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OPTIMIZATION OF PRODUCTION COSTS WITH SIMPLEX METHOD

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Abstract.

One of the problems in the company is my resource limitation, the time of production and the tools used in the production process. Companies in making decisions in production planning in the presence of these limitations, should seek to maximize the profit generated. However, in the production process a production planning reference is required to maximize the results obtained and minimize the production costs used. To solve the problem, needed a problem solving tool that is linear program using simplex method. Simplex method is one of the methods of linear program in solving the problem of more than two variables that can be applied into everyday life and can be used in production process planning. With one of the ultimate goal is the achievement of the optimum value with the constraints of limited resources. The results of the simplex method have decreased costs incurred less than the usual costs incurred every month and the results obtained using the simplex method can be used as a reference in making decisions to get optimal results on production costs in the company.

Keywords: Optimization, Minimization, Simplex Method

1.1 INTRODUCTION

The scope of mathematics is very broad, the application of mathematics in life has spread wide enough because it has positive effect with many benefits. In the production sector, which converts raw materials into new varied products expect maximum profit with minimal production costs.

Linear program is one of the solution problem in determining the optimal solution. "The problem of linear programming is basically concerned with the determination of the optimal allocation of limited resources (limited resources) to meet an objective (objective)" [1]

There are several problem solving methods in the linear program that are graphical method, algebraic method, gauss jhordan method, and simplex method.

"Most linear programming problems in the real world have more than two variables that lead to completion with less effective chart methods" [2]. The algebraic method will be more complicated in finding problem solving if more than three variables, as well as the gausss jordan method, must be more thorough in the process to obtain the minimum solution.

"In 1947 a mathematician from the United States named George D. Dantzig devised a way of deciphering and solving linear programming problems with Simplex Methods" [3]. With the simplex method will be in the final result which is the best value in minimizing profit.

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Before performing iterative calculations to determine the optimal solution, at the pre-analysis stage, determine the decision variable of the real problem. Then formulate the problem into the standard form of linear programming so that the formation of objective function and constraint function, change the inequality into the form of linear equation by adding slack variable, surplus variable and additional variable. Presents the data into the initial simplex table and determines in advance the initial feasible baseline settlement that provides the zero goal function. Specifies which variables go into the decision variables and that comes out of the base variable, based on key and key row columns. Perform calculations to generate a new split in the simplex table by iterating the simplex method until the optimal value of the destination function is reached. When we have obtained the optimal value of the objective function then we are finished in the process of simplex analysis.

1.2 RESEARCH OBJECTIVES

The purpose of this study is to optimize production costs as a limited resource in this case minimizing costs.

1.3 METHODS

This study uses a study of literature studies followed by case study research. Begin by collecting various sources concerned with linear program material and simplex methods such as journals, books, theses, and the internet. Discusses the material of simplex mathematics, slack variables, surplus variables, additional variables and materials related to this research. The next step collects data from the Business Entity owner and takes samples needed in data processing. The data taken is secondary data.

2. LITERATURE REVIEW

Rumahorbo [4] From the results of his research has concluded that the simplex method can be used as solution in solving linear program problem more than two variables consistently in case of maximization and minimization.

Sunarsih [5] also argues that the most successful technique in solving linear programming problems with the large number of decision and limiting variables can be used the simplex method.

Conclusion of Sukanta [6] in Simplex Method Linear Program In Polyster Material In Indonesia that the simplex method can be taken into consideration for use in minimizing costs with the use of materials to be more optimal.

In Chandra's study [5] also says that the number of iterations is not influenced by the number of variables, but depends on the value of the objective function of the previous iteration.

3. RESULT AND DISCUSSION

3.1 Simplex method algorithm

Simplex method algorithm in analyzing data as follows:

1. Identify decision variables and formulate them into mathematical symbols.

2. Identify the objective function to be achieved and the function of the boundary into the mathematical model.

3. Function objectives and boundary functions are formulated into standard form of simplex method by adding slack variables, surplus variables, and additional variables.

4. Creating initial table of simplex method Initial table

5. Enter the value of each variable into the simplex initial table

6. Specify a key column based on the largest z value.

7. Determine the solution ratio

$$= \frac{s}{nthe\ key\ row\ column\ value}$$

8. Determining the lock row based on the smallest ratios (without z row)
9. Specifies the cell element that is the slice of the key column and the lock row
10. perform a stages (iteration) that begins by specifying a new row of keys
new row of keys = $\frac{Key\ Lock\ lines}{elemen\ cell}$
11. transform a line other than the lock line
new row besides row lock = old row - [(old column value) x (new row key)]
(if the coefficient on the z row still exists that is positive, then back to the numbers 6 - 11)
12. Testing the optimality, until all the coefficients on the z-row is no longer a positive value, which means the table is optimal.

3.2 Mathematical Model of Simplex Method

Minimize objective function (purpose function)

$$z - c_1x_1 - c_2x_2 - c_3x_3 + M(r_1 + r_2 + r_3 + r_4 + r_6 + r_7 + r_9) = 0 \quad (1)$$

With constraints

$$\begin{aligned}
a_{11}x_1 + a_{12}x_2 + a_{13}x_3 - s_1 + r_1 &= l_1 \\
a_{21}x_1 + a_{22}x_2 + a_{23}x_3 - s_2 + r_2 &= l_2 \\
a_{31}x_1 + a_{32}x_2 + a_{33}x_3 - s_3 + r_3 &= l_3 \\
a_{41}x_1 + a_{42}x_2 + a_{43}x_3 - s_4 + r_4 &= l_4 \\
a_{51}x_1 + a_{52}x_2 + a_{53}x_3 + s_5 &= l_5 \\
a_{61}x_1 + a_{62}x_2 + a_{63}x_3 - s_6 + r_6 &= l_6 \\
a_{71}x_1 + a_{72}x_2 + a_{73}x_7 - s_7 + r_7 &= l_7 \\
a_{81}x_1 + a_{82}x_2 + a_{83}x_8 + s_8 &= l_8 \\
a_{91}x_1 + a_{92}x_2 + a_{93}x_8 - s_9 + r_9 &= l_9
\end{aligned} \quad (2)$$

Description

Z : minimal production costs

x_n : the number of production

c_1, c_2, c_3 : production cost 1 kg of product

a_{11}, a_{12}, a_{13} : Material A for 1 kg of product.

a_{21}, a_{22}, a_{23} : Material B for 1 kg of product.

a_{31}, a_{32}, a_{33} : Material C for 1 kg of product.

a_{41}, a_{42}, a_{43} : Material D for 1 kg of product.

a_{51}, a_{52}, a_{53} : Material E for 1 kg of product.

a_{61}, a_{62}, a_{63}: depreciation material 1 (Fuel oil) for 1 kg of product

a_{71}, a_{72}, a_{73}: depreciation materia 2 ((Firewood for 1 kg of product.)
a_{81}, a_{82}, a_{83} : wages for 1 kg of product.
a_{91}, a_{92}, a_{93} : packaging cost (sack) for 1 kg of product.
s_5, s_8 : Slack Variable

$s_1, s_2, s_3, s_4, s_6, s_7, s_9$: variable surplus
$r_1, r_2, r_3, r_4, r_6, r_7, r_9$: additional variables
$l_1, l_2, l_3, l_4, l_5, l_6, l_7, l_8, l_9$: Limitation of resources

3.2 Decision Variables

In this study, which became a decision, that is:

x_1 : the number of square opak production

x_2 : the number of animal feed production

x_3: the number of round opak production

3.3 Function Goals

The objectives to be achieved can be seen in the following table.

No	**Produk**	**Production Cost 1 kg (Rp)**
1	Square Opak	4035
2	Animal Feed	1902
3	Round Opak	5146

3.4 Function Constraints

With the constraints and limitations of resources owned can be seen in the table below.

Table 2. Production Constraints Table

No	**Product**	**Object A**	**Object B**	**Object C**	**Object D**	**Object E**
1	Square Opak	3	3,75	0,9	0,45	0 gr
2	Animal Feed	3,333333333	0	0	0	0 gr
3	Round Opak	3	6	2	0,45	1gr
		91500 kg	67500 gr	17600gr	7425gr	2500 gr

Table 3. Table Resource Limits

No	**Product**	**fuel oil (ml)**	**firewood (cm^3)**	**Pay(Rp)**	**packaging (Rp)**
1	Square Opak	6,9231	0,3	7,05	9
2	Animal Feed	16,6667	0	7,3333	6
3	Round Opak	15,3846	1,04	15	9

Subject to

$$3x_1 + 3{,}333333333x_2 + 3x_3 \leq 91500 \quad (4)$$
$$3{,}75x_1 + 6x_3 \leq 67500$$
$$0{,}9x_1 + 2x_3 \leq 17600$$
$$0{,}45x_1 + 0{,}45x_3 \leq 7550$$
$$x_3 \leq 2500$$
$$6{,}9231x_1 + 16{,}6667x_2 + 15{,}3846x_3 \geq 345384{,}6$$
$$0{,}3x_1 + 1{,}04x_3 \geq 6800$$
$$7{,}05x_1 + 7.3333x_2 + 15x_3 \leq 233850$$
$$9x_1 + 6x_2 + 9x_3 \geq 224100$$

Formulation of objective functions and constraint functions by adding slack variables, surplus variables, and additional variables as follows:

With Constraint

$3x_1 + 3{,}3333x_2 + 3x_3 - s_1 + r_1 = 91500$

$\rightarrow r_1 = 91500 - 3x_1 - 3{,}3333x_2 - 3x_3 + s_1$

$3{,}75x_1 + 6x_3 - s_2 + r_2 = 67500$

$\rightarrow r_2 = 67500 - 3{,}75x_1 - 6x_3 + s_2$

$0{,}9x_1 + 2x_3 - s_3 + r_3 = 17600$

$\rightarrow r_3 = 17600 - 0{,}9x_1 - 2x_3 + s_3$

$0{,}45x_1 + 0{,}5x_3 - s_4 + r_4 = 7550$

$\rightarrow r_4 = 7550 - 0{,}45x_1 - 0{,}5x_3 + s_4$

$x_3 + s_5 = 2500$

$6{,}9231x_1 + 16{,}6667x_2 + 15{,}3846x_3 - s_6 + r_6 = 345384{,}6$

$\rightarrow r_6 = 345384{,}6 - 6{,}9231x_1 - 16{,}6667x_2 - 15{,}3846x_3 + s_6$

$0{,}3x_1 + 1{,}04x_3 - s_7 + r_7 = 6800$

$\rightarrow r_7 = 6800 - 0{,}3x_1 - 1{,}04x_3 + s_7$

$7{,}05x_1 + 7.3333x_2 + \ 15x_3 + s_8 = 233850$

$9x_1 + 6x_2 + 9x_3 - s_9 + r_9 = 224100$

$\rightarrow r_9 = 224100 - 9x_1 - 6x_2 - \ 9x_3 + s_9$

Minimize

$z = 4035x_1 + 1902x_2 + 5146\, x_3 + Mr_1 + Mr_2 + Mr_3 + Mr_4 + Mr_6 + Mr_7 + Mr_9$

$$z = 4035x_1 + 1902x_2 + 5146\, x_3 + M\big(91500 - 3x_1 - 3{,}3333x_2 - 3x_3 \ + s_1\big)$$
$$+M(67500 - 3{,}75x_1 - 6x_3 + s_2) + M(17600 - 0{,}9x_1 - 2x_3 + s_3)$$
$$+M(7550 - 0{,}45x_1 - 0{,}5x_3 + s_4) \ + M(345384{,}6 - 6{,}9231x_1 - 16{,}6667x_2 - 15{,}3846x_3 +$$
$$s_6) + M(6800 - 0{,}3x_1 - \ 1{,}04x_3 + s_7) + M(224100 - 9x_1 - 6x_2 - \ 9x_3 + s_9)$$
$$z = 4035x_1 + 1902x_2 + 5146\, x_3 + 91500M - 3Mx_1 - 3{,}3333Mx_2$$
$$- 3Mx_3 \ + Ms_1 + 67500M - 3{,}75Mx_1 - 6Mx_3 + Ms_2 + 17600M$$
$$-0{,}9Mx_1 - 2Mx_3 + Ms_3 + 7550M - 0{,}45Mx_1 - 0{,}5Mx_3 + Ms_4$$
$$+345384{,}6M - 6{,}9231Mx_1 - 16{,}6667Mx_2 - 15{,}3846Mx_3 + Ms_6$$
$$+6800M - 0{,}3Mx_1 - \ 1{,}04Mx_3 + Ms_7 + 224100M - 9Mx_1 - 6Mx_2$$
$$- \ 9Mx_3 + Ms_9$$
$$z = (4035x_1 - 3Mx_1 - 3{,}75Mx_1 - 0{,}9Mx_1 - 0{,}45Mx_1 - 6{,}9231Mx_1$$
$$-0{,}3Mx_1 - 9Mx_1) + (1902x_2 - 3{,}3333Mx_2 - 16{,}6667Mx_2 - 6Mx_2)$$
$$+(5146\, x_3 - \ 3Mx_3 - 6Mx_3 - 2Mx_3 - 0{,}5Mx_3 - 15{,}3846Mx_3$$
$$-1{,}04Mx_3 - \ 9Mx_3 + 91500M + 67500M + 17600M + 7550M$$
$$+345384{,}6M + 6800M + 224100M + Ms_1 + Ms_2 + Ms_3 + Ms_4 + Ms_6$$
$$+Ms_7 + Ms_9$$
$$z = (4035 - 24{,}3231M)x_1 + (1902 - 26M)x_2 + \big(5146 - 36{,}9246M\big)x_3$$
$$+760434{,}6M + Ms_1 + Ms_2 + Ms_3 + Ms_4 + Ms_6 + Ms_7 + Ms_9$$

$$z - (4035 - 24{,}3231M)x_1 - (1902 - 26M)x_2 - \big(5146 - 36{,}9246M\big)x_3$$
$$-Ms_1 - Ms_2 - Ms_3 - Ms_4 - Ms_6 - Ms_7 - Ms_9 = 760434{,}6M$$

4 COMPLETION WITH SIMPLEX TABLE

The function objectives and function constraints have been formulated into the standard form of the simplex method by adding the slack variable, arranged into the simplex initial table.

Table 4. initial table minimization

VD	Z	X1	X2	X3	r1	s1	r2	s2	r3	s3	r4	s4	s5	r6	s6	r7	s7	s8	r9	s9	S	rs
Z	1	-4035+24.3231M	-1902+26M	-5146+36.9246M	0	-M	0	-M	0	-M	0	-M	0	0	-M	0	-M	0	0	-M	760434.6M	
r1	0	3	3.3333	3	1	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	91500	30500
r2	0	3.75	0	6	0	0	1	-1	0	0	0	0	0	0	0	0	0	0	0	0	67500	11250
r3	0	0.9	0	2	0	0	0	0	1	-1	0	0	0	0	0	0	0	0	0	0	17600	8800
r4	0	0.45	0	0.5	0	0	0	0	0	0	1	-1	0	0	0	0	0	0	0	0	7550	15100

s5	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	2500	2500
r6	0	6.9231	16.6667	15.3846	0	0	0	0	0	0	0	0	0	1	-1	0	0	0	0	0	345384.6	22450.0215
r7	0	0.3	0	1.04	0	0	0	0	0	0	0	0	0	0	0	1	-1	0	0	0	6800	6538.46154
s8	0	7.05	7.3333	15	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	233850	15590
r9	0	9	6	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	-1	224100	24900

Table 5. first iteration

VD	Z	X1	X2	X3	r1	s1	r2	s2	r3	s3	r4	s4	s5	r6	s6	r7	s7	s8	r9	s9	S	Rs
Z	1	-4035+24.323076923M	-1902+26M	0	0	-M	0	-M	0	-M	0	-M	5146-36.9246M	0	-M	0	-M	0	0	-M	12865000+668123.1M	
r1	0	3	3.333333333	0	1	-1	0	0	0	0	0	0	-3	0	0	0	0	0	0	0	84000	25200
r2	0	3.75	0	0	0	0	1	-1	0	0	0	0	-6	0	0	0	0	0	0	0	52500	
r3	0	0.9	0	0	0	0	0	0	1	-1	0	0	-2	0	0	0	0	0	0	0	12600	
r4	0	0.45	0	0	0	0	0	0	0	0	1	-1	-0.5	0	0	0	0	0	0	0	6300	
x3	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	2500	
r6	0	6.9231	16.6667	0	0	0	0	0	0	0	0	0	-15.3846	1	-1	0	0	0	0	0	306923.1	18415.3492
r7	0	0.3	0	0	0	0	0	0	0	0	0	0	-1.04	0	0	1	-1	0	0	0	4200	
s8	0	7.05	7.3333	0	0	0	0	0	0	0	0	0	-15	0	0	0	0	1	0	0	196350	26775.1217
r9	0	9	6	0	0	0	0	0	0	0	0	0	-9	0	0	0	0	0	1	-1	201600	33600

Table 6. Second Iteration

VD	Z	X1	X2	X3	r1	s1	r2	s2	r3	s3	r4	s4	s5	r6	s6	r7	s7	s8	r9	s9	S	Rs
Z	1	-3244.937408+ 13.52306252M	0	0	0	-M	0	-M	0	-M	0	-M	3390.312959-12.924672M	114.1197718-1.55999688M	-114.1197718 +0.55999688M	0	-M	0	0	-M	47890994.12+ 189324.0216M	
r1	0	1.615382769	0	0	1	-1	0	0	0	0	0	0	0.076913846	-0.1999996	0.1999996	0	0	0	0	0	22615.50278	14000.0891
r2	0	3.75	0	0	0	0	1	-1	0	0	0	0	-6	0	0	0	0	0	0	0	52500	14000
r3	0	0.9	0	0	0	0	0	0	1	-1	0	0	-2	0	0	0	0	0	0	0	12600	14000
r4	0	0.45	0	0	0	0	0	0	0	0	1	-1	-0.5	0	0	0	0	0	0	0	6300	14000
x3	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	2500	
x2	0	0.415385169	1	0	0	0	0	0	0	0	0	0	-0.923074154	0.05999988	-0.05999988	0	0	0	0	0	18415.34917	44333.1889
r7	0	0.3	0	0	0	0	0	0	0	0	0	0	-1.04	0	0	1	-1	0	0	0	4200	14000
s8	0	4.003855938	0	0	0	0	0	0	0	0	0	0	-8.230820308	-0.43999712	0.43999712	0	0	1	0	0	61304.71994	15311.42
r9	0	6.507688985	0	0	0	0	0	0	0	0	0	0	-3.461555077	-0.35999928	0.35999928	0	0	0	1	-1	91107.90498	14000.0398

Table 7. Third iteration

VD	Z	X1	X2	X3	r1	s1	r2	s2	r3	s3	r4	s4	s5	r6	s6	r7	s7	s8	r9	s9	S	rs
Z	1	0	0	0	0	-	865.3166422	-865.3166422	0	-	0	-	-1801.586894+	114.1197718	-114.1197718	0	-	0	0	-	93320117.83	

						M	- 3.606150006M	+2.606150006M		M		M	8.712228037M	- 1.55999688M	+0.55999688M		M			M	+1.146275754M	
r1	0	0	0	0	1	-1	-0,430768738	0,430768738	0	0	0	0	2,66153	-0,1999996	0,1999996	0	0	0	0	0	0,144003912	0,054105764
X1	0	1	0	0	0	0	0,266666667	-0,266666667	0	0	0	0	-1,6	0	0	0	0	0	0	0	14000	-8750
r3	0	0	0	0	0	0	-0,24	0,24	1	-1	0	0	-0,56	0	0	0	0	0	0	0	0	0
r4	0	0	0	0	0	0	-0,12	0,12	0	0	1	-1	0,22	0	0	0	0	0	0	0	0	0
x3	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	2500	2500
x2	0	0	1	0	0	0	-0,110769378	0,110769378	0	0	0	0	-0,2585	0,05999988	-0,05999988	0	0	0	0	0	12599,9568	-48750,52233
r7	0	0	0	0	0	0	-0,08	0,08	0	0	0	0	-0,56	0	0	1	-1	0	0	0	0	0
s8	0	0	0	0	0	0	-1,067694917	1,067694917	0	0	0	0	-1,8247	-0,43999712	0,43999712	0	0	1	0	0	5250,736798	-2877,666664
r9	0	0	0	0	0	0	-1,735383729	1,735383729	0	0	0	0	6,95075	-0,35999928	0,35999928	0	0	0	1	-1	0,259199482	0,03729088

Table 8. the fourth iteration

VD	Z	X1	X2	X3	r1	s1	r2	s2	r3	s3	r4	s4	s5	r6	s6	r7	s7	s8	r9	s9	S	
Z	1	0	0	0	0	-M	-117.367118 +1.145974378M	117.367118 -2.145974378M	0	-M	8189.031335 -39.60103653M	-8189.031335 +38.60103653M	0	114.1197718-1.55999688M	-114.1197718 +0.55999688M	0	-M	0	0	-M	93320117.83 +1.146275754M	rs
r1	0	0	0	0	1	-1	1,020972867	-1,020972867	0	0	-12,09784671	12,09784671	0	-0,1999996	0,1999996	0	0	0	0	0	0,144003912	0,011903268
X1	0	1	0	0	0	0	-0,606060606	0,606060606	0	0	7,272727273	-7,272727273	0	0	0	0	0	0	0	0	14000	-1925
r3	0	0	0	0	0	0	-0,545454545	0,545454545	1	-1	2,545454545	-2,545454545	0	0	0	0	0	0	0	0	0	0
s5	0	0	0	0	0	0	-0,545454545	0,545454545	0	0	4,545454545	-4,545454545	1	0	0	0	0	0	0	0	0	0
x3	0	0	0	1	0	0	0,545454545	-0,545454545	0	0	-4,545454545	4,545454545	0	0	0	0	0	0	0	0	2500	550
x2	0	0	1	0	0	0	-0,251746406	0,251746406	0	0	1,174808559	-1,174808559	0	0,05999988	-0,05999988	0	0	0	0	0	12599,9568	-10725,11491
r7	0	0	0	0	0	0	-0,385454545	0,385454545	0	0	2,545454545	-2,545454545	0	0	0	1	-1	0	0	0	0	0
s8	0	0	0	0	0	0	-2,062958993	2,062958993	0	0	8,2938673	-8,2938673	0	-0,43999712	0,43999712	0	0	1	0	0	5250,736798	-633,0866661
r9	0	0	0	0	0	0	2,055932979	-2,055932979	0	0	-31,5943059	31,5943059	0	-0,35999928	0,35999928	0	0	0	1	-1	0,259199482	0,008203994

Table 9. fifth iteration

VD	Z	X1	X2	X3	r1	s1	r2	s2	r3	s3	r4	s4	s5	r6	s6	r7	s7	s8	r9	s9	S	
Z	1	0	0	0	0	-M	415.5168656 -1.365906854M	-415.5168656 +0.365906854M	0	-M	-M	0	0	20.81038261 -1.12015986M	-20.81038261 +0.12015986M	0	-M	0	259.193266 -1.221771944M	-259.193266 +0.221771944M	93320185.02 +0.829593099M	rs
r1	0	0	0	0	1	-1	0,233730947	-0,233730947	0	0	0	0	0	-0,062151466	0,062151466	0	0	0	-0,382912249	0,382912249	0,044753256	-0,191473385
X1	0	1	0	0	0	0	-0,132803181	0,132803181	0	0	0	0	0	-0,082868622	0,082868622	0	0	0	0,230191076	-0,230191076	14000,05967	105419,6106
r3	0	0	0	0	0	0	-0,379814447	0,379814447	1	-1	0	0	0	-0,029004018	0,029004018	0	0	0	0,080566877	-0,080566877	0,020882893	0,054981828
s5	0	0	0	0	0	0	-0,249668655	0,249668655	0	0	0	0	1	-0,051792889	0,051792889	0	0	0	0,143869423	-0,143869423	0,03729088	0,14936148
x3	0	0	0	1	0	0	0,249668655	-0,249668655	0	0	0	0	0	0,051792889	-0,051792889	0	0	0	-0,143869423	0,143869423	2499,962709	-10013,12203
x2	0	0	1	0	0	0	-0,175298211	0,175298211	0	0	0	0	0	0,0466136	-0,0466136	0	0	0	0,037184186	-0,037184186	12599,96644	71877,32494
r7	0	0	0	0	0	0	-0,219814447	0,219814447	0	0	0	0	0	-0,029004018	0,029004018	1	-1	0	0,080566877	-0,080566877	0,020882893	0,095002367

s8	0	0	0	0	0	0	-1,523253029	1,523253029	0	0	0	0	0	-0,534501056	0,534501056	0	0	1	0,262511458	-0,262511458	5250,804841	3447,099555
s4	0	0	0	0	0	0	0,065072896	-0,065072896	0	0	-1	1	0	-0,011394435	0,011394435	0	0	0	0,031651273	-0,031651273	0,008203994	-0,126073896

Table 10. iteration sixth

VD	Z	X1	X2	X3	r1	s1	r2	s2	r3	s3	r4	s4	s5	r6	s6	r7	s7	s8	r9	s9	S	
Z	1	0	0	0	0	-M	-M	0	1093.999633 -0.963383192M	-1093.999633 -0.036616808M	-M	0	0	-10.92000198 -1.092217877M	10.92000198 +0.092217877M	0	-M	0	347.3333995 -1.299388718M	-347.3333995 +0.299388718M	93320207.86 +0.809474871M	rs
r1	0	0	0	0	1	-1	0	0	-0,61538193	-0,61538193	0	0	0	-0,080000015	0,080000015	0	0	0	-0,333332848	0,333332848	0,05760421	0,17281288
X1	0	1	0	0	0	0	0	0	-0,349652791	0,349652791	0	0	0	-0,072727286	0,072727286	0	0	0	0,202020643	-0,202020643	14000,05236	-69300,108
s2	0	0	0	0	0	0	-1	1	2,63286457	-2,63286457	0	0	0	-0,07636365	0,07636365	0	0	0	0,212121675	-0,212121675	0,054981828	-0,2591995
s5	0	0	0	0	0	0	0	0	-0,657343756	0,657343756	0	0	1	-0,032727279	0,032727279	0	0	0	0,090909289	-0,090909289	0,023563641	-0,2591995
x3	0	0	0	1	0	0	0	0	0,657343756	-0,657343756	0	0	0	0,032727279	-0,032727279	0	0	0	-0,090909289	0,090909289	2499,976436	27499,6808
x2	0	0	1	0	0	0	0	0	-0,461536448	0,461536448	0	0	0	0,060000011	-0,060000011	0	0	0	-3,63636E-07	3,63636E-07	12599,9568	3,465E+10
r7	0	0	0	0	0	0	0	0	-0,578741669	0,578741669	0	0	0	-0,012218184	0,012218184	1	-1	0	0,033939468	-0,033939468	0,008797093	-0,2591995
s8	0	0	0	0	0	0	0	0	-4,010518932	4,010518932	0	0	0	-0,418179894	0,418179894	0	0	1	-0,060603526	0,060603526	5250,72109	86640,5211
s4	0	0	0	0	0	0	0	0	0,171328122	-0,171328122	-1	1	0	-0,016363639	0,016363639	0	0	0	0,045454645	-0,045454645	0,01178182	-0,2591995

Table 11. the seventh iteration

VD	Z	X1	X2	X3	r1	s1	r2	s2	r3	s3	r4	s4	s5	r6	s6	r7	s7	s8	r9	s9	S	
Z	1	0	0	0	1042.001714-0.898167462M	-1042.001714-0.101832538M	-M	0	452.7706076-0.410667166M	-1735.228659 +0.516099218M	-M	0	0	-94.28015428-1.020364467M	94.28015428 +0.020364467M	0	-M	0	-M	0	93320267.89 +0.757736644M	rs
s9	0	0	0	0	3,000004364	-3,000004364	0	0	-1,846148475	-1,846148475	0	0	0	-0,240000393	0,240000393	0	0	0	-1	1	0,172812883	-0,093607
X1	0	1	0	0	0,60606281	-0,60606281	0	0	-0,722612892	-0,023307311	0	0	0	-0,12121232	0,12121232	0	0	0	0	0	14000,08728	-600673,6
s2	0	0	0	0	0,63636595	-0,63636595	-1	1	2,241256463	-3,024472676	0	0	0	-0,127272936	0,127272936	0	0	0	0	0	0,091639186	-0,030299
s5	0	0	0	0	0,272728264	-0,272728264	0	0	-0,825175802	0,48951171	0	0	1	-0,054545544	0,054545544	0	0	0	0	0	0,039273937	0,0802308
x3	0	0	0	1	-0,272728264	0,272728264	0	0	0,825175802	-0,48951171	0	0	0	0,054545544	-0,054545544	0	0	0	0	0	2499,960726	-5107,049
x2	0	0	1	0	-1,09091E-06	1,09091E-06	0	0	-0,461535776	0,461537119	0	0	0	0,060000098	-0,060000098	0	0	0	0	0	12599,9568	27299,985
r7	0	0	0	0	0,101818552	-0,101818552	0	0	-0,641398966	0,516084372	0	0	0	-0,02036367	0,02036367	1	-1	0	0	0	0,01466227	0,0284106
s8	0	0	0	0	-0,181810843	0,181810843	0	0	-3,898635824	4,122402039	0	0	0	-0,403635024	0,403635024	0	0	1	0	0	5250,710616	1273,7017
s4	0	0	0	0	0,136364132	-0,136364132	0	0	0,087412099	-0,255244145	-1	1	0	-0,027272772	0,027272772	0	0	0	0	0	0,019636968	-0,076934

Table 12. iteration eighth

VD	Z	X1	X2	X3	r1	s1	r2	s2	r3	s3	r4	s4	s5	r6	s6	r7	s7	s8	r9	s9	S	
Z	1	0	0	0	1384.345872-0.999988943M	-1384.345872-1.1057E-05M	-M	0	-1703.802869 +0.230750251M	0	-M	0	0	-162.7488489 -1000000211M	162.7488489 +2.114E-07M	3362.296466-1.000028768M	-3362.296466 +2.87677E-05M	0	-M	0	93320317.18 +0.743073952M	rs
s9	0	0	0	0	3,364231949	-3,364231949	0	0	-4,140575099	0	0	0	0	-0,312845764	0,312845764	3,577222206	-3,577222206	0	-1	1	0,22526308	-0,0629715
X1	0	1	0	0	0,610661121	-0,610661121	0	0	-0,751579639	0	0	0	0	-0,12213198	0,12213198	0,045161822	-0,045161822	0	0	0	14000,08794	-309998,29
s2	0	0	0	0	1,233065726	-1,233065726	-1	1	-1,517612732	0	0	0	0	-0,246612652	0,246612652	5,860422911	-5,860422911	0	0	0	0,177566288	-0,0302992
s5	0	0	0	0	0,176152247	-0,176152247	0	0	-0,216801819	0	0	0	1	-0,035230379	0,035230379	-0,948511013	0,948511013	0	0	0	0,025366613	0,02674361

x3	0	0	0	1	-0,176152247	0,176152247	0	0	0,216801819	0	0	0	0	0,035230379	-0,035230379	0,948511013	-0,948511013	0	0	0	2499,974633	-2635,6833
x2	0	0	1	0	-0,091057987	0,091057987	0	0	0,11207088	0	0	0	0	0,078211441	-0,078211441	-0,894305552	0,894305552	0	0	0	12599,94369	14089,0814
s3	0	0	0	0	0,197290516	-0,197290516	0	0	-1,242818037	1	0	0	0	-0,039458024	0,039458024	1,937667666	-1,937667666	0	0	0	0,028410606	-0,0146623
s8	0	0	0	0	-0,995121669	0,995121669	0	0	1,224759786	0	0	0	0	-0,240973184	0,240973184	-7,987845137	7,987845137	1	0	0	5250,593497	657,322896
s4	0	0	0	0	0,186721381	-0,186721381	0	0	-0,229809928	0	-1	1	0	-0,037344202	0,037344202	0,494578326	-0,494578326	0	0	0	0,026888609	-0,0543667

Table 13. the ninth iteration

VD	Z	X1	X2	X3	r1	s1	r2	s2	r3	s3	r4	s4	s5	r6	s6	r7	s7	s8	r9	s9	S
Z	1	0	0	0	2008.773072-0.999994286M	-2008.773072-571441E-06M	-M	0	-2472.3253 +0.230756827M	0	-M	0	3544.815422-3.03293E-05M	-287.6340391-0.999999143M	287.6340391-8.57113E-07M	-M	0	0	-M	0	93320407,1
s9	0	0	0	0	4,028573975	-4,028573975	0	0	-4,958223255	0	0	0	3,771408195	-0,445713904	0,445713904	0	0	0	-1	1	0,320930931
X1	0	1	0	0	0,619048326	-0,619048326	0	0	-0,761902308	0	0	0	0,047613388	-0,123809418	0,123809418	0	0	0	0	0	14000,08915
s2	0	0	0	0	2,321431224	-2,321431224	-1	1	-2,857133654	0	0	0	6,178550203	-0,464285316	0,464285316	0	0	0	0	0	0,334295178
s7	0	0	0	0	0,185714498	-0,185714498	0	0	-0,228570692	0	0	0	1,054284016	-0,037142825	0,037142825	-1	1	0	0	0	0,026743614
x3	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	2500
x2	0	0	1	0	-0,257143494	0,257143494	0	0	0,316482919	0	0	0	-0,942852049	0,111428476	-0,111428476	0	0	0	0	0	12599,91977
s3	0	0	0	0	0,557143494	-0,557143494	0	0	-1,685712077	1	0	0	2,042852049	-0,111428476	0,111428476	0	0	0	0	0	0,080230843
s8	0	0	0	0	-2,478580318	2,478580318	0	0	3,050547079	0	0	0	-8,421457452	0,055717952	-0,055717952	0	0	1	0	0	5250,379873
s4	0	0	0	0	0,278571747	-0,278571747	0	0	-0,342856038	0	-1	1	0,521426024	-0,055714238	0,055714238	0	0	0	0	0	0,040115421

From the calculation result of simplex method gives minimum value of z = 93320407,1 when X_1 = 1400,08915≈X_1 = 1400, X_2 = 12599,91977≈X_2 = 12600, and x_3 = 2500. In the ninth iteration also obtained s_8 = 5250,379873 which is the excess material (residual material), s_2 = 0.334295178, s_3 = 0,080230843, s_4 = 0,040115421, s_7 = 0,026743614 and s_9 = 0,320930931 which is use of material that exceeds the limit.

5. CONCLUSION

From the research result, it can be concluded that the total cost of production per month is the minimum production cost by producing square opak 14000 kg, animal feed 12600 kg and opak bulk 2500 kg, so in the month required production cost equal to Rp 93.320.407,1

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