

Implementation of The Fuzzy Inference System to Determine The Amount of Purchase of Supplement Drug Products Based on Inventory and Sales Data at XYZ Pharmacy

by Sofia Debi Puspa Debi Puspa

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Implementation of The Fuzzy Inference System to Determine The Amount of Purchase of Supplement Drug Products Based on Inventory and Sales Data at XYZ Pharmacy

Fani Puspitasari*
Industrial Engineering, Trisakti
University, Jakarta
fani.puspitasari@trisakti.ac.id

Sofia Debi Puspa
Mechanical Engineering, Trisakti
University, Jakarta
sofia.debi.puspa@trisakti.ac.id

Christian Kenny Verel
Industrial Engineering, Trisakti
University, Jakarta
christiankenny@gmail.com

ABSTRACT

The Health Service Industry is one of the important and crucial industries to be maintained in order to support the welfare of the community. XYZ Pharmacy, which is located in the Jakarta area, is one of the industrial companies engaged in Health Services and focuses on the skin and genital area. The need for planning the number of purchases of medicinal products for Inventory at XYZ Pharmacy is very important. It was found that there were problems with the company, namely experiencing a very large amount of stock and decreasing stock in supplement products so that many products expired and lost customer trust. The purpose of this study was to determine the number of drug purchases at XYZ Pharmacy to reduce decreasing or excess drug stock. The method used in this study is the Fuzzy Sugeno and Fuzzy Mamdani method. The application of the Fuzzy Sugeno and Fuzzy Mamdani methods uses three variables, namely: the number of inventories, the number of sales, and the number of drug purchases with the help of MATLAB software. Determination of safety stock and reorder points conducted by XYZ Pharmacy is carried out to minimize inventory running out which has an impact on customer satisfaction levels. The results of this study are In Fuzzy Mamdani's calculation, the Enervon C Tab Strip 4S/25 STRP product has a fulfilled presentation result of 79%. In Fuzzy Sugeno's calculation, the Enervon C Tab Strip 4S/25 STRP product has a fulfilled presentation result of 31%. It can be concluded that the application of Fuzzy Mamdani is better than the Fuzzy Sugeno method for calculating the inventory of Enervon C Tab Strip 4S/25 STRP products. In the calculation of the Safety Stock of the Enervon C Tab Strip 4S/25 STRP product, the results are 75 packs per month with reorder points of 80 packs per month for Calcium Carbonat + Vitamin D3 400 of 61 packs per month with reorder points of 65 packs per month.

CCS CONCEPTS

• Insert your first CCS term here; • Insert your second CCS term here; • Insert your third CCS term here;

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KEYWORDS

Fuzzy inference system, Inventory, Purchases and Sales, Safety stock

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1 INTRODUCTION

The health care industry is one of the most important sectors that has a great influence on people's welfare. One of the health service industries is pharmaceutical services or known as pharmacies. Pharmacy is one of the health services that help, maintain, and realize the community in the creation of optimal health. One of the most important elements in the operation of a pharmacy is the inventory element. The right supply of drugs in the pharmacy will affect the performance and activities in terms of operations. In inventory storage, there needs to be a more effective and efficient way to organize and control large amounts of inventory. Without proper supplies, pharmacies will be faced with the risk of not being able to meet the needs of their customers. Inventory is carried out to ensure certainty that when needed these products are available [1].

This study uses the application of the Fuzzy Inference System method, which can be used to optimize the amount of drug inventory for each certain time period and determine the right time to purchase drugs for supplies at the pharmacy. In the Fuzzy Inference System method, this study made observations using the Fuzzy Sugeno method to determine the number of purchases of supplemental medicinal products. The calculation of the Sugeno method has an output of constant numbers or linear equations. This method has the advantage of being very clear and easy to use compared to other methods.

Determination of sufficient stock, excess, and shortage of stock is calculated based on the reduction of the amount of inventory with the number of sales. The Enervon C Tab Strip 4S/25 STRP Supplement ran out of stock in October 2020 and July 2021 and experienced very thin stock and sometimes even sales that exceeded the existing inventory. Because of this problem, customers will usually move to another place with very complete product conditions. In table 1, the months of January, March, May, June, and August

Table 1: Enervon C Tab Strip 4S/25 STRP supplement data sample

Year 2020/2021	Supplement Drugs			Description
	Enervon C Tab Strip 4S/25 STRP			
	Inventory	Sales	Purchase	
18 September	25	25	0	Sufficient stock
October	0	0	0	Sufficient stock
December	150	100	150	Excess stock 50 pack
January	50	70	0	Short stock 20 pack
February	130	100	150	Excess stock 30 pack
March	130	150	100	Short stock 20 pack
April	105	73	125	Excess stock 32 pack
May	32	75	0	Short stock 43 pack
June	-43	3	0	Short stock 40 pack
July	29	100	75	Short stock 71 pack
August	-21	25	50	Short stock 46 pack

have a number of stocks that are less than the total sales, so the company borrows drugs from other pharmacies to meet the number of customer requests. There is a sample data for the Enervon C Tab Strip 4S/25 STRP supplement for the period September 2020 to August 2021 in Table 1.

The objectives to be achieved in this research are as follows:

- Determining the number of purchases of supplementary medicinal products Enervon C Tab Strip 4S/25 STRP using the Fuzzy Mamdani method and the Fuzzy Sugeno method based on three input variables of inventory, purchases, and sales at XYZ Pharmacy.
- Knowing the minimum amount of drug stock (safety stock) that is carried out to meet customer demand at the XYZ Pharmacy on Enervon C Tab Strip 4S/25 STRP supplement drug products
- Knowing the reorder point or reorder point that is used by XYZ Pharmacy in fulfilling customer requests at XYZ Pharmacy on Enervon C Tab Strip 4S/25 STRP supplement drug products

2 FUZZY

2.1 Fuzzy Logic

Tables are "float elements" which should be inserted after their first text reference and have specific styles for identification. Do not use images to present tables, or they will be inaccessible to readers using assistive technologies. Fuzzy logic was first developed by Lotfi A Zadeh in 1965, who is a professor at the University of California, Berkeley [3]. There are several things that need to be known in understanding the fuzzy system, namely:

1. Fuzzy variable is a variable to be discussed in a fuzzy system. Examples are: age, temperature, speed, and distance [2].
2. Fuzzy set is a group that represents a certain condition or condition in a fuzzy variable. Fuzzy set has 2 attributes [2], namely:

1. Linguistics, namely naming a group that represents a certain situation or condition using natural language, such as: Near, Medium, Far

2. Numeric, which is a value (number) that indicates the size of a variable, such as: 30,40,45.
3. The universe of speech is the entire value obtained for operation in a fuzzy variable, the universe of speech is a set of real numbers that always increases (increases) monotonically from left to right [2]. For example, the universe of talks for the temperature variable: [0 40].
4. Domain is the entire value that is allowed in the universe of talk and can be operated in a fuzzy set [2]. Like the universe of conversation, the domain is a set of real numbers that always increases (increases) monotonically from left to right as shown in Figure 6.2. Examples of domains are Near [0 5], Medium [7, 10], and Far [15, 20].

2.2 Fuzzy Mamdani

This method was first proposed by Ebrahim Mamdani in 1975. This method is the simplest method and is often used for research compared to other methods [6]. To determine the output there are several stages, namely:

- a. The formation of a fuzzy set is that there are input and output variables.
- b. Fuzzyfication is done to squeeze a crisp number into the fuzzy variable from the input variable.
- c. Implication, is used to determine the form of the final fuzzy number which is determined by filling the fuzzy output set into the output variable.
- d. Aggregation is the process of combining the output functions of the implication process by following the IF THEN rules into a single fuzzy set using the MAX function.
- e. Deffuzzyfication, this process uses the input of a fuzzy set obtained from the applicable fuzzy rules and the output is the domain number of the fuzzy set. In general, it can be written using equation 2) as follows:

$$X = \frac{\int_1^x x\mu(x) dx}{\int_1^x \mu(x) dx} \tag{1}$$

Information:

x = output variable

X = Fuzzy output area center point

$\mu(x)$ = membership function of the output variable

2.3 Fuzzy Sugeno

In the Sugeno method, fuzzification, fuzzy operations, and implications are the same as the Mamdani method. The difference is only in aggregation and defuzzification. If in the Mamdani method the aggregation is the area under the curve, then in the Sugeno method the aggregation is in the form of singletons.

Defuzzification in the Sugeno method is simpler, because it only calculates the center of single-ton

$$z^* = \frac{\sum \mu_c(\bar{z}) \cdot \bar{z}}{\sum \mu_c(\bar{z})} \quad (2)$$

which in this case, \bar{z} is the singleton value

3 RESEARCH METHODOLOGY

Research Methodology is the stages or steps of the process flow in conducting systematic and precise research so as to get good research results. The research method used is the Fuzzy Inference System, namely Fuzzy Sugeno. The initial stage begins with identifying the problems that occur. To clarify the research methodology, a flow chart is made as shown in Figure 1.

4 RESULT

4.1 Safety Stock

Calculation of safety stock using data that is a service level of 95% with a service factor of 1.64 and data on the average number of sales per month. With the safety stock formula, the following results are obtained:

- Enervon C Tab Strip 4S/25 STRP:

Sample	x	x ²
September	25	625
October	0	0
November	50	2500
December	100	10000
January	70	4900
February	100	10000
March	150	22500
April	73	5329
May	75	5625
June	3	9
July	100	10000
August	25	625
Total	771	72113

Calculation:

$$SS = Z \cdot x \cdot \sigma$$

$$SS = 1,64 \cdot x \cdot \sqrt{\frac{\sum x^2 - \frac{(\sum x)^2}{n}}{n-1}}$$

$$SS = 1,64 \cdot x \cdot \sqrt{\frac{72113 - \frac{(771)^2}{12}}{12-1}}$$

$$SS = 1,64 \cdot x \cdot 45,303$$

$$SS = 74,297 = 75 \text{ pack}$$

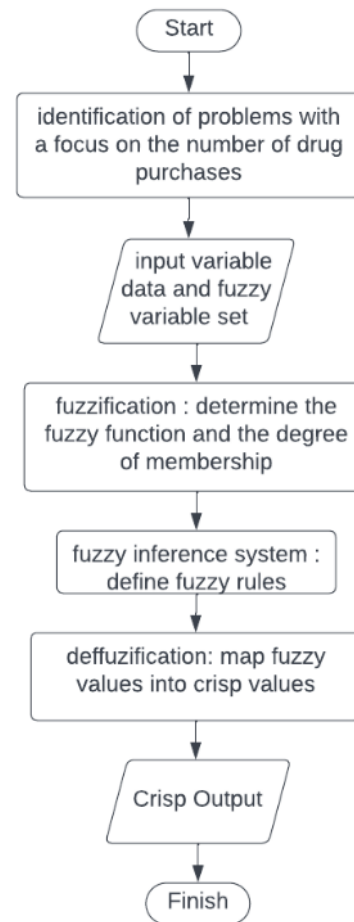


Figure 1: Fuzzy Methodology Flowchart

The safety stock for the Enervon C Tab Strip 4S/25 STRP product is 75 packs.

4.2 Reorder Point

The reorder point is the time when a reorder must be held so that the inventory can be above the safety stock or equal to zero. After the safety stock has been obtained, you can calculate the reorder point value. With the reorder point formula, the following results are obtained:

$$ROP = (d \cdot x \cdot L) + SS$$

$$ROP = \left(\frac{771}{365} \cdot x \cdot 2 \right) + 75$$

$$ROP = 79,22 \approx 80 \text{ pack}$$

4.3 Solving with Fuzzy Mamdani Method

a. Fuzzification

There are 3 fuzzy variables modeled in this study, namely:

- ◆ Inventory (psd): consists of 3 fuzzy sets, namely: low, medium, and high.
- ◆ Sales (pj): consists of 3 fuzzy sets, namely: decreasing, normal, and increasing.
- ◆ Purchases (pbl): consists of 3 fuzzy sets, namely: few, medium, and many.

b. Fuzzy Rules

After performing the Fuzzification stage, then the formation of fuzzy logic rules is carried out. In this study, nine possible combinations were obtained from the number of variables from each fuzzy set that was formed. The rules are as follows:

- ◆ IF (Inventory is Low) and (Sales is Decreasing) then (Purchases is Few)
- ◆ IF (Inventory is Normal) and (Sales is Decreasing) then (Purchases is Few)
- ◆ IF (Inventory is High) and (Sales is Decreasing) then (Purchases is Few)
- ◆ IF (Inventory is Low) and (Sales is Normal) then (Purchases is High)
- ◆ IF (Inventory is Normal) and (Sales is Normal) then (Purchases is Normal)
- ◆ IF (Inventory is High) and (Sales is Normal) then (Purchases is Few)
- ◆ IF (Inventory is Low) and (Sales is Increasing) then (Purchases is Many)
- ◆ IF (Inventory is Normal) and (Sales is Increasing) then (Purchases is Many)
- ◆ IF (Inventory is High) and (Sales is Increasing) then (Purchases is Many)

c. Determining the compositions of the rule

In this study, taking one of the product samples, namely Enervon C Tab Strip 4S/25 STRP in the September 2021 period with a total inventory of 25 packs, a total purchase of 0 packs, and a total sales of 25 packs, so that a value is obtained for each variables are as follows:

- **Inventory Variable**

$$\mu_{psdLOW}(25) = \frac{90-25}{90-(-50)} = \frac{65}{140} = 0,464$$

$$\mu_{psdNORMAL}(25) = 0$$

$$\mu_{psdHIGH}(25) = 0$$

- **Sales Variables**

$$\mu_{pjIDECREASING}(25) = \frac{80-25}{90-0} = \frac{55}{90} = 0,611$$

$$\mu_{pjINORMAL}(25) = 0$$

$$\mu_{pjINCREASING}(25) = 0$$

- **Purchase Variables**

$$\mu_{pblFEW}(0) = 1$$

$$\mu_{pblNORMAL}(0) = 0$$

$$\mu_{pblMANY}(0) = 0$$

After performing the Fuzzification stage which determines the degree of membership for each fuzzy set and forms the fuzzy rules of each related fuzzy variable, the next step that needs to be done is to compose the fuzzy basic rules. The following is the composition of the rules formed, namely:

1. IF (Inventory is Low) and (Sales is Decreasing) then (Purchases is Few)

$$\begin{aligned} \alpha - \text{predikat1} &= \\ &= \mu_{psdLOW} \cup \mu_{pjIDECREASING} \\ &= \mu_{psdLOW}(25) \cup \mu_{pjIDECREASING}(25) \\ &= \min(0,464; 0,611) = 0,464 \end{aligned}$$

When $\mu_{pblFEW} = 0.464$ then the value of x can be determined as follows:

$$\begin{aligned} \alpha - \text{predikat1} &= \\ &= \frac{90 - x}{90} = 0,464 \\ (90x0,464) &= 90 - x \\ x &= 48,24 \end{aligned}$$

2. IF (Inventory is Normal) and (Sales is Decreasing) then (Purchases is Few)

$$\begin{aligned} \alpha - \text{predikat2} &= \\ &= \mu_{psdNORMAL} \cup \mu_{pjIDECREASING} \\ &= \mu_{psdNORMAL}(25) \cup \mu_{pjIDECREASING}(25) \\ &= \min(0; 0,611) \\ &= 0 \end{aligned}$$

No fuzzy output region is formed

3. IF (Inventory is High) and (Sales is Decreasing) then (Purchases is Few)

$$\begin{aligned} \alpha - \text{predikat3} &= \\ &= \mu_{psdHIGH} \cup \mu_{pjIDECREASING} \\ &= \mu_{psdHIGH}(25) \cup \mu_{pjIDECREASING}(25) \\ &= \min(0; 0,611) \\ &= 0 \end{aligned}$$

No fuzzy output region is formed

4. IF (Inventory is Low) and (Sales is Normal) then (Purchases is High)

$$\begin{aligned} \alpha - \text{predikat4} &= \\ &= \mu_{psdLOW} \cup \mu_{pjINORMAL} \\ &= \mu_{psdLOW}(25) \cup \mu_{pjINORMAL}(25) \\ &= \min(0,464; 0) \\ &= 0 \end{aligned}$$

No fuzzy output region is formed

5. IF (Inventory is Normal) and (Sales is Normal) then (Purchases is Normal)

$$\begin{aligned} \alpha - \text{predikat5} &= \\ &= \mu_{psdNORMAL} \cup \mu_{pjINORMAL} \\ &= \mu_{psdNORMAL}(25) \cup \mu_{pjINORMAL}(25) \\ &= \min(0; 0) \\ &= 0 \end{aligned}$$

No fuzzy output region is formed

6. IF (Inventory is High) and (Sales is Normal) then (Purchases is Few)

$$\begin{aligned} \alpha - \text{predikat6} &= \\ &= \mu_{psdHIGH} \cup \mu_{pjINORMAL} \\ &= \mu_{psdHIGH}(25) \cup \mu_{pjINORMAL}(25) \\ &= \min(0; 0) \end{aligned}$$

$$= 0$$

No fuzzy output region is formed

7. IF (Inventory is Low) and (Sales is Increasing) then (Purchases is Many)

$$\begin{aligned} \alpha - \text{predikat7} &= \\ &= \mu_{PsdLOW} \cup \mu_{PjIINCREASING} \\ &= \mu_{PsdLOW}(25) \cup \mu_{PjIINCREASING}(25) \\ &= \min(0, 464; 0) \\ &= 0 \end{aligned}$$

No fuzzy output region is formed

8. IF (Inventory is Normal) and (Sales is Increasing) then (Purchases is Many)

$$\begin{aligned} \alpha - \text{predikat8} &= \\ &= \mu_{PsdNORMAL} \cup \mu_{PjIINCERASING} \\ &= \mu_{PsdNORMAL}(25) \cup \mu_{PjIINCERASING}(25) \\ &= \min(0; 0) \\ &= 0 \end{aligned}$$

No fuzzy output region is formed

9. IF (Inventory is High) and (Sales is Increasing) then (Purchases is Many)

$$\begin{aligned} \alpha - \text{predikat9} &= \\ &= \mu_{PsdHIGH} \cup \mu_{PjIINCERASING} \\ &= \mu_{PsdHIGH}(25) \cup \mu_{PjIINCERASING}(25) \\ &= \min(0; 0) \\ &= 0 \end{aligned}$$

No fuzzy output region is formed. Defuzzification

The last stage in the research with Fuzzy Mamdani is the stage of affirmation (defuzzification). The steps in defuzzification with the Centroid method are as follows:

The first inference is a linear function, so:

$$\begin{aligned} M1 &= \int_0^{48,24} 0,464 x \, dx \\ M1 &= \left. \frac{0,464 x^2}{2} \right|_0^{48,24} \\ M1 &= (0,232)(48,24)^2 - (0,232)(0)^2 \\ M1 &= 539,887 \end{aligned}$$

Area for the first Inference:

$$\begin{aligned} A1 &= (0,464)(48,24 - 0) \\ A1 &= 22,384 \end{aligned}$$

The second inference is an ascending function, so:

$$\begin{aligned} M2 &= \int_{48,24}^{90} \frac{90-x}{90-0} x \, dx \\ M2 &= \left. \frac{90x^2}{2(90)} - \frac{x^3}{3(90)} \right|_{48,24}^{90} \\ M2 &= \left(\frac{90(90)^2}{2(90)} - \frac{(90)^3}{3(90)} \right) - \left(\frac{90(48,24)^2}{2(90)} - \frac{(48,24)^3}{3(90)} \right) \\ M2 &= 602,225 \end{aligned}$$

Area for the second Inference:

$$\begin{aligned} A2 &= (0,464) \left(\frac{90 - 48,24}{2} \right) \\ A2 &= 9,69 \end{aligned}$$

The center point can be obtained as follows:

$$\begin{aligned} z^* &= \frac{\int_a^b x \cdot \mu(x) \cdot dx}{\int_a^b \mu(x) \cdot dx} \\ z^* &= \frac{M1 + M2}{A1 + A2} \\ z^* &= \frac{539,887 + 602,225}{22,384 + 9,69} \\ z^* &= 35,608 \approx 36 \end{aligned}$$

In the Enervon C Tab Strip 4S/25 STRP product, the excess remaining inventory can be said to be good because the sales of these products are quite fast and are in demand by customers. The calculation results were carried out on the percentage of Enervon C Tab Strip 4S/25 **49** product fulfillment, which was 79%. The following table shows the results of the number of purchases using the Fuzzy Mamdani method for Enervon C Tab Strip 4S/25 STRP product in Table 3.

4.4 Solving with Fuzzy Sugeno Method

a. Fuzzy Rules

- ◆ IF (Inventory is Low) and (Sales is Decreased) then (Buying is mf1)
- ◆ IF (Inventory is Medium) and (Sales is Decreased) then (Buying is mf1)
- ◆ IF (Inventory is High) and (Sales is Decreased) then (Buying is mf1)
- ◆ IF (Inventory is Low) and (Sales is Normal) then (Purchases is mf2)
- ◆ IF (Inventory is Medium) and (Sales is Normal) then (Purchase is mf2)
- ◆ IF (Inventory is High) and (Sales is Normal) then (Purchases is mf2)
- ◆ IF (Inventory is Low) and (Sales is Increase) then (Buying is mf3)
- ◆ IF (Inventory is Medium) and (Sales is Increase) then (Purchasing is mf3)
- ◆ IF (Inventory is High) and (Sales is Increase) then (Buying is mf3)

Where

$$\begin{aligned} \text{mf1} &= \sum(\text{average number of demand}) = 65 \\ \text{mf2} &= \sum(\text{average number of demand}) + 10 = 75 \\ \text{mf3} &= \sum(\text{average number of demand}) + 20 = 85 \end{aligned}$$

b. Determining the compositions of the rule
Similar to the use of the Mamdani method, the Sugeno method, After performing the Fuzzyfication stage which determines the degree of membership for each Fuzzy set and forms the Fuzzy rules from each of the related Fuzzy variables, the next step that needs to be done is to compose the Fuzzy basic rules. The fuzzy operators that will be used are AND and -predicate

c. Defuzzification

Fuzzy Sugeno method uses a weighted average derived from the calculation of the composition of the rules on the nine formed rules. The equation obtained is as follows

$$z = \frac{\sum_{a=1}^9 x_a \mu(x_a)}{\sum_{a=1}^9 \mu(x_a)}$$

Table 3: Result of Purchase of Fuzzy Mamdani Enervon C Tab Strip 4S/25 STRP method

Year 2020/2021	Supplement Medicine			Stock	Safety Stock	Fulfilled/not	Percentage
	Enervon C Tab Strip 4S/25 STRP						
	Inventory	Sales	Purchase				
September	25	25	0	36	75	not fulfilled	-52%
October	0	0	0	71	75	not fulfilled	-5%
November	50	50	50	92	75	fulfilled	23%
December	150	100	150	83	75	fulfilled	11%
January	50	70	0	122	75	fulfilled	63%
February	130	100	150	113	75	fulfilled	51%
March	60	150	100	107	75	fulfilled	43%
April	10	73	125	118	75	fulfilled	57%
May	78	75	0	171	75	fulfilled	128%
June	3	3	0	203	75	fulfilled	171%
July	75	100	75	244	75	fulfilled	225%
August	25	25	50	254	75	fulfilled	239%
Mean							79%

Table 4: Result of Purchase of Fuzzy Sugeno Enervon C Tab Strip 4S/25 STRP method

Year 2020/2021	Supplement Medicine			Stock	Safety Stock	Fulfilled/Not	Percentage
	Enervon C Tab Strip 4S/25 STRP						
	Inventory	Sales	Purchase				
September	90	65	25	65	75	Not fulfilled	-13%
October	130	65	0	130	75	Fulfilled	73%
November	198	68	50	148	75	Fulfilled	97%
December	228	80	100	128	75	Fulfilled	71%
January	201	73	70	131	75	Fulfilled	75%
February	211	80	100	111	75	Fulfilled	48%
March	196	85	150	46	75	Not fulfilled	-39%
April	120	74	73	47	75	Not fulfilled	-37%
May	121	74	75	46	75	Not fulfilled	-39%
June	111	65	3	108	75	Fulfilled	44%
July	188	80	100	88	75	Fulfilled	17%
August	153	65	25	128	75	Fulfilled	71%
Mean							31%

Before calculating with Fuzzy Sugeno, there was a stock shortage that occurred in Enervon C Tab Strip 4S/25 STRP products in January, February, May, June, July, and August 2021. After calculating with Fuzzy Sugeno, the stock was fulfilled and can meet customer needs at XYZ Pharmacy. In the Enervon C Tab Strip 4S/25 STRP product, the excess remaining inventory can be said to be good because the sale of the product is quite fast and is in demand by customers. When viewed from the number of safety stock that has been carried out in the previous calculation, in September 2020, March, April, and May 2021, the remaining inventory results were not met according to the safety stock with a total of 75 packs. The calculation results were carried out on the percentage of Enervon C Tab Strip 4S/25 STRP product fulfillment, which was 31%.

5 CONCLUSION

Based on the results of the application of Fuzzy Sugeno to determine the number of purchases for Enervon C Tab Strip 4S/25 STRP products, it can be concluded as follows:

1. In Fuzzy Mamdani's calculation, the Enervon C Tab Strip 4S/25 STRP product has a fulfilled presentation result of 79% while the Enervon C Tab Strip 4S/25 STRP product has a fulfilled presentation result of 79%. It can be concluded that the application of Fuzzy Mamdani is better than the Fuzzy Sugeno method for calculating the inventory of Enervon C Tab Strip 4S/25 STRP products.
2. In the calculation of safety stock, for Enervon C Tab Strip 4S/25 STRP, the results are 75 packs per month, while
- (1) In the calculation of the reorder point, the results are 80 packs per month

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