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# OPTIMIZATION OF MINIMUM ORDERS FOR COOKIES PRODUCTION TO ACHIEVE MAXIMUM PROFITS USING BRANCH AND BOUND METHOD

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***ABSTRACT***

In order to maintain business continuity, the cookie production business requires several steps by creating a strategy for allocating cookie production after receiving orders and also promotions. This is because entrepreneurs often receive consumer requests that do not match their profit targets. Therefore, this research was carried out to determine the minimum number of orders that must be received for one production of cookies to achieve profits. To find out this, considering that the profit, production factors and products produced are closely related to linear programming, researchers used the linear programming method. This research was conducted to find out the optimal consumer demand to achieve profits so as not to experience losses in one production of cookies at Nur’s Cookies House Business. This research uses a case study type of research where the calculation process uses linear program calculation, namely the simplex method and the branch and bound method. The solution obtained is a combination of consumer requests or consumer orders that must be accepted by the Nur’s Cookies House Business to carry out one production, namely 1 recipe of Monde Jam, 1 recipe of Mawaran, and 1 recipe of Nastar to get a maximum profit of Rp 420.000,-.

**Keywords :** minimum order optimization, integer linear programming, simplex method, branch and bound method

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## PRELIMINARY

One of the important things in the business world is the quality of the product of the business. This was conveyed by entrepreneurs that they must have a good strategy to create and maintain product quality so that it is suitable for consumption by consumers and also suitable as a product that consumers are looking for. Having a good strategy in a business will make production in that business run effectively and efficiently so that this business is worthy of competing with other businesses. Businesses also have the aim of generating maximum profits by planned targets. Based on the results of the interview, one of the efforts made to achieve these business objectives are by optimizing consumer demand to achieve profits so as not to experience losses in one production.

Along with the development of the business world accompanied by intense competition, many problems arise that affect the production of small-scale businesses. However, every company wants to gain profits with a sales strategy (Sikas & Binsasi, 2021). Sales strategies can be done by optimizing the fastest route that must be taken to distribute products, such as research conducted by Ropiqoh and Lubis (2023). These conditions cause many small businesses to continue producing the goods or services they sell even though they are not making a profit. Entrepreneurs continue to do this to maintain consumer trust so that their small businesses continue to grow and remain worthy of competing with other businesses. Meanwhile, maximum profits are obtained from maximum sales. Maximum sales means being able to meet existing demands (Nasution & Prakarsa, 2020).

This was also experienced by the small business managed by Mrs. Nur, where the business was named Nur’s Cookies House. Nur’s Cookies House is a home-based pastry business run by Mrs. Nur Fadilah herself in Ngampelrejo Village, Jember City. Some of the pastries produced are Monde jam, Mawaran, Nastar, Cipiran, Elepant Ears, Banket, Cork Eggs, Kastangel, Onion Stiks, Egg Nuts, Sagon, and Peanut Cookies. However, in this study, the researchers only took Monde Jam, Nastar and Mawaran Cookies as samples because these three products are the cookies that have the highest consumer interest, but consumer demand varies with each production. Along with the development of society’s creativity and increasing competition, the efforts that entrepreneurs must make are to convince that their products are more suitable and have the best quality for consumer consumption. Apart from that, production time also greatly influences consumer confindence in the product and entrepreneurs.

In order to maintain business continuity, a dry cookies production business requires several steps by creating a strategy in allocating dry cookies production after receiving how many orders and promotions. This is because entrepreneurs often receive consumer requests that not make profits. Therefore, this research was carried out with the aim of determining the minimum number of orders that must be received for once dry cookies production in order to gain profits. To find out this, considering that the level of profit, production factors and products produced are closely related to linear programming, research using one of the linear programming methods, namely the simpelex method.

The simplex method has been widely used by previous researchers to answer various problems, especially production problems related to finding the optimum point of production and production profits (Mardia, Zulyanty & Apriyanti, 2023). Several studies that have been conducted using the simplex method include Ambarsari, Hasanah, Astindari, Sari and Masruro (2024), Ghaliyah, Harahap and Badruzzaman (2021), Ismail, Achmad and Mahmud (2022), Susanti (2021), Mardia, Zulyanty and Apriyanti (2023) and Sari, Sundari, Rahmawati and Susanti (2020) which explains that by optimizing production using linear programming by using the simplex method, optimal production combinations also effective and efficient allocation of the use production factors are obtained so as to obtain optimal profits. In research conducted by Lalang, Loban, Adrianigsih and Djenlau (2023), Lestari, Sholehah and Muttaqien (2023), Lina, Marlissa, Rumetna and Lopulalan (2020), Panday and Anggaina (2023) and Indrayanti, Risqiati and Royanti (2022), it is explained that the simplex method can be used as a reference in decision making, because it accelerates sales to innovate in producing production so that existing limites resources can be utilized to obtain maximum profits. Meanwhile, research conducted by Bella, Safitri, Habibatunnurohmah, Fidya, Affandy and Wahyuningsih (2022) explains that to minimize the spread of Covid-19 in Lamongan Regency, we must find out the combination of prevention and control efforts using the simplex method. There is also research conducted by Anti and Sudrajat (2021), Aulia and Amrullah (2023), Syifa, Istiqomah, Puspita, Ratnasari and Khabibah (2023) and Pradana, Hartama, Andani, Solikhun, Tata and Hardinata (2020) which explains that using the simplex method calculations to obtain maximum profits, manufacturers should produce products that provide optimal results. Meanwhile, in the research of Hidayah, Harahap and Badruzzaman (2022), it was explained that through the results of calculations using a linear programming, the profits obtained increased from the predictions of optimization calculations carried out manually. Apart form that, based on research conducted by Aini, Fikri and Sukandar (2021), Hani and Harahap (2021) and Tamiza, Kustiawati, Fathinah and Sulistiono (2023) explained that to get maximum profits it is best to produce products that are in accordance with the optimal combination of simplex method calculations.

Furthermore, the simplex method can be used to optimize (maximize or minimize) an objective function with constraints that have more than 2 variables and can determine the maximum profit prediction and the combination of products that must be produced to get maximum profit. However, in this research, researchers carry out calculations using the simplex method to find out the optimization of the minimum order for dry cookies in order to get a profit in one production.

In the simplex method, we get a case called integer linear programming. An integer program is a special case of a linear program where all (or some) variables are element of non-negative whole numbers (Naik, Alim & Indulkar, 2023). If we using the simplex method to solve problem of linear programming in the real life, there needs to be a method to get whole variables for the result. One of method that can be used is the branch and bound method. The branch and bound method is a method that is often used for optimal solution of linear programs that produce integer decision variables (Andarayani & Sari, 2022).

Some example of research that have been carried out using the branch and bound method are research conducted by Dali, Lesnussa and Ilwaru (2022) to determine optimal production profits. As well as research conducted by Azzahrha, Sari and Fauzi (2021) and Syafitri, Kamid and Rarasati (2021) to find out the combination of products that must be produced to achieve profits. Based on the previous research, we know that by using the branch and bound method, we can get variables in the whole numbers.

## METHODS

The type of research carried out is a case study with the steps carried out in this research as follows :

1. Collecting data was carried out by interviewing Mrs. Nur as the owner of a pastry business called Nur's Cookies House. The data needed is quantitative data (Ismail, Achmad & Mahmud, 2022) in the form of:
   a. Three types data of pastries that have the most consumer interest and frequently ordered.
   b. Recipe data for three types of pastries that most consumer interest and frequently ordered.
   c. Data on the prices of recipe ingredients for three types of patries that have the most consumer interest and frequently ordered.
   d. Profit data of recipe for three types of pastries that have the most consumer interest and frequently ordered.
   e. Data result of five previous sales results.
2. Analyzing and modelling data into mathematical form so that it becomes a linear programming.
3. Calculations using the simplex method.

   The simplex method is a method used to solve linear programming problems with a number of decision variables of more than 2. The simplex method is one of solving linear programming with the process of finding a solution using an interation path, namely determining the feasible point of the goal to be achieved with the help of a table until it is obtained an optimal solution (Anti & Sudrajat, 2021). The calculation results using the simplex method are not always in the form of integers, while the linear programming problems in this study are problems in daily life, so the decimal results are not valid to be used as a solution to the problem. If the calculation results using the simplex method are already in the form of integers, then the results can be used as a solution to the problem in this study. Furthermore, if the calculation results using the simplex method are in decimal form, then the calculation needs to be continued with one of the integer linear programming methods, namely using the branch and bound method.

4. Settlement uses the branch and bound method

The following are the steps or stages in using the branch and bound method (Ayunda, Winarno, Nugraha, & Momon, 2021) :

1. Solving problems using the simplex method,
2. If the optimal solution is in the form of an integer, then the optimal solution is accepted or successfully achieved. Meanwhile, if the solution is in the form of a decimal, then the results need to be processed using the branch and bound method,
3. The solution in decimal form is branced into sub-problems (branching) that lead to the solution by forming a search tree structure and doing restrictions (bounding) to achieve the optimal solution. This aims to eliminate continuous solutions that are not included in determining the optimal solution in the form of an integer in the problem,
4. A feasible integer solution is as good as or better than the upper bound for each sub-problem sought. If such a solution occurs, a sub-problem with the best upper bound is selected to be branched. Furthermore, iteration is carried out again as in number 3 until the optimal solution in the form of an integer is obtained.

## RESULT AND DISCUSSION

The results of this research are in the form of calculations and combinations of the minimum number of consumer request that can be ordered so as to obtain a profit. These results useful as a reference for carrying out production so that the business does not experience losses. The data presented in this research is data on pastry production at Nur’s

Cookies House obtained from interviews with Mrs. Nur Fadilah as the owner of the Nur's Cookies House in Ngampelrejo Village, Jember City. The data used in this research are three pastries namely Monde Jam, Mawaran and Nastar which have a high level of consumer interest.

In Nur's Cookies House business, the ingredient for pastry required for one production of three types of patries, namely Monde Jam, Mawaran and Nastar, it require a maximum of 4 kg of wheat flour, 2 ounces of room butter, 2 kg of butter, 2 ounces of white powdered milk, 1,5 kg granulated sugar, 1,5 kg jam, 2 liters of cooking oil, 10 eggs, 10 pcs vanilla and 3 tsp backing powder. Apart from that, a fee of Rp 16.000,- for gas, Rp 10.000 for electricity and Rp 150.000,- for wages for production workers. Furthemore, the selling price of Monde jam is Rp 130.000,-, for Mawaran is Rp 140.000,- and Rp 150.000,- for Nastar. In one production, it will produce 2 kg per type of pastry and generate a maximum total profit of Rp 91.200,-.

The following presents data that was obtained after conducting an interview with Mrs. Nur Fadilah as the owner of the Nur's Cookies House in Ngampelrejo Village, Jember City.

**Table 1. Types of Ingredients, Products, Availability and Benefits**

| Constraint | Monde Jam | Mawaran | Nastar | Availability |
|---|---|---|---|---|
| Flour | 1 kg | 1,2 kg | 1 kg | 4 kg |
| Room Butter | ½ oz | 1/3 oz | ¼ oz | 2 oz |
| Butter | ¼ kg | ½ kg | ½ kg | 2 kg |
| White Milk Powder | 1 oz | ½ oz | ¼ kg | 5 oz |
| Sugar | 4 oz | ½ kg | ¾ kg | 2 kg |
| Jam | ¼ kg | ½ kg | ½ kg | 1,5 kg |
| Cooking Oil | ¾ liter | ¼ liter | 0,2 liter | 2 liter |
| Egg | 2 items | 4 items | 3 items | 10 items |
| Vanilla | 2 pcs | 3 pcs | 3 pcs | 10 pcs |
| Backing Powder | 1 tsp | ½ tsp | ½ tsp | 3 tsp |
| Gas | Rp 5.000,- | Rp 5.000,- | Rp 5.000,- | Rp 16.000,- |
| Electricity | Rp 3.000,- | Rp 3.000,- | Rp 3.000,- | Rp 10.000,- |
| Power | Rp 40.000,- | Rp 40.000,- | Rp 40.000,- | Rp 150.000,- |

After obtaining the data above, the next steps taken are:

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

   $x_1$ is a number of orders for Monde jam,

   $x_2$ is a number of orders Mawaran,

   $x_3$ is a number of orders Nastar,

   $F_{max}$ is maximum total profit.

2. Determine the objective function to be minimized.

The objective function is a function of the decision variable that will be maximized (for income of profit) or minimized (for cost). The purpose of this research is to determine the number of consumer requests that must be received for each product in order to make a profit in one production. Then the objective function that will be maximized is obtained as follows:

$$F_{max} = 130.000x_1 + 140.000x_2 + 150.000x_3$$

3. Create boundaries (constraints)

$$\begin{array}{rcrcrcl}
x_1 & + & 1{,}2x_2 & + & x_3 & \leq & 4 \\
0{,}5x_1 & + & 0{,}3x_2 & + & 0{,}25x_3 & \leq & 1{,}5 \\
0{,}25x_1 & + & 0{,}5x_2 & + & 0{,}5x_3 & \leq & 2 \\
0{,}1x_1 & + & 0{,}05x_2 & + & 0{,}25x_3 & \leq & 0{,}5 \\
0{,}4x_1 & + & 0{,}5x_2 & + & 0{,}75x_3 & \leq & 2 \\
0{,}25x_1 & + & 0{,}5x_2 & + & 0{,}5x_3 & \leq & 1{,}5 \\
0{,}75x_1 & + & 0{,}25x_2 & + & 0{,}2x_3 & \leq & 2 \\
2x_1 & + & 4x_2 & + & 3x_3 & \leq & 10 \\
2x_1 & + & 3x_2 & + & 3x_3 & \leq & 10 \\
x_1 & + & 0{,}5x_2 & + & 0{,}5x_3 & \leq & 3 \\
5.000x_1 & + & 5.000x_2 & + & 5.000x_3 & \leq & 16.000 \\
3.000x_1 & + & 3.000x_2 & + & 3.000x_3 & \leq & 10.000 \\
40.000x_1 & + & 40.000x_2 & + & 40.000x_3 & \leq & 150.000
\end{array}$$

4. Change the constraints and objective function to in canonical/ready simplex form.

This step aims to determine the value of the decision variables so that they are balanced. In this step, a sign constraint is needed, namely a constraint that explains that the value of the decision variable will only have a non-negative value or the decision variable can have a positive value. Variables that have the sign (≤) are called slack variables, which means that one positive variable must be added to the equation (constraint). Meanwhile, variables that have the sign (≥) are called surplus variables, which means that one negative variable must be added t the equation (constraint) (Sitopu et al., 2023).

a. Canonical form of constraints

$$\begin{array}{rcrcrcrcl}
x_1 & + & 1{,}2x_2 & + & x_3 & + & x_4 & = & 4 \\
0{,}5x_1 & + & 0{,}3x_2 & + & 0{,}25x_3 & + & x_5 & = & 1{,}5 \\
0{,}25x_1 & + & 0{,}5x_2 & + & 0{,}5x_3 & + & x_6 & = & 2 \\
0{,}1x_1 & + & 0{,}05x_2 & + & 0{,}25x_3 & + & x_7 & = & 0{,}5 \\
0{,}4x_1 & + & 0{,}5x_2 & + & 0{,}75x_3 & + & x_8 & = & 2 \\
0{,}25x_1 & + & 0{,}5x_2 & + & 0{,}5x_3 & + & x_9 & = & 1{,}5 \\
0{,}75x_1 & + & 0{,}25x_2 & + & 0{,}2x_3 & + & x_{10} & = & 2 \\
2x_1 & + & 4x_2 & + & 3x_3 & + & x_{11} & = & 10
\end{array}$$

$$2x_1 + 3x_2 + 3x_3 + x_{12} = 10$$
$$x_1 + 0{,}5x_2 + 0{,}5x_3 + x_{13} = 3$$
$$5.000x_1 + 5.000x_2 + 5.000x_3 + x_{14} = 16.000$$
$$3.000x_1 + 3.000x_2 + 3.000x_3 + x_{15} = 10.000$$
$$40.000x_1 + 40.000x_2 + 40.000x_3 + x_{16} = 150.000$$

b. Canonical form of the objective function.

$$F_{max} = 130.000x_1 + 140.000x_2 + 150.000x_3 + 0.x_4 + 0.x_5 + 0.x_6 + 0.x_7$$
$$+0.x_8 + 0.x_9 + 0.x_{10} + 0.x_{11} + 0.x_{12} + 0.x_{13} + 0.x_{14} + 0.x_{15}$$
$$+0.x_{16}$$

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

**Table 2. Simplex of Objective Function and Constraints and for Nur's Cookies House**

| | $C_j$ | 130.000 | 140.000 | 150.000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $C_i$ | $x_i$ / $x_j$ | $x_1$ | $x_2$ | $x_3$ | $x_4$ | $x_5$ | $x_6$ | $x_7$ | $x_8$ | $x_9$ | $x_{10}$ | $x_{11}$ | $x_{12}$ | $x_{13}$ | $x_{14}$ | $x_{15}$ | $x_{16}$ | $b_i$ | $R_i$ |
| 0 | $x_4$ | 1 | 1,2 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | |
| 0 | $x_5$ | 0,5 | 0,3 | 0,25 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1,5 | |
| 0 | $x_6$ | 0,25 | 0,5 | 0,5 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | |
| 0 | $x_7$ | 0,1 | 0,05 | 0,25 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0,5 | |
| 0 | $x_8$ | 0,4 | 0,5 | 0,75 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | |
| 0 | $x_9$ | 0,25 | 0,5 | 0,5 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1,5 | |
| 0 | $x_{10}$ | 0,75 | 0,25 | 0,2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | |
| 0 | $x_{11}$ | 2 | 4 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 10 | |
| 0 | $x_{12}$ | 2 | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 10 | |
| 0 | $x_{13}$ | 1 | 0,5 | 0,5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 3 | |
| 0 | $x_{14}$ | 5.000 | 5.000 | 5.000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 16.000 | |
| 0 | $x_{15}$ | 3.000 | 3.000 | 3.000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 10.000 | |
| 0 | $x_{16}$ | 40.000 | 40.000 | 40.000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 150.000 | |
| | $z_j$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| | $z_j - c_j$ | -130.000 | -140.000 | -150.000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |

Consider the value of $z_j - c_j$, because $z_j - c_j$ is not optimal, then iteration must be carried out until we get the optimal of $z_j - c_j$. The maximum requirement results is $z_j - c_j \geq 0$. Meanwhile, the minimum requirement to get optimal result is $z_j - c_j \leq 0$.

Based on the simplex table above, we didn't get the optimal value of $z_j - c_j$, therefore it is necessary to iterate until we get the optimal results of $z_j - c_j$.

6. Iteration 1

a. Define the key column. The key column in the function that is maximized can be seen from the smallest $z_j - c_j$ value. Next, determines the value of $R_i$ by dividing $b_i$ by the key column. Furthemore, specifies the key row. The key row in the function that is maximized or minimized can be seen from the smallest $R_i$ value.

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

| | $C_j$ | 130.000 | 140.000 | 150.000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $C_i$ | $x_i$ / $x_j$ | $x_1$ | $x_2$ | $x_3$ | $x_4$ | $x_5$ | $x_6$ | $x_7$ | $x_8$ | $x_9$ | $x_{10}$ | $x_{11}$ | $x_{12}$ | $x_{13}$ | $x_{14}$ | $x_{15}$ | $x_{16}$ | $b_i$ | $R_i$ |
| 0 | $x_4$ | 1 | 1,2 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 4 |
| 0 | $x_5$ | 0,5 | 0,3 | 0,25 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1,5 | 6 |
| 0 | $x_6$ | 0,25 | 0,5 | 0,5 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 4 |
| 0 | $x_7$ | 0,1 | 0,05 | 0,25 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0,5 | 2 |
| 0 | $x_8$ | 0,4 | 0,5 | 0,75 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2,6 |
| 0 | $x_9$ | 0,25 | 0,5 | 0,5 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1,5 | 3 |
| 0 | $x_{10}$ | 0,75 | 0,25 | 0,2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 10 |
| 0 | $x_{11}$ | 2 | 4 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 10 | 3.33 |
| 0 | $x_{12}$ | 2 | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 10 | 3,33 |
| 0 | $x_{13}$ | 1 | 0,5 | 0,5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 3 | 6 |
| 0 | $x_{14}$ | 5.000 | 5.000 | 5.000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 16.000 | 3,2 |
| 0 | $x_{15}$ | 3.000 | 3.000 | 3.000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 10.000 | 3,33 |
| 0 | $x_{16}$ | 40.000 | 40.000 | 40.000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 150.000 | 3,75 |
| | $z_j$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| | $z_j - c_j$ | -130.000 | -140.000 | -150.000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |

b. Carry out the Elementary Row Operations step and we get the results in Table 4 below.

**Table 4. Simplex Table**

| | $C_j$ | 130.000 | 140.000 | 150.000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $C_i$ | $x_i$ / $x_j$ | $x_1$ | $x_2$ | $x_3$ | $x_4$ | $x_5$ | $x_6$ | $x_7$ | $x_8$ | $x_9$ | $x_{10}$ | $x_{11}$ | $x_{12}$ | $x_{13}$ | $x_{14}$ | $x_{15}$ | $x_{16}$ | $b_i$ | $R_i$ |
| 0 | $x_4$ | 0,6 | 1 | 0 | 1 | 0 | 0 | -4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | |
| 0 | $x_5$ | 0,4 | 0,25 | 0 | 0 | 1 | 0 | -1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | |
| 0 | $x_6$ | 0,05 | 0,4 | 0 | 0 | 0 | 1 | -2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | |
| 150.000 | $x_3$ | 0,4 | 0,2 | 1 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | |
| 0 | $x_8$ | 0,1 | 0,35 | 0 | 0 | 0 | 0 | -3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0,5 | |
| 0 | $x_9$ | 0,05 | 0,4 | 0 | 0 | 0 | 0 | -2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0,5 | |
| 0 | $x_{10}$ | 0,67 | 0,21 | 0 | 0 | 0 | 0 | -0,8 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1,6 | |
| 0 | $x_{11}$ | 0,8 | 3,4 | 0 | 0 | 0 | 0 | -12 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 4 | |
| 0 | $x_{12}$ | 0,8 | 2,4 | 0 | 0 | 0 | 0 | -12 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 4 | |
| 0 | $x_{13}$ | 0,8 | 0,4 | 0 | 0 | 0 | 0 | -2 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | |
| 0 | $x_{14}$ | 3.000 | 4.000 | 0 | 0 | 0 | 0 | -20.000 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 6.000 | |
| 0 | $x_{15}$ | 1.800 | 2.400 | 0 | 0 | 0 | 0 | -12.000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 4.000 | |
| 0 | $x_{16}$ | 24.000 | 32.000 | 0 | 0 | 0 | 0 | -160.000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 70.000 | |
| | $z_j$ | 60.000 | 30.000 | 150.000 | 0 | 0 | 0 | 600.000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 300.000 | |
| | $z_j - c_j$ | -70.000 | -110.000 | 0 | 0 | 0 | 0 | 600.000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 300.000 | |

In Table 4, the optimal of $z_j - c_j$ were not obtained, we continued to iteration 2 with the same steps.

7. Interation 2.

a. Define the key columns and rows.

**Table 5. Iteration 2 (Determining The Key Columns and Rows)**

| | $C_j$ | 130.000 | 140.000 | 150.000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $C_i$ | $x_i$ / $x_j$ | $x_1$ | $x_2$ | $x_3$ | $x_4$ | $x_5$ | $x_6$ | $x_7$ | $x_8$ | $x_9$ | $x_{10}$ | $x_{11}$ | $x_{12}$ | $x_{13}$ | $x_{14}$ | $x_{15}$ | $x_{16}$ | $b_i$ | $R_i$ |
| 0 | $x_4$ | 0,6 | 1 | 0 | 1 | 0 | 0 | -4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 |
| 0 | $x_5$ | 0,4 | 0,25 | 0 | 0 | 1 | 0 | -1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 4 |
| 0 | $x_6$ | 0,05 | 0,4 | 0 | 0 | 0 | 1 | -2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2,5 |
| 150.000 | $x_3$ | 0,4 | 0,2 | 1 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 10 |
| 0 | $x_8$ | 0,1 | 0,35 | 0 | 0 | 0 | 0 | -3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0,5 | 1,43 |
| 0 | $x_9$ | 0,05 | 0,4 | 0 | 0 | 0 | 0 | -2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0,5 | 1,25 |
| 0 | $x_{10}$ | 0,67 | 0,21 | 0 | 0 | 0 | 0 | -0,8 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1,6 | 7,62 |
| 0 | $x_{11}$ | 0,8 | 3,4 | 0 | 0 | 0 | 0 | -12 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 4 | 1,18 |
| 0 | $x_{12}$ | 0,8 | 2,4 | 0 | 0 | 0 | 0 | -12 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 4 | 1,6 |
| 0 | $x_{13}$ | 0,8 | 0,4 | 0 | 0 | 0 | 0 | -2 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 5 |
| 0 | $x_{14}$ | 3.000 | 4.000 | 0 | 0 | 0 | 0 | -20.000 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 6.000 | 1,5 |
| 0 | $x_{15}$ | 1.800 | 2.400 | 0 | 0 | 0 | 0 | -12.000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 4.000 | 1,67 |
| 0 | $x_{16}$ | 24.000 | 32.000 | 0 | 0 | 0 | 0 | -160.000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 70.000 | 2,19 |
| | $z_j$ | 60.000 | 30.000 | 150.000 | 0 | 0 | 0 | 600.000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 300.000 | |
| | $z_j - c_j$ | -70.000 | -110.000 | 0 | 0 | 0 | 0 | 600.000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 300.000 | |

b. Carry out the Elementary Row Operations step and we get the results Table 6 below.

**Table 6. Simplex Table**

| | $C_j$ | 130.000 | 140.000 | 150.000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $C_i$ | $x_i$ / $x_j$ | $x_1$ | $x_2$ | $x_3$ | $x_4$ | $x_5$ | $x_6$ | $x_7$ | $x_8$ | $x_9$ | $x_{10}$ | $x_{11}$ | $x_{12}$ | $x_{13}$ | $x_{14}$ | $x_{15}$ | $x_{16}$ | $b_i$ | $R_i$ |
| 0 | $x_4$ | 0,36 | 0 | 0 | 1 | 0 | 0 | -0,47 | 0 | 0 | 0 | -0,29 | 0 | 0 | 0 | 0 | 0 | 0,82 | |
| 0 | $x_5$ | 0,34 | 0 | 0 | 0 | 1 | 0 | -0,12 | 0 | 0 | 0 | -0,074 | 0 | 0 | 0 | 0 | 0 | 0,71 | |
| 0 | $x_6$ | -0,044 | 0 | 0 | 0 | 0 | 1 | -0,59 | 0 | 0 | 0 | -0,12 | 0 | 0 | 0 | 0 | 0 | 0,53 | |
| 150.000 | $x_3$ | 0,35 | 0 | 1 | 0 | 0 | 0 | 4,71 | 0 | 0 | 0 | -0,059 | 0 | 0 | 0 | 0 | 0 | 1,76 | |
| 0 | $x_8$ | 0,018 | 0 | 0 | 0 | 0 | 0 | -1,76 | 1 | 0 | 0 | -0,102 | 0 | 0 | 0 | 0 | 0 | 0,088 | |
| 0 | $x_9$ | -0,044 | 0 | 0 | 0 | 0 | 0 | -0,59 | 0 | 1 | 0 | -0,12 | 0 | 0 | 0 | 0 | 0 | 0,029 | |
| 0 | $x_{10}$ | 0,62 | 0 | 0 | 0 | 0 | 0 | -0,059 | 0 | 0 | 1 | -0,062 | 0 | 0 | 0 | 0 | 0 | 1,35 | |
| 140.000 | $x_2$ | 0,24 | 1 | 0 | 0 | 0 | 0 | -3,53 | 0 | 0 | 0 | 0,29 | 0 | 0 | 0 | 0 | 0 | 1,18 | |
| 0 | $x_{12}$ | 0,24 | 0 | 0 | 0 | 0 | 0 | -3,53 | 0 | 0 | 0 | -0,71 | 1 | 0 | 0 | 0 | 0 | 1,18 | |
| 0 | $x_{13}$ | 0,71 | 0 | 0 | 0 | 0 | 0 | -0,59 | 0 | 0 | 0 | -0,12 | 0 | 1 | 0 | 0 | 0 | 1,53 | |
| 0 | $x_{14}$ | 2.058,8 | 0 | 0 | 0 | 0 | 0 | -5.882,35 | 0 | 0 | 0 | -1.176,5 | 0 | 0 | 1 | 0 | 0 | 1.294,1 | |
| 0 | $x_{15}$ | 1.235,3 | 0 | 0 | 0 | 0 | 0 | -3.529,41 | 0 | 0 | 0 | -705,88 | 0 | 0 | 0 | 1 | 0 | 1.176,5 | |
| 0 | $x_{16}$ | 16.470,6 | 0 | 0 | 0 | 0 | 0 | -47.058,8 | 0 | 0 | 0 | -9.411,8 | 0 | 0 | 0 | 0 | 1 | 32.352,9 | |
| | $z_j$ | 85.882,3 | 140.000 | 150.000 | 0 | 0 | 0 | 211.764,7 | 0 | 0 | 0 | 49.999,9 | 0 | 0 | 0 | 0 | 0 | 429.411,8 | |
| | $z_j - c_j$ | -44.117,7 | 0 | 0 | 0 | 0 | 0 | 211.764,7 | 0 | 0 | 0 | 49.999,9 | 0 | 0 | 0 | 0 | 0 | 429.411,8 | |

In Table 6, the optimal of $z_j - c_j$ were not obtained, we continued to iteration 3 with the same steps.

8. Iteration 3.

   a. Define the key columns and rows.

**Table 7. Iteration 3 (Determining The Key Columns and Rows)**

| | $C_j$ | 130.000 | 140.000 | 150.000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $C_i$ | $x_i$ / $x_j$ | $x_1$ | $x_2$ | $x_3$ | $x_4$ | $x_5$ | $x_6$ | $x_7$ | $x_8$ | $x_9$ | $x_{10}$ | $x_{11}$ | $x_{12}$ | $x_{13}$ | $x_{14}$ | $x_{15}$ | $x_{16}$ | $b_i$ | $R_i$ |
| 0 | $x_4$ | 0,36 | 0 | 0 | 1 | 0 | 0 | -0,47 | 0 | 0 | 0 | -0,29 | 0 | 0 | 0 | 0 | 0 | 0,82 | 2,3 |
| 0 | $x_5$ | 0,34 | 0 | 0 | 0 | 1 | 0 | -0,12 | 0 | 0 | 0 | -0,074 | 0 | 0 | 0 | 0 | 0 | 0,71 | 2,1 |
| 0 | $x_6$ | -0,044 | 0 | 0 | 0 | 0 | 1 | -0,59 | 0 | 0 | 0 | -0,12 | 0 | 0 | 0 | 0 | 0 | 0,53 | -12 |
| 150.000 | $x_3$ | 0,35 | 0 | 1 | 0 | 0 | 0 | 4,71 | 0 | 0 | 0 | -0,059 | 0 | 0 | 0 | 0 | 0 | 1,76 | 5 |
| 0 | $x_8$ | 0,018 | 0 | 0 | 0 | 0 | 0 | -1,76 | 1 | 0 | 0 | -0,102 | 0 | 0 | 0 | 0 | 0 | 0,088 | 5 |
| 0 | $x_9$ | -0,044 | 0 | 0 | 0 | 0 | 0 | -0,59 | 0 | 1 | 0 | -0,12 | 0 | 0 | 0 | 0 | 0 | 0,029 | -0,7 |
| 0 | $x_{10}$ | 0,62 | 0 | 0 | 0 | 0 | 0 | -0,059 | 0 | 0 | 1 | -0,062 | 0 | 0 | 0 | 0 | 0 | 1,35 | 2.2 |
| 140.000 | $x_2$ | 0,24 | 1 | 0 | 0 | 0 | 0 | -3,53 | 0 | 0 | 0 | 0,29 | 0 | 0 | 0 | 0 | 0 | 1,18 | 5 |
| 0 | $x_{12}$ | 0,24 | 0 | 0 | 0 | 0 | 0 | -3,53 | 0 | 0 | 0 | -0,71 | 1 | 0 | 0 | 0 | 0 | 1,18 | 5 |
| 0 | $x_{13}$ | 0,71 | 0 | 0 | 0 | 0 | 0 | -0,59 | 0 | 0 | 0 | -0,12 | 0 | 1 | 0 | 0 | 0 | 1,53 | 2,2 |
| 0 | $x_{14}$ | 2.058,8 | 0 | 0 | 0 | 0 | 0 | -5.882,35 | 0 | 0 | 0 | -1.176,5 | 0 | 0 | 1 | 0 | 0 | 1.294,1 | 0,6 |
| 0 | $x_{15}$ | 1.235,3 | 0 | 0 | 0 | 0 | 0 | -3.529,41 | 0 | 0 | 0 | -705,88 | 0 | 0 | 0 | 1 | 0 | 1.176,5 | 0,9 |
| 0 | $x_{16}$ | 16.470,6 | 0 | 0 | 0 | 0 | 0 | -47.058,8 | 0 | 0 | 0 | -9.411,8 | 0 | 0 | 0 | 0 | 1 | 32.352,9 | 1,9 |
| | $z_j$ | 85.882,3 | 140.000 | 150.000 | 0 | 0 | 0 | 211.764,7 | 0 | 0 | 0 | 49.999,9 | 0 | 0 | 0 | 0 | 0 | 429.411,8 | |
| | $z_j - c_j$ | -44.117,7 | 0 | 0 | 0 | 0 | 0 | 211.764,7 | 0 | 0 | 0 | 49.999,9 | 0 | 0 | 0 | 0 | 0 | 429.411,8 | |

b. Carry out the Elementary Row Operations step and we get the results in Table 8 below.

**Table 8. Simplex Table**

| | $C_j$ | 130.000 | 140.000 | 150.000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $C_i$ | $x_i$ / $x_j$ | $x_1$ | $x_2$ | $x_3$ | $x_4$ | $x_5$ | $x_6$ | $x_7$ | $x_8$ | $x_9$ | $x_{10}$ | $x_{11}$ | $x_{12}$ | $x_{13}$ | $x_{14}$ | $x_{15}$ | $x_{16}$ | $b_i$ | $R_i$ |
| 0 | $x_4$ | 0 | 0 | 0 | 1 | 0 | 0 | 0,57 | 0 | 0 | 0 | -0,086 | 0 | 0 | 0 | 0 | 0 | 0,59 | |
| 0 | $x_5$ | 0 | 0 | 0 | 0 | 1 | 0 | 0,86 | 0 | 0 | 0 | 0,12 | 0 | 0 | 0 | 0 | 0 | 0,49 | |
| 0 | $x_6$ | 0 | 0 | 0 | 0 | 0 | 1 | -0,71 | 0 | 0 | 0 | -0,14 | 0 | 0 | 0 | 0 | 0 | 0,56 | |
| 150.000 | $x_3$ | 0 | 0 | 1 | 0 | 0 | 0 | 5,71 | 0 | 0 | 0 | 0,14 | 0 | 0 | 0 | 0 | 0 | 1,54 | |
| 0 | $x_8$ | 0 | 0 | 0 | 0 | 0 | 0 | -1,71 | 1 | 0 | 0 | -0,09 | 0 | 0 | 0 | 0 | 0 | 0,08 | |
| 0 | $x_9$ | 0 | 0 | 0 | 0 | 0 | 0 | -0,71 | 0 | 1 | 0 | -0,14 | 0 | 0 | 0 | 0 | 0 | 0,06 | |
| 0 | $x_{10}$ | 0 | 0 | 0 | 0 | 0 | 0 | 1,71 | 0 | 0 | 1 | 0,29 | 0 | 0 | 0 | 0 | 0 | 0,96 | |
| 140.000 | $x_2$ | 0 | 1 | 0 | 0 | 0 | 0 | -2,86 | 0 | 0 | 0 | 0,43 | 0 | 0 | 0 | 0 | 0 | 1,03 | |
| 0 | $x_{12}$ | 0 | 0 | 0 | 0 | 0 | 0 | -2,86 | 0 | 0 | 0 | -0,58 | 1 | 0 | 0 | 0 | 0 | 1,03 | |
| 0 | $x_{13}$ | 0 | 0 | 0 | 0 | 0 | 0 | 1,43 | 0 | 0 | 0 | 0,28 | 0 | 1 | 0 | 0 | 0 | 1,08 | |
| 130.000 | $x_1$ | 1 | 0 | 0 | 0 | 0 | 0 | -2,86 | 0 | 0 | 0 | -0,57 | 0 | 0 | 1 | 0 | 0 | 0,63 | |
| 0 | $x_{15}$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -0,59 | 1 | 0 | 400 | |
| 0 | $x_{16}$ | 0 | 0 | 0 | 0 | 0 | 0 | -0,04 | 0 | 0 | 0 | -0,02 | 0 | 0 | -7,99 | 0 | 1 | 22.000 | |
| | $z_j$ | 130.000 | 140.000 | 150.000 | 0 | 0 | 0 | 85.714,4 | 0 | 0 | 0 | 7.142,9 | 0 | 0 | 21,43 | 0 | 0 | 457.143 | |
| | $z_j - c_j$ | 0 | 0 | 0 | 0 | 0 | 0 | 85.714,4 | 0 | 0 | 0 | 7.142,9 | 0 | 0 | 21,43 | 0 | 0 | 457.143 | |

In the 3$^{th}$ iteration of the simplex table, the production of Monde Jam ($x_1$) is 0,63, the production of Mawaran ($x_2$) is 1,03 and the production of Nastar ($x_3$) is 1,54. The simplex table also shows that the value is $z_j - c_j \geq 0$, so the results obtained are optimal. So, the maximum profit that will be obtained by the Nur's Cookies House Business from calculations using the simplex method is Rp 457.143,-.

However, the results are still in decimal numbers, then the calculations are needed using the branch and bound method to get integer results.

9. Calculations using the branch and bound method.

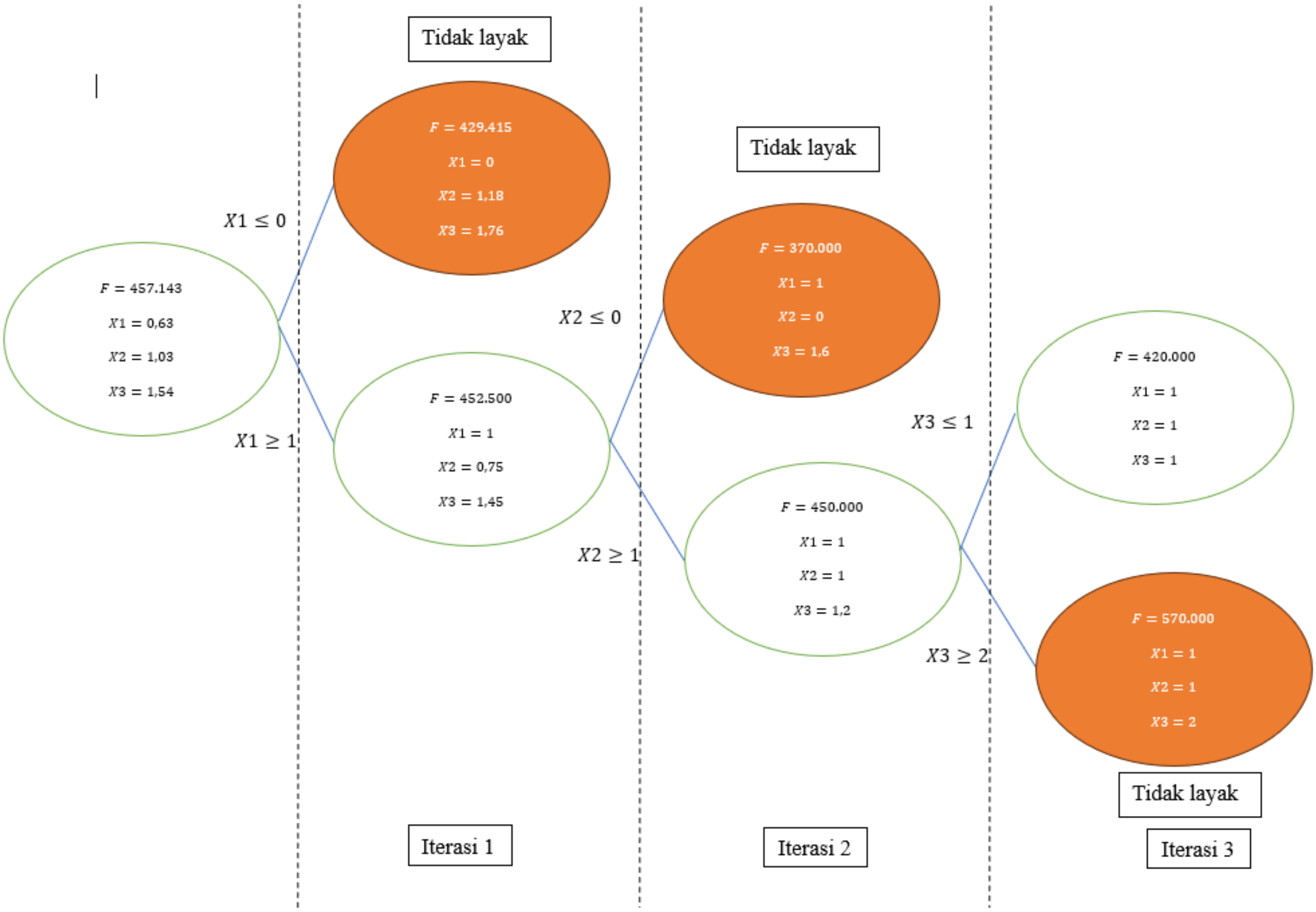


**Figure 1. Calculations of The Branch and Bound Method**

Based on the results of calculations using the branch and bound method, the solution obtained by substitution value of constraints are $x_1 = 1$, $x_2 = 1$, and $x_3 = 1$. We get

$$F_{max} = 130.000x_1 + 140.000x_2 + 150.000x_3$$

$$F_{max} = 130.000(1) + 140.000(1) + 150.000(1)$$

$$F_{max} = 420.000$$

So, the minimal consumer request or consumer order that the Nur's Cookies House Business must received in one production are 1 Monde Jam recipe, 1

Mawaran recipe, and 1 Nastar recipe, in order to get a maximum profit Rp 420.000,-.

## CONCLUSION

Based on the aim of research and solving problems that occur in the Nur's Cookies House business, this research aims to optimize the minimal number of consumer requests or orders that must be received in order to get maximum profits in one production using the integer linear programming method, that is simplex method and branch and bound menthod. Based on the calculation results using the simplex and brancah and bound methods, the optimal production strategy to maximize profits is to accept consumer orders for at least 1 Monde Jam recipe, 1 Mawaran recipe, and 1 Nastar recipe per production, to obtain a maximum profit of at least Rp 420.000,-.

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