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## Determining Tilapia Quality Using the Fuzzy Logic

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### ABSTRACT

Fish are living things with the highest trophic level in a body of water. Fish are living creatures that live in aquatic environments in fresh, brackish and marine waters. Tilapia is one of the leading commodities of aquaculture and is a widely used freshwater fish, and its production is quite high. Fuzzy logic is a logic that deals with the concept of partial truth, where classical logic states that everything can be expressed in binary terms (0 or 1). Various theories in the development of fuzzy logic show that fuzzy logic can be used to model various systems. A very adaptable and data-tolerant approach is mamdani fuzzy. Therefore, in this research, a mamdani fuzzy model will be developed to evaluate the quality of tilapia. This research uses fuzzy logic to evaluate the quality of tilapia based on its texture, taste, and size. In this study, researchers modeled 4 fuzzy variables, with 3 inputs (texture, taste, and size), 1 output (price), and a total of 4 fuzzy variables. The MIN IMPLICATION function was used in the inference procedure in the fuzzy operator application. Next, the MAX approach is used in the compilation of all fuzzy outputs. Then comes the affirmation, also known as defuzzification which is done using the Centroid method. The results show with 10 trial data it is seen that the higher the input value of size, the higher the output value of price.

**Keywords:** Tilapia ; Fuzzy Logic ; Mamdani

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### 1. INTRODUCTION

Fish are living things with the highest trophic level in a body of water. Fish are living creatures that live in aquatic environments in fresh, brackish and marine waters (Fauzia & Suseno, 2020). Based on interviews from sources, the water elements in tilapia use turbid water that tends to be clear, has no odor, and the water temperature adjusts to the cultivation area. In determining good and healthy water, papaya leaves can be used, but the papaya leaves are eaten by the fish, indicating that the water is good and healthy. However, when it rains the water temperature can be controlled using coarse salt put into the water. For water management, it can be done daily by splashing and not often changing the water so that tilapia are not stressed (Martawijaya, 2019).

Freshwater fish of the tilapia species have been widely cultivated in Indonesia. People like tilapia because the meat is delicious and fast to produce (Arfiati et al., 2022). Because the protein content in it functions as a medium for microorganisms to grow, tilapia has the disadvantage of being one of the fishery products that is easily rotten and damaged (Roobab et al., 2022). According to (Puspita & Rahmawan, 2021) quality is a matter related to products, people or labor, efforts and tasks, and the environment that approves or leaves customer confidence.

Fuzzy logic is a technique for mapping input variables that contain uncertainty or firmness, usually fuzzy is used to solve problems whose output results are linguistic (Raharjo et al., 2021). Fuzzy Mamdani is a method that is very flexible and tolerant of data. So the author made a Fuzzy mamdani model to analyze the quality of tilapia, because the Fuzzy Mamdani method can handle uncertain or imprecise data by using fuzzy sets that represent the level of certainty of the data. The ability to handle complex problems by combining several factors that affect the texture, flavor, and size of the fish. This method will be applied by the author in terms of determining the quality of tilapia based on texture, taste, and size (Chen & Feng, 2020).

Research on fish quality using fuzzy methods is one way to evaluate fish quality more accurately. This method uses fuzzy logic to measure the level of maturity, fat saturation, and other qualities of fish using criteria that are uncertain or cannot be measured with certainty.

In this study, researchers can determine the quality of fish by using several factors such as texture, flavor, size and

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price. These factors are then converted into fuzzy variables that can be measured with different scales (Radhitya & Sudipa, 2020).

Fuzzy methods are used because they provide better results than traditional classification methods. This is because this method allows researchers to determine the quality of fish more accurately. In addition, this method can also measure the level of fat saturation in fish better than other methods. Based on the explanation above, the study aim is to analyze how to determine the quality of tilapia in the pond using artificial intelligence with fuzzy logic rules.

## 2. LITERATURE REVIEW

Some previous studies, namely by (Adeyi et al., 2021) have shown that fuzzy methods can be used to evaluate fish quality with more accurate results than traditional classification methods (Tutuhaturunewa, 2021). However, further research is still needed to evaluate the effectiveness of fuzzy methods in measuring overall fish quality (Parenreng et al., 2022). Other research on the application of fuzzy to water quality in fish habitats is by (Amalia et al., 2021; Kristiantya et al., 2021). Overall, research on fish quality using fuzzy methods is one way to evaluate fish quality more accurately (Dowlati et al., 2012). This method can be used by the fishing and fish processing industry to determine the quality of the products produced and make the right decisions (Pazouki, 2021; Wiratama et al., 2022). However, further research is still needed to evaluate the effectiveness of fuzzy methods in measuring the overall quality of fish.

## 3. METHOD

### 3.1. Data Collection Method

This research develops a model to assess the quality of tilapia using fuzzy logic techniques. The data for this study came from interviews with the owner of the tilapia pond at the Kontener Warkop business. The interview was conducted to find out what affects the quality of tilapia, then conduct a literature study related to determining the quality of fish so that the parameters obtained in determining the quality of fish are texture, taste, size and price.

## 4. RESULT

Data was obtained from interviews and literature studies related to determining fish quality parameters. Based on data collection, the parameters obtained in determining the quality of fish are the attributes of texture, taste, size and price. Several stages to determine the quality of tilapia, namely:

- a. Formation of fuzzy sets.
- b. Application of rules (rule) for determining the quality of tilapia.
- c. Rule composition and assertion (Defuzzy)

At this stage, the input and output variables which consist of one or more fuzzy sets are determined. Price serves as the output variable in this analysis. During this research, literature studies and interviews with tilapia pond owners were used to determine the input factors for this study. Based on the results of interviews with the owners of tilapia ponds, the researchers decided to use three input variables, namely texture, taste and size.

### 4.1. Formation of Fuzzy Sets

Data processing techniques involve identifying variables and conversational universes, then creating fuzzy sets that are represented in the attached table.

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Table 1  
Determination of Variables and the Universe of Set.

| Function | Variable | Universe Set | Description    |
|----------|----------|--------------|----------------|
| Input    | Texture  | 0-100        | TilapiaTexture |
|          | Flavor   | 0-100        | TilapiaFlavor  |
|          | Size     | 0-1          | TilapiaSize    |
| Output   | Price    | 0-50         | TilapiaPrice   |

Table 2  
Fuzzy Set

| Fungsi        | Variable | Himpunan Fuzzy Set    | Universe Set           |
|---------------|----------|-----------------------|------------------------|
| Input         | Texture  | <b>Mushy [0-100]</b>  | [-40 -5 10 25]         |
|               |          | <b>Solid</b>          | [25 50 75]             |
|               |          | <b>Chewy</b>          | [75 85 100 100]        |
|               | Flavor   | <b>Savory [0-100]</b> | [0 25 50]              |
|               |          | <b>Sweet</b>          | [50 75 100]            |
|               | Size     | <b>Small [0-1]</b>    | [-0.45 -0.05 0.05 0.4] |
| <b>Medium</b> |          | [0.2 0.45 0.8]        |                        |
| <b>Large</b>  |          | [0.6 0.9 1 1]         |                        |
| Output        | Price    | <b>Cheap [0-50]</b>   | [0 12.5 25]            |
|               |          | <b>Standar</b>        | [15 25 35]             |
|               |          | <b>Expensive</b>      | [25 37.5 50]           |

**4.2. Texture Variable**

The following is a texture variable using a trapezoidal curve (for the fuzzy sets Mushy, Solid and Chewy) as shown in Figure 1.



Fig. 1 Input Variabel Tekstur

Membership function:

Based on the smallest to the largest texture, the membership function is formulated as follows:

$$\mu_{Mushy}(x) = \begin{cases} 0 & ; x \geq 25 \\ \frac{25-x}{25-10} & ; 10 \leq x \leq 25 \\ 1 & ; x \leq 10 \end{cases}$$

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$$\mu_{Solid}(x) = \begin{cases} 0 & ; x \leq 25 \text{ or } x \geq 75 \\ \frac{x-25}{50-25} & ; 25 \leq x \leq 50 \\ \frac{75-x}{75-50} & ; 50 \leq x \leq 75 \\ 0 & \end{cases}$$

$$\mu_{Chewy}(x) = \begin{cases} 0 & ; x \leq 75 \\ \frac{x-75}{25-75} & ; 75 \leq x \leq 85 \\ 1 & ; x \geq 85 \end{cases}$$

**4.2 Taste Variable**

To represent the taste variables in a triangular shape (for the savory and sweet fuzzy sets) as shown in Figure 2.



Fig. 2 Taste Variable Input

Membership function:

Based on the smallest to the largest sense, the membership function is formulated as follows:

$$\mu_{Savory}(x) = \begin{cases} 0 & ; x \leq 10 \text{ or } x \geq 50 \\ \frac{x-10}{25-10} & ; 10 \leq x \leq 25 \\ 1 & ; x = 25 \\ \frac{25-x}{50-25} & ; 25 \leq x \leq 50 \\ 0 & \end{cases}$$

$$\mu_{Sweet}(x) = \begin{cases} 0 & ; x \leq 50 \text{ or } x \geq 100 \\ \frac{x-50}{75-50} & ; 50 \leq x \leq 75 \\ 1 & ; x = 75 \\ \frac{75-x}{100-75} & ; 75 \leq x \leq 100 \\ 0 & \end{cases}$$

**4.3. Size Variable**

To represent the size variable in the form of a trapezoid (for the set *fuzzy* Small, Medium and Large) as shown in Figure 3.

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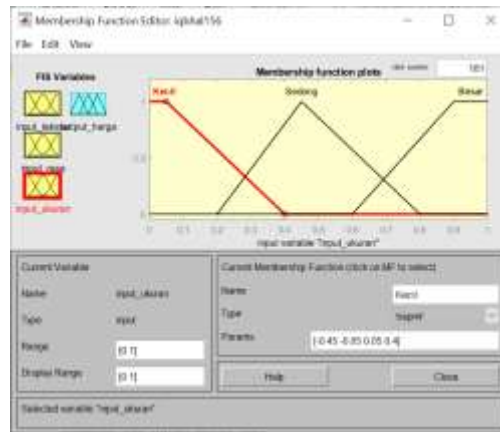


Fig. 3 Input Variable Size

Membership function:

Based on the smallest to the largest size, the membership function is formulated as follows:

$$\mu_{Small}(x) = \begin{cases} 0 & ; x \geq 0.4 \\ \frac{0.4 - x}{0.4 - 0.05} & ; 0.05 \leq x \leq 0.4 \\ 1 & ; x \leq 0.05 \end{cases}$$

$$\mu_{Medium}(x) = \begin{cases} 0 & ; x \leq 0.2 \text{ or } x \geq 0.8 \\ \frac{x - 0.2}{0.45 - 0.2} & ; 0.2 \leq x \leq 0.45 \\ \frac{0.8 - x}{0.8 - 0.45} & ; 0.45 \leq x \leq 0.8 \end{cases}$$

$$\mu_{Big}(x) = \begin{cases} 0 & ; x \geq 1 \\ \frac{0.9 - x}{0.9 - 1} & ; 0.9 \leq x \leq 1 \\ 1 & ; x \leq 1 \end{cases}$$

#### 4.4. Price Variable

To represent the price variable using a triangular shape curve (for the Cheap, Standart and Expensive fuzzy set) as shown in Figure 4.

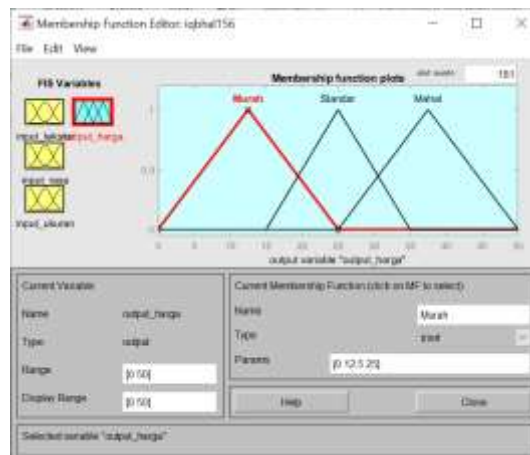


Fig. 4 Price variable output using MATLAB

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Membership function:

Based on the smallest to the largest price, the membership function is formulated as follows:

$$\mu_{\text{Cheap}}(x) = \begin{cases} 0 & ; x \leq 5 \text{ or } x \geq 25 \\ \frac{x - 5}{12.5 - 5} & ; 5 \leq x \leq 12.5 \\ \frac{25 - x}{25 - 12.5} & ; 12.5 \leq x \leq 25 \end{cases}$$

$$\mu_{\text{Standar}}(x) = \begin{cases} 0 & ; x \leq 15 \text{ or } x \geq 35 \\ \frac{x - 15}{25 - 15} & ; 15 \leq x \leq 25 \\ \frac{35 - x}{35 - 25} & ; 25 \leq x \leq 35 \end{cases}$$

$$\mu_{\text{Expensive}}(x) = \begin{cases} 0 & ; x \leq 25 \text{ or } x \geq 50 \\ \frac{x - 25}{37.5 - 25} & ; 25 \leq x \leq 37.5 \\ \frac{50 - x}{50 - 37.5} & ; 37.5 \leq x \leq 50 \end{cases}$$

## DISCUSSIONS

### Application Of The Rules (Rule) To Determine Tilapia Quality

The rules for this study were developed using literature studies and interviews with pond owners. Rules follow the IF-THEN format. Guidelines for this research are as follows:

Table 3.  
Fuzzy Rules

| No  | Fuzzy Rules  |
|-----|--|
| 1.  | IF (input_texture is Chewy) AND (input_taste is Savory) AND (input_size is Big) THEN (output_price is Expensive)   |
| 2.  | IF (input_texture is Chewy) AND (input_taste is Savory) AND (input_size is Medium) THEN (output_price is Standard) |
| 3.  | IF (input_texture is Chewy) AND (input_taste is Savory) AND (input_size is Small) THEN (output_price is Cheap)     |
| 4.  | IF (input_texture is Chewy) AND (input_taste is Sweet) AND (input_size is Large) THEN (output_price is Expensive)  |
| 5.  | IF (input_texture is Chewy) AND (input_taste is Sweet) AND (input_size is Medium) THEN (output_price is Standard)  |
| 6.  | IF (input_texture is Chewy) AND (input_taste is Sweet) AND (input_size is Small) THEN (output_price is Cheap)      |
| 7.  | IF (input_texture is Dense) AND (input_taste is Savory) AND (input_size is Large) THEN (output_price is Expensive) |
| 8.  | IF (input_texture is Dense) AND (input_taste is Savory) AND (input_size is Medium) THEN (output_price is Standard) |
| 9.  | IF (input_texture is Dense) AND (input_taste is Savory) AND (input_size is Small) THEN (output_price is Cheap)     |
| 10. | IF (input_texture is Dense) AND (input_taste is Sweet) AND (input_size is Big) THEN (output_price is Expensive)    |
| 11. | IF (input_texture is Solid) AND (input_taste is Sweet) AND (input_size is Medium) THEN (output_price is Standard)  |
| 12. | IF (input_texture is Dense) AND (input_taste is Sweet) AND (input_size is Small) THEN (output_price is Cheap)      |
| 13. | IF (input_texture is soft) AND (input_taste is Savory) AND (input_size is large) THEN (output_price is expensive)  |
| 14. | IF (input_texture is Soft) AND (input_taste is Savory) AND (input_size is Medium) THEN (output_price is Standard)  |
| 15. | IF (input_texture is soft) AND (input_taste is savory) AND (input_size is small) THEN (output_price is cheap)      |
| 16. | IF (input_texture is Soft) AND (input_taste is Sweet) AND (input_size is Large) THEN (output_price is              |

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- Expensive)
17. IF (input\_texture is Soft) AND (input\_taste is Sweet) AND (input\_size is Medium) THEN (output\_price is Standard)
  18. IF (input\_texture is soft) AND (input\_taste is sweet) AND (input\_size is small) THEN (output\_price is cheap)

**Composition Of Rules And Assertions (Defuzzy).**

The minmin implication is used in the inference process in the fuzzy operator application. Next, the MAX method is used to arrange all outputs. then, utilize the Centroid technique for affirmation or defuzzification. Using this approach, the fuzzy location center is used to determine the answer. Structured in the following way:

$$z = \frac{\int_z z\mu(z)dz}{\int_z \mu(z)dz} \tag{1}$$

In this study, the centroid approach is applied for defuzzification. By choosing the center of the fuzzy area, a clear solution can be found. Figure 5 illustrates the display of software defuzzification. By entering simulation data in the input column, output will be produced. An example of the input entered in Figure 5 is [50 50 0.5], which means the texture variable input is 50, the flavor variable input is 50, and the size input is 0.5, resulting in an output of 25 for price.



Fig. 5 Mamdani Method Defuzzification

Following are some examples of the price per unit output of fish produced by the mamdani method using various inputs. Fish prices, which were determined by the Mamdani system during this study, are shown in Table 4 and serve mainly as a reminder of the idea.

Table 4.  
Output price of tilapia with the mamdani method

| No | Texture | Taste | Size(Kg) | Price(in thousands) |
|----|---------|-------|----------|---------------------|
| 1  | 10      | 30    | 0.05     | 12.5                |
| 2  | 15.9    | 80.9  | 0.264    | 16.6                |
| 3  | 13.2    | 45    | 0.25     | 17.6                |
| 4  | 50      | 50    | 0.5      | 25                  |
| 5  | 80      | 15    | 0.45     | 25                  |
| 6  | 72      | 63    | 0.606    | 26.9                |

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|    |      |      |       |      |
|----|------|------|-------|------|
| 7  | 62.2 | 59.8 | 0.703 | 32.9 |
| 8  | 79.3 | 85   | 0.882 | 37.5 |
| 9  | 90   | 45   | 1     | 37.5 |
| 10 | 80   | 78   | 1     | 37.5 |

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## 5. CONCLUSION

The mamdani fuzzy method can be used to determine the quality of tilapia from the price output variables and input variables such as texture, taste and size. Suugestion for future research is this study only discusses the application of the fuzzy logic method. So that it can be developed again by making a website. In addition, input and output variables can be increased with more variety.

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