Journal of Applied Science, Technology & Humanities
Volume 2, Issue 4, September, 2025, Pages 491-508

ISSN 3032-5765
DOI: https://doi.org/10.62535/xnxxdt92

Implementation of Fuzzy Logic in Management Decision Making Supply of Raw Materials for Pie Production in the Food Industry

Alif Permata Gusti[1*]
[1*]Food Quality Assurance Supervisor, College of Vocational Studies, IPB University
pgst04permata@apps.ipb.ac.id

Alief Riza Candra Dewi Afivah[2], **Dinda Anissa Rahmah**[3], **Muhammad Naufal Denasfi**[4], **Nasya Alivia Cahyaning Putri**[5], **Rinriani Hanifah**[6], **Tyara Restiani**[7], **Mrr Lukie Trianawati**[8], **Daffa Zulqisthi**[9], **Muhammad Faiz Assariy**[10], **Chika Hayya Sabillah**[11]
[2345678]Food Quality Assurance Supervisor, College of Vocational Studies, IPB University
[91011] Computer Engineering Technology, College of Vocational Studies, IPB University
[2]risa29dewi@apps.ipb.ac.id, [3]dindaanissarahmah@apps.ipb.ac.id, [4]mndnaufal@apps.ipb.ac.id, [5]nasyaalivia@apps.ipb.ac.id, [6]rinrianihanifah@apps.ipb.ac.id, [7]aratyararestiani@apps.ipb.ac.id, [8]mrrlukietrianawati@apps.ipb.ac.id, [9]zulqs@apps.ipb.ac.id, [10]faizmuhammad@apps.ipb.ac.id, [11]chikahayya_asabillah@apps.ipb.ac.id

ABSTRACT

Raw material inventory management is a crucial element in the food industry to ensure smooth production processes. Unstable inventory can lead to risks of material spoilage, stock shortages, and quality degradation, which impact the fulfillment of market demand. The Fuzzy Logic method, specifically Fuzzy Sugeno, is used to address the complexity and uncertainty in inventory management. This method allows inventory data to be processed more flexibly, producing accurate numerical outputs that can be directly applied to operational decisions. This study employs a descriptive qualitative approach with a literature review to examine the role of Fuzzy Logic in decision-making related to raw material inventory, along with data analysis of production in the food industry. Production data for pie crusts from April 2023 to May 2024 shows inventory fluctuation patterns, with initial stock ranging from 996 to 1153 units, production from 300 to 1579 units, and incoming stock from 310 to 1535 units each month. Through the application of Fuzzy Sugeno, initial stock, production, and incoming stock membership values are categorized into fuzzy sets (low, medium, and high) to map uncertainty in input data. Implementing Fuzzy Sugeno on MATLAB generates more precise outputs aligned with inventory management needs in the food industry. The results indicate that using the Fuzzy Sugeno method can improve stock prediction accuracy and reduce the risk of overstocking or understocking, supporting more efficient and stable operations. This approach provides an adaptive solution to market demand changes, essential for business sustainability and production stability in the food industry.

Keywords: inventory management, fuzzy logic sugeno, food industry, stock uncertainty, demand prediction.

INTRODUCTION

The management of raw material inventory is a crucial aspect in the food industry. A stable availability of raw materials is essential to ensure the smoothness of the production process (Anton & Gusrianty, 2023). The efficiency and accuracy of inventory management become critical points given the perishable nature of food products (Nugroho et al., 2023). It is necessary to have competent strategies to reduce the risks of damage, raw material shortages, and quality degradation, with the expectation that the output achieved by the company can optimally meet market demand (Hilmansyah & Hilpiah, 2019). However, decision-making in inventory management does not solely depend on quantity calculations (Umam, 2023). Various uncertain factors will influence it. Internal factors, such as demand fluctuations and supply variability, are among these (Azizah & Fauziyah, 2020). Meanwhile, external factors like weather also affect inventory dynamics (Pinem & Utomo, 2020). To address these risks, a fuzzy logic-based approach offers an innovative solution that can adapt to complexity and uncertainty (Aisuwarya & Annafi, 2017). This approach allows for flexibility in processing uncertain data, leading to more accurate and relevant decisions for stock management in the industry (Haque & Sriani, 2023). According to Muflihunna & Mashuri (2022), the Sugeno fuzzy logic method is particularly suitable because the output is in the form of numerical values that can be directly applied in operational decisions. Sugeno provides efficient solutions for decision-making that requires easily calculable figures, making it highly relevant in raw material inventory management (Warmansyah & Hilpiah, 2019). This method enables the conversion of input data into fuzzy values, which are then processed through a series of inference rules to produce outputs that are responsive to changes in market demand (Nasution et al., 2022). Moreover, research shows that Sugeno fuzzy logic has the advantage of adjusting stock predictions with a high level of accuracy, thus reducing the risks of overstocking or stockouts (Mawardani et al., 2022). The implementation of the Sugeno method in software like MATLAB is also a trend in the industry, including the food sector, because it facilitates fast and efficient predictive analysis (Putra et al., 2018). Such applications support more effective and efficient management, ensuring that the production process runs smoothly without disruptions due to material shortages or unused stock accumulation (Irdayanti et al., 2024). The application of the Sugeno fuzzy logic model in managing the raw material inventory for pie production in the food industry is expected to enhance the efficiency and effectiveness of stock predictions. This is intended to provide stock management solutions that are more adaptive to market demand (Simon et al., 2018). The desired outcome is to support operational sustainability and business stability, particularly in the food industry. In this regard, the fuzzy logic-based approach offers innovative solutions to handle the complexities and uncertainties that may hinder business processes (Anugrahwaty & Azmy, 2017). Therefore, fuzzy logic models can be effectively identified and applied in decision-making for managing raw material inventory in pie production within the food industry. This is aimed at improving the efficiency and quality of inventory management (Kastina & Silalahi, 2016).

METHODS

Research Approach

This research employs a qualitative descriptive approach aimed at gaining an in-depth understanding of the application of Fuzzy Logic in decision-making related to raw material inventory management in the food industry. This approach was chosen for its ability to provide detailed descriptions of the phenomena being studied through the analysis of information from various sources (Maruwu, 2023). With this approach, it is hoped that the research can explore the role of Fuzzy Logic in managing inventory uncertainties, optimizing cost efficiency, and providing an overview of the challenges and opportunities faced in the implementation of Fuzzy Logic in the food industry.

Data Collection

Data collection in this study is conducted using the literature review method as part of the qualitative descriptive approach. This literature review involves gathering information and secondary data from relevant sources, such as scientific journals, articles, and related documents that discuss Fuzzy Logic and raw material inventory management (Melfianora, 2019). Data sources are selected based on relevance, validity, and credibility to support the theoretical and empirical analysis of this research. Through the literature review, the researcher can establish a strong theoretical foundation, examine previous research findings, and understand the key concepts related to Fuzzy Logic in the context of the food industry.

Data Analysis

The Fuzzy Logic method is used to address uncertainty and ambiguity in the decision-making process. Fuzzy Logic allows membership values to exist within a continuous range between 0 and 1, indicating the degree of certainty or uncertainty of a statement. This differs from traditional binary logic, which recognizes only two values (true or false). This method is particularly suitable for applications occurring in the real world, where many variables are involved and the available information is often inaccurate or incomplete (Mayasari et al., 2018)..

One variant of Fuzzy Logic used for modeling and decision-making is the Fuzzy Sugeno method, where each fuzzy rule generates a numerical output, which can be a linear function or a constant. The main advantage of this method is that it makes the outputs easier to compute, making it more suitable for applications that require numerical-based decisions, such as inventory management. This system essentially breaks down the problem into several simple rules that can be evaluated simultaneously, which facilitates data analysis and interpretation (Sihombing, 2024).

The Fuzzy Sugeno system consists of three main components: fuzzification, fuzzy inference, and defuzzification. Membership values in the fuzzy set are converted into crisp inputs during the fuzzification stage. Then, in the fuzzy inference stage, these membership values are combined with predefined fuzzy rules to generate the appropriate output. Finally, the defuzzification process converts the fuzzy output back into crisp values that can be used for decision-making (Darmawi et al., 2020).

The use of the Sugeno fuzzy logic method has the potential to handle inventory management variables, both simple and complex. This is particularly applicable in cases where there are variations in the quantity of available inventory and uncertainties in demand. This data analysis method allows for more suitable and responsive solutions to market dynamics (Warmansyah & Hilpiah, 2019). It aids in better and more efficient decision-making in the food industry.

Through data analysis conducted with the Sugeno fuzzy method using MATLAB, this research aims to demonstrate the effectiveness of the Fuzzy Logic approach in optimizing raw material inventory management. The results of this implementation are expected to provide valuable insights into how Fuzzy Logic can be utilized as a decision-making tool that is more accurate and data-driven in the context of food industry management.

RESULTS AND DISCUSSION

Data Collection

Table 1. Pie crust production data for the period April 2023 to May 2024

Month of production	Initial stock	Production quantity	Incoming goods	Final stock
April 2023	1000	300	310	1010
May 2023	1010	598	620	1032
June 2023	1032	799	920	1153
July 2023	1153	861	730	1022
August 2023	1022	670	673	1026
September 2023	1026	1108	1140	1058
October 2023	1058	1579	1535	1014
November 2023	1014	1090	1095	1019
December 2023	1019	659	730	1090
January 2024	1090	672	650	1068
February 2024	1068	1195	1145	1018
March 2024	1018	1200	1178	996
April 2024	996	1220	1250	1026
May 2024	1026	1100	1115	1041

The data above represents a datasets of pie crust production from April 2023 to May 2024. The collected data includes initial stock, production volume, incoming goods, and ending stock for each month. This data has been gathered to analyze production patterns of pie crust and identify the factors affecting the ending stock.

Needs Analysis

1. **Input Analysis**

   The input variables are factors that influence the output variables. There are three input variables: Initial Stock, Production, and Incoming Goods. These three input variables are grouped into three fuzzy sets: low, medium, and high. This categorization is done to accommodate uncertainties in the data.

Table 2. Variable input

Function	Variable	Fuzzy set	Universe set	Domain
Input	Initial stock	Few	996-1153	[996-1075]
		Medium		[996-1075-1153]
		High		[1075-1153]
	Production	Few	300-1579	[300-940]
		Medium		[300-940-1579]
		High		[940-1579]
	Incoming goods	Few	310-1535	[310-923]
		Medium		[310-923-1535]
		High		[923-1535]

2. Output Analysis

The output variables are factors that are influenced by the input variables. The output is the result that is intended to be predicted or analyzed. The output variable includes the ending stock of pie crust, which is categorized into three fuzzy sets: low, medium, and high.

Table 3. Variable output

Function	Variable	Fuzzy set	Domain
Output	Final stock	Few	[996]
		Medium	[1075]
		High	[1153]

3. Rules

Rules in fuzzy logic are a set of guidelines that connect input variables with output variables. These rules help address the uncertainties present in the data and facilitate decision-making regarding the ending stock value based on combinations of input variable values. Fuzzy logic allows for decision-making based on “if-then” rules that reflect the relationship between input and output variables. There are 27 possible combinations for creating different fuzzy rules.

Table 4. Rules

No	Input			Output
	Initial Stock (x1)	Incoming Goods (x2)	Production (x3)	Final Stock
1	Few	Few	Few	Few

2	Few	Few	Moderate	Moderate
3	Few	Few	Many	Many
4	Few	Moderate	Few	Few
5	Few	Moderate	Moderate	Few
6	Few	Moderate	Many	Moderate
7	Few	Many	Few	Few
8	Few	Many	Moderate	Few
9	Few	Many	Many	Moderate
10	Moderate	Few	Few	Moderate
11	Moderate	Few	Moderate	Moderate
12	Moderate	Few	Many	Many
13	Moderate	Moderate	Few	Few
14	Moderate	Moderate	Moderate	Moderate
15	Moderate	Moderate	Many	Many
16	Moderate	Many	Few	Few
17	Moderate	Many	Moderate	Moderate
18	Moderate	Many	Many	Many
19	Moderate	Few	Few	Moderate
20	Many	Few	Moderate	Moderate
21	Many	Few	Many	Many
22	Many	Moderate	Few	Moderate
23	Many	Moderate	Moderate	Moderate
24	Many	Moderate	Many	Many
25	Many	Many	Few	Few
26	Many	Many	Moderate	Many
27	Many	Many	Many	Many

Fuzzy Sugeno Design

1. **Initial Stock Input Variable**

The input variable of initial stock, often referred to as the initial stock, is the amount of inventory or raw materials available before the production process begins (Fatwa et al., 2022). Initial stock is one of the essential input variables used to manage inventory optimally to meet production needs without significant shortages or surpluses (Yudha & Putri, 2024).

Initial stock serves as a key variable in inventory management systems, helping to balance supply and demand. In this context, pie companies need to ensure that the initial stock level is adequate to meet production requirements without stagnation due to excessive stock (Alim et al., 2023). If the initial stock is too low, the company may experience shortages of raw materials, potentially disrupting production. Conversely, if the initial stock is too high, there will be additional storage costs and the risk of losses due to expired products.

Based on initial stock input data for pie crusts obtained from a food industry producing pies, the minimum initial stock generated was 996 units, while the maximum was 1,153 units. This initial stock data range, from 996 to 1,153 units with a midpoint of 1,075 units, can be used as an input variable for initial stock. This range can then be applied to calculate fuzzy sets using the following formula.

Fuzzy logic can be applied to manage uncertainty in fluctuating market demand. This method enables more flexible decision-making in managing initial stock, allowing companies to adapt to changing market conditions (Zhang & Wang, 2024). For example, by using the Sugeno fuzzy logic approach, the "initial stock" input can be processed into a relevant fuzzy value, which can then be used for inference and defuzzification to produce a more accurate value.

$$\mu SEDIKIT\,[x_2] = \begin{cases} 1\,;\; x \le a \\ \dfrac{b-x}{b-a}\,;\; a \le x \le b \\ 0\,;\; x \ge b \end{cases}$$

$$\mu SEDANG\,[x_2] = \begin{cases} 0\,;\; x \le a \;atau\; x \ge c \\ \dfrac{x-a}{b-a}\,;\; a \le x \le b \\ \dfrac{c-x}{c-b}\,;\; b \le x \le c \end{cases}$$

$$\mu BANYAK\,[x_2] = \begin{cases} 0\,;\; x \le b \\ \dfrac{x-b}{c-b}\,;\; b \le x \le c \\ 1\,;\; x \ge c \end{cases}$$

This formula serves as the foundation for developing a fuzzy-based prediction system that can accommodate market demand uncertainty and fluctuations. The Sugeno fuzzy logic transforms the “Initial Stock” input into a fuzzy value, which is then processed using inference rules and defuzzified to produce an accurate value. Based on the obtained data, the value of “a” can be replaced with the minimum production value, which is 996 units, the value of “b” with the midpoint of production, which is 1,075 units, and the value of “c” with the maximum production value, which is 1,153 units. Thus, it can be applied in the set as follows.

$$\mu Sedikit[x_1] = \begin{cases} 1 & ;\; x \le 996 \\ \dfrac{1075-x}{1075-996} & ;\; 996 \le x \le 1075 \\ 0 & ;\; x \ge 1075 \end{cases}$$

$$\mu Sedang[x_1] = \begin{cases} 0 & ;\; x \le 996 \;or\; x \ge 1153 \\ \dfrac{x-996}{1075-996} & ;\; 996 \le x \le 1075 \\ \dfrac{1153-x}{1153-1075} & ;\; 1075 \le x \le 1153 \end{cases}$$

$$\mu Banyak[x_1] = \begin{cases} 0 & ;\; x \le 1075 \\ \dfrac{x-1075}{1153-1075} & ;\; 1075 \le x \le 1153 \\ 1 & ;\; x \ge 1153 \end{cases}$$

The calculated set values represent a membership function used to convert crisp data into fuzzy set data. This set value requires a triangular membership function, which acts as a curve to map input data points to membership values ranging from 0 to 1. For the “Initial Stock” variable, the triangular membership function can be constructed based on the domain obtained from the following table.

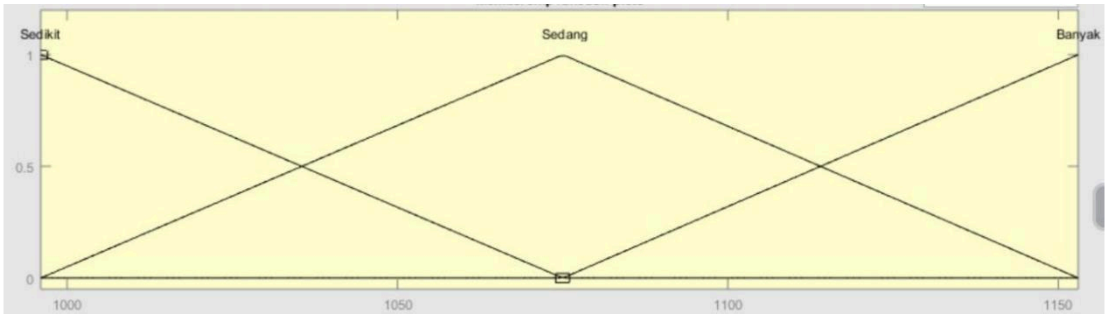

Figure 1 Membership function of the “Initial Stock” input variable

2. Production Input Variables

In determining the raw materials needed in the industry, production volume is key to ensuring the efficiency, quality, and sustainability of company operations. Incorrect production volume can lead to inefficiencies, uncertain or uncontrolled raw material inventory, and reduced marketing opportunities (Wicaksono et al., 2023). Production is an activity aimed at creating a product, whether a good or service, that will be used by consumers. To generate profit for an industry, an optimal production process is essential (Gustian & Gayatri, 2020). The number of products to be produced in an industry is determined by market demand and previous product inventory (Nasution & Prakarsa, 2020). Optimizing product production requires consideration of several factors, including market demand and previous product inventory. This optimization will have a positive impact on the subsequent production process (Priyo, 2017). By optimizing the production process, the need for raw materials becomes more efficient.

Based on pie crust production data obtained from a food industry producing pies, the minimum production output was 300 units, while the maximum was 1,579 units. This production data range, from 300 to 1,579 units with a midpoint of 940 units, can be used as a variable for initial production stock. This range can then be applied to calculate fuzzy sets using the following formula.

$$\mu SEDIKIT\ [x_2] = \begin{cases} 1\ ;\ x \le a \\ \frac{b-x}{b-a}\ ;\ a \le x \le b \\ 0\ ;\ x \ge b \end{cases}$$

$$\mu SEDANG\ [x_2] = \begin{cases} 0\ ;\ x \le a\ atau\ x \ge c \\ \frac{x-a}{b-a}\ ;\ a \le x \le b \\ \frac{c-x}{c-b}\ ;\ b \le x \le c \end{cases}$$

$$\mu BANYAK\ [x_2] = \begin{cases} 0\ ;\ x \le b \\ \frac{x-b}{c-b}\ ;\ b \le x \le c \\ 1\ ;\ x \ge c \end{cases}$$

The formula structured as above can be directly used to calculate fuzzy sets to determine the membership function for the "Production" variable. Based on the obtained data, the value of "a" can be replaced with the minimum production value, which is 300 units; the value of "b" with the midpoint of production, which is 940 units; and the value of "c" with the maximum production value, which is 1,579 units. Thus, it can be applied in the set as follows.

$$\mu SEDIKIT\ [x_2] = \begin{cases} 1\ ;\ x \leq 300 \\ \dfrac{940 - x}{940 - 300}\ ;\ 300 \leq x \leq 940 \\ 0\ ;\ x \geq 940 \end{cases}$$

$$\mu SEDANG\ [x_2] = \begin{cases} 0\ ;\ x \leq 300\ atau\ x \geq 1579 \\ \dfrac{x - 300}{940 - 300}\ ;\ 300 \leq x \leq 940 \\ \dfrac{1579 - x}{1579 - 940}\ ;\ 940 \leq x \leq 1579 \end{cases}$$

$$\mu BANYAK\ [x_2] = \begin{cases} 0\ ;\ x \leq 940 \\ \dfrac{x - 940}{1579 - 940}\ ;\ 940 \leq x \leq 1579 \\ 1\ ;\ x \geq 1579 \end{cases}$$

The set values obtained as above are used to determine the function and membership values to be applied. The membership function used is the triangular membership function, with membership values ranging from 0 to 1. Based on the obtained set, the triangular membership function for the "Production" variable is as follows.

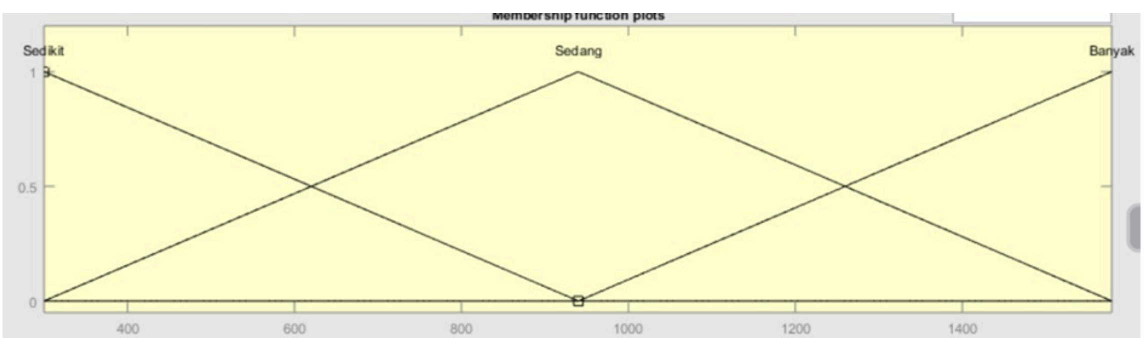

Figure 2 Membership function of the "Production" input variable

Once the membership values are converted into crisp inputs and an appropriate membership function is established, they will then be combined with predefined rules to obtain the desired output.

3. Input Variable Incoming Goods

The implementation of fuzzy logic on the input variable "Incoming Goods" aims to optimize the decision-making process in the inventory system by considering aspects of uncertainty and variability in the quantity of goods entering the warehouse. The determination of the membership function for the variable “Incoming Goods” is divided into three categories that represent actual conditions in the field: Low, Medium, and High.

Fuzzy Logic is an enhancement of Boolean logic that introduces the concept of partial truth, where classical logic states that everything can be expressed in binary terms (0 or 1, black or white, yes or no) (Setia & Ramadan, 2019). In its implementation, fuzzy logic allows systems to handle data uncertainty in a more natural manner, similar to human decision-making processes. The system can provide smoother and more adaptive responses to changes in input, resulting in more accurate and consistent outputs.

Based on the input data for the initial stock of pie crust obtained from one of the food industries producing pies, the minimum initial stock produced is 310 units, while the maximum is 1535 units. This initial stock can be used as an input variable for the initial stock, which lies within the range of 310 to 1535 units, with a midpoint value of 923 units. This range can then be used to calculate the fuzzy set using the following formula.

$$\mu SEDIKIT\ [x_2] = \begin{cases} 1\ ;\ x \le a \\ \dfrac{b-x}{b-a}\ ;\ a \le x \le b \\ 0\ ;\ x \ge b \end{cases}$$

$$\mu SEDANG\ [x_2] = \begin{cases} 0\ ;\ x \le a\ atau\ x \ge c \\ \dfrac{x-a}{b-a}\ ;\ a \le x \le b \\ \dfrac{c-x}{c-b}\ ;\ b \le x \le c \end{cases}$$

$$\mu BANYAK\ [x_2] = \begin{cases} 0\ ;\ x \le b \\ \dfrac{x-b}{c-b}\ ;\ b \le x \le c \\ 1\ ;\ x \ge c \end{cases}$$

The formulated equations can be directly used to calculate the fuzzy set in determining the membership function for the variable “Production.” Based on the obtained data, the value ￼ can be filled with the minimum production of 310 units, the value ￼ with the median production of 923 units, and the value ￼ with the maximum production of 1535 units. This equation serves as the foundation for developing a fuzzy-based prediction system capable of addressing uncertainties and fluctuations in market demand. By using Sugeno fuzzy logic, the input “Initial Stock” is converted into a fuzzy value, which is then processed through inference rules and defuzzified to generate accurate predictive values. Thus, it can be applied in the following sets.

$$\mu_{Sedikit}[x_3] = \begin{cases} 1 & ; x \le 310 \\ \frac{923 - x}{923 - 310} & ; 310 \le x \le 923 \\ 0 & ; x \ge 923 \end{cases}$$

$$\mu Sedang[x_3] = \begin{cases} 0 & ; x \le 310 \ or \ x \ge 1535 \\ \frac{x - 310}{923 - 310} & ; 310 \le x \le 923 \\ \frac{1535 - x}{1535 - 923} & ; 923 \le x \le 1535 \end{cases}$$

$$\mu_{Banyak}[x_3] = \begin{cases} 0 & ; x \le 923 \\ \frac{x - 923}{1535 - 923} & ; 923 \le x \le 1535 \\ 1 & ; x \ge 1535 \end{cases}$$

The calculated set values serve as the basis for the membership function, which is used to convert crisp data into fuzzy data. This set requires a triangular membership function, which acts as a curve to map input data points to membership values within the range of 0 to 1. Based on these set values, the triangular membership function is used as a reference to determine the function and membership values. For the variable “Incoming Goods,” this triangular membership function can be constructed with the domain obtained from the following table.

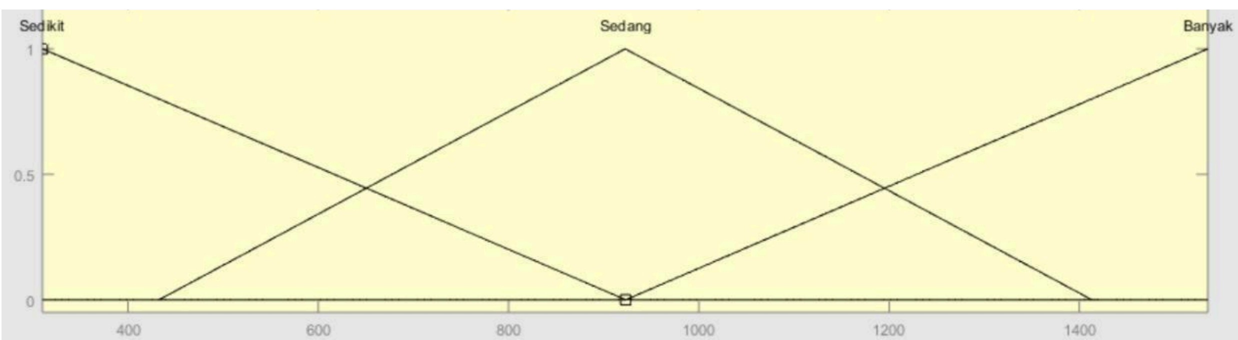

Figure 3 Membership function of the “Incoming Goods” input variable

4. Defuzzification

Defuzzification is a crucial process in fuzzy logic systems that aims to convert fuzzy values into crisp or real values. In the context of pie production, defuzzification assists in decision-making related to the quality, quantity, and types of raw materials used. For example, when determining the amount of ingredients such as flour, sugar, and others, pie producers can utilize fuzzy systems to capture uncertainties and variations in consumer preferences and production conditions. Thus, the defuzzification process yields results that are more accurate and aligned with real-world conditions (Mardiana *et al.*, 2021).

Commonly used defuzzification methods include centroid, bisector, and mean of maxima. In pie production, the centroid method is often chosen because it provides a more representative outcome of the resulting fuzzy values. For instance, when considering various pie flavors that consumers prefer, the fuzzy system can evaluate sales data and flavor preferences. The results of this evaluation are then defuzzified to determine which flavors should be produced in greater quantities, enabling producers to meet market demand more efficiently (Hidayati & Purwanto, 2020).

The application of defuzzification in pie production not only enhances production efficiency but also aids in the development of more innovative new products. By analyzing data and integrating the results of defuzzification, producers can create flavor combinations that align with market tastes and current trends. This is essential for maintaining competitiveness in the increasingly competitive food industry (Rizki *et al.,* 2022).

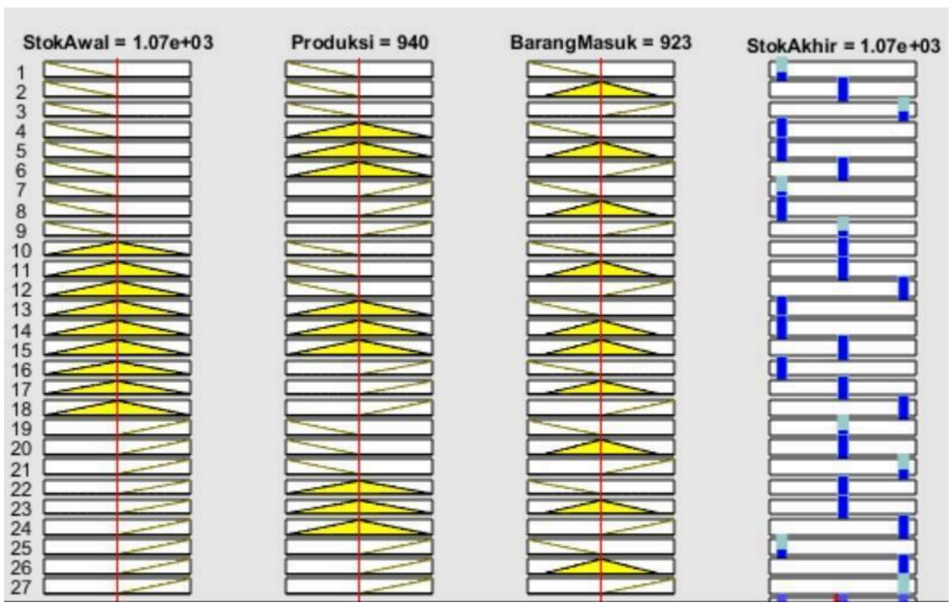

Figure 4 Defuzzification of the rules results

In the context of fuzzy logic systems, the surface of defuzzification results represents a crucial visualization that assists in understanding how fuzzy values translate into crisp outputs. This surface is typically generated by plotting the output values against varying inputs, which allows producers to observe the relationships and interactions between different factors involved in production processes. For example, in pie production, the surface can illustrate how changes in ingredient quantities (such as flour or sugar) affect the final output, such as the preferred flavor or quality rating of the pie. This visualization is not only useful for decision-making but also aids in identifying optimal production conditions and parameters that lead to the best possible outcomes (Davis & Thompson, 2021).

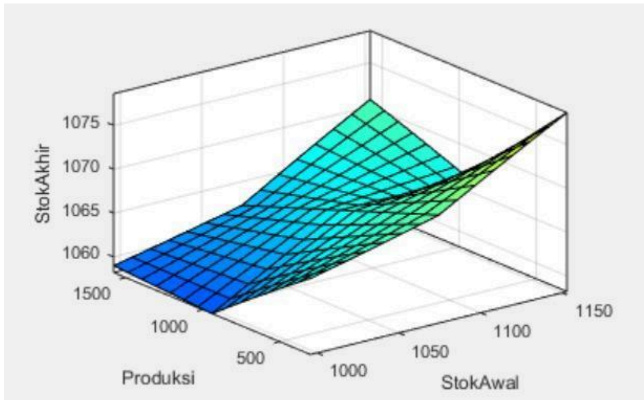

Figure 5 Surface of defuzzification results

Moreover, analyzing the surface of defuzzification results can provide insights into consumer preferences and market trends, enabling producers to adapt their strategies accordingly. By examining the contours of the surface, producers can pinpoint areas that represent high satisfaction levels or optimal ingredient combinations, facilitating targeted adjustments to recipes or production techniques. This data-driven approach can lead to more effective marketing strategies and product innovations, ensuring that offerings remain aligned with consumer desires and expectations. Ultimately, the surface of defuzzification results serves as a powerful tool for enhancing product quality and fostering competitiveness within the food industry (Garcia & Lee, 2023).

CONCLUSION

A deep understanding of how to manage raw material inventory in the food sector is the achievement and expected output of this experiment. The emphasis is on the application of Fuzzy Logic methods, specifically Fuzzy Sugeno. This method has proven effective in dealing with uncertainty and can enhance accuracy in stock projections. Utilizing this method allows companies to adapt more quickly to changes in market demand, ultimately reducing risks in inventory management. The implementation of fuzzy logic methods not only supports operational continuity and business stability but also demonstrates significant potential for improving efficiency and long-term profitability for companies. Therefore, this research encourages companies to continue developing and utilizing fuzzy-based systems in inventory management within the industry.

ACKNOWLEDGEMENT

Companies are expected to continue developing the available management systems by leveraging the latest and advanced technologies, including more sophisticated fuzzy algorithms. It is also important to provide training for employees to ensure they understand Fuzzy Logic methods, allowing for optimal results. Additionally, a gradual evaluation of the inventory management process is necessary to identify

areas that require improvement. Building good collaboration with suppliers will enhance the company's flexibility and its ability to respond to changes in market demand.

REFERENCES

Aisuwarya, N., & Annafi, S. 2017. 'Pendekatan Fuzzy Logic dalam Manajemen Persediaan Industri Pangan'. *Jurnal Teknologi Pangan*, 5(2), 22-29.

Alfiansyah, H., Hunusalela, Z. F., & Nadeak, T. E. Y. (2023). Pengoptimalan persediaan bahan baku Natur E DN revitalizing dengan metode fuzzy Mamdani dan algoritma Within Wagner pada PT Darya Varia Laboratoria. Jurnal Teknik Industri, 13(2).

Alim, M., Junaidi, D., & Rina, Y. 2023. 'Sistem Prediksi Permintaan Menggunakan Metode Fuzzy'. *Jurnal Sistem Informasi dan Teknologi*. 8(3), 78-90.

Anugrahwaty, L., & Azmy, R. 2017. 'Pengelolaan Persediaan Bahan Baku Berbasis Fuzzy Logic di Industri Pangan'. *Jurnal Sistem Informasi*, 8(1), 45-51.

Anton, P., & Gusrianty, M. 2023. 'Peran Pengelolaan Persediaan dalam Stabilitas Produksi Industri Pangan'. *Jurnal Manajemen Operasional*, 11(1), 102-109.

Atika, D. N., & Sukmono, T. (2024). Fuzzy logic optimizes global inventory management. Innovation in Industrial Engineering. https://doi.org/10.21070/IJINS.V25I2.1131

Azizah, N., & Fauziyah, D. 2020. 'Faktor Internal dalam Pengelolaan Persediaan Bahan Baku Industri Pangan'. *Jurnal Ilmiah Manajemen*, 13(3), 56-63.

Banaeian, N., Mobli, H., Fahimnia, B., Nielsen, I. E., & Omid, M. (2018). Green supplier selection using fuzzy group decision making methods: A case study from the agri-food industry. Computers & Operations Research, 89, 337-347. https://doi.org/10.1016/j.cor.2016.02.015

Besta, C. S., Kastala, A. K., Ginuga, P. R., & Vadeghar, R. K. (2013). MATLAB interfacing: Real-time implementation of a fuzzy logic controller. IFAC Proceedings Volumes, 46(32), 349-354.

Çunkas, M., & Aydoğdu, O. (2010). Realization of fuzzy logic controlled brushless DC motor drives using Matlab/Simulink. Mathematics and Computers in Simulation, 15(2), 218-229. https://doi.org/10.3390/mca15020218

Darmawi D. Y., Nurcahyo G. W., & Sumijan S. 2020. 'Fuzzy sistem fuzzy menggunakan metode sugeno dalam akurasi penentuan suhu kandang ayam pedaging'. *J Inf dan Teknol*. 3:72–77. doi:10.37034/jidt.v3i2.95.

Davis, J.., Thompson, R. 2021. Visualization Techniques for Fuzzy Logic Systems: Understanding Defuzzification Outputs. *Journal of Computational Intelligence in Engineering*. 29(4): 305-315.

Fadhli, A. 2022. 'Analisis Perencanaan Persediaan Bahan Baku Air Conditioner (Tube Assy) Menggunakan Metode Adaptive Neuro Fuzzy Inference System (ANFIS) Pada PT Pratika Nugraha Jaya'. *Scientific Journal of Industrial Engineering*, Vol. 3. https://jim.unindra.ac.id/index.php/sijie/article/download/5899/1293

Fatwa M., Rizki R., & Sriwinarty P., Supriyadi E. 2022. 'Pengaplikasian matlab pada perhitungan matriks'. *Papanda J Math Sci Res.* 1(2): 81-93. doi: 10.56916/pjmsr.v12.260.

Garcia, M, Lee, A. 2023. Consumer Preference Analysis Through Fuzzy Logic: Insights and Innovations in Food Production. *International Journal of Food Science and Technology*. 58(2): 175-185.

Gozali, Mohamad Imam. (2020). Sistem Pengambil Keputusan Menggunakan Fuzzy Sugeno untuk Menentukan Penyakit Obesitas Anak Usia 0 sampai 16 Tahun. Jurnal Teknologi dan Manajemen Informatika, 6(2), 90-96. https://jurnal.unmer.ac.id/index.php/jtmi

Gustian, D., & Gayatri, N. R. 2020. 'Penentuan Tingkat Produksi Barang Dengan Fuzzy Mamdani'. *Jurnal Rekayasa Teknologi Nusa Putra*, *6*(2), pp.1-9. https://doi.org/10.52005/rekayasa.v6i2.76.

Haque, M., & Sriani, L. 2023. 'Implementasi Fuzzy Logic untuk Pengelolaan Persediaan Bahan Baku'. *Journal of Industrial Management*, 14(1), 33-40.

Hidayati R., Purwanto H. 2020. Application of Fuzzy Logic in Quality Control of Pie Production. *Journal of Food Quality*. 43(2): 123-130.

Hilmansyah, R., & Hilpiah, A. 2019. 'Optimalisasi Pengelolaan Persediaan dalam Menyikapi Permintaan Pasar'. Jurnal Manajemen Persediaan, 7(3), 87-95.

Huang, H., Xu, H., Chen, F., Zhang, C., & Mohammadzadeh, A. (2023). An applied type-3 fuzzy logic system: Practical Matlab Simulink and M-files for robotic, control, and modeling applications. Symmetry, 15(2), 475. https://doi.org/10.3390/sym15020475

Irdayanti, F., *et al*. 2024. 'Penggunaan MATLAB dalam Implementasi Fuzzy Logic untuk Pengelolaan Persediaan'. *Jurnal Teknologi dan Informatika,* 10(2), 119-126.

Ismail, R., Surorejo, S., & Septiana, P. (2022). Systematic literature review: Penerapan metode fuzzy logic dalam sistem pakar. IJIR, 3(2), 47-53.

Kastina, W., & Silalahi, A. 2016. 'Efisiensi Manajemen Persediaan Bahan Baku di Industri Pangan'. *Jurnal Teknologi Industri Pangan*, 5(1), 42-48.

Mardiana R. Sari DA, Abdurrahman M. 2021. Fuzzy Logic for Decision Making in Food Production: A Case Study on Pie. *Food Science and Technology International*. 27(3): 240-250.

Maruwu, M. 2023. 'Pendekatan penelitian pendidikan: metode penelitian kualitatif, metode penelitian kuantitatif dan metode penelitian kombinasi (mixed method)'. *J Pendidikan Tambusai*. 7(1):2896-2910.

Mawardani, E., *et al*. 2022. 'Keunggulan Fuzzy Logic Sugeno dalam Prediksi Stok Industri Pangan'. *Jurnal Riset Teknologi Pangan*, 9(4), 208-215.

Mayasari, O., Nasution N. Y., & Goejantoro DR. 2018. 'Multi-attribute decision making with fuzzy technique for order preference by similarity to ideal solution method (FTOPSIS) (case study: financial ratios stock of building construction sector LQ45 Indonesia stock exchange'. *J EKSPONENSIAL*. 9(1):41–51.

Melfianora, M. 2019. Penulisan karya tulis ilmiah dengan studi literatur. *Open Science Framework,* 12(1):14-26.

Mittal, M., Jain, V., Pandey, J. T., Jain, M., & Dem, H. (2024). Optimizing inventory management: A comprehensive analysis of models integrating diverse fuzzy demand functions. Mathematics, 12(1), 70. https://doi.org/10.3390/math12010070

Muchtar, H., & Syamsur, R. A. (2020). Fuzzy logic pada sistem pendingin ruangan berbasis Raspberry. RESISTOR: Elektronika Kendali Telekomunikasi Tenaga Listrik Komputer, 4(2). e-ISSN: 2621-9700, p-ISSN: 2654-2684.

Muflihunna, R., & Mashuri, H. 2022. 'Metode Fuzzy Logic Sugeno untuk Keputusan Operasional'. *Jurnal Teknik Industri*, 15(2), 94-101.

Nasir, J., & Suprianto, J. (2017). Analisis fuzzy logic menentukan pemilihan motor Honda dengan metode Mamdani. Jurnal Edik Informatika, 3(2), 177-186. http://dx.doi.org/10.22202/jei.2017.v3i2.1962

Nasution, T., *et al*. 2022. 'Pengelolaan Persediaan Berbasis Fuzzy Logic dalam Menghadapi Dinamika Pasar'. *Jurnal Manajemen Teknologi*, 10(3), 153-160.

Nasution, V. M., & Prakarsa, G., 2020. 'Optimasi Produksi Barang Menggunakan Logika Fuzzy Metode Mamdani'. *Jurnal Media Informatika Budidarma*, *4*(1), pp.129-135. http://dx.doi.org/10.30865/mib.v4i1.1719.

Nisa, A. K., Abdyl, M., & Zaki, A. (2020). Penerapan fuzzy logic untuk menentukan minuman susu kemasan terbaik dalam pengoptimalan gizi. Journal of Mathematics, Computation, and Statistics, 3(1), 51-56. http://www.ojs.unm.ac.id/jmathcos

Nugroho, A., *et al*. 2023. Efektivitas Manajemen Persediaan untuk Produk Pangan yang Mudah Rusak. *Jurnal Logistik dan Distribusi*, 12(1), 18-25.

Pinem, Y., & Utomo, H. 2020. 'Pengaruh Faktor Eksternal Terhadap Persediaan Bahan Baku Industri Pangan'. *Jurnal Ekonomi dan Manajemen*, 9(2), 63-70.

Pradnyawati, N. P. J., Handarkho, Y. D., & Ardanari, P. (2023). Implementasi logika fuzzy metode Tsukamoto berbasis web untuk prediksi jumlah produksi jajan Banten. Jurnal Informatika Atma Jogja, 4(1), 9-16.

Priyo, W. T, 2017. 'Penerapan Logika Fuzzy Dalam Optimasi Produksi Barang Menggunakan Metode Mamdani'. *Jurnal Ilmiah Soulmath: Jurnal Edukasi Pendidikan Matematika*, *5*(1), pp.14-21. https://doi.org/10.25139/sm.v5i1.453.

Putra, Y., *et a*l. 2018. 'Implementasi MATLAB dalam Aplikasi Fuzzy Logic Sugeno untuk Manajemen Stok'. *Jurnal Rekayasa Sistem*, 7(1), 74-81.

Putri, N. N., Djatna, T., & Muslich. (2018). Adaptive neuro-fuzzy inference system (ANFIS) approach to raw material inventory control at PT XYZ. International Journal of Engineering and Management Research, 8(6), 220-225. https://doi.org/10.31033/ijemr.8.6.23.

Rizki A, Yanti A, Setiawan B. 2022. Innovation in Food Product Development Using Fuzzy Logic: A Focus on Pie Production. *International Journal of Culinary Science*. 10(1): 45-55.

Sihombing, F. A. 2024. 'Kajian fuzzy metode mamdani dan fuzzy metode sugeno serta implementasinya'. *Innov J Soc Sci Res*. 4(4):4940–4955.

Simon, D., *et al*. 2018. 'Model Fuzzy Logic Sugeno untuk Prediksi Permintaan Bahan Baku di Industri Pangan'. *Jurnal Teknologi Manajemen*, 8(3), 45-52.

Setia, B., & Ramadan, A. 2019. 'Penerapan Logika Fuzzy pada Sistem Cerdas'. *Jurnal Sistem Cerdas*, 2(1), 61-66.

Sitinjak, B. R., Panjaitan, B. A., Ram, A., & Andani, S. R. (2024). Penerapan metode fuzzy Sugeno dalam penentuan jumlah produksi minyak goreng (Studi kasus: Minyak goreng Fortune). Volume 2 No 2 Juni 2024, 2(2).

Sitio, Sartika Lina Mulani. (2018). Penerapan Fuzzy Inference System Sugeno untuk Menentukan Jumlah Pembelian Obat (Studi Kasus: Garuda Sentra Medika). Jurnal Informatika Universitas Pamulang, 3(2). ISSN 2541-1004.

Sonalitha, E., Sarosa, M., & Naba, A. (2015). Pemilihan pemasok bahan mentah pada restoran menggunakan metode fuzzy analytical hierarchy process. Jurnal EECCIS, 9(1), 49-54.

Susetyo, J., Oesman, T. I., Wibowo, A. H., & Aliffian, M. Y. (2020). Proposed control of raw material inventory in condition of not required with fuzzy Mamdani method in CV. Pinus Bag's Specialist. Journal of Engineering Design and Technology, 20(3), 167-175. http://ojs.pnb.ac.id/index.php/LOGIC

Umam, M. 2023 'Aspek Kuantitas dan Kualitas dalam Pengambilan Keputusan Manajemen Persediaan'. *Jurnal Manajemen Produksi*, 14(2), 77-83.

Wahab, F., Sumardiono, A., Al Tahtawi, A. R., & Mulayari, A. F. A. (2017). Desain dan purwarupa fuzzy logic control untuk pengendalian suhu ruangan. JTERA - Jurnal Teknologi Rekayasa, 2(1), 1-8. p-ISSN 2548-737X, e-ISSN 2548-8678.

Warmansyah, J., & Hilpiah, D. 2019. 'Penerapan metode fuzzy sugeno untuk prediksi persediaan bahan baku'. *Teknois J Ilm Teknol Inf dan Sains*. 9(2):12–20. doi:10.36350/jbs.v9i2.58.

Wicaksono, B., Febrianto, A., Monika, L., & Arifin, S. 2023. 'Sistem Pendukung Keputusan Jumlah Produksi Dengan Metode Fuzzy'. *JURIHUM: Jurnal Inovasi dan Humaniora*, *1*(1), pp.105-115.

Yudha, F. A., & Putri, R. A. 2024. 'Implementation of sugeno fuzzy logic methods for predicting pie crust raw material stock'. *J of Tech.* 8(1):1916-2581. doi: 10.31253/te.v8i1.3193.

Zhang, X., & Wang, Y. 2024. 'Fuzzy Logic in Supply Chain Management: A Review'. *International Journal of Production Economics*. 205: 114-127.