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Assessment of Chicken Egg Appearance Using Mamdani Fuzzy Logic with Weight and Sphericity Inputs

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Abstract

This study aims to design an egg appearance assessment system using fuzzy logic with input parameters of weight and sphericity. Manual egg sorting based on physical characteristics such as size and shape is often time-consuming and subjective, necessitating an automated classification system. The Mamdani fuzzy inference system was implemented using MATLAB Fuzzy Logic Toolbox to simulate the decision-making process. Triangular and trapezoidal membership functions were used for the input variables (weight and sphericity) and output variables (appearance quality), with linguistic terms such as light, normal, heavy, and abnormal, normal, round. The rule base consisted of nine if–then statements, with the defuzzification process using the centroid method. The system produced a crisp output value of 31.67, which falls into the "good" category, indicating that eggs weighing 55 g and with a roundness of 0.85 are classified as good quality eggs. Visualization through Surface Viewer and Rule Viewer shows that this model is capable of capturing nonlinear relationships between variables and providing adaptive classification results. The results of this study indicate that Mamdani fuzzy logic can assess egg quality accurately and efficiently, and serve as a reliable basis for the development of intelligent automatic sorting systems in the poultry industry.

Keywords: Egg quality, Fuzzy logic, Mamdani method, Sphericity, Weight.

INTRODUCTION

Chicken eggs are a common source of animal protein due to their high nutritional value and affordable price. According to the Badan Pusat Statistik (BPS, 2024), Indonesia's egg production will reach more than six million tons in 2024. This makes egg quality a crucial factor when buying eggs. Egg quality can be determined by physical parameters such as egg white index, egg yolk index, aroma, weight, roundness, and shell shape. Of these physical parameters, weight and shape are key indicators of egg quality.

Based on research (Widyantara *et al.,* 2017), the internal quality of eggs can be determined by their weight. Egg weight determines the size and quality class of eggs. Meanwhile, roundness determines uniformity of shape, ease of handling, and efficiency in storage and packaging. Measuring these two parameters on an industrial scale manually requires time and effort. Therefore, combining the two with an intelligent system will result in a more efficient, accurate, and objective method. This can facilitate the physical assessment of egg quality.

An intelligent system is needed to overcome uncertainty in the egg quality determination process and provide objective and efficient quality assessment results. The fuzzy logic method offers a solution by converting vague numerical data into linguistic decisions that mimic the way humans assess quality. Fuzzy logic is an approach used to map the relationship between input and output data based on the principle of uncertainty. In fuzzy set theory, an object can be part of several sets simultaneously, with varying degrees of membership in each set. Fuzzy logic is part of a soft computing approach that serves to map problems from input data to desired outputs. This method has several advantages, including being easy to understand because it is based on simple mathematical concepts and has a high degree of flexibility in its application (Athiyah *et al.,* 2021).

Among the various fuzzy logic models, the Mamdani method is the most widely used for quality classification systems because it produces decisions that are easy to understand and implement in automated systems. This model combines expert-based if–then rules with a defuzzification process to convert membership values into representative final outputs. This model is known to be more flexible, intuitive, and tolerant of data variations, allowing it to adapt to uncertain input conditions. The analysis process in the Mamdani system uses human logic-based linguistic rules and easy-to-understand mathematical algorithms, making it effective for automated decision-making applications (Prastika *et al*., 2024).

The application of Mamdani fuzzy logic in egg quality assessment systems plays an important role in improving the accuracy and efficiency of the sorting process. This method is capable of managing uncertain data and producing quality assessments that mimic human reasoning, but with more consistent and objective results. By utilizing weight and roundness parameters, this system can automatically classify egg quality, supporting the development of smart technology to improve food product quality.

METHODS

This study employed a quantitative descriptive simulation approach using a Mamdani Fuzzy Inference System (FIS) developed in MATLAB. The input variables consisted of egg weight and sphericity, with domain ranges determined from previous empirical studies. Egg weight was assigned a domain of 0–80 g, while the sphericity ratio ranged from 0.75 to 0.90. The output variable, namely appearance quality, was set within a range of 0–100. Prior to modeling, the input domains were established to ensure that all membership functions were defined within realistic biological intervals.

The construction of membership functions was performed using trapezoidal functions, selected due to their ability to represent stable membership regions with plateau areas that correspond to typical biological variability. This choice is theoretically supported by studies such as Lima et al. (2025) and Kusumadewi et al. (2022), which note that trapezoidal functions provide smoother representation of physical measurements and improved interpretability for classification tasks compared to triangular functions. For egg weight, the linguistic terms Light, Normal, and Heavy were defined with parameters (a–b–c–d) of (0,0,30,40), (30,40,50,60), and (50,60,70,80), respectively. Egg sphericity consisted of Abnormal (0.75,0.75,0.795,0.80), Normal (0.795,0.80,0.81,0.82), and Round (0.81,0.82,0.90,0.90).

The output variable had two membership sets: Good (0,0,25,75) and Poor (25,75,100,100). These definitions allowed the system to accommodate natural uncertainty and overlapping characteristic boundaries typically encountered in egg shape and weight assessment.

A total of nine fuzzy rules were formulated based on the complete combination of the three weight categories and three sphericity categories. These rules described the logical relationship between input conditions and egg quality outcomes, such as "If weight is Normal and sphericity is Round, then appearance quality is Good." The Mamdani inference mechanism was applied using the AND–min operator for rule antecedents, min implication, max aggregation, and centroid defuzzification. Simulation was conducted using a case input of 55 g egg weight and 0.85 sphericity to represent a middle-range physical condition. MATLAB Rule Viewer and Surface Viewer were used to display the inference process and observe the resulting decision surfaces.

Model validation was conducted not only through logical consistency inspection but also through a series of measurable evaluation steps. First, rule consistency and membership overlap were examined to ensure that no contradictory rules existed and that transitions between linguistic sets met the recommended overlap threshold of 10–20% for biological systems, as noted by Widayat *et al.* (2024). Second, output behavior validation was performed by analyzing the smoothness of the 3D decision surface; the system was required to produce monotonically increasing outputs when input variables increased, without abrupt discontinuities. Additionally, a defuzzification stability test was carried out by applying ±5% perturbations to input values and verifying that variations in crisp outputs did not exceed 20%, following fuzzy model stability criteria for agricultural classification systems (So *et al.,* 2022). Finally, the model output was compared with expert-based interpretations reported in previous egg quality studies (Mahesa *et al.,* 2019) to confirm practical coherence.

To maintain methodological clarity, the practical purpose of the system was placed separately from procedural steps. The developed fuzzy model is intended to serve as a conceptual foundation for automated egg-sorting technology, potentially applicable to embedded control systems or conveyor-based quality assessment devices. This separation ensures that the Methods section focuses strictly on scientific procedures while practical implications remain part of the discussion rather than the methodological framework.

RESULTS AND DISCUSSION

Table 1. Model Fuzzy Inference Rule

Type	Name	Category	Fuzzy Set
Data Input	Egg Weight	Light	(0, 0, 30, 40)
		Normal	(30, 40, 50, 60)
		Heavy	(50, 60, 70, 80)
	Egg Sphericity	Abnormal	(0.75, 0.75, 0.795, 0.8)
		Normal	(0.795, 0.8, 0.81, 0.82)
		Round	(0.81, 0.82, 0.9, 0.9)
Data Output	Result	Good	(0, 0, 25, 75)
		Poor	(25, 75, 100, 100)

Study Case

The study case used has an egg weight criterion of 55 and an egg sphericity criterion of 0.85, resulting in an assessment. After obtaining the case study, the next step is to complete the Fuzzy Inference System (FIS) stages as follows.

1. **Creating Fuzzy Sets and Input**

   This stage is the first step in designing a fuzzy logic system, in which input variables, output variables, the range (domain) of each variable, and the formation of membership functions are determined. The fuzzy approach was chosen because of its ability to model uncertainty and variability in physical data that cannot be explicitly categorized (Sipan and Pramuyanti, 2020). This system was built using the Mamdani Fuzzy Inference System approach, with AND-min, OR-max, min implication, max aggregation, and centroid defuzzification operators (Mahesa *et al.,* 2019).

The designed fuzzy system has two input variables, namely Egg Weight and Egg Roundness, and one output variable, namely Result, which describes the appearance quality of the egg. Each variable is represented in the form of a trapmf membership function because this function is capable of describing a range of values with a full area ($\mu = 1$) in the middle and a smooth transition area on the left and right sides (Rancapan *et al.,* 2019). The trapmf function also provides a clearer linguistic interpretation than the triangular function (trimf) in the case of physical data such as egg weight and shape.

The egg weight variable represents the weight of the egg in grams, which is divided into three linguistic categories: Light, Normal, and Heavy. Eggs weighing less than 30 grams are categorized as Light, while eggs weighing more than 70 grams are categorized as Heavy. Furthermore, Egg Sphericity describes the degree of roundness of the egg based on the ratio between its long axis and its wide axis, where a value close to 1 indicates a more spherical egg shape. Result is an output variable that assesses the final appearance of the egg with two linguistic categories: Good and Bad.

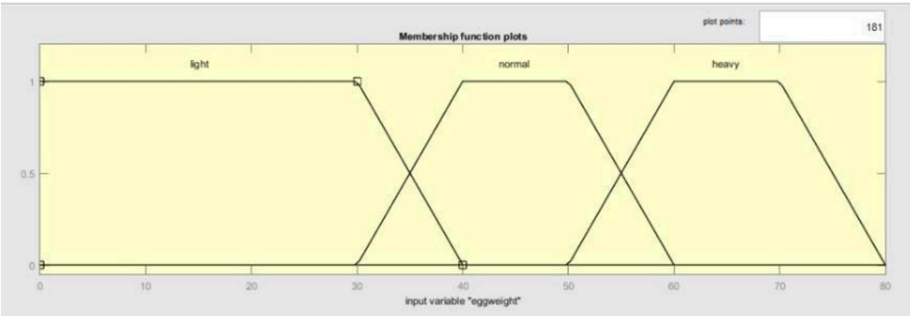

Figure 1. Input Egg Weight

This figure depicts the input variable egg weight in the range 0-80, categorized into three parameters: light, normal, and heavy.

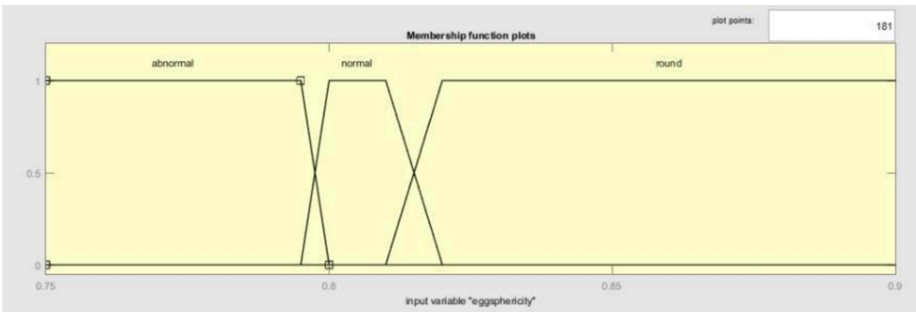

Figure 2. Input Egg Sphericity

This figure depicts the input variable egg sphericity in the range 0.75-0.9, categorized into three parameters: abnormal, normal, and round.

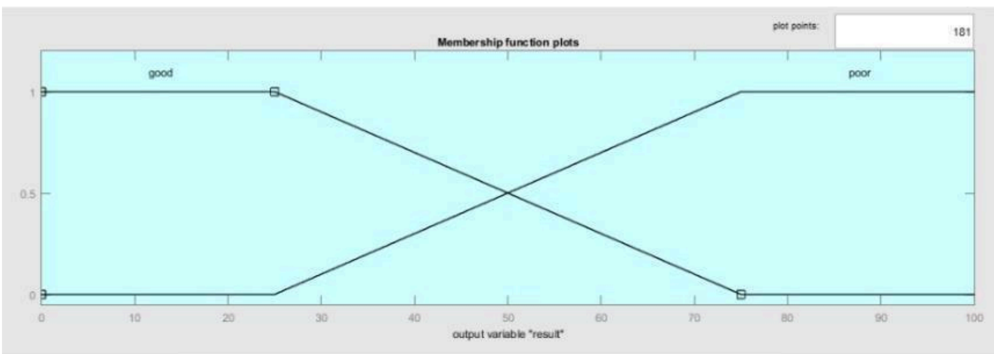

Figure 3. Output Result

This figure depicts the output result variable in the range 0-100, categorized into three parameters: good and poor.

Membership Set Input Egg Weight

The egg weight variable consists of three linguistic sets: light, normal, and heavy. Based on the trapezoidal membership function parameters (light = 0, 0, 30, 40); normal = 30, 40, 50, 60; and heavy = 50, 60, 70, 80), the input value of 55 grams falls within the normal and heavy sets. To calculate the membership degree, the linear formula on the descending and ascending sides of the trapmf function is used, namely:

$$\mu\text{Normal } (55) = \frac{60-55}{60-50} = \frac{5}{10} = 0{,}5$$

$$\mu\text{Heavy } (55) = \frac{55-50}{60-50} = \frac{5}{10} = 0{,}5$$

An egg weighing 55 grams has the same membership degree (μ = 0.5) in two categories, normal and heavy, indicating that the egg is in the transition zone between the two categories, which shows the concept of ambiguity or natural uncertainty in physical data (Saatchi, 2024)

Egg Sphericity Input Membership Set

There are three linguistic categories for the egg sphericity variable: abnormal, normal, and round. Based on the parameters used, the abnormal variable is (0.75, 0.75, 0.795, 0.8); normal is (0.795, 0.8, 0.81, 0.82); and round is (0.81, 0.82, 0.9, 0.9). An input value of 0.85 is in the plateau area of the round set, which produces:

$$\mu\text{Round } (0{,}85) = 1$$

As a result, eggs with a sphericity value of 0.85 are fully categorized as round. This indicates that these eggs have a perfectly or ideally round shape.

Collect All Input

- Fuzzy Set Light : µp_light[55] = 0
- Fuzzy Set Normal : µp_normal[55] = 0.5
- Fuzzy Set Heavy : µp_heavy[55] = 0.5
- Fuzzy Set Abnormal : µp_ubnormal[0,85] = 0
- Fuzzy Set Normal : µp_normal[0,85] = 0
- Fuzzy Set Round : µp_round[0,85] = 1

2. Implementing Fuzzy Operators

The implementation of fuzzy operators in a chicken egg sorting system using weight and sphericity parameters is an important part of the fuzzy inference process that determines the final quality classification. After the egg weight data is measured, all variables are converted into fuzzy membership values at the fuzzification stage. For example, the weight variable can be categorized as light, normal, and heavy, while the sphericity variable can be classified as abnormal, normal, and round. These membership category values are then processed using fuzzy operators to evaluate the predetermined IF–THEN logic rules. Commonly used operators are AND and OR, which are implemented using t-norm and s-norm functions, respectively (Chowdury S & Kar R., 2020) In egg sorting systems, the AND operator is usually represented by an algebraic multiplication or minimum function, while the OR operator uses a maximum function. These operators are used to combine the membership values of all input variables into a single value called firing strength, which indicates the degree of truth of each rule.

The application of fuzzy operators offers advantages over conventional methods because it can accommodate the natural uncertainty in egg size and shape. This method allows for decision-making that more closely resembles human judgment, especially in cases where the boundary between “good” and “bad” eggs is unclear. According to So *et al.* (2022), a fuzzy inference system with min-max operators and centroid defuzzification produces egg quality classifications that are more stable and consistent with human perception. Furthermore, incorporating physical parameters such as weight and sphericity into the fuzzy system improves the accuracy of non-destructive quality detection (Luo *et al.,* 2025). Simple operators such as min and max provide the best results for agricultural classification applications because they are efficient and easy to interpret.

Thus, the implementation stage of fuzzy operators plays an important role in ensuring the accuracy and consistency of egg sorting results based on two main parameters: weight and sphericity. This system is capable of assessing egg quality intelligently and adaptively, providing a strong foundation for the application of intelligent assessment systems in the modern food sector.

1. If (eggweight is light) and (eggsphericity is abnormal) then (result is poor) (1)
2. If (eggweight is light) and (eggsphericity is normal) then (result is poor) (1)
3. If (eggweight is light) and (eggsphericity is round) then (result is poor) (1)
4. If (eggweight is normal) and (eggsphericity is abnormal) then (result is poor) (1)
5. If (eggweight is normal) and (eggsphericity is normal) then (result is good) (1)
6. If (eggweight is normal) and (eggsphericity is round) then (result is good) (1)
7. If (eggweight is heavy) and (eggsphericity is abnormal) then (result is poor) (1)
8. If (eggweight is heavy) and (eggsphericity is normal) then (result is good) (1)
9. If (eggweight is heavy) and (eggsphericity is round) then (result is good) (1)

Figure 4. Fuzzy Rule Base

- **Rule 1**
  IF light AND abnormal THAN poor
  A1 = min (μp_light [55], μp_abnormal [0.85] = min (0,0)
  A1 = 0
- **Rule 2**
  IF light AND normal THAN poor
  A2 = min (μp_light [55], μp_normal [0.85] = min (0,0)
  A2 = 0
- **Rule 3**
  IF light AND round THAN poor
  A3 = min (μp_light [55], μp_round [0.85] = min (0,1)
  A3 = 0
- **Rule 4**
  IF normal AND abnormal THAN poor
  A4 = min (μp_normal [55], μp_abnormal [0.85] = min (0.5, 0)
  A4 = 0
- **Rule 5**
  IF normal AND normal THAN good
  A5 = min (μp_normal [55], μp_normal [0.85] = min (0.5, 0)
  A5 = 0
- **Rule 6**
  IF normal AND round THAN good
  A6 = min (μp_normal [55], μp_round [0.85] = min (0.5, 1)
  A6 = 0.5
- **Rule 7**
  IF heavy AND abnormal THAN poor
  A7 = min (μp_heavy [55], μp_abnormal [0.85] = min (0.5,0)
  A7 = 0

- **Rule 8**
  IF heavy AND normal THAN good
  A8 = min (μp_heavy [55], μp_normal [0.85] = min (0.5, 0)
  A8 = 0
- **Rule 9**
  IF heavy AND round THAN good
  A9 = min (μp_heavy [55], μp_round [0.85] = min (0.5, 1)
  A9 = 0,5

3. **Applying the Implication Function**

In compiling this fuzzy rule base, each rule is given a weight = 1 and uses the logical operator And (min). The weight value is used to indicate the degree of influence or confidence in a rule compared to other rules. This means that all rules have the same degree of importance on the final result of the system (Rizandi *et al.*, 2025). This method, the output value of each rule is determined by the smallest membership degree of the input variables involved in that rule. The higher the firing strength value of the calculation, the greater the contribution of that rule to the overall inference result. In this case, there are nine rules in the fuzzy logic application example. However, the data is only taken from rules one and six, because the calculated firing strength values are the highest among each parameter. This shows that fuzzy logic is selective only rules relevant to the input conditions are used in the calculation process, making the system more efficient and realistic. This case, the input to be used:

- Egg weight = 55 grams
- Egg sphericity = 0.85

For rule number 1
“IF egg weight is Light AND egg sphericity is Abnormal, THEN result is Poor”

The first step is to determine the degree of membership of each variable to its category, namely the degree of membership of egg weight to the light parameter and the degree of membership of roundness to abnormal. The final step is to calculate the firing strength value or α-predicate for rule 1 by the min operator so that the calculation results are as follows:

IF light AND abnormal THAN poor
A1 = min (μp_light [55], μp_abnormal [0.85] = min (0,0)
A1 = 0

The value A1=0 means that this rule does not contribute to the inference process because the given input combination is not included in the membership range of both variables, namely Light (0–40) and Abnormal (0.8). Therefore, rule 1 does not affect the output result.

For rule number 6

“IF egg weight is Normal AND egg sphericity is Round, THEN result is Good”

The first step is to determine the membership degree of each variable to its category, namely the membership degree of egg weight to the normal parameter and the membership degree of roundness to round. The final step is to calculate the firing strength value or α-predicate for rule 6 by the min operator, so that the calculation results are as follows:

IF normal AND round THEN good

A6 = min (μp_normal [55], μp_round [0.85] = min (0.5, 1)

A6 = 0.5

The value A6 = 0.5 means that this rule is partially active, with a degree of fulfillment of 0.5. This means that the given input partially fulfills the conditions to produce a Good output, and this value will later be used in the next stage to form a fuzzy set of output variables.

These two rules show that with an egg weight of 55 grams and a roundness of 0.85, the system is more inclined to classify the appearance of the chicken egg as Good, in accordance with the combination of inputs that are close to the ideal conditions (normal weight and round shape).

4. **Composing All Outputs**

The stage of composing all outputs is the process of combining all fuzzy results generated from each active rule in the Mamdani fuzzy inference system. In this study, the calculation results show that two active rules, namely rules 6 and 9, each have a membership degree (firing strength) of 0.5 with the output category Good. These two rules are combined using the maximum (max) operator aggregation method, because they have the same output category. This aggregation process follows the principle described by Dalvand *et al.* (2022) that the aggregation stage aims to combine all the implication results from each rule into a single fuzzy set that is ready to be used in the defuzzification process. The use of the max operator provides the most stable and accurate results for fuzzy inference systems because this method selects the highest membership value among all active rules, thereby mimicking the way humans make decisions based on the highest probability (Kusumadewi *et al.* 2022).

Based on the MATLAB implementation using the Fuzzy Logic Toolbox, the composition process is performed automatically after the implication stage. The membership function of the ''Good'' output is defined with trapezoidal parameters [0, 0, 25, 75]. Based on the clipping results with a value of $\alpha = 0.5$, this function becomes constant at $\mu = 0.5$ for the range $0 \leq x \leq 50$ and decreases linearly to $\mu = 0$ at $x = 75$. Mathematically, the composition result function can be expressed as:

$$\mu_{SF}(x) = \begin{cases} 0.5, & 0 \leq x \leq 50 \\ \dfrac{x-50}{75-25}, & 50 < x \leq 75 \\ 0, & x > 75 \end{cases}$$

This function illustrates that the system has a confidence level of 0.5 for the Good category in most areas of the output domain. This composition result function represents the system's confidence area for non-binary decisions, i.e., decisions that are not entirely “good” or “bad” but are a combination of both to a certain degree, making the fuzzy method more realistic than the deterministic approach (So *et al.* 2022). After obtaining the output composition results, the next step is defuzzification using the centroid method to determine the crisp output values.

5. **Defuzzyfikasi**

Defuzzification is the process of converting a fuzzy set resulting from rule composition into a single (crisp) value that represents the actual conditions in the domain of the fuzzy set (Wahyudi *et al*., 2023). The defuzzification process takes place by taking the fuzzy output value obtained from rule evaluation and then entering it into the output membership function. The magnitude of this fuzzy output value is expressed as the degree of membership in the membership function. Next, these values are processed using the defuzzification method to produce a final value in the form of a crisp output. Defuzzification is the final stage in a fuzzy logic control system, with the aim of converting the results of the inference engine in the form of a fuzzy set into a single real number. This converted value is then used as an action taken by the fuzzy logic control system (Siregar *et al*., 2023). In this study, the method used for defuzzification is the Centroid method.

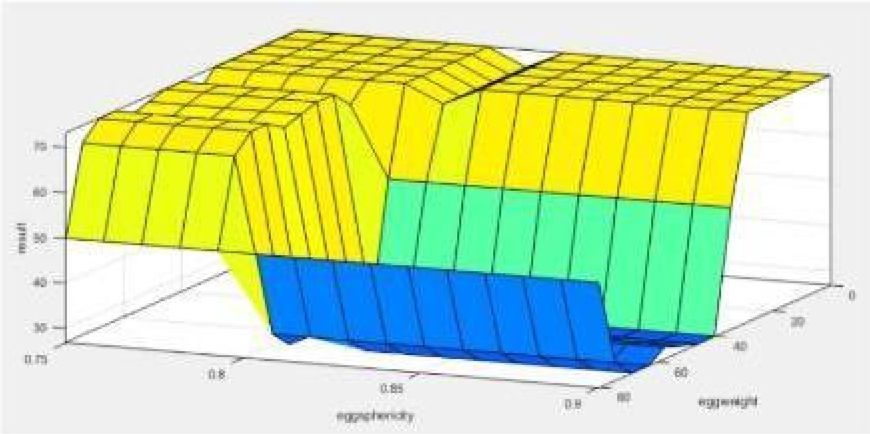

Figure 5. Surface Viewer

Figure 5 is a display result from Surface Viewer, a three-dimensional visualization feature that shows the relationship between two input variables to one output variable in the Mamdani fuzzy system. Surface viewer is used to display the overall input to output graph based on rules (Kastina & Silalahi, 2016). In this study, the two input variables are egg weight and egg roundness (eggsphericity), while the output variable is the egg quality assessment result (result). The X-axis represents the egg weight value, the Y-axis shows eggsphericity, and the Z-axis depicts the egg quality results based on the defuzzification value. The surface formed shows a nonlinear interaction between the two input variables and the output, which is visualized in a color gradation from blue (low quality) to yellow (high quality).

The display shows that the greater the egg weight and the closer it is to a perfect sphere, the egg quality value increases significantly. The graded surface pattern indicates transitions between fuzzy sets, for example from "light" to "medium" and from "less round" to "slightly round." This indicates that the Mamdani system is capable of capturing subtle variations in uncertain data, without being limited to hard value boundaries. Thus, the Surface Viewer provides an overview of how the combination of two input parameters influences the final egg quality. This visualization is very useful for understanding the decision patterns generated by the fuzzy system and verifying whether the rules developed have produced logical and consistent output.

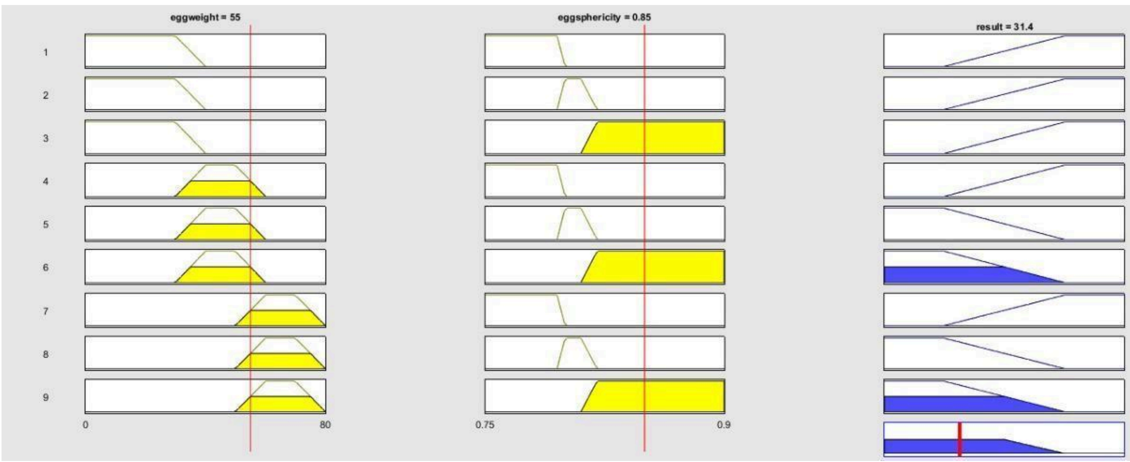

Figure 6. Rule Viewer

Figure 6 displays the results of the Rule Viewer, a display that interactively demonstrates the fuzzy inference process. The Rule Viewer functions to display a membership graph of the input values, resulting in an output value graph based on the specified rule (Kastina

& Silalahi, 2016). In this display, the entered eggweight value is 55 g and the eggsphericity value is 0.85. The yellow area in each membership set indicates the activation level (degree of membership) in a particular category, for example, medium eggweight and slightly rounded eggsphericity. Based on the combination of these two values, the system activates the relevant fuzzy rule, then produces an output result of 31.4 in the image. However, there is a difference between the value in the image and the value in the manual calculation that produces an output result of 31.6 caused by small differences in the firing strength (α) level or membership function (MF) parameters. The value of 31.4 is the result of the defuzzification process, which is the stage of converting fuzzy output into crisp values so that it can be interpreted quantitatively. Based on the quality scale used, this value falls into the "good" category. This demonstrates that the fuzzy system can provide realistic and flexible assessments, even when the input falls between two different categories.

Based on the visualization results in the Surface Viewer and Rule Viewer, the Mamdani fuzzy logic system demonstrates adaptive capabilities in determining egg quality based on weight and roundness parameters. Both displays demonstrate that the fuzzy inference process operates consistently according to established rules, thus supporting a more objective and representative quality assessment of real-world conditions.

Calculating Moment (M)

$$M_{\text{rect}} = \text{area} \times \text{centroid}_x = 25 \times 25 = 625$$

$$M_{\text{tri}} = \int_{50}^{75} \frac{75 - x}{50} x \, dx = 364.5833333$$

$$\text{Total momen } M = 625 + 364.5833333 = 989.5833333$$

Calculating Area (A)

$$A_{\text{rect}} = 50 \times 0.5 = 25$$

$$A_{\text{tri}} = \frac{1}{2} \times 25 \times 0.5 = 6.25$$

$$\text{Total luas } A = 25 + 6.25 = 31.25$$

Calculating the Center Point (Centroid)

$$z^* = \frac{M}{A} = \frac{989.5833333}{31.25} \approx 31.6666667$$

The centroid method is used to calculate the z-value based on the results of rule aggregation. The centroid is the center point of the fuzzy set that has the maximum value (Sinaga *et al.,* 2023). Based on the calculation results, the centroid value (defuzzified value) obtained is 31.67. This value is obtained by dividing the total moment M=989.58 by the area A=31.25, resulting in a crisp value of $z*$ =31.67. This centroid value is the result of the defuzzification process, which is the stage of converting the output of the fuzzy system, which was originally in the form of a set of membership values, into a single definite value that can be used in decision making. Thus, the number 31.67 represents the final value that best describes the overall condition of the fuzzy system being analyzed. This value is the output of the system and can be used as a basis for further decision-making or evaluation, depending on the context of the system's application.

CONCLUSION

This study successfully demonstrated the application of the Mamdani fuzzy inference system in assessing chicken egg performance based on weight and roundness parameters. The developed model was able to simulate the human decision-making process in egg classification using the MATLAB Fuzzy Logic Toolbox. The system produced a crisp output value of 31.67, indicating that eggs weighing 55 g and with a roundness of 0.85 were classified as "good." Visualization through Surface Viewer and Rule Viewer proved that this model was capable of handling nonlinear relationships and uncertainty in input data. The results of this study prove that the Mamdani fuzzy logic method provides an accurate, adaptive, and consistent approach to assessing egg quality. This research can be the basis for the development of a more efficient and objective automatic egg sorting system in the poultry industry.

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