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Production Optimization of "Aku Pisang" Banana Chips in Aceh Jaya Regency Using POM-QM for Windows Software

Agustiar[1]*, Muhammad Riski Firwanda[2], Meli Maria Gultom[3], Qhisthina Atikah[4]
[1, 2, 3]Universitas Teuku Umar
[4]Universitas Syiah Kuala
Corresponding Author: Agustiar agustiar@utu.ac.id

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ABSTRACT

This study aims to determine the optimal production mix for the "Aku Pisang" MSME in Aceh Jaya Regency using the Linear Programming method. The primary challenges faced by the partner include limitations in raw materials (bananas, cooking oil, and seasoning) and energy capacity, which hinder maximum profit attainment. Data were processed using POM-QM for Windows software to optimize the production of chocolate and balado (spicy) variants. The results indicate an optimal production mix of 62.5 units of the chocolate variant and 50 units of the balado variant per day. This combination yields a maximum daily net profit of IDR 833,121.25. Duality analysis confirms that flavor powder is a binding constraint; therefore, development strategies should prioritize increasing the supply of this material to enhance operational efficiency.

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INTRODUCTION

The Micro, Small, and Medium Enterprises (MSMEs) sector serves as the backbone of the regional economy, contributing significantly to the Gross Regional Domestic Product (GRDP), including in Aceh Jaya Regency. According to the Ministry of Cooperatives and SMEs (2022), the contribution of this sector is crucial for maintaining national and regional economic stability through labor absorption and the utilization of local potential. Amidst increasingly competitive market pressures, food processing industries based on local commodities, such as banana chips, are required to implement efficient operational management to ensure business sustainability. This efficiency depends heavily on the synchronized allocation of resources to maintain optimal productivity (Prawirosentono, 2010). Banana chips are a snack with stable demand and broad appeal due to their crisp texture and versatility across various flavor variants.

One growing business in Aceh Jaya is "Aku Pisang," a banana chip producer focusing on two main variants: chocolate and balado. In its business activities, "Aku Pisang" faces significant challenges in determining the optimal product mix. Historically, production volume decisions have relied on intuition and daily experience, which are conventional in nature. This decision-making pattern often triggers inefficiencies, either in the form of stockouts leading to lost sales opportunities or overproduction resulting in raw material waste and inventory instability. The core issue in the production of "Aku Pisang" lies in the complexity of allocating limited resources. The production process for each 100-gram pack of banana chips requires specific inputs: 250 grams of raw bananas, 25 ml of cooking oil, and seasoning powder (0.08 kg for chocolate or 0.04 kg for balado). Additionally, there is an energy constraint where one 3 kg LPG cylinder can only produce an average of 300 packs. This situation is further complicated by variations in raw material costs, which directly create differences in profit margins between variants.

To address these resource limitations and cost fluctuations, an analytical approach is required to develop systematic, data-driven production planning. Linear Programming (LP) is a highly relevant method for this issue. This mathematical optimization technique allows companies to determine the best solution or maximum profit amidst various resource constraints (Taha, 2017). The application of LP in multi-variant industries enables firms to identify an optimal intersection point that is difficult to achieve through intuition alone (Render et al., 2014). Along with technological advancements, Linear Programming models can now be solved rapidly and accurately using the POM-QM for Windows application. This software is specifically designed to facilitate optimization modeling and provide recommendations for optimal production volumes based on raw material availability, production capacity, and prevailing selling price structures (Universal Systems, Inc., 2019). The use of computer-aided tools in operations research significantly assists in minimizing manual calculation errors and accelerating data-driven managerial decision-making (Turban & Aronson, 2001). Therefore, this research was conducted to develop a production optimization model for "Aku Pisang" using

POM-QM for Windows, providing a tangible solution to maximize profit and enhance MSME competitiveness.

LITERATURE REVIEW

MSME Operations and Production Management

Operational management in MSMEs focuses on efficiently transforming inputs into outputs to meet market demand, despite limited capital and resources (Stevenson, 2018). Systematic production planning includes raw material requirement analysis, production capacity monitoring, and determining the optimal product composition. Prawirosentono (2010) states that productivity depends on how management synchronizes human resources, machinery, and materials. In the food processing industry, cost variables are heavily influenced by production yield, the ratio of finished product weight to raw materials, and energy consumption efficiency per unit (Nasendi, 2021). Understanding the cost structure, which encompasses direct raw materials, energy (LPG), and packaging costs, serves as the foundation for determining break-even points and unit profit margins (Rivai & Sagala, 2019).

Linear Programming in Production Optimization

Linear Programming (LP) is one of the most effective operations research techniques used to solve limited resource allocation problems (Render et al., 2014). This method works by maximizing or minimizing a linear objective function subject to a set of linear constraints. According to Kusumadewi & Purnomo (2010), the fundamental components of LP modeling include decision variables representing activity levels, an objective function reflecting profit or cost targets, and resource constraints representing physical realities in the field. Using LP in multi-variant industries allows companies to find the best product mix that cannot be achieved through intuition or trial and error (Heizer & Render, 2017).

Duality Analysis and the Role of Technology (POM-QM)

In addition to providing an optimal (primal) solution, LP modeling provides strategic information through duality analysis. This analysis yields "shadow prices," which, according to Sudarsono & Mulyadi (2020), describe the marginal value or potential profit increase if a binding constraint is increased by one unit. This provides managers with strategic insights to prioritize the procurement of critical resources. In the digital era, complex mathematical models can be solved quickly using software like POM-QM for Windows. Taha (2017) emphasizes that computer-based software in operations research minimizes manual errors and speeds up data-driven decision making.

METHODOLOGY

This study employs a quantitative approach using mathematical optimization models. Primary data were collected through direct observation and interviews at "Aku Pisang," covering cost parameters, raw material requirements, and daily operational constraints.

Analysis Method: Linear Programming

This study applies Linear Programming (LP) to solve resource allocation problems. According to Taha (2017), LP is an effective optimization technique for maximizing an objective function (such as profit) under specific linear constraints. This method allows business owners to transition from estimation-based decision-making to data-driven management (Render et al., 2014).

Variable and Parameter Identification

The decision variables in this model are defined as:

X_1: Number of chocolate-flavored banana chip packs produced (100g).

X_2: Number of balado-flavored banana chip packs produced (100g).

Table 1. Input Parameters and Resource Constraints

Cost Component / Input	Chocolate Variant (X1)	Balado Variant (X2)	Symbol	Available Capacity	Unit
Flavor Powder	0,08	0,04	<=	5 (Choco) / 2 (Balado)	kg
Labor Time	-	-	<=	480	min/day
Production Capacity	-	-	<=	115	units/day
Net Profit per Unit	8.383,30	6.183,30	(Z)	-	IDR

Mathematical Model Formulation

Based on the parameters above, the model is formulated as follows:

Objective Function:

Maximize $Z = 8.383{,}3X_1 + 6.183{,}3X_2$

Constraint Functions:

Includes technical constraints on seasoning (($0{,}08X_1 \leq 5$ dan $0{,}04X_2 \leq 2$)), labor time availability, and total maximum output capacity.

Data Processing with POM-QM

All mathematical calculations were performed using POM-QM for Windows Version 5. The use of this software refers to Universal Systems, Inc. (2019) guidelines, enabling accurate and fast Simplex model resolution, sensitivity analysis, and duality to support strategic decision making (Turban & Aronson, 2001).

RESULTS AND DISCUSSION

Optimal Solution Analysis (Linear Programming Results)

After all input parameters were entered into the POM-QM for Windows software, the Simplex method was executed. The optimization results (Figure 1) indicate that the production mix yielding maximum profit for "Aku Pisang" is 62.5 units of the chocolate variant (X_1) and 50 units of the balado variant (X^2). With net contribution margins of IDR 8,383.3 for X_1 and IDR 6,183.3 for X_2, the maximum daily net profit attained is IDR 833,121.25. Both variables are classified as "Basic," implying both variants contribute positively to profit and should be produced simultaneously.

Linear Programming Results

optimasi keripik pisang Solution

	X1	X2		RHS	Dual
Maximize	20000	15000			
jam kerja	8	4	<=	800	0
coklat	8	0	<=	500	2500
balado	0	4	<=	200	3750
kapasitas produksi	1	1	<=	115	0
Solution->	62,5	50		2000000	

Figure 1. Output results in the POM QM software

Sensitivity and Ranging Analysis

The solution table (Figure 2) provides an overview of the basis structure and stability. Decision variables X_1 and X_2 remain in the optimal solution as long as cost parameters and resource availability stay within the specified feasibility ranges. Simplex iterations (Figure 3) confirm that the solution has reached an optimal and stable point within the feasible region.

optimasi keripik pisang solution

Variable	Value	Reduced Cost	Original Val	Lower Bound	Upper Bound
X1	62,5	0	20000	0	Infinity
X2	50	0	15000	0	Infinity
	Dual Value	Slack/Surplus	Original Val	Lower Bound	Upper Bound
jam kerja	0	100	800	700	Infinity
coklat	2500	0	500	0	520
balado	3750	0	200	0	210
kapasitas pro...	0	2,5	115	112,5	Infinity

Figure 2. Output results after running to determine the upper and lower limits

optimasi keripik pisang solution

Cj	Basic Variables	Quantity	20000 X1	15000 X2	0 slack 1	0 slack 2	0 slack 3	0 slack 4
Iteration 1								
0	slack 1	800	8	4	1	0	0	0
0	slack 2	500	8	0	0	1	0	0
0	slack 3	200	0	4	0	0	1	0
0	slack 4	115	1	1	0	0	0	1
	zj	0	0	0	0	0	0	0
	cj-zj		20.000	15.000	0	0	0	0
Iteration 2								
0	slack 1	300	0	4	1	-1	0	0
20000	X1	62,5	1	0	0	0,125	0	0
0	slack 3	200	0	4	0	0	1	0
0	slack 4	52,5	0	1	0	-0,125	0	1
	zj	1.250.000	20000	0	0	2500	0	0
	cj-zj		0	15.000	0	-2.500	0	0
Iteration 3								
0	slack 1	100	0	0	1	-1	-1	0
20000	X1	62,5	1	0	0	0,125	0	0
15000	X2	50	0	1	0	0	0,25	0
0	slack 4	2,5	0	0	0	-0,125	-0,25	1
	zj	2.000.000	20000	15000	0	2500	3750	0

Figure 3. Overall output results after running

Constraint Analysis (Slack and Surplus)

Resource availability was analyzed by reviewing slack variable values (Figure 4). The results show:

1) Raw Material Constraint (Flavor Powder): The slack values for both chocolate and balado powders are zero. This indicates that the seasoning inventory is fully utilized and constitutes a binding constraint limiting production volume.
2) Capacity Constraint (Labor and Tools): The slack value for labor hours is 100, and for production capacity is 2.5. This indicates remaining time and space resources that are not yet fully utilized.

optimasi keripik pisang solution

Variable	Status	Value
X1	Basic	62.5
X2	Basic	50
slack 1	Basic	100
slack 2	NONBasic	0
slack 3	NONBasic	0
slack 4	Basic	2.5
Optimal Value (Z)		2000000

Figure 4. Slack Variable Values for each variable

Duality Analysis (Shadow Price)

The shadow price (Figure 5) provides strategic information on potential profit increases. The chocolate and balado powder constraints have dual values of 2,500 and 3,750, respectively. This implies that every additional unit of seasoning supply will linearly increase profit. Conversely, the dual values for labor hours and production capacity are zero, as adding these resources will not increase profit as long as the seasoning constraint remains unresolved.

optimasi keripik pisang solution

Original Problem						
Maximize	X1	X2				
jam kerja	8	4	<=	800		
coklat	8	0	<=	500		
balado	0	4	<=	200		
kapasitas produksi	1	1	<=	115		
Dual Problem						
	jam kerja	coklat	balado	kapasitas p...		
Minimize	800	500	200	115		
X1	8	8	0	1	>=	20000
X2	4	0	4	1	>=	15000

Figure 5. Optimization of "Aku Pisang" chips and dual solution

Graphical Interpretation

The feasible region visualization is presented in Figure 6. The optimal point is located at the outermost corner (extreme point) where constraint lines intersect, specifically at coordinates X_1 = 62.5 and X_2 = 50. This point is the furthest feasible point touched by the isoprofit line, mathematically proving it provides the maximum profit. The optimization results using Linear Programming (LP) demonstrate that "Aku Pisang" can significantly increase production efficiency through an appropriate product mix. The findings confirm that mathematical models provide much more accurate results than intuition-based decisions.

Product Mix Synergy and Maximum Profit

The success in determining this product mix aligns with Sudarsono & Mulyadi (2020), who stated that applying LP in the MSME sector can improve resource allocation efficiency by 20-30%. For "Aku Pisang," optimization does not necessarily mean producing only one type of item, but rather finding the equilibrium where all available resources are proportionally absorbed to yield the highest contribution margin.

Binding Constraint Analysis

A key finding is the identification of flavor powder as a binding constraint (zero slack). Theoretically, according to Taha (2017), a constraint is binding if its availability is exhausted in reaching the optimal solution. In the context of MSMEs in Aceh Jaya, reliance on seasoning supplies from outside the region often becomes a primary bottleneck. This is supported by Widodo (2020), who noted that the stability of the auxiliary material supply chain is often a more critical factor for snack industry sustainability than labor factors.

Capacity Efficiency and Idle Capacity

The results show positive slack in labor hours (100 minutes) and production capacity, implying idle capacity. According to Stevenson (2018), labor slack suggests flexibility to increase production volume if raw material (seasoning) constraints are resolved. Conversely, investing in new machinery without increasing seasoning supply would only increase fixed costs without impacting profit, as explained by the Law of Diminishing Returns.

Shadow Price Implications for Management

The high shadow prices for seasoning signal that management should prioritize capital allocation for seasoning stocks. This aligns with Render et al. (2014), who emphasize that the shadow price is a crucial economic indicator for determining whether the cost of acquiring additional resources is proportional to the resulting profit increase.

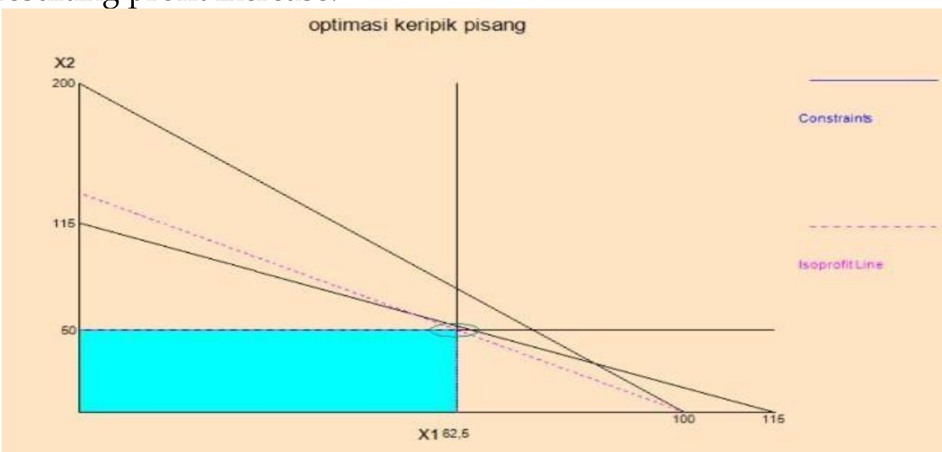

Figure 6. Demand and supply graph of "Aku Pisang" and maximum optimization

CONCLUSIONS AND RECOMMENDATIONS

The optimal production combination to achieve maximum daily net profit is 62.5 units of chocolate banana chips (X_1) and 50 units of balado banana chips (X_2), yielding IDR 833,121.25. Flavor powder availability is the critical binding constraint limiting profit growth, while labor and equipment resources remain sufficient. MSME owners are advised to prioritize budgets for seasoning procurement to avoid production bottlenecks. Optimization software like POM-QM should be used periodically to adjust production plans to raw material price fluctuations. Furthermore, better inventory management of flavor powder is necessary due to its high marginal value toward daily net profit.

FURTHER STUDY

Future research could utilize Integer Programming to ensure production volumes are generated as whole numbers, which is more applicable in the field. Additionally, incorporating marketing cost variables or using a stochastic model approach could help anticipate market demand uncertainty.

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