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Implementation of Fuzzy Logic on Recommendation Levels of Packaged Milk Based on Price and Nutritional Value

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Abstract

The abundance of packaged milk products in the market requires consumers to consider several factors to obtain high-quality packaged milk at an affordable price. Milk demand in Indonesia showed a slight increase from 2019 to 2020, rising from 16.23 in 2019 to 16.27 in 2020. However, the average milk demand in Indonesia has remained fluctuating, largely due to the increasing prices of milk products on the market. This study aims to determine the recommendation level for packaged milk by considering both price and nutritional content. The method used in this research involves a mathematical assessment of milk products using fuzzy logic. The data for this study is derived from previous research on packaged milk samples as the observation objects. The results indicate that sample 16 is highly recommended due to its low price and very high nutritional content.

Keywords: fuzzy logic, nutrition, packaged milk, price, recommendation level.

INTRODUCTION

Currently, packaged milk is widely available on the market. Due to high consumer demand, manufacturers compete to produce packaged milk products with various flavors and unique packaging to attract consumers' attention. Packaged milk is processed using the Ultra-High Temperature Processing (UHT) method (Nugroho, 2021). The variety of packaged milk products on the market requires consumers to consider several factors in order to obtain quality packaged milk at an affordable price.

Cow's milk contains the following nutrients: calcium, vitamin A, vitamin B, vitamin D, amino acids, calories, fat, phosphorus, iodine, zinc, iron, magnesium, vitamin E, and thiamine (Putri, 2016). Cow's milk offers numerous health benefits, including preventing heart disease and vascular disorders, preventing goiter, enhancing cognitive function, supporting individuals with anemia, maintaining skin health, promoting relaxation, supporting the growth of teeth and bones, maintaining overall health, accelerating healing, enhancing vision, and acting as a neutralizing agent to prevent osteoporosis (Vanga & Raghavan, 2018).

According to Indonesian National Standards (SNI), fresh milk is defined as liquid derived from healthy cows, obtained through milking, with no additions or reductions to its natural content (Widyananda & Samholi, 2022). Packaged milk usually undergoes pasteurization, a process conducted at a temperature of 71 degrees Celsius for 15 minutes (Wulandari *et al.*, 2016). Previous research has shown that pasteurization does not alter the nutritional content of milk (Apriliyani, 2018).

The food safety of packaged milk is closely related to its nutritional content. As mentioned earlier, packaged milk undergoes pasteurization. This Ultra-High Temperature (UHT) pasteurization process can inactivate pathogenic microorganisms (Puspitasari A and Maligan JM 2019), an important measure to ensure food safety. This process is designed to preserve the nutritional content of milk while also making it safe for consumers, even if stored for several days. High nutritional content and maintained food safety help packaged milk products meet quality and safety standards (Putra IA and Jumiono A 2021).

The rising demand for milk in Indonesia influences consumer preferences regarding packaged milk. Consumer preference is an individual's decision to favor or disfavor a consumed product (Putra FW *et al.*, 2023). During the purchase of milk products, consumers assess the characteristics of the milk available before making a purchasing decision (Milareva HA *et al*., 2023). These characteristics include not only texture, appearance, and taste but also the nutritional content in the packaged milk.

The demand for milk in Indonesia slightly increased from 2019 to 2020, with demand rising from 16.23 in 2019 to 16.27 in 2020. On average, milk demand in Indonesia remains fluctuating, influenced by the increasing prices of milk products. In 2020, the average price of packaged milk was Rp 5,300 per liter (Winahyu, 2023), which rose to Rp 6,000 per liter in 2021. Based on this data, consumers may consider choosing a milk brand that offers higher nutritional content relative to the price paid for the product. Based on these considerations, this study aims to assist consumers in selecting packaged milk by evaluating both price and nutritional content using fuzzy logic. This research also provides valuable insights for consumers regarding the advisability of purchasing packaged milk products that are priced relatively high but offer limited nutritional benefits. By assessing these factors, the study offers a comprehensive recommendation on whether such products are worth the investment

Factors such as price and quality are essential in influencing consumer decisions regarding packaged milk. Consumers who choose milk rich in nutrients, vitamins, and calcium aim to support bone health and growth (RTR AP *et al*., 2015). Packaged milk containing probiotics is also beneficial for smooth digestion. Besides nutritional content, price is a key factor; consumers often have to balance product quality with their budget, impacting both their health and finances (Nurhasna FN *et al.*, 2022). Products with high nutritional content can improve long-term health, but if the price becomes too high, consumers may opt for cheaper products that could potentially compromise health (Yuliana R *et al.*, 2019).

Fuzzy logic is a logic concept that accounts for ambiguity and uncertainty between true and false. Fuzzy logic has a membership range between 0 and 1, with the membership degree indicating the mapping of input data points to their membership values (Prayudha, 2018). The fuzzy logic method has been used by previous researchers to recommend suitable food products based on their nutritional content. According to previous research, research was conducted to predict coffee quality using the Mamdani fuzzy method and compare it with other methods. The results showed that the Mamdani fuzzy method was more accurate in determining coffee quality compared to the manual method (Rahmawati DA, 2015). A similar approach was also applied to recommend menu items based on consumer preferences. The findings indicated that the fuzzy method could provide appropriate recommendations based on the criteria specified or desired by consumers (Wijayanto DDK, 2014). These results demonstrate that the fuzzy method can provide reasonably accurate recommendations or decisions.

Fuzzy logic control systems process sensor data transmitted to a motor. Fuzzy logic is processed using fuzzification, which produces defuzzification values (Nasution, 2022). Based on the above discussion, an analysis was conducted to recommend suitable packaged milk based on product price and nutritional value. This resulted in identifying a suitable brand of packaged milk that aligns with the desired price using the fuzzy logic method. The novelty of this research lies in the application of a more accurate fuzzy logic method, which provides more specific recommendation levels, thus significantly aiding consumers in selecting the packaged milk products they should purchase

METHODS

Data Collection Techniques

The data collection technique used in this research is secondary data. According to Sugiyono (2018), secondary data is a source that does not directly provide data to the data collector. The secondary data in this study was obtained from Nisa *et al*. (2020), which focused on research regarding the application of fuzzy logic in determining recommendations for packaged milk beverages. In that study, data collection was conducted using an independent observation technique, enabling the researchers to observe ongoing phenomena directly and involve themselves in collecting the desired data and information to address the research questions. The data collected was quantitative, with the researchers gathering samples of various brands of packaged milk obtained from minimarkets and supermarkets.

Data Analysis Techniques

This research is applied research that mathematically examines milk products using fuzzy logic. Fuzzy logic is a multi-valued logic system that can assign values with simple criteria, such as yes or no and true or false. Fuzzy logic can draw conclusions from ambiguous, unclear, and imprecise information (Ismail *et al*., 2022). In fuzzy logic theory, the concept of a fuzzy set is used to categorize items based on linguistic variables represented by membership functions (Laksono *et al.*, 2011). The data used in this study is derived from previous research examining samples of packaged milk as the observation objects. A total of 33 samples of packaged milk were analyzed in this research. The nutritional contents analyzed include fat (L), protein (P), carbohydrates (K), sodium (N), potassium (I), and calcium (C), which were then accumulated into a total nutrition score (NT). The steps taken to achieve the research objectives involved collecting data on the nutritional content and price of milk products and analyzing this data using the Mamdani model with the aid of the FIS (Fuzzy Inference System) software application (Nisa *et al*., 2020).

In this research, after acquiring data based on Nisa *et al*. (2020), variable definitions were performed, specifically for the price and nutritional content variables of packaged milk. This was followed by a fuzzification process for each fuzzy variable, with each input and output variable represented by several fuzzy sets. Once the input and output variables were established, the next step was to formulate rules in the form of fuzzy implications that describe the relationship between the input and output variables.

The software used for processing fuzzy logic was Matlab. Testing was conducted by analyzing the system developed in Matlab and through manual calculations. The data processing method employed was the fuzzy Mamdani approach. The final step in this research was to draw conclusions. This stage provided results to determine the recommendation level for packaged milk.

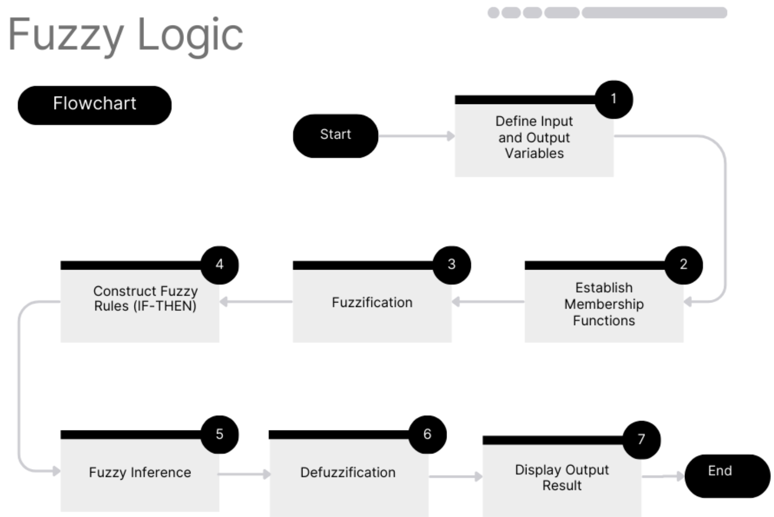

Figure 1. Flowcharts of the Fuzzy Logic Process

RESULTS AND DISCUSSION

Determination of Fuzzy Variables and Universe of Discourse

When purchasing a product, consumers consider not only quality but also price affordability (Ningsih, 2021). Price represents the set of values exchanged by consumers to acquire goods and services that can be possessed or used for their intended purpose (Sumarsid & Paryanti, 2022). This also applies to the selection of packaged milk, which has become a popular beverage among various groups and is easily accessible in numerous locations. The wide variety of milk brands on the market makes the selection process more diverse and complex, requiring consumers to carefully balance product quality and price. The quality of packaged milk can be assessed based on its nutritional content, which includes various nutrients such as protein, carbohydrates, fats, minerals, and vitamins (Susilawati *et al*., 2021).

In this research, the variables used are the price and nutrition of milk as inputs and the level of recommendation for packaged milk as the output. The data on price and nutrition of packaged milk were sourced from a previous study conducted by Nisa et al. (2020), which included 33 samples of packaged milk. The nutritional contents analyzed include fat (L), protein (P), carbohydrates (K), sodium (N), potassium (I), and calcium (C), which were then accumulated into a total nutrition score (NT).

Table 1. Price and Nutritional Content Data of Samples

Sample	Price (Rp)	L (g)	P (g)	K (g)	N (g)	I (g)	C (g)	NT (g)
1	9600	2,5	3	16	0,105	0,256	0,222	22,083
2	9600	2,5	3	28	0,105	0,256	0,389	34,250
3	9600	2	3	18	0,105	0,256	0,222	23,583
4	4600	6	6	9	0,04	0,4	0,222	21,662
5	5300	3,5	6	22	0,05	0,36	0,222	32,132
6	5500	7	7	12	0,1	0,37	0,222	26,692
7	5500	6	6	20	0,075	0,28	0,222	32,577
8	5500	4,5	5	23	0,12	0,27	0,166	33,057
9	5500	5	5	24	0,125	0,3	0,222	34,647
10	5500	5	6	25	0,095	0,26	0,222	36,577
11	5500	3	5	22	0,11	0,32	0,222	30,652
12	4900	3,5	7	21	0,035	0,343	0,256	32,134
13	4900	4	5	18	0,06	0,15	0,2003	27,410
14	4900	4	6	24	0,045	0,26	0,166	34,472
15	4200	4	4	23	0,085	0,4	0,222	31,707
16	4200	4,5	5	26	0,04	0,22	0,222	45,982
17	6900	3	6	21	0,05	0,33	0,333	30,714
18	6900	2,5	5	19	0,115	0,26	0,333	27,209
19	5500	3	3	19	0,1	0,1	0,055	25,255
20	5500	4	3	24	0,06	0,1	0,055	31,215
21	4200	3	4	16	0,075	0,23	0,222	23,527
22	4200	3	4	15	0,075	0,24	0,278	22,593
23	5400	2	7	20	0,125	0,36	0,278	29,763
24	6700	2,5	5	24	0,105	0,31	0,723	32,638
25	12900	3	7	24	0,07	0,1	0,389	34,559
26	4400	3,5	3	23	0,065	0,25	0,278	30,093
27	4400	3	3	21	0,063	0,24	0,1669	27,470
28	8000	1,5	2	37	0,115	0,1	0,278	40,993
29	8000	1,5	2	37	0,065	0,1	0,166	40,832
30	8000	1,5	2	37	0,16	0,1	0,166	40,927
31	8000	1,5	1	37	0,18	0,1	0,166	39,947
32	3000	2,5	2	16	0,05	0,1	0,166	20,817

33	3000	2	2	15	0,055	0,1	0,166	19,322

(Source: Nisa *et al.*, 2021)

According to Table 1, the universe of discourse or allowable range varies according to each variable's criteria. The universe of discourse represents the entire range used to define the boundaries within which all values of the input and output variables lie, allowing the inference process to be conducted within these limits (Dewi *et al*., 2023). For the price variable, the universe of discourse ranges from Rp0 to Rp15,000. For the total nutritional content variable, the range is from 0 g to 50 g. These defined limits ensure that all inputs and outputs are considered within a consistent framework for analysis and recommendation.

Fuzzification

Fuzzification is the process of converting crisp values into fuzzy values based on membership functions (Fitra, 2014). One of the criteria in creating membership functions is overlapping, where each set member within each variable overlaps with others. The curve used for constructing all membership functions is a triangular curve.

Table 2. Fuzzy set domain

Function	Variable	Membership	Domain
Input	Price	Very Cheap	[0 5000]
		Cheap	[3000 9000]
		Expensive	[7000 13000]
		Very Expensive	[11000 15000]
	Nutrition	Very Low	[0 10]
		Low	[5 20]
		Medium	[15 35]
		High	[30 45]
		Very High	[40 50]
Output	Recommendation level	Not Recommended	[0 0,3]
		Less Recommended	[0,2 0,6]
		Recommended	[0,4 0,8]
		Highly Recommended	[0,7 1]

The price variable is defined with four membership levels: very cheap, cheap, expensive, and very expensive. Nutritional content is defined with five membership levels: very low, low, medium, high, and very high. Meanwhile, the level of recommendation for packaged milk is defined with four membership levels: not recommended, less recommended, recommended, and highly recommended.

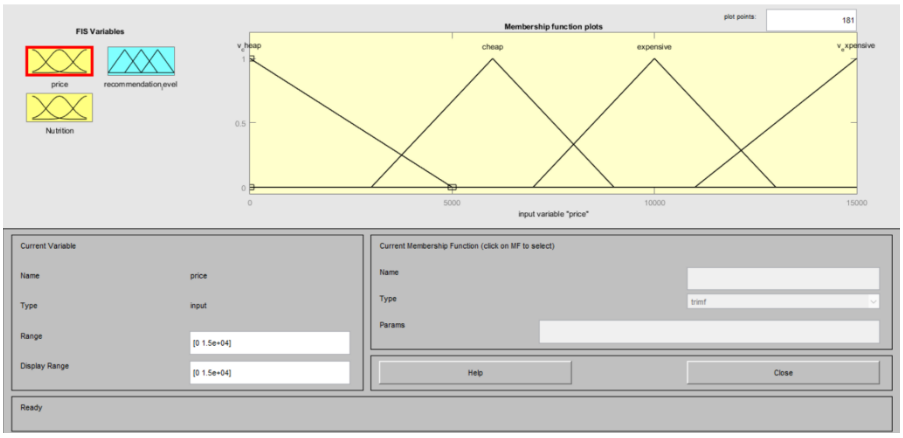

Figure 2. Membership Function Editor: Price

The graph in Figure 2 represents the membership function for the price variable, which is divided into four levels: very cheap, cheap, expensive, and very expensive. The membership function is defined over the range [0;15000] for the price$\mu[x]$, as follows:

$$\mu_{very\_cheap}[x] = \begin{cases} 1\,; x \leq 0 \\ \dfrac{5000 - x}{5000 - 0}\,; 0 \leq x \leq 5000 \\ 0\,; x \geq 5000 \end{cases}$$

$$\mu_{cheap}[x] = \begin{cases} 0\,; x \leq 3000 \\ \dfrac{x - 3000}{6000 - 3000}\,; 3000 \leq x \leq 6000 \\ \dfrac{9000 - x}{9000 - 6000}\,; 6000 \leq x \leq 9000 \\ 0; x \geq 9000 \end{cases}$$

$$\mu_{expensive}[x] = \begin{cases} 0\,; x \leq 7000 \\ \dfrac{x - 7000}{10000 - 7000}\,; 7000 \leq x \leq 10000 \\ \dfrac{13000 - x}{13000 - 10000}\,; 10000 \leq x \leq 13000 \\ 0; x \geq 13000 \end{cases}$$

$$\mu_{very\_expensive}[x] = \begin{cases} 0\,; x \leq 11000 \\ \dfrac{x - 11000}{15000 - 11000}\,; 11000 \leq x \leq 15000 \\ 1\,; x \geq 15000 \end{cases}$$

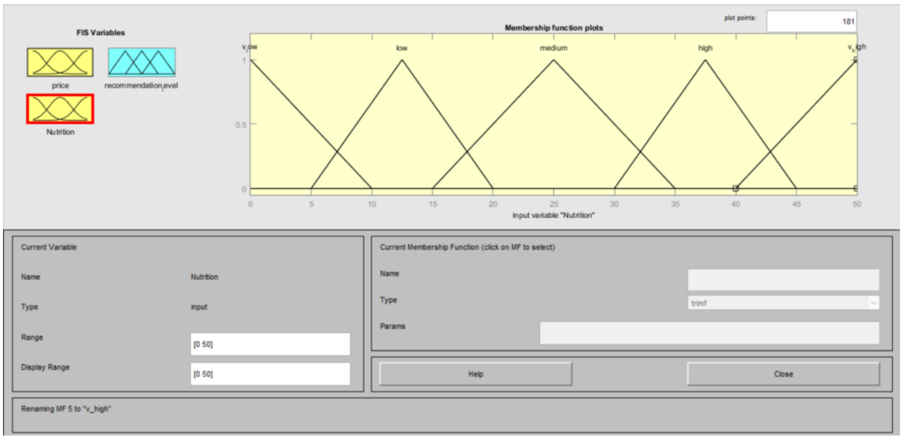

Figure 3. Membership Function Editor: Nutrition

The graph in Figure 3 represents the membership function for the nutrition variable, which is divided into five levels: very low, low, medium, high, and very high. The membership function is defined over the range [0; 50] for nutrition $\mu[x]$, as follows:

$$\mu_{very\_low}[x] = \begin{cases} 1\,; x \leq 0 \\ \dfrac{10 - x}{10 - 0}\,; 0 \leq x \leq 10 \\ 0\,; x \geq 10 \end{cases}$$

$$\mu_{low}[x] = \begin{cases} 0\,; x \leq 5 \\ \dfrac{x - 5}{12{,}5 - 5}\,; 5 \leq x \leq 12{,}5 \\ \dfrac{20 - x}{20 - 12{,}5}\,; 12{,}5 \leq x \leq 20 \\ 0; x \geq 20 \end{cases}$$

$$\mu_{medium}[x] = \begin{cases} 0\,;\, x \le 15 \\ \dfrac{x-15}{25-15}\,;\, 15 \le x \le 25 \\ \dfrac{35-x}{35-25}\,;\, 25 \le x \le 35 \\ 0;\, x \ge 35 \end{cases}$$

$$\mu_{high}[x] = \begin{cases} 0\,;\, x \le 30 \\ \dfrac{x-30}{37{,}5-30}\,;\, 30 \le x \le 37{,}5 \\ \dfrac{45-x}{45-37{,}5}\,;\, 37{,}5 \le x45 \\ 0;\, x \ge 45 \end{cases}$$

$$\mu_{very\_high}[x] = \begin{cases} 0\,;\, x \le 40 \\ \dfrac{x-40}{50-40}\,;\, 40 \le x \le 50 \\ 1\,;\, x \ge 50 \end{cases}$$

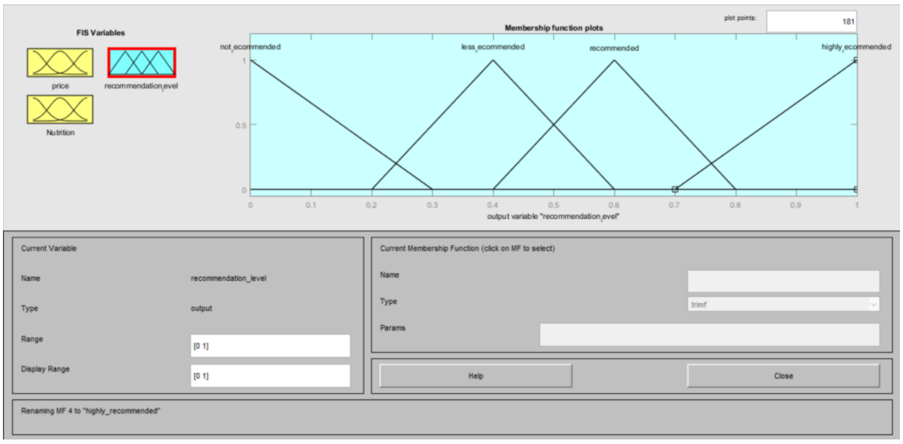

Figure 4. Membership Function Editor: Recommendation Level

The graph in Figure 4 represents the membership function for the recommendation level, which is divided into four levels: not recommended, less recommended, recommended, and highly recommended. The membership function is defined over the range [0; 1] for the recommendation level $\mu[x]$, as follows:

$$\mu_{not\_recommended}[x] = \begin{cases} 1\,;\, x \le 0 \\ \dfrac{0{,}3-x}{0{,}3-0}\,;\, 0 \le x \le 0{,}3 \\ 0\,;\, x \ge 0{,}3 \end{cases}$$

$$\mu_{less\_recommended}[x] = \begin{cases} 0\,;\, x \le 0{,}2 \\ \dfrac{x-0{,}2}{0{,}4-0{,}2}\,;\, 0{,}2 \le x \le 0{,}4 \\ \dfrac{0{,}6-x}{0{,}6-0{,}4}\,;\, 0{,}4 \le x \le 0{,}6 \\ 0;\, x \ge 0{,}6 \end{cases}$$

$$\mu_{recommended}[x] = \begin{cases} 0\,;\, x \le 0{,}4 \\ \dfrac{x-0{,}4}{0{,}6-0{,}4}\,;\, 0{,}4 \le x \le 0{,}6 \\ \dfrac{0{,}8-x}{0{,}8-0{,}6}\,;\, 0{,}6 \le x \le 0{,}8 \\ 0;\, x \ge 0{,}8 \end{cases}$$

$$\mu_{highly\_recommended}[x] = \begin{cases} 0\,;\, x \le 0{,}7 \\ \dfrac{x-0{,}7}{1-0{,}7}\,;\, 0{,}7 \le x \le 1 \\ 1\,;\, x \ge 1 \end{cases}$$

In sample 16, based on the data in Table 1 with a price of Rp4200 and nutrition 45.982 g, the membership level for the milk recommendation will be calculated as follows:

$$\mu_{very\_cheap}[4200] = \frac{5000 - 4200}{5000 - 0} = 0{,}16$$

$$\mu_{cheap}[4200] = \frac{4200 - 3000}{6000 - 3000} = 0{,}4$$

$$\mu_{expensive}[4200] = 0$$

$$\mu_{very\_expensive}[4200] = 0$$

$$\mu_{very\_low}[45{,}982] = 0$$

$$\mu_{low}[45{,}982] = 0$$

$$\mu_{medium}[45{,}982] = 0$$

$$\mu_{high}[45{,}982] = 0$$

$$\mu_{very\_high}[45{,}982] = \frac{45{,}982 - 40}{50 - 40} = 0{,}5982$$

This calculation is performed in the same manner and adjusted for the other 32 packaged milk samples.

Fuzzy Rules Determination

Fuzzy rules determination is the process of conditioning fuzzy inputs and actions (outputs) based on fuzzy inputs. Syntactically, fuzzy rules are written as IF antecedent THEN consequent. Two fuzzy rule models are commonly used in various applications: the Mamdani model and the Sugeno model (Cholilulloh *et al.*, 2018). In this research, 20 rules were established. This is based on the possible combinations from 5 membership levels of the nutrition variable and 4 membership levels of the price variable. The rules in this study use an IF-THEN structure: IF (Price is A) AND (Nutrition is B) THEN (Recommendation Level is C).

Table 3. Fuzzy Rules

Rules	IF	Price	AND	Nutrition	THEN	Recommendation Level
1	IF	Very Cheap	AND	Very Low	THEN	Not Recommended
2	IF	Very Cheap	AND	Low	THEN	Less Recommended
3	IF	Very Cheap	AND	Medium	THEN	Recommended
4	IF	Very Cheap	AND	High	THEN	Highly Recommended
5	IF	Very Cheap	AND	Very High	THEN	Highly Recommended
6	IF	Cheap	AND	Very Low	THEN	Not Recommended
7	IF	Cheap	AND	Low	THEN	Less Recommended
8	IF	Cheap	AND	Medium	THEN	Recommended
9	IF	Cheap	AND	High	THEN	Highly Recommended
10	IF	Cheap	AND	Very High	THEN	Highly Recommended
11	IF	Expensive	AND	Very Low	THEN	Not Recommended
12	IF	Expensive	AND	Low	THEN	Less Recommended
13	IF	Expensive	AND	Medium	THEN	Less Recommended
14	IF	Expensive	AND	High	THEN	Recommended
15	IF	Expensive	AND	Very High	THEN	Recommended
16	IF	Very Expensive	AND	Very Low	THEN	Not Recommended
17	IF	Very Expensive	AND	Low	THEN	Not Recommended
18	IF	Very Expensive	AND	Medium	THEN	Less Recommended
19	IF	Very Expensive	AND	High	THEN	Less Recommended
20	IF	Very Expensive	AND	Very High	THEN	Recommended

The recommendation levels established include four categories: not recommended (5 rules), less recommended (6 rules), recommended (5 rules), and highly recommended (4 rules). Based on the defined rules, the applicable rules for sample 16 are R5 and R10, with the following values:

$\alpha5$ = min [$\mu_{very\_cheap}(4200)$; $\mu_{very\_high}(45{,}982)$] = min [0,16 ; 0,5982] = 0,16
$\alpha10$ = min [$\mu_{cheap}(4200)$; $\mu_{very\_high}(45{,}982)$] = min [0,4 ; 0,5982] = 0,4

$\alpha5 \rightarrow 0{,}16 = \frac{x-0{,}7}{1-0{,}7} \rightarrow 0{,}748$
$\alpha10 \rightarrow 0{,}4 = \frac{x-0{,}7}{1-0{,}7} \rightarrow 0{,}82$
Thus, based on the recommendation level rules, the implication region for sample 16 is as follows.

$$\mu_{recommended\_level}[z] = \begin{cases} 0 ;\ x \leq 0{,}7 \\ \frac{x-0{,}7}{1-0{,}7} ;\ 0{,}7 \leq x \leq 0{,}748 \\ 0{,}16 ;\ 0{,}748 \leq x \leq 0{,}82 \\ 0{,}4 ;\ 0{,}82 \leq x \leq 1 \\ 1;\ x \geq 1 \end{cases}$$

This calculation is performed in the same manner and adjusted for the other 32 packaged milk samples.

Defuzzification

Defuzzification is the final process in a fuzzy system. This process involves modifying the input data that has been entered into the fuzzy set to retrieve its crisp form (Virdaus & Ihsanto 2021). Defuzzification is carried out by calculating the moment and the area of the implication result, where the composition function has been simplified beforehand, resulting in the composition function for sample 16 as follows:

$$\mu_{recommended\_level}[z] = \begin{cases} 0 ;\ x \leq 0{,}7 \\ 3{,}33x - 2{,}33 ;\ 0{,}7 \leq x \leq 0{,}748 \\ 0{,}16 ;\ 0{,}748 \leq x \leq 0{,}82 \\ 0{,}4 ;\ 0{,}82 \leq x \leq 1 \\ 1;\ x \geq 1 \end{cases}$$

Moment calculation for sample 16
M1 = $\int_{0{,}7}^{0{,}748} (3{,}33z - 2{,}33)z\,dz = 0{,}00284282$
M2 = $\int_{0{,}748}^{0{,}82} (0{,}16)z\,dz = 0{,}00903168$
M3 = $\int_{0{,}82}^{1} (0{,}4)z\,dz = 0{,}06552$

Calculation of implication area for sample 16
A1 = $\frac{0{,}4\times((1-0{,}7)+(1-0{,}82))}{2} = 0{,}096$
A2 = $\frac{0{,}1\times 0{,}16}{2} = 0{,}008$

Thus, the center of gravity for sample 16 is calculated as:
z* = $\frac{0{,}00284282+0{,}00903168+0{,}06552}{0{,}096-0{,}008} = 0{,}879 \approx 0{,}88$

Defuzzification is performed using MATLAB software. Based on the membership function and the fuzzy rules established, the output recommendation level for packaged milk can be determined by entering the price and nutrition data for each sample. For sample 16, the input values of price and nutrition [4200;45,98] yield a recommendation membership degree of 0.88, as shown in Figure 5.

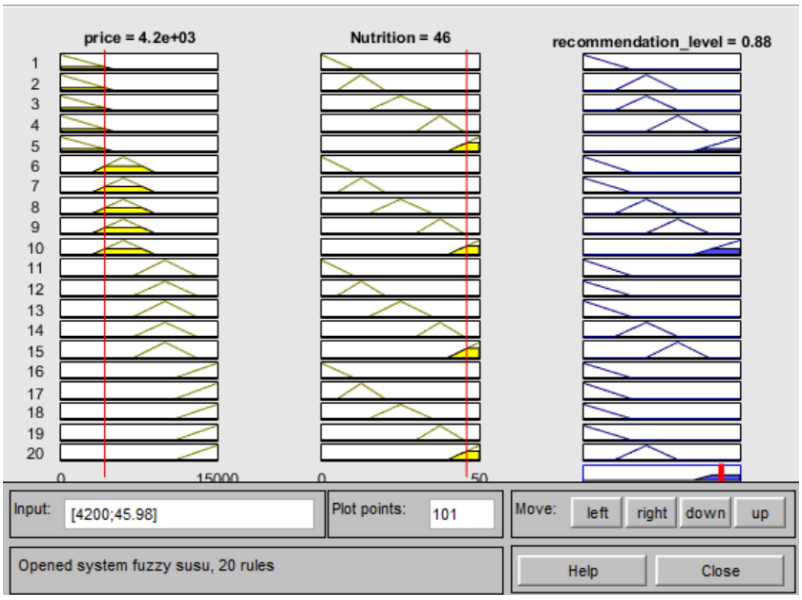

Figure 5. Recommendation Level Membership Degree of Sample 16

The same method is applied to obtain the membership degree for the other 32 samples. The membership degree results for all packaged milk samples are displayed in Table 4, which is organized according to their recommendation ranking.

Table 4. Membership Degree Ranking of Each Packaged Milk Sample

Sample	Price (Rp)	Nutrition (g)	Membership Degree	Category
16	4200	45,982	0,88	Highly Recommended
10	5500	36,577	0,6	Recommended
9	5500	34,647	0,588	Recommended
14	4900	34,472	0,583	Recommended
28	8000	40,993	0,543	Recommended
30	8000	40,927	0,54	Less Recommended
29	8000	40,832	0,536	Less Recommended
8	5500	33,057	0,535	Less Recommended
24	6700	32,638	0,52	Less Recommended
7	5500	32,577	0,518	Less Recommended
5	5300	32,132	0,5	Less Recommended
12	4900	32,134	0,5	Less Recommended
31	8000	39,947	0,5	Less Recommended
15	4200	31,707	0,481	Less Recommended
20	5500	31,215	0,459	Less Recommended
17	6900	30,714	0,436	Less Recommended
11	5500	30,652	0,433	Less Recommended
26	4400	30,093	0,405	Less Recommended
4	4600	21,662	0,4	Less Recommended
6	5500	26,692	0,4	Less Recommended
13	4900	27,41	0,4	Less Recommended
18	6900	27,209	0,4	Less Recommended
19	5500	25,255	0,4	Less Recommended
21	4200	23,527	0,4	Less Recommended
22	4200	22,593	0,4	Less Recommended
23	5400	29,763	0,4	Less Recommended
27	4400	27,47	0,4	Less Recommended

32	3000	20,817	0,4	Less Recommended
33	3000	19,322	0,4	Less Recommended
2	9600	34,25	0,373	Less Recommended
25	12900	34,559	0,143	Not Recommended
1	9600	22,083	0,104	Not Recommended
3	9600	23,583	0,0988	Not Recommended

Based on the output presented in Table 4, it can be observed that sample 16 has the highest membership degree of 0.88. This result indicates that sample 16 is the most recommended for consumers due to its high nutritional content and affordable price. Meanwhile, the packaged milk sample that is not recommended for consumers is sample 3, which has a membership degree of 0.0988.

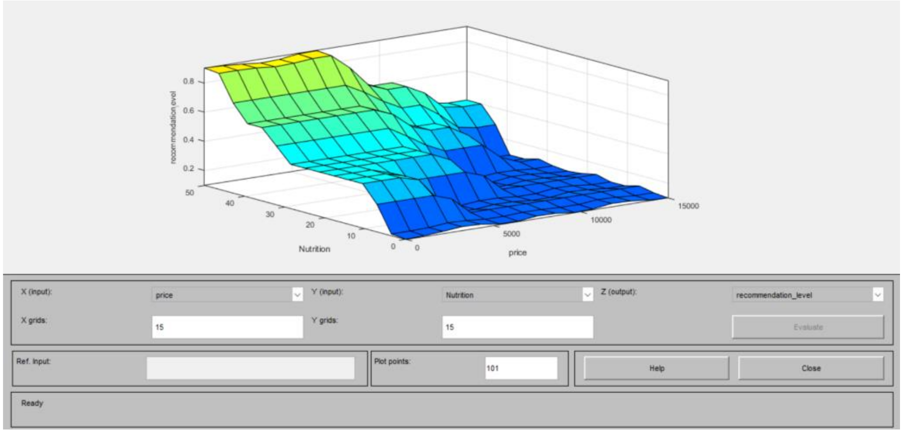

Figure 6. Surface View

Figure 6 illustrates the relationship between the price variable, the nutrition variable, and the recommendation level. The X-axis represents the price variable, ranging from 0 to 15,000, the Y-axis represents nutrition, ranging from 0 to 50, and the Z-axis represents the recommendation level, ranging from 0 to 1. The graph displays a color gradient transitioning from blue (in the low region) to green and yellow (in the high region). The colors in the graph indicate the recommendation level based on the price and nutrition variables. Areas marked in dark blue represent the lowest recommendation levels, while yellow areas indicate the highest recommendation levels.

CONCLUSION

This research employed fuzzy logic to recommend the suitability level of packaged milk based on price and nutritional content. Among the 33 milk samples analyzed, sample 16 emerged as the most recommended product due to its high nutritional content and relatively affordable price. These findings indicate that fuzzy logic can be an effective tool for evaluating food products based on multiple factors, such as nutritional quality and price, which are relevant to consumers. It is hoped that this research will provide insight for consumers in selecting milk products that align with their nutritional needs and budget, as well as for producers to enhance product competitiveness through quality and pricing.

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