International Journal of Social Science, Educational, Economics, Agriculture Research and Technology (IJSET) | ISSN (e) : 2827-766X
Volumes 3 No. 6 (2024)

IMPLEMENTATION OF THE SIMPLEX METHOD IN MAXIMIZED DONUT PRODUCTION PROFITS AT ARSYILA BAKERY

Gayus Simarmata[1]*, Juli Antasari Br Sinaga[2], Lilis[3], Yuliana Nainggolan[4], Jelli Sijabat[5], Vania Yocelin Sagala[6].
[1,2,4,5,6,] Program Studi Matematika, Fakultas Matematika dan Ilmu Pengetahuan Alam, Universitas HKBP Nommensen Pematangasiantar, Indonesia
[3,] Politeknik Adiguna Maritim Indonesia, Medan, Indonesia
E-mail: gayuspermata224@gmail.com

Received	:01 April 2024	Published	:28 May 2024
Revised	:15 April 2024	DOI	:https://doi.org/10.54443/ijset.v3i6.1513
Accepted	:10 May 2024	Publish Link	:https://www.ijset.org/index.php/ijset/index

Abstract

Arsyila Bakery, a bakery MSME, faces challenges in determining the most efficient donut production combination. Production decisions have been based on intuition, potentially leading to waste of raw materials and inability to generate maximum profits. This study aims to formulate a Linear Program model as a decision-making tool in determining donut production strategies, namely Potato Donuts x_1 and Milk Donuts x_2, in order to obtain optimal daily profits. A quantitative approach is used through the Linear Program optimization method with the objective function of maximizing profits z = 3000x_1 + 2000x_2, which is limited by nine constraints of raw material availability and production capacity. The model is solved using the Simplex Method algorithm through POM-QM software for Windows. The analysis results show that the optimal solution is achieved by producing 8 units of Potato Donuts and 0 units of Milk Donuts, resulting in a maximum profit of Rp24,000 per day. The binding constraints in the model are Sugar and Potatoes, which are the main limiting factors of production. The economic value (shadow price) indicates that the addition of sugar has the greatest impact on increasing profits, at IDR 2,000 per kilogram, followed by potatoes at IDR 5,000 per kilogram. Based on these findings, it is recommended that Arsyila Bakery implement this optimal production combination and prioritize increasing sugar stock to support improved operational performance and achieve higher profits.

Keywords: Linear Program, Simplex Method, Arsyila Bakery, Donut Production.

INTRODUCTION

The bakery industry is a growing and fiercely competitive business sector, particularly for products like donuts. Amidst the dynamics of consumer demand and market competition, businesses are required to manage their production processes more strategically to achieve optimal profits. Arsyila Bakery, as an MSME focused on donut production, faces challenges in determining the most efficient production volume, particularly when balancing market demand, raw material availability, and daily operational costs. MSMEs play a crucial role in strengthening Indonesia's economic structure. In addition to creating jobs, they also contribute significantly to regional economic growth. However, many MSMEs still operate with simplistic development patterns. Production decisions are often based solely on experience or estimates, rather than measurable calculations. This often leads to wasted raw materials and suboptimal profits. This problem also occurs at Arsyila Bakery, where daily production volume decisions still rely on intuition without clear mathematical calculations.

Optimal production planning is essential for a business to run more efficiently and generate higher profits. Optimization is essentially the process of determining the best choice based on existing constraints. In the context of donut production, optimization means finding the production quantity that will yield the greatest profit while still considering the limitations of raw materials, production capacity, and costs (Sari, D., and Rahmawati, f. 2022). Linear programming is one of the most appropriate mathematical approaches to help solve optimization problems. This approach is used to maximize or minimize an objective function related to profit, costs, or resource utilization, while still considering existing constraints. When production problems involve many variables and constraints, graphical methods are no longer adequate, requiring a more systematic and efficient solution.

The Simplex Method is the most widely used algorithm for solving linear programming models with a complex number of variables and constraints. This method works step by step through a simplex table calculation process to achieve the optimal value of the objective function (Heizer and Render, 2014). For MSMEs like Arsyila Bakery, applying the simplex method can provide a more accurate picture of the production strategy that must be implemented to maximize profits (Setiawan, 2020). Previous studies have shown that using the simplex method can help small businesses overcome inefficient production. Several studies in food processing businesses have shown that a mathematical approach can significantly increase profits compared to production based on estimates. A similar situation was found at Arsyila Bakery, where fluctuating demand and limited raw materials made it difficult for the business owner to determine the most profitable production volume. This study aims to develop a linear programming model as a decision-making tool for Arsyila Bakery in determining the optimal donut production quantity. By applying the simplex method, this study is expected to provide recommendations for the most efficient production quantity, thereby improving operational performance, reducing waste, and maximizing profits.

METHOD

This study uses a quantitative approach with a Linear Program optimization method to determine the amount of donut production that will maximize profits for Arsyila Bakery. The first step begins with collecting primary data in the form of raw material requirements for each donut product, such as the amount of flour, sugar, butter, yeast, powdered milk, and ice water needed to produce one dough or one production batch. This data was obtained through direct weighing of raw materials and recording of recipe formulations routinely used in the production process. In addition, raw material price data and the selling price of each product were also collected to calculate the net profit per donut unit. Secondary data in the form of raw material purchase records and daily production quantities were also used to ensure material availability during the observation period. All data were then formulated into a Linear Program mathematical model, consisting of an objective function in the form of profit maximization, written as:

$$\boldsymbol{Z \sum_{i=1}^{n} c_i x_i} \qquad (1)$$

where Z is the total profit, c_i is the net profit per unit of product, and x_i is the number of units of product to be produced. The constraints in the model come from the maximum amount of raw materials available, which is formulated as a linear inequality:

$$\boldsymbol{\sum_{i=1}^{n} a_{ij} x_i \le b_j} \qquad (2)$$

where is the requirement for raw material j to produce one unit of product i, and is the total inventory of raw material j available in one production process. Since this study does not include elements of labor, production time, or human resource capacity, all limitations are focused on the availability of physical raw materials and processing capacity of equipment, such as mixer capacity or maximum number of batches per day, if necessary.$\boldsymbol{a_{ij} b_j}$ After the model is fully formulated, the solution is performed using the POM-QM for Windows software through the Linear Programming – Simplex Method module. The objective function and all constraints are entered into the system, then POM-QM runs the simplex algorithm to find the optimal solution in the form of the production quantity of each type of donut that provides maximum profit without exceeding the available raw material limit. The results obtained are analyzed to determine the efficiency of material use, the contribution of each product to the total profit, and the most profitable production combination for Arsyila Bakery. This model provides a more measurable and systematic basis for decisions in daily production planning, especially when raw materials are limited but profits are to be maximized.

RESULTS AND DISCUSSION

Interviews have shown that Arsyila Bakery produces two types of donuts: potato donuts and milk donuts. The following are the raw materials used by type of donut produced.

Table 1. Raw material availability data

Raw material	Potato donuts (x_1)	Milk donuts (x_2)	Supply
Wheat	4 kg	2 kg	40 kg
Potato	2 kg	0	16 kg
Egg	1 Kg	1 kg	12 kg
Sugar	1 kg	1 kg	8 kg
Yeast	0.05 kg	0.05 kg	2 kg
Milk powder	0.1 kg	0.1 kg	3 kg
Margarine	0.5 kg	0.5 kg	6 kg
Water	1 liter	1 liter	10 liters
Production capacity	1	1	80 pcs
Profit	Rp. 3,000	Rp. 2,000	

Mathematical equation model

By applying linear programming, this research can determine the optimal solution by developing decision variables, an objective function, and constraint functions that describe raw material limitations and profit targets. The solution process follows specific steps that must be carried out systematically. The steps for solving this problem are outlined as follows:

1. **Determine the function of a variable**
   $x_1 =$ potato donuts
   x_2 = milk donuts
2. Determine the objective function
   Z = 3,000 + 2,000x_1x_2
3. Determine the constraint or limit function
   a. Wheat : $4 + 2x_1x_2 \leq 40$
   b. Potato : $2x_1 \leq 16$
   c. Egg : $x_1 + x_2 \leq 12$
   d. Sugar : $x_1 + x_2 \leq 8$
   e. Yeast : $0.05 + 0.05x_1x_2 \leq 2$
   f. Milk powder : $0.1 + 0.1x_2 \leq 3$
   g. Margarine : $0.5 + 0.5x_1x_2 \leq 6$
   h. Water : $x_1 + x_2 \leq 10$
   i. Production capacity : $x_1 + x_2 \leq 80$
4. Calculating constraint or limit functions by adding slack variables
   a. Wheat : $4 + 2x_1x_2 + s_1 = 40$
   b. Potato : $2x_1 + s_2 = 16$
   c. Egg : $x_1 + x_2 + s_3 = 12$
   d. Sugar : $x_1 + x_2 + s_4 = 8$
   e. Yeast : $0.05 + 0.05x_1x_2 + s_5 = 2$
   f. Milk powder : $0 + 0.10.1x_2 + s_6 = 3$
   g. Margarine : $0.5 + 0.5x_1x_2 + s_7 = 6$
   h. Water : $x_1 + x_2 + s_8 = 10$
   i. Production capacity : $x_1 + x_2 + s_9 = 80$
5. Calculating simplex with linear programming

This section presents the results of linear programming calculations using the simplex method using POM_QM to determine the combination of potato donut and milk donut production that provides maximum profit. All data on raw material requirements and inventory have been entered according to the previous table. The POM-QM output displayed includes the optimal production quantity, maximum profit value, and information on remaining or full usage for each raw material constraint. These results are then analyzed to determine which materials are limiting production and how these solutions are implemented in daily production activities. The following are the results of the iterations of the simplex method calculations with POM-Q.

Iteration table 1.

usaha donat Arsyila Bakery solution													
Cj	Basic Variable	Quantity	3000 X1	2000 X2	0 slack 1	0 slack 2	0 slack 3	0 slack 4	0 slack 5	0 slack 6	0 slack 7	0 slack 8	0 slack 9
Iteration 1													
0	slack 1	40	4	2	1	0	0	0	0	0	0	0	0
0	slack 2	16	2	0	0	1	0	0	0	0	0	0	0
0	slack 3	12	1	1	0	0	1	0	0	0	0	0	0
0	slack 4	8	1	1	0	0	0	1	0	0	0	0	0
0	slack 5	2	0,05	0,05	0	0	0	0	1	0	0	0	0
0	slack 6	3	0,01	0,01	0	0	0	0	0	1	0	0	0
0	slack 7	6	0,05	0,05	0	0	0	0	0	0	1	0	0
0	slack 8	10	1	1	0	0	0	0	0	0	0	1	0
0	slack 9	80	1	1	0	0	0	0	0	0	0	0	1
	zj	0	0	0	0	0	0	0	0	0	0	0	0
	cj-zj		3.000	2.000	0	0	0	0	0	0	0	0	0

Iteration table 2

Iteration 2													
0	slack 1	8	0	2	1	-2	0	0	0	0	0	0	0
3000	X1	8	1	0	0	0,5	0	0	0	0	0	0	0
0	slack 3	4	0	1	0	-0,5	1	0	0	0	0	0	0
0	slack 4	0	0	1	0	-0,5	0	1	0	0	0	0	0
0	slack 5	1,6	0	0,05	0	-0,025	0	0	1	0	0	0	0
0	slack 6	2,92	0	0,01	0	-0,005	0	0	0	1	0	0	0
0	slack 7	5,6	0	0,05	0	-0,025	0	0	0	0	1	0	0
0	slack 8	2	0	1	0	-0,5	0	0	0	0	0	1	0
0	slack 9	72	0	1	0	-0,5	0	0	0	0	0	0	1
	zj	24.000	3000	0	0	1500	0	0	0	0	0	0	0
	cj-zj		0	2.000	0	-1.500	0	0	0	0	0	0	0

Iteration table 3

Iteration 3													
0	slack 1	8	0	0	1	-1	0	-2	0	0	0	0	0
3000	X1	8	1	0	0	0,5	0	0	0	0	0	0	0
0	slack 3	4	0	0	0	0	1	-1	0	0	0	0	0
2000	X2	0	0	1	0	-0,5	0	1	0	0	0	0	0
0	slack 5	1,6	0	0	0	0	0	-0,05	1	0	0	0	0
0	slack 6	2,92	0	0	0	0	0	-0,01	0	1	0	0	0
0	slack 7	5,6	0	0	0	0	0	-0,05	0	0	1	0	0
0	slack 8	2	0	0	0	0	0	-1	0	0	0	1	0
0	slack 9	72	0	0	0	0	0	-1	0	0	0	0	1
	zj	24.000	3000	2000	0	500	0	2000	0	0	0	0	0

The final results obtained are as follows:

usaha donat Arsyila Bakery Solution					
	X1	X2		RHS	Dual
Maximize	3000	2000			
terigu	4	2	<=	40	0
kentang	2	0	<=	16	500
telur	1	1	<=	12	0
gula	1	1	<=	8	2000
ragi	,05	,05	<=	2	0
susu bubuk	,01	,01	<=	3	0
margarin	,05	,05	<=	6	0
air	1	1	<=	10	0
kapasitas produksi	1	1	<=	80	0
Solution->	8	0		24000	

Based on the results of optimization calculations using POM-QM, it was found that the production strategy that provides maximum profit is to produce 8 units of Potato Donuts and 0 units of Milk Donuts, so that the total daily profit achieved is IDR 24,000. Simplex analysis shows that Sugar and Potatoes are consumable resources (binding constraints) so they are the main limiting factors in the production process, while Flour, Eggs, and Yeast still have remaining. The economic value (shadow price) also indicates that Sugar has the greatest impact on increasing profits, because the addition of 1 kg of Sugar has the potential to increase profits by IDR 2,000, followed by Potatoes which provide an additional IDR 500 per kilogram. Thus, the Kyus Donut business should focus production on Potato Donuts, prioritize increasing Sugar stock as the most critical raw material, and re-evaluate the formula or profit margin of Milk Donuts so that it can contribute more optimally to total profits.

CONCLUSION

Based on the analysis of the Linear Program model using the Simplex Method in the case of donut production at Arsyila Bakery, several important findings can be concluded. This study successfully formulated the production problem into a measurable mathematical model and was able to determine the most efficient production strategy, so that the research objectives were achieved. The optimization results showed that the production combination that provides maximum profit is producing 8 units of Potato Donuts (x_2) and 0 units of Milk Donuts (x_2), with a total daily profit of Rp24,000. Constraint analysis identified that Sugar and Potatoes are consumable resources (binding constraints) and are the main limiting factors that determine the upper limit of profits. From an economic perspective, the shadow price value indicates that Sugar has the most significant impact on increasing profits, namely Rp2,000 for every additional 1 kg, making it the most critical raw material in the production process. These findings emphasize the importance of Sugar and Potato inventory management and the implementation of production strategies.

Thank You (Optional IF ANY)

The authors would like to thank HKBP Nommensen University, Pematangsiantar, for the support and funding provided for this research. They also extend their gratitude to all parties who assisted and contributed to the successful completion of this research.

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