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Research Article

Corn Waste Grinding and Processing Machine as Cattle Feed in The Border Area of The Republic of Indonesia and The Democratic Republic of Timor-Leste (RI-RDTL)

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ABSTRACT

Corn straws and cobs are wastes from corn farming that are not utilized. This corn waste has potential as an alternative use for cattle but has low nutritional quality. Therefore, this corn waste is fermented to improve its nutritional quality. This study aimed to analyze the effect of straw and corncob fermentation on nutrient content and characteristics of rumen fluid in vitro. This experiment consisted of three (3) experimental stages. Experiment Phase 1: Manufacture of a multifunctional grinding machine. This experiment uses a qualitative method through a description of the tools made. Experiment Phase 2: Processing straw and corncobs with the EM4 fermentation method. This experiment used a completely randomized design with six treatments, namely control (elephant grass and grinting grass), corn straw, fermented corn straw, corncob, and fermented corncob with five replications. The variables measured were nutrient content (dry matter, organic matter, ash, crude protein, crude fat, crude fiber, and extracts without nitrogen. Experiment Phase 3: Test the nutritional quality of fermented corn straw and cobs with the In Vitro method. This experiment used a randomized block design with six treatments, namely control (elephant grass and grinting grass), corn straw, fermented corn straw, corncob, and fermented corncob with four replications. The variables measured were the characteristics of the rumen fluid (pH, VFA, and NH₃). The results of the Phase 1 experiment show that the feed grinding machine has specifications adapted to its function. Stage 2 showed that the treatment significantly affected the nutrient content. Stage 3 showed that different treatments had a significant effect on NH₃ and no significant effect on pH and VFA. Based on the results of experiments that have been carried out, corncob fermentation can improve its nutritional content.

Keywords: corn cobs, fermentation, nutritional content, straw

INTRODUCTION

Indonesia has a tropical climate with two seasons are rainy and dry. Nusa Tenggara Timur (NTT) is one of the provinces, located in the eastern part of Indonesia. What distinguishes this province from others is that the dry in NTT is longer than the rainy season. From June to September, wind currents come from Australia and do not contain much water vapour, resulting in the dry season. On the other hand, from December to March, wind currents originating from Asia and the Pacific Ocean contain a lot of water vapour, resulting in the rainy season. This makes NTT a region with a climate that is dry for 8 months and wet for 4. Based on rainfall and rainy days, NTT has low rainfall and short rainy days (BPS Nusa Tenggara Timur, 2021). This

causes the availability of forage as animal feed to be limited because it is abundantly available during the rainy season while during the dry season the land conditions are dry so that forage for animal feed is also limited.

The limited availability of feed in the dry season makes it difficult for farmers to fulfil their livestock feed requirements. In addition, livestock that are herded or grazed can only eat dry grass, which has low nutritional quality. Therefore, livestock lack both quantity and quality of feed in the dry season. The condition of livestock in this long dry season can be termed as the feed consumed by livestock is used for survival rather than to increase livestock production. Abbas *et al.* (2023) also supported addressing dry season forage scarcity by converting agricultural waste (corn cob waste) into a valuable resource, thereby improving farmer's understanding of waste management as well as their economic situation through sustainable practices.

Waste in the form of corn cobs is produced from the processing activities in the corn agricultural industry, and its quantity is expected to continue increasing along with the growth in production capacity (Chairunnisa and Ciptandi, 2018). To anticipate the coming dry season, where forage is increasingly difficult to find, farmers are looking for solutions by utilizing unused agricultural waste to make animal feed (Abbas *et al.*, 2023). In general, the community raises livestock, particularly sheep and beef cattle, as a side business and a form of savings. This is made possible due to the supportive natural conditions, availability of grass, and the local government's attention to the development of beef cattle (Fathurohman *et al.*, 2022).

Corn cobs are organic waste with unique characteristic and structure, requiring specialised techniques for processing and assembly. Additionally, the processing of corn cob waste has started to develop, one of the uses being as a primary ingredient in animal feed production. From the results obtained, it appears that corn cob waste has the potential to be developed into animal feed products, especially for ruminant livestock (Abbas *et al.*, 2023).

Maize is the leading agricultural commodity of NTT. In 2021 the area of maize farms in NTT reached 290,664 ha with maize production of 750,166 tonnes (BPS, 2021). This maize farming produces waste, namely maize straw and corn stalks, where these by-products are not utilised by the community. Therefore, after the main maize product is obtained, these by-product are simply burned, even though maize straw and cobs can be used as alternative or supplementary feed for livestock. These maize straw and cobs still contain nutrients that are good enough to fulfil the needs of livestock. The high fiber content in corn husk makes it prone to oxidative degradation during storage (Wang *et al.*, 2023).

However, they have low palatability due to the taste and colour of the maize straw and cobs which are less preferred by livestock. In addition, maize straw and cobs contain high levels of lignin. This lignin can inhibit degradation of cellulose and hemicellulose materials in the rumen. Selulase is an enzyme that accelerate the breakdown of cellulose in fibers into monosaccharides (Cui *et al.*, 2021). This straw and corn stover can be improved by fermentation using EM4. This feed processing can improve the nutritional quality and palatability of livestock. In addition, it can also preserve so that this fermented feed can be stored for a long time as a backup feed in the dry season.

The processing of fermented feed ingredients of straw and corn stalks requires a multi-purpose feed grinder, where this tool can be used to chop straw and corn stalks and can finely grind feed ingredients. A new technology is needed that is appropriate for the processing of feed ingredients, cheap so that it is not difficult for people to have this tool, and easy to use.

MATERIAL AND METHODS

This research was carried out in December 2021-February 2022 in Belu Regency, East Nusa Tenggara Province. The research that has been conducted consists of three interrelated experimental phases, namely: Experiment Phase 1: The construction of a multifunctional grinding machine, which is ashredder, grinder, and pelletiser. Furthermore, this machine was used to shred straw and corn stover in Phasi II of the experiment. Experiment Phase II: Processing of straw and corn strover with EM 4 fermentation method. The fermented maize straw and cobs were analysed fro their nutritional content (dry matter, organic matter, ash, crude protein, crude fiber, crude fat, calcium, and phosphorus). Experiment Phase III: Test the nutritional quality of fermented straw and corn stover using the In Vitro method. Furthermore, pH, VFA, dan NH_3 were analysed.

Phase I Experiment: Manufacture of Multifunctional Feed Grinder Machine

The grinding machine was designed and assambled at Sumber Makmur Workshop, Kediri, East Java (Figure 1). The manufacturing process time of this grinding machine is from 27 December 2021 until 18 January 2022.

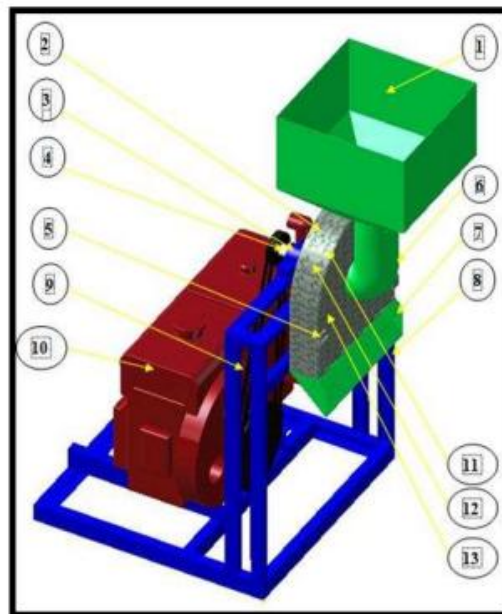


Figure 1. Design of the grinding machine (Personal documentation)

Description:

- | | | |
|------------------------------|-------------------|------------------------------|
| 1. Hooper in | 6. Hinge | 11. Strainer or filter plate |
| 2. Machine body | 7. Outlet | 12. Dynamic hammer |
| 3. Bearing and bearing house | 8. Machine frame | 13. Static hammer |
| 4. Engine shaft | 9. V-belt | |
| 5. Locking bolt | 10. Diessel motor | |

Phase II Experiment: Fermentation of Straw and Corn Stover

Materials

Elephant grass (*Penisetum purpureum*) and wild grass, straw, corn cobs, EM4, molasses, rice bran, and water.

Equipment

Consisting of GSF scales with a capacity of 5 kg, glass plastic, sprayer, measuring cup, 60°C oven Philip Harris Ltd Shanstone England, 105°C oven Memmert, Ney Vulcan D-550 furnace, food melting equipment (Blender Philip), analytical balance Sartorius cp 224, and a set of proximate analysis tools.

Experimental methods

The experiment was an experimental trial with a completely randomised design consisting of 6 treatments, namely elephant grass and wild grass (control 1 and 2) and 4 treatments : unfermented corn straw, fermented corn straw, unfermented corn stover, and fermented corn stover. Each treatment was repeated 5 times. The mathematical model for this experiment according to Steel and Torrie (2002).

$$Y_{ij} = \mu + \alpha_i + \varepsilon_{ij}$$

Description:

Y_{ij} = observation value of the i-th treatment j-th replication

μ = general mean value

α_i = the effect of the i-th treatment

ε_{ij} = error of the i-th treatment of the j-th replication

i = treatment a, b, c, and i

j = 1st, 2nd, 3rd, and 4th repetitions

Table 1. Variety analysis

SK	DB	JK	KT	F Hit	F Tabel	
					0.05	0.01
Perlakuan	5	JKP	KTP	KTP/KTG	2.62	3.90
Galat	24	JKG	KTG			
Total	29	JKT				

Description:

SK = Source of variation

Db = Free degree

JK = Sum of squares

KT = Centre square

JPK = Sum of treatment squares

JKS = Sum of squares of remainder

JKT= Total square

KTP = Centre square pf treatment

KTS = Centre square of remainder

F hit = F count

If there is an effect of treatment, the DMRT (duncan's Multiple Range Test) further test is conducted according to Steel and Torrie (20002). Paramenetr measured were total dry matter, organic matter, ash, crude protein, crude fiber, crude fat, calcium and phosphorus by Proximate analysis method (AOAC, 2016).

Experimental Implementation

Sample preparation

Elephant grass, wild grass, straw and corn stiover were obtained in the area around beu Regenct, East Nusa Tenggara. The collection of these samples used the Simple Random Sampling method, which is ransdom sampling, then composited into one. Elephant seaweed, this wild grass is t aken all parts except the r oots. Corn straw as an old plant that has been taken corn fruit. Corn stalk is part of the corn fruit that has been peeled off the skin and seeds. After the corn

straw, corn stalks, elephant grass, and weeds were collected, each of them was placed in a sack and brought to the Farm Animal Husbandry Unit of SVD Halikelen Nenuk Mission, Atambua, Belu Regency, East Nusa Tenggara.

Fermentation process

The fermentation process carried out in this study was solid fermentation. The fermentation method used was the fedd material fermentation method by the SVD Halikelen Nenuk Mission Agricultural Farm Unit, Atambua, Belu Regency, East Nusa Tenggara. Inoculum was prepares first before fermentation, mixing 20 ml EM4, 40 ml molasses, and 30 ml water. Next, 1 kg of corn straw and corn stalk samples were prepared. The, the inoculum that has been prepared is sprayed with a sprayer to the corn straw and corn cobs evenly. After that, sprinkle 100 g of rice bran evenly. Once done, the processed maize straw or corn stalks are placed in plastic and sealed. This fermentation process lasts for 3 weeks. The fermentation process of corn straw or corn cobs with EM4 can be seen in Figure 2.

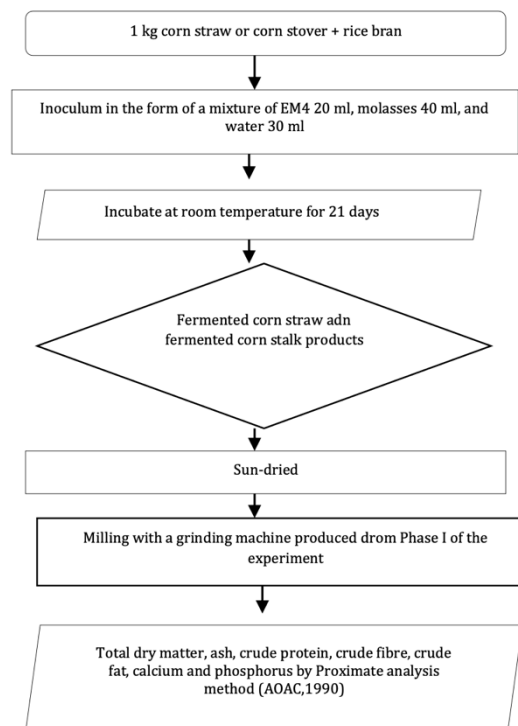


Figure 2. Fermentation of corn straw or corn stover with EM4

Experiment Phase III: The Nutritional Quality of Fermented Corn Straw and Cobs

Materials

Elephant grass (*Penisetum pupureum*), wild grass, corn straw, corn cobs, fermented corn straw, fermnated corn cobs, cow rumen fluid as microbial source, Mc Dougall's solution as a buffer, chemical for VFA and NH₃ analysis.

Equipment

Consisted of analytical balances, a set of in vitro tools such as gauze, erlenmeyer, test tubes, measuring cups and waterbath shakers; a set of VFA and NH₃ analysistools and Hana pH meter.

Experimental methods

The experimental was an experimental trial with a Randomised Group Design (RBD) consisting of 6 treatments, namely elephant grass and wild grass (control 1 and 2) and 4 treatments: unfermented corn straw, fermented corn straw, unfermented corn stalks and fermented corn stalks with 3 replication for each rumen fluid collection.

RESULTS AND DISCUSSION

Manufacturing of Multifunctional Grinder

This grinding machine is named Kakuluk G-01 Machine (Figure 3, 4). This name is based on the name of the place where the idea and the forerunner of this grinding machine was born, namely Fatuketi Vilage, Kakuluk Mesak District, Atambua, Belu Regency, East Nusa Tenggara.



Figure 3. Kakuluk G-01 Milling Machine



Figure 4. Kakuluk G-01 machine view from right side, left side, and top side

Kakuluk G-01 machine has many functions, namely chopper, grinder, and pellesiter. The grinder function of this machine can grind materials coarsely, semi-coarsely, and finely (flour). There are many types of materials that can be chopped and ground with this tool. Examples of animal feed ingredients that can be chopped or ground, namely various types of fodder grass, grains (corn, soybeans, wheat and sorghum). Kakuluk G-01 machine is multifunctional because it has 4 filters with different diameters, namely 2cm; 1cm; 0.5cm; and 0.25cm (Figure 5). The

Kakuluk G-01 machine has two pairs of main knives and several subsidiary knives, therefore it is very good at both chopping and grinding (Figure 6).

Pellet making function is one of the advantages of Kakuluk G-01 Machine. This pellet making machine is in one device. Where, when this pellet making machine will be turned on, the engine turning pulley rope can be moved manually from the grinding machine turning pulley to the pellet machine and vice versa (Figure 7). Kakuluk G-01 machine has a powerful motor that can work for a long time in large quantities. This machine is fuelled by petrol or pertalit (Figure 8).

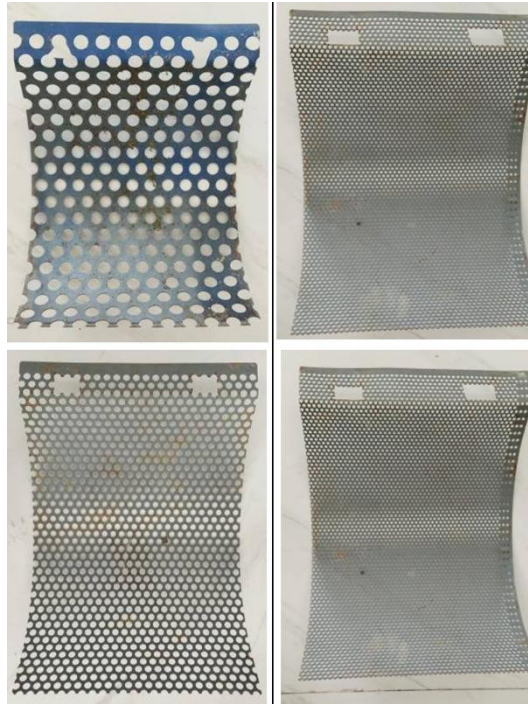


Figure 5. Top left filter 2 cm diameter, bottom left 1 cm diameter, top right 0.5 cm diameter, and bottom right 0.25 cm diameter

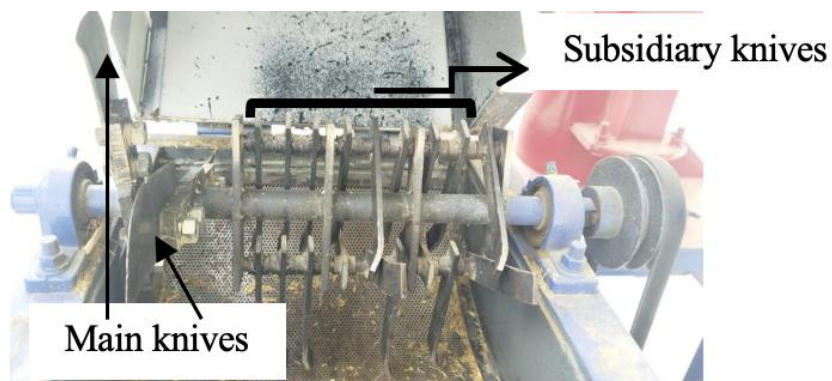


Figure 6. Main and subsidiary knives



Figure 7. Pellet making machine



Figure 8. Kakuluk G-01 Machine

The use of this tool is quite easy and practical. The following is the procedure for using the grinding machine: 1) Determined the size of the filter to be used according to what material will be ground or chopped, 2) The lever is pulled to turn on the engine, and for grinding speed can be set, 3) Materials, such as forage or grain, are fed into the grinding machine, and 4) the results of the grinding are collected in the lower bin. Procedure for using the pellet machine: 1) The materials are prepared (the materials used are in powdery from), 2) The lever is pulled to start the machine, and the speed can be adjusted, 3) The materials are fed into the machine to be processed into pellets, and 4) The pellets are collected.

This machine was designed to emphasize the potensial benefits of corn waste as animal feed, which is also supported by Fathurohman *et al.* (2023), who demonstrated a machine capacity of 25 kg of corn cobs, allowing local farmers to maximize the use of corn waste the help of the disc mill machine.

In additon, Du *et al.* (2024) describes the design and performance testing of a corn straw crusher and rubbing machine, equipped with flattening rollers, a cutting mechanism, and a crushing and rubbing system to effectively process the straw. Performance tests showed that the machine achieved a filamentous straw output of 97.2% at 20% moisture content and a productivity of 82.8 kg (kWh), indicating its efficiency and effectiveness in straw processing. The

study also highlights the importance of this technology in supporting agricultural sustainability and improving livestock fooder quality.

Fermentation Straw and Corn Cob

Content nutrients

Average nutrient content consisting of sry matter, organic matter, crude protein, crude fat, crude fiber, calcium (Ca), phosphorus (P), and Nitrogen free extract (NFE) od elephant grass, grinting grass, corn straw, fermented corn straw, orn stover, and fermented corn stover are shown in Table 2.

Study Wang *et al.* (2024) investigates the effect of bacterium-enzyme compound fermentation on the quality and fermentation parameters of corn straw, particularly focusing on its impact on nutrient digestibility and rumen fermentation in Hu sheep. Key findings reveal that the fermentation process significantly enhances the nutritional value of corn straw by improving its digestibility, altering the ruminal microbiota, and optimizing fermentation quality.

Table 2. Average content nutrient

Forage	Dry Matter	Organic Matter	Ash	Crude Protein	Crude Fat	Crude Fiber	NFE
Elephant grass	90.87 ^c	88.06 ^b	11.94 ^a	10.05 ^a	1.40 ^b	32.04 ^c	44.57 ^c
Grinting grass	91.04 ^c	88.28 ^b	11.72 ^a	7.02 ^{bc}	1.87 ^a	32.05 ^c	47.34 ^c
Corn straw	91.31 ^c	89.41 ^{ab}	10.59 ^{ab}	7.13 ^{bc}	0.84 ^c	45.10 ^a	36.34 ^c
Fermented corn straw	91.91 ^{cd}	89.95 ^a	10.05 ^b	7.56 ^b	1.40 ^b	35.02 ^b	45.97 ^c
Corn cobs	94.61 ^a	90.93 ^a	9.07 ^b	6.86 ^c	0.73 ^c	33.09 ^c	57.10 ^a
Fermented corn cobs	92.80 ^b	90.93 ^a	9.07 ^b	6.54 ^c	0.85 ^c	31.21 ^c	52.34 ^b

Notes: different superscripts in the same column indicate significantly different ($P < 0.05$)

Test of Nutritional Quality of Fermented Corn Straw and Stover by In Vitro Method

Rumen fluid characteristic

Mean parameters of rumen fluid characteristic consisted of pH, VFA dan NH₃ are shown in Table 3.

Table 3. Mean pH, VFA dan NH₃

Forage	pH	VFA (mM)	NH ₃ (mg/100ml)
Elephant grass	6.79	123.75	15.28
Grinting grass	6.83	121.25	14.25
Corn straw	6.80	116.25	9.63
Fermented corn straw	6.78	115.00	9.63
Corn cobs	6.79	118.75	11.75
Fermented corn cobs	6.81	116.25	10.05

Notes: different superscripts in the same column indicate significantly different ($P < 0.05$)

The result of analysis of variance showed that all different forages had no significant effect ($P > 0.05$) on pH and VFA, and significantlty different ($P < 0.01$) on NH₃. Based on the DMRT further test results, NH₃ of elephant grass was significantly different ($P < 0.05$) with other forages; grinting grass was significantly different ($P < 0.05$) with other forages, and corn stover was

significantly different ($P < 0.05$) with other forages. Furthermore, NH_3 of corn straw, fermented corn straw and fermented corncob were significantly different ($P < 0.05$) from elephant grass, grinting grass and corncob.

The pH value of rumen fluid in this study ranged from 6.68-5.83, this range of pH values is still in optimal conditions for rumen microbial growth. In this study, the fermented or unfermented corn straw, fermented or unfermented corn stalks and controls (elephant grass and grinting) showed no change or decrease in the pH of rumen fluid. According to Pazla *et al.* (2024) rumen microbes can perform optimal activity if the pH of the rumen is in normal conditions, namely 6-6.9. This rumen pH conditions is influenced by the fermentation process of feed ingredients in the rumen which produces a neutral pH. In addition, rumen pH is also influenced by the balance between VFA and NH_3 production. This is in accordance with the opinion of Arora (1995) that the pH of the rumen will remain due to the balance of VFA (acidic) and NH_3 (alkaline), besides that the pH value of the rumen is also influenced by the provision of McDougalls buffer (artificial saliva) which plays a role in maintaining pH so that the pH of the rumen remains stable by fermentation products, namely NH_3 , where pH is directly proportional to the concentration of NH_3 .

The average VFA obtained from this experiment was 116.25-123.75 mM. This result is sufficient for livestock survival because the concentration of VFA required for a livestock to grow normally is around 80-160 mM (Pazla *et al.* 2023a; Zain *et al.* 2024). VFA from fermented or unfermented corn straw, fermented or unfermented corn stalks can match the VFA from the control (elephant grass and grinting). This is influenced by the carbohydrate content of these materials which are also uniform. According to Pazla *et al.* (2021), VFA is a fermentation product of carbohydrates such as cellulose, hemicellulose, and starch.

The average NH_3 obtained was 9.63-15.28 mg/100ml. The NH_3 value obtained in this study is still within normal limits. The maximum NH_3 concentration in the rumen ranges from 8.5-30 mg/100 ml (Elihasridas *et al.* 2023; Putri *et al.* 2024). The NH_3 value of maize straw showed the same value as fermented maize straw. This is thought to be influenced by the crude protein content of these materials which is not much different. According to Zain *et al.* (2023), NH_3 is a fermentation product of crude protein. The NH_3 value of fermented corn stover showed a decrease compared to unfermented corn stover straw. This is thought to be influenced by the lower crude protein content compared to before fermentation. This is due to the fermentation process that takes place on the maize straw, where there is a change in the crude protein content of the fermented maize straw.

The NH_3 values of elephant grass and grinting grass showed higher values than other forages, while elephant grass had a higher NH_3 value than grinting grass. The NH_3 value of corn stalks was higher than that of corn straw, as well as the NH_3 of fermented corn stalks with fermented corn straw. This is influenced by the different crude protein content of these materials. According to Pazla *et al.* (2023b), each organism has its own specific protein and an organism has a different protein composition in its cells and tissues. He further explained that high feed protein content and easily degradable protein will result in an increase in NH_3 concentration in the rumen. He further explained that ammonia production in the rumen is influenced by the amount of feed protein consumed, feed degradation rate, length of feed in the rumen, rumen pH (Moante *et al.*, 2004).

CONCLUSION

The grinding machine that has been made has specifications in accordance with its function and this grinding machine can function as a copper / cutter and grinder of feed ingredients. Processing of corn waste (straw and corn stalks) with the fermentation method can improve the nutritional content and nutritional quality.

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