THE USE OF THE FUZZY INFERENCE SYSTEM IN DETERMINING THE QUALITY OF GOATSKIN AS RAW MATERIAL FOR THE LEATHER INDUSTRY

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ABSTRACT. Leather products are affected by the quality of the raw hide, the pre-treatment, and the tanning process. Furthermore, some leather products use quality goatskins with the right determination as raw materials. This study aims to determine the quality of goatskin through the use of Fuzzy Logic science. It was conducted using the Sugeno Fuzzy Inference System (FIS), while data analysis was carried out through the Matlab R2018a program. The criteria for using this method were the factors that affected the quality of raw goatskin such as thickness, length of the backline, skin area, number of scratches on the skin, number of holes, presence of boils, lice bumps, and hair loss. The results of the analysis showed that Sugeno FIS could be used to help determine the quality of goatskin with a good accuracy level with a MAPE value of 18%. Furthermore, the FIS method could be used as an appropriate modeling system for determining the quality of goatskin as a raw material for the leather tanning industry.

KEY WORDS: expert decision, quality of goatskin, tanning industry

UTILIZAREA SISTEMULUI DE INFERENȚĂ FUZZY PENTRU A DETERMINA CALITATEA PIEILOR DE CAPRĂ CA MATERIE PRIMĂ PENTRU INDUSTRIA DE PIELĂRIE

REZUMAT. Produsele din piele sunt afectate de calitatea pielii brute, de procesul de pre-tratare și de procesul de tăbăcire. În plus, unele produse din piele folosesc ca materie primă piei de capră a căror calitate înaltă a fost confirmată. Acest studiu își propune să determine calitatea pielii de capră prin utilizarea sistemului cu logică Fuzzy. Acesta a fost realizat folosind sistemul de inferență fuzzy Sugeno (FIS), în timp ce analiza datelor a fost efectuată cu ajutorul programului Matlab R2018a. Criteriile de utilizare a acestei metode au fost factorii care au afectat calitatea pielii brute de capră, cum ar fi grosimea, lungimea șirei spinării, segmentul pielii, numărul de zgârieturi pe piele, numărul de găuri, prezența furunculelor, a mușcăturilor de păduchi și pierderea părului. Rezultatele analizei au arătat că sistemul de inferență fuzzy Sugeno ar putea fi utilizat pentru a determina calitatea pielii de capră cu un nivel de acuratețe bun, cu valoarea MAPE de 18%. Mai mult, metoda FIS ar putea fi utilizată ca un sistem de modelare adecvat pentru determinarea calității pielii de capră ca materie primă pentru industria de pielărie.

CUVINTE CHEIE: decizie pe baza analizei experților, calitatea pielii de capră, industria de pielărie

L'UTILISATION DU SYSTÈME D'INFÉRENCE FLOUE POUR DÉTERMINER LA QUALITÉ DE LA PEAU DE CHÈVRE EN TANT QUE MATIÈRE PREMIÈRE POUR L'INDUSTRIE DU CUIR

RÉSUMÉ. Les produits en cuir sont affectés par la qualité du cuir brut, le prétraitement et le processus de tannage. De plus, certains produits en cuir utilisent des peaux de chèvre comme matières premières avec la confirmation de leur haute qualité. Cette étude vise à déterminer la qualité de la peau de chèvre grâce à l'utilisation du système de la logique floue. Elle a été réalisée à l'aide du système d'inférence floue Sugeno (FIS), tandis que l'analyse des données a été effectuée via le logiciel Matlab R2018a. Les critères d'utilisation de cette méthode ont été les facteurs qui affectent la qualité de la peau de chèvre brute, tels que l'épaisseur, la longueur de la moelle épinière, la zone de la peau, le nombre d'égratignures sur la peau, le nombre de trous, la présence de furoncles, les piqures de poux et la perte de cheveux. Les résultats de l'analyse ont montré que Sugeno FIS peut être utilisé pour aider à déterminer la qualité de la peau de chèvre avec un niveau de précision bon, avec une valeur MAPE de 18 %. En outre, la méthode FIS pourrait être utilisée comme système de modélisation approprié pour déterminer la qualité de la peau de chèvre en tant que matière première pour l'industrie du tannage du cuir.

MOTS-CLÉS : décision d'expert, qualité des peaux de chèvre, industrie du tannage

INTRODUCTION

The business processing system in the livestock industry has entered the digital era with the aim of increasing the use of technology. One of the technological improvements is on the part of the quality grouping system. This process must be carried out by the industry on a regular basis and needs to be carried out by industry players so that productivity can be achieved. However, sometimes the manual process cannot be carried out quickly due to the limitations of experts who select the quality of raw materials. This can have an impact on the quality and time in the process in the industry. On the other hand, technological developments and methods that continue to develop are very helpful for tanning industry players in carrying out the grading work to determine the quality of goatskin before the tanning process is carried out.

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Cattle hides have high economic value compared to other livestock by-products. Thus, this is the only livestock by-product still being exported by Indonesia. The number of exports to countries such as China, Hong-Kong, Italy, and Germany in 2015-2019 reached 5,500 tons. Meanwhile, these hides are exported in the form of non-food products, namely as raw materials for the leather tanning industry. Tanning treatment improves skin properties and increases its strength and flexibility.

The quality of the rawhides for tanning raw materials reduces when the skin is removed from the livestock's body. Moreover, this quality is influenced by the treatment before and during tanning, and at the time of processing [1chrome hydroxide was converted to chrome sulfate as tanning agent by addition of concentred sulfuric acid. Cr2O3 content of chrome sulfate was determined before being used for tanning. The result showed that Cr2O3 content was 3958.6 mg/l. Variation of recovered chrome sulfate concentrations for tanning jacket leather were 25, 50, 75 and 100% respectively. Controls were made with the use of 100% of industrial grade chrome sulfate. The best result were goat jacket leather tanned with recovered chrome of 75 and 100 % for its physical properties and 25% for its chemical properties. Test results of SEM showed that chrome was morphologically presence in tanned goat leather mass.","container-title":"Majalah Kulit, Karet, dan Plastik","DOI":"10.20543/mkkp.v31i2.176","ISSN":"18296971, 24604461","issue":"2","journalAbbreviation":"MKKP","language":"id","page":"107-114","source":"DOI.org (Crossref]. Factors that affect the quality of goatskin include thickness, backline length, skin area, scratches on skin, holes on skin, scars, tick and lice lumps, flea spots, and hair loss. Leather tanning is a method used to prevent skin degradation due to putrefactive bacteria, by mixing raw leather with tanning material [2].

A method used to determine the quality of rawhides is the Fuzzy Inference System (FIS) [3]. Moreover, Starkey *et al*. [4] stated that this system could be used to solve the problem of data and modeling uncertainty and optimize various objectives. FIS is a computational framework used to analyze systems that have a level of uncertainty in determining the numbers and limits of each factor for decision making [3]; Sitio [5] also stated that Fuzzy logic is capable of generating inputs and outputs without neglecting existing factors. Fuzzy logic could be applied as a problem-solving control system methodology applied to a system [6]. While according to Mukaromah [7], FIS is based on three components, namely basic concepts, databases, and reasoning mechanisms. Research related to the application of FIS for various needs including [8, 9], etc.

Previously, determination of skin quality was carried out manually, hence the process was deemed less efficient. Moreover, measuring the quality of goatskin is an important part of the raw material or leather tanning process, however, the this was still carried out manually, and was considered slow and imprecise. Therefore, this research aims to determine the quality of the skin using the Sugeno Fuzzy method because Sugeno FIS improves the weaknesses of a pure Fuzzy system by adding a simple mathematical calculation such as THEN. In this change, the fuzzy system has a Weighted Average Value in the IF-THEN fuzzy rules section [5]. The purpose of this study is to obtain the appropriate method for the precise and quick determination of quality of rawhides goatskin compared to the manual method.

EXPERIMENTAL

This study used salt-preserved goatskin from the Regional Technical Implementation Unit (UPTD) for leather processing in West Sumatra, Indonesia. The skin used is 100 samples which will be assessed by the expert and after being assessed by the expert, it is followed by the FIS method. It also implemented the FIS method developed by Sugeno, which is now referred to as the Sugeno method and was cited by Setiawan *et al*. [10]. The software used was the Matlab R2018a Tool Box. Fuzzy logic is the most suitable way to map an input space into an output space [11] and can be expressed in binary terms [12].

According to experts, the quality of goat skin is determined manually according to the custom in determining the quality of the skin. Experts are people who work in the leather tanning industry with more than 20 years of experience. Skin measurements were made using a roller measuring 80 cm. This size is used

as a reference that the skin with a size of ≥80 cm is Quality 1. If goat skin has a size of less than 80 cm, then it is classified as Quality 2, Quality 3 and Reject. The quality assessment is also combined with the level of damage to the skin such as the surface of the goat skin damaged by ticks, hair loss and the size of the holes in the skin.

Sugeno FIS Logic

Fuzzy Sugeno is represented in the form of IF-THEN, and the system output is a constant or linear equation [11]. Sitio [5] states that the typical fuzzy rules in the Sugeno fuzzy model are formed: when x is A and y is B then z = f (x, y), where A and B are fuzzy sets in antecedents and z = f (x, y) function decisively in consequence. When f (x, y) is a first-order polynomial, the resulting FIS is called the first-order Sugeno fuzzy model. Furthermore, when f is constant, a zero-order Sugeno fuzzy model is generated. This fuzzy inference system has characteristics, which consequently are not part of a fuzzy set, but form a linear equation with data on the quality characteristics of goatskin according to the input criteria. This study used several variables that determine the quality of goatskin such as thickness, backline length, skin area, scratches on skin, holes on skin, scars, tick and lice lumps, flea spots, hair loss The following is the Figure 1 flow diagram of the fuzzification process.

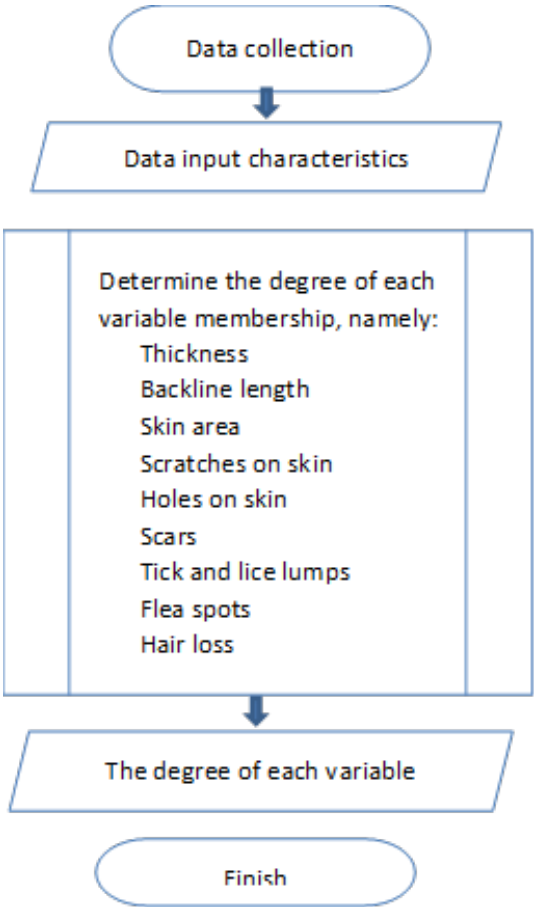

Figure 1. Flowchart of the fuzzification process

Fuzzification Process

After determining the variable membership function, a fuzzy logic rule is formed based on the existing data. In Table 1, the parameters, fuzzy and domain sets are shown for analyzing data on quality determination of goatskin. Fuzzy rules for the determination of goatskin quality were obtained from the opinion of experts at the Regional Technical Implementation Unit of as a leather processing facility Figure 2.

Table 1: Input parameter data, fuzzy set, and domain

Parameter	Fuzzy set	Domain (x)
Thickness	Thick	x >2
	Thin	0,5 <x≤2
	Very thin	x≤0,5
Backline length	Long	x >60
	Short	45 <x≤60
	Very short	x≤45
Skin area	Wide	x>3500
	Wide enough	3500 <x≤4500
	Narrow	x<5500
Scratches on skin	Low	x≤3%
	Medium	3%<x≤9%
	High	x>9%
Holes on skin	Low	x≤3%
	Medium	3%<x≤9%
	High	x>9%
Scars	Low	x≤3%
	Medium	3%<x≤9%
	High	x>9%
Tick and lice lumps	Low	x≤3%
	Medium	3%<x≤9%
	High	x>9%
Hair loss	Low	x≤3%
	Medium	3%<x≤9%
	High	x>9%

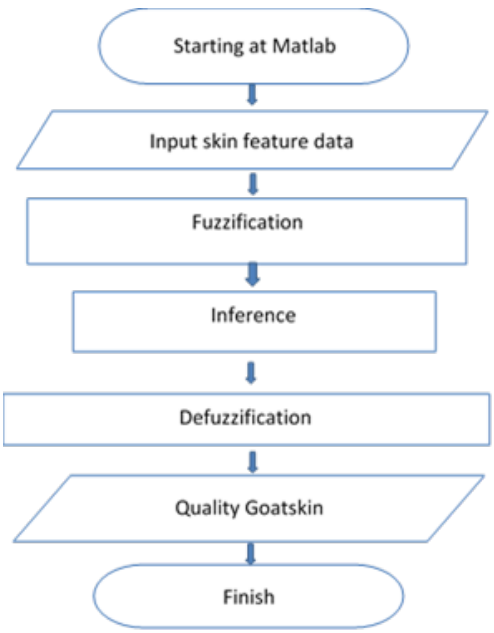

Figure 2. Flowchart of Sugeno's FIS method

Inference

The inference is a calculation framework based on IF-THEN fuzzy rules and thinking. The result output of each rule is z, which is in the form of a crisp set based on the predicate. This is also known as the Fuzzy Rule-Based System.

Defuzzification

Defuzzification was carried out using the Sugeno method, and is the final stage after fuzzification and inference are carried out [13]. Defuzzification is used to calculate the average output value of the alpha predicate and weighted calculation:

$$Defuzzification = \frac{\sum_{i=1}^{n} \propto i * zi}{\sum_{i=1}^{n} \propto i} \quad (1)$$

Description:

$\propto i$: *Degree of membership in rule to* $-\ i$

zi

The output parameter value of rule to $-\ i$

The quality classification and category of rawhides goatskin was obtained from experts in the leather tanning industry was obtained by interview. Therefore, they are grouped into: Quality 1, Quality 2, Quality 3 and Reject. Mean absolute percentage error (MAPE) is used to determine the percentage of accuracy from the use of the FIS method [14]. The MAPE value is used to analyze the predictions where the MAPE value is listed in Table 2 and the following calculation method:

$$\text{MAPE} = \frac{1}{n}\sum_{t-1}^{n}\left|\frac{At-Ft}{At}\right| \quad (2)$$

Description:
At = Value actual
Ft = Prediction value
n = data total

Table 2: Assessment based on quality category of goat skin

Category	FIS (Fuzzy Inference System)	Expert Opinion
Quality 1	66	61
Quality 2	17	26
Quality 3	10	6
Reject	7	7
Total	100	100

RESULTS AND DISCUSSION

Range and Membership Functions

The use of fuzzy application to determine the quality of goatskin as raw material for tanning is carried out by changing inputs such as thickness, backline length, skin area, scratches on skin, holes on skin, scars, tick and lice lumps, flea spots, hair loss. Therefore, the output is the quality of the goatskin. The basic fuzzy rules describe the relationship between the membership function and the membership function form by using the Sugeno method, it also shows that the system's output is in the form of constants or linear equations. The set

$$\mu[x] = \begin{cases} 0\ ; x \geq a \\ \frac{1-a}{b-a}\ ; a < x \leq b \\ 1\ ; x \leq b \end{cases} \quad (3)$$

starts when the domain with a zero degree of membership [0] moves to the right of the domain that has a higher degree of membership.

Description:

a^0 = The value of a domain that has zero membership degrees;

b^0 = The value of a domain that has a membership degree of one;

x^0 = The input values will be converted into fuzzy numbers.

The following is the fuzzification process of the determined variables used to measure the quality of goat skin:

Skin Thickness

Thickness variables are divided into three categories, namely thickness with very thin, thin, and thick levels and they are based on the thickness of the goatskin. The skin thickness

variable is depicted using the membership function as shown in Figure 3. Among them are membership functions which include the following:

$$\mu[x]\text{Very thin} = \begin{cases} 0\,; x \le 0{,}5 \\ \frac{1-x}{1-0{,}5} \\ 1\,; x \ge 1 \end{cases} \quad ; 0{,}5 < x \le 1 \tag{4}$$

$$\mu[x]\text{Thin} = \begin{cases} 0\,; x < 1 \\ \frac{x-1}{1-0{,}5} \\ \frac{2-x}{2-1} \end{cases} \quad ; 0{,}5 < x \le 1 \quad ; 1 < x \le 2 \tag{5}$$

$$\mu[x]\text{Thick} = \begin{cases} 0\,; x \le 1 \\ \frac{x-1}{2-1} \\ 1\,; x > 2 \end{cases} \quad ; 1 < x \le 2 \tag{6}$$

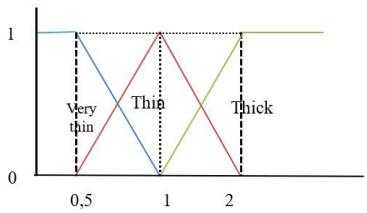

Figure 3. The fuzzy variable set for goatskin thickness

Back Line Length

The variable back line length is also divided into three types, namely the very short, short, and long levels. Where these levels are based on the back line length on the goatskin. The back line length variable is depicted using the membership function as shown in Figure 4. Among them are membership functions:

$$\mu[x]\text{Very short} = \begin{cases} 0\,; x \le 45 \\ \frac{60-x}{60-45} \\ 1\,; x \ge 60 \end{cases} \quad ; 45 < x \le 60 \tag{7}$$

$$\mu[x]\text{Short} = \begin{cases} 0\,; x \le 55 \\ \frac{x-55}{55-45} \\ \frac{65-x}{65-60} \end{cases} \quad ; 55 < x \le 60 \quad ; 60 < x \le 65 \tag{8}$$

$$\mu[x]\text{long} = \begin{cases} 0\,; x \le 60 \\ \frac{x-70}{70-60} \\ 1\,; x > 70 \end{cases} \quad ; 60 \le x \le 70 \tag{9}$$

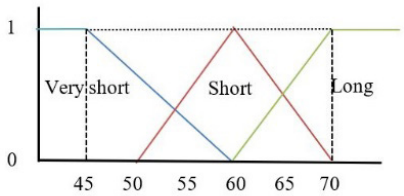

Figure 4. The set of fuzzy variables for the backline length of the goatskin

Skin Area

The goatskin area variable is divided into three, namely with a small wide, wide enough, wide. The skin area variable is depicted using the membership function as shown in Figure 5. The following membership functions include:

$$\mu[x]\text{Small wide} = \begin{cases} 0\,; x \le 4500 \\ \frac{4500-x}{4500-3000} \\ 1\,; x > 3000 \end{cases} \quad ; 3000 < x \le 4500 \tag{10}$$

$$\mu[x]\text{Wide enough} = \begin{cases} 0\,; x \le 3500, \\ \frac{x-2500}{4500-2500} \\ \frac{5500-x}{4500-3500} \end{cases} \quad ; 3500 < x \le 4500 \quad ; 4500 < x \le 5500 \tag{11}$$

$$\mu[x]\text{Wide} = \begin{cases} 0\,;\ x \le 4500 \\ \frac{x-4500}{5000-4500} \quad ;4500 \le x \le 6000 \\ 1\,;x > 6000 \end{cases} \tag{12}$$

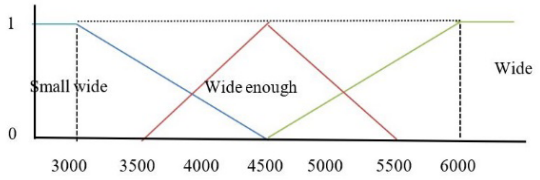

Figure 5. The set of fuzzy variables for goatskin area

Scratches on Skin

Variable scratches on the skin are also divided into three types, namely low, medium and high. The scratches on skin variable is depicted using the membership function as shown in Figure 6. Furthermore, these levels are based on scratches on goatskin with a membership function:

$$\mu[x]\text{Low} = \begin{cases} 0\,;x \le 6 \\ \frac{6-x}{6-3} \quad ;3 < x \le 6 \\ 1\,;x \ge 3 \end{cases} \tag{13}$$

$$\mu[x]\text{Medium} = \begin{cases} 0\,;x \le 6, \\ \frac{x-3}{6-3} \quad ;3 < x \le 6 \\ \frac{9-x}{9-6};6 < x \le 9 \end{cases} \tag{14}$$

$$\mu[x]\text{High} = \begin{cases} 0\,;\ x \le 6 \\ \frac{x-6}{9-6} \quad ;6 \le x \le 9 \\ 1\,;x > 9 \end{cases} \tag{15}$$

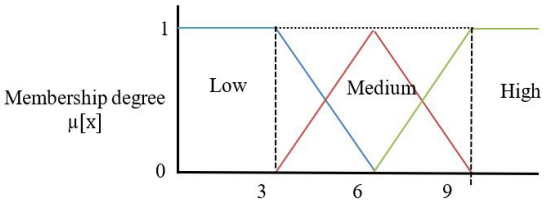

Figure 6. The set of Fuzzy variables for scratches on goatskin

Hole in Skin

The hole in skin variable is depicted using the membership function as shown in Figure 7. This hole in the skin variable is divided into three types, namely low, medium and high levels, and are based on holes in goatskin with a membership function:

$$\text{Low} = \begin{cases} 0\,;x \le 6 \\ \frac{6-x}{6-3} \quad ;3 < x \le 6 \\ 1\,;x \ge 3 \end{cases} \tag{16}$$

$$\mu[x]\text{Medium} = \begin{cases} 0\,;x \le 6, \\ \frac{x-3}{6-3} \quad ;3 < x \le 6 \\ \frac{9-x}{9-6};6 < x \le 9 \end{cases} \tag{17}$$

$$\mu[x]\text{High} = \begin{cases} 0\,;\ x \le 6 \\ \frac{x-6}{9-6} \quad ;6 \le x \le 9 \\ 1\,;x > 9 \end{cases} \tag{18}$$

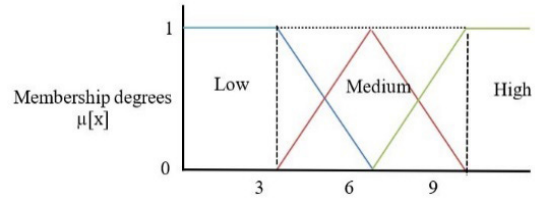

Figure 7. The set of fuzzy variables for holes in goatskin

Scars

The variable known as the presence of scars on the skin is divided into three levels, namely low, medium and high levels. The skin scars variable is depicted using the membership function as shown in Figure 8. These levels are based on the presence of scars in goatskin and they possess membership functions:

$$\text{Low} = \begin{cases} 0\,; x \le 6 \\ \frac{6-x}{6-3} \quad ; 3 < x \le 6 \\ 1\,; x \ge 3 \end{cases} \tag{19}$$

$$\mu[x]\text{Medium} = \begin{cases} 0\,; x \le 6, \\ \frac{x-3}{6-3} \quad ; 3 < x \le 6 \\ \frac{9-x}{9-6}; 6 < x \le 9 \end{cases} \tag{20}$$

$$\mu[x]\text{High} = \begin{cases} 0\,; x \le 6 \\ \frac{x-6}{9-6} \quad ; 6 \le x \le 9 \\ 1\,; x > 9 \end{cases} \tag{21}$$

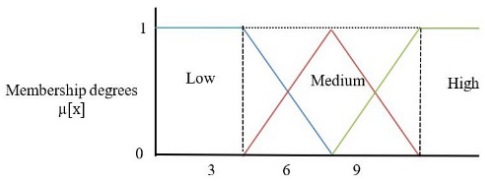

Figure 8. The set of fuzzy variables for the presence of scars on goat skin

Tick and Lice Lumps

The presence of ticks and lice on the skin is a variable that is divided into three levels, namely low, medium and high levels. The tick and lice lumps thickness variable is depicted using the membership function as shown in Figure 9. This ranking is based on the presence of ticks and lice lumps on the goatskin with a membership function:

$$\text{Low} = \begin{cases} 0\,; x \le 6 \\ \frac{6-x}{6-3} \quad ; 3 < x \le 6 \\ 1\,; x \ge 3 \end{cases} \tag{22}$$

$$\mu[x]\text{Medium} = \begin{cases} 0\,; x \le 6, \\ \frac{x-3}{6-3} \quad ; 3 < x \le 6 \\ \frac{9-x}{9-6}; 6 < x \le 9 \end{cases} \tag{23}$$

$$\mu[x]\text{High} = \begin{cases} 0\,; x \le 6 \\ \frac{x-6}{9-6} \quad ; 6 \le x \le 9 \\ 1\,; x > 9 \end{cases} \tag{24}$$

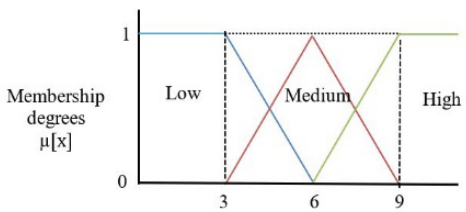

Figure 9. The set of fuzzy variables for the presence of tick and lice lumps goatskin

Hair Loss

The variable hair loss on the skin is divided into three levels, consisting of low, medium and high levels. The hair loss variable is depicted using the membership function as shown in Figure 10. These levels are based on the presence of tick and lice lumps on the skin of goats with membership functions:

$$\text{Low} = \begin{cases} 0\,; x \le 6 \\ \frac{6-x}{6-3} \quad ; 3 < x \le 6 \\ 1\,; x \ge 3 \end{cases} \tag{25}$$

$$\mu[x]\text{Medium} = \begin{cases} 0\,; x \le 6, \\ \frac{x-3}{6-3} \quad ; 3 < x \le 6 \\ \frac{9-x}{9-6}; 6 < x \le 9 \end{cases} \tag{26}$$

$$\mu[x]\text{High} = \begin{cases} 0\,; x \le 6 \\ \frac{x-6}{9-6} \quad ; 6 \le x \le 9 \\ 1\,; x > 9 \end{cases} \tag{27}$$

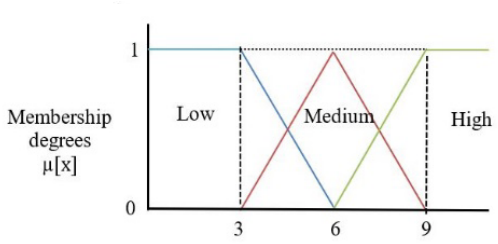

Figure 10. The set of fuzzy variables for the hair loss of goat skin

Inference

Inference is a fuzzy implication rule obtained by combining each input variable. Consequently, the 20 fuzzy rules were obtained from the opinion of experts from the Regional Technical Implementation Unit of Padang Panjang City in 2019. The fuzzy inference method used was the first-order Fuzzy Sugeno, while the antecedents and consequences were represented by propositions in a fuzzy set, and a linear equation respectively. The consequence in this research, refers to data obtained in the field and information from informants. Rules and implications were formed to state the relationship between input and output. Furthermore, the operator used to connect two inputs is known as the AND operator, and IF-THEN is used to draw maps between the input-outputs. Propositions that follow IF are called antecedents, while propositions that follow THEN are called consequent [10]. The results on the classification analysis of the quality of goat skin used MatLab with FIS Sugeno. The display of the rule composition and defuzzification can be seen in Figure 11 below:

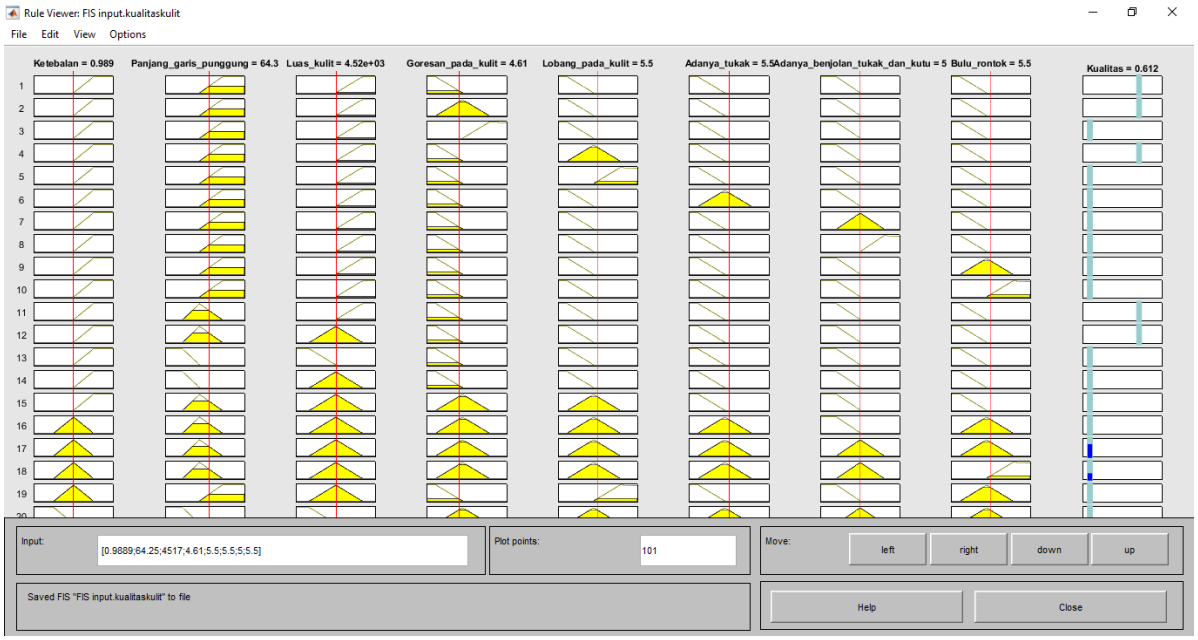

Figure 11. Simulation results of the quality of goat skin using MatLab

Testing Data

Table 3: Recapitulation of Sugeno FIS assessment

Variable	Fuzzy set	Domain	Number of skins with values based on domain
Thickness	Thick	x >2	
	Thin	0,5 <x≤2	4
	Very thin	x≤0,5	96
Back line length	Long	x >60	
	Short	45 <x≤60	2
	Very short	x≤45	98
Skin area	Wide	x>3500	
	Wide enough	3500 <x≤4500	17
	Narrow	x<5500	83
Scratches on skin	Low	x≤3%	
	Medium	3%<x≤9%	2
	High	x>9%	98
Holes in skin	Low	x≤3%	
	Medium	3%<x≤9%	4
	High	x>9%	96
Scars	Low	x≤3%	2
	Medium	3%<x≤9%	4
	High	x>9%	94
Tick and lice lumps	Low	x≤3%	5
	Medium	3%<x≤9%	7
	High	x>9%	87
Hair loss	Low	x≤3%	2
	Medium	3%<x≤9%	3
	High	x>9%	95

The quality classification of goat skin was obtained from 100 test data. Meanwhile, the results of the test with Fuzzy logic compared to expert opinion can be seen in Table 3. Based on the quality assessment of goat skin, it was found that determining the quality of rejected leather through FIS and expert opinion had similar results. This is because the criteria for rejected skin depends on the level of damage to the skin such as small skin, and defects with a high degree of damage. However, there are differences in the number of skin types consisting of Quality 1, 2 and 3. The value of Quality 1 using the FIS method shows a higher number than expert opinion. This is presumably because the FIS observation uses measurable variables and has clear boundaries, resulting in an overall value for determining the quality of goat skin. Furthermore, the inference system can read explicit values, which lead to desired results in the output variables. Meanwhile, the expert assessment system is carried out manually, by observing parameters such as the color of the fur which looks alive and not gloomy, hair loss due to bacteria, holes, scars and defects in the raw skin caused during peeling work, and defects because of various skin diseases. Therefore, the FIS method is a more appropriate method to determine the quality of raw goatskin.

Table 4: MAPE values to measure the accuracy level of the FIS method

MAPE value	Prediction accuracy
MAPE ≤ 10%	Hight
10% < MAPE ≤ 20%	Good
20% < MAPE ≤ 50%	Reasonable
MAPE > 50%	Low

Table 4 shows that the defuzzification process used can produce an overall value for determining the quality of goat skin from a fuzzy consequent area. This is because the inference system can read firm values, and produces the desired results in the output variable. After comparing 100 goat skin samples using Sugeno's logical assessment it was found that 7 goat skins had different quality determination results from experts.

From the research that has been done, the results of the comparison of the Sugeno FIS assessment using the average percentage or Mean Absolute Percentage Error (MAPE) are shown in Table 4. The MAPE value obtained from each quality indicates that the accuracy of this FIS method is high. Based on the total MAPE obtained is 18%. Thus, these results indicate that the accuracy of forecasting results using FIS has a good level of accuracy. Based on this, Sugeno FIS can be used as a determinant of the quality of goat skin based on thickness, length of back line, skin area, number of scratches on the skin, number of holes, presence of ulcers, tick bumps, and hair loss. Mean Absolute Percentage Error is a method that can be used to calculate error from predicted least square method of data [15], this way in calculating the predicted error gives the organization's choice to consider the utilization of a method of prediction [16].

CONCLUSIONS

Sugeno FIS can be used to determine the quality of goat skin with a good accuracy level. This system can be used as an appropriate model in determining the quality of goat skin as a raw material in the leather tanning industry.

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