

# Effectiveness of the Anaerobic Haylage Method for Flax Waste Utilization in the Diet of Friesian Holstein Cows

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**Abstract:** The haylage dry feed fermentation method is one of the methods of preserving grass feed, dried herbs, or dry agricultural waste for animal feed. This study aims to determine the quality of hemp flakes waste that has been dried for 6 months and has a water content of <3% using the Haylage method. The research parameters include physical quality, pH, temperature and palatability which were tested on 5 Friesian Holstein cows. The method used was an experiment using a Completely Randomized Design (CRD) consisting of 6 treatments based on differences in the concentration of hemp flakes and bran waste. The data obtained were analyzed using Analysis of Variance (ANOVA) and continued with Duncan's Multiple Range Test (DMRT). The study was conducted in July-September 2023. The results showed that the physical quality (color, aroma, mold and mucus) of haylage stored for 4 weeks in treatments 1-5 showed better results compared to the control treatment, its fermentation properties were still stable with a pH of 4.88-5.00 and a temperature of 27-28°C, so it can last for 2 years if stored properly. This can be seen at the level of livestock palatability > 50%. The best haylage formulation was in treatment 4 (25% hemp flake waste + 75% bran + 15% molasses + 15% probiotics).

**Keywords:** Experiment, Haylage, Palatability, Quality, Hemp, Waste

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## Introduction

Agricultural and agro-industrial waste production is still a product that has not been optimally utilized, so it is necessary to study the possibility of utilizing it as optimal animal feed. Agricultural waste on average has a high crude fiber content, but its availability is quite abundant in nature so that its further utilization is needed with a touch of technology that can convert these raw materials into nutritious feed and a source of energy for livestock so that it can be used as feed ingredients, especially ruminants [1, 2]. One technology that can be used is feed preservation technology. Feed preservation technologies that can be carried out include making hay, silage, haylage and ammoniation [3].

Haylage is a process of preserving green fodder using anaerobic fermentation technology. Haylage is a continuation of the process of hay into silage. Hay is a preservation method by reducing the water content from around 80% to only 10-20% so that it could the green fodder can last a long time [3, 4]. Silage is a technique for preserving fresh green fodder using the fermentation method and under anaerobic conditions with the aim of increasing the storage life of green fodder. Indonesia is rich in natural fiber materials, one of which comes from the hemp plant. In addition to producing fiber, hemp plants also provide biomass in the form of processing waste, one of which is decortication waste [5, 6]. Hemp husk waste is quite a lot, one hectare of hemp plants per year can produce around 58,750 kg of wet husk waste or 13,160 kg of compost [7]. This fiber skin waste if not utilized was troublesome because it requires a large disposal area. The production and nutritional quality of hemp waste is a potential that has not been utilized optimally as animal feed, especially as a substitute for green fodder. Utilization of hemp waste as animal feed is also an effort to implement the zero waste concept. Utilization of hemp stem waste as animal feed is constrained by low nutrient digestibility due to the high levels of lignified crude fiber as the stem structure [7, 8]. Hemp stem waste has a crude fiber content of 37.81%; non-nitrogen extractable material (BETN) 43.83% and crude protein 8.53%. The nutrient content of hemp decortication waste is quite high, namely P (0.19%), K (1.02%), Ca (0.93%) and Mg (0.40%) [6, 8]. This study utilized hemp decortication waste (hemp chips) that had been stored for 6 months and had a water content of less than 3% originating from the Wonosobo hemp fiber industry. Researchers will compare the formulation of hemp chips as a feed ingredient in the form of quality haylage to the level of livestock palatability. The livestock used in this study were dairy cattle (*Bos taurus*). According to the report of the Central Statistics Agency (BPS), the population of beef cattle in Indonesia has continued to increase by 3.49% over the past 5 years. Cattle as ruminants can consume green fodder in a day as much as 10% of their body weight [9]. This large amount of need must be available continuously every day. In other words, if the cattle population increases, demand will continue to increase. The main problem with green fodder is that its availability in the dry season is less than in the rainy season, so it is necessary to make efforts to utilize feed by applying feed preservation technology to support an optimal and long-term livestock feed availability system [3]. Based on the background that has been described, it is necessary to conduct research on the analysis of the utilization of hemp flakes waste from the decortication of the Wonosobo hemp fiber factory which has been stored for 6 months and has a water content of less than 3% with the dry feed fermentation method (Haylage) including physical quality (color, aroma, mold and mucus), fermentation quality (pH and temperature) and livestock palatability.

## Materials and Methods

### Tools and Materials

The tools used in this study were choppers, machetes, digital scales, tarpaulins, plastic basins, plastic drums per kilogram, plastic, raffia rope, sample containers, feed trays, pH meters, thermometers and test animal earrings. While the materials used in this study were all for the manufacture of dry fermented feed, the materials were hemp flakes that had been stored for 6 months and had a water content of less than 3%, bran, molasses, probiotics, and water.

### Research Design

This study used an experimental method with a completely randomized design (CRD) consisting of 6 treatments with 5 replications. This formulation aims to determine the most effective mixture of hemp and bran waste materials with the same concentration of molasses and probiotics. The formula used in this study was as follows:

P-0: 100% Hemp Waste + 0% Bran + 0% Molasses + 0% Probiotics

P-1: 100% Hemp Waste + 0% Bran + 15% Molasses + 15% Probiotics

P-2: 75% Hemp Waste + 25% Bran + 15% Molasses + 15% Probiotics

P-3: 50% Hemp Waste + 50% Bran + 15% Molasses + 15% Probiotics

P-4: 25% Hemp Waste + 75% Bran + 15% Molasses + 15% Probiotics

P-5 : 0% Hemp Waste + 100% Bran + 15% Molasses + 15% Probiotics

Note: (P -) = n - treatment

### Haylage Making Procedure

Haylage production in this study had a total weight of 37 kg with a cost of Rp. 111,375.00 for all formulation treatments every 5 repetitions, at a cost of Rp. 3,010.00 / kg. The hemp flake waste used was 17.25 kg, bran 17.25 kg at a price of Rp. 77,625.00, molasses 3.75 kg at a price of Rp. 15,000,000, probiotics 3.75 kg at a price of Rp. 18,750.00 and water as much as 500 ml. Hemp flake waste was prepared, then chopped to a size of 3 cm using a chopping machine and manually using cutting tools (machete and scissors).

The results of the enumeration were weighed according to the treatment. For treatment P0, 5 kg (100%) of flax flakes were put into the silo. For treatment P1, 5 kg (100%) of flax flakes, 0.75 kg (15%) of molasses (previously diluted with 100 ml of water) and 0.75 kg (15%) of probiotics were mixed, then mixed well and put into the silo. For treatment P2, aromatic bran was made first by mixing 1.25 kg (25%) of bran, 0.75 kg (15%) of molasses (previously diluted with 100 ml of water) and 0.75 kg (15%) of probiotics. Then 3.75 kg (75%) of flax flakes were prepared and sprinkled with aromatic bran, mixed well and put into the silo. Do the same as P2 for treatments P3 and P4 which were adjusted to their respective formulations. And for the P5 treatment, only make aromatic bran by mixing 5 kg (100%) bran, 0.75 kg (15%) molasses (previously diluted with 100 ml of water) and 0.75 kg (15%) probiotics, stir until evenly mixed and placed in a silo.

After all the haylage material was put into the silo, it was then compacted again using the feet to ensure there was no air between the haylage piles, the effective haylage compaction technique with feet was by rotating the silage from the top of the drum/silo, then sucking the air in the plastic silo using a vacuum and tied with raffia rope (tied neatly, tightly and not leaking). The mixture was allowed to ferment anaerobically for 4 weeks. After 4 weeks the haylage was ready to be given to livestock [3]. After that the haylage was opened and tested for physical quality characteristics (color, aroma, mold and mucus), fermentation characteristics (pH and temperature) and palatability.

### Physical Characteristics Testing (Color, Aroma, Fungus and Slime)

Determination of physical quality in the form of color, aroma, texture and presence of fungi from hemp flake waste straw with different formulations was carried out organoleptically using 10 limited panelists. Limited panelists were people who have high sensitivity to ensure bias can be avoided. The panelists have known the factors in organoleptic assessment and know the processing method and the effect of raw materials on the final result. Decisions were taken through each panelist filling out an assessment form with a predetermined scale. The inclusion criteria for this study were that the panelists did not have disorders in the sense of smell, sight, and taste, and had sensitivity and were willing to participate in this study.

**Table 1: Physical characteristics assessment scale (color, aroma, mold and mucus)**

Category	Score				
	1	2	3	4	5
Color	Black	Dark brown	Chocolate	Brownish yellow	Brownish green
Aroma	Rotten	Rancid	Odorless	Fragrant	Very fragrant (small fermentation aroma)
Mold	More than 10% from whole straw	5-10% from whole straw	1-5% from whole straw	0.5% from whole straw	No mold
Mucus	More than 10% from whole straw	5-10% from whole straw	1-5% from whole straw	0.5% from whole straw	Not slimy

### Haylage Fermentation Characteristics Testing (pH and Temperature)

Haylage pH measurement using the Naumann and Bassler procedure (1976), 10 grams of newly opened haylage was taken and mixed with 100 ml of distilled water, blended at medium speed for 30 seconds, the pH of the haylage liquid was measured using a calibrated pocket pH meter. Meanwhile, haylage temperature testing was measured using a thermometer. The temperature of the haylage in the silo can be known after the haylage enzymatic process was complete.

### Livestock Palatability Testing

The palatability test method used was to provide unlimited feed to livestock. All-you-can-feed was the provision of feed continuously and feed was always available, while monitoring to the length of time for livestock to finish feed. Duration of eating, the length of eating was the time needed for livestock to finish feed in a certain time. The duration of feeding in research livestock shows different time intensities [10]. Haylage was given to 5 male Friesian Holstein cows for 1 day. All haylage

treatments were divided into 3 feeding times, namely morning, afternoon and evening [11]. The livestock population used as a research sample was only 5 because this research was conducted with materials and methods available on small-scale farms or community farms.

## Data Analysis

The data collection technique used in the observation of silage quality was observation conducted to obtain data on the physical properties of 6 haylage treatment samples made from hemp flake waste including color, aroma, presence of mold and presence of haylage mucus as well as data on fermentation properties in the form of pH and haylage temperature. The results of the observation were obtained by processing Statistical data from several samples using the Statistical Program for Social Science (SPSS) software. In evaluating the palatability of haylage, consumption data for each feed serving period showed the preference for haylage descriptively analysis of hemp flake waste by test animals. The average feed consumption time data were analyzed using an analysis of variance (ANOVA) experimental design. If there was a significant difference, namely the calculated F was greater than the F table at the 5% level, then it was continued with the Duncan Multiple Range Test (DMRT).

## Results and Discussion

### Physical Characteristics of Haylage

Table 2: Average results of physical characteristics tests of hemp flake waste in various treatments

Treatment	Variables			
	Color	Aroma	Mold	Mucus
P-0	3.40	3.00	5.00	5.00
P-1	3.80	3.90	5.00	5.00
P-2	3.90	4.30	5.00	5.00
P-3	4.00	4.40	5.00	5.00
P-4	4.00	4.60	5.00	5.00
P-5	3.90	4.60	5.00	5.00

Note: (P -) = n - treatment



Figure 1: Physical quality (color, aroma, mold and slime) of Haylage tested by panelists

### Haylage Color

The average value of haylage color results can be seen in Table 2. The haylage color results data tested by the panelists as in figure 1 were obtained with values ranging from 3.40 - 4.00 with a brownish yellow color interpretation. The highest average value of haylage color was found in treatments 3 and 4, which was 4.00, while the lowest average value of haylage color was found in treatment 0, which was 3.40.

In the study on hemp plant waste used as animal feed silage, the best color was yellowish green to brownish green [12]. This was supported by Yang that the color of good haylage was brownish green. While the color of hemp flake waste haylage was brownish yellow. This was because the previous study used fresh hemp leaf waste, while in this study dry hemp flake waste was used and had a water content of 3%, causing the color of the hemp flake waste to turn brownish yellow after fermentation [13].

The results of the analysis of diversity of the ANOVA Statistical test and the DMRT follow-up test showed that the treatment based on the difference in the provision of flax flakes and bran had a very significant effect ( $P < 0.05$ ) on the color of haylage with a significance value of 0.001. The results of the Duncan multiple range follow-up test showed that the average haylage color score in treatments 4 and 5 was significantly higher than treatments 0 and 1. In other words, the provision of bran greatly affected the fermentation process of flax flake waste haylage, as evidenced by the change in color from the original material.

## Haylage Aroma

The average value of the haylage aroma score can be seen in Table 2. The data on the aroma of hemp flake waste haylage tested by the panelists as in Figure 1 were obtained with a score ranging from 3.00 - 4.60 with an interpretation of sour aroma (fermentation aroma). The highest average value of the haylage aroma score was found in treatments 4 and 5, which was 4.60, while the lowest average value of the haylage aroma score was found in treatment 0 (control), which was 3.00. Regarding hemp plants used as animal feed silage, they produce a fragrant aroma [12, 14]. Good haylage was one that has a sour aroma [14, 15]. The sour aroma formed in hemp flake waste haylage was caused by the growth of lactic acid bacteria (LAB) during the fermentation process. In addition, the addition of molasses and probiotics functions as a starter to optimize the quality of silage to be better [16].

The results of the analysis of variance of the ANOVA Statistical test and the DMRT further test showed that the treatment based on the difference in the provision of water hyacinth and bran had a very different effect ( $P < 0.05$ ) on the aroma of haylage with a significance value of 0.001. The results of the Duncan multiple range test showed that the average score of the aroma of haylage in treatments 4 and 5 was significantly higher than treatment 0 (control). P-0 became the treatment with the lowest score due to the absence of starters such as molasses and probiotics in the treatment, so that it could there was no fermentation activity that could change the aroma of water hyacinth waste. This shows that the provision of starters (molasses and probiotics) greatly affects the aroma of water hyacinth waste haylage fermentation.

## Presence of Haylage Fungus

The results of the study of the presence of fungi tested by the panelists as in Figure 1 based on Table 2. show an average score of 5.00. The results of the ANOVA Statistical test diversity analysis showed that the treatment based on the difference in the provision of flax flakes and bran did not have a significant effect ( $P < 0.05$ ) on the presence of haylage fungi with a significance value of undefined. This was because the presence of fungi was not found in each treatment and its repetition. It can be interpreted that the haylage of flax chip waste was fermented well and the silo was tightly closed without oxygen. Herlinae et al. (2015) and Wiguna et al. (2024) stated that in the fermentation process if oxygen has run out, breathing will stop and the condition becomes anaerobic [25]. In such a situation, fungi will not grow and only bacteria were still active, especially acid-forming bacteria.

## Presence of Haylage Mucus

The results of the study on the presence of mucus tested by the panelists as in Figure 1 based on Table 2. show an average score of 5.00. The results of the ANOVA Statistical test diversity analysis showed that the treatment based on the difference in the provision of flax flakes and bran did not have a significant effect ( $P < 0.05$ ) on the presence of haylage mucus with a significance value of undefined. This happened because no mucus was found in each treatment. Thus, it can be interpreted that the haylage of flax flake waste was fermented well. The absence of mucus indicates that there was no damage due to the absence of oxygen entering the silo or the absence of unexpected mold growth.

The mucus contained in fermented feed was an indication of the presence of spoilage microbes. The mucus was produced by microbes from the capsule system, this capsule system makes spoilage and pathogenic microbes resistant to phagocytosis, thereby increasing their virulence to livestock. Mucus was produced from the release of several components of the microbial capsule; Mucus production was prominent in microorganisms grown in sucrose-containing media. This slime solution was like a gel consisting of dextrin [17].

## Haylage Fermentation Characteristics Haylage pH Value

The acidity level (pH) of straw can be one of the criteria for straw fermentation, straw with a pH value <5.0 indicates that the silage was stable. The pH value of straw from hemp flake waste can be seen in the following table.

**Table 3: Haylage pH Value**

Haylage pH Value	
Treatment	pH value
P-0	6.83
P-1	5
P-2	5
P-3	4.96
P-4	4.92
P-5	4.88

Note: (P -) = n - treatment

The Table 3 shows the results of the pH value of each treatment. In the P-0 treatment, the pH value of the haylage was 6.83 while the pH values of the haylage P-1, P-2, P-3, P-4, P-5 were respectively with pH values of 5, 5, 4.96, 4.92, and 4.88. This can be seen from the results of the study that in the P-0 treatment the haylage was not fermented while for the P-1, P-2, P-3, P-4 and P-5 treatments fermentation had occurred well, namely the good pH quality for haylage was in the range of 4.5 - 5.5 [4, 18]. This was supported by Xinchao's research (2016) that a good fermentation process will reduce the pH to 5.5.

In the P-0 treatment, there was no fermentation process due to the absence of starters such as molasses, probiotics and bran. While in the P-1 to P-5 treatments, starters such as molasses, probiotics and bran were added so that it could the fermentation process (ensilage) occurred due to the presence of LAB. The ensilage process will produce organic acids (especially lactic acid) by fermenting water-soluble carbohydrates (WSC) anaerobically, resulting in a decrease in pH and durability of animal feed [19, 20].

## Haylage Temperature Value

The next straw fermentation indicator was temperature. Straw temperature can be one of the straw fermentation criteria, straw with increasing temperature values indicates a stable silage process. The temperature of the hemp flake waste straw can be seen in the following table.

**Table 4: Haylage Temperature Values**

Haylage Temperature Value	
Treatment	Temperature (°C)
P-0	22
P-1	27
P-2	27
P-3	28
P-4	28
P-5	28

Note: (P -) = n - treatment

The Table 4 shows the results of the temperature values for each treatment. In the P-0 treatment, the haylage temperature value was 22°C while the haylage temperature values for P-1, P-2, P-3, P-4, P-5 were 27, 27, 28, 28 and 28 respectively. From the results of the study, it can be seen that in the P-0 treatment, haylage did not experience fermentation, while for the P-1, P-2, P-3, P-4 and P-5 treatments fermentation had occurred well, this was in accordance with the research of Ali et al. that the average temperature value during ensilage was in the range of 27-28°C. This was a good condition for silage production because the temperature was below the ambient temperature ( $\pm 29^\circ\text{C}$ ) [21]. This was supported by the research of Okine et al. that a good silage temperature was 25-37°C [22].

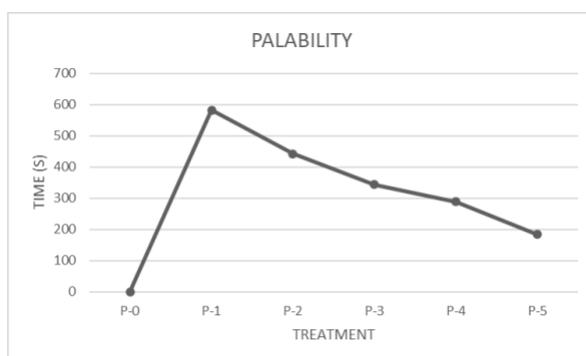
In the P-0 treatment, there was no fermentation process because there was no starter such as molasses, probiotics and bran so that it could there was no change in temperature due to the ensilage process. While in the P-1 to P-5 treatments, starters were added in the form of molasses, probiotics and bran so that it could the fermentation process (ensilation) occurred due to the presence of LAB so that it could the temperature during the ensilage process increased. Haylage from this study was included in the good category because the temperature at the time of harvesting was still several degrees below the ambient temperature. Silage temperatures that exceed 5-10oC from the ambient temperature can be said to be contaminated by microorganisms such as mold and fungi. The fast ensilage process can stimulate the growth of LAB for the formation of lactic acid and there was no long heating so that it could the silage temperature can be stable [17].

## Evaluation of Livestock Palatability

Palatability was the degree of preference for certain food ingredients that were selected and eaten along with the response given by livestock, both ruminants and mammals [10]. Palatability or the level of livestock's preference for rations can be seen from the time it takes for livestock to finish 250 grams of haylage. The data from the palatability test of hemp flake waste haylage were presented in Table 5 below.

**Table 5: Palatability value ha of hemp flake waste (s/250 grams)**

Repeat	Treatment					
	P-0	P-1	P-2	P-3	P-4	P-5
1	0	578	454	323	287	183
2	0	569	445	347	285	185
3	0	579	445	340	286	184
4	0	583	440	357	288	182
5	0	586	441	333	289	186
<b>Total</b>	<b>0</b>	<b>2895</b>	<b>2225</b>	<b>1700</b>	<b>1435</b>	<b>920</b>
<b>Means</b>	<b>0</b>	<b>579</b>	<b>445</b>	<b>340</b>	<b>287</b>	<b>184</b>
<b>Standard Deviation</b>	<b>0</b>	<b>6.44</b>	<b>5.52</b>	<b>13.00</b>	<b>1.58</b>	<b>1.58</b>



**Graph 1: Palatability of hemp chip waste haylage**

Note: (P -) = n - treatment

Note: Different superscripts in the same column indicate differences ( $p < 0.05$ )

The data in Table 5 and graph 1 show that the highest feed consumption was in treatment 5 (haylage with a formulation of 100% bran + 15% molasses + 15% probiotics) for 184 seconds/250 grams. While the highest feed consumption with the use of hemp flake waste material was in treatment 4 (haylage with a formulation of 75% bran + 25% hemp flake waste) for 287 seconds/250 grams. It was suspected that in treatments 4 and 5 the bran raw material was quite a lot. Bran was generally used in the preparation of livestock rations as a source of reinforcement, a source of carbohydrates and protein (crude fiber less than 18%). Bran can be used as a concentrate feed that contains energy and was preferred by livestock. As a livestock feed ingredient, bran has advantages and disadvantages. The advantages of bran as a feed ingredient were that it was easy to obtain, its use does not compete with humans, it has a high nutritional content such as 10.8% crude protein, 5.1% fat, 11.5% crude fiber, and 2980 kcal/kg metabolic energy content [10, 22], while the disadvantages of bran as animal feed were

its high crude fiber content and the presence of phytic acid compounds that can bind minerals so that it could they were difficult to utilize by digestive enzymes. The high crude fiber content of bran was a nutrient limiting factor that causes bran to not be utilized excessively in rations [11].

The lowest feed consumption was in treatment 0 (100% flax flake waste formulation), namely haylage feed was not eaten at all by livestock [23]. This was because the raw material in this treatment was only pure flax flake waste without any additional ingredients which causes the taste of the haylage feed to be bland and does not produce an aroma that livestock likes. In addition to the absence of bran, the presence of molasses and probiotics greatly affects the fermented feed. Likewise, in flax plants that were made into animal feed silage, silage with a formulation of flax leaves, rice bran, 0.5% aromatic bran and 5% molasses can increase livestock palatability by > 50% due to the aroma from the addition of molasses [14]. In the study of Ates et al using fresh flax so that it could only 5% molasses was needed to create an optimal formulation [12].

Molasses was a by-product of the sugar processing industry in liquid form [16] which causes the feed to become bland if not added. In addition, the role of probiotics was also very important to improve livestock palatability. Probiotics contain LAB which, when fermented, can improve feed quality. Fermentation of feed by LAB can also improve the aroma of feed so that it could it can increase livestock appetite [24]. Therefore, the presence of bran, molasses, and probiotics has an important effect on livestock palatability. The physical and chemical state of feed reflected in its appearance, aroma, and taste can describe its attractiveness so that it could it can stimulate livestock to consume it [21].



**Figure 2: Haylage feed consumed by cattle**

The results of the analysis of diversity of the ANOVA Statistical test and the DMRT follow-up test showed that the treatment based on the difference in the provision of hemp chips and bran had a very significant effect ( $p < 0.05$ ) on palatability with a significance value of 0.000. The results of the Duncan multiple range test showed that the average haylage aroma score in treatments 4 and 5 was significantly higher than treatment 0 (control).

Factors that influence eating behavior in cattle include: feeding place, type of feed, amount of feed given and feeding period. Judging from the results of the study, all treatments (1-5) had a palatability level of >50% and were better than the control treatment (P-0), as can be seen in Figure 2, cattle were consuming haylage feed. The best formulation obtained from this study was treatment 5, but in this formulation, there was no raw material of flax flake waste. So we conclude that the best flax flake waste haylage formulation was in treatment 4, namely with a percentage of 25% flax flake waste, 75% bran, 15% molasses, and 15% probiotics. However, to make production costs more efficient, such as purchasing bran raw materials which were increasing day by day and to make maximum use of every plant waste, especially flax flake waste, treatments 1, 2 and 3 can be used as animal feed. From the research results for the production of haylage from hemp waste  $\pm 37$  kg was Rp. 111,375.00 with a price per kilogram of Rp. 3,010.00 when compared to buying feed in the market ranging from Rp. 250,000.00 - 350,000.00 / 50 kg or equivalent to Rp. 5000.00 - 7,000.00 / kg, making feed from hemp waste more economical and hemp waste can be utilized optimally. Feed aroma significantly influences livestock palatability. The smell of feed that livestock likes was fragrant, fresh and not rancid. The most fragrant aroma will affect the palatability and acceptance of feed by livestock. This can be interpreted that regardless of the presence or absence of bran, molasses and probiotics can still be used to improve the palatability of livestock and ensure it a quality fermented haylage feed.

Appropriate technology for making straw can improve the quality of forage (HMT) and agricultural waste (rice straw) as feed for beef cattle, so that it could beef cattle experience a weight gain of 0.4-0.5 kg/hour. Haylage can last up to two years if stored properly [20, 26]. The quality of the straw produced was influenced by the raw material of the straw, the type of silo, preservatives, and other factors including weathering, mechanical treatment, post-harvest forage treatment, plant structure and protein content. Good haylage has characteristics including a sour smell, no mold, no slime, uniform color (brownish green) and clear texture [3].

## Conclusion

Based on the results of haylage research on hemp chip waste for 4 weeks, we conclude that hemp chip waste that has been stored for 6 months with a water content of 3% was still effective as animal feed through the haylage dry feed fermentation method. The physical quality of the fermented dry feed from hemp chip waste was still stable and better than the control treatment (P-0). The palatability of 5 cows to the fermented dry feed from hemp chip waste was above 50%. The best formulation in this study was treatment 5 (100% bran + 15% molasses + 15% probiotics). While the best hemp chip waste haylage formulation was in treatment 4 (25% hemp chip waste + 75% bran + 15% molasses + 15% probiotics). Fermented haylage feed was a livestock feed technology that can utilize various types of plant waste, not limited to hemp chip waste. This technology supports the "zero waste" principle and when stored properly, haylage can last for up to two years.

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All animal procedures were carried out in accordance with institutional guidelines and approved by the Ethics Committee of Padjadjaran University, Indonesia. Animal welfare was monitored throughout the study to minimize discomfort.

## Authors Contributions

Conceptualization: Ruly Budiono; Methodology: Joko Kusmoro; Investigation: Erin Nurinsani Waafi;

Formal analysis: Sukono;

Writing – original draft: Ruly Budiono, Erin Nurinsani Waafi;

Writing – review & editing: All authors;

Supervision and project administration: Joko Kusmoro, Sukono.

## Ethics

Ethical review and approval were not required for this study because the research was conducted on smallholder community farms using routine feeding practices without invasive procedures. All animals were handled humanely in accordance with local regulations and generally accepted standards of animal welfare.

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