Chicken Weight Prediction in Close House Farm Using Fuzzy Method

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Abstrak

Peternakan ayam dengan sistem Close House merupakan kandang dengan sistem tertutup yang dilakukan pada peternakan modern yang memiliki tujuan untuk menyediakan suhu dan kelembaban ideal bagi ayam yang diternakkan. Dalam meningkatkan produksi ayam, perhitungan untuk mendapatkan bobot ayam yang ideal hanya menggunakan hitungan manual pada faktor-faktor yang mempengaruhi produktivitas ayam. Hal ini menyebabkan para peternak tidak dapat memprediksi bobot ayam saat masa panen. Oleh sebab itu diperlukan suatu teknik prediksi pada bobot ayam yang dapat meningkatkan produktivitas peternakan. Penelitian ini bertujuan untuk melakukan prediksi bobot ayam pada peternakan Close House menggunakan metode Fuzzy Logic dengan mengimplementasikan metode – metode Łukasiewicz. Data yang digunakan pada penelitian ini adalah faktor-faktor yang mempengaruhi bobot ayam diantaranya jumlah ayam yang masuk, bobot awal ayam, suhu kandang, kelembaban kandang, kuantitas air, kuantitas pakan, serta sirkulasi udara (kecepatan angin) dalam kandang. Hasil perhitungan fuzzy dengan metode Łukasiewicz terhadap faktor-faktor tersebut dapat digunakan untuk memprediksi boboy ayam saat masa panen dan sesuai bobot yang ditetapkan saat masa panen. Keakuratan nilai prediksi tersebut dengan uji Mean Absolute Percentage Error (MAPE) menunjukkan nilai 5.3981%. Disimpulkan bahwa perhitungan fuzzy dengan metode Łukasiewicz dapat digunakan untuk memprediksi bobot ayam saat masa panen.

Kata kunci*— Logika Fuzzy, Łukasiewicz, Peternakan Close House, Bobot Ayam*

Abstract

Chicken farms with a Close House system are one of a farm for chicken using closed system that are run on modern farms that aiming to provide the ideal temperature and humidity for chickens that are raised. In increasing chicken production, the calculation to get the ideal chicken weight only uses manual calculations on the factors that affect chicken productivity. This causes farmers to be unable to predict the weight of chickens at harvest. Therefor we need a predictive technique on chicken weight that can increase farm productivity. This proposed research aims to predict the weight of chickens on Close House farms using the Fuzzy Logic method by implementing the Łukasiewicz methods. The data used in this proposed research are factors that affect the weight of chickens such as the total of registered DOC (Day Old Chick) on farm, initial weight of DOC, temperature on farm, humidity on farm, water quantity, feed quantity, and air circulation (wind speed) on farm. The results of fuzzy calculations using the Łukasiewicz method on these factors obtained the appropriate weight values for chickens at harvest time and it fit to the determined weight at the harvest time. The accuracy of these predicition values using Mean Absolute Percentage Error (MAPE) is 5.3981%. It is concluded that fuzzy calculations using Łukasiewicz method can be used to predict the weight of chickens at harvest.

Keywords— *Fuzzy Logic, Łukasiewicz, Close House Farm, Chicken Weight*

1. INTRODUCTION

The Artificial Intelligence has been develop where it reached a phase that can assist in obtaining solutions to a problem in many fields. With the development of artificial intelligence and to support Indonesian Goverment Programs related to the Industiral Revolution 4.0, there is much more industries from various fields can take advantage of artificial intelligence. One area that is very likely to take advantage of the use of artificial intelligence is the livestock industry.

One of the benefit that can be applied using an Artificial Intelligence is using fuzzy algorithm on livestock industry. Fuzzy algorithm can be defined as a set of fuzzy instructions that executed to make approximate solution to a particular problem [1]. Fuzzy algorithm can be used to assist decision making, where it can help to solve problems by considering all data that requires decision based on the input. Fuzzy method also can be used to predict a problem, for example in a study entitled "Perancangan Aplikasi Fuzzy Logic untuk Prediksi Kasus Positif Covid-19 Mengguunakan Metode Tsukamoto" [2]. There is other study that use fuzzy to predict a problem entitled "Aplikasi *Fuzzy Logic* Memprediksi Intensitas Cahaya Lampu pada Kandang Ternak Ayam Broiler"[3]. Another study for predicting using fuzzy is "Fuzzy Model for Predicting Cloacal Temperature of Broiler Chickens" [4]. In livestock industry, fuzzy algorithm also can be used to predict the weight of animals, especially in this study is to predict chicken weight.

Chicken are one of the most widely bred poultry animals because they are easy to maintenance and the costs involved in raising chickens are lower than other livestock. Based on data from Statistics Indonesia [5], chickens is one of food commodity that most consumed in each province in Indonesia. Especially on broiler farms, livestock can be harvested relatively quickly compared to other livestock [6]. Therefore, chicken farming is a business that is very popular with many farmers because the demand for chicken consumption is quite high in Indonesia and the production period is releatively faster. In its maintenance, many farmers find it difficult to predict the weight of the chickens to be harvested because this is closely related to the amount of feed, feed quality, temperature in the close house, and the initial weight of the chickens. These constraints can cause difficulties for breeders to determine and improve the quality of chickens to be harvested. However, this problems can be solved by using fuzzy logic to predict chicken weight in order to produce the desired quality of chicken. According to the author, the fuzzy method is more suitable for calculating prediction of the chicken weight because there are incorrect data that can be tolerated by fuzzy logic. The fuzzy method was also chosen because it is able to model expert experience without having to go through a training process, so it is considered more suitable for the prediction needs of chicken weight.

The needs for breeders to predict the weight of chickens is closely related to optimizing the existing needs of the farm, therefore the author felt the need to conduct this study so farmer can minimize the cost of farm in every production period.

2. METHODS

For this research, some requirment are analyzed for gathering any information that used for calculating chicken weight at harvest time. These information are gathered from the record of some production period of Closed House Farm at Jenderal Soedirman University. In one period can be divided into 3 categories for every 10 day for accurate result because in every 10 day there was some different rule to implement into Fuzzy. Input variable that used in Fuzzy method collected from farm condition in every period where it can be affect the weight of chicken. Rule used in this research was gathered from expert who is lecturer from Faculty of Animal Husbandry in Jenderal Soedirman University that responsible for Close House Farm.

The results from expert and informations from record of production periods, input variable can be obtained from farm conditions on each production period such as amount of DOC (Daily old chicken), DOC weight, amount of feed, amount of water used, room temperature,

humidity, and wind velocity in farm. Output data for this fuzzy is the weight of chicken at harvest time. For fuzzy classification in each input and output variable can be divided into three classification: low, medium, and high. For sample data was gathered from recording of six production periods. For input proces, fuzzy set created from input variable and each domain obtained base on observation and pattern grouping of values for each variable from observations and and intervies with livestock managers on Jenderal Soedirman University's Close House Farm.

In general for this fuzzy system, the work flow can be describe using flowchart that shown in Figure 1.

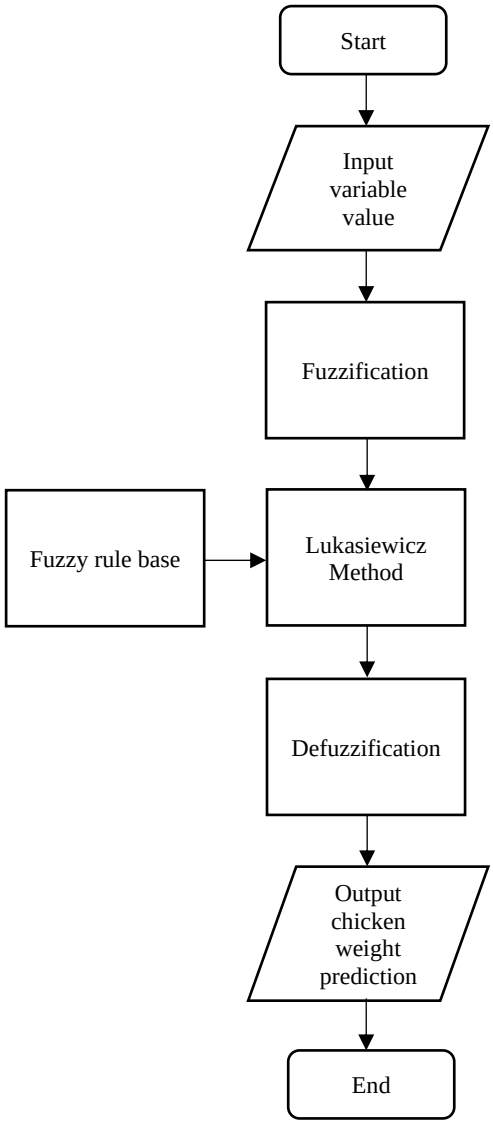

Fig. 1 Lukasiewicz's Method Flowchart

Based on Fig. 1, this fuzzy system begin by inserting input value. There are seven input variable to input which are amount of DOC (Daily old chicken), DOC weight, amount of feed, amount of water used, room temperature, humidity, and wind velocity. Then the system transform input variables into fuzzy sets using fuzzification. Then using Lukasiewicz's method, implication can be done by implement those fuzzy sets using fuzzy rules that was made before. After impllication has been calculated then using deffuzification to calculate prediction value of chicken weight.

Using Lukasiewicz's method, output process is a process that carried out after the process of drawing conclusions that was characterized by the defuzzification stage to produce crisp values from several fuzzy output evaluation results from the rule base. Fuzzy Lukasiewicz can be written using (1)[7].

$$\mu_{QL}(x,y) = \min[1,1 - \mu_{FP1}(x) + \mu_{FP2}(y)] \quad (1)$$

In (1) the variable $\mu_{FP1}(x)$ is for varibale input and $\mu_{FP2}(y)$ is for variable output. While the result of $\mu_{QL}(x,y)$ is always less than or equal to 1 then it can be simplify into (2).

$$\mu_{QL}(x,y) = (1 - \mu_{FP1}(x) + \mu_{FP2}(y)) \quad (2)$$

For Lukasiewicz's method there are some basic operation like algebraic product operator(3), algebraic sum operator(4) and negation operator(5).

$$\mu(_{A\cap B}) = \mu_A[x] \,.\, \mu_B[y] \quad (3)$$

$$\mu(_{A\cup B}) = \mu_A[x] + \mu_B[y] - \mu_A[x] \,.\, \mu_B[y] \quad (4)$$

$$\mu_{A'(x)} = 1 - \mu_A[x] \quad (5)$$

Algebraic product operator is using when each variables from the rules connected by AND connector. Algebraic sum operator is using when each variables from the rules connected by OR connector. Negation operation is using when each variables from the rules connected by NOT connector.

Inference system have basic elements there are rule base, inference engine, fuzzyfication and defuzzyfication [8]. Rule base for this research was determined from discussion with expert. For inference engine is using Generalized Modus Ponens (GMP) that can be written using (6).

$$\mu B'(x) = \sup_{X \in U} t(\mu A'(x),(\mu A \rightarrow B(x,y)) \quad (6)$$

While in this inference engine, on implication $(\mu A \rightarrow B(x,y))$ can be writen in clasical logic that can be written using (7).

$$\mu_{FR}(\bar{x},\bar{y}) = s(c(\mu_{\bar{A}}(\bar{x})), \mu_{\bar{B}}(\bar{y})) \quad (7)$$

The $\mu_{\bar{A}}(\bar{x})$ in (7) is a fact while $\mu_{\bar{B}}(\bar{y})$ is a result from fuzzy rule that using fuzzy implication process. So the inference engine then can be written using (8).

$$\mu B'(x) = \sup_{X \in U} t(\mu A'(x),(\mu_{FR}(\bar{x},\bar{y})) \quad (8)$$

After all inference for every rule gathered then combining those inference values for each rule using composite inference to obtain a combined value of fuzzy rules with membership functions using (9).

$$\mu_{FR\ combined}(\bar{x},y) = s(\mu_{FR1}(\bar{x},y), \mu_{FR2}(\bar{x},y), \mu_{FR3}(\bar{x},y),..) \quad (9)$$

Then for gather final result of prediction value is using defuzzification. Defuzzication method on this study using centroid method Centroid method can be written using (10)[9].

$$z^* = \frac{\int_z z\mu(z)dz}{\int_z \mu(z)dz} \quad (10)$$

Crisp solution obtained using center point (*z) in fuzzy area. In this research, inference engine and defuzzification is calculated as much as the long from coordinate in fuzzy variable output for every rule.

After the component for calculating solution has been defined, the next process is define prototype data for prediction value. Prediction value can be obtained from latest production period in closed house farm. For data testing on this research is using several production period so the solution can be more accurate.

The implementation for this research, first step is obtaining value of input variables on every 10 days in 1 production period. Even the data on every production period was recorded daily, the data for this research is average value for every input variable for every 10 days. In one production period minimum take 30 days for DOC to grow so there will be 3 group of data for every 10 days. After input variable value collected then fuzzy calculation for predicting Final chicken weight (FCW) can be started. There are 3 iteration for every 10 days to calculate the prediction then for the final prediction it calculated by take the average from those 3 iteration. The average result then will be error from actual final weight using Mean Absolute Persentage Error (MAPE). MAPE is a method that used to calculate the accuracy of a prediction[10] that can be written using (11)[11].

$$\text{MAPE} = \frac{100}{n}\sum_{t=1}^{n}\left|\frac{At - Ft}{At}\right| \quad (11)$$

Based on (9), At is real value while Ft is prediction value. The smaller precentage of error in MAPE, the more accurate the predicted value will be. MAPE interpretation if less than 10% then it is a high accurate value, 11 - 20% then it is a good accurate value, 21 - 50% then it is a reasonably accurate value, and more than 51% then it is an inaccurate value [12]. In this research, for calculating error in MAPE is use 6 data from actual production period.

3. RESULTS AND DISCUSSION

In this research, data for variables that was collected from closed house farm then be modified into fuzzy domain. Fuzzy domain for 7 variables input, 1 variable output and rules from those variables on each categories is determined from discussion with expert. The result for fuzzy domain can be seen in these table.

TABLE I
INPUT AND OUTPUT VARIABLES

Variable	Set of Fuzzy	Support	Unit
Amount of DOC	Low	[17000,20000]	chickens
	Medium	[18500,21500]	
	High	[20000,23000]	
DOC Weight	Low	[16,28]	gram
	Medium	[27,39]	
	High	[38,50]	
Amount of Feed	Low	[45000,60000]	kg
	Medium	[52500,67500]	
	High	[60000,75000]	
Amount of Water Used	Low	[75000,100000]	liter
	Medium	[87500,112500]	
	High	[100000,125000]	
Room Temperature	Low	[27,32]	°C
	Medium	[29.5,34.5]	
	High	[32,37]	
Humidity	Low	[45,60]	%
	Medium	[52.5,67.5]	
	High	[60,75]	
Wind Velocity	Low	[0,2]	m/s
	Medium	[1,3]	
	High	[2,4]	

Final Chicken Weight	Low	[2000,2250]	gram
	Medium	[2125,2375]	
	High	[2250,2500]	

Based on table I, those variables was choosen because it can affect chicken weight. Even the condition inside farm can affect chicken weight like Room Temperature, Humidity, and Wind Velocity. If those 3 variables not suit for the chicken it can affect the final chicken weight. For every variable there are 3 set of fuzzy membership. As shown in Table I, the variable of Amount of DOC has Universe of Discourse (UoD) [17000,23000]. The variable of DOC Weight has UoD [16,50]. The variable of Amount of Feed has UoD [45000,75000]. The variable of Amount of Water Used has UoD [75000,125000]. The variable of Room Temperature has UoD [27,37]. The variable of Humidity has UoD [45,75]. The variable of Wind Velocity has UoD [0,4]. The variable of Final Chicken Weight has UoD [2000,2500]. For all of variable are using the combination between left sided trapezoidal fuzzy, triangular fuzzy membership and right sided trapezoidal fuzzy.

Next step is determine fuzzy rule that had been discussed with expert. The result was there are 27 rules from each 10 days which total are 81 rules to be implemented in this fuzzy calculation. For these rules can be shown in Table II, Table III and Table IV.

TABLE II
FUZZY RULES FIRST 10 DAYS

Amount of DOC	DOC Weight	Amount of Food	Amount of Water Used	Room Temperature	Humidity	Wind Velocity	Final Chicken Weight
High	High	High	High	High	Medium	Medium	High
High	High	High	High	Medium	Medium	Medium	Medium
High	High	High	High	Low	Medium	Medium	Low
Medium	Medium	Medium	Medium	High	Medium	Medium	Medium
Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
Medium	Medium	Medium	Medium	Low	Medium	Medium	Low
Low	Low	Low	Low	High	Medium	Medium	Low
Low	Low	Low	Low	Medium	Medium	Medium	Low
Low	Low	Low	Low	Low	Medium	Medium	Low
High	High	High	High	High	High	High	High
High	High	High	High	Medium	High	High	Medium
High	High	High	High	Low	High	High	Low
Medium	Medium	Medium	Medium	High	High	High	Medium
Medium	Medium	Medium	Medium	Medium	High	High	Medium
Medium	Medium	Medium	Medium	Low	High	High	Low
Low	Low	Low	Low	High	High	High	Low
Low	Low	Low	Low	Medium	High	High	Low
Low	Low	Low	Low	Low	High	High	Low
High	High	High	High	High	Low	Low	Medium
High	High	High	High	Medium	Low	Low	Low
High	High	High	High	Low	Low	Low	Low
Medium	Medium	Medium	Medium	High	Low	Low	Medium
Medium	Medium	Medium	Medium	Medium	Low	Low	Low
Medium	Medium	Medium	Medium	Low	Low	Low	Low
Low	Low	Low	Low	High	Low	Low	Low
Low	Low	Low	Low	Medium	Low	Low	Low
Low	Low	Low	Low	Low	Low	Low	Low

TABLE III
FUZZY RULES SECOND 10 DAYS

Amount of DOC	DOC Weight	Amount of Food	Amount of Water Used	Room Temperature	Humidity	Wind Velocity	Final Chicken Weight
High	High	High	High	High	Medium	Medium	Medium
High	High	High	High	Medium	Medium	Medium	High
High	High	High	High	Low	Medium	Medium	Medium
Medium	Medium	Medium	Medium	High	Medium	Medium	Low

Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
Medium	Medium	Medium	Medium	Low	Medium	Medium	Medium
Low	Low	Low	Low	High	Medium	Medium	Low
Low	Low	Low	Low	Medium	Medium	Medium	Low
Low	Low	Low	Low	Low	Medium	Medium	Low
High	High	High	High	High	High	High	Medium
High	High	High	High	Medium	High	High	High
High	High	High	High	Low	High	High	Low
Medium	Medium	Medium	Medium	High	High	High	Low
Medium	Medium	Medium	Medium	Medium	High	High	Medium
Medium	Medium	Medium	Medium	Low	High	High	Medium
Low	Low	Low	Low	High	High	High	Low
Low	Low	Low	Low	Medium	High	High	Low
Low	Low	Low	Low	Low	High	High	Low
High	High	High	High	High	Low	Low	Low
High	High	High	High	Medium	Low	Low	Medium
High	High	High	High	Low	Low	Low	Low
Medium	Medium	Medium	Medium	High	Low	Low	Low
Medium	Medium	Medium	Medium	Medium	Low	Low	Medium
Medium	Medium	Medium	Medium	Low	Low	Low	Low
Low	Low	Low	Low	High	Low	Low	Low
Low	Low	Low	Low	Medium	Low	Low	Low
Low	Low	Low	Low	Low	Low	Low	Low

TABLE IV
FUZZY RULES THIRD 10 DAYS

Amount of DOC	**DOC Weight**	**Amount of Food**	**Amount of Water Used**	**Room Temperature**	**Humidity**	**Wind Velocity**	**Final Chicken Weight**
High	High	High	High	High	Medium	Medium	Low
High	High	High	High	Medium	Medium	Medium	Medium
High	High	High	High	Low	Medium	Medium	High
Medium	Medium	Medium	Medium	High	Medium	Medium	Low
Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
Medium	Medium	Medium	Medium	Low	Medium	Medium	Medium
Low	Low	Low	Low	High	Medium	Medium	Low
Low	Low	Low	Low	Medium	Medium	Medium	Low
Low	Low	Low	Low	Low	Medium	Medium	Low
High	High	High	High	High	High	High	Low
High	High	High	High	Medium	High	High	Medium
High	High	High	High	Low	High	High	High
Medium	Medium	Medium	Medium	High	High	High	Low
Medium	Medium	Medium	Medium	Medium	High	High	Low
Medium	Medium	Medium	Medium	Low	High	High	Medium
Low	Low	Low	Low	High	High	High	Low
Low	Low	Low	Low	Medium	High	High	Low
Low	Low	Low	Low	Low	High	High	Medium
High	High	High	High	High	Low	Low	Low
High	High	High	High	Medium	Low	Low	Low
High	High	High	High	Low	Low	Low	Low
Medium	Medium	Medium	Medium	High	Low	Low	Low
Medium	Medium	Medium	Medium	Medium	Low	Low	Low
Medium	Medium	Medium	Medium	Low	Low	Low	Low
Low	Low	Low	Low	High	Low	Low	Low
Low	Low	Low	Low	Medium	Low	Low	Low
Low	Low	Low	Low	Low	Low	Low	Low

Based on Table II; Table III; and Table IV, the final chicken weight was strongly affected by condition in farm which are Room Temperature; Humidity; and Wind Velocity. Although the other rules still significantly affecting the result like amount of DOC that can be affecting the grow of their weight because if the amount of doc was exceed the limit of farm then it can make the farm over populated by DOC then the room temperature become too hot for DOC to grow.

After fuzzy rules obtained then perform implication function to predict the weight. Given in one production period on first ten day there is a condition in farm with variable value as follows:

a. Amount of DOC : 21000
b. DOC weight : 44.3 gr
c. Amount of food : 72650 kg
d. Amount of water use : 106000 liter
e. Room temperature : 33 ºC
f. Humidity : 63 %
g. Wind velocity : 1.016 m/s

those variable value then used to calculated the fuzzy value by implement it into rules on the Table II.

Based on fuzzy implication using classic logic then it used to calculate for each coordinate length of the domain of Final chicken weight variable that based on Table I then it calculate 501 times from value 2000 into value 2500. Then fuzzy implication continues to next rules with the same way with R1 before. The results of calculating the implication function of each rule contained int the first 10 days are then inferred using Generalized Modus Ponens. The Inference for each rule using the same way like fuzzy implication that it calculated for each coordinate length of the domain of Final chicken weight variable. After all inference for every rule gathered then combining those inference values for each rule .

The result of combining inference values is a single fuzzy set that shown at Figure 2.

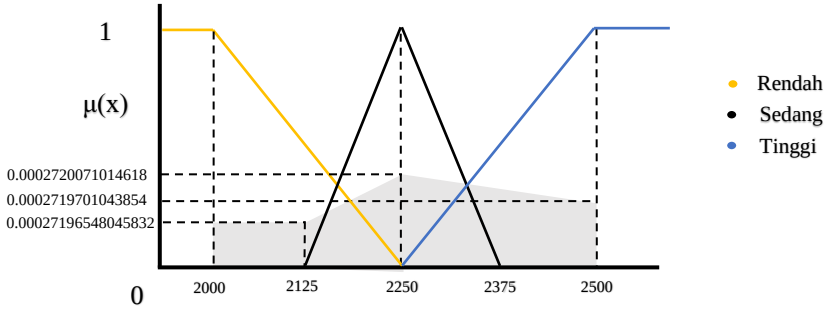

Fig. 2 Area of combined inference values on Final chicken weight value

Based on Fig. 2, the value of inference value at coordinate 2000 is 0.01254302838643 then it increase until coordinate 2500.

Next step is calculating defuzzification from inference value. After we got every value of inference for every coordinate, then calculating defuzzification from each final chicken weight coordinate using (10). After defuzzification value from each coordinate is obtained then combine all the value from each coordinate. The defuzzification result for first ten days from combined value of each coordinate is 2250.0006913754.

After all this was just calculating for first ten day, and we need to calculate the rest for second ten days and third ten days using the same method and formula with different rules for each category of ten days. For second and third ten days, there is some different variable value for room temperature; humidity; and wind velocity because those variable are changing because the farm condition is changed due to make chicken feels comfort and reduces the possibility of chickens becoming stressed and dead. Defuzzification result for second ten days is 2249.99859627 and defuzzification result for third ten days is 2251.1703537585. After we have defuzzification value for each ten days then we calculate the average of it so the value of final chicken weight prediction from one period is 2250.389880468 gram.

For this research, the data collected from farm was six period for comparing the actual final chicken weight with predicted value for each period. List of the comparison between prediction result an actual weight for each period can be seen in Table V.

TABLE V

PREDICTION VALUE AND ACTUAL WEIGHT

Period	First ten days prediction	Second ten days prediction	Third ten days prediction	Average prediction	Actual weight
12	2250.0006913754	2249.99859627	2251.1703537585	2250.389880468	2430
13	2249.9999353017	2249.9990831564	2250.6168353012	2250.2052845864	2042
14	2249.9682522817	2250.0567169078	2250.7182500469	2250.2477397455	2240
15	2250.0076098098	2250.0522916022	2250.1655528899	2250.075151434	2160
16	2250.0019742075	2250.0016999221	2250.1389752437	2250.0475497911	2160
17	2249.9999805012	2249.9978535568	2251.9845458749	2250.660793311	2100

Based on Table V, seems that the prediction value is different with actual weight. To calculate how much error percentage for this research using MAPE on six period. The result of MAPE on six period is 5.39812039179551841299360033938 or 5.3981% if the value rounded. Based on [11], the value of MAPE is in high accurate value category because the error is still less than 10%.

IV. CONCLUSION

Fuzzy Lukasiewicz method can be used to solving the prediction of final chicken weight on each period using farm condition as a variable. There are seven variable input to calculate the prediction of final chicken weight. For each period to calculating final chicken weight prediction is divided into three categories which is first ten day, second ten day and third ten day because the condition in farm is changing in each ten day that affect the development of chickens especially chicken's weight. For each category there was 27 rules that used to calculate the fuzzy prediction and its different output for each category despite the composition of rule is same. Test has been done in several period of production shows that the result of fuzzy prediction for each period has low percentage error that calculated using MAPE which is 5.3981%. While MAPE shown highly accurate, comparing the prediction result with actual wegiht is still high in difference.

Further research can be done by adding variable that affect chicken weight such as health condition of the chicken, death rate of the chicken and so forth. Further research also can be done by optimizing rules so the prediction result will be more accurate.

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