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Implementation of Fuzzy Linear Programming (FLP) on Optimizing the Production of Vegetable Rice and Lontong in Warung Makan Ibu Eni

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ABSTRACT
Sellers of vegetable rice and lontong want to increase production levels, but are hampered by determining the quantity of ingredients and the time to produce them. This research aims to optimize the production of vegetable rice and lontong using Fuzzy Linear Programming-Right Hand Side (FLP-RHS) by considering uncertainty in demand, raw material prices and production time. It is hoped that the research results can help sellers determine optimal production quantities. The research was conducted at Warung Makan Ibu Eni which is located on Jalan Sekip Gang Suropati, Medan Petisah District, Medan City, Indonesia. Data was obtained through direct interviews with the owner of Ibu Eni's food stall to obtain information regarding production time, raw material supplies, selling prices and daily production. Data is processed using FLP and using the POM-QM application. In order to obtain maximum profit, namely Rp. 812.070, 37.93 packs of vegetable rice must be produced and 52.3 packs of lontong must be produced.
Keyword: vegetable rice, lontong, fuzzy linear programming, right-hand side fuzzy

1. Introduction

Vegetable rice dan lontong is a combination of rice or lontong and vegetable soup containing various vegetables such as pumpkin, carrots, and potatoes cooked in coconut milk. vegetable dan lontong is one of the specialties usually consumed by the people of Medan city as a breakfast dish, with an affordable price of around 8-15 thousand. Due to the interest and purchasing power of the community towards vegetable rice and lontong, many vegetable rices and lontong sellers make the decision to increase the amount of production, but are constrained in determining the amount of ingredients and time to produce them. Therefore, proper

calculations are needed to produce and determine the amount of lontong and vegetable to be produced. This research aims to optimize the production of vegetable rice and lontong with Fuzzy Linear Programming (FLP) in a limited time. FLP is an appropriate method to solve optimization problems with data uncertainty.

Fuzzy is a mathematical concept that describes uncertainty and ambiguity. Simply put, fuzzy is defined as fuzzy or vague, which means that a value can be true or false simultaneously. In fuzzy, membership degrees are known which have a range of values from zero to one [3]. Fuzzy logic was first proposed by Lotfi Zadeh in a 1965 paper for the journal Information and Control. Fuzzy logic is a variable processing approach that allows several possible truth values to be processed through the same variable [4].

Fuzzy Linear Programming (FLP) is a development of a linear program applied in a fuzzy environment to achieve the goal of maximizing or minimizing a problem. FLP is a linear program expressed by an objective function and a constraint function that has fuzzy parameters and fuzzy inequalities. The goal of FLP is to find an acceptable solution based on the criteria expressed in the objective function and constraints. The solution is in the form of a fuzzy set that has a certain degree of truth in the interval [0,1] [5].

By using FLP, the optimum value of the number of products that must be produced according to demand and the availability of production resources can be obtained [1]. The FLP method is proven to be able to increase sales results. FLP solution will provide better and optimal results when compared to ordinary linear programming solutions. FLP also allows the right-hand side (RHS) of the model to also have fuzzy values. This makes FLP with RHS more flexible and can handle optimization problems with more complex uncertainties.

This research uses FLP-RHS to optimize the production of vegetable rice and lontong by considering uncertainty in demand, raw material prices, and production time. The results of the study are expected to help sellers of vegetable rice and lontong to determine the optimal amount of production and increase their profits. In previous research, [6] have applied the FLP method to optimize the production profit of mango sticky rice produced by CMG Stores. In this study, the profit obtained by the company was IDR 2.275.000. Meanwhile, by using the FLP method, the profit obtained was IDR 3.487.000. In other words, the company's profit increased by Rp1.212.000 or 53,272% by producing original variants of 500 pieces, original green tea 410 pieces, original mix berry 406 pieces, mix berry green tea 404 pieces, mango kiwi 190 pieces, and mango kiwi green tea 110 pieces. As well as in [2] which optimizes hijab production, it can be concluded that the use of FLP can produce the right value to find out how many hijabs must be produced for each model to get maximum profit. So, this research is expected to contribute to the literature on production optimization using FLP.

2. Method

1. Research Location: The research was conducted at Warung Makan Ibu Eni located at Jalan Sekip Gang Suropati, Medan Petisah District, Medan City, Indonesia.
2. Data Collection: Data was obtained through direct interviews with the owner of Warung Makan Ibu Eni to obtain information regarding production time, raw material inventory, selling price, and daily production.
3. Research Variables:
   a) Decision Variable

x = the amount of vegetable rice produced (pack)

y = number of lontong produced (packs)

b) Constraint Variables

1) Production time.

2) Amount of rice usage and inventory.

3) A lot of pumpkin usage and inventory.

4) Amount of carrot usage and inventory.

5) A lot of potato usage and inventory.

6) Amount of coconut milk usage and inventory.

4. Analysis Method: Data is processed using Fuzzy Linear Programming (FLP) and using the POM-QM application.1. Introduction. It begins with general discussion. The first sentence of opening paragraph should make readers appeal and curious. Then, background of research and related previous of study are explained after opening paragraph and before end paragraph. This section logically links the existed research problems with the approach that is operated to solve the problem. Introduction ends with the aim and purpose of research or the activity and main research finding.

3. Result and Discussion

Warung Makan Ibu Eni, located on Jalan Sekip Gang Suropati Medan, produces two types of food, namely vegetable rice and lontong, using rice, pumpkin, carrots, potatoes, and coconut milk as ingredients. Both meals are sold at a price of Rp9.000. The following is the raw material inventory data obtained for 1 month, namely February 16, 2024 to March 16, 2024.

Table 1. Raw Material Inventory Data

Date	Rice (gram)	Pumpkins (gram)	Carrots (gram)	Potatoes (gram)	Coconut Milk (mL)
16 Feb	5700	1120,7	468,7	1919,3	6200
17 Feb	5700	1383,8	476,3	1757,0	8400
18 Feb	6300	1387,9	416,4	1829,0	8500
19 Feb	4800	1147,2	454,1	1650,0	7900
20 Feb	6100	1178,0	317,3	1694,7	8000
21 Feb	5700	1424,2	360,8	1990,5	7600
22 Feb	6500	1306,3	458,0	1865,0	8600
23 Feb	5000	1160,8	465,5	1617,9	8300
24 Feb	6500	1124,0	456,2	1941,3	7900
25 Feb	5100	1291,1	346,1	2061,3	8800
26 Feb	5400	1242,1	409,7	1710,1	6400
27 Feb	5400	1117,6	451,0	1712,9	7800
28 Feb	5500	1208,8	344,5	1766,3	7700

29 Feb	5600	1251,5	372,8	1686,0	7900
01 Mar	5500	1377,7	480,2	2004,7	8600
02 Mar	4700	1319,5	309,7	1859,7	7100
03 Mar	4700	1209,8	464,5	1694,2	7000
04 Mar	5900	1362,1	330,0	1663,8	7600
05 Mar	6300	1461,2	487,9	1880,3	8800
06 Mar	4900	1221,8	469,1	1941,4	7500
07 Mar	5600	1300,8	398,4	1684,1	8800
08 Mar	5200	1252,4	470,7	1664,1	7400
09 Mar	5600	1295,8	304,2	1924,8	8900
10 Mar	4900	1473,1	432,7	1695,7	8200
11 Mar	4600	1239,3	381,6	1670,9	6400
12 Mar	5000	1159,6	478,7	1698,2	7700
13 Mar	5700	1209,5	444,6	2001,0	7700
14 Mar	4800	1344,3	352,5	2093,8	7200
15 Mar	5800	1329,0	464,5	2023,4	8300
16 Mar	6200	1102,0	316,4	1886,7	6400
Average	5500	1266,7	412,8	1819,6	7800

In addition, data on the production time of each material is also obtained as follows.

Table 2. Production Time Data of Raw Materials

Raw Materials	Weight	Many Packs	Production Times (Minutes)
Rice for vegetable rice	2000 gram	20	30
Rice for lontong	2000 gram	50	300
Soup	7000 mL	100	60
Pumpkins	1000 gram	100	10
Carrots	400 grams	100	5
Potatos	1700 gram	100	30

From Table 1, it is obtained that the inventory tolerance of rice is 17.77%, pumpkin 16.29%, carrots 18.20%, potatoes 15.07%, and coconut milk 14%. Then the minimum tolerance of all raw materials is obtained, namely 14%. From Table 2, a mathematical model can be obtained for the time constraint function of vegetable rice and rice cake production, by dividing the production time by the number of packs obtained for each raw material, then summing. Then by dividing the weight of raw materials by the number of packs produced, a constraint function for the inventory of each raw material is obtained.

Then, FLP will be formed with two decision variables, namely x states the number of packs of vegetable rice that must be produced and y states the number of packs of rice cake that must be produced. So, with a tolerance of 14% for each constraint function, the mathematical model formulation is as follows.

Minimize $Z = 9000x + 9000y$

Constraints

$$\begin{aligned} 2{,}55x + 7{,}05y &\le 435 + 60{,}9t \\ 100x + 40y &\le 5500 + 770t \\ 10x + 10y &\le 1266{,}7 + 177{,}338t \\ 4x + 4y &\le 412{,}8 + 57{,}792t \\ 17x + 17y &\le 1819{,}6 + 254{,}744t \\ 70x + 70y &\le 7800 + 1092t \\ x, y &\ge 0 \end{aligned}$$

For $t = 0$, the following linear program form is obtained.

Maximize $Z = 9000x + 9000y$

Subject to,

$$\begin{aligned} 2{,}55x + 7{,}05y &\le 435 \\ 100x + 40y &\le 5500 \\ 10x + 10y &\le 1266{,}7 \\ 4x + 4y &\le 412{,}8 \\ 17x + 17y &\le 1819{,}6 \\ 70x + 70y &\le 7800 \\ x, y &\ge 0 \end{aligned}$$

By using POM-QM software, we have the solution.

$$\begin{aligned} Z &= 758955{,}3 \\ x &= 35{,}45 \\ y &= 48{,}88 \end{aligned}$$

For $t = 1$, the following linear program form is obtained.

Maximize $Z = 9000x + 9000y$

Subject to,

$$\begin{aligned} 2{,}55x + 7{,}05y &\le 495{,}9 \\ 100x + 40y &\le 6270 \\ 10x + 10y &\le 1444{,}038 \\ 4x + 4y &\le 470{,}592 \\ 17x + 17y &\le 2074{,}344 \\ 70x + 70y &\le 8892 \\ x, y &\ge 0 \end{aligned}$$

By using POM-QM software, the solution is,

$$\begin{aligned} Z &= 865208{,}9 \\ x_1 &= 40{,}41 \\ x_2 &= 55{,}72 \end{aligned}$$

From these two results, the value of P_0 can be determined, which is the difference between Z at $t = 1$ and Z

at $t = 0$. P0 serves for the formation of FLP. Thus, we have $P_0 = 865208{,}9 - 758955{,}3 = 106253{,}6$.

Then, the solution will be solve using Fuzzy Linear Programming (FLP).

Table 3. Fuzzy Constraint Data and Objective Function

	Fuzzy Constraints	
	$t = 0$	$t = 1$
Objective Function	758955,3	865208,9
Constraint 1	435	495,9
Constraint 2	5500	6270
Constraint 3	1266,7	1444,038
Constraint 4	412,8	470,592
Constraint 5	1819,6	2074,344
Constraint 6	7800	8892

With constraints $\lambda = 1 - t$, FLP model can be formed as follows.

Maximize λ

Subject to,

$$106253{,}6\lambda - 9000x - 9000y \leq -865208{,}9 + 106253{,}6 = -758955{,}3$$
$$60{,}9\lambda + 2{,}55x + 7{,}05y \leq 435 + 60{,}9 = 495{,}9$$
$$770\lambda + 100x + 40y \leq 5500 + 770 = 6270$$
$$177{,}338\lambda + 10x + 10y \leq 1266{,}7 + 177{,}338 = 1444{,}038$$
$$57{,}792\lambda + 4x + 4y \leq 412{,}8 + 57{,}792 = 470{,}592$$
$$254{,}744\lambda + 17x + 17y \leq 1819{,}6 + 254{,}744 = 2074{,}344$$
$$1092\lambda + 70x + 70y \leq 7800 + 1092 = 8892$$
$$\lambda, x, y \geq 0$$

So the form of the linear program is

Maximize λ

Subject to,

$$-106253{,}6\lambda + 9000x + 9000y \geq 758955{,}3$$
$$60{,}9\lambda + 2{,}55x + 7{,}05y \leq 495{,}9$$
$$770\lambda + 100x + 40y \leq 6270$$
$$177{,}338\lambda + 10x + 10y \leq 1444{,}038$$
$$57{,}792\lambda + 4x + 4y \leq 470{,}592$$
$$254{,}744\lambda + 17x + 17y \leq 2074{,}344$$
$$1092\lambda + 70x + 70y \leq 8892$$
$$\lambda, x, y \geq 0$$

By using POM-QM software, the solution is obtained.

$$\lambda = 0{,}5$$
$$x_1 = 37{,}93$$

$$x_2 = 52{,}3$$

So, the Z value is 812070, with the values for each constraint:

constraint 1 $= 2{,}55x + 7{,}05y = (2{,}55)(37{,}93) + (7{,}05)(52{,}3) = 465{,}4365$

constraint 2 $= 100x + 40y = (100)(37{,}93) + (40)(52{,}3) = 5885$

constraint 3 $= 10x + 10y = (10)(37{,}93) + (10)(52{,}3) = 902{,}3$

constraint 4 $= 4x + 4y = (4)(37{,}93) + (4)(52{,}3) = 360{,}92$

constraint 5 $= 17x + 17y = (17)(37{,}93) + (17)(52{,}3) = 1533{,}91$

constraint 6 $= 70x + 70y = (70)(37{,}93) + (70)(52{,}3) = 6316{,}1$

So, in order to obtain the maximum profit of Rp812.070, vegetable rice must be produced in 37,93 packs and lontong must be produced in 52,3 packs; with an additional production time of 30,4365 grams; an additional rice of 385 grams; and no addition of pumpkin, carrots, and coconut milk.

4. Conclusion

Based on the discussion, the production optimization of Warung Makan Ibu Eni using FLP is done by finding a solution for FLP with t = 0 and t = 1. By using ordinary linear programming, the maximum profit of Rp758.955,3 is obtained if vegetable rice is produced as much as 35,45 packs and lontong as much as 48,88 packs. While using FLP with a 14% tolerance, the maximum profit of Rp812.070 is obtained if vegetable rice is produced as many as 37,93 packs and lontong should be produced as many as 52,3 packs.

5. Conflict of Interest

The authors declare there is no conflict of interest.

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