Jambura Journal of Animal Science

(Animal Science Department, Faculty of Agriculture, State University of Gorontalo)

https://ejurnal.ung.ac.id/index.php/jjas/index

p-ISSN: 2655-4356 e-ISSN: 2855-2280

Research Article

Fermentation of Sago Pulp Using Pleurotus Ostreatus on Dry Matter, Protein and Crude Fiber Content

*Sony A. E. Moningkey, Selvie D. Anis, Meity R. Imbar, Betty Bagau, Fenny R. Wolayan, Mursye N. Regar, Norrytha L. Wuntu

Faculty of Animal Husbandry, University of Sam Ratulangi, Manado, Indonesia

*Correspondance Author: sonnymoningkey@gmail.com

Jambura Journal of Animal Science, Volume 7 No 2, May 2025

Keywords:
Protein;
Dry matter;
Sago pulp;
Crude fiber;
White oyster mushrooms;

ABSTRACT. This study aims to determine the effect of the fermentation time of sago pulp using white oyster mushrooms (*Pleurotus ostreatus*) on the content of dry matter, protein and crude fiber. Field research has been conducted in Tomohon city and the results of the study were analyzed at the Food and Non-Food Sample Testing Laboratory, Manado Industrial Standardization and Service Center. This study used a Completely Randomized Design (CRD) consisting of 4 treatments and 5 replications. The treatment design was P0 = Fermentation Time 0 days; P1 = Fermentation Time 2 weeks; P2 = Fermentation Time 4 weeks and P3 = Fermentation Time 6 weeks. The variables measured in this study were dry matter, protein and crude fiber content. The results of the diversity analysis showed that the treatment of sago pulp fermentation time using white oyster mushrooms showed very significant different results ($P < 0.01$) on the dry matter and protein content. The average value of dry matter for each treatment obtained was P0 = 44.94%; P1=44.94%; P2=46.54% and P3=46.96%, while the average protein value was P0=3.32%; P1=3.36%; P2=5.29% and P3=4.99%. Analysis of diversity shows that the treatment gives a response to the crude fiber content showing no significant difference ($P>0.05$) with an average value of each treatment was P0=22.22%; P1=21.62%; P2=18.53% and P3=18.84%. The results of the study showed that the treatment of sago pulp fermentation for 4 weeks using white oyster mushrooms (*Pleorotus ostreatus*) showed the best results in terms of dry matter and protein content

Citation APA Style:
Moningkey S.A.E., Anis S.D., Imbar M.R., Bagau B., Wolayan R. F., Regar M.N., Wuntu N.L. 2025. Fermentation of Sago Pulp Using Pleurotus Ostreatus on Dry Matter, Protein and Crude Fiber Content. Jambura Journal of Animal Science,7 (2) 75-81

Received: 20.04.2025 |Accepted: 20.05.2025|Online published: 31.05.2025

INRODUCTION

Feed is one of the most important factors in livestock farming, where feed is the largest component in production costs, so that the use of feed sources from industrial waste can be used as alternative feed to reduce production costs. Feed has a very important role in livestock life. Limited feed can cause a decrease in livestock productivity and can interfere with normal production and reproduction (Salvia et al., 2022).This problem can be overcome if the potential of agriculture or industry and its waste are taken into account in livestock farming. Preparation of feedstuff must be easy to obtain and in sufficient quantities to avoid large costs. Tuturoong et al., (2014), stated that various agricultural by-products can be used as sources of raw materials for feed, such as plantation waste and agricultural industrial waste that does not compete with human needs, for example sago pulp. Food processing waste is often used as raw material for animal feed because it still contains nutritional value and easily obtained at affordable prices, and reduces production costs (Budiarto et al., 2023). One of the food wastes that can be used as alternative feed is sago pulp, where sago pulp is a by-product of the sago-making process from the sugar palm plant.

The use of sago pulp as an alternative feed is quite promising, although it is realized that its use requires a touch of technology, because sago pulp has limitations for use as animal feed. The limitations of sago pulp utilization are its high crude fiber content and low protein, therefore it is necessary to process it first before giving it to livestock. The nutritional content of sago pulp are water content 11.68%, crude protein 3.38%, crude fat 1.01%, crude fiber 22.44%, ash 12.43%, cellulose 16%, hemicellulose 17.90%, lignin 0.07% and silica 0.04% (Dinata, 2020). According to Rianza et al., (2019), sago pulp contains up to 30.14% crude fiber and 4.37% crude protein. The nutritional content of sago pulp can be increased by making physical, chemical, and biological changes with fermentation technology, and fermentation is needed to increase protein levels and reduce crude fiber levels in sago pulp.

Fermentation is a biological feed processing that utilizes microbes, both bacteria and fungi. White oyster mushrooms (*Pleurotus ostreatus*) are wood-rotting fungi that can grow on fibrous feed. The growth of white oyster mushrooms can take place optimally if the nutritional content needed for their growth and development is available (Argyropoulos, et al, 2022; Ginting, et al, 2018). The fermentation process has been shown to increase the nutritional content of feed or food ingredients, because in this process the substrate is broken down by microbes so that there is an increase in the nutritional value contributed by the microbes themselves (Moningkey et al., 2020., Moningkey et al., 2022). The purpose of this study was to observe the effect of the fermentation time of sago pulp using white oyster mushrooms (*Pleurotus ostreatus*) on the dry matter, protein and crude fiber content.

MATERIALS AND METHODS

This research was conducted at the research location in Tomohon City and the results of the study were analyzed at the Food and Non-Food Sample Testing Laboratory, Manado Industrial Standardization and Service Center. The study took place from October to December 2023. This study used Sago pulp and White Oyster Mushrooms (*Pleurotus ostreatus*) and the tools used were clear plastic bags measuring 12 cm x 25 cm x 0.8 cm, PVC rings, paper, rubber bands, sterile tweezers, sterile scalpels, scales and scissors.

This study used an experimental method using a Completely Randomized Design (CRD). The treatments in this study were: P0: 0 days (Without fermentation), P1: Fermentation period 2 weeks; P2: Fermentation period 4 weeks; P3: Fermentation period 6 weeks. Each treatment was repeated 5 times. In general, this research has been conducted through several steps of activities: (1) Sago pulp as much as 10 kg plus bran as much as 1.5 kg, and $CaCO_3$ as much as 0.15 kg. These ingredients are mixed until evenly distributed and water is added about 60% of the weight of the mixture. The texture of the mixture is observed until moisture decrease. (2) The sago pulp substrate mixture is put into a transparent plastic bag measuring 12 cm x 25 cm x 0.8 mm, then the mouth of the plastic bag is inserted into the polaron ring and folded outward then tied with a rubber band and then tightly closed with paper. (3) The substrate is wet sterilized by steaming for 30 minutes at a temperature of approximately 121^{o} C, then cooled for 6 hours. The sterile substrate is fermented with white oyster mushrooms (*Pleurotus ostreatus*) by sprinkling inoculum (F2 seeds / white oyster mushrooms on corn media) evenly on the surface of the baglok according to the dose (10 gr / kg of material). This step is done quickly (the plastic bag should not be opened for too long) and as much as possible in a closed room. (4) The fermented substrate is stored on a shelf according to the treatment duration at room temperature and humidity of 80-90%. Furthermore, the plastic is opened according to the treatment duration and weighed and then analyzed in the laboratory. (Tuturoong et al., 2014).

The variables observed in this study were dry matter, protein and crude fiber content. Data were analyzed using analysis of variance (ANOVA), significantly different treatments were continued with the BNJ (Honestly Significant Difference) test. The mathematical model is as follows:

$$Y_{ij} = \mu + T_i + \epsilon_{ij}$$

Note:

i = 1,2,3,4.

j = 1,2,3,4,5

Y_{ij} = response of observation of experimental units receiving treatment i and replication j

μ = mean

T_i = effect of treatment i

ϵ_{ij} = effect of error.

RESULTS AND DISCUSSION

The Effect of Treatment on Dry Matter

The results of the experiment on the effect of the fermentation time of sago pulp using white oyster mushrooms (*Pleurotus ostreatus*) on the dry matter, protein and crude fiber content were listed in Table 1 below.

Table 1. Effect of Treatment on Dry Matter, Protein and Fiber Content

Variable	Treatment			
	P0	P1	P2	P3
Dry Matter of Sago (%)	44,94±0,59^{a}	44,94±0,56^{a}	46,54±0,75^{b}	46,96±0,75^{b}
Protein of sago (%)	2,32±0,19^{c}	3,36±0,26^{b}	5,29±0,14^{a}	4,99±0,13^{a}
Fiber of Sago (%)	22,22±0,72	21,65±0,94	18,53±0,48	18,84±0,38

Note: Different superscripts on the same row indicate a very significant difference (P<0.01)

The average value of dry matter of fermented sago pulp was P0=44.94±0,59%, P1=44.94±0,56%, P2=46.54±0,75% and P3=46.96±0,75%. The difference in water content before and after fermentation was caused by activities during the fermentation process which can increase water content. Based on the analysis of variance, it shows that the treatment has a very significant effect (P<0.01) on the dry matter content of fermented sago pulp of white oyster mushrooms (*Pleurotus ostreatus*). The BNJ test for treatment P3 showed the highest result with a value of 46.96%. Treatment P3 showed a very significant result higher than treatments P0 and P1 but when compared to treatment P2 it was the same as P3. The fermentation process causes beneficial changes in terms of nutrition, digestibility, and increased shelf life (Buckle et al., 1987). Anjasari et al., (2024) stated that the fermentation process is assisted by microbes including bacteria, protozoa, and molds (fungi). The microbes that can be used are fungi because they are able to produce various types of different enzymes. Fungi are the main microorganisms that can produce cellulase.

Dry matter was calculated as the difference between 100% and the percentage of water content of a feed material that is heated so that its size remains the same. Water content is the percentage of water content of a material that can be expressed based on wet weight (wet basis) or dry weight (dry basis) (Novianty, 2014). Dry matter is the fixed weight of a material that no longer contains water after being heated at a certain temperature in a drying oven and is one of the results of dividing the fractions obtained from the feed after reducing its water content (Anggorodi, 1994). According Kunaepah (2008) there are many factors that affect fermentation, including substrate, temperature, pH, oxygen and microbes used. During the microbial process, microorganisms consume some of the organic matter and produce by-products such as gases and other compounds. This process can reduce the water content in the material, thereby increasing the dry matter content.

Effect of Treatment on Protein Content

Table 1 shows that the average protein content was 2.32±0,19%; 3.36±0,56%; 5.29±0,14% and 4.99±0,13%, where the highest protein content was found in the 4-week fermentation period with a value of 5.29% and the lowest protein content was found in the 0-day fermentation period with a value of 2.32%. The results of the experiment on the effect of fermentation time on protein levels can be seen in Table 1. The results of the analysis of protein content variations showed that the treatment had a very significant effect ($P<0.01$). Further BNJ tests showed that treatment P2 had a very significant effect ($P<0.01$) on treatments P0 and P1 but was not significant ($P>0.05$) on treatment P3, and treatment P1 had a very significant effect ($P<0.01$) on treatment P0.

The results of this study were still higher than the study by Badarina et al., (2013) which also stated that coffee skin waste fermented with white oyster mushrooms (*Pleurotus ostratus*) can increase crude protein from 10.36% to 12.14%. The increase in protein levels with increasing fermentation time in this study was due to the addition of microbes through *Pleurotus ostreatus* which increased over time. According to Daniel et al. (2023), fermentation also plays an important role in the process of increasing protein, because in the fermentation process there are microbes that play a role in increasing the protein content of sago pulp fermentation.

The protein content at a fermentation time of 4 weeks showed a higher value compared to a fermentation time of 0 days, 2 weeks or 6 weeks. This shows that fermentation for 4 weeks was the optimal time for microorganisms to degrade protein. Irawan (2012) stated that in the fermentation process, microorganisms will utilize the nutrient content of the substrate for their body's protein synthesis, so that in the end they will reproduce themselves and increase the crude protein content of feed ingredients. Based on research conducted by Johan (2014), it was concluded that the use of white tiam mushroom (*Pleurotus ostreatus*) planting media waste can increase crude protein during the incubation period.

The fermentation process plays an important role in increasing protein, because in the fermentation process there are microbes that play a role in increasing the protein content of sago pulp fermentation. This is in accordance with the opinion of Mutmainah (2019) who stated that fermentation is the process of decomposing organic compounds into simpler compounds by involving microorganisms. The fermentation process can increase the availability of nutrients such as protein and metabolic energy and is able to break down complex components into simpler components, in addition fermentation can also increase the nutritional value of low-quality materials and function in preserving feed ingredients and is one way to eliminate anti-nutritional substances or toxins contained in a feed ingredient (Moningkey et al, 2023).

Effect of Treatment on Crude Fiber Content

Table 1 show that the lowest crude fiber content was found in the substrate with a fermentation treatment for 4 weeks (P2) with a value of 18.53%. Based on the results of the analysis of variance, it shows that the treatment did not have a significant effect ($P>0.05$) on the crude fiber content. However, in terms of quantity, the crude fiber content after fermentation decreased at P2 by 18.53%. This shows that microorganisms work optimally to degrade complex crude fiber compounds into simpler compounds.

The results of the research that has been conducted show that the percentage of crude fiber content decreases along with the length of fermentation time. This was in accordance with the opinion of Fransiska and Destiarti, (2012) who stated that the longer the fermentation time, the lower the crude fiber content. The results of this study also have the same tendency as the research of Hatta et al., (2014), in their research on copra cake fermentation using a combination of *Pleurotus ostreatus* fungi with *Trichoderma viridae*, showing that the longer the fermentation process, the lower the crude fiber content. Rostini et al, (2022) stated that the decrease in the level of feed fiber fermented by cellulolytic microbes is due to the number of cellulolytic microbes that correspond to the number of available nutrient sources so that there is no competition between microbes and microbes can grow optimally in carrying out cellulose degradation activities in feed ingredients, or in other words cellulolytic microbes are able to produce cellulase enzymes that can degrade cellulose. Mayasari (2020), stated that in the fermentation process, the composition and nutrient content of a medium for microbial growth must be balanced so that microbes can grow optimally. Crude fiber is part of carbohydrates, mostly derived from plant cell walls and containing cellulose, hemicellulose, and lignin (Suparjo, 2010). Among the three components, lignin is the most difficult to digest, so the high content of this component in feed ingredients will reduce the utility value of feed ingredients, so a method is needed to break down lignocellulose bonds into separate components.

CONCLUSION

Fermentation of sago pulp for 4 weeks using white oyster mushrooms (*Pleurotus ostreatus*) could increase crude protein 5,39% %, dry matter 46,54% and reduce crude fiber 18,53%.

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