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Optimization of Profits and Management of Raw Material Stocks in Laundry Soap MSMEs Using Integer Linear Progamming (ILP)

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Abstract

Micro, Small, and Medium Enterprises (MSMEs) have an important role in the economy, including in the household soap industry. The main problem that is often faced is the management of raw materials and the determination of production quantities that are not optimal. This study aims to optimize sales profits and the efficiency of the use of raw materials in laundry soap MSMEs in Gombong Village, Warungpring District, Pemalang Regency by using the Integer Linear Programming (ILP) method. The data was obtained through direct interviews with MSME owners and processed using the IBM ILOG CPLEX Optimization Studio. The optimization model is built on two types of products, namely ordinary soap and soap plus fragrance, taking into account the constraints of the availability of active ingredients, clean water, liquid fragrances, and plastic bottles. The optimization results showed that the optimal production amount was 47 bottles of ordinary soap and 53 bottles of soap plus fragrance, with a maximum profit of IDR 267,500. This study shows that the ILP method is effective in supporting measured and efficient production decision-making.

Keywords: MSMEs, Laundry Soap, Integer Linear Programming, Optimization, CPLEX.

INTRODUCTION

MSMEs (Micro, Small, and Medium Enterprises) play an important role in the national economy, especially in creating jobs and meeting the needs of the community. One of the MSME sectors that continues to grow is household soap production. Increasing public awareness of cleanliness has led to a higher demand for laundry soap (Pangan et al., 2023).

However, the perpetrator MSMEs often face problems in terms of raw material management and suboptimal profit calculations. This is a challenge in itself, especially in maintaining production efficiency with limited resources (Zuserain et al., 2021), (Astuti et al., 2023).

This research focuses on MSME laundry soap in Gombong Village, Warungpring District, Pemalang Regency, which uses three main ingredients in its production, namely cleaning active ingredients, liquid fragrances, and 500 ml plastic bottles. The limitation of raw materials requires careful production planning so that profits can still be maximized.

To overcome this problem, the Integer Linear Programming (ILP) method is applied, a mathematical approach that aims to optimize objective functions such as profits, by paying attention to various existing constraints. ILP has proven to be effective in aiding decision-making in various sectors, including MSMEs, especially in terms of efficiency and proper allocation of resources (Maspaitella & Tupan, 2016), (Putri & Tengah, 2024).

With this approach, MSME actors are expected to develop more efficient production strategies, avoid waste, and increase profits to the maximum.

METHODS

1. Conceptual Model

The conceptual model in this study explains the relationship between the main variables that affect the production process of laundry soap in MSMEs, namely cleaning active ingredients, liquid fragrances, and 500 ml plastic bottles as packaging. These three materials act as a limiting factor (constraint) in production, while the output in the form of the number of products produced will affect the total profit.

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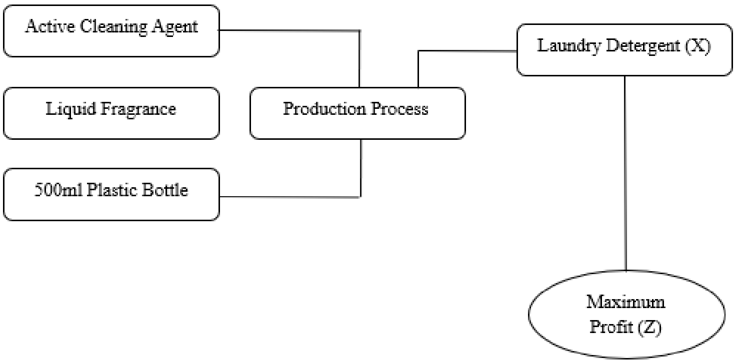

Figure 1. Conceptual Model

This image shows a conceptual model of the laundry soap production process in MSMEs. The three main components such as cleaning active ingredients, liquid fragrances, and plastic bottles serve as the main inputs in the system. The three ingredients are processed at the production stage to produce the final product in the form of laundry soap, which in this model is denoted by the variable X. Furthermore, the number of products X The results produced will contribute to the achievement of the main goal, which is to obtain maximum profits Z. This diagram helps illustrate the direct relationship between the use of raw materials, the production process, and the final result to be achieved optimally.

2. System Characterization

In this MSME-based laundry soap production system, system characterization is carried out by identifying three main components, namely system objects, decision variables, and model parameters.

a. Thing
The following are some of the objects in Laundry Soap MSMEs, namely:
   a) Regular laundry soap.
   b) Laundry soap plus perfume.

b. Variabel
The following are some of the variables that exist in Laundry Soap MSMEs, including:
   a) The amount of Ordinary Laundry Soap to be produced (X1).
   b) The amount of Laundry Soap Plus Fragrance to be produced (X2).

c. Parameter
Parameters are fixed values that are used in the model as a constraint and reference in the calculation process. The parameters used include:
   a) Material requirements per soap bottle
   b) Availability of raw materials per period (e.g. per day), and
   c) Profit per laundry soap bottle

3. Integer Linear Progamming (ILP)

This study uses primary data obtained through direct interviews with owners of laundry soap MSMEs in Gombong Village, Warungpring District, Pemalang Regency. The analysis method used is Integer Linear Programming (ILP), according to (Adriantantri & Indriani, 2021) Integer Linear Progamming (ILP) is a mathematical modeling approach that aims to Optimize profits Taking into account the various limitations of available resources, especially production raw materials.

Integer Linear Programming is a type of linear programming, in which the result variable is limited to the value of an integer. In the context of this study, the decision variable in the form of the number of units of laundry soap produced per day must be in the form of integers because it is impossible to produce partial units.

In general, the mathematical model form of Integer Linear Programming for maximization cases can be written as follows:

$$\text{Maximize } Z = \sum_{j=1}^{n} C_j X_j$$

$$\text{with the constraint : for every } \sum_{j=1}^{n} a_{ij} X_j \leq b_i i = 1, 2, ..., m$$

$$X_j \geq 0 \text{ and } X_j \in Z \text{ for all j}$$

Where:

a. Z is a function of the objective (total profit),
b. Xj is the decision variable (the number of products produced),
c. Cj profit per unit of product to j,
d. AIJ is the amount of raw materials needed to produce one unit of product J,

e. BI is the maximum amount of raw materials available.

DISCUSSION

In research related to profit optimization and raw material stock management in laundry soap MSMEs as a case study used in Gombong Village, Warungpring District, Pemalang Regency, the following results were given:

1. Determination of Purpose Functions

Objective functions are functions that describe the main objectives in a linear program problem, which are related to the optimal management of resources to obtain maximum profits. The objective value Z of an existing issue is calculated based on the difference between total revenue and all expenses incurred. In the production of laundry soap by MSMEs in Gombong Village, Warungpring District, Pemalang Regency, there are main obstacles related to the availability of soap raw materials. Based on the results of the survey of the production and sales process of laundry soap as a case study in the regions, production and sales data per unit were obtained as shown in the table below, including the following:

Table 1. Raw Material Requirements One Bottle of Laundry Soap

Raw Materials	Regular Soap (x1)	Soap Plus Fragrance (X2)	Stock Available (per day)
Active Ingredients (grams)	100	100	10.000
Clean Water (ml)	280	280	30.000
Liquid Fragrance (ml)	0	20	2.000
500ml Plastic Bottle / One Bottle	1	1	150

Table 2. Advantages of Selling Laundry Soap

Component	Regular Soap (x1)	Soap Plus Fragrance (x2)
Selling Price per Bottle	5.000	6.500
Production Cost per Bottle	2.500	3.500
Profit per Bottle	2.500	3.000

Thus, sales that have been carried out by MSMEs of laundry soap in Gombong village have a profit of Rp 2,500 per bottle of ordinary soap (X1), and Rp 3,000 per bottle of soap plus fragrance (X2). Therefore, the overall objective function can be formulated as follows: Maximize Z = 2,500 X1 + 3,000 X2............................ (1)

2. Defining Constraint Functions

Regarding the data in the restriction function, this study was conducted to see the amount of raw materials used by MSMEs of laundry soap in producing each type of laundry soap and the capacity of raw materials owned in one day of sales.

3. Linear Calculation of Progamming

Regarding the existing survey data, the Integer Linear Progamming variable is used with the following explanation:

a. Decision Variables

X1 = Total Sales of Ordinary Soap Products

X2 = Total Sales of Soap Plus Fragrance Products

b. Purpose Function

$$\text{Maximize } Z = 2{,}500\,X1 + 3{,}000\,X2$$

c. Limiting Function

Active Ingredient : $100\,X1 + 100\,X2 \leq 10{,}000$

Clean Water : $280\,X1 + 280\,X2 \leq 30{,}000$

Liquid Fragrance : $20\,X2 \leq 2.000$

Plastic Bottle : $1\,X1 + 1\,X2 \leq 150$

$X1, X2 \geq 0$

4. Data Processing Using IBM ilog CPX Optimization Studio

After the above data is discussed, the data processing is carried out using the IBM ILOG CPLEX Optimization Studio, the following is the output produced:

a. The image below shows the coding for the existing variable issues that have been incorporated into CPLEX:

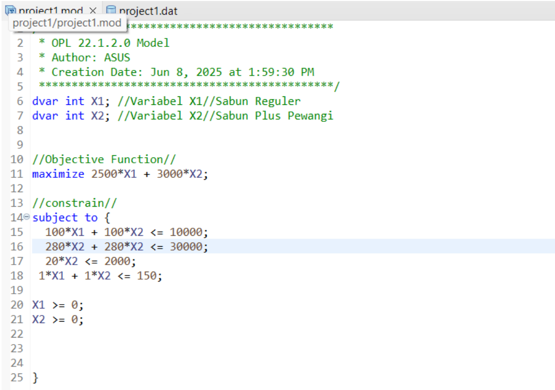

Figure 2. CPLEX Coding Software

b. The following is a view of the results of Run in CPLEX

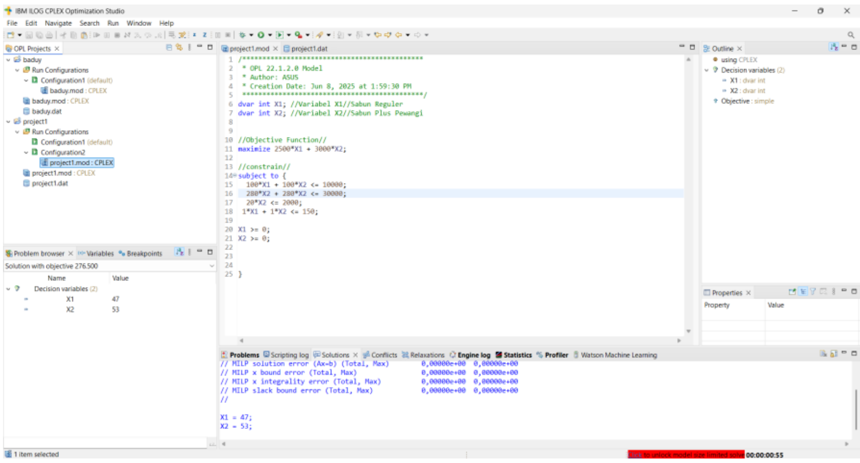

Figure 3. CPLEX Running Results

c. The following is a breakdown of the (optimal) solution results from the values of X1, and X2:

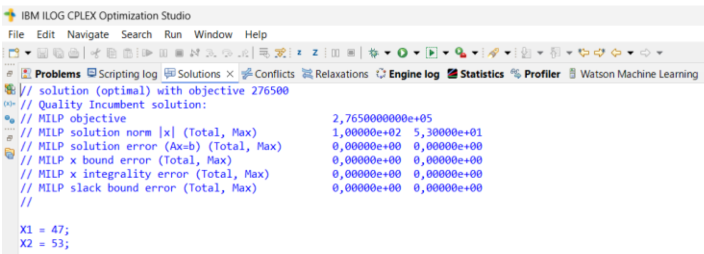

Figure 4. CPLEX Solution Results

d. The following are the results of the Decision Variables:

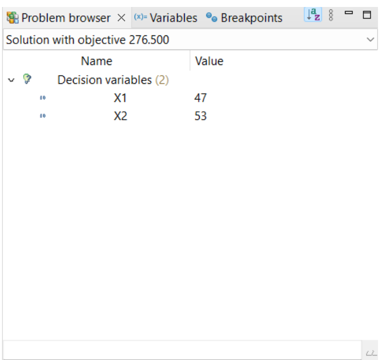

Figure 5. CPLEX Decision Variables

Thus, from the results of data processing using the IBM ILOG CPLEX Optimization Studio application, the results of the decision variables for X1 = 47, and X2 = 53 were obtained, resulting in the optimal solution for the production process, which was 267,500,-.

5. Model Validation

The following is a validation of the model that has been designed using the IBM ILOG CPLEX Optimization Studio application:

Table 3. Maximum Profit Model Validation

Kind	Selling Price	Advantage	Sales-Related Solutions
Regular Soap	5.000	2.500	47
More soaps	6.500	3.000	53

a. Selling Price (Capital)
   (47 x Rp. 5,000) + (53 x Rp. 6,500) = Rp. 579,500

b. Advantage
   (47 x Rp. 2,500) + (53 x Rp. 3,000) = Rp. 276,500

c. Percentage of Untold Stories
   $\frac{\text{Keuntungan}}{\text{Modal}}$ x 100% = $\frac{\text{Rp. 276.500}}{\text{Rp. 579.500}}$ x 100% = 47%

Table 4. Raw Material Stock Model Validation

Raw Materials	Pretend		Stock Availability
Active Ingredients (grams)	100	100	10.000
Clean Water (ml)	280	280	30.000
Liquid Fragrance (ml)	0	20	2.000
500ml Plastic Bottle / One Bottle	1	1	150

d. Active Ingredients
   100 X1 + 100 X2 ≤ 10.000
   (100 x 47) + (100 x 53) = 10,000

e. Clean water
   280 X1 + 280 X2 ≤ 30,000
   (280 x 47) + (280 x 53) = 28,000

f. Liquid Fragrance
   20 X2 ≤ 2,000
   20 x 53 = 1.060

g. 500 ml Plastic Bottle
   1 X1 + 1 X2 ≤ 150
   (1 x 47) + (1 x 53) = 100

CONCLUSION

The application of the Integer Linear Programming (ILP) method with the help of IBM ILOG CPLEX Optimization Studio has proven to be effective in optimizing laundry soap sales. The optimization results showed that the optimal sales number was 47 bottles of ordinary soap and 53 bottles of soap with fragrance, which resulted in a maximum profit of IDR 267,500. To achieve these results, the raw materials used include 10,000 grams of active ingredients, 28,000 ml of clean water, 1,060 ml of liquid fragrance, and 100 500 ml plastic bottles. The remaining raw materials were also found, namely 2,000 ml of clean water, 940 ml of liquid fragrance, and 50 plastic bottles, which indicates that there is an opportunity for efficiency in further production. Thus, ILP not only maximizes profits, but also supports efficiency in the use of resources.

In this study, the results of calculations used to optimize the sales of laundry soap products, both regular variants and with additional fragrances can be used as a reference in planning the needs of raw materials efficiently. This approach helps prevent excess stock or unused food waste. In addition, if business actors want to increase sales volume, production can be carried out by adjusting the amount of raw materials based on multiples of the optimal calculation results that have been obtained. In this way, the production process can run more directed, scalable, and remain efficient in the use of resources.

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