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Optimizing MSMEs Profits using the Simplex Method

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ABSTRACT

This research aims to calculate the maximum profit from selling spinach chips, onion cakes and steak cakes at Guna Asih MSMEs and to determine the use of the simplex method for raw material constraints faced by Guna Asih MSMEs. In addition, this research uses POM-QM for Windows software to estimate the maximum profit obtained from each production of spinach chips, onion cakes and cystic cakes at Guna Asih UMKM so as to have an accurate estimate. This research method involves problem identification, selection of problem-solving models, data collection, data processing and analysis, model implementation, and evaluation of results.
The research results show that the simplex method can be used to determine maximum profits in Guna Asih MSMEs. The maximum profit obtained by MSMEs is IDR. 1,277,778 per day when only producing spinach chips (X1) 1.12 times more than previous production or 336 pcs and producing onion cakes (X2) 5 times more than previous production or 500 pcs. This profit is greater than the profit before optimization which only earned IDR. 900,000 from 300 pcs of spinach chips, 100 pcs of onion cakes and 60 pcs of steak cakes. Apart from that, the use of POM-QM for Windows software is very relevant in solving linear programming problems using the simplex method because it can help in completing maximum profit level calculations quickly, precisely and accurately.

Keywords: Linear programming; simplex method; MSMEs

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INTRODUCTION

MSMEs (Micro, Small and Medium Enterprises) play an important role in the Indonesian economy, especially at the regional level. MSMEs are able to survive the economic crisis and support the national economy. MSMEs also play a role in labor absorption. Therefore, it is important to empower MSMEs. MSMEs contribute more than 60% of Gross Domestic Product (GDP) and are able to absorb 97% of the workforce in Indonesia (Hamdani, 2020). Nevertheless, MSMEs in Indonesia still face various challenges in developing their businesses. One of the districts that has considerable MSME potential is Majalengka. According to data from the Majalengka Cooperative and MSME Office in 2022, there were around 12,450 MSME players spread across 26 sub-districts.

A fairly developed MSME in Majalengka is Guna Asih. Guna Asih, which is located in the Lamejajar Environment Rt 17 Rw 06, Cicenang Village, Cigasong District, Majalengka Regency, is one of the MSMEs engaged in the culinary field. Guna Asih MSMEs have been established for around 17 years and have MUI Halal certification. Some of the products in Guna Asih such as spinach chips, spinach chips are chips made from spinach leaves which are fried using flour that has been seasoned, spinach chips have a savory, crispy taste and fragrant aroma. Furthermore, onion cake products, onion cake is a type of traditional Indonesian cake made from wheat flour, eggs, and green onions, the characteristic of onion cake is that it has a crunchy and savory texture. And cystic cake products, cystic cake is a long-shaped snack and also has a crunchy texture. Products in Guna Asih have entered the Majalengka gift shop.

Guna Asih MSME produces various snacks such as spinach chips, onion cakes and cystic cakes. The time needed to produce spinach chips, onion cakes and cystic cake products is around 8 hours per day. The capacity required for raw materials is 50kg rice flour, 20kg starch, 100 eggs, 250 bunches of spinach and 5kg green onions. The profit per day obtained for spinach chips is IDR 500,000, for onion cakes IDR 200,000 and cystic fibers IDR 200,000. However, Guna Asih MSMEs have not made optimizations related to production volumes which have an impact on the level of profit. Therefore, a relevant method is needed to overcome these problems. One of the relevant methods related to this problem is the simplex method.

Linear programming is a mathematical model with decision variables, objective functions, and constraints that are linear. The use of linear programming in the MSME sector can help determine production quantities, selling prices, budget allocations, and other optimization aspects such as minimizing costs and maximizing profits (Rumetna et al., 2020; Susanto, 2020). Linear programming can help MSMEs plan product combinations and production volumes that can maximize profits by considering existing resource constraints. Linear program problems can be found in various fields and can help make decisions to choose the most appropriate alternative and the best solution (Rico et al., 2019). Recent research shows that the application of linear programming with the simplex method can help to optimize profits in small and medium industries (Livvy et al., 2023; Tamiza et al., 2023). In addition, the POM QM for windows method can also help in solving linear programming problems (Rusdiana & Istiono, 2023).

Based on this phenomenon and previous research, the purpose of this study is to calculate the maximum profit at Guna Asih MSMEs from the sale of spinach chips, onion cakes and cystic cakes and to find out the use of the simplex method on raw material constraints experienced by Guna Asih MSMEs. The results of this research are relevant to be applied to Guna Asih MSMEs in order to maximize their profits through production planning for spinach chips, onion cakes, and cystic cakes. The application of linear programs is expected to determine the right combination of products and daily production quantities for Guna Asih MSMEs. Thus, Guna Asih MSMEs can optimally utilize the availability of raw materials to increase their profits.

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LITERATURE REVIEW

Linear Programming

According to Chong & Zak (2008) linear programming models a situation where the administrator wants to maximize or minimize some linear objective with constraints in the form of linear inequalities or equations. It is a convex optimization problem that can be solved efficiently. According to Dantzig (2002), linear programming is an optimization problem that involves linear functions with linear constraints. It aims to find the maximum or minimum point of a function with linear constraints (linear limits). Linear programming is widely used for resource optimization with certain constraints in various fields. Linear programming is a mathematical method of allocating scarce resources to achieve a single goal such as maximizing profits and minimizing costs (Mulyono, 2017). These limited resources if in one industry or company include all factors of production such as machinery, labour, raw materials, capital, technology and information (Syaifuddin, 2011).

Linear programming is a mathematical method for solving real variable selection problems to determine maximum and minimum functions. Three main components comprise a linear program. First, the objective function must be constrained or optimized. Second, constraints that must be met by the solution are created. Third, the decision variables of the problem (Taha, 2007). The purpose of using linear programming is to develop a model that can be used to assist decision making in determining the optimal allocation of company resources to various alternatives. The allocations made depend on the available resources and the demand for these resources. Meanwhile, the aim of allocation is to maximize profits or minimize costs (Meflinda & Mahyarani, 2011). This means that linear programming is a mathematical method with linear characteristics for finding an optimal solution by maximizing or minimizing the objective function against a set of constraints.

The linear method contains three points: (1) Decision variables, which are problem variables that will affect the value of the goal to be achieved; (2) Objective function, which is the goal to be achieved that must be realized into a linear mathematical function; (3) Functional constraints, which are management facing various constraints to realize its goals.

1. Decision variables, are variables whose values are selected for decision making. This variable is generally denoted by $X_1, X_2, ..., X_n$.
2. Objective function, is the function to be optimized (maximized or minimized). The objective function is denoted by Z with the formulation $\mathbf{Z = f (X_1, X_2, ..., X_n)}$.
3. Constraints, are restrictions that must be met. If the objective function is to maximize then the constraint function is $g_i (X_1, X_2, ..., X_n) \leq b_i$. However, if the objective is to minimise then the constraint becomes $g_i (X_1, X_2, ..., X_n) \geq b_i$.

Simplex Method

Linear programming problems can be solved through two methods, namely the graph method and the simplex method. The graph method uses a graphical approach in determining the optimum decision variable value but is only limited to two decision variables. While for two or more decision variables can use the simplex method where this method uses a simplex table approach as a determinant of the optimum decision variable value obtained by iterating repeatedly on the simplex table until the optimum value is found. To solve linear programming problems, this research will use the simplex method.

The simplex method is more efficient and equipped with a test-criteria that can tell when the count should be stopped and when to continue until an optimal solution is obtained (maximum profit, maximum revenue, maximum cost). In general, tables are used, from the first table that provides an initial basic feasible solution to the last solution that provides the optimal solution (Aini et al., 2021).

According to Hillier & Lieberman (2013), the steps in the simplex method are:

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1. Develop a mathematical model of a linear programming problem consisting of an objective function and a constraint function.
2. Convert the constraint inequality into standard/canonical form.
3. Create an initial simplex table consisting of base and non-base variables.
4. Perform iteration by calculating the Zj-value (objective function), selecting the entry variable, calculating the ratio, selecting the exit variable, and updating the table.
5. Iteration is stopped if it has reached the optimum solution. The optimum solution can be maximum or minimum.

POM QM For Windows

The QM for Windows program is a package of computer programs that focuses on operational research, quantitative methods, and problem solving. DS and POM for Windows were previously combined into QM for Windows. QM for Windows has more modules than the POM for Windows program. However, some modules are only available in the POM or DS for Windows programs, and are not available in QM (Effendy, 2022).

The stages of working on linear programming with the Graph method using POMQM software are as follows:

1. Click the POM-QM icon on the computer desktop
2. Click the module and select linear programming
3. Click new
4. Fill in the number of constraint functions in Number Of Constraints
5. Fill in the number of variables in Number Of Variables
6. Click Ok
7. Change the contents according to the constraint function
8. Input Maximize according to the objective function
9. Input based on each constraint function
10. Input based on the number of constraints
11. Click solve

METHODS

This research includes a survey using a quantitative approach. The data source used is primary data obtained directly through interviews with the owners of Guna Asih MSMEs. The interview can be carried out on Saturday 20 January 2024. The data taken and the information obtained are in the form of raw material inventory and sales of spinach chips, onion cakes and cystic cakes. The observation process carried out is to see the inventory of raw materials in the warehouse, the production process of making spinach chips, onion cakes and cystic cakes and the marketing process. Data processing and analysis using the simplex method in Linear Programming manually and using POM-QM software for windows. Then linear program modeling is done by identifying decision variables, objective functions and constraint functions. Finally, evaluating the results is done by analyzing the results of the analysis of the use of simplex method in linear programming generated through POM-QM for windows software (Aini et al., 2021; Rumetna et al., 2020; Rusdiana & Istiono, 2023; Sari et al., 2020).

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RESULTS AND DISCUSSION

Based on the results of interviews with MSME owners, it was found that the Guna Asih MSME produces three types of products, namely Spinach Chips, Onion Cake and Cystic Cake using raw materials of rice flour, starch, eggs, spinach and spring onions. In one production day, Guna Asih MSMEs can produce 300 pcs of spinach chips with a profit of Rp. 500,000, to produce 100 pcs of onion cakes with a profit of Rp. 200,000, and produce 60 pcs of cystic cake with a profit of Rp. 200,000. The raw materials needed to produce spinach chips, onion cakes and cystic fibre can be seen in Table 1.

Table 1. Allocation of Raw Material

No	Materials	Allocation of raw material			Capacity
		Spinach Chips (X_1)	Cake Onions (X_2)	Cystic Cake (X_3)	
1	Rice Flour	20 kg	7 kg	7 kg	50 kg
2	Strach Flour	12 kg	1 kg	2 kg	20 kg
3	Eggs	45 pcs	15 pcs	22 pcs	100 pcs
4	Spinach	200 bunch	-	-	250 bunch
5	Chives	-	1 kg	1 kg	5 kg
	Profits (IDR)	**500.000**	**200.000**	**200.000**	

Source: Primary data, 2024

Based on Table 1, it can be seen that the objective function in the problem is profit maximization. Therefore, the objective function can be formulated as follows:

$$Z_{max} = 500{,}000\ X1 + 200{,}000\ X2 + 200{,}000\ X3$$

While the formulation for the constraint function is:

Rice flour : $20\ X1 + 7\ X2 + 7\ X3 \leq 50$
Starch flour : $12\ X1 + X2 + 2\ X3 \leq 20$
Egg : $45\ X1 + 15\ X2 + 22\ X3 \leq 100$
Spinach : $200\ X1 + X2 + X3 \leq 250$
Chives : $X1 + X2 + X3 \leq 5$

Testing Optimization Results Using POM-QM For Windows Software

In order to be more efficient, information technology is used in the form of POM-QM for windows tools as well as testing the results obtained previously. The following are the steps of solving a linear programming with the simplex method using POM-QM for windows software.

Objective
(•) Maximize
( ) Minimize

Guna Asih

	X1	X2	X3		RHS	Equation form
Maximize	500000	200000	200000			Max 500000X1 + 200000X2 + 200000X3
Rice Flour	20	7	7	<=	50	20X1 + 7X2 + 7X3 <= 50
Strach Flour	12	1	2	<=	20	12X1 + X2 + 2X3 <= 20
Eggs	45	15	22	<=	100	45X1 + 15X2 + 22X3 <= 100
Spinach	200	0	0	<=	250	200X1 <= 250
Chives	0	1	1	<=	5	X2 + X3 <= 5

Note: X1= Spinach Chips, X2= Cake Onions, X3= Cystic Cake
Source: POM-QM for windows, 2024

Figure 1. Data Entry into POM QM for windows

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After completing the data input, the next step is to select the solve button and then select the Iterations menu. Then the solution to the liner programming problem with the simplex method will be obtained as follows:

Objective
Maximize
Minimize

Guna Asih Solution

Cj	Basic Variables	Quantity	500000 X1	200000 X2	200000 X3	0 slack 1	0 slack 2	0 slack 3	0 slack 4	0 slack 5
Iteration 1										
0	slack 1	50	20	7	7	1	0	0	0	0
0	slack 2	20	12	1	2	0	1	0	0	0
0	slack 3	100	45	15	22	0	0	1	0	0
0	slack 4	250	200	0	0	0	0	0	1	0
0	slack 5	5	0	1	1	0	0	0	0	1
	zj	0	0	0	0	0	0	0	0	0
	cj-zj		500.000	200.000	200.000	0	0	0	0	0
Iteration 2										
0	slack 1	25	0	7	7	1	0	0	-0,1	0
0	slack 2	5	0	1	2	0	1	0	-0,06	0
0	slack 3	43,75	0	15	22	0	0	1	-0,225	0
500000	X1	1,25	1	0	0	0	0	0	0,005	0
0	slack 5	5	0	1	1	0	0	0	0	1
	zj	625.000	500000	0	0	0	0	0	2500	0
	cj-zj		0	200.000	200.000	0	0	0	-2.500	0
Iteration 3										
0	slack 1	4,5833	0	0	-3,2667	1	0	-0,4667	0,005	0
0	slack 2	2,0833	0	0	0,5333	0	1	-0,0667	-0,045	0
200000	X2	2,9167	0	1	1,4667	0	0	0,0667	-0,015	0
500000	X1	1,25	1	0	0	0	0	0	0,005	0
0	slack 5	2,0833	0	0	-0,4667	0	0	-0,0667	0,015	1
	zj	1.208.333...	500000	200000	293333,3	0	0	13333,33	-500	0
	cj-zj		0	0	-93.333,3...	0	0	-13.333,3...	500,0	0
Iteration 4										
0	slack 1	3,8889	0	0	-3,1111	1	0	-0,4444	0	-0,3333
0	slack 2	8,3333	0	0	-0,8667	0	1	-0,2667	0	3,0
200000	X2	5	0	1	1	0	0	0	0	1,0
500000	X1	0,5556	1	0	0,1556	0	0	0,0222	0	-0,3333
0	slack 4	138,8889	0	0	-31,1111	0	0	-4,4444	1	66,6667
	zj	1.277.777...	500000	200000	277777,8	0	0	11111,11	0	33333,33
	cj-zj		0	0	-77.777,7...	0	0	-11.111,1...	0	-33.333,3...

Source: POM-QM for Windows, 2024

Figure 2. Iteration of Production Data

Based on Figure 2, solving linear programming problems with the simplex method in accordance with the conditions that occur in the Guna Asih MSMEs, it is obtained that at iteration-4 it has shown an optimal point. Then, to find out the maximum profit and the number of products that must be produced can be seen in Figure 3 below:

Objective
Maximize
Minimize

Guna Asih Solution

	X1	X2	X3		RHS	Dual
Minimize	500000	200000	200000			
Rice Flour	20	7	7	<=	50	0
Strach Flour	12	1	2	<=	20	0
Eggs	45	15	22	<=	100	11111,11
Spinach	200	0	0	<=	250	0
Chives	0	1	1	<=	5	33333,33
Solution	,56	5	0		1277778,0	

Note: X1= Spinach Chips, X2= Cake Onions, X3= Cystic Cake
Source: POM-QM for windows, 2024

Figure 3. Problem Solving Solution

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The analysis results show that the application of Linear Program using POM-QM for windows software can help Guna Asih MSMEs in calculating the maximum profit from the limited raw materials they have because it is fast, precise and accurate (efficient).

Based on Figure 3, the results show that Guna Asih MSMEs will get maximum profit of Rp. 1,277,778 per day when only producing spinach chips (X1) 1.12 times more than the previous production or 336 pcs and producing onion cakes (X2) 5 times more than the previous production or 500 pcs.

CONCLUSION

Based on the results of the linear programming analysis through the simplex method at UMKM Guna Asih, optimal results were obtained. This means that with limited raw materials, the simplex method can be used to determine the maximum profit of product sales at UMKM Guna Asih. The maximum profit obtained by UMKM Guna Asih is Rp. 1,277,778 per day when only producing spinach chips (X1) 1.12 times more than the previous production or 336 pcs and producing onion cakes (X2) 5 times more than the previous production or 500 pcs. The profit is greater than the profit before optimization which only earned Rp. 900,000 from 300pcs of spinach chips, 100pcs of onion cakes and 60pcs of cystic cake. In addition, the use of POM-QM for windows software is very relevant in solving linear programming problems with the simplex method because it can help in completing the calculation of the maximum profit level quickly, precisely and accurately.

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