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# ANALYSIS OF PRODUCTION PLANNING TO OBTAIN MAXIMUM PROFIT FROM "ES KUL-KUL" SALES USING THE SIMPLEX METHOD

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***ABSTRACT***

"Es Kul-Kul" production business located in a shop called the Muawanah Cooperative, is experiencing difficulty in maximizing profits due to changing consumer demand and challenges in determining the supply of raw materials needed. The owner continues to produce "Es Kul-Kul" based on the average daily consumer order, thereby sacrificing the efficiency of utilizing raw materials and capital. This study aims to analyze production planning to maximize profits from the sale of "Es Kul-Kul" at the Muawanah Cooperative UMKM using the simplex method. The research method employed in this study is a case study, with data analysis and processing conducted using linear programming, specifically the simplex method. The results of the study showed that the optimal production combination consisted of 50 banana-flavored skewers, and 100 strawberry-flavored skewers, with a total profit of IDR 800.000 per day. This approach has succeded in increasing production cost efficiency and optimizing profits, which is relevant for application to other UMKM. Possible further research is research based on optimization problems that occur in the surrounding environment with different methods and more detailed instruments to produce more accurate and realistic research.

**Keywords:** Linear Programming, Simplex Method, Production Profit Planning, UMKM

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## PRELIMINARY

Production planning is a management process in a business whose function is to assist in making all decisions regarding adjusting production capacity so that the company can reduce costs without ignoring the quality of the products produced (Siswanto, Nuroktavia, Wahyudi, & Syah, 2022). In linear programming, the simplex method is widely applied in production planning, in addition to providing a literature review on how the business world applies it to various needs ranging from planning related to raw materials, labor, quality, costs and technology used in the process. However, production planning is now getting more attention because it plays an important role as a contributor to the success of a businesses (Fadly, 2024; Masula, Huda, & Winarno, 2024).

In this study, research was conducted on the production of "Es Kul-Kul" in a shop called the Muawanah Cooperative. These UMKM have difficulty in maximizing profits due to changing consumer demand and difficulty in determining the supply of raw materials needed. The owner continues to produce "Es Kul-Kul" based on the average consumer order per day, thus sacrificing the efficiency of using raw materials and capital. Proper use of capital will help their business grow even further. UMKM business people use various business strategies to take advantage of and overcome various market changes that occur, so as not to be left behind in the competition.

Business people who have been actively involved in the market continue to do things that make their products sell well and make big profits, one of which is selling "Es Kul-Kul by creating innovations for the products or business they are involved in, so that they can compete with other products (Fadly, 2024). "Es Kul-Kul" is a modern food product that appeared on the market in the early 2000s, featuring main ingredients in the form of fruit, such as bananas, melons, grapes, strawberries, and watermelon, coated in chocolate and frozen, then enjoyed like a popsicle. The flavors and toppings that can be given include chocolate, tiramisu, vanilla, green tea, strawberry, and taro. Then for the toppings, we can sprinkle nuts, muesli, cheese, oreo, milo, chocochips, and others (Mulyono, Saryanto, Purbanuswanto, Triyono, & Wibisono, 2024; Putri, Annisa, & Yanti, 2024).

Production managers or owners of UMKM businesses often face the challenge of determining the optimal production quantity to achieve maximum profit. Profit optimization is a step to reduce costs incurred to achieve the highest possible profit level (Daryani, Aritonang, & Panggabean, 2024). By considering these problems, this research was carried out to analyze the production planning of "Es Kul-Kul" sales. In this case, the analysis was carried out in terms of the amount of materials available, the capital available, the estimated amount to be sold, and the profit obtained from each stick of "Es Kul-Kul". This helps business owners determine maximum profits for optimizing the use of raw materials and production capital (Agustina, Nainggolan, & Panggabean, 2024; Sari, Sundari, Rahmawati, & Susanto, 2024).

In previous research conducted by Liu, Long, Wu, Xu, Sang, & Lei, (2023), they discussed the problem of determining the Two-Line Elements (TLE) that optimizes several TLEs using the simplex method. In addition, research conducted by Sari, Sundari, Rahmawati, & Susanto, (2020), in the culinary sausage trading business, traders must allocate raw materials and increase profits using the simplex method. The method has proven to be effective and computationally compact. This study was conducted, which aims to maximize profits on “Es Kul-Kul” sales using the simplex method to differentiate previous research from the research to be conducted. Therefore, to maximize the output of “Es Kul-Kul” sales, linear programming is used, which is a science that discusses how to determine the optimal value in a linear problem (Aini, Fikri, & Sukandar, 2021; Ambarsari & Fadia, 2025; Daryani, Aritonang, & Panggabean, 2024). In linear programming, there are limitations and requirements for linear problems in the form of a system of inequalities. Solving linear programs can be done in various ways, such as simplex, graphical, etc. (Ambarsari, Hasanah, Astindari, Sari, & Masruro, 2024; Lina, Rumetna, Tindage, Pormes, & Ferdinandus, 2023).

This optimal problem can be solved by applying the simplex method in linear programming because it has more than 2 constraints. According to Hani & Harahap, (2021), and Daryani, Aritonang, & Panggabean, (2024), Linear Programming is an optimization technique used to find the optimum value (maximum or minimum) that can be obtained from the value of a set of linear problem solutions from a linear objective function within a certain constraint framework. The use of linear programming can be found in various fields and plays an important role in the decision-making process by identifying the best solution (Sari, Sundari, Rahmawati, & Susanto, 2020; Lina et al., 2022). In solving optimization problems in various sectors such as economics, industry, banking, education, and other fields that can be expressed in linear form. Linear programming is often used as a tool to solve problems such as resource management, with the ultimate goal of finding minimum or maximum values. This is based on research that has been conducted by Aulia, (2023), Febrianti & Harahap, (2021), Hani & Harahap, (2021), Hasanah, Ambarsari, Astindari, Nuryami, & Fadia, (2024), Tamiza, Kustiawati, Fathinah, & Sulistiono, (2023), and Lina et al., (2020).

The simplex method according to Susanti, (2021), Sundari et al., (2022) and Rumetna et al., (2020) is one of the solution techniques in linear programming, which is used as a decision-making technique to find optimal values that include many inequalities and multiple variables. Meanwhile, according to Lina, & Rumetna, (2022), the simplex method is a way of solving linear programming problems by finding feasible solutions and using iterative procedures, developing solutions until an efficient solution is obtained in solving optimization problems. The simplex method is used to solve linear programming problems by finding a solution that meets the requirements, following an iterative process, developing solution steps, and ultimately producing an efficient solution to the problem (Rumetna et al., 2022).

## METHODS

The mathematical background that needs to be mastered in this research is vectors, matrices, and elementary row operations as well as the simplex method. Furthermore, this research was conducted at the Muawanah Cooperative. The research was a case study, encompassing the following activities :

1. Problem Identification. The main problem in this research is to maximize profits with limited raw materials. This was obtained based on the results of an interview with the owner of "Es Kul-Kul" business at the Muawanah Cooperative using the simplex method manually.
2. Data collection was conducted through interviews with product sellers to obtain data for processing. The data required for this study included capital expenditures, raw material prices, production volume, and profit per unit.
3. Selection of problem-solving model. The model used is a linear programming method, namely the simplex method, which will be carried out manually. The simplex method was chosen as the solution method because this study has more than two constraints that cannot be solved using graphical methods.
4. Data processing and analysis is carried out using the simplex method in a manual linear program and continued using the MATLAB application to test the accuracy of the calculation results.
5. Evaluation of results. Evaluation of results was conducted by comparing the research findings with the actual conditions experienced by UMKM.
6. Implementing optimal solutions is a decision-making steps based on the results of calculations using the simplex method, which is the authority of the UMKM.

The research steps will be easier to understand by paying attention to the following flowchart diagram:

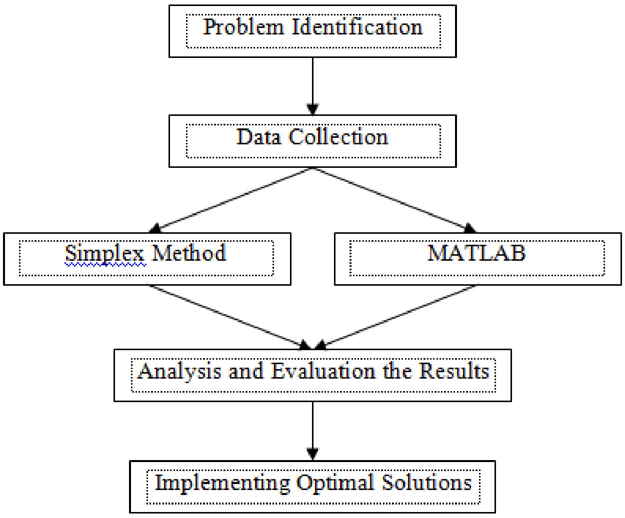


**Figure 1. Flowchart Diagram**

## RESULT AND DISCUSSION

Based on the results of interview with the owner of the "Es Kul-Kul" business at the Muawanah Cooperative, the following data was obtained :

**Table 1. Daily Production Cost of "Es Kul-Kul" of Muawanah Cooperative**

| Material | Quantity | Price |
|---|---|---|
| Banana | 5 Sections | IDR 50.000 |
| Red Grapes | 3 kg | IDR 114.000 |
| Strawberry | 2 kg | IDR 120.000 |
| Chocolate Paste | 1 kg | IDR 60.000 |
| Oil | ½ liter | IDR 10.000 |
| Skewers | 2 Packs | IDR 7.500 |
| Plastic Packaging | 2 Packs | IDR 7.500 |
| Total | | IDR 369.000 |
| Total Production | | 300 Skewers |

After the production process, the product is sold at a unit price of IDR 1.000 for banana, IDR 3.000 for red grapes, and IDR 3.000 for strawberries.

The simplex method is used to calculate the optimal production combination of the three flavor variants to maximize profits. After obtaining the above data, the next step is :

1. Modelling data into mathematical form. To obtain the correct formulation, the symbols $x_1, x_2, x_3$, and $F_{max}$ are used where :

   $x_1$ is a production quantity of banana flavored "Es Kul-Kul",

   $x_2$ is a production quantity of red grape flavored "Es Kul-Kul",

   $x_3$ is a production quantity of strawberry flavored "Es Kul-Kul",

   $F_{max}$ is maximum total profit.

2. Determine the objective function to be maximized.

   The objective function is a function of the decision variables that aims to maximize (for revenue or profit) or minimize (for cost) (Ambarsari & Fadia, 2025). The purpose of this study is to maximize raw materials in order to achieve maximum profit. Then the objective function that will be maximized is obtained as follows:

$$F_{max} = 1000x_1 + 3000x_2 + 3000x_3$$

3. Creating boundaries (constraints)

$$\begin{array}{ccccccc}
x_1 & + & 0.x_2 & + & 0.x_3 & \leq & 100 \\
0.x_1 & + & 0{,}02x_2 & + & 0.x_3 & \leq & 3 \\
0.x_1 & + & 0.x_2 & + & 0{,}02x_3 & \leq & 2 \\
0{,}003x_1 & + & 0{,}003x_2 & + & 0{,}003x_3 & \leq & 1 \\
0{,}001x_1 & + & 0{,}001x_2 & + & 0{,}001x_3 & \leq & 0{,}5 \\
x_1 & + & x_2 & + & x_3 & \leq & 300 \\
x_1 & + & x_2 & + & x_3 & \leq & 300
\end{array}$$

4. Transforming constraints and objective functions into canonical/ready simplex form.

   To solve this problem with the simplex method, we add a slack variables ($s_1$,$s_2$,$s_3$,$s_4$,$s_5$,$s_6$,$s_7$) to convert constraints into equations :

   a. Canonical form of constraint function.

$$\begin{array}{ccccccccc}
x_1 & + & 0.x_2 & + & 0.x_3 & + & s_1 & = & 100 \\
0.x_1 & + & 0{,}02x_2 & + & 0.x_3 & + & s_2 & = & 3 \\
0.x_1 & + & 0.x_2 & + & 0{,}02x_3 & + & s_3 & = & 2 \\
0{,}003x_1 & + & 0{,}003x_2 & + & 0{,}003x_3 & + & s_4 & = & 1 \\
0{,}001x_1 & + & 0{,}001x_2 & + & 0{,}001x_3 & + & s_5 & = & 0{,}5 \\
x_1 & + & x_2 & + & x_3 & + & s_6 & = & 300 \\
x_1 & + & x_2 & + & x_3 & + & s_7 & = & 300
\end{array}$$

   b. Canonical form of the objective function.

$$\mathrm{F}_{\max} = 1000\mathrm{x}_1 + 3000\mathrm{x}_2 + 3000\mathrm{x}_3 + 0.\mathrm{s}_1 + 0.\mathrm{s}_2 + 0.\mathrm{s}_3 + 0.\mathrm{s}_4 + 0.\mathrm{s}_5 + 0.\mathrm{s}_6 + 0.\mathrm{s}_7$$

5. Arrange the objective function and constraints into a simplex table.

**Table 2. Simplex Table**

| | $C_j$ | 1.000 | 3.000 | 3.000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $C_i$ | $x_i$ / $x_j$ | $x_1$ | $x_2$ | $x_3$ | $s_1$ | $s_2$ | $s_3$ | $s_4$ | $s_5$ | $s_6$ | $s_7$ | $b_i$ | $R_i$ |
| 0 | $s_1$ | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | |
| 0 | $s_2$ | 0 | 0,02 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 3 | |
| 0 | $s_3$ | 0 | 0 | 0,02 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | |
| 0 | $s_4$ | 0,003 | 0,003 | 0,003 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | |
| 0 | $s_5$ | 0,001 | 0,001 | 0,001 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0,5 | |
| 0 | $s_6$ | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 300 | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | $s_7$ | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 300 |
| | $z_j$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | $z_j - c_j$ | -1.000 | -3.000 | -3.000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Since the value of $z_j - c_j$ has not yet reached the optimal result, iterations are needed until $z_j - c_j$ becomes optimal. The maximum requirement to achieve the ideal result is $z_j - c_j \geq 0$. Meanwhile, the minimum requirement to achieve the optimal result is $z_j - c_j \leq 0$.

6. Iteration 1
   a. Identifying the key column. The key column in the function that is maximized can be seen from the smallest $z_j - c_j$ value.

**Table 3. Interation 1 (Determining The Key Columns)**

| | $C_j$ | 1.000 | 3.000 | 3.000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $C_i$ | $x_i$ / $x_j$ | $x_1$ | $x_2$ | $x_3$ | $s_1$ | $s_2$ | $s_3$ | $s_4$ | $s_5$ | $s_6$ | $s_7$ | $b_i$ | $R_i$ |
| 0 | $s_1$ | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | |
| 0 | $s_2$ | 0 | 0,02 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 3 | |
| 0 | $s_3$ | 0 | 0 | 0,02 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | |
| 0 | $s_4$ | 0,003 | 0,003 | 0,003 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | |
| 0 | $s_5$ | 0,001 | 0,001 | 0,001 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0,5 | |
| 0 | $s_6$ | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 300 | |
| 0 | $s_7$ | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 300 | |
| | $z_j$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| | $z_j - c_j$ | -1.000 | -3.000 | -3.000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |

   b. Determine the value of $R_i$ by dividing $b_i$ by the key column.

**Table 4. Simplex Table, Iteration 1 (Determining the value of $R_i$)**

| | $C_j$ | 1.000 | 3.000 | 3.000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $C_i$ | $x_i$ / $x_j$ | $x_1$ | $x_2$ | $x_3$ | $s_1$ | $s_2$ | $s_3$ | $s_4$ | $s_5$ | $s_6$ | $s_7$ | $b_i$ | $R_i$ |
| 0 | $s_1$ | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | - |
| 0 | $s_2$ | 0 | 0,02 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 3 | 150 |
| 0 | $s_3$ | 0 | 0 | 0,02 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | - |
| 0 | $s_4$ | 0,003 | 0,003 | 0,003 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 333,33 |
| 0 | $s_5$ | 0,001 | 0,001 | 0,001 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0,5 | 500 |
| 0 | $s_6$ | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 300 | 300 |
| 0 | $s_7$ | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 300 | 300 |
| | $z_j$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| | $z_j - c_j$ | -1.000 | -3.000 | -3.000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |

   c. Define the key row. The smallest $R_i$ value can be used to identify the key row in the function being maximized or minimized.

**Table 5. Simplex Table, Iteration 1 (Determining Key Rows)**

| | $C_j$ | 1.000 | 3.000 | 3.000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $C_i$ | $x_i$ / $x_j$ | $x_1$ | $x_2$ | $x_3$ | $s_1$ | $s_2$ | $s_3$ | $s_4$ | $s_5$ | $s_6$ | $s_7$ | $b_i$ | $R_i$ |
| 0 | $s_1$ | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | - |
| 0 | $s_2$ | 0 | 0,02 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 3 | 150 |
| 0 | $s_3$ | 0 | 0 | 0,02 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | - |
| 0 | $s_4$ | 0,003 | 0,003 | 0,003 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 333,33 |
| 0 | $s_5$ | 0,001 | 0,001 | 0,001 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0,5 | 500 |
| 0 | $s_6$ | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 300 | 300 |
| 0 | $s_7$ | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 300 | 300 |
| | $z_j$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| | $z_j - c_j$ | -1.000 | -3.000 | -3.000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |

d. Change the key row, column and set the key value to 1, while the other key rows are set to 0. The following OBE procedures are carried out and the results are shown in Table 6.

1) $B_2' = 50B_2$
2) $B_4' = -\frac{3}{1000}B_2' + B_4$
3) $B_5' = -\frac{1}{1000}B_2' + B_5$
4) $B_6' = -B_2' + B_6$
5) $B_7' = -B_2' + B_7$

**Table 6. Simplex Table, Iteration 1**

| | $C_j$ | 1.000 | 3.000 | 3.000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $C_i$ | $x_i$ / $x_j$ | $x_1$ | $x_2$ | $x_3$ | $s_1$ | $s_2$ | $s_3$ | $s_4$ | $s_5$ | $s_6$ | $s_7$ | $b_i$ | $R_i$ |
| 0 | $s_1$ | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | |
| 3000 | $x_2$ | 0 | 1 | 0 | 0 | 50 | 0 | 0 | 0 | 0 | 0 | 150 | |
| 0 | $s_3$ | 0 | 0 | 0,02 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | |
| 0 | $s_4$ | 0,003 | 0 | 0,003 | 0 | - 0,15 | 0 | 1 | 0 | 0 | 0 | 0,55 | |
| 0 | $s_5$ | 0,001 | 0 | 0,001 | 0 | - 0,05 | 0 | 0 | 1 | 0 | 0 | 0,35 | |
| 0 | $s_6$ | 1 | 0 | 1 | 0 | - 50 | 0 | 0 | 0 | 1 | 0 | 150 | |
| 0 | $s_7$ | 1 | 0 | 1 | 0 | - 50 | 0 | 0 | 0 | 0 | 1 | 150 | |
| | $z_j$ | 0 | 3.000 | 0 | 0 | 150.000 | 0 | 0 | 0 | 0 | 0 | 450.000 | |
| | $z_j - c_j$ | -1.000 | 0 | -3.000 | 0 | 150.000 | 0 | 0 | 0 | 0 | 0 | 450.000 | |

Since in iteration 1, the optimal $z_j - c_j$ has not been achieved, the process is continued to iteration 2 by following similar steps.

7. Interation 2.

a. Identifying the key column. The key column in the function to be maximized can be identified by its lowest $z_j - c_j$ value.

**Table 7. Iteration 2 (Determining The Key Columns)**

| $C_i$ | $C_j$ / $x_i$ \ $x_j$ | 1.000 $x_1$ | 3.000 $x_2$ | 3.000 $x_3$ | 0 $s_1$ | 0 $s_2$ | 0 $s_3$ | 0 $s_4$ | 0 $s_5$ | 0 $s_6$ | 0 $s_7$ | $b_i$ | $R_i$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | $s_1$ | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | |
| 3000 | $x_2$ | 0 | 1 | 0 | 0 | 50 | 0 | 0 | 0 | 0 | 0 | 150 | |
| 0 | $s_3$ | 0 | 0 | 0,02 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | |
| 0 | $s_4$ | 0,003 | 0 | 0,003 | 0 | - 0,15 | 0 | 1 | 0 | 0 | 0 | 0,55 | |
| 0 | $s_5$ | 0,001 | 0 | 0,001 | 0 | - 0,05 | 0 | 0 | 1 | 0 | 0 | 0,35 | |
| 0 | $s_6$ | 1 | 0 | 1 | 0 | - 50 | 0 | 0 | 0 | 1 | 0 | 150 | |
| 0 | $s_7$ | 1 | 0 | 1 | 0 | - 50 | 0 | 0 | 0 | 0 | 1 | 150 | |
| | $z_j$ | 0 | 3.000 | 0 | 0 | 150.000 | 0 | 0 | 0 | 0 | 0 | 450.000 | |
| | $z_j - c_j$ | -1.000 | 0 | -3.000 | 0 | 150.000 | 0 | 0 | 0 | 0 | 0 | 450.000 | |

b. Determine the value of $R_i$ by dividing $b_i$ by the key column.

**Table 8. Simplex Table, Iteration 2 (Determining the value of $R_i$)**

| $C_i$ | $C_j$ / $x_i$ \ $x_j$ | 1.000 $x_1$ | 3.000 $x_2$ | 3.000 $x_3$ | 0 $s_1$ | 0 $s_2$ | 0 $s_3$ | 0 $s_4$ | 0 $s_5$ | 0 $s_6$ | 0 $s_7$ | $b_i$ | $R_i$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | $s_1$ | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | - |
| 3000 | $x_2$ | 0 | 1 | 0 | 0 | 50 | 0 | 0 | 0 | 0 | 0 | 150 | - |
| 0 | $s_3$ | 0 | 0 | 0,02 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 100 |
| 0 | $s_4$ | 0,003 | 0 | 0,003 | 0 | - 0,15 | 0 | 1 | 0 | 0 | 0 | 0,55 | 183,33 |
| 0 | $s_5$ | 0,001 | 0 | 0,001 | 0 | - 0,05 | 0 | 0 | 1 | 0 | 0 | 0,35 | 350 |
| 0 | $s_6$ | 1 | 0 | 1 | 0 | - 50 | 0 | 0 | 0 | 1 | 0 | 150 | 150 |
| 0 | $s_7$ | 1 | 0 | 1 | 0 | - 50 | 0 | 0 | 0 | 0 | 1 | 150 | 150 |
| | $z_j$ | 0 | 3.000 | 0 | 0 | 150.000 | 0 | 0 | 0 | 0 | 0 | 450.000 | |
| | $z_j - c_j$ | -1.000 | 0 | -3.000 | 0 | 150.000 | 0 | 0 | 0 | 0 | 0 | 450.000 | |

c. Define the key row. The smallest $R_i$ value can be used to identify the key row in the function being maximized or minimized.

**Table 9. Simplex Table, Iteration 2 (Determining Key Rows)**

| $C_i$ | $C_j$ / $x_i$ \ $x_j$ | 1.000 $x_1$ | 3.000 $x_2$ | 3.000 $x_3$ | 0 $s_1$ | 0 $s_2$ | 0 $s_3$ | 0 $s_4$ | 0 $s_5$ | 0 $s_6$ | 0 $s_7$ | $b_i$ | $R_i$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | $s_1$ | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | - |
| 3000 | $x_2$ | 0 | 1 | 0 | 0 | 50 | 0 | 0 | 0 | 0 | 0 | 150 | - |
| 0 | $s_3$ | 0 | 0 | 0,02 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 100 |
| 0 | $s_4$ | 0,003 | 0 | 0,003 | 0 | - 0,15 | 0 | 1 | 0 | 0 | 0 | 0,55 | 183,33 |
| 0 | $s_5$ | 0,001 | 0 | 0,001 | 0 | - 0,05 | 0 | 0 | 1 | 0 | 0 | 0,35 | 350 |
| 0 | $s_6$ | 1 | 0 | 1 | 0 | - 50 | 0 | 0 | 0 | 1 | 0 | 150 | 150 |
| 0 | $s_7$ | 1 | 0 | 1 | 0 | - 50 | 0 | 0 | 0 | 0 | 1 | 150 | 150 |
| | $z_j$ | 0 | 3.000 | 0 | 0 | 150.000 | 0 | 0 | 0 | 0 | 0 | 450.000 | |
| | $z_j - c_j$ | -1.000 | 0 | -3.000 | 0 | 150.000 | 0 | 0 | 0 | 0 | 0 | 450.000 | |

d. Change the key row, column and set the key value to 1, while the other key rows are set to 0. The following OBE procedures are carried out and the results are shown in Table 10.

1) $B_3' = 50B_3$

2) $B_4' = -\frac{3}{1000}B_3' + B_4$

3) $B_5' = -\frac{1}{1000}B_3' + B_5$

4) $B_6' = -B_3' + B_6$

5) $B_7' = -B_3' + B_7$

**Table 10. Simplex Table, Iteration 2**

| | $C_j$ | 1.000 | 3.000 | 3.000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $C_i$ | $x_i$ / $x_j$ | $x_1$ | $x_2$ | $x_3$ | $s_1$ | $s_2$ | $s_3$ | $s_4$ | $s_5$ | $s_6$ | $s_7$ | $b_i$ | $R_i$ |
| 0 | $s_1$ | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | |
| 3000 | $x_2$ | 0 | 1 | 0 | 0 | 50 | 0 | 0 | 0 | 0 | 0 | 150 | |
| 3000 | $x_3$ | 0 | 0 | 1 | 0 | 0 | 50 | 0 | 0 | 0 | 0 | 100 | |
| 0 | $s_4$ | 0,003 | 0 | 0 | 0 | - 0,15 | - 0,15 | 1 | 0 | 0 | 0 | 0,25 | |
| 0 | $s_5$ | 0,001 | 0 | 0 | 0 | - 0,05 | - 0,05 | 0 | 1 | 0 | 0 | 0,25 | |
| 0 | $s_6$ | 1 | 0 | 0 | 0 | - 50 | - 50 | 0 | 0 | 1 | 0 | 50 | |
| 0 | $s_7$ | 1 | 0 | 0 | 0 | - 50 | - 50 | 0 | 0 | 0 | 1 | 50 | |
| | $z_j$ | 0 | 3.000 | 3.000 | 0 | 150.000 | 150.000 | 0 | 0 | 0 | 0 | 750.000 | |
| | $z_j - c_j$ | -1.000 | 0 | 0 | 0 | 150.000 | 150.000 | 0 | 0 | 0 | 0 | 750.000 | |

Since in iteration 2, the optimal $z_j - c_j$ has not been achieved, the process is continued to iteration 3 by following similar steps.

8. Iteration 3.

   a. Identifying the key column. The key column in the function to be maximized can be identified by its lowest $z_j - c_j$ value.

**Table 11. Iteration 3 (Determining The Key Columns)**

| | $C_j$ | 1.000 | 3.000 | 3.000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $C_i$ | $x_i$ / $x_j$ | $x_1$ | $x_2$ | $x_3$ | $s_1$ | $s_2$ | $s_3$ | $s_4$ | $s_5$ | $s_6$ | $s_7$ | $b_i$ | $R_i$ |
| 0 | $s_1$ | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | |
| 3000 | $x_2$ | 0 | 1 | 0 | 0 | 50 | 0 | 0 | 0 | 0 | 0 | 150 | |
| 3000 | $x_3$ | 0 | 0 | 1 | 0 | 0 | 50 | 0 | 0 | 0 | 0 | 100 | |
| 0 | $s_4$ | 0,003 | 0 | 0 | 0 | - 0,15 | - 0,15 | 1 | 0 | 0 | 0 | 0,25 | |
| 0 | $s_5$ | 0,001 | 0 | 0 | 0 | - 0,05 | - 0,05 | 0 | 1 | 0 | 0 | 0,25 | |
| 0 | $s_6$ | 1 | 0 | 0 | 0 | - 50 | - 50 | 0 | 0 | 1 | 0 | 50 | |
| 0 | $s_7$ | 1 | 0 | 0 | 0 | - 50 | - 50 | 0 | 0 | 0 | 1 | 50 | |
| | $z_j$ | 0 | 3.000 | 3.000 | 0 | 150.000 | 150.000 | 0 | 0 | 0 | 0 | 750.000 | |
| | $z_j - c_j$ | -1.000 | 0 | 0 | 0 | 150.000 | 150.000 | 0 | 0 | 0 | 0 | 750.000 | |

   b. Determine the value of $R_i$ by dividing $b_i$ by the key column.

**Table 12. Simplex Table, Iteration 3 (Determining the value of $R_i$)**

| | $C_j$ | 1.000 | 3.000 | 3.000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $C_i$ | $x_i$ / $x_j$ | $x_1$ | $x_2$ | $x_3$ | $s_1$ | $s_2$ | $s_3$ | $s_4$ | $s_5$ | $s_6$ | $s_7$ | $b_i$ | $R_i$ |
| 0 | $s_1$ | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 100 |
| 3000 | $x_2$ | 0 | 1 | 0 | 0 | 50 | 0 | 0 | 0 | 0 | 0 | 150 | - |
| 3000 | $x_3$ | 0 | 0 | 1 | 0 | 0 | 50 | 0 | 0 | 0 | 0 | 100 | - |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | $s_4$ | 0,003 | 0 | 0 | 0 | - 0,15 | - 0,15 | 1 | 0 | 0 | 0 | 0,25 | 83,33 |
| 0 | $s_5$ | 0,001 | 0 | 0 | 0 | - 0,05 | - 0,05 | 0 | 1 | 0 | 0 | 0,25 | 250 |
| 0 | $s_6$ | 1 | 0 | 0 | 0 | - 50 | - 50 | 0 | 0 | 1 | 0 | 50 | 50 |
| 0 | $s_7$ | 1 | 0 | 0 | 0 | - 50 | - 50 | 0 | 0 | 0 | 1 | 50 | 50 |
| | $z_j$ | 0 | 3.000 | 3.000 | 0 | 150.000 | 150.000 | 0 | 0 | 0 | 0 | 750.000 | |
| | $z_j - c_j$ | -1.000 | 0 | 0 | 0 | 150.000 | 150.000 | 0 | 0 | 0 | 0 | 750.000 | |

c. Define the key row. The smallest $R_i$ value can be used to identify the key row in the function being maximized or minimized.

**Table 13. Simplex Table, Iteration 3 (Determining Key Rows)**

| | $C_j$ | 1.000 | 3.000 | 3.000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $C_i$ | $x_i$ / $x_j$ | $x_1$ | $x_2$ | $x_3$ | $s_1$ | $s_2$ | $s_3$ | $s_4$ | $s_5$ | $s_6$ | $s_7$ | $b_i$ | $R_i$ |
| 0 | $s_1$ | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 100 |
| 3000 | $x_2$ | 0 | 1 | 0 | 0 | 50 | 0 | 0 | 0 | 0 | 0 | 150 | - |
| 3000 | $x_3$ | 0 | 0 | 1 | 0 | 0 | 50 | 0 | 0 | 0 | 0 | 100 | - |
| 0 | $s_4$ | 0,003 | 0 | 0 | 0 | - 0,15 | - 0,15 | 1 | 0 | 0 | 0 | 0,25 | 83,33 |
| 0 | $s_5$ | 0,001 | 0 | 0 | 0 | - 0,05 | - 0,05 | 0 | 1 | 0 | 0 | 0,25 | 250 |
| 0 | $s_6$ | 1 | 0 | 0 | 0 | - 50 | - 50 | 0 | 0 | 1 | 0 | 50 | 50 |
| 0 | $s_7$ | 1 | 0 | 0 | 0 | - 50 | - 50 | 0 | 0 | 0 | 1 | 50 | 50 |
| | $z_j$ | 0 | 3.000 | 3.000 | 0 | 150.000 | 150.000 | 0 | 0 | 0 | 0 | 750.000 | |
| | $z_j - c_j$ | -1.000 | 0 | 0 | 0 | 150.000 | 150.000 | 0 | 0 | 0 | 0 | 750.000 | |

d. Change the key row, column and set the key value to 1, while the other key rows are set to 0. The following OBE procedures are carried out and the results are shown in Table 14.

1) $B_6' = B_6$

2) $B_1' = -B_6' + B_1$

3) $B_4' = -\frac{3}{1000}B_6' + B_4$

4) $B_5' = -\frac{1}{1000}B_6' + B_5$

5) $B_7' = -B_6' + B_7$

**Table 14. Simplex Table, Iteration 3**

| | $C_j$ | 1.000 | 3.000 | 3.000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $C_i$ | $x_i$ / $x_j$ | $x_1$ | $x_2$ | $x_3$ | $s_1$ | $s_2$ | $s_3$ | $s_4$ | $s_5$ | $s_6$ | $s_7$ | $b_i$ | $R_i$ |
| 0 | $s_1$ | 0 | 0 | 0 | 1 | 50 | 50 | 0 | 0 | - 1 | 0 | 50 | |
| 3000 | $x_2$ | 0 | 1 | 0 | 0 | 50 | 0 | 0 | 0 | 0 | 0 | 150 | |
| 3000 | $x_3$ | 0 | 0 | 1 | 0 | 0 | 50 | 0 | 0 | 0 | 0 | 100 | |
| 0 | $s_4$ | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | - 0,003 | 0 | 0,1 | |
| 0 | $s_5$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | - 0,001 | 0 | 0,2 | |
| 1000 | $x_1$ | 1 | 0 | 0 | 0 | - 50 | - 50 | 0 | 0 | 1 | 0 | 50 | |
| 0 | $s_7$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | - 1 | 1 | 0 | |
| | $z_j$ | 1.000 | 3.000 | 3.000 | 0 | 100.000 | 100.000 | 0 | 0 | 1.000 | 0 | 800.000 | |
| | $z_j - c_j$ | 0 | 0 | 0 | 0 | 100.000 | 100.000 | 0 | 0 | 1.000 | 0 | 800.000 | |

In the simplex table on the $3^{th}$ iteration, we get recommendation to produce banana falvored “Es Kul-Kul” ($x_1$) were 50 sticks, red grape flavored "Es Kul-Kul" ($x_2$) were 150 sticks and strawberry flavored "Es Kul-Kul" ($x_3$) were 100 sticks. The simplex table also shows that the value is $z_j - c_j \geq 0$, so the results obtained are optimal. Therefore, according to the calculation results using the simplex method, the highest income that can be earned from selling "Es Kul-Kul" is IDR 800.000.

9. Validation of simplex calculations using MATLAB Software.

```
>> f=[-1000 -3000 -3000];
>> A=[1 0 0;0 0.02 0;0 0 0.02;0.003 0.003 0.003;0.001 0.001 0.001;1 1 1;1 1 1];
>> b=[100 3 2 1 0.5 300 300];
>> Aeq=[];
>> beq=[];
>> lb=[0 0 0 0 0 0 0];
>> ub=[];
>> [X,Z]=linprog(f,A,b,Aeq,beq,lb,ub)
Warning: Length of lower bounds is > length(x); ignoring extra bounds.
> In checkbounds at 27
  In linprog at 242
Optimization terminated.

X =

    50
   150
   100


Z =

 -800000

>> Z=Z*-1

Z =

   800000
```

**Figure 2. Calculations using MATLAB Software**

Based on the results of calculations using MATLAB software, we obtained by substitution value of constraints are $x_1 = 50$, $x_2 = 150$, and $x_3 = 100$. We get

$$F_{max} = 1.000x_1 + 3.000x_2 + 3.000x_3$$
$$\mathrm{F}_{\mathrm{max}} = 1.000(50) + 3.000(150) + 3.000(100)$$
$$\mathrm{F}_{\mathrm{max}} = 800.000$$

So, the results of calculations using MATLAB software was the same with the results of simplex method calculations manually. Furthermore, The results of the analysis of the sales planning of "Es Kul-Kul" production using the simplex method show different results from the income obtained by the owner so far. Previously, the income obtained by the owner per day was IDR 700.000 with the production of 100 sticks of banana, red grape, and strawberry flavored "Es Kul-Kul" each. Meanwhile, the recommendation for "Es Kul-Kul" production planning using the simplex method is to produce 50 sticks of banana flavored "Es Kul-Kul", 150 sticks of red grape flavored "Es Kul-Kul", and 100 sticks of strawberry flavored "Es Kul-Kul", so that the income obtained reaches IDR 800.000.

## CONCLUSION

Based on the research results, it can be conclude that the results of the analysis of the sales planning of "Es Kul-Kul" production using the simplex method was recommended because previously the production of "Es Kul-Kul" was 100 sticks of banana flavored, 100 sticks of red grape flavored, and 100 sticks of strawberry flavored, with an income of IDR 700.000 per day. Meanwhile, by using the simplex method with the same raw materials and production costs, we get recommendation to produce 50 sticks of banana flavor, 150 sticks of red grape flavor, and 100 sticks of strawberry flavor of "Es Kul-Kul" with a total income of IDR 800.000 per day. So, by using the simplex method, we can get bigger income with the same raw materials and production costs. This approach is able to optimize the use of raw materials, reduce waste, and increase production cost efficiency. Furthermore, the implementation of this method is recommended for UMKM to implement similarly to periodic evaluations to adapt to market dynamics. Possible further research is research based on optimization problems that occur in the surrounding environment with different methods and more detailed instruments to produce more accurate and realistic research.

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