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Application of Integer Linear Programming in the Optimization of Profit Production of Processed Glutinous Rice in the Household Industry of Long Pejeng Village

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ABSTRACT

Glutinous rice is a variety of rice that plays an important role in local culture, especially in the tradition of opening fields. When the harvest season arrives, local communities usually hold thanksgiving in the form of uman (eating) ubek parties at the beginning of the harvest and post-harvest parties as an expression of gratitude for the harvest. In the tradition of the Dayak community, especially Dayak Kenyah, glutinous rice is used as the main ingredient for making various specialties such as lemang, ubek (kenta), and undat ao. So glutinous rice is used as the main commodity for the household industry in Long Pejeng Village. Various types of processed products produced by this industry, including lemang, fried sticky rice, klepon and bubur candil, use glutinous rice as the main raw material. This study aims to optimize the profit of glutinous rice production by applying integer linear programming. The method used in this research is the simplex method to find the optimal solution, as well as the Gomory Cutting Plane method to obtain a feasible integer solution for each type of product. The results showed that the optimal production quantity was 281 packs per one-time production, consisting of 112 packs of lemang, 56 packs of fried sticky rice, 45 packs of klepon, and 68 packs of candil porridge, with a maximum profit of Rp887,368.00. Optimization using this method is proven to significantly increase profits by 14.4% compared to the previous production method and increase efficiency in the use of raw materials and production capacity.

I. Introduction

Long Pejeng Village is a village located in Busang District, East Kutai Regency, East Kalimantan. The village is characterized by the practice of field agriculture. One of the rice varieties in this village is sticky rice. Because it has high cultural value and is considered an obligation in the local culture, glutinous rice has become a commodity for the household industry in Long Pejeng Village. The industrial production uses glutinous rice as raw material to produce various types of preparations such as lemang, fried sticky rice, klepon, and bubur candil. Therefore, to support the development of the sector, the application of mathematics can be an effective solution.

In general, mathematics is divided into two, namely pure mathematics and applied mathematics. Applied mathematics can be used outside the field of mathematics. With the emergence of mathematical applications both in everyday life and in other sciences. For example, the principle of economics, which is to use a small capital to generate maximum profit, so an optimization problem arises. In order to get more optimal profits, one part of the application of mathematics is the application of operations research techniques.

Operations research was first introduced in the UK as a result of the study of military operations during World War II, which was very effective in solving military problems by optimizing military forces in using war equipment efficiently[1]. Research literally means an organized process of seeking the truth about a problem. While operation is an action applied to some problem[2]. The focus of operations research is to make the best decision-making process by utilizing existing analytical tools and the existence of limited resources[3]. And aims to apply a scientific approach to solve / analyze problems, take the right strategy and appropriate targets systematically to achieve predetermined goals, namely satisfactory results[4].

Linear programming is one of the mathematical models used to solve optimization problems, namely maximizing or minimizing an objective function that depends on a number of input variables[1]. In addition to being designed to assist managers in planning and making decisions in allocating limited resources to achieve company goals, but due to limited resources, it can also minimize costs[5]. This method recognizes two types of functions, namely the objective function and the constraint function[2]. Decision variables in linear programming problem solving are often fractional numbers. However, in some specific cases there are those who want the solution to be an integer. Thus, integer linear programming arises where in the general form of linear programming there is an additional requirement that the decision variable must be an integer[6].

The simplex method is a commonly used method to solve all linear programming problems, whether involving two variables or more than two decision variables[7]. In addition, it also solves problems that include multiple inequalities and large limiting variables[2]. The simplex method is an iterative procedure, which moves step by step, starting from an extreme point in the feasible region (solution space) towards the optimum extreme point[8]. This method can work by converting the constraints on linear programming problems in the form of inequalities into equations. In changing the inequality $\leq$ to an equation is by adding a slack variable[9].

The Gomory cutting plane method is a method used to solve integer linear programming, both pure and mixed integers with the addition of a new constraint called Gomory. This constraint is given if the value of the decision variable is not integer (fractional value)[10].

Based on the description above, the authors are interested in conducting research on production profit optimization using integer linear programming method with gomory cutting plane**.**

II. Method

In this research using literature studies related to the research topic. After studying topics related to research, the next step is to collect data in the form of materials used in each type of processed, types of processed products, production costs, material inventory, selling prices, profits, and the amount of processed production once produced. The first step is to formulate the data into a linear programming model. The second step is to solve the model using the simplex method. The next step is to solve the optimum results into integer form using the gomory cutting plane method. Then compare the profit results obtained using the gomory cutting plane method with the company's profit.

The steps of the gomory cutting plane method on solving integer linear programming problems are as follows:

1. Solve the integer linear programming problem with the simplex method and ignore the integer terms. The steps in calculating the simplex method according to [11], that is:
   i. Determine the objective function and constraint function.
   ii. Convert the objective function and constraints into standardized form.
   iii. Create the initial simplex table.
   iv. Determine the key column (decision variable) and key row as the basis for iteration. The key column is determined by the smallest Z value (negative).
   v. Determine the key row based on the smallest index value.
   $$index = \frac{Right\ Value(RV)}{Key\ Column\ (KC)}$$
   vi. Create a new key row by dividing the old key row by the key number. The key number is the value positioned at the intersection of the key column and key row.

$$new\ key\ row = \frac{old\ key\ row}{key\ figure}$$

vii. Create a new row by changing the row values (other than the key row) so that the key column values = 0, by following the calculation as follows:

$$new\ line = old\ line - (\text{RKCV} \times NKL)$$

with:

RKCV: Row Key Column Value
NKL: New Key Lines

viii. Repeat the above steps (steps iv-vii), until there are no negative values in row Z.

a. If the solution of step 1 contains fractional-valued variables, perform the following steps:
   a. Select any row of the simplex optimum table in column b_i that contains a fraction. If there are several variables with fractional values, choose the row that contains the largest fraction, this is chosen to make iterative faster.
   b. Suppose the i-th row is the selected row and the equation formed in the i-th row is

$$\sum_{j=1}^{n} a_{ij}x_j = b_i$$

   with additional constraints:

$$Sg_i - \sum_{j=1}^{n} f_{ij}x_i = -f_i$$

   c. It is then solved using the simplex method with the selected equation placed in the last row [6].

III. Results and Discussion

In this section we will discuss the process of optimizing the profitability of glutinous rice production using the gomory cutting plane method. Before discussing the optimization process, researchers have taken data directly. The data is secondary data, namely raw material data, product types, production costs, raw material inventory, selling prices, profits and the amount of processed production once produced. In this study, the data obtained is based on one-time production. The data is presented in Tables 1 to 5.

Table 1. Processed Raw Material Data of Each Packaging (gram)

No.	Raw Materials Used	Processed Products			
		Lemang	Fried Sticky Rice	Klepon	Candil Porridge
1.	Glutinous Rice	49	0	0	0
2.	Glutinous Rice Flour	0	90	45	116
3.	Salt	0,55	2	0,42	2
4.	Tapioca Flour	0	0	4	0,65
5.	Aren Sugar	0	0	6	69
6.	Old Coconut	0	0	44	0
7.	Pandan Leaves	0,22	0	0	0,22
8.	Coconut Milk	33	0	0	4
9.	Turmeric	1	0	0	0
10.	Cooking Oil	0	5	0	0
11.	Sugar	0	0	0	23

Table 2. Amount of Processed Production in a Single Production

Symbol	Type of Processed	Production Quantity
x_1	Lemang	120
x_2	Fried Sticky Rice	50
x_3	Klepon	50
x_4	Candil Porridge	50
	Total	270

Table 3. Production Cost and Selling Price (Rp)

No.	Type of Processed	Production Cost	Selling Price
1.	Lemang	13.533	15.000
2.	Fried Sticky Rice	2.826	5.000
3.	Klepon	2.132	5.000
4.	Candil Porridge	8.055	15.000

Table 4. Advantages of Each Type of Processed Product (Rp)

No.	Type of Processed	Advantage
1.	Lemang	1.467
2.	Fried Sticky Rice	2.174
3.	Klepon	2.868
4.	Candil Porridge	6.945

Table 5. Raw Material Inventory for One Time Production (gram)

No.	Raw Materials	Supplies
1.	Glutinous Rice	40.000
2.	Glutinous Rice Flour	15.000
3.	Salt	500
4.	Tapioca Flour	10.000
5.	Aren Sugar	5.000
6.	Old Coconut	2.000
7.	Pandan Leaves	50
8.	Coconut Milk	4.000
9.	Turmeric	200
10.	Cooking Oil	10.000
11.	Sugar	20.000

Based on the data presented in the table above, the objective function is to maximize the profit per unit of each processed product. So the objective function is:

Profit maximization:

$$Z = 1.467x_1 + 2.174x_2 + 2.868x_3 + 6.945x_4$$

Constraint function:

$$49x_1 \leq 40.000$$
$$90x_2 + 45x_3 + 116x_4 \leq 15.000$$
$$0{,}55x_1 + 2x_2 + 0{,}42x_3 + 2x_4 \leq 500$$
$$4x_3 + 0{,}65x_4 \leq 10.000$$
$$6x_3 + 69x_4 \leq 5.000$$
$$44x_3 \leq 2.000$$
$$0{,}22x_1 + 0{,}22x_4 \leq 50$$
$$33x_1 + 4x_4 \leq 4.000$$
$$x_1 \leq 200$$
$$5x_2 \leq 10.000$$
$$23x_4 \leq 20.000$$
$$x_1, x_2, x_3, x_4 \geq 0$$

Data processing is carried out using two methods, namely the simplex method to determine the optimal amount of production then continued with the gomory cutting plane method to find the amount of production in integer form.

First, solving using the simplex method. The first step is to determine the objective function, in this case maximizing profit with the price per unit per product as the coefficient of the decision variable of the number of product units to be produced for each type of preparation. The objective function is expressed in the following mathematical form:

$$Z = 1.467x_1 + 2.174x_2 + 2.868x_3 + 6.945x_4$$

While the constraint function in this case is a maximum of 11 raw materials available in one production. The constraint function is expressed in the form of a mathematical inequality as follows:

$$\begin{aligned}
&49x_1 + S_1 \leq 40.000\\
&90x_2 + 45x_3 + 116x_4 + S_2 \leq 15.000\\
&0{,}55x_1 + 2x_2 + 0{,}42x_3 + 2x_4 + S_3 \leq 500\\
&4x_3 + 0{,}65x_4 + S_4 \leq 10.000\\
&6x_3 + 69x_4 + S_5 \leq 5.000\\
&44x_3 + S_6 \leq 2.000\\
&0{,}22x_1 + 0{,}22x_4 + S_7 \leq 50\\
&33x_1 + 4x_4 + S_8 \leq 4.000\\
&x_1 + S_9 \leq 200\\
&5x_2 + S_{10} \leq 10.000\\
&23x_4 + S_{11} \leq 20.000\\
&x_1, x_2, x_3, x_4 \geq 0, \text{ and}\\
&x_1, x_2, x_3, x_4 \text{ integers.}
\end{aligned}$$

Then convert the objective and constraint functions into standardized form.
Objective function:

Maximize

$$Z = 1.467x_1 + 2.174x_2 + 2.868x_3 + 6.945x_4$$

Constraint function:

$$\begin{aligned}
&49x_1 + S_1 = 40.000\\
&90x_2 + 45x_3 + 116x_4 + S_2 = 15.000\\
&0{,}55x_1 + 2x_2 + 0{,}42x_3 + 2x_4 + S_3 = 500\\
&4x_3 + 0{,}65x_4 + S_4 = 10.000\\
&6x_3 + 69x_4 + S_5 = 5.000\\
&44x_3 + S_6 = 2.000\\
&0{,}22x_1 + 0{,}22x_4 + S_7 = 50\\
&33x_1 + 4x_4 + S_8 = 4.000\\
&x_1 + S_9 = 200\\
&5x_2 + S_{10} = 10.000\\
&23x_4 + S_{11} = 20.000
\end{aligned}$$

The next step is to organize the equations into Table 6.

Table 6. Simplex Table

B.V	Z	x_1	x_2	x_3	x_4	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	S_{10}	S_{11}	RV
Z	1	1.467	2.174	2.868	6.945	0	0	0	0	0	0	0	0	0	0	0	
S_1	0	49	0	0	0	1	0	0	0	0	0	0	0	0	0	0	40.000
S_2	0	0	90	45	116	0	1	0	0	0	0	0	0	0	0	0	15.000
S_3	0	0,55	2	0,42	2	0	0	1	0	0	0	0	0	0	0	0	500
S_4	0	0	0	4	0,65	0	0	0	1	0	0	0	0	0	0	0	10.000
S_5	0	0	0	6	69	0	0	0	0	1	0	0	0	0	0	0	5.000
S_6	0	0	0	44	0	0	0	0	0	0	1	0	0	0	0	0	2.000
S_7	0	0,22	0	0	0,22	0	0	0	0	0	0	1	0	0	0	0	50
S_8	0	33	0	0	4	0	0	0	0	0	0	0	1	0	0	0	4.000
S_9	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	200
S_{10}	0	0	5	0	0	0	0	0	0	0	0	0	0	0	1	0	10.000
S_{11}	0	0	0	0	23	0	0	0	0	0	0	0	0	0	0	1	20.000

Determine the key column (decision variable), key number, and key row as the basis for iteration. The key column is determined by the smallest (negative) Z value. In Table 7 below, it is known that the coefficient value with the largest negative is -6.945 then the key column is in column x_4;

Table 7. First Iteration Simplex Starting Table

B.V	Z	x_1	x_2	x_3	x_4	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	S_{10}	S_{11}	RV
Z	1	−1.467	−2.174	−2.868	−6.945	0	0	0	0	0	0	0	0	0	0	0	
S_1	0	49	0	0	0	1	0	0	0	0	0	0	0	0	0	0	40.000
S_2	0	0	90	45	116	0	1	0	0	0	0	0	0	0	0	0	15.000
S_3	0	0,55	2	0,42	2	0	0	1	0	0	0	0	0	0	0	0	500
S_4	0	0	0	4	0,65	0	0	0	1	0	0	0	0	0	0	0	10.000
S_5	0	0	0	6	69	0	0	0	0	1	0	0	0	0	0	0	5.000
S_6	0	0	0	44	0	0	0	0	0	0	1	0	0	0	0	0	2.000
S_7	0	0,22	0	0	0,22	0	0	0	0	0	0	1	0	0	0	0	50
S_8	0	33	0	0	4	0	0	0	0	0	0	0	1	0	0	0	4.000
S_9	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	200
S_{10}	0	0	5	0	0	0	0	0	0	0	0	0	0	0	1	0	10.000
S_{11}	0	0	0	0	23	0	0	0	0	0	0	0	0	0	0	1	20.000

The ratio value is obtained from the division result between the right value and each corresponding number in the key column. Determine the key row based on the smallest index (ratio) value.

$$index = \frac{Right\ Value(RV)}{Key\ Column\ (KC)}$$

Table 8. Simplex Table First Iteration

B.V	Z	x_1	x_2	x_3	x_4	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	S_{10}	S_{11}	RV	Index
Z	1	−1.467	−2.174	−2.868	−6.945	0	0	0	0	0	0	0	0	0	0	0		
S_1	0	49	0	0	0	1	0	0	0	0	0	0	0	0	0	0	40.000	∞
S_2	0	0	90	45	116	0	1	0	0	0	0	0	0	0	0	0	15.000	129,31
S_3	0	0,55	2	0,42	2	0	0	1	0	0	0	0	0	0	0	0	500	250
S_4	0	0	0	4	0,65	0	0	0	1	0	0	0	0	0	0	0	10.000	15.384,6
S_5	0	0	0	6	69	0	0	0	0	1	0	0	0	0	0	0	5.000	72,463
S_6	0	0	0	44	0	0	0	0	0	0	1	0	0	0	0	0	2.000	∞
S_7	0	0,22	0	0	0,22	0	0	0	0	0	0	1	0	0	0	0	50	227,27
S_8	0	33	0	0	4	0	0	0	0	0	0	0	1	0	0	0	4.000	1.000
S_9	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	200	∞
S_{10}	0	0	5	0	0	0	0	0	0	0	0	0	0	0	1	0	10.000	∞
S_{11}	0	0	0	0	23	0	0	0	0	0	0	0	0	0	0	1	20.000	869,56

The key row is determined based on the row that has the smallest ratio value. In Table 8, it can be seen that the smallest ratio value is 72.46, so the key row is in row S_5. The key number is obtained from the intersection value between the key column and key row. Then the key number is 69. Then create a new row by dividing the old key row by the key number. The key number is the value positioned at the intersection of the key column and key row.

$$\text{new key row} = \left(\frac{0}{69};\frac{0}{69};\frac{0}{69};\frac{6}{69};\frac{69}{69};\frac{0}{69};\frac{0}{69};\frac{0}{69};\frac{0}{69};\frac{1}{69};\frac{0}{69};\frac{0}{69};\frac{0}{69};\frac{0}{69};\frac{0}{69};\frac{0}{69}\right)$$
$$= (0;\ 0;\ 0;\ 0{,}09;\ 1;\ 0;\ 0;\ 0;\ 0;\ 0{,}01;\ 0;\ 0;\ 0;\ 0;\ 0;\ 0)$$

Find the new value of the rows, with the formula $new\ line = old\ line - (Row\ Key\ Column\ Value \times New\ Key\ Row)$. So that the results of the first iteration are presented in Table 9.

Table 9. Simplex Table of First Iteration Results

B.V	Z	x_1	x_2	x_3	x_4	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	S_{10}	S_{11}	RV
Z	1	−1.467	−2.174	−2.264,09	0	0	0	0	0	100,65	0	0	0	0	0	0	503.260,9
S_1	0	49	0	0	0	1	0	0	0	0	0	0	0	0	0	0	40.000
S_2	0	0	90	34,91	0	0	1	0	0	−1,68	0	0	0	0	0	0	6.594,2
S_3	0	0,55	2	0,25	0	0	0	1	0	−0,03	0	0	0	0	0	0	355,07
S_4	0	0	0	3,94	0	0	0	0	1	−0,01	0	0	0	0	0	0	9.952,9
x_4	0	0	0	0,09	1	0	0	0	0	0,01	0	0	0	0	0	0	72,46
S_6	0	0	0	44	0	0	0	0	0	0	1	0	0	0	0	0	2.000
S_7	0	0,22	0	−0,02	0	0	0	0	0	0	0	1	0	0	0	0	34,06
S_8	0	33	0	−0,35	0	0	0	0	0	−0,06	0	0	1	0	0	0	3.710,15
S_9	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	200
S_{10}	0	0	5	0	0	0	0	0	0	0	0	0	0	0	1	0	10.000
S_{11}	0	0	0	−2	0	0	0	0	0	−0,33	0	0	0	0	0	1	18.333,33

Repeat the steps above, until there are no negative values in the Z row. So that the optimal table results of the simplex method are presented in Table 10.

Table 10. Optimal Table of Simplex Method

B.V	Z	x_1	x_2	x_3	x_4	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	S_{10}	S_{11}	RV
Z	1	0	0	0	0	0	24,16	0	0	0	0	0	44,45	0	0	0	892762,4
S_1	0	0	0	0	0	1	0	0	0	0,09	−0,01	0	−1,48	0	0	0	34467,52
x_2	0	0	1	0	0	0	0,01	0	0	−0,02	−0,01	0	0	0	0	0	55,64
S_3	0	0	0	0	0	0	−0,02	1	0	0,01	0,01	0	−0,02	0	0	0	170,52
S_4	0	0	0	0	0	0	0	0	1	−0,01	−0,09	0	0	0	0	0	9773,65
x_4	0	0	0	0	1	0	0	0	0	0,01	0	0	0	0	0	0	68,51
x_3	0	0	0	1	0	0	0	0	0	0	0,02	0	0	0	0	0	45,45
S_7	0	0	0	0	0	0	0	0	0	0	0	1	−0,01	0	0	0	10,09
x_1	0	1	0	0	0	0	0	0	0	0	0	0	0,03	0	0	0	112,91
S_9	0	0	0	0	0	0	0	0	0	0	0	0	0,03	1	0	0	87,09
S_{10}	0	0	0	0	0	0	−0,06	0	0	0,09	0,04	0	0	0	1	0	721,82
S_{11}	0	0	0	0	0	0	0	0	0	−0,33	0,05	0	0	0	0	1	18424,24

Based on the iterations that have been done, obtained $x_1 = 112{,}91$; $x_2 = 55{,}64$; $x_3 = 45{,}45$; and $x_4 = 68{,}51$. From this solution, the types of preparations that must be produced are 112,908 packs of lemang, 55,64 packs of fried sticky rice, 45,45 packs of klepon, and 68,51 packs of candil porridge. However, this solution is not the right solution to use, as a product must be an integer number. Therefore, an integer solution is required. Therefore, the gomory cutting plane method will be used to find an integer solution.

Second, because the decision variables with the simplex method have not been integer, it is necessary to solve using the Gomory cutting plane method by adding new constraints or Gomory 1. Based on Table 10, the following equation is obtained:

$$\begin{gathered} x_4 + 0{,}01S_5 = 68{,}51 \\ x_3 + 0{,}02S_6 = 45{,}45 \\ x_1 + 0{,}03S_8 = 112{,}91 \\ x_2 + 0{,}01S_2 - 0{,}02S_5 - 0{,}01S_6 = 55{,}64 \end{gathered} \tag{1}$$

Based on equation (1), the gomory cutting plane method can be run by adding new constraints. In the equation above, the variables that are first run, namely x_4. So it can be calculated,

Addition of Gomory 1 constraint:

$$x_4 + 0{,}01S_5 = 68{,}51$$
$$Sg_1 - 0{,}01S_5 = -0{,}51$$

Next, insert Gomory into the final simplex table which can be seen in Table 11.

Table 11. Gomory Addition Table 1

B.V	Z	x_1	x_2	x_3	x_4	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	S_{10}	S_{11}	Sg_1	**RV**
Z	1	0	0	0	0	0	−24,16	0	0	−57,47	−32,64	0	−44,45	0	0	0	0	892.762,4
S_1	0	0	0	0	0	1	0	0	0	0,09	−0,01	0	−1,48	0	0	0	0	34.467,52
x_2	0	0	1	0	0	0	0,01	0	0	−0,02	−0,01	0	0	0	0	0	0	55,64
S_3	0	0	0	0	0	0	−0,02	1	0	0,01	0,01	0	−0,02	0	0	0	0	170,52
S_4	0	0	0	0	0	0	0	0	1	−0,01	−0,09	0	0	0	0	0	0	9.773,65
x_4	0	0	0	0	1	0	0	0	0	0,01	0	0	0	0	0	0	0	68,51
x_3	0	0	0	1	0	0	0	0	0	0	0,02	0	0	0	0	0	0	45,45
S_7	0	0	0	0	0	0	0	0	0	0	0	1	−0,01	0	0	0	0	10,09
x_1	0	1	0	0	0	0	0	0	0	0	0	0	0,03	0	0	0	0	112,91
S_9	0	0	0	0	0	0	0	0	0	0	0	0	−0,03	1	0	0	0	87,09
S_{10}	0	0	0	0	0	0	−0,06	0	0	0,09	0,04	0	0	0	1	0	0	721,82
S_{11}	0	0	0	0	0	0	0	0	0	−0,33	0,05	0	0	0	0	1	0	18.424,24
Sg_1	0	0	0	0	0	0	0	0	0	−0,01	0	0	0	0	0	0	1	−0,51

Based on Table 11, the right-hand side of the Gomory 1 addition is negative, making it infeasible. To be able to solve the table to be feasible, it will be continued by using the simplex method.

1. Determine the key row: Sg_1 is the key row because it has the largest negative right value.
2. Determine the key column: the key column is the column with the smallest absolute division ratio, S_5.
3. Form the next table with the procedure in primal simplex.

Table 12. Gomory 1 Completion

B.V	Z	x_1	x_2	x_3	x_4	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	S_{10}	S_{11}	Sg_1	**RV**
Z	1	0	0	0	0	0	−24,16	0	0	0	−32,64	0	−44,45	0	0	0	−5.747	895.693,37
S_1	0	0	0	0	0	1	0	0	0	0	−0,01	0	−1,48	0	0	0	9	34.462,93
x_2	0	0	1	0	0	0	0,01	0	0	0	−0,01	0	0	0	0	0	−2	55,66
S_3	0	0	0	0	0	0	−0,02	1	0	0	0,01	0	−0,02	0	0	0	−0,3333	170,6166
S_4	0	0	0	0	0	0	0	0	1	0	−0,09	0	0	0	0	0	−1	9.774,16
x_4	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	68
x_3	0	0	0	1	0	0	0	0	0	0	0,02	0	0	0	0	0	0	45,45
S_7	0	0	0	0	0	0	0	0	0	0	0	1	−0,01	0	0	0	0	10,09
x_1	0	1	0	0	0	0	0	0	0	0	0	0	0,03	0	0	0	0	112,91
S_9	0	0	0	0	0	0	0	0	0	0	0	0	−0,03	1	0	0	0	87,09
S_{10}	0	0	0	0	0	0	−0,06	0	0	0	0,04	0	0	0	1	0	9	717,23
S_{11}	0	0	0	0	0	0	0	0	0	0	0,05	0	0	0	0	1	−33	18.441,07
S_5	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	-100	51

In Table 12, the value of the decision variable in the right segment still has a fractional value. Therefore, the iteration continues until all right segment values are positive and the addition of the Gomory variable will stop after an integer value is obtained in the decision variable.

Table 13. Optimal Table of Gomory Cutting Plane Method

B.V	Z	x_1	x_2	x_3	x_4	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	S_{10}	S_{11}	$Sg1$	$Sg2$	$Sg3$	$Sg4$	RV
Z	1	0	0	0	0	0	0	0	0	2.367,6	2.391,8	0	0	0	0	0	−5.747	−1.632	−1.481,6	−2.416	899.322
S_1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	9	−0,5	−49,33	0	34.508
x_2	0	0	1	0	0	0	0	0	0	−0,98	−0,99	0	0	0	0	0	−2	−0,5	0	1	56
S_3	0	0	0	0	0	0	0	1	0	1,96	1,98	0	0	0	0	0	0,33	0,5	0	−2	171,7
S_4	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	−1	−4,5	0	0	9.776
x_4	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	68
x_3	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	45
S_7	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	−0,33	0	10,39
x_1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	112
S_9	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	−0,99	0	88
S_{10}	0	0	0	0	0	0	0	0	0	5,88	5,94	0	0	0	1	0	9	2	0	−6	720,2
S_{11}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	−33	2,5	0	0	18.440
S_5	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	−100	0	0	0	51
S_6	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	−50	0	0	22,5
S_8	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	−33,33	0	30,33
S_2	0	0	0	0	0	0	1	0	0	98	99	0	0	0	0	0	0	0	0	−100	64

Based on the calculation of iterations of the dual simplex method with the addition of Gomory, it is obtained that all values in the Z row are positive, the right segment of the constraint is positive, and the decision variable has an integer value, meaning that the solution using the Gomory cutting plane method of integer optimum solution has been obtained. The integer optimum solution using the Gomory cutting plane method obtained the values $x_2 = 56$, $x_4 = 68$, $x_3 = 45$, and $x_1 = 112$ with the maximum Z value of Rp889.322,32.

IV. Conclusion

The conclusion obtained from this research is that the profit optimization model of glutinous rice production in the Long Pejeng Village Household Industry obtained, namely:

Profit maximization:

$$Z = 1.467x_1 + 2.174x_2 + 2.868x_3 + 6.945x_4$$

Constraint function:

$$49x_1 \leq 40.000$$
$$90x_2 + 45x_3 + 116x_4 \leq 15.000$$
$$0{,}55x_1 + 2x_2 + 0{,}42x_3 + 2x_4 \leq 500$$
$$4x_3 + 0{,}65x_4 \leq 10.000$$
$$6x_3 + 69x_4 \leq 5.000$$
$$44x_3 \leq 2.000$$
$$0{,}22x_1 + 0{,}22x_4 \leq 50$$
$$33x_1 + 4x_4 \leq 4.000$$
$$x_1 \leq 200$$
$$5x_2 \leq 10.000$$
$$23x_4 \leq 20.000$$
$$x_1, x_2, x_3, x_4 \geq 0$$

The model is an integer linear programming model with four variables and eleven constraints. And the results of the calculations that have been done, the amount of production in the previous Long Pejeng Village Household Industry is 120 packs of lemang, 50 packs of fried sticky rice, 50 packs of klepon, and 50 packs of candil porridge with a total profit of Rp775.390,00. However, after using the gomory cutting plane method, the amount of production changed to 112 packs of lemang, 56 packs of fried sticky rice, 45 packs of klepon and 68 packs of candil porridge with a total profit of Rp887,368.00. This shows that the optimal amount of processed glutinous rice production is the gomory cutting plane method, which increases the profit of processed glutinous rice in the Long Pejeng Village Household Industry by Rp111.978,00 or 14,4%.

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References

[1] M. Trihudiyatmanto, *Riset Operasional & Penyelesaian Menggunakan Software WinQSB*, no. May. 2018.

[2] L. Alfaris *et al.*, *Riset Operasi*, vol. 5, no. 1. Bandung: INDIE PRESS, 2022. [Online]. Available: https://revistas.ufrj.br/index.php/rce/article/download/1659/1508%0Ahttp://hipatiapress.com/hpjournals/index.php/qre/article/view/1348%5Cnhttp://www.tandfonline.com/doi/abs/10.1080/09500799708666915%5Cnhttps://mckinseyonsociety.com/downloads/reports/Educa

[3] R. Rachmatika, R. Maulida, and K. Harefa, *Teknik Riset Operasional*, no. Riset Operasi. Tangerang Selatan: Unpam Press, 2014.

[4] P. Affandi, *Buku Ajar Riset Operasi*. Malang: CV IRDH Anggota IKAPI, 2019.

[5] R. E. Febriansah and B. H. Prasojo, *Buku Ajar Riset dan OPerasi*. Sidoarjo: UMSIDA PRESS, 2018.

[6] S. Basriati, “Integer Linear Programing Dengan Pendekatan Metode Cutting Plane dan Branch and Bound Untuk Optimasi Produksi Tahu,” *J. Sains Mat. dan Stat.*, vol. 4, no. 2, pp. 95–104, 2018.

[7] Zulyadaini, *Buku Program Linier*. Yogyakarta: Tangga Ilmu, 2017. [Online]. Available: http://repository.unbari.ac.id/292/1/Buku Program Linier.pdf

[8] H. Nufus and E. Nurdin, *Program Linear*. Pekan Baru: Cahaya Firdaus, 2016.

[9] J. H. Lumbantoruan, “Buku Materi Pembelejaran Pemrograman Linear,” *Glob. Heal.*, vol. 167, no. 1, pp. 1–5, 2020, [Online]. Available: https://www.e-ir.info/2018/01/14/securitisation-theory-an-introduction/

[10] Nico, Iryanto, and G. Tarigan, “Aplikasi Metode Cutting Plane Dalam Optimisasi Jumlah Produksi Tahunan Pada PT. XYZ,” *saintia Mat.*, vol. 2, no. 2, pp. 127–136, 2014.

[11] D. Wirdasari, “Metode Simpleks dalam Programming,” vol. 6, no. 1, pp. 276–286, 2009.