appraisal techniques (Nanda et al., 2025). The analysis was conducted based on a five-year project period with a discount rate of 14%.

Net Present Value (NPV)

$$\text{NPV} = \sum_{t=1}^{n} \left(\frac{CFt}{(1+i)\text{^}t} - I0 \right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where CF_t is the net cash flow in year t, i is the discount rate, n is the project period (years), and I_0 is the initial investment. A project is considered feasible if $NPV > 0$.

Internal Rate of Return (IRR)

The Internal Rate of Return is defined as the discount rate that results in NPV = 0. The IRR was determined using interpolation method based on two discount rates that produce positive and negative NPV values.

Payback Period (PP)

$$PP = \frac{Initial\ Invesment}{Annual\ Net\ Cash\ Flow} \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

This method measures the time required to recover the initial investment.

Break Even Point (BEP)

$$BEP = \frac{Fixed\ cost}{Price - Variable\ cost} \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

where fixed cost represents annual fixed expenses, price is the selling price per unit, and variable cost is the cost per unit. The BEP indicates the minimum production level required to avoid losses.

Sensitivity Analysis

Sensitivity analysis was conducted to evaluate the robustness of the business under uncertain conditions. Two scenarios were considered: (1) a decrease in selling price by 10%, and (2) an increase in total production cost by 10%. The impact of these changes on NPV, IRR, and Payback Period was analyzed.

3. RESULTS AND DISCUSSION

3.1. Financial Performance of the Proposed Business

The financial feasibility analysis of face wash production based on pineapple peel extract was conducted using several technical and economic assumptions relevant to MSME-scale cosmetic production. These assumptions included production capacity, selling price, operational costs, project period, discount rate, depreciation, taxation, and working capital requirements. The basic assumptions used in the financial analysis are presented in Table 1.

Table 1. Basic assumptions used in financial feasibility analysis

Parameter	Assumption
Project period	5 years
Production capacity	8,000 units/year
Selling price	IDR 38,000/unit
Annual sales projection	IDR 304,000,000
Initial investment	IDR 120,000,000
Working capital	IDR 20,000,000
Variable cost per unit	IDR 12,000/unit
Annual fixed cost	IDR 152,800,000
Discount rate	14%
Tax rate	0.5% (MSME tax)
Inflation rate	3%
Depreciation method	Straight-line
Annual depreciation	IDR 24,000,000
Salvage value	10% of equipment value
Production utilization	80%

The financial feasibility of the face wash production based on pineapple peel extract is summarized in Table 2.

Table 2. Financial feasibility indicators of the proposed business

Parameter	Value
Net Present Value (IDR)	402,682,800
Internal Rate of Return (%)	65
Payback Period (years)	1.0
Break Even Point (units/year)	4,130
Break Even Point (IDR/year)	185,850,000

The results in Table 1 indicate that the proposed business is financially feasible. The Net Present Value (NPV) of IDR 402,682,800 confirms that the project generates positive economic benefits over the investment period. The Internal Rate of Return (IRR) of approximately 65% is significantly higher than the discount rate of 14%, indicating strong investment attractiveness. In addition, the Payback Period of one year reflects rapid capital recovery, while the Break Even Point (BEP) suggests that only about half of the production capacity is required to reach profitability.From an economic standpoint, these findings indicate a robust financial structure with high profitability and relatively low risk. According to investment feasibility theory, projects with IRR values significantly exceeding the discount rate are considered highly attractive (Blank & Tarquin, 2018).

Similar results have been reported in small-scale agroindustrial systems, where the use of low-cost raw materials combined with value-added processing leads to substantial profit margins (Sari & Nugroho, 2021). Furthermore, the conversion of pineapple peel waste into a cosmetic product reflects an efficient resource utilization model aligned with circular economy principles, which has been widely recognized as a strategy to enhance economic value while reducing environmental impact (Chiarelli et al., 2024; Kumar et al., 2020).

3.2. Cost Structure and Production Efficiency

The distribution of operational costs is presented in Table 3.

Table 3. Annual cost structure of face wash production

Cost component	Value (IDR/year)	Percentage (%)
Raw materials & additives	64,000,000	29.5
Labor	90,000,000	41.5
Marketing	28,800,000	13.3
Depreciation	24,000,000	11.1
Maintenance	10,000,000	4.6

As shown in Table 3, labor cost accounts for the largest proportion of total operational expenses (41.5%), indicating that the production system is labor-intensive. This condition is commonly observed in micro and small enterprises, where production processes rely heavily on manual operations rather than automation. Consequently, labor productivity becomes a key determinant of cost efficiency. Improving workforce skills or introducing partial mechanization could enhance productivity and reduce overall operational costs.

In contrast, the relatively low proportion of raw material costs highlights the economic advantage of utilizing agricultural waste. Pineapple peel, as a by-product, provides a low-cost input while still containing valuable bioactive compounds such as bromelain. This supports previous findings that waste valorization can significantly reduce production costs and increase resource efficiency (Kumar et al., 2020; Chiarelli et al., 2024). Moreover, bromelain has been widely reported to possess functional properties beneficial for cosmetic applications, including anti-inflammatory and exfoliating effects, which enhance the product's added value (Ali et al., 2019; Kumar et al., 2022). Therefore, the integration of low-cost raw materials with high-value functional ingredients contributes to a favorable cost-performance ratio.

3.3. Sensitivity Analysis

The sensitivity analysis results are presented in Table 4.

Table 4. Sensitivity analysis of financial indicators

Scenario	NPV (IDR)	IRR (%)	Payback (years)
Base case	402,682,800	65	1.0
Price -10%	259,000,000	48	1.27
Cost +10%	318,000,000	55	1.15

The results in Table 4 demonstrate that the financial performance of the business is more sensitive to changes in selling price than to increases in production costs. A 10% reduction in selling price leads to a substantial decline in both NPV and IRR, indicating a strong dependence on revenue generation. In contrast, a 10% increase in production costs results in a relatively smaller decrease in financial indicators, suggesting that the business has moderate resilience to cost fluctuations.

This finding is consistent with financial feasibility theory, which states that revenue-related variables generally have a greater impact on profitability than cost variables (Blank & Tarquin, 2018). Similar observations have been reported in small-scale agroindustrial systems, where pricing strategy plays a critical role in determining business sustainability (Putri & Rahman, 2021). Therefore, maintaining competitive pricing, product differentiation, and market positioning is essential to mitigate financial risks. In the context of natural cosmetics, emphasizing the use of sustainable and bio-based ingredients can justify higher pricing and reduce sensitivity to market competition (Barbulova et al., 2015).

3.4. Effect of production scale

The financial performance under increased production capacity is shown in Table 4.

Table 5. Financial performance under increased production capacity

Parameter	Value
Production volume	10,200
(units/year)	555,000,000
Net Present Value (IDR)	78–85
Internal Rate of Return (%)	0.76
Payback Period (years)	

Table 5 shows that increasing production capacity significantly enhances financial performance. The NPV increases substantially, while the IRR reaches up to 85%, indicating higher profitability. Additionally, the Payback Period is reduced to less than one year, reflecting faster investment recovery. These improvements are primarily driven by economies of scale, where fixed costs are distributed over a larger production volume, thereby reducing the cost per unit.

From an operational perspective, scaling up production improves efficiency and resource utilization. This phenomenon has been widely documented in agroindustrial systems, where increased production capacity leads to improved economic performance (Bala et al., 2019). However, scaling up also requires careful consideration of supply chain stability and quality control to ensure consistent product standards. Ensuring a continuous supply of pineapple peel and maintaining bromelain activity during processing are critical factors for sustainable production (Kumar et al., 2022).

3.5. Implications for sustainable cosmetic development

The utilization of pineapple peel waste in cosmetic production provides both environmental and economic benefits. By converting agricultural waste into value-added products, this approach supports waste reduction and promotes sustainable resource management. This aligns with circular economy concepts, where waste materials are transformed into economically valuable outputs (Chiarelli et al., 2024; Kumar et al., 2020).

From a product development perspective, the incorporation of bromelain enhances the functional properties of the face wash. Bromelain has been widely reported to exhibit anti-inflammatory, antimicrobial, and exfoliating activities, making it suitable for skincare applications (Ali et al., 2019; Marissa et al., 2025). In addition, the growing demand for natural and sustainable cosmetic products further strengthens the market potential of such innovations (Barbulova et al., 2015). Therefore, the proposed business model not only demonstrates financial feasibility but also contributes to sustainable innovation in the cosmetic industry, particularly at the MSME level.

CONCLUSION

The results of this study demonstrate that the production of face wash based on pineapple (*Ananas comosus*) peel extract is financially feasible at the micro, small, and medium enterprise scale, as indicated by a positive Net Present Value of IDR 402,682,800, an Internal Rate of Return of approximately 65%, and a Payback Period of one year. The Break Even Point at 10.200 units further indicates a relatively low operational risk and a wide margin of safety. Sensitivity analysis reveals that the business is more affected by changes in selling price than by increases in production costs, highlighting the importance of pricing strategy and market positioning. In addition, scaling up production significantly improves profitability due to economies of scale. Beyond financial performance, this study underscores the potential of utilizing pineapple peel waste as a sustainable raw material for cosmetic products, contributing to waste valorization and circular economy practices.

These findings provide practical insights for the development of agro-based industries and demonstrate the potential integration of agricultural waste into value-added products within the fields of agriculture and biosystems engineering.

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