Optimization of production planning for food and beverage MSMEs: case in the covid-19 pandemic

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Abstract. *Micro, Small, and Medium Enterprises (MSMEs) in the food and beverage sector is one of the sectors negatively affected by the COVID-19 outbreak, even though this sector is one of the largest contributors to the Gross Domestic Product of the non-oil and gas industry in Indonesia. This study intends to provide an overview of solutions in the form of case studies on the Mahkota Caman MSME in Bekasi, Indonesia, which experienced a decline in sales during the pandemic, resulting in overstock and damage to non-durable raw materials. As a result, it leads to an increase in inventory costs and even a loss of sales. The solution offered by this study is an optimization of production planning, namely determining what products and how many of these products should be produced in a certain period. The method used is goal programming, both with and without priority, so that Mahkota Caman can meet consumer demands, and minimize production costs, while minimizing the purchase of raw materials. The results of this study indicate that the optimal optimization method used by Mahkota Caman is goal programming with priority because it provides a more efficient solution to production costs and the purchase of raw materials. Based on the results of this study, it is recommended that optimization methods be used by MSMEs in the food and beverage sector during a pandemic, and to avoid using only feeling in production planning.*

Keywords: covid-19, goal programming, food and beverage, optimization, production planning.

1. Introduction

The growth of Micro, Small, and Medium Enterprises (MSMEs, or in Indonesia called *Unit Usaha Kecil Menengah,* UMKM) has a significant effect on economic growth in Indonesia (Halim, 2020). To date, there are a total number of 64,194,057 units of MSMEs in Indonesia, or in other words, 99.99% of the total business units in Indonesia are considered as MSMEs, and they contributed up to Rp. 8,573.9 trillion (57.8%) of Indonesia's Gross Domestic Product (GDP) (Kementerian Koperasi, Usaha Kecil dan Menengah, 2018). Around 60% of the MSMEs, or 1.9 million units, are categorized as small and micro-scale food and beverage sector, which is equivalent to 99.6% of the entire food and beverage manufacturing industry in Indonesia. The food and beverage sector is the largest contributor to the GDP of the non-oil and gas industry (Kemenperin, 2017; Nugeroho et al.,).

Since 2019, there were approximately 3,322 cooperatives and 185,184 MSMEs affected by the Covid-19 outbreak, and the business sector most affected was the food and beverage sector: some of them experienced declining sales (56%), lack of capital (22%), delays in product distribution (15%), and difficulty in attaining raw materials (4%) (KemkopUKM, 2020, Setiawan, 2020). Various industrial sectors, including the culinary business, experienced disruptions such as decreases in raw material supply and product demand, labor shortages, and business uncertainties (Ezizwita & Sukma, 2021). Culinary businesses over the world have been forced to temporarily close their businesses or even go bankrupt (Septiningrum, 2021).

One of the MSMEs affected by COVID-19 is Mahkota Caman Restaurant located in Bekasi City, Indonesia. Based on the interview conducted by the researchers in 2021, Mahkota Caman also experienced a decrease in income just like other culinary businesses despite being the only restaurant that provides Indonesian specialties in its area adjacent to residential housing. The decline in income occurred due to a decrease in the level of sales and demand. Since the occurrence of Covid-19, Mahkota Caman has only been able to provide 50% of the total capacity for dine-in and only operates from 11.00 AM to 08.00 PM due to the policy of limiting capacity and business operating hours by the government. This condition is exacerbated by the habit of restaurant employees who have been forecasting sales only by guessing or by feeling.

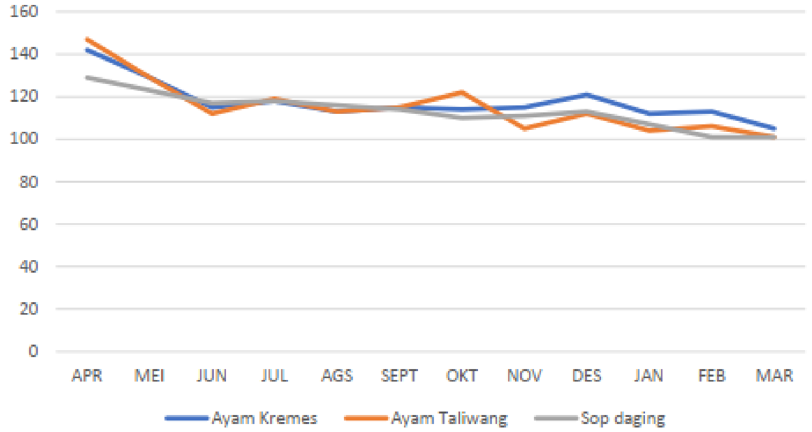

Figure 1 Sales of Ayam Kremes, Ayam Taliwang, and Sup Daging of Mahkota Caman.

Figure 1 presents sales data in in April 2020 - March 2021 for the three most popular menus: ayam kremes (fried chicken with crispy flakes), ayam taliwang (spicy grilled chicken), and sup daging (meat or beef soup). It can be seen that there was a downward trend in sales for the three menus during the 12 months period of time. This sales decline may lead to overstock, or in other words, excessiveness of raw materials. Overstock can be detrimental because some production materials can expire, especially if the raw materials are perishable food ingredients. Every month in April 2020 to March 2021, Mahkota Caman experiences an excess of 3 to 27 servings of meat raw materials, including chicken, beef soup, catfish, empal, beef ribs, and tilapia can be seen in Figure 2.

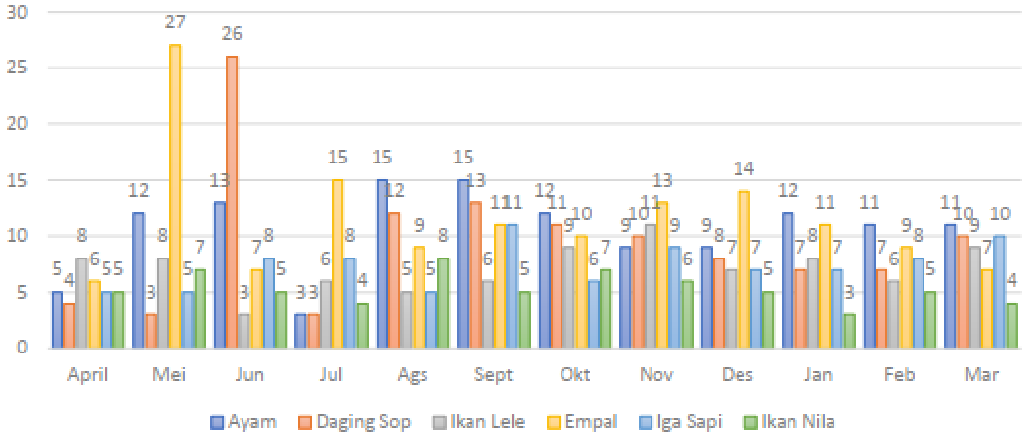

Figure 2 Mahkota Caman Raw Materials Overstock in April 2020 – March 2021.

The problems experienced by Mahkota Caman SMEs can be overcome if there is proper production planning. Production planning is a sequence of steps that aims to ensure that raw materials will be available in the specified period with the right amount in order to save production costs. It is important for a company to know the right amount of input variation in terms of time and quantity, as well as to make efficient use of these inputs so that the company knows accurately how much product they have to produce (Vincent et al., 2018).

Goal Programming is a continuation of the linear programming method (Onuoha, 2013). Linear programming itself is a mathematical model that explains the problem of optimization limitations (Stevenson, 2018). Goal programming can be defined as a method that is able to solve problems by minimizing deviations from various goals to be achieved by using deviational variables (Onuoha, 2013). The end result of goal programming is a solution that is closest to the desired goal because it is not always possible to fully achieve every goal. Nafisah et al. (2016) explain that there are two types of goal programming models, namely (1) non-preemptive goal programming which is a model where weights are used to compare the importance of goals and (2) preemptive goal programming which uses priorities to state the importance of the goal. Kumar (2019) then proposes a new model that combines priorities and weights into a single-goal programming model called weighted priority goal programming. Using weights and priorities, the goal of this model is to minimize underachievement, overachievement, or both (Fowdur et al., 2018).

Goal programming has several elements. First, there is an objective function that can be formulated depending on the objective, whether using weights and/or priorities. In determining the objective function, an element of objective constraint is needed which is the deviation in the calculation. There are several types of deviation variables depending on the achievement of goals. Prasad & Reddy (2018) proposes that the achievement of goals can be divided into three, namely minimization of underachievement, minimization of overachievement, and minimization of underachivement and overachievement. The non-negative element means that the variables contained in a goal programming are greater than or equal to zero (Oey et al., 2020). Finally, there are structural or environmental constraints related to the goals to be achieved in goal programming (Abideen & Mohamad, 2020). There are several steps to formulate a goal programming: (1) determining the decision variables, (2) stating the constraints, (3) determining the priorities and weights, (4) stating the objective functions, and (5) stating the non-negative constraints (Yuliani & Pujiyanta, 2014).

Forecasting is the basis of operations management decision-making processes which provides information on future demand and aims to adjust supply and demand (Stevenson, 2018). Forecasts can be classified based on the time horizons they cover. Short-term forecasting is used if a company forecasts in a time span of up to one year (generally less than three months), e.g. in purchasing planning, job scheduling, labor levels, job assignments, and production levels (Heizer et al., 2017). A short-term forecasting is used in the case of Mahkota Caman that determines the amount of production each week. Forecasting can be done using two approaches – quantitative and qualitative – but this study uses a quantitative approach that utilizes mathematical models based on historical data or the development of associative models that show causal variable relationships to make forecasts (Taufik et al., 2021). Specifically, the type of quantitative forecasting used is exponential smoothing with trend adjustment, which is used when a trend is seen (Heizer, et al., 2017).

There is no single best forecasting method, but it is important to consider the accuracy of the forecasting method (Heriansyah, 2018; Singh et al., 2019; Qadafi et al., 2022). Measuring the level of forecast error in the forecasting model is done by comparing the forecast value and the actual value. Some of the most commonly used measures to measure the overall forecast error are (1) Mean Absolute Deviation (MAD) which is calculated by dividing the absolute number of Forecast Errors by the number of data periods (n), (2) Mean Squared Error (MSE) which is the average – the average difference between the forecast and the actual data squared, and (3) the Mean Absolute Percent Error (MAPE) which is calculated by calculating the average absolute difference between the forecast and the actual data. MAD and MSE both have the same drawback in which their value depends on the size of the forecasted product. MAPE can be used to overcome this drawback found in MAD and MSE. MAPE can be used to overcome these shortcomings because it provides the final solution in the form of a percentage (Heriansyah, 2018).

The focus of this research is to carry out the most effective production plan of Mahkota Caman using goal programming method which is preceded by forecasting. In this study, the Goal Programming method is used to determine the optimal production volume, while the results of sales forecasting will be used as constraints in meeting consumer demand. The three most popular menus previously mentioned will be optimized, namely ayam kremes, ayam taliwang, and sup daging. Furthermore, this study will compare the results of using priority and non-priority in planning production to find out whether using feeling in determining the amount of production is indeed detrimental to Mahkota Caman.

2. Method

This research is a descriptive research, a type of research that aims to solve problems that occur when the research is conducted (Soendari, 2012). A quantitative approach is used as a main approach to present the data, but qualitative data are also described as complement.

Procedure

Data acquisition and processing is carried out through several stages can be seen in Figure 3. Overall, the steps taken are capturing the phenomenon and problems, data collection, data processing (using forecasting and goal programming), and analysis.

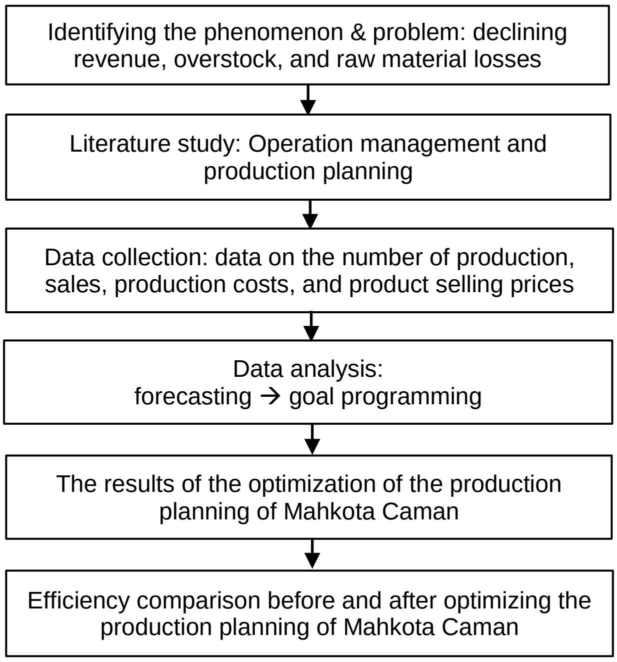

Figure 3 Research Steps.

First of all, the researcher captures the problem through interviews with the owner of the Mahkota Caman regarding the production planning system and the sales problems during the COVID-19 pandemic, as well as through analyzing the recording of production costs, use and purchase of raw materials, variety and type of food offered, and the selling price in April 2020 to March 2021. A literature study about operation management and production planning was done to identify the data needed and the methods to process the data. Two data analysis methods are used, forecasting and goal programming.

To determine the most suitable forecasting method in this study, it is necessary he pattern of sales of Mahkota Caman is necessary to analyze the patterns of sales or demand. An exponential smoothing forecasting method with trend adjustment is used after finding a downward trend in sales. The following is a mathematical model used based on Heizer et al. (2017):

$$F_t = \alpha\,(A_{t-1}) + (1-\alpha)\,(F_{t-1}+T_{t-1})$$
$$T_t = \beta\,(F_t - F_{t-1}) + (1-\beta)\,Tt_{-1}$$
$$FIT_t = F_t + T_t$$

Where,

- Ft = exponentially smoothed forecasting average of the t period data series
- T_t = exponentially smoothed trend in period t
- A_t = Actual demand in period t
- α = smoothing constant for average ($0 \leq \alpha \leq 1$)
- β = smoothing constant for trend ($0 \leq \beta \leq 1$)
- FIT_t = forecast value with trend

α and β are determined based on the smallest error measurement (MAD, MSE, and MAPE) obtained from the calculation of Exponential Smoothing with Trend Adjustment on each menu. Therefore, the accuracy of forecasting are also searched by using Error Measurement to determine which forecast is most accurate. A mathematical model proposed by Heizer et al. (2017) was used:

• Mean Absolute Deviation

$$MAD = \frac{\sum|Actual - Forecast|}{n} \quad (1)$$

• Mean Squared Error

$$MSE = \frac{\sum(Forecast\ errors)^2}{n} \quad (2)$$

• Mean Absolute Percent Error

$$MAPE = \frac{\sum_{i=1}^{n} 100|Aktual_i - Forecast_i|/Aktual_i}{n} \quad (3)$$

Where, n = number of forecast periods.

Goal programming is used to determine the optimal production volume because Mahkota Caman has several goals to be achieved. POM-QM Is used to calculate the formula. Specifically, goal programming with priority is used because the objectives of the caman crown can be arranged according to their priority and weights. The determination of priorities and their weights is based on the results of interviews and the use of the AHP Calculator can be seen in Table 1.

Table 1 Mahkota Caman's Goal Priority

Priority	Goals	Weight
1	Meet consumer demand	0,64
2	Minimize production costs	0,23
3	Minimize the purchase of raw materials	0,13
TOTAL		1

Yuliani & Pujiyanta (2014) proposes a mathematical model of the minimization function for Goal Programming with priority is as follows:

$$Z = \sum_{i=1}^{m} P_k(d_i^- - d_i^+) \quad (4)$$

Where,
d_i^- = deviation variable for the achievement of less than the specified target.
d_i^+ = deviation variable for achieving more than the specified target.
P_k = priority (k = 1, 2, ..., K)

The constraint function based on its relationship to the objective function is described in Table 2.

Table 2 Goal Constraint Types

Constraint function	Variable deviation in objective function	Desired RHS value
$a_{ij}x_j + d_i^- = b_i$	d_i^-	$= b_i$
$a_{ij}x_j - d_i^+ = b_i$	d_i^+	$= b_i$
$a_{ij}x_j + d_i^- - d_i^+ = b_i$	d_i^-	b_i or more
$a_{ij}x_j + d_i^- - d_i^+ = b_i$	d_i^-	b_i or less
$a_{ij}x_j + d_i^- - d_i^+ = b_i$	d_i^- and d_i^+	$= b_i$

Source: Yuliani & Pujiyanta (2014)

Where,
x_j = decision variable at source *j*.
b_i = constraint capacity at point *i*.
a_{ij} = constraint function parameters at point *i* for the decision variable at source *j*.
k = the total number of priority levels in the model.

The non-negative function is as follows:

$$xj, d_i^+, d_i^+ \geq 0$$

The optimal production volume, production costs, and raw materials will be obtained after calculating. The result of this calculation using Goal Programming with priority are then compared with conditions before using Goal Programming to know the efficiency comparison before and after optimizing the production planning of Mahkota Caman.

Materials

There are several data needed in forecasting and goal programming, especially to achieve the goals that have been written before in Table 1. The second goal – to minimize production costs – can be achieved if the production cost data is available. Based on the results of an interview with the owner of Mahkota Caman, the predicted production cost for the next nine months (April to December 2021) for Ayam Kremes, Ayam Taliwang, and Beef Soup is Rp.31,500,000.00. Production costs in this study consist of raw material costs, labor, and overhead costs. Table 3 describes the total cost of production for each menu to be studied.

Table 3 Production cost of Ayam Kremes, Ayam Taliwang, and Sup Daging

No	Menu	Total Production Cost
1	Ayam Kremes	Rp.11,000.00
2	Ayam Taliwang	Rp.8,125.00
3	Sup Daging	Rp.15,700.00

The third objective – to minimize the purchase of raw materials – can be achieved if the data on the purchase of raw materials is known. The owner of the MSME Mahkota Caman wants to minimize the purchase of raw materials that cannot last long because it can result in losses. Table 4 presents usage and purchase data for perishable raw materials in Mahkota Caman. The optimal production volume, production costs, and raw materials are obtained after calculating using the Goal Programming method with priority. Purchase of raw materials and production costs using Goal Programming with priority then compared with conditions before using Goal Programming.

Table 4 The Usage of Raw Materials for the Next 9 Months (April to December 2021)

Raw Material	Usage for each menu per serving (grams)			Purchase for 9 months (gram)
	Ayam Kremes	Ayam Taliwang	Sop Daging	
Onion	25	25	1,5	54.000
Garlic	20	17,5	3,5	45.000
Santan	16,25	16,25	0	36.000
Chilli	0	25	0	27.000
Potato	0	0	50	54.000
Carrot	0	0	50	54.000

3. Results and Discussion

Forecasting Result of Mahkota Caman

Table 5 presents the smallest error measurements resulting from the exponential smoothing with trend adjustment method from each menu. The results of exponential smoothing with trend adjustment with the smallest error measurement for each menu can be seen in the Figure 4.

Table 5 The Smallest Error Measurements Results from the Exponential Smoothing with Trend Adjustment Method from Each Menu

Menu	α	β	Error Measurements		
			MAD	MSE	MAPE
Ayam Kremes	0,79	0,02	04,90	51,78	04,20%
Ayam Taliwang	0,64	0,05	06,90	97,59	06,04%
Sop Daging	0,60	0,25	02,63	13,78	02,33%

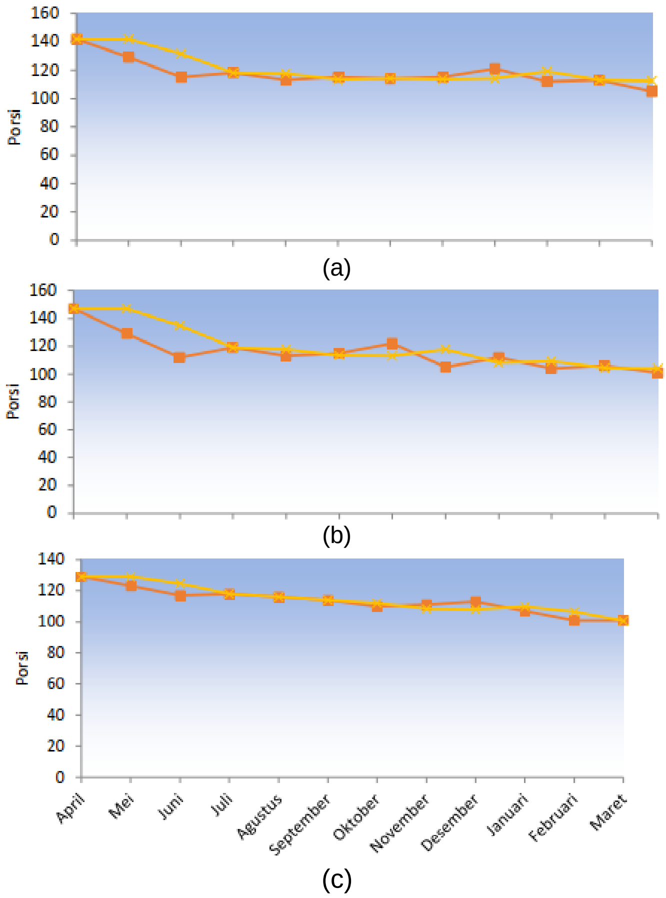

Figure 4 Exponential Smoothing with Trend Adjustment for (A) Ayam Kremes, (B) Ayam Taliwang, and (C) Sup Daging for April 2020 – March 2021

The results of forecasting sales of each menu for the next 9 (nine) months (April – December 2021) are presented in Table 6.

Table 6 Forecasting Results of Exponential Smoothing with Trend Adjustment Method in April – December 2021

No.	Month	Forecasting results		
		A*	B*	C*
1	April	106	101	100
2	May	106	100	98
3	June	105	98	96
4	July	105	96	94
5	August	104	95	92
6	September	103	93	90
7	October	103	92	88
8	November	102	90	86
9	December	101	89	83

*Note: (A) *ayam kremes*, (B) *ayam taliwang*, and (C) *sop daging*

Application of the Goal Programming Method for Mahkota Caman

Based on the forecasting results that have been described previously, the mathematical model for Goal Programming with priority is as follows.

$$Min\ Z = P_1(d_1^- + d_1^+ + d_2^- + d_2^+ + d_3^- + d_3^+) + P_2(d_4^+) + P_3(d_5^+)$$

The formulation of the constraints obtained based on the data previously described (in the methods section) is as follows.

(1) Meet consumer demand. In this study, the results of sales forecasting for ayam kremes, ayam taliwang, and sop *daging* menus for a year starting from April 2020 to March 2021 are used as obstacles in meeting consumer demand. The equation for the constraints in meeting consumer demand is written as follows:

$$X_1 + d_1^- - d_1^+ = 931$$
$$X_2 + d_2^- - d_2^+ = 851$$
$$X_3 + d_3^- - d_3^+ = 824$$
$$d_1^-, d_1^+, d_2^-, d_2^+, d_3^-, d_3^+ \geq 0$$

Where, X_1 = ayam kremes; X_2 = ayam taliwang; dan X_3 = sop daging

(2) Minimize production costs. Based on the data previously presented in Methods (Table 3), the mathematical model for the constraint to minimize production costs for the next nine months is as follows:

$$31.500.000 = 11.000X_1 + 8.125X_2 + 15.700X_3 + d_4^+$$
$$Max\ Z = d_4^-$$
$$d_4^-, d_4^+ \geq 0$$

(3) Minimize the purchase of raw materials. Based on the data in the Methods (Table 4), the mathematical model for the purpose of minimizing the purchase of raw materials is as follows:

$$54.000 = 25X_1 + 25X_2 + 1,5X_3 + d_5^+$$
$$45.000 = 20X_1 + 17,5X_2 + 3,5X_3 + d_6^+$$
$$36.000 = 16,25X_1 + 16,25X_2 + 0X_3 + d_7^+$$
$$27.000 = 0X_1 + 25X_2 + 0X_3 + d_8^+$$
$$54.000 = 0X_1 + 0X_2 + 50X_3 + d_9^+$$
$$54.000 = 0X_1 + 0X_2 + 50X_3 + d_{10}^+$$
$$Max\ Z = d_5^-, d_6^-, d_7^-, d_8^-, d_9^-, d_{10}^-$$
$$d_5^-, d_5^+, d_6^-, d_6^+, d_7^-, d_7^+, d_8^-, d_8^+, d_9^-, d_9^+, d_{10}^-, d_{10}^+ \geq 0$$

Goal Programming With Priority Results

The results of the previous forecast are used for the calculations in goal programming with priority. Several assumptions were made: the price of raw materials are constant and raw materials are always sufficient for production. Table 7 presents the results of Goal Programming with priority using POM-QM:

Table 7 Goal Programming With Priority Results

Decision variable analysis	**Value**		
Ayam Kremes	931		
Ayam Taliwang	851		
Sop Daging	824		
Priority analysis	**Non-achievement**		
Meet consumer demand	0		
Minimize production costs	0		
Minimize the purchase of raw materials	0		
Constraint analysis	**RHS**	d_i^-	d_i^+
1. Meet consumer demand for ayam kremes	931	0	0
2. Meet consumer demand for ayam taliwang	851	0	0
3. Meet consumer demand for sop daging	824	0	
4. Minimize production costs	31.500.000	0	1.407.824
5. Minimize the purchase of onions	54.000	0	8.214
6. Minimize the purchase of garlics	45.000	0	8.603
7. Minimize the purchase of santan	36.000	0	7.042
8. Minimize the purchase of chillies	27.000	0	5.725
9. Minimize the purchase of potatos	54.000	0	12.800
10. Minimize the purchase of carrots	54,000	0	12.800

Based on Table 7, it can be seen that all priorities can be achieved with 931 portions of ayam kremes, 851 portions of ayam taliwang, and 824 portions of sop daging. For the second goal (to minimize production costs), no positive deviations and a negative deviation of 1,407,824 can be seen. This shows that Mahkota Caman can reduce its production costs by Rp1,407,824 to achieve the goal of minimizing production costs.

The objective of minimizing the purchase of perishable raw materials can be achieved entirely because there are no positive deviations. Mahkota Caman can save 8,214 grams of onion, 8,603.5 grams of garlic, 7,042.5 grams of santan (coconut milk), 5,725 grams of chili, and 12,800 grams of potatoes and carrots for the next nine months (April to December 2021).

The Comparison of Before and After Using Goal Programming with Priority

Table 8 presents a comparison between the quantity of raw material purchases, the difference in the quantity of purchases, and the efficiency of their purchases before (April 2020 – March 2021) and after (April – December 2021, forecasting results) using goal programming with priority.

Table 8 Comparison of the Goal of Minimizing the Purchase of Raw Materials Before and After Using Goal Programming with Priority Results

Raw Material	Purchase quantity (gram)		Quantity difference (gram)	Efficien-cy (%)
	Before	After		
Onion	54.000	45.786	8.214	15,21%
Garlic	45.000	36.397	8.603	19,12%
Santan	36.000	28.958	7.042	19,56%
Chilli	27.000	21.275	5.725	21,20%
Potato	54.000	41.200	12.800	23,70%
Carrot	54.000	41.200	12.800	23,70%

Based on Table 8, Mahkota Caman can streamline the purchase of perishable raw materials with efficiency percentages ranging from 15.21%-23.70% if they use goal programming results with priority. The highest level of purchasing efficiency can be done on potatoes (23.70%) and carrots (23.70%), while the smallest level of efficiency occurs in shallots (15.21%).

4. Conclusion and Suggestion

Mahkota Caman experienced overstock and losses for raw materials that were easily damaged (especially potatoes and carrots) because they only used feeling in determining production volume, accompanied by the COVID-19 factor which caused a decline in sales. The results of goal programming with priority state that there are negative deviations for the purpose of minimizing production costs and the goal of minimizing the purchase of raw materials which shows that all the goals in the goal programming with priority can be achieved. When the results of before and after using goal programming with priority are compared, it can be concluded that Mahkota Caman should use the calculation results of goal programming with priority because it has more efficient production costs and raw material purchases.

We suggest that food and beverage MSMEs in the era of the Covid-19 pandemic should use optimization methods for their production planning. Optimization methods are very helpful in systematically identifying goals, constraints, and degrees of freedom in a process or factory, which leads to benefits such as improved design quality, and solutions, more precise and reliable problems, and faster decision-making.

Practically, Mahkota Caman can overcome the decline in sales through several changes. To meet customer demands, Mahkota Caman should be considering to become a partner in food delivery applications that uses bundling and promotion techniques. To achieve the goal of minimizing production costs, conducting supervision and training allows Mahkota Caman to ensure that the cooking staff will use raw materials efficiently. To minimize overstock, Mahkota Caman should buy raw materials with required quantity only. Mahkota Caman often buys these raw materials in large enough quantities, causing losses due to raw materials that cannot last long or are easily damaged.

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