Intelligent Control Masin Fermentor Development With Temperature Control System

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Abstract

Masin is a typical Sumbawa, Indonesia sauce made from tiny shrimp. A closed fermentation process makes Masin for seven to fourteen days. This research aims to increase the productivity of making masin by optimizing the fermentation process by maintaining the fermentation temperature at the optimal temperature using a fuzzy logic control system. The masin fermenter is in the form of a cube of 640 mm X 640 mm X 550 mm and a fermentation container with a diameter of 380 mm and a height of 440 mm equipped with a heater and Arduino, with the setting point of the fermenter is 37ºC. Furthermore, product quality tests were carried out on the third, fifth, seventh, ninth, twelfth and fourteenth days, with an organoleptic test, bacterial count, protein, fat, fiber, and carbohydrate content. Then the fermentation results with the fermenter were compared with normal fermentation. The organoleptic test result is that using a fermentor for 12 days is the most preferred by participants in terms of color, aroma and texture, while for taste, they prefer samples of a 9-days fermenter. The highest growth of lactic acid bacteria was found in the 7-day fermenter, which was 3.3×10^7. The highest protein content was found in the 5-day fermenter sample, which was 12.21%, the highest fat content was found in 3 days of normal fermentation, 23.15%, the highest fiber content was found in the 3-day standard fermentation sample, 26.12%, and the highest carbohydrate content was found in the 7-day fermenter was 11.32%.

Keywords
Masin, Temperature Control Systems, Fuzzy Logic, Fermentors

1. Introduction
Masin is a traditional sauce from Sumbawa, a type of chili sauce that is a fermented product of tiny fresh shrimp with added salt (NaCl) and tamarind (Asmawati et al., 2020). Making masin is traditionally done by mixing all the masin ingredients, storing it in a closed container, and then fermenting it at room temperature for 3 to 7 days (Ramzi, 2016). As with other fermented products, this can lead to unstable and non-uniform product quality. Traditional masin-making has several problems: production is not optimal due to long fermentation time, less sterile masin-making space and unequal masin quality. Previous research has developed a bioreactor or fermenter for the masin fermentation based on an ON-OFF control system. Temperature control in fermenters generally uses an ON-OFF control system. However, several researchers have developed fermenters with a P.I.D. control system (Rohman et al., 2021). The ON-OFF control system will provide a temperature profile constantly changing around the set point. In contrast, the conventional P.I.D. control system will provide a system response. However, a precise mathematical model of the system is required for its design. In addition to conventional control systems, intelligent control systems also have the potential to be applied to temperature control in masin fermenters. The advantages of

the ON-OFF system are ease and the disadvantages of the variable process; the ON-OFF system will be bumpy and will not be stable, so it is only suitable for systems that can tolerate process variable fluctuations.

Intelligent control systems can potentially be applied to temperature control in pasteurizers to cover the shortcomings of existing conventional systems. The application of fuzzy logic in the control field has been widely developed. The advantage of this system is that it can quickly process input in the form of actual (exact) values into fuzzy quantities and process them using a rule base to produce decisions that are fuzzy system outputs. The fuzzy logic technique is innovative for designing solutions for multi-parameter control and non-linear models. Therefore, this method provides more solutions than conventional control designs (Nurdiansyah et al., 2019).

A control system using a fuzzy logic system has been developed for temperature control using various types of control system devices. The same as in the study on designing a yogurt fermenter with a fuzzy logic control system using an ATMEGA32 microcontroller (Al Riza et al., 2015). However, temperature control in masin fermenters with fuzzy logic is rarely or never done. This study aimed to determine the difference in temperature profile between fuzzy logic and on-off systems in a masin fermenter and the quality of masin using a fermenter and ordinary fermentation.

1.1 Objectives
This study aims to increase the productivity of making masin by optimizing the fermentation process by maintaining the fermentation temperature at the optimal temperature using a fuzzy logic control system.

2. Literature Review
Temperature control is useful for maintaining the temperature of the medium during the stirring process. Because if the temperature in the medium undergoes an irregular temperature change, the results of the medium will not be optimal. Therefore, an automatic control technique is needed to regulate the temperature in the bioreactor tube (Baskoro et al., 2020). This tempe fermentation optimization tool works at temperatures between 30ºC - 37ºC. Under these conditions, the fermentation time of raw tempeh into cooked tempeh takes 18 hours with the test criteria of normal color, smell, and taste. This tool works based on the Arduino Mega2560 microcontroller control (Yunas & Pulungan, 2020). Control and Monitoring of Heating Air Temperature Using a Fuzzy Logic Controller (FLC) (Pramono, 2014). The control method used is Mamdani-type fuzzy logic control. This research resulted in a system that can control the temperature through the fan speed and the time the lights are on while the air is lit through the pump time (Ubaidillah et al., 2020). If the yeast content and fermentation time can be optimal, then the fermentation process can run well to produce good quality and proper consumption. The authors designed an application system built using Matlab software, whereas in this study, the authors used the fuzzy method (Surbakti et al., 2020). Controlling temperature and stirring time In making yogurt, it is necessary to get maximum yogurt results. The Mamdani fuzzy logic method is used to study the fermentation temperature, which is carried out with a temperature setpoint of 45 °C (Widiyanto et al., 2021).

3. Methods
The masin fermenter is made of galvanized iron 3x3 in the form of a cube of 640 mm X 640 mm X 550 mm and a fermentation vessel with a diameter of 380 mm and a height of 440 mm. equipped with a heater and Arduino. The main components in the electronic circuit are the D.S. sensor as an input to the fuzzy logic system on FERMAS-KECE, heater blower as output to the system, h-bridge as a speed controller for the heater blower, Arduino as a microcontroller in the fuzzy logic system, and power supply as a power provider. . In designing the Fuzzy Logic controller using the LabView program. The fuzzy inference system used in this fermenter temperature controller is the Mamdani method. In the Mamdani method, to get the output, 4 steps are needed, namely: formation of fuzzy sets (fuzzification), application of implication functions (rules), and confirmation (defuzzification). The composition of the rules uses the IF THEN operator. In contrast, the Mean Of Max (M.O.M.) method is used for defuzzification. The input membership function uses a temperature variable that has 5 fuzzy sets, namely very cold (cold), cold, warm, hot and very hot (hot). The values of the fuzzy set are very cold (25, 27, 27, 29), cold (27, 29, 29, 31), warm (29, 31, 31, 33), hot (31, 33, 33, 35). , and very hot (33, 35, 35, 37) (Ayuti et al., 2016). The setpoint value is 37oC. The input of this membership function is a temperature value read by the D.S. sensor.

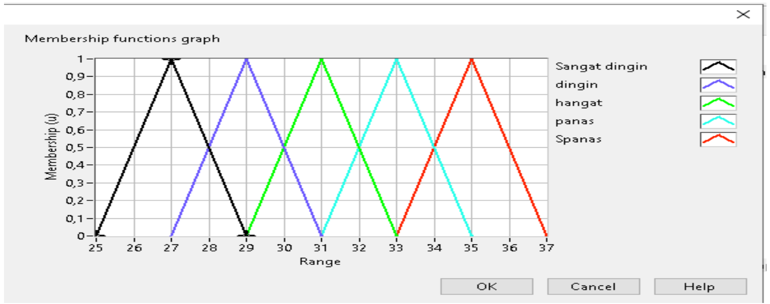

Figure 1 Input Membership Function

In the output membership function, the expected output is the heat released by the heater to heat the salt tank. The output membership function uses a speed variable with 5 fuzzy sets: fast, medium, slow, very slow and slow S.P. The values of the fuzzy set are fast (235, 245, 255, 255), medium (225, 235, 235, 245), slow (215, 225, 225, 235), slow (205, 215, 215, 225) and SPL is slow (195, 195, 205, 215). The amount of heat depends on the amount of P.W.M. issued by the microcontroller resulting from calculating the defuzzification method.(Figure 2)

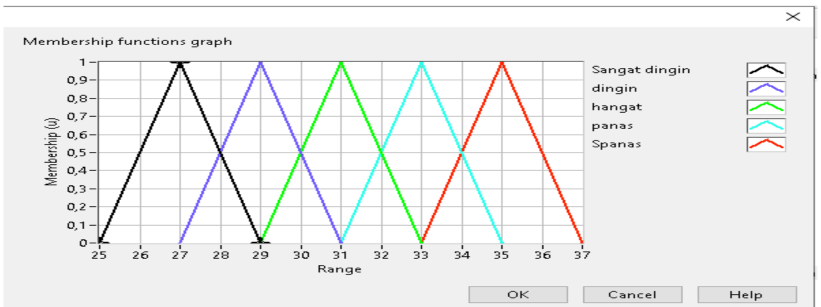

Figure 2 Output Membership Function

Fuzzy Rule Base contains fuzzy logic statements. The Fuzzy Rule Base is in the form of an IF-Then statement which states a condition statement. The preparation of the Rule Base is very influential on the decision-making stage carried out by the plant. The rule base in this design is as follows:

1. If (temperatur is SDingin) then (speed is Cepat)
2. If (temperatur is Dingin) then (speed is Sedang)
3. If (temperatur is Hangat) then (speed is Lambat)
4. If (temperatur is Panas) then (speed is SLambat)
5. If (temperatur is SPanas) then (speed is SPLambat)

Calibration of D.S. sensors and mercury thermometers can use comparison or simulation methods. The calibration uses a method of comparing the standard measuring instrument (mercury thermometer) to the measuring load used, then calculating the deviation based on the applicable standard. In calibration, we will take a minimum of 5-10 samples because the more samples, the better (Sulaeman et al., 2011). Testing of masin products is carried out in 2 ways: organoleptic and salty content. Organoleptic tests include color, aroma, texture and taste parameters, which are carried out using the hedonic or preference test (Ramzi, 2016). The chemical test includes protein, fat content, fiber, carbohydrates and total B.A.L. in masin.

5. Results and Discussion

Sensor calibration is carried out before the masin fermentation process starts in the fermenter. The comparison was carried out with three experiments using water media. From the three experiments, the D.S. sensor and mercury thermometer showed a temperature of 27 °C. This proves that the sensor has been calibrated. (Table 1)

Table 1 Sensor D.S. Calibration With Thermometer Mercury

No.	Time	Thermometer Mercury	Sensor D.S.
1	10 first minute	27 °C	27 °C
2	10 second minutes	27 °C	27 °C
3	10 third minutes	27 °C	27 °C

In previous research, the temperature control system was made using an Arduino Uno microcontroller with input in the form of a signal from the infrared temperature sensor. The temperature control output is connected to a relay to control the actuator in the form of a heater, namely incandescent lamps. The control used is the on-off method, the actuator (incandescent lamp) will turn off when the reactor temperature reaches the set point and will turn on when the reactor temperature is below the set point. The error analysis results in a sampling time of 5 seconds for 10 minutes. After reaching the setting point, it was found that the positive error was 0.2 oC. The maximum negative error obtained is -0.5 oC. From these data, it can be concluded that the on-off control system can produce a temperature profile that has a steady state error above the set point during the fermentation process (Rohman et al., 2021).

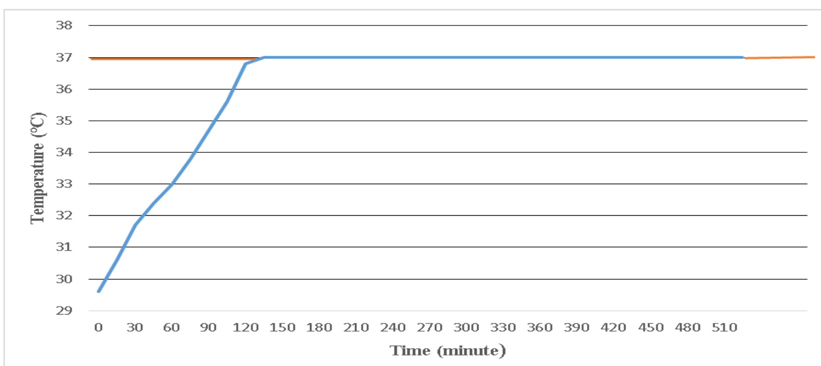

Figure 3 Fuzzy Logic System Temperature Profile

In the current study, the control system used is a fuzzy logic system by using an actuator control method with Pulse Width Modulator (P.W.M.). By using this P.W.M. mode, the speed of the blower heater can be controlled according to the percentage of the P.W.M. signal. Using fuzzy control mode shows a settling time of about 2 hours, slightly longer than the ON-OFF control mode because when approaching the set point, P.W.M. works less than 100% to ensure there is no overshoot or excessive error when it reaches the set point. This shows that the resulting temperature profile has a lower steady-state error than the ON-OFF control system in the previous study. (Figure 3)

To determine the system's resistance to disturbances, a test is carried out by providing cooling disturbances in the form of (cold water) on a system that has reached stability for a set value. The purpose of testing with this disturbance is to determine the speed of the system response to return to its original reference after being disturbed. The time required to return to the original reference is called recovery time.

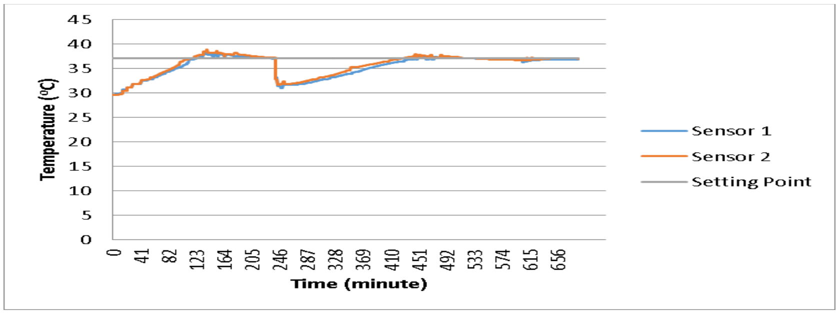

Figure 4 Response To Disturbance

In the disturbance test, the cold water is initially set at a reference temperature of 37^{0}C. The initial temperature value is 28^{0}C. After ± 1 hour 20 minutes, the air temperature will reach 37^{0}C and oscillate at that state. After the air temperature is stable, cold water is added to the plant. Then it is known that the air temperature in the plant drops to 33^{0}C within 35 minutes. Gradually returns to its original reference within ± 2 hours. (Figure 4)

From the testing with disturbances that have been carried out, it can be concluded that the fuzzy logic control system built can withstand external disturbances quite well, and the temperature drop can still be tolerated in the fermentation process.

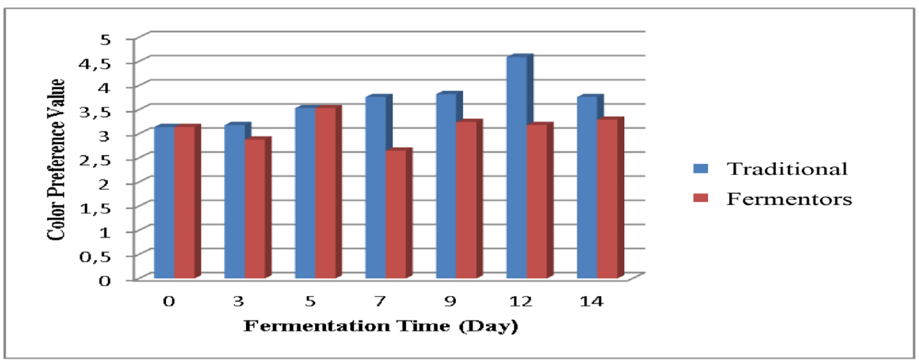

Figure 5 Color Grading Results

The Figure 5 shows that the 12th-day fermenter sample has the highest preference value with very favorable criteria because, on the 12th-day fermenter sample, the amount of astaxanthin is more than that of the 14th-day fermenter sample, which has the lowest preference value. This follows the statement that astaxanthin's low value can also be affected by the long fermentation time.

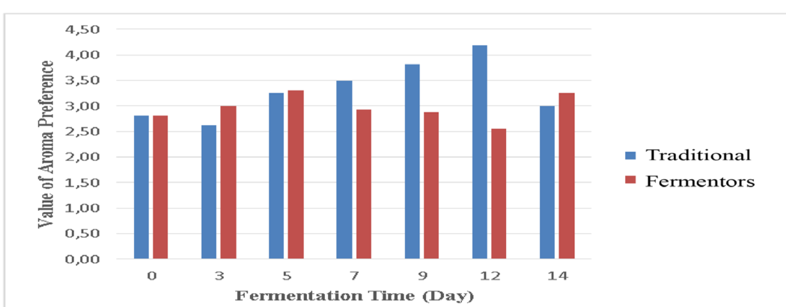

Figure 6 Scent Assessment Results

The Figure 6 above shows that the highest value was obtained on the 12th day of the fermenter sample, according to the authors. According to the researchers, the preferred aroma was a distinctive salty aroma. During fermentation, protein compounds decompose into amino acids, hydrogen sulfide (H2S), and mercaptans that cause odor. The smell is very sharp. This very sharp aroma is what the researcher likes. The 12th-day fermenter sample has the highest preference rating, presumably because the longer the fermentation process, the more volatile compounds formed.

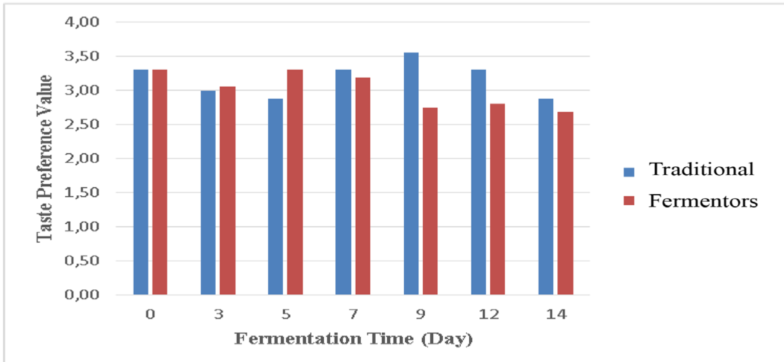

Figure 7 Taste Assessment Results

The Figure 7 shows that the highest value of preference for salty rebon shrimp in each sample is not significantly different. The highest value was obtained on the ninth day of the fermenter sample with the criteria of dislike to very like. According to the researcher, the salty taste tends to be fishy. This is because the raw material for salty is rebon shrimp.

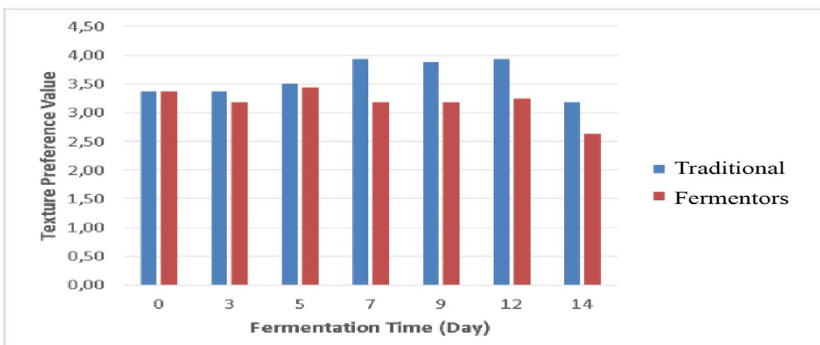

Figure 8 Texture Assessment Results

The Figure 8 above shows the highest values obtained on the 12th-day fermenter samples, seventh-day fermenters and 9th-day fermenters with criteria according to the author's dislike to like. According to the author, the texture is a bit soft.

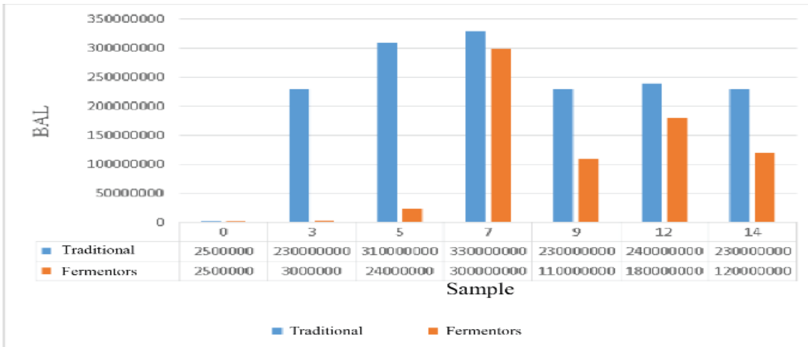

Figure 9 Total growth of B.A.L.

The total growth of lactic acid bacteria with long fermentation days 0, 3rd, 5th, 7th, 9th, 12th and 14th samples of the masin fermenter (F.M.) increased, and the total growth of lactic acid bacteria was highest on the 7th day, as much as 3.3 X 10^7. However, it decreased on day 9. This was due to reduced nutrients and the formation of compounds resulting from metabolism, which tend to be toxic to bacteria (Sulistijowati, 2012). (Figure 9)

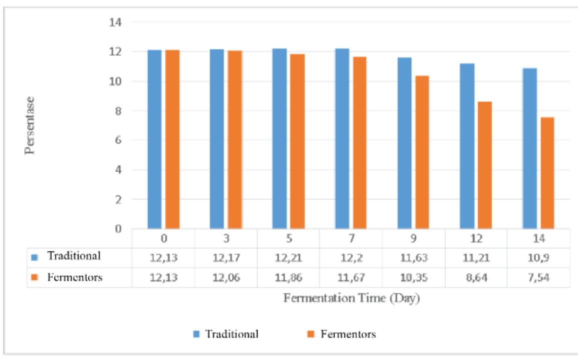

Figure 10 protein content (A)

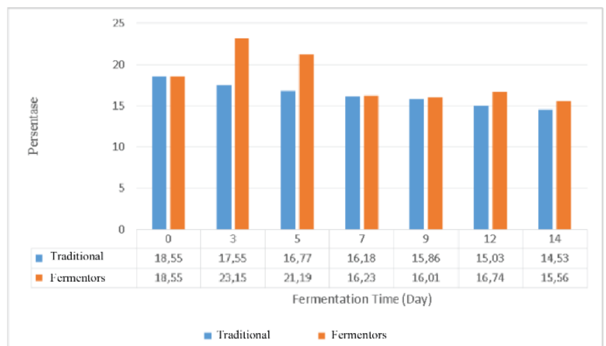

Figure 11 fat content (B)

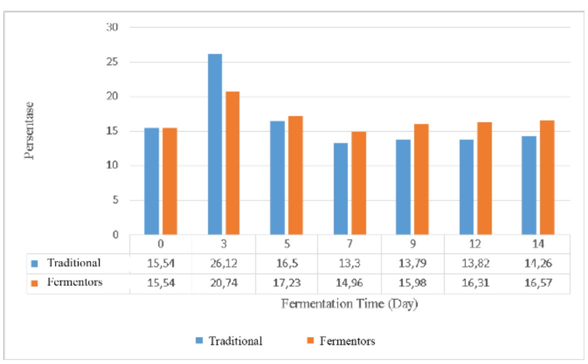

Figure 12 fiber content (C)

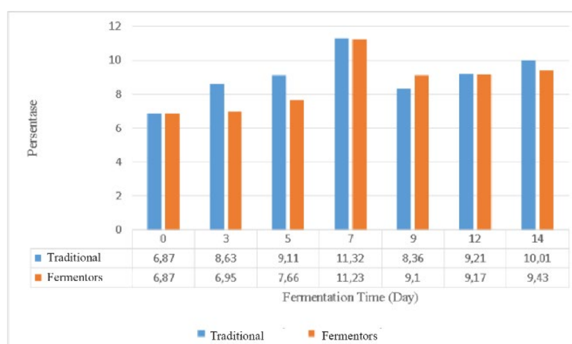

Figure 13 carbohydrate content (D)

Regarding protein nutrition, it shows that the average masin rebon shrimp protein obtained in fermentation using a fermenter or traditional fermentation has decreased compared to the protein content in fresh rebon shrimp. Fresh rebon shrimp has a protein content of 16.2% (Directorate of Nutrition of the Ministry of Health). , 1992). However, in this study, the highest protein was found in the FM 5 fermentation sample (masin fermenter), which was 12.21%.
The nutritional content of fat content shows that on the 3rd day of ordinary fermentation, the highest percentage is 23.15%, while on the 3rd day of masin fermentation, the highest percentage is 17.55%. On the third day, the masin fermenter fermented fiber content produced the highest percentage compared to ordinary fermentation, which was

26.12%. The highest percentage of carbohydrate content was found in the 7th day masin fermenter sample, which was 11.32%.(Figures 10 – 13).

6. Conclusion

Based on the design, testing, analysis and discussion that have been carried out in this study, the following conclusions can be drawn:

The measurement of the fermentation process using the ON-OFF control mode shows a steady state error above the set point, while the fuzzy logic control mode shows a lower steady-state error than the ON-OFF control system in previous studies. The results of the organoleptic test using a fermenter for 12 days were most favored by participants in terms of color, aroma and texture, while for the taste, they preferred a 9-day fermenter sample. The highest growth of lactic acid bacteria was found in the 7-day fermenter, which was 3.3 X 10^7. The highest protein content was found in the 5-day fermenter sample, namely 12.21%, the highest fat content was found in the 3-day normal fermentation sample, 23.15%, the highest fiber content was found in the 3-day standard fermentation sample, 26.12%, and carbohydrate content. The highest was found in the 7-day fermenter, namely 11.32%

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Acknowledgements

I am grateful to Hore Research Team, the Sumbawa University of Technology, the Indonesian Endowment Fund for Education (LPDP), the Rural Research Program and all of those with whom I have had the pleasure to work during these projects.

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