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Optimization of Chocolate Drink Production at MSMEs Grah Indonesia using The Simplex Method

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ABSTRACT

Micro, small, and medium enterprises (MSMEs) play an important role in economic growth in various regions of Indonesia. MSME Grah Indonesia produces chocolate drinks with three products, namely grass jelly cappuccino, taro, and chocolate pop ice. The weaknesses of the MSME Grah Indonesia include limited management capabilities, capital, technology, market access, technical and non-technical costs in the field that are difficult to avoid. The study aimed to maximize the production profit of SMEs Grah Indonesia and determine the optimal number and types of beverage products using the simplex method. The simplex method can be used to maximize or minimize based on the constraint function or available resources. The results shows that the profit of the contemporary chocolate drink production of MSMEs Grah Indonesia is IDR 2,000,000 per month, with a total production of 200 cups of grass jelly cappuccino (X_1), 67 cups of taro (X_2), and 400 cups of chocolate pop ice (X_3). The raw materials needed to produce contemporary chocolate drinks at MSME Grah Indonesia are 20 kg of sugar, 10 liters of sweetened condensed milk, 200 sachets of cappuccino powder, 2 kg of taro powder, 400 sachets of chocolate pop ice powder, and grass jelly 10 kg.

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Introduction

MSME Grah Indonesia is a unit of Micro, Small, and Medium Enterprises (MSMEs) producing various types of contemporary chocolate drinks. There are several types of beverages produced, including: cappuccino grass jelly, taro, and chocolate pop ice. Conditions of increasingly fierce market competition, require producers to adjust product attributes to consumer needs in order to compete, including chocolate drink products produced by MSMEs Grah Indonesia. MSME Grah Indonesia as a business unit that wants to develop, of course, must pay attention to customer buying interest in the products produced and must be able to provide goods or services of high value to its customers.

There are several weaknesses of MSMEs in Indonesia, including: management, organization, technology, capital, operational and technical fields in the field, limited market access, licensing constraints, and non-technical costs in the field that are difficult to avoid (Lestari, 2013). Therefore, MSME business actors also need to know precisely about the various costs and benefits (profits) that can be generated from running the business. Frequently, business actors (small traders) have not been able to estimate the amount of raw material needed to meet their production needs, let alone have several types of products produced. So far, the business actor, the Grah Indonesia, providing raw materials for beverages are not based on prior calculations, so it is not uncommon for these traders to not be able to utilize all the raw materials that are already available, or even must throw away the remaining raw materials because they have expired. In addition, the supply of excess raw materials can also result in the amount of production costs needed to be greater.

Linear programming is a mathematical method of allocating limited resources to achieve a goal such as maximizing profits and minimizing costs (Ma et al., 2012). Linear programming is a mathematics that consists of a linear objective function with some linear constraints (Siringoringo, 2005). The objective function, which depends on a few input variables, is used to direct the analysis to detect the purpose of the problem formulation, while the constraint function is to determine the available resources and the demand for these resources. The formulation of the objective function is divided into 2 categories, i.e., maximizing or minimizing the desired variables, such as: maximizing product profits, maximizing the amount of production, minimizing production costs, minimizing losses, etc.

Linear programming is a technical analysis of the operational research group with the aim of finding, selecting, and determining the best alternative from among the alternatives using the graphical method and the simplex method (Agustina et al., 2017); (Rofatin B dan Sumarsih, 2020). In general, the graphical method can only be used to solve linear programming problems that have 2 variables, while the simplex method is designed to solve linear programming problems that have 2 or more variables. Thus, in the real world with complex problems and variables, the application of the simplex method is more widely used.

The application of linear programming in the form of graphical methods and simplex methods is used to optimize the objective function with limited resource factors as a function of constraints, such as labor, raw materials, machine working hours, etc. (Zenis et al., 2018). The implementation of the linear programming method is widely used in various problems (Susdarwono, 2020), including: public transportation, private and state industrial activities, and other resource allocation problems, including the use of agricultural land (Mellaku et al., 2018); (Dimyati, Tjuju T. dan Dimyati, 2002) (Wu & Ge, 2012).

This study aims to maximize the production profit of MSME Grah Indonesia and determine the number and types of beverage products that are feasible to be produced optimally using linear programming.

Materials and Methods

Research procedures

The research was conducted in one of the fast-food beverages MSMEs located in Gampong Meunasah Lamlhom, Lhoknga Sub-district, Aceh Besar District. The research was conducted using a qualitative descriptive approach, which aims to describe and interpret the solution of linear programming using the simplex method related to the problem of optimizing the amount of production of various types of beverages produced by SMEs of Indonesian Grah Culinary Beverages.

Linear Programming is an optimization technique to find a solution of an objective function which is linear in form of resources which are also linear and limited. Generally, the constraints contained in linear programming problems are translated first into a mathematical formulation. The mathematical model used to express a linear programming problem is as follows:

Objective function:

$$Z \max / \min = \sum_{j=1}^{n} cj.xj \quad \text{.....(1)}$$

Constraint functions:

$$\sum_{j=1}^{n} a_{ij}\, x_j \leq b_i, \text{ or} \quad \text{.....(2)}$$

$$\sum_{j=1}^{n} a_{ij}\, x_j = b_i, \text{ or} \quad \text{.....(3)}$$

$$\sum_{j=1}^{n} a_{ij}\, x_j \leq b_i, \quad \text{.....(4)}$$

$$X_j \geq 0, \text{for } j = 1, 2 \ldots \ldots n$$

Data Collection Methods

The data obtained in the study were based on the results of experiments, calculations, and preliminary analyzes that had been carried out previously, so that the data on raw materials, profit selling prices of beverages, and the amount of availability of raw materials were obtained. There are 3 types of beverages produced by this hawker beverage business, which are called cappuccino *cincau* (grass jelly), taro, and chocolate pop ice. The types and amounts of raw materials needed to produce the three types of beverages vary. The three types of beverage products are estimated to provide a profit of IDR 3000 per cup. In general, the availability and need for the number and type of raw materials for each type of beverage produced by modern snack MSMEs are as shown in Table 1. Based on the standard rules that apply in the analysis of the simplex method, an objective function, 3 (three) variables and 6 (six) the function of the constraints on the problems to be studied were formed, namely: the objective function is maximizing the profit of the contemporary chocolate drink production of MSME Grah Indonesia (Z max); 3 (three) variable types of products produced, namely: Cappuccino *Cincau* Drink (X_1), Taro Drink (X_2), and Chocolate Pop Ice Drink (X_3); 6 (six) constraint functions as a limiting factor, namely: granulated sugar (constraint 1), sweetened condensed milk (constraint 2), cappuccino powder (constraint 3), Taro powder (constraint 4), pop ice powder chocolate (constraint 5) and grass jelly (constraint 6).

Table 1. Average availability and needs of raw materials for production of contemporary chocolate drinks MSMEs Grah Indonesia

No.	Raw materials	Unit	Raw material requirements per cup/serving			Availability of raw materials per month
			Cappuccino *cincau* (gelatin)	Taro	Pop Ice Coklat	
1.	Sugar	gram	75	50	75	20.000
2.	Milk	ml	25	75	-	15.000
3.	Cappuccino powder	sachet	1	0	0	240
4.	Taro powder	gram	-	25	-	10.000
5.	Pop ice powder	sachet	-	-	1	400
6	*Cincau* (grass jelly)	gram	25	-	-	10.000

Based on the data as shown in Table 1, the following mathematical equations were obtained:

Objective function:

$$\text{Max } Z = 3000\, X_1 + 3000\, X_2 + 3000\, X_3 \quad \text{.....(5)}$$

Constraint functions:

$$75\, X_1 + 50\, X_2 + 75\, X_3 \leq 20.000 \quad \text{.....(6)}$$

$$25\, X_1 + 75\, X_2 \leq 10.000 \quad \text{.....(7)}$$

$$X_1 \leq 240 \quad \text{.....(8)}$$

$$25\, X_2 \leq 10.000 \quad \text{.....(9)}$$

$$X_3 \leq 400 \ldots\ldots\ldots\ldots \quad \text{.....(10)}$$

$25\ X_1 \leq 5000$…….....(11)

The objective function and the constraint functions (equations 5-11) are in accordance with the rules of the simplex method and the calculation process based on these equations has been carried out. Data analyses were carried out using Operation Management Quantity Management (POM QM) software version 5, with the aim of obtaining the maximum profit results from the MSME business of Grah Indonesia. Thus, after the simplex analysis were complete, conclusions could be drawn based on the optimal solution obtained and could later be applied to MSMEs Grah Indonesia.

Results and Discussion

The stages of the optimization process and the optimization results of the simplex method with the aim of optimizing the profit of modern chocolate drink production of MSMEs Grah Indonesia using Operation Management Quantity Management (POM QM) software version 5 as shown in Table 2 and Table 3. The maximum profit generated by MSMEs Grah Indonesia is about IDR 2,000,000 per month with the production of cappuccino grass jelly (X_1) as many as 200 cups, taro (X_2) as many as $66.67 \approx 67$ cups, and pop ice chocolate (X_3) as many as 400 cups. Furthermore, the information obtained were that:

1. The profit obtained by the cappuccino *cincau* variant drink per unit is IDR 3,000, so by producing as much as 200 cups. The profit earned is IDR 600,000.00.
2. The profit obtained by the Taro variant drink per unit is 3000, so by producing as many as 67 cups. The profit earned is IDR 201,000.00.
3. The profit obtained by the chocolate pop ice variant drink per unit is 3000, so by producing as many as 400 cups. The profit earned is IDR 1,200,000.00.

Table 2. Stages of optimizing the production profit of MSME Grah Indonesia using the simplex method

Cj	Basic Variables	Quantity	3000 X1	3000 X2	3000 X3	0 slack 1	0 slack 2	0 slack 3	0 slack 4	0 slack 5	0 slack 6
Iteration 1											
0	slack 1	20,000	25	75	25	1	0	0	0	0	0
0	slack 2	10,000	25	75	0	0	1	0	0	0	0
0	slack 3	240	1	0	0	0	0	1	0	0	0
0	slack 4	10,000	0	25	0	0	0	0	1	0	0
0	slack 5	400	0	0	1	0	0	0	0	1	0
0	slack 6	5,000	25	0	0	0	0	0	0	0	1
	zj	0	0	0	0	0	0	0	0	0	0
	Cj - zj		3,000	3,000	3,000	0	0	0	0	0	0
Iteration 2											
0	slack 1	15,000	0	75	25	1	0	0	0	0	-1
0	slack 2	5,000	0	75	0	0	1	0	0	0	-1
0	slack 3	40	0	0	0	0	0	1	0	0	-0.04
0	slack 4	10,000	0	25	0	0	0	0	1	0	0
0	slack 5	400	0	0	1	0	0	0	0	1	0
3000	X1	200	1	0	0	0	0	0	0	0	0.04
	zj	600,000	3000	0	0	0	0	0	0	0	120

	Cj - zj		0	3,000	3,000	0	0	0	0	0	-120
Iteration 3											
0	slack 1	10,000	0	0	25	1	-1	0	0	0	0
3000	X2	66.6667	0	1	0	0	0.013	0	0	0	-0.013
0	slack 3	40	0	0	0	0	0	1	0	0	-0.04
0	slack 4	8,333.33	0	0	0	0	-0.33	0	1	0	0.333
0	slack 5	400	0	0	1	0	0	0	0	1	0
3000	X1	200	1	0	0	0	0	0	0	0	0.04
	zj	800,000	3000	3000	0	0	40	0	0	0	80
	Cj - zj		0	0	3,000	0	-40	0	0	0	-80
Iteration 4											
3000	X3	400	0	0	1	0.04	-0.04	0	0	0	0
3000	X2	66.6667	0	1	0	0	0.013	0	0	0	-0.013
0	slack 3	40	0	0	0	0	0	1	0	0	-0.04
0	slack 4	8,333.33	0	0	0	0	-0.333	0	1	0	0.333
0	slack 5	0	0	0	0	-0.04	0.04	0	0	1	0
3000	X1	200	1	0	0	0	0	0	0	0	0.04
	zj	2,000,000	3000	3000	3000	120	-80	0	0	0	80
	Cj - zj		0	0	0	-120	80	0	0	0	-80
Iteration 5											
3000	X3	400	0	0	1	0	0	0	0	1	0
3000	X2	66.6667	0	1	0	0.013	0	0	0	-0.333	0.013
0	slack 3	40	0	0	0	0	0	1	0	0	-0.04
0	slack 4	8,333.33	0	0	0	-0.333	0	0	1	8.333	0.333
0	slack 2	0	0	0	0	-1	1	0	0	25	0
3000	X1	200	1	0	0	0	0	0	0	0	0.04
	zj	2,000,000	3000	3000	3000	40	0	0	0	2000	80
	Cj - zj		0	0	0	-40	0	0	0	-2,000	-80

In addition to the maximum profit and the number of beverages produced for each type of product, it is also known that there are several excess resources, including the cappuccino powder resources of 40 sachets, and taro powder of 8333.33 grams, while for other various resources are completely used up, as shown in the Table 4. Availability of resources in the form of raw materials for granulated sugar, sweetened condensed milk, *cincau* (grass jelly), and chocolate pop ice powder are used up and all of them can be utilized properly, while the availability of resources or raw materials for cappuccino powder and taro powder has not been fully utilized.

Table 3. Results of optimizing the profits of contemporary chocolate beverage products of MSMEs Grah Indonesia

	X_1	X_2	X_3		RHS
Maximize	3000	3000	3000		
Constraint 1	25	75	25	< =	20000
Constraint 2	25	75	0	< =	10000
Constraint 3	1	0	0	< =	240

Constraint 4	0	25	0	< =	10000
Constraint 5	0	0	1	< =	400
Constraint 6	25	0	0	< =	5000
Solution =>	200	66.67	400		2000000

Table 4. Optimum variables from the simplex method analysis

Variable	Status	Value
X1	Basic	200
X2	Basic	66.67
X3	Basic	400
slack 1	NON Basic	0
slack 2	Basic	0
slack 3	Basic	40
slack 4	Basic	8333.33
slack 5	NON Basic	0
slack 6	NON Basic	0
Optimal Value (Z)		2000000

However, in real conditions, this is not the case. The status of excess resources often changes every month, and it is common to sometimes have to throw away the remaining raw materials because they have expired, as well as the profits obtained so far < IDR 2,000,000.00 per month. MSME Grah Indonesia conducts this trading business on average 20 days per month. Therefore, if the results of this optimization are applied, the number of contemporary chocolate drink productions per day are 10 cups of grass jelly cappuccino, 3-4 cups of taro, and 20 cups of chocolate pop ice. This condition should require further market analysis, considering what products are preferred by buyers. This is in accordance with the statement of Nurrahman and Fikriah (2017) which stated that the quantity of market demand and consumer purchasing power greatly affects the sale of a product.

Optimization of the amount of production of a product is an important point in a business, but optimization of production can be carried out properly if the amount of production is in accordance with the number of requests. This is in line with the statement that if the number of requests from consumers can be clearly identified (fixed), then the company will know the number of products that must be produced (Nuryana, 2019). In addition, production optimization is needed by companies in order to optimize the resources used, so that a production can produce products in the expected quantity and quality (Andini & Slamet, 2016).

If the application of the optimization results of the simplex method to the production benefits of MSMEs Grah Indonesia can be carried out, it is necessary to re-determine the amount of raw material purchases according to the optimization results as shown in Table 4. There is an excess supply of cappuccino powder and taro powder, namely: 40 sachets of excess cappuccino powder and taro powder excess as much as 8,333 grams ≈ 8.3 kg.

The results of optimizing production profits produce several alternative decisions that can be implemented, including:

1. Implement the resulting optimal solution, in order to obtain the maximum profit according to the optimization results (IDR 2,000,000 per month). The optimization results show that the required cappuccino powder and taro powder are 200 sachets per month and 1,667 grams or 1.67 kg ≈ 2 kg per month respectively. Reducing the supply of cappuccino powder and taro powder can reduce raw material costs and production costs.
2. Make changes to product selling prices, so that the amount of profit for each product per cup is also different. this needs to be done because the amount of raw materials and production costs for each type of drink that is sold varies. So it is necessary to determine the new selling price, in accordance with the needs of the resulting production costs. For example, the selling price of taro products (X_2) is higher than grass

jelly or grass jelly cappuccino products (X_1) and the selling price of chocolate pop ice (X_3) is cheaper than the other products.

Conclusions

The results of optimizing the profit of modern chocolate drink production of MSMEs Grah Indonesia were obtained in the amount of IDR 2,000,000 per month, with a total production of 200 cups of grass jelly cappuccino, 67 cups of taro and 400 cups of chocolate pop ice. The number of raw materials needed to produce contemporary chocolate drinks at MSME Grah Indonesia are: 20 kg of sugar, 10 liters of sweetened condensed milk, 200 sachets of cappuccino powder, 2 kg of taro powder, 400 sachets of chocolate pop ice powder, and 10 kg of grass jelly There is an excess supply of cappuccino powder and taro powder, namely: 40 sachets of excess cappuccino powder and taro powder excess as much as 8,333 grams ≈ 8.3 kg. These are much better than the real conditions that have occurred so far, where the status of the resource often changes with the profit obtained < IDR 2,000,000.00 per month.

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