Physical and chemical quality of forage feed pellets with different types of materials and compositions

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Abstract. The aimed of this study was to determine the physical (durability) and chemical quality of forage feed pellets with different raw materials and compositions. This study used two (2) weed raw materials with different forms, namely in the form of fresh and in the form of hay that has been milled. Each raw material was formulated and processed in the same way, a mixture of forage and rice bran, consisted of 90%: 20% and 80%: 20% (calculated based on dry matter, mixed in as fed), pelleted, then dried in the sunshine. Each treatment has three (3) replications. Dried forage pellets were tested with the PDI (pellet durability index) test and chemical quality test (proximate) in the Forage and Pasture Science Laboratory. The experimental design used a Randomized Completely Block Design where there were blocks of material types and blocks of material composition. The variables observed were physical quality in the form of PDI and chemical quality in the form of dry matter (DM), organic matter (OM), crude protein (CP), crude fibre (CF), extract ether (EE) and nitrogen-free extract (NFE). The data were statistically analysed with program SPSS version 26. If there was a significant difference, it was continued with the least significant different (LSD) test. The conclusion of this study was that the physical quality of forage pellets (PDI number) made from weed (Synedrella nodiflora) or Legetan was affected by composition, but neither hay nor fresh weed material affected its quality. The type of raw material in the form of hay and fresh affects the chemical quality of forage pellets in the form of DM, OM, CP, CF and NFE, but does not affect EE. EE was influenced by the composition of the pellets.

1. Introduction
Livestock reared for energy used or products taken by breeding so as to increase the income of farmers. Feed is very necessary in breeding livestock to grow healthy and strong. Feed serves to maintain the immune system and health. In order for livestock to grow as expected, the type of feed given to livestock must be of good quality and in sufficient quantities. The feed that is often given to working cattle includes forage and concentrates[1].

The availability of forage during the dry season is an obstacle at this time. Efforts are needed to make feed stock during the rainy season, with preservation. Preservation of feed by silage and hay still requires a large enough space for storage. Therefore, it is necessary to find an alternative for food preservation other than silage and hay. Based on that we need to find alternatives for the preservation of forage in other forms[2].
For the preservation of feed is not only concerned in nutrition, but also in volume. Therefore, a new technology is needed for the preservation of forage fodder by making forage pellets that are almost 100% dry matter[2].

Forage feed pellets have the advantage of being easy to store, durable with quality that does not change much. Hay can also be stored for a long time, but the pellet form is more compact and can be combined with other energy sources. Pellet allows livestock to not select the feed so that all can be consumed (reducing the risk of spilling). There has not been much research related to forage pellets based on the Legetan weed (*Synedrella nodiflora*). Legetan is a type of weed with high nutrition with CP content up to 20%. Chemical composition of *Synedrella nodiflora* according to Bindelle et al.[3] were dry matter (18%), crude protein(20.7%), crude fibre (23%), organic matter (15.7%), neutral detergent fibre (37.6%), acid detergent fibre (32.5%), and lignin (16.7%) [4]. According to Adjibode et al.[5], *Synedrella nodiflora* can be given to livestock as feed and consumed by humans due to the absence of toxicity. Therefore, this research is expected to be a contribution to the work of scientific research in animal husbandry, especially in terms of ruminant animal feed[6].

2. Materials and methods

The research was conducted from September to November 2020 at the Forage Animal Feed and Pasture Laboratory, Faculty of Animal Husbandry, Gadjah Mada University.

2.1. Materials

This study used a forage chopper, tray, pellet press machine, pellet durability index (PDI) tester, and a set of proximate analysis tests. The pellet durability index (PDI) test to measure pellet hardness was carried out at the feed mill company owned by PT. Japfa Comfeed Indonesia (Medan). The materials used in this study were rice bran, molasses, weeds harvested from the Forage, Animal Feed and Pasture Laboratory.

2.2. Method

This research used an experimental method and was carried out at the Animal Feed Forage Laboratory, Faculty of Animal Husbandry, Gadjah Mada University.

Formulation of forage pellets using Legetan raw materials, both fresh and hay mixed with rice bran (DM 88%, CP 12% and CF 5.2%) and pollard (DM 88%, CP 16% and CF 6.8%). Legetan is mixed with rice bran with a composition of 90:10 and 80:20 (calculated based on dry matter but mixed in as fed). There are 4 resulting combinations, namely: P1M1, P1M2, P2M1 and P2M2 with P and M as follows: P1 = fresh form of Legetan; P2 = hay; M1 = Forage mix with rice bran 90:10; M2 = Forage mix with rice bran 80:20.

The experimental design in this research is a Randomized Completely Block Design with block types of materials and blocks of material composition. The data were statistically analysed using SPSS version 26 program. If there was a significant difference, then it was continued with the least significant different (LSD) test.

After being mixed with binder materials according to the treatment, the next step is:

1) Each treatment was made in three replications. Additional binder according to treatment. The process of making pellets by inserting the mixture into the pelletizer machine 3-5 times. The pellets were then subjected to physical and chemical tests. Measurement of PDI value based on Thomas and van der Poel [7].

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PDI \text{ value} = \frac{\text{pellet weight after spinning} \times 100 \%}{\text{pellet weight before spinning}}
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Density test: The finished forage pellet is put into a volumetrix (1 liter capacity) lifted by 15 cm, then dropped. Repeat 2 times, then re-measured the weight and volume compared to the weight and volume before being dropped.
2) Chemical test
Analysis of nutrient content with proximate analysis to obtain the content of organic matter, dry matter, crude protein, crude fibre, extract ether and NFE [8].
The variables observed were physical quality in the form of pellet durability and chemical quality in the form of dry matter, organic matter, crude protein, crude fibre, crude fat and NFE.

3. Results and discussion
Observations on research made from Legetan are concerned with the physical (PDI) and chemical quality (organic matter, dry matter, crude protein, crude fibre, extract ether and BETN) of forage pellets.

3.1. Pellet durability index (PDI)
In the physical quality test, a hardness test or pellet durability index (PDI) is carried out, the PDI value in the forage legetan pellet can be seen in Table 1.
Results of analysis variance showed that there were significant differences of treatment composition of the PDI value. PDI value was not significantly affected by the type of forage. The real difference in the composition is due to the presence of rice bran which also functions as an adhesive, possibly affecting the binding capacity. Krisnan and Ginting [9] stated that the durability of pellets is influenced by the composition of materials such as fat, starch, protein, and fibre. PDI can also be affected by the particle size of the pellet.

| Block | repetition | Treatment | Average | Block$^m$ |
|-------|------------|-----------|---------|-----------|
| Fresh | P1         | 96.4      | 95      | 95.7      |
|       | P2         | 98        | 96.8    | 97.4      |
| Hay   | P1         | 98        | 96.6    | 97.3      |
|       | P2         | 97.6      | 95.8    | 96.7      |
|       | Average    | 97.5±0.76 | 96.05±0.82 | 96.75±0.82b |

$^a$Different superscripts in the same column show significant differences(P<0.05)
$^m$non significant
K1 = composition of forage 90% and rice bran 10%
K2 = composition of forage 80% and rice bran 20%

3.2. Dry matter (DM)
Based on the results of the analysis of variance in Table 2, it shows that there is no significant difference from the composition treatment to the dry matter content. The average value of dry matter content shows 93.16% for composition 1 and composition 2 with a value of 93.17%. The results of the analysis of variance in blocks showed that the basic ingredients of forage pellets had an effect and there was a very significant difference (P<0.05) on the dry matter content of forage pellets Legetan. The dry matter content of pellets with hay-based ingredients was 93.72% and fresh-based ingredients was only 92.62%. This is probably due to the effect of hydrolysis processing, resulting in the heating process and starch gelatinization during pellet formation.
This difference is due to the raw material of fresh forage still retain a lot of water content, so that when fresh forage is processed into pellets, the dry matter content in pellets made from fresh forage contains a low dry matter content. In principle, the higher the dry matter of a material, the water content will decrease or vice versa. This is in accordance with Syarief and Halid [10] which states that water content is the amount of water content in a material based on dry weight which is influenced by the type of material, temperature and humidity of the environment. The water content in these pellets
can be caused by the oxidation of the feed ingredients which produces free water molecules in the pellet feed[11].

**Table 2.** Dry matter of Legetan forage pellets (%).

| Block | Treatment | Average Block |
|-------|-----------|---------------|
|       | K1        | K2            |               |
| Fresh | P1        | 92.4          | 92.75         | 92.58<sup>a</sup> |
| Hay   | P1        | 93.9          | 93.68         | 93.79<sup>b</sup> |
|       | K2        | 92.53         | 92.78         | 92.66<sup>a</sup> |
|       | P2        | 93.82         | 93.46         | 93.64<sup>b</sup> |
|       | **Average** | **93.16±0.81** | **93.17±0.47** |               |

<sup>a</sup> Different superscripts in the same column show significant differences (P<0.05)
<sup>b</sup> non significant

3.3. Organic matter (OM)

The content of organic matter in the pellets of forage legetan can be seen in Table 3.

**Table 3.** Organic matter of Legetan forage pellets (%).

| Block | Treatment | Average Block |
|-------|-----------|---------------|
|       | K1        | K2            |               |
| Fresh | P1        | 76.63         | 77.67         | 77.65<sup>a</sup> |
| Hay   | P1        | 72.19         | 73.95         | 73.07<sup>b</sup> |
|       | K2        | 76.71         | 77.67         | 77.19<sup>a</sup> |
|       | P2        | 73.54         | 72.10         | 72.82<sup>b</sup> |
|       | **Average** | **74.41±2.61** | **75.71±2.27** |               |

<sup>a</sup> Different superscripts in the same column show significant differences (P<0.05)
<sup>b</sup> non significant

The results of the analysis of variance in organic matter content of forage pellets in Table 3, show that there is no significant difference from the composition treatment to organic matter content. The basic ingredients of forage pellets had a significant effect (P<0.05) on the organic matter content of Legetan forage pellets. The highest organic matter content was obtained at 77.65% in fresh basic ingredients, while hay was only 73.07%. This is due to differences in the mineral content in the soil in the basic ingredients, so that the organic matter content in the forage pellets is different. The percentage of ash content is also very likely to be influenced by the pelleting process, which comes from other objects carried during the pellet making process. The rotation of the metal and the friction that occurs in the pellet machine is also possible to affect the content of inorganic materials (ash content) in the pellets produced[12].

3.4. Crude protein (CP)

Based on Table 4, it shows the value of crude protein content of 11.04% for composition 1 and composition 2 with a value of 11.47%. This shows that there is no significant difference from the composition treatment to crude protein content. The results of the analysis of variance in blocks showed that the highest crude protein content was obtained at 13.05% on fresh base ingredients, while hay-based ingredients only amounted to 9.93%. This shows the effect and there is a significant difference (P<0.05) on the crude protein content of the forage Legetan pellets. These results can be influenced by the age of cutting plants. The cutting age of the plant affects the quality and quantity of forage[13,14].
Table 4. Crude protein of Legetan forage pellets (%).

| Block | repetition | Treatment | Average | Block |
|-------|------------|-----------|---------|-------|
|       |            | K1        |         |       |
|       |            | K2        |         |       |
| Fresh | P1         | 12.01     | 12.27   | 12.14^a|
|       | P2         | 12.75     | 13.35   | 13.05^a|
| Hay   | P1         | 10.40     | 9.38    | 9.89^b |
|       | P2         | 9.00      | 10.86   | 9.93^b |
| Average |           | 11.04±1.68| 11.47±1.72|       |

^aDifferent superscripts in the same column show significant differences(P<0.05)
^bnon significant

3.5. Extract ether (EE)

Extract ether content in pellets of forage legetan can be seen in Table 5.

Table 5. Extract ether of Legetan forage pellets (%).

| Block | repetition | Treatment | Average | Block |
|-------|------------|-----------|---------|-------|
|       |            | K1        |         |       |
|       |            | K2        |         |       |
| Fresh | P1         | 3.10      | 3.39    | 3.25  |
|       | P2         | 3.18      | 3.59    | 3.39  |
| Hay   | P1         | 2.49      | 3.69    | 3.09  |
|       | P2         | 2.49      | 3.78    | 3.14  |
| Average |           | 2.82±0.38^a| 3.61±0.17^b|       |

^aDifferent superscripts in the same column show significant differences(P<0.05)
^bnon significant

The results of the analysis of variance in extract ether content of forage Legetan pellets in Table 5 show that there is a significant difference in the composition treatment of EE content, where the highest EE content was obtained at 3.61% in composition 2 treatment, while in composition 1 treatment only 2.82%. The results of the analysis of variance in blocks showed that the basic ingredients of forage pellets did not have a significant effect on the EE content of forage pellets. The value of EE content is 3.39% for fresh base ingredients and haybased ingredients with a value of 3.14%. Fat content is influenced by feed composition. This is in accordance with Setyono[15] that nutrition and pellet structure are influenced by the composition of the feed ingredients used.

3.6. Crude fibre (CF)

The content of crude fibre content in pellets of forage Legetan can be seen in Table 6.

Table 6. Crude fibre of Legetan forage pellets (%).

| Block | repetition | Treatment | Average | Block |
|-------|------------|-----------|---------|-------|
|       |            | K1        |         |       |
|       |            | K2        |         |       |
| Fresh | P1         | 19.81     | 19.41   | 19.61^a|
|       | P2         | 19.77     | 21.44   | 20.61^a|
| Hay   | P1         | 22.7321.10| 21.95   | 21.92^b|
|       | P2         | 21.95     | 21.38   | 21.67^b|
| Average |           | 21.07±1.51| 20.83±0.96|       |

^aDifferent superscripts in the same column show significant differences(P<0.05)
^bnon significant
The results in Table 6 show that there is no significant difference from the composition treatment to crude fibre content. The results of the analysis of variance in blocks showed that the basic ingredients of forage pellets had a significant effect (P<0.05) on the crude fibre content of forage pellets. The highest crude fibre content was obtained at 21.92% in the hay base material, while the fresh base material was only 21.07%. This data is in sync with crude protein data where the CP of hay-based ingredients is lower than that of fresh base ingredients. The possibility of weeds in the form of hay harvested earlier than fresh weeds. Russell and Johnson [16] stated that the increase in crude fibre content of hay with increasing age was caused by an increase in the structure of carbohydrates and lignin.

3.7. Nitrogen-free extract (NFE)
The results in Table 11 show that there is no significant difference from the composition treatment to the content of the extract without nitrogen. The results of the analysis of variance in the block showed that the basic ingredients of forage pellets had a significant effect (P<0.05) on the content of the extract material without nitrogen forage pellets. The highest levels of NFE were obtained at 42.16% on fresh base ingredients, while hay-based ingredients only amounted to 38.18%. This data is in sync with the CP (Table 7) and CF (Table 10) data. The trend of increasing BETN is due to a decrease in crude fibre. This is in accordance with the opinion of Tillman et al [17], that a decrease in the crude fibre content of a feed ingredient will increase the BETN content.

| Block repetition | Treatment | K1 | K2 | Average Block |
|------------------|-----------|----|----|--------------|
| Fresh P1         | 41.71     | 42.62 | 42.16<sup>a</sup> |
| Fresh P2         | 41.01     | 39.29 | 40.15<sup>a</sup> |
| Hay P1           | 36.57     | 39.78 | 38.18<sup>b</sup> |
| Hay P2           | 38.66     | 37.52 | 38.09<sup>b</sup> |
| Average<sup>ns</sup> | 39.49±2.34 | 39.80±2.11 |

<sup>a,b</sup>Different superscripts in the same column show significant differences(P<0.05)
<sup>ns</sup>non significant

4. Conclusions
The physical quality of forage pellets (PDI value) made from weed (*Synedrella nodiflora*) was influenced by composition, but neither hay nor fresh weed material affected its quality. The type of basic ingredients in the form of hay and fresh affects the chemical quality of forage pellets in the form of dry matter (DM), organic matter (OM), crude protein (CP), crude fibre (CF) and nitrogen-free extract material (BETN) but does not affect the extract ether (EE). Extract ether is influenced by the composition of the pellets. Weed material in the form of fresh produce forage pellets with better quality than weed material in the form of hay. Suggestion: to find out more concrete efficiency (nutrition, price and productivity of livestock) it is necessary to try it on livestock.

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