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Analysis of Fiber Fractions in Corn Cobs Fermented with *Phanerochaete chrysosporium* Supplemented with Different Carbohydrate Sources

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ABSTRACT

This study aimed to evaluate the content of Neutral Detergent Fiber (NDF), Acid Detergent Fiber (ADF), cellulose, and hemicellulose in corn cobs fermented with white rot fungi (*Phanerochaete chrysosporium*) and supplemented with various carbohydrate sources. A Completely Randomized Design was employed, consisting of four treatments with four replications each. The results revealed the highest NDF content in T3 (80.16%), followed by T2 (79.50%), T0 (77.30%), and T1 (73.63%). The highest ADF content was observed in T1 (47.08%), T0 (45.78%), T3 (44.85%), and T2 (43.13%). The highest cellulose content was recorded in T2 (17.51%), followed by T1 (15.32%), T0 (15.32%), and T3 (13.39%). For hemicellulose, the highest values were found in T2 (36.37%), followed by T3 (35.30%), T0 (31.51%), and T1 (26.54%). It can be concluded that fermenting corn cobs with *P. chrysosporium* and supplementing with different carbohydrate sources significantly (P<0.01) affected the fiber fractions (NDF, ADF, cellulose, and hemicellulose). Rice bran (T1) was most effective in reducing NDF and hemicellulose content, molasses (T2) in reducing ADF content, and tapioca flour (T3) in lowering cellulose content.

Keywords: Corn cobs, *Phanerochaete chrysosporium*, NDF, ADF, cellulose, hemicellulose

INTRODUCTION

The availability of high-quality forage that does not compete with human consumption is crucial for the success of livestock farming. The limited availability of superior grass often leads farmers to use field grass or agricultural by-products. One abundant yet underutilized agricultural by-product in Solok City is the residue from corn plants. Corn (*Zea mays* L.) is highly beneficial as both human food and livestock feed. In April 2024, Indonesia's corn production reached 1,619,123.87 tons (Statistics Indonesia, 2024). Of this, 20%-30% consists of corn cobs (Neni, 2018). Based on this data, approximately 323,824.77–485,737.16 tons of corn cobs are produced annually, often burned by farmers as waste. However, corn cobs, as a by-product of corn production, can still be utilized as a substitute for forage.

Corn cobs are the remnants obtained after the corn kernels are separated. The main product is shelled corn, while the remaining cob is referred to as the core or stalk (Rohaeni et al., 2006). Corn cobs contain 90% Dry Matter (DM), 2.8% Crude Protein (CP), 0.7% Crude Fat (CF), 1.5% Ash, 32.7% Crude Fiber (CF), 80% cell wall, 25% cellulose, 6% lignin, and 32% Acid Detergent Fiber (ADF) (Kadir, 2014). Their low protein content and high fiber content require technological improvements before being used as feed, including fermentation biotechnology.

Feed fermentation involves enzymatic processes produced by microorganisms that chemically alter organic compounds like carbohydrates, fats, proteins, crude fiber, and other organic substances under aerobic or anaerobic conditions (Kurniati et al., 2017). *Phanerochaete chrysosporium*, a type of white rot fungus, utilizes crude fiber as a nutrient source. Fermenting corn cobs with *P. chrysosporium* reduces their crude fiber content. The enzymes produced by *P. chrysosporium* during fermentation function optimally when supplied with energy from carbohydrates.

Rice bran, molasses, and tapioca flour were selected as carbohydrate sources because of their nutritional content, frequent use in similar studies, and availability in the Solok area. Given these considerations, this study aimed to evaluate the NDF, ADF, cellulose, and hemicellulose content of corn cobs fermented with *Phanerochaete chrysosporium* and supplemented with rice bran, molasses, and tapioca flour.

MATERIALS AND METHODS

Research Materials

The materials used in this study included 1,600 g of corn cobs, 400 g of white rot fungus (*Phanerochaete chrysosporium*), 40 g each of rice bran, molasses, and tapioca flour, distilled water, plastic bags (¼ kg), and laboratory-grade chemicals for fiber analysis. The equipment used comprised a knife, cutting board, weighing scales, buckets, stationery, and laboratory apparatus.

Research Methods

This study employed a Completely Randomized Design (CRD) with four treatments, each replicated four times. The treatments were as follows:

T0: Fermentation of corn cobs without carbohydrate supplementation (control).
T1: Fermentation of corn cobs with rice bran supplementation.
T2: Fermentation of corn cobs with molasses supplementation.
T3: Fermentation of corn cobs with tapioca flour supplementation.

Parameters Measured

The parameters measured in this study were:
a. Neutral Detergent Fiber (NDF) content.
b. Acid Detergent Fiber (ADF) content.
c. Cellulose content.
d. Hemicellulose content.

Experimental Procedures

1. Corn cobs were chopped into small pieces (approximately 1 cm x 1 cm) using a copper cutting machine.
2. Chopped corn cobs were weighed (300 g) for each treatment.
3. Samples were grouped based on the specific treatments (T0, T1, T2, T3).
4. *P. chrysosporium* was added at 25% of the total sample weight.
5. Samples were placed in individual plastic bags and fermented for 14 days.
6. After fermentation, samples were collected, and crude fiber analysis was conducted at the Ruminant Feed Laboratory, Andalas University.

RESULTS AND DISCUSSION

The research data on the average content of NDF, ADF, Cellulose, and Hemicellulose are shown in Table 1.

Table 1. Average Content of NDF, ADF, Cellulose, and Hemicellulose in Fermented Corn Cobs

Treatments	NDF(%)	ADF(%)	Selulosa(%)	Hemiselulosa(%)
T0 (without carbohydrate)	77.30b	45.78b	15.32b	31.51b
Tl (rice bran supplementation)	73.63c	47.08a	17.51a	26.54c
T2 (molasses supplementation)	79.50a	43.13d	15.14b	36.37a
T3 (tapioca flour supplement	80.16a	44.85c	13.39c	35.30a

Note: Different superscripts (a, b, c) within the same column indicate significant differences (P<0.01)

The Effect on NDF Content

The analysis of variance revealed that different carbohydrate sources significantly (P<0.01) affected the NDF content of corn cobs fermented with *Phanerochaete chrysosporium*. This is attributed to the influence of carbohydrate supplementation on the production of ligninolytic enzymes by *P. chrysosporium*. These ligninolytic enzymes degrade lignin in the substrate, breaking it down into simpler, more readily utilized chemical components. This finding aligns with Leisola and Garcia (1989), who reported that *P. chrysosporium*, a fungus in the Basidiomycetes class, exhibits strong lignin-degrading capabilities, effectively reducing crude fiber content in its substrate.

In this study, the NDF content of fermented corn cobs ranged from 73.63% to 80.16%. Duncan's New Multiple Range Test indicated significant differences (P<0.01) among treatments. Treatments T2 and T3 showed no significant difference (P>0.05) from each other but were significantly higher (P<0.05) than T0 and T1. The higher NDF content in T2 and T3 compared to T0 (control) can be attributed to the contribution of these carbohydrate sources as energy substrates for *P. chrysosporium* to produce cellulase enzymes during fiber degradation. Zacchi et al. (2010) similarly noted that *P. chrysosporium* is a unique fiber-degrading fungus capable of breaking down lignin while leaving behind cellulose.

The lower NDF content in T1 compared to T0 is likely due to the addition of rice bran during the 14-day fermentation period. Rice bran serves as an effective carbohydrate source, promoting the activity of *P. chrysosporium* in reducing NDF content within this incubation period. The enzymes secreted by *P. chrysosporium* effectively utilized rice bran, which has a higher crude fiber content compared to the other carbohydrates.

The Effect on ADF Content

Statistical analysis showed a highly significant effect (P<0.01) of different carbohydrate sources on the ADF content of corn cobs fermented with Phanerochaete chrysosporium. This was due to the influence of carbohydrate supplementation on the growth and development of fungal mycelium

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which facilitated the production of fiber-degrading enzymes. According to Harry (2007), sufficient energy sources during fermentation are essential for microbial metabolism, thereby enhancing their performance in degrading the substrate's crude fiber.

The ADF content ranged from 43.13% to 47.08% across treatments. Duncan's New Multiple Range Test further confirmed highly significant differences (P<0.01) among treatments. Treatment T1 exhibited the highest ADF content compared to T0 (control), which may be attributed to the contribution of rice bran as a carbohydrate source that also contains fiber. Rice bran's ADF content typically ranges from 39.78% to 42.76% (Wahyuningsih, 2021). The ADF values in this study were lower than those reported by Astuti et al. (2015), who observed ADF content ranging from 54.03% to 67.40% in palm fronds fermented with local livestock waste microorganisms.

Treatments T2 and T3 had significantly lower ADF content compared to T0 (control). This reduction can be attributed to the breakdown of cell walls, particularly lignin from lignocellulosic bonds, resulting in a decrease in ADF. The reduction in ADF is a cumulative effect of breaking down fiber fractions such as cellulose and lignin (Nelson and Suparjo, 2011). Lyne (1982) noted that the degradation of cell walls and cell contents, including cellulose and hemicellulose, from lignocellulosic bonds leads to reduced ADF content. These components are further converted into simple sugars, which serve as energy sources for microorganisms

The Effect Content of Cellulose

The cellulose content of corn cobs fermented with *Phanerochaete chrysosporium* and supplemented with different carbohydrate sources showed a highly significant difference (P<0.01). This result can be attributed to the impact of various carbohydrate sources on the development of fungal mycelium, which promotes the production of fiber-degrading enzymes. According to Amnur (2015), cellulase is one of the enzymes produced by microorganisms, functioning to degrade cellulose into glucose. Fogarty (1983) stated that cellulose is a primary component of plant cell walls, alongside hemicellulose and lignin. Cellulose content is strongly influenced by ADF content; as ADF content increases, cellulose content also tends to rise.

In this study, cellulose content ranged from 13.39% to 17.51%, with DMRT analysis indicating highly significant differences (P<0.01) among treatments. Treatment T1 showed significantly higher cellulose content compared to T0 (control), while T2 and T3 had lower cellulose content than T0. The lowest cellulose content in T3, which used tapioca flour as the carbohydrate source, can be attributed to the high solubility and degradability of tapioca flour. This property

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enhances fungal growth and cellulase activity, leading to a reduction in cellulose content .Richana and Sunarti (2004) noted that tapioca flour is a type of starch with high water absorption capacity, causing its granules to swell easily. This characteristic facilitates enzymatic hydrolysis, making tapioca flour an effective energy source for fungal metabolism .

The Effect on Hemicellulose Content

The hemicellulose content of corn cobs fermented with *Phanerochaete chrysosporium* and supplemented with different carbohydrate sources showed a highly significant difference (P<0.01). This effect is likely due to the influence of carbohydrate supplementation on fungal mycelium development, which enhances the production of fiber-degrading enzymes.

In this study, the hemicellulose content ranged from 26.54% to 36.37%, with post-hoc analysis using Duncan's New Multiple Range Test (DNMRT) confirming highly significant differences (P<0.01) among treatments. Hemicellulose is a low molecular weight polysaccharide, typically accounting for 15% to 30% of the dry weight of lignocellulosic material (Taherzadeh, 1999).

Treatment T1 showed significantly lower hemicellulose content compared to T0 (control), while treatments T2 and T3 exhibited higher hemicellulose levels than T0. This outcome may be attributed to the incomplete degradation of cellulose, which serves as an essential carbon source for the fungal production of hemicellulose-degrading enzymes.

The covalent bonds between hemicellulose and lignin in lignocellulose form a protective layer around cellulose. To achieve efficient hydrolysis of cellulose and hemicellulose, this structure must be modified by removing lignin (Hamelinck et al., 2005). The hemicellulose content observed in this study (26.54%–36.37%) was higher than the findings of Mokoginta (2014), who reported an increase in hemicellulose content from 24.31% to 28.69% in pineapple peel fermented with 20% molasses.

Conclusions

Based on the results of this study, it can be concluded that fermenting corn cobs with *Phanerochaete chrysosporium* and supplementing with different carbohydrate sources significantly (P<0.01) affected the fiber fraction contents (NDF, ADF, cellulose, and hemicellulose):

1. Supplementation with rice bran (T1) was the most effective in reducing NDF and hemicellulose content.
2. Supplementation with molasses (T2) was the most effective in reducing ADF content.
3. Supplementation with tapioca flour (T3) was the most effective in reducing cellulose content.

Further research is recommended to:

Explore the use of other carbohydrate sources to optimize the fermentation process and nutrient composition of corn cobs.

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