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Fiber and ash content of fermented palm oil fronds using liquid organic supplements as potential feed ingredients for ruminant

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ABSTRACT

Inadequate feed causes low productivity of livestock, which is indicated by a slow rate of development and low body weight. Alternative non-conventional feed ingredients derived from oil palm waste have shown the potential to be used as livestock feed. Therefore, this study aimed to evaluate the fiber and ash content of palm fronds fermented with liquid organic supplements. The waste raw material was obtained after grinding the palm fronds and followed by a fermentation process using liquid organic supplements. This process was continued with fiber and ash analysis at the Laboratory of Nutrition Science and Feed Technology, Faculty of Agriculture, Syiah Kuala University. A complete randomized design was employed with four treatments using liquid organic supplements at levels of 0%, 4%, 6%, and 8%, with four replications. The measured parameters were water content, crude fiber, ash, and nitrogen-free extract (NFE). The results showed that the addition of liquid organic supplements had no significant effect ($P>0.05$) on the levels of crude fiber, ash, NFE, and water content. Among all treatments, the results were observed in the P3 treatment (8%) which had the lowest crude fiber content and ash content, namely 22 ± 0.589 and 3.72 ± 0.112, as well as had the highest NFE and water content of 78.15 ± 0.501 and 57.9 ± 0.304, respectively. This indicated that the use of liquid organic supplements had the potential to improve the quality of oil palm midrib fiber and positively impact animal feed.

Introduction

Feed is one of the aspects that significantly affect livestock productivity. Inadequate feed conditions both in quality and quantity will lead to low livestock productivity, which is indicated by slow development rates and low body weight (Pratama *et al.*, 2019). Therefore, it becomes necessary to explore alternative sources that can fulfill the nutritional requirements of animals. A promising non-conventional feed ingredient that has gained attention is oil palm derived from plantation waste. Indonesia is one of the leading oil palm producers in the world, with a plantation area of approximately 13 million ha. According to the (Directorate General of Plantations, 2015), the country has a total production of 14,898 tons/year, and by-products as palm fronds reach 40-50 fronds/plant/year (Triyanti and Rozi, 2021).

The abundance of oil palm fronds presents an opportunity for their use as an alternative feed for ruminants (Ghani *et al.,* 2017). However, there are limitations associated with the use of palm fronds as ruminant feed, particularly due to their high crude fiber content (Astuti *et al.,* 2022). The crude fiber fraction in the form of lignin can reduce the digestibility of the feed, which is most commonly found in feed based on agricultural waste (Zhong *et al.,* 2021). The composition of palm fronds includes dry matter 97.39%, crude protein 2.23%, crude fat 3.04%, crude fiber 47%, ash 3.96%, Neutral Detergent Fiber (NDF) 76.09%, Acid Detergent Fiber (ADF) 57 .56%, hemicellulose 18.51%, lignin 14.23%, and cellulose 43% (Astuti *et al.,* 2017). Moreover, there is a significant challenge in the use

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of palm fronds due to the high lignin of 30.18% (Febrina *et al.,* 2014) dry matter digestibility at 40% (Fariani *et al.,* 2013), and energy 4.9–5.6 MJ ME/kg DM (Fariani *et al.,* 2022). This makes it necessary to carry out further processing to reduce crude fiber content and improve the quality of animal feed derived from agricultural waste. There are various methods for processing agricultural waste, including ammoniation, physical processing, and fermentation. Among these methods, fermentation is considered safer for livestock health and more economical.

The fermentation process causes changes in complex molecules such as proteins, carbohydrates, and fats, thereby transforming the molecules into simpler and more digestible forms (Astuti and Yelni, 2015). A liquid organic supplement derived from palm frond waste is one of the ingredients that can be used in fermentation. This supplement comprises decomposer bacteria such as *Lactobacillus* sp., *Azetobacter* sp., *Pseudomonas aeruginosa, Saccharomyces* sp., and *Bacillus* sp., which function as natural agents for breaking down organic matter (Sarungu *et al.,* 2020). Therefore, providing liquid organic supplements to palm fronds as a fermentation agent becomes necessary to reduce the levels of crude fiber and ash.

Materials and Methods

Sample collection

The samples used were palm fronds obtained from several community-owned oil palm plantations in the district of Bireuen. After collection, samples were first chopped to a size of ±5 cm and dried in an oven at 60ºC for 48 hours. The dried samples were ground using a hammer mill to pass through a 1 mm sieve. Subsequently, mashed samples were analyzed to determine fiber and ash content.

Fermentation procedure

After the chopping process, the palm fronds were weighed at 500 g and the solution was made by mixing liquid organic supplements according to the treatment. A total of 5 ml molasses was added and mixed with 111.5 ml water and allowed to stand for 15 minutes (ingredient A). Subsequently, a total of 300 g of bran was weighed from the substrate (20 g). The bran was stirred onto the substrate (ingredient B), while ingredients A and B were mixed and stirred until evenly distributed. The mixture obtained was compacted and put into the plastic container, ensuring it was airtight and covered with plastic. The homogeneous mixture was fermented anaerobically for 14 days (Table 1).

Table 1. Composition of materials used in the palm frond fermentation process

Feedstuff	Treatments			
	P0 (g)	**P1 (g)**	**P2 (g)**	**P3 (g)**
Palm Frond	500	500	500	500
Molasses	5	5	5	5
Liquid Organic Supplements	0	4	6	8
Water	111.5	111.5	111.5	111.5
Bran	300	300	300	300

Measurement of water content

A total of 1 g sample was weighed and placed in a cup. The sample was put in an oven for 8 hours at a temperature of 105ºC, weighed, and calculated using the equation below:

Moisture Content (%)= (Sample weight (fresh-dry)/(fresh sample weight) x 100

Determination of crude fiber

Determination of crude fiber was carried out by taking 1 ml of sample and dissolving it with 100 ml of 1.25% H2SO4. The sample was heated to boiling, digested for 30 minutes, and filtered using filter paper assisted by a Buchner funnel. The resulting residue was rinsed with 20–30 ml of boiling water and 25 ml of water 3 times. The residue was re-destructed with 1.25% NaOH for 30 minutes, filtered, and rinsed successively with 25 ml of boiling 1.25% H2SO4, 25 ml of water 3 times, and 25 ml of alcohol. Subsequently, the residue was transferred to a porcelain cup and dried in an oven at 130ºC for 2 hours. The residue that cooled along with the porcelain cup was weighed (A), put in a furnace with a temperature of 600ºC for 30 minutes, cooled, and weighed again (B).

Determination of ash

The ash content was determined by weighing 1 g of the sample, which was placed in a porcelain cup and fired until it was not smoking. Subsequently, the sample was incinerated in a furnace at a temperature of 600ºC for 6 hours and weighed. Ash content was calculated by the following formula:

Ash Content (%) = (Ash Weight)/(Sample Weight) x 100

Nitrogen free extract (NFE)

NFE content was determined by the following formula: Ash + CP + CF + EE – 100%

Data analysis

In this study, the experimental design used was a Completely Randomized Design (CRD) with 4 treatments and 4 replications. Therefore, there were 16 treatment units, and the levels were as follows:

P0= 500 g palm fronds + 300 g bran + 5 ml molasses

P1= 4% liquid organic supplements (500 g palm fronds + 300 g bran + 5 ml molasses + 4 ml liquid organic supplements)
P2= 6% liquid organic supplements (500 g palm fronds + 300 g bran + 5 ml molasses + 6 ml liquid organic supplements)
P3= 8% liquid organic supplements (500 g palm fronds + 300 g bran + 5 ml molasses + 8 ml liquid organic supplements)

The data obtained were analyzed by analysis of variance (ANOVA) using SPSS version 16. When a significant difference was found, the analysis proceeded with Duncan's Multiple Range Test to determine the best treatments.

Results

Water content

Water content is the percentage of water contained in the material. Based on the data presented in Table 2, the use of liquid organic supplements showed no significant effect (P>0.05) on the water content of the palm fronds. Incubation for 14 days with liquid organic supplements concentrations reaching 8% did not show significant results, although there was a slight increase in the P3 treatment. Moreover, all treatments had a high water content.

Crude fiber

ANOVA showed that the use of liquid organic supplements at various levels had no significant effect (P<0.05) on the crude fiber content of fermented palm fronds. These results indicated that the use of oil palm fermentation with supplements had not significantly reduced the crude fiber content of the palm fronds. The lowest and highest crude fiber content was achieved by the P3 and P2 treatments at 22% and 37.4%, respectively.

Ash

The results of observations on the ash content of fermented palm fronds using liquid organic supplements were shown in Table 2. The values obtained revealed that the ash content ranged from a maximum of 5.18% to a minimum of 3.72%. These results indicated that the ash content in this study was relatively low.

Nitrogen free extract

The results of ANOVA showed that the fermentation of palm fronds using liquid organic supplements had no significant effect (P<0.05) on the non-nitrogen-free extract (NFE). The NFE value obtained revealed that the fermentation treatment with various levels of liquid organic supplements administration did not increase the NFE content significantly. However, the data presented showed an increasing tendency to increase, where the lowest NFE content was found in the 4% treatment, namely 74.48%, and the highest value of 78.15% was obtained in the 8% treatment.

Table 2. The results of adding various levels of liquid organic supplement to the nutritional content of palm fronds

Treatments	Crude fiber (%)	Ash (%)	Water content (%)	Nitrogen free extract
P0	34.5±1.255	4.35±0.481	57.4±0.360	76.32±0.434
P1	33±1.757	3.94±0.025	56.4±0.384	74.48±1.898
P2	37.4±1.299	5.18±0.637	57.3±0.647	76.55±0.212
P3	22±0.589	3.72±0.112	57.9±0.304	78.15±0.501

P0 (control); P1 (4% liquid organic supplements); P2 (6% liquid organic supplements); P3 (8% liquid organic supplements)

Discussion

The water content analysis showed a higher level compared to 36.89% and 35% reported by Rizali *et al.*, (2018) and Biyatmoko, (2013), respectively. In this study, the P3 treatment showed higher results than others due to the absence of pre-treatment such as steaming that facilitated the breakdown of fiber bonds in the palm fronds. This made it difficult for enzymes produced by bacteria to penetrate the substrate. There was also an increase in the presence of microorganisms, which contributed to the rise in water content. According to Kurniawan and Fathul (2015), there was a decrease in dry matter and an increase in water content due to the initial fermentation process in the form of respiration that took place, where glucose was replaced by CO_2, H_2O, and heat.

Water content is a marker that is used as a reference to ensure feed storage time. The large water content is caused by the quality of raw materials and water activity by microbes (Noferdiman and Yani, 2013). The water content value of fermented palm fronds with liquid organic supplements is 57.9%. Good water content for the storage stage of feed ingredients from agro-industrial waste is a maximum of 14% (Aregheore, 2002). Therefore, the water content observed in this study significantly deviates far from the recommended standard.

The results of crude fiber analysis showed lower values than the 34.75% and 22.68% obtained by Haq *et al.* (2018) and Awiyanata *et al.* (2021), respectively. The decrease in fiber content in the P3 treatment during the fermentation process was due to the ability of the bacteria *Lactobacillus* sp., *Azetobacter* sp., *Pseudomonas aeruginosa, Saccharomyces* sp., and *Bacillus* sp. These bacteria secreted various enzymes, particularly cellulase, which effectively degraded fiber in the form of cellulose and hemicellulose in palm fronds. This contributed to the production of single-cell protein (SCP) such as pure proteins, thereby enhancing the protein content of oil palm fronds.

The insignificant decrease in fiber content in the substrate was caused by the relatively low dose of liquid organic supplements used in the fermentation. Meanwhile, the inoculum contained in the supplements was less suitable for the type of substrate, resulting in suboptimal results (Achmad and Rostini, 2018).

According to the data from (Zullaikah *et al.,* 2022), the Indonesian National Standard (SNI) set the maximum ash content in ruminant feed at 12% of the total ingredients (SNI 3148.2:2009). The minerals contained in the feed ingredients were related to the ash content. This showed that a decrease in the ash content indicated an increase in nutrients such as protein, fat, carbohydrates, and vitamins. Ash content is a mixture of inorganic substances contained in the material and serves as a measure of total minerals (Pratama *et al.,* 2022).

The results showed that the ash content of fermented palm fronds with liquid organic supplements decreased in the P3 treatment. The value obtained was lower compared to the 5.8% reported by Tan *et al.* (2016). The low ash content was caused by microbes that only used the minerals contained in the material for their body parts. The ash content calculated by proximate analysis did not reflect significant feed values but was used in the calculation of NFE. The decline of the ash content in feed ingredients was expected because the ash content was related to inorganic materials in the form of minerals. Therefore, when inorganic materials (ash) decreased, nutrients such as proteins, fats, carbohydrates, and vitamins increased.

This phenomenon occurred because the additive content contained accelerated the formation of lactic acid, thereby increasing lactic acid bacteria. Similarly, Nompo (2013) reported that the content of NFE substrate increased when there was a decrease in crude fiber.

The easily fermentable nutrient fraction, namely NFE, was rapidly hydrolyzed in the fermentation process. This indicated that the levels of NFE in the fermentation media decreased during the fermentation process. Crude fiber is an insoluble structural carbohydrate, while NFE is a soluble non-structural carbohydrate.

Conclusions

The addition of liquid organic supplements at various levels did not affect the water content, crude fiber content, ash content, and NFE of the oil palm fronds and leaves. However, the addition of liquid organic supplements at an 8% level resulted in the lowest ash and crude fiber content as well as the highest moisture content and NFE content.

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