Research Article

Nutritional Evaluation of Fermented Goroho Banana Peel for Super Native Chicken

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Abstract | The study aims to determine the nutritional and digestibility of Goroho banana peel fermented with various inoculums in super native chickens. The material and method for determining nutritional quality consist of fermented Goroho banana peel (FGBP) feed incubated with various starters. The experiment used a Completely Randomized Design method. The material used consisted of 25 super native chickens aged 60 days. Digestibility determination of fermented Goroho banana peels in super native chickens consisted of 5 feed treatments with 5 replications. The nutritional variables consisted of water content, crude protein, crude fat, crude fiber, nitrogen-free extract, gross energy, calcium, phosphorus, hemicellulose, cellulose and lignin. The digestibility variables consisted of organic matter digestibility, crude fiber digestibility and protein digestibility. The data obtained were analyzed using analysis of variance and further tested using Duncan's multiple range tests. The results of the study showed that Goroho banana peel fermented with various starters increased all variables excluding nitrogen-free extract, gross energy, hemicellulose and lignin content. The use of feed containing 10% fermented Goroho banana peel in super native chickens did not have a negative effect on organic matter digestibility as well as on protein and crude fiber digestibility which optimally increased.

Keywords | Digestibility, Fermententation, Goroho banana peel, Inoculum, Nutritional, Super native chicken

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INTRODUCTION

Agricultural waste of Goroho banana peel (*Musa acuminafe sp*) has the potential to be used as poultry feed, because it is abundantly available and has quite good nutritional content (Ruru *et al*., 2018). Goroho banana plants are local varieties that grow widely in the Provinces of Gorontalo and North Sulawesi. It is known that Goroho banana peels have fairly high crude fiber content, where on average they contain cellulose and hemicellulose of 40% of the total crude fiber. Initial proximate analysis of Goroho banana peels contains nutrients, namely 89.38% dry matter, 6.47% crude protein, 4.72% crude fat, 17.29% crude fiber, 55.75% non-nitrogen extract (NFE), 0.61% beta carotene and gross energy 5290 Kcal/kg. High-fiber feed is primarily used for ruminant livestock (Khan *et al*., 2022; Arief *et al*., 2023). Poultry fiber feed may affect blood metabolites, metabolized viscosity, and intestinal morphology (Anwar *et al*., 2023; Khoni *et al*., 2024). The fact that chickens have trouble consuming and digesting high-fiber feed, it is possible to use Goroho banana peels as a source of poultry feed if the peels' crude fiber content is decreased.

One technology to reduce crude fiber content is by fermentation. Fermentation is the process of *breaking* down feed materials from hard structures physically, chemically, and biologically so that materials from complex structures become simple. The purpose of fermentation is in addition to improving nutrition, reducing crude fiber, and feed materials can be stored for a long time. Fermentation is also used to improve the bioavailability and bioaccessibility of nutrients, reduce antinutritional factors (such as lectins, phytic acid, proteinase inhibitors, oxalic and tannins acids) and pathogenic microorganisms, preserve food products as well as to enhance the economic value (Adebo *et al*., 2022; Sun *et al*., 2022). Fermented feeds are a form of biological feed created by transforming the feed ingredients into microbial bacterial proteins, small bioactive peptides, amino acids, and active probiotics (Hlangwani *et al*., 2020). The fermentation method by adding lactic acid bacteria starter is using rumen fluid and Alfaafa microbacter solution (Ma-11). The rumen fluid starter or fermentor is obtained from cattle slaughter waste containing bacterial and fungal microorganisms (Jusadi *et al*., 2013; Purbowati *et al*., 2014; Basri, 2017), and contains various enzymes such as amylase, protease, xylanase, mannase, phytase and cellulase from several reports stated that it can reduce crude fiber content and improve the quality of fermented materials so that they are easily digested (Moningkey *et al*., 2020; Burhanuddin *et al*., 2022; Safir *et al*., 2023). Ma-11 solution is known to contain Rhizobium sp, cellulolytic, proteolytic and amylolytic bacteria which can improve nutrient content such as protein, carbohydrates, fat and crude fiber. Rachmawati et al. (2021) stated that Ma-11 is a decomposer that is able to quickly break down organic material chains, composed of Rhizobium sp bacteria combined with various other microbes taken from cow rumen fluid, these microbes function to break down cellulose, hemicellulose and lignin which are components of crude fiber so that they are easier to digest.

Super native chicken is a cross between Bangkok native chicken as a male and female purebred chicken with the advantage of having high environmental adaptation, relatively fast growth performance levels so that the harvest period is shorter, low mortality rates with low feed conversion values compared to local chickens and are in great demand by the community (Soaleh *et al*., 2022; Triyanty *et al*., 2022; Masili *et al*., 2018; Noferdiman *et al*., 2020). Increasing the productivity of super native chicken requires quality feed to fulfill its nutrition, because good quality feed with balanced nutrition will provide optimal results. The difficulty that farmers always face is getting quality feed, because the price of commercial feed on the market is very expensive, the largest production cost is the purchase of feed (60-70%).

The use of Goroho banana peels as an alternative feed because it is known to have quite good nutritional quality allows it to be used to increase the productivity of super native chickens. Increasing nutrition and reducing crude fiber contained in Goroho banana peels through a fermentation process using Rhizopus oligosphorus and Trichoderma viride molds as inoculum has been tested and resulted in improved nutritional levels of protein, fat, gross energy, NFE, although followed by increased levels of crude fiber components, allegedly due to the contribution of crude fiber from the mold cells used (Djunu *et al*., 2021; Djunu *et al*., 2022). The application of digestibility tests using Goroho banana peels in laying hens has also been tested which resulted in good digestibility values in the Rhizopus oligosphorus and Trichoderma viride starter mixing method incubated for 120 hours (Djunu *et al*., 2021). The fermentation method on Goroho banana peel using rumen fluid fermenter material combined with Ma-11 solution, rice bran, rotten tempeh and molasses and applied to the digestibility test on super native chickens is not yet available information so evaluation and study are needed.

MATERIALS AND METHODS

Research Material

The research materials consist of tools and materials for the analysis of the nutritional content of Goroho banana peels and digestibility analysis. The tools used were: plastic bags, tarpaulin, knife, raffia rope, digital scales, measuring cups, buckets, gloves, ovens, a set of proximate analysis tools, and a set of Van Soest analysis tools, battery cages, feeders, drinkers, thermometers, feces containers, lamps for lighting and writing instruments. The materials used consist of concentrated feed, yellow corn, bran, Goroho banana peels, water, rumen fluid, molasses, Ma-11 solution, rotten tempeh and 25 super kampung chickens, male, 60 days old.

Research Methods

Nutritional content of goroho banana peels: The procedure starts from making starter fermentation formula 1 and formula 2 (Figure 1). Formula 1 was mixing 0.5 kg of bran with 2.5 liters of water; the mixture was boiled, removed and cooled, after cooling it was filtered to take the water. The filtered water was added with 250 grams of decomposed soybean product, 1 liter of molasses and 1 liter of Ma-11 solution. The solution mixture was put in a plastic bucket container and tightly close, a hose was added to the bucket which is connected to a bottle filled with water as a discharge of gas produced during fermentation.

The solution was incubated for 3-4 days in a dry and shady place. The solution is filtered again after incubation and is ready to be used as a starter for fermentation of Goroho banana peel. Formula 2 solution preparation procedure works like formula 1 but the Ma11 solution material was replaced with rumen fluid, with the composition of the solution consisting of 0.5 kg of bran + 2.5 liters of water + 1 liter of molasses and 1 liter of rumen fluid (Table 1).

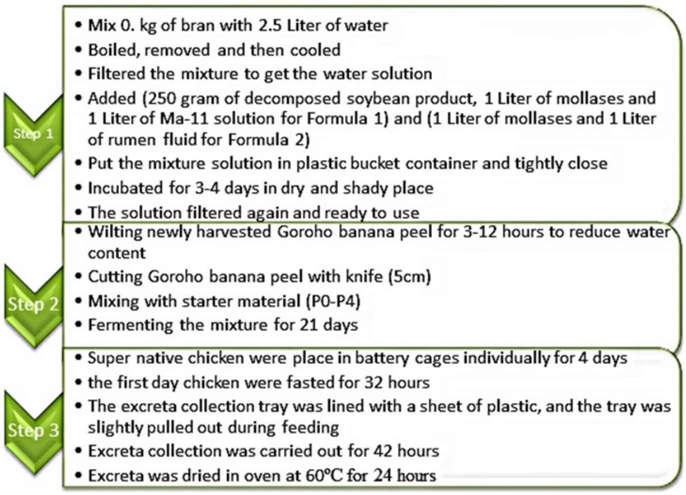

Figure 1: A flowchart showing the steps of the fermentation process (Step 1: preparation of starters, Step 2: fermentation of banana peels, Step 3: feeding trials and data collection).

Table 1: Composition of feed ingredients and composition of feed nutrients for treatment.

Feed ingredients	Treatments				
	P0	P1	P2	P3	P4
Corn	55	50	50	50	50
Concentrate	30	30	30	30	30
Bran	15	10	10	10	10
Goroho banana peel	10	10	10	10	10
Total	100	100	100	100	100
Nutritional Composition	**Treatments**				
	P0	**P1**	**P2**	**P3**	**P4**
Energy Metabolic (Kkal/kg)	3015	3137	3137	3137	3137
Crude Protein (%)	13,28	12,97	12,97	12,97	12,97
Crude Fat (%)	4,34	3,96	3,96	3,96	3,96
Crude Fiber (%)	4,67	4,65	4,65	4,65	4,65
Calcium (%)	0,25	0,34	0,34	0,34	0,34
Phosporus (%)	0,55	0,51	0,51	0,51	0,51

The making of fermented Goroho banana peel feed was by wilting newly harvested Goroho banana peel for 3-12 hours to reduce its water content, cutting the Goroho banana peel using a knife with a size of 5 cm, mixing it with starter material and fermenting it for 21 days. After 21 days, the silage was opened and then its nutritional content was tested. The treatment method uses a field trial method using a Completely Randomized Design. The experimental feed was composed of 5 types of feed treatments, namely (P0): Goroho banana peel without fermentation (P1): Goroho banana peel with the addition of 4% Ma-11 starter (P2): Goroho banana peel with the addition of 4% rumen fluid starter (P3): Goroho banana peel with the addition of 4% formula 1 starter (Ma-11 1 liter + Molasses 1 liter + water 2.5 liters + bran 0.5 kg + rotten tempeh ¼ kg) and (P4): Goroho banana peel with the addition of 4% formula 2 starter (rumen fluid 1 liter + molasses 1 liter + water 2.5 liters and bran 0.5 kg).

Digestibility of fermented goroho banana peels:

Method for determining the digestibility of fermented Goroho banana peels in super native chickens, using a completely randomized design (CRD) consisting of 5 feed treatments with 5 replications, namely: (P0) 100% basal feed (P1) 90% basal feed + 10% Goroho banana peels fermented with 4% Ma-11 starter (P2) 90% basal feed + 10% Goroho banana peels fermented with 4% rumen fluid starter (P3) 90% basal feed + 10% Goroho banana peels fermented with 4% formula 1 starter and (P4) 90% basal feed + 10% Goroho banana peels fermented with 4% formula 2 starter.

Dry matter digestibility (DM), organic matter digestibility (BO), protein digestibility (P) and crude fiber digestibility (CF) were adopted according to the method of Farell (1978). Testing procedure Chickens were kept for three weeks with details of 14 days of adaptation period and 4 days for data collection. Individually, super native chickens were placed in battery cages suitable for determining digestibility analysis, namely with a size of 45 x 35 x 50 cm made of wire, and equipped with a place to eat and drink and a place to eat designed in such a way as to reduce feed spillage as little as possible, so that they can consume 100 gr/head/day of feed for one hour.

The experiment lasted for approximately 4 days, the first day the chickens were fasted for 32 hours. The excreta collection tray was lined with a sheet of plastic, and the tray was slightly pulled out during feeding, then the tray was pushed in so that all excreta could be collected. Excreta collection was carried out for 42 hours. Feathers and scales that enter the tray must be removed, after 42 hours the plastic container with the excreta was dried in an oven at 60°C for 24 hours, or if the excreta were too wet then the plastic and tray can be directly put into the oven and dried for 48 hours. The dried excreta was removed from the plastic, left in the open air for 3 hours, then the excreta was weighed for dry weight and then ground for analysis.

Research Variables

The research variables for the analysis of the nutritional content of Goroho banana peels include water content,

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crude protein (CP), crude fat (CFa), crude fiber (CFi), nitrogen-free extract (NFE), gross energy (GE), calcium (Ca), phosphorus (P), hemicellulose, cellulose and lignin. Digestibility analysis includes dry matter digestibility (DMd), organic matter digestibility (OMd), protein digestibility (Pd) and crude fiber digestibility (CFid).

Data Analysis

The data obtained were tabulated and analyzed using a completely randomized design (CRD) with the help of Microsoft Excel 2010, if there were an effect of treatment, the Duncan's multiple distance tests were continued (Stell et al., 1997). Linear Regression Analysis using SAS.

RESULTS AND DISCUSSION

Nutritional Content of Fermented Goroho Banana Peels

The results of the study on the effect of fermentation treatment on the nutritional content of Goroho banana peels can be seen in Table 2 and Figure 2.

Table 2: Average nutritional content of unfermented and fermented Goroho banana peels.

Nutrients content	Treatments				
	P0	P1	P2	P3	P4
Water (%)	11,75 ± 0,26^{d}	13,36 ± 0,30^{b}	17,58 ± 0,17^{a}	13,16 ± 0,08^{b}	12,24 ± 0,11^{c}
Crude Protein (%)	5,46 ± 0,15^{c}	6,57 ± 0,19^{b}	6,50 ± 0,47^{b}	7,53 ± 0,04^{a}	5,35 ± 0,15^{c}
Crude Fat (%)	5,76 ± 0,17^{c}	6,56 ± 0,09^{b}	6,83 ± 0,04^{b}	7,97 ± 0,11^{a}	5,99 ± 0,30^{c}
Crude Fiber (%)	8,41 ± 0,04^{d}	10,89 ± 0,18^{b}	9,47 ± 0,05^{c}	10,93 ± 0,05^{b}	11,42 ± 0,03^{a}
Nitrogen-free Extract (%)	67,29 ± 0,21^{a}	60,93 ± 0,76^{d}	62,56 ± 0,94^{b}	56,99 ± 0,72^{e}	61,63 ± 0,24^{c}
Gross Energy (Kkal/kg)	5007,80 ± 57,58^{b}	4925,80 ± 21,58^{b}	5401,40 ± 49,58^{a}	4917,00 ± 24,08^{b}	4872,40 ± 38,39^{b}
Calsium (%)	0,69 0,05^{b}	0,70 ± 0,06^{b}	0,71 ± 0,07^{b}	0,77 ± 0,06^{ab}	0,84 ± 0,07^{a}
Posphor (%)	0,38 0,01^{c}	0,46 ± 0,01^{ab}	0,48 ± 0,00^{a}	0,45 ± 0,03^{b}	0,48 ± 0,02^{a}
Hemiselulosa (%)	35,63 ± 1,63^{a}	28,49 ± 0,15^{b}	25,22 ± 1,28^{c}	25,01 ± 1,05^{c}	23,46 ± 0,18^{d}
Selulosa (%)	2,70 0,72^{d}	5,61 ± 0,53^{c}	8,81 ±1,86^{a}	7,86 ± 0,98^{ab}	6,55 ± 0,67^{bc}
Lignin (%)	18,83 0,47^{a}	18,98 ± 0,48^{a}	17,66 ± 1,11^{b}	16,66 ± 0,34^{c}	15,87 ± 0,32^{c}

Note: Different superscript letters in the same row indicate highly significant differences (P<0.01).

Water

Water content is the amount of water content in feed ingredients expressed in percent. The water content in feed ingredients determines the freshness and durability of the feed. High water content in feed causes microbes to grow and develop easily, resulting in changes in the feed ingredients. The results of the proximate analysis showed water content in Goroho banana peels (P0-P4) varied between 11.75% -17.58%. The effect of non-fermentation treatment (P0) was very significantly different (P <0.01) from the fermented treatment (P1-P4). On average, fermentation treatment caused the highest increase in water content in Goroho banana peel feed ingredients at (P2) 17.58% with an increase of 49.62%.

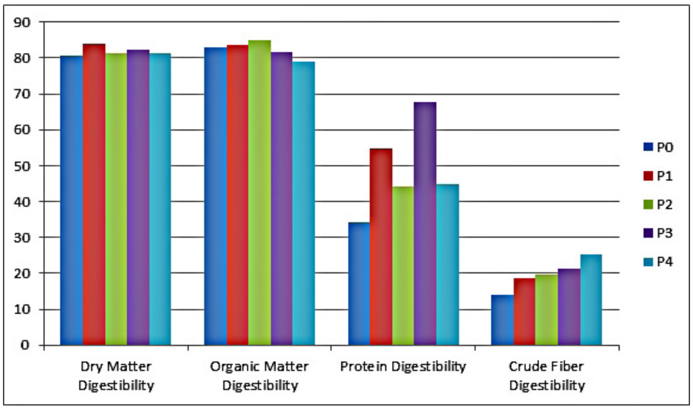

Figure 2: The nutritional content of Goroho banana peels across different treatments (P0-P4).

The increase in water content in fermentation treatments using rumen fluid inoculum or Ma-11 was caused by the fermentation process, bacteria, fungi and molds multiplying greatly and producing CO_2 and H_2O. Lehninger (1990) stated that in the fermentation process, organic material degradation occurs which produces energy, water components and carbon dioxide. The fermentation process of Goroho banana peel increases the water content, in (P2) by 49.62%, from 11.75 increasing to 17.58%, in (P1) by 13.70%, from 11.75 increasing to 13.36%, in (P3) by 12.00%, from 11.75 increasing to 13.16% and (P4) by 4.17%, from 11.75 increasing to 12.24%.

Crude Protein

The percentage value of crude protein content in Goroho banana peel (P0-P4) varies between 5.35-7.53%. The results of further tests between the treatment of Goroho banana peel without fermentation (P0) and fermented (P1-P4) had a very significant effect (P<0.01). The highest protein value was in P3 (7.53%) and the lowest in P4 (5.35%). The increase in crude protein content of Goroho banana peel in fermentation using inoculum formulation 1 (Ma-11 1 liter + Molasses 1 liter + water 2.5 liters + bran 0.5 kg + rotten tempeh 1⁄4) incubated for 21 days (P3) was more optimal than other treatments (P0, P1, P2 and P4) due to the microbes in formulation 1 being able to produce more protease enzymes so that it can increase protein production more than other treatments.

Formula 1 inoculum (Ma-11) consists of proteolytic, amylolytic and cellulolytic microbes (Rachmawati et al., 2021). These microbes grow rapidly in media that get food from bran and molasses and the addition of Rhizopus oligosphorus mold in rotten tempeh, which has an impact on increasing protein levels in Goroho banana peels. Rhizopus oligosphorus mold produces protease enzymes with high proteolytic activity. Rhizopus oligosphorus in addition to having proteolytic properties was also lipolytic (Husada *et al*., 2018). The increase in protein content of Goroho banana peels occurred in (P3) by 37.91%, from (P0): 5.46% increased to 7.53%, then in (P1): 20.33% from 5.46 increased to 6.57%, in (P2): 19.05% from 5.46 increased to 6.50%. In (P4) there was a decrease in crude protein content of 2.01% from 5.46 decreased by 5.35%, the decrease in (P4) was caused by microbes in formula 2 utilizing more protein contained in Goroho banana peels to grow and multiply cells so that the protein nutrient content was reduced.

Crude Fat

The nutritional content of crude fat in Goroho banana peels in the treatments (P0-P4) varies between 5.76% (P0) and 7.97% (P3). The highest fat content value was the same as the protein content in (P3) which was fermented using formula 1 inoculum. The high value of crude fat in Goroho banana peels was thought to be due to microbial activity in (P3) being more optimal in converting banana peel carbohydrates into fat, the final result of which hydrolysis accumulated into microbial cell fat. Suari *et al*. (2019) stated that the best carbon source is carbohydrates which play a role in microbial growth, around 15-18% of the carbohydrates available in the media are converted into fat.

The crude fat content in Goroho banana peels increased by an average of 38.37% in (P3), from (P0) 5.76 increasing to 7.97% (P2): 18.58%, from 5.76 increasing to 6.83% (P1): 13, 89%, from 5.76 increasing to 6.56% and (P4) by 3.99%, from 5.76 to 5.99%. The low crude fat content of Goroho banana peels without fermentation (P0) compared to the fermentation treatment was because the crude fat in banana peels in (P0) comes purely from Goroho banana peels or there was no fat contribution from microbial cells. The fat content in (P4) was not significantly different from (P0) and between fermentation treatments (P1-P4) the value was lower, because during fermentation the fat was hydrolyzed by the lipase enzyme produced by microbes so that the fat content in Goroho banana peels decreases. Fat is used to fulfill energy needs by fungi or mold.

Crude Fiber

The results of Duncan's test, the crude fiber content in Goroho banana peel between the non-fermentation treatment (P0) had a very significant difference ($P<0.01$) with the fermentation treatment (P1-P4). The highest crude fiber content in (P4) 11.42% and the lowest in (P0) 8.41%. The fermentation treatment on average experienced an increase in crude fiber in Goroho banana peel, this suspected due to the contribution of cellulose and chitin contained in microbes. Judoamidjoyo *et al*. (1992) stated that the increase in cellulose components after fermentation was caused by the continued increase and development of mold microorganisms (in P4 the mold grew more optimally) where the mold cell wall consisted of cellulose and chitin components. The increase in crude fiber in fermented banana peels was: (P4) 35.79%, from 8.41 to 11.42%, next (P3) was 29.96%, from 8.41 to 10.93% (P1) was 29.40%, from 8.41 to 10.89% (P2) was 12.00%, from 8.41 increased by 9.47%.

Nitrogen-Free Extract (NFE)

NFE contains sugar carbohydrates and starch as a source of microbial energy (Wea et al., 2022). The ability of microbes that live and grow in the fermentation process to take and utilize energy from the Goroho banana peel substrate media causes different effects in each treatment. The fermentation process of feed ingredients, the NFE content in the fermented material tends to decrease because NFE is widely used by microbes as a source of energy in their growth. Microbes will use easily digestible energy sources such as sucrose, glucose and fructose derived from carbohydrates (NFE) of banana peels. Continuous microbial activity when degrading the substrate has an impact on the use of more energy from NFE, made NFE content of the fermented material was reduced.

During the fermentation treatment (P1-P4) the NFE content of Goroho banana peels decreased on average or decreased very significantly ($P < 0.01$) compared to banana peels without fermentation (P0), because during fermentation there was degradation of the substrate by microbes contained in each treatment (P1-P4). During the degradation of the fermentation method substrate (P3), the microbes utilize more carbohydrates than protein and fat as an energy source, resulting in a greater reduction in NFE. The fermentation process reduces NFE content, the largest decrease was in (P3) by 15.31%, from 67.29 to 56.99%, then in (P1) by 9.45%, from 67.29 to 60.93%. In (P4) by 8.41%, from 67.29 to 61.63% and in (P2) by 7.03% from 67.29 to 62.56%.

Gross Energy

Fermentation using various inoculums causes an increase in the energy content of the original material as in (P2), this reflects the process of decomposing crude fiber that was difficult to digest into easier to digest due to the activity of the cellulase enzyme produced by microbes, bacteria, molds and fungi that can hydrolyze cellulose into glucose. In contrast, the decrease in gross energy in Goroho banana peels after fermentation (P1, P3 and P4) was caused by microbes requiring a lot of energy in breaking down the substrate, carbohydrates in the material to produce energy in the form of heat, CO2 and H2O. The gross energy content in banana peels after fermentation increased as in (P2) by 7.85% from 5007.80 to 5401.40 kcal/kg. A decrease can occur after fermentation, such as in (P1) of 1.64% from 5007.80 decreased to 4925.80 kcal/kg, in (P3) of 1.81% from 5007.80 decreased to 4917.00 kcal/kg and in (P4) of 2.70% from 5007.80 to 4872.40 kcal/kg (Figure 3).

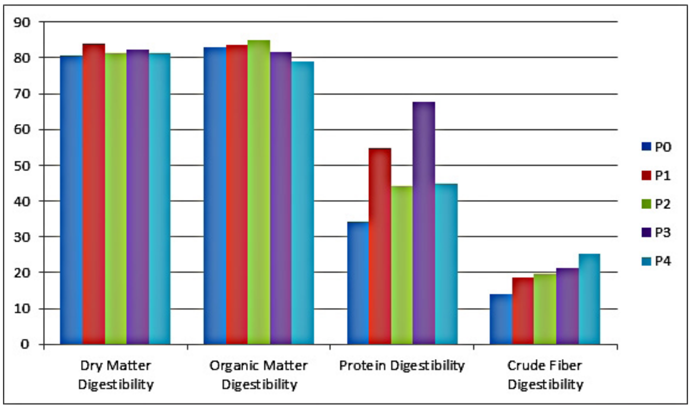

Figure 3: The gross energy of Goroho banana peels across different treatments (P0-P4).

Calcium and Phosphorus

The calcium content of Goroho banana peel after fermentation increased on average. The calcium content in order from the highest number were (P4): 0.84 (P3): 0.77 (P2): 0.71 and (P1) 0.70%. In the Phosphorus mineral, from the highest to the lowest value in order (P2): 0.48 (P4): 0.48 (P1): 0.46 and (P3): 0.45%. Further tests showed that there was a very significant difference ($P<0.01$) between unfermented banana peel and fermented banana peel.

The increase in calcium and phosphorus content was thought due to the hydrolysis of phytic acid in Goroho banana peel by the phytase enzyme produced by bacteria, mold and fungi in the fermentation inoculum. Sine and Soeharto (2018) stated that the phytase enzyme produced by microbes can break down phytic acid that binds several mineral elements into phosphorus and inositol, by breaking down the phytic acid, mineral elements such as Fe, Ca, P, Mg and Zn become more available to be utilized.

Goroho banana peel was predicted to contain phytic acid which naturally binds calcium and phosphorus elements as well as other elements such as Zn, Fe and Mg. Banana peel has thick fiber containing starch and calcium minerals which are quite high, in Aryani *et al.* (2018) stated that fiber derived from fruits has better quality because it contains high soluble fiber with low phytic acid content. The level of phytic acid in plants depends on the variety, climate and phosphorus levels in the soil.

The increase in calcium nutrient content in Goroho banana peel after fermentation at (P4) was 21.74% from 0.69 to 0.84%. Treatment P3 of 11.59%, increased from 0.69 to 0.77%. Furthermore, treatment P2 of 2.89% increased from 0.69 to 0.71% and (P1) of 1.45%, from 0.69 increased by 0.70%. Phosphorus minerals increased as in (P2) and (P4) increased by 26.32% from 0.38 increased to 0.48%, in (P1) of 21.05% from 0.38 increased to 0.46% and (P3) of 18.42% from 0.38 increased to 0.45%.

Hemicellulose

Hemicellulose is a polysaccharide matrix whose structure consists of glucose, xylose, galactose, mannose, rhamnose and arabinose. The fermentation process in the hemicellulose fiber component is more easily hydrolyzed by enzymes produced by microorganisms than cellulose (Van Soest, 1982). The results of further tests on the hemicellulose content of fermented Goroho banana peels decreased on average in all fermentation treatments (P1-P4), and the largest decrease in (P4) 23.46%. The cause of the decrease in hemicellulose (P1-P4) was due to the loosening of the lignohemicellulose bonds during the fermentation process, making it easier for the penetration of the hemicellulase enzyme produced by microbes to digest hemicellulose, which will later be used by microorganisms as an energy source. With the help of the hemicellulase enzyme, hemicellulose can be degraded into sugar monomers and acetic acid (Perez *et al*., 2002). The hemicellulose content of fermented Goroho banana peels decreased the most in (P4) by 34.16%, from 35.63 to 23.46%, in (P3) of 29.81%, from 35.65 decreased by 25.01%, in (P2) of 29.22%, from 35.63 decreased by 25.22% and (P1) of 20.04% from 35.63 decreased by 28.49%.

Cellulose

Cellulose is a polymer of glucose that consists of a linear chain connected by β-1,4 glycosidic bonds found in plant cell walls. The results of fermentation (P1-P4) on Goroho banana peels have an effect on increasing cellulose content. The results of further tests between treatments (P0-P4) were very significantly different. Fermentation of Goroho banana peel, using microbes consisting of bacteria, molds and fungi (P2-P5), the highest increase in the fermentation treatment (P2) using Ma-11 inoculum, due to the contribution of cellulose from molds and fungi on the substrate. Molds have the characteristic of not having chlorophyll and living as parasites. These microorganisms have bodies consisting of branched threads called hyphae and these hyphae are components of cellulose. The increase in cellulose content in fermented Goroho banana peels, in (P2) was 226.30%, from 2.70 to 8.81%. In (P3) was 191.11%, from 2.70 to 7.86%, in (P4) was 142.60%, from 2.70 increased to 6.55% and in (P1) was 107.77%, from 2.70 to 5.61%.

Lignin

Lignin is an amorphous heteropolymer structure, composed of three phenylpropane units, namely: p-coumaryl, coniferyl and sinaply alcohol whose existence is bound by different bonds, one of the functions of lignin components is to strengthen the structure of the plant so that it is resistant to microbial attacks and oxidation stress (Hendriks and Zeeman, 2009). Fermentation treatment (P2, P3 and P4) on Goroho banana peels had a very significant effect on reducing lignin content (P <0.01), the best decrease in lignin content in inoculum formula 2 (P4), from 18.83% to 15.87%. The lignin content decreased due to the maximum microbes in degrading lignin through the activity of the enzymes produced. It was suspected that lignin degrading enzymes such as lignase enzymes in the form of lignin peroxidase, manganese peroxidase and laccase work more optimally in degrading the substrate. Fermentation (P2, P3 and P4) reduced the lignin component of Goroho banana peel, the largest in (P4) by 15.72%, from 18.83 decreased to 15.87%, in (P3) by 11.52%, from 18.83 decreased to 16.66%, then in (P2) by 6.21%, from 18.83 decreased to 17.66%. In contrast, in (P1) the lignin content increased by 0.80% from 18.83 increased to 18.98% and was not significantly different from (P0) or without fermentation.

Digestibility of Goroho Banana Peels in Super Native Chickens

The average results of digestibility of Goroho banana peels in super native chickens can be seen in Table 3 and Figure 4.

Table 3: Average digestibility of dry matter, organic matter, protein and crude fiber of goroho banana peel feed (*Musa acuminafe sp*) in super native chickens.

Variables (%)	Treatments				
	P0	P1	P2	P3	P4
Dry Matter Digestibility	80,67 ±0,86[a]	84,11 ±1,24[a]	81,31 ±6,54[a]	82,21 ±5,44[a]	81,43 ±6,26[a]
Organic Matter Digestibility	82,95 ±0,86[a]	83,79 ±1,27[a]	85,06 ±6,50[a]	81,70 ±5,65[a]	78.97 ±6.06[a]
Protein Digestibility	34,25 ±0,64[a]	54,90 ±0,23[c]	44,24 ±1,17[b]	67,74 ±0,71[d]	44,72 ±0,68[b]
Crude Fiber Digestibility	14,10 ±2,72[a]	18,57 ±1,82[b]	19,76 ±2,40[b]	21,28 ±2,98[b]	25,35 ±2,79[c]

Note: Different superscript letters in the same row indicate highly significant differences (P<0.01).

Dry Matter Digestibility

Digestibility is the amount of feed nutrients that are retained or can be absorbed by the body. Digestibility is a method of assessing a feed ingredient, the higher the digestibility value of a feed ingredient, the more feed nutrients are absorbed. Things that can affect feed digestibility are: environmental temperature, livestock species, physical form of feed, feed composition, physical form of feed ingredients, feed travel rate in the digestive tract, crude fiber content of feed, nutrient deficiencies and feed processing. Other factors are metabolites of secondary compounds contained in the feed (Karimipoor and Rezvani, 2023).

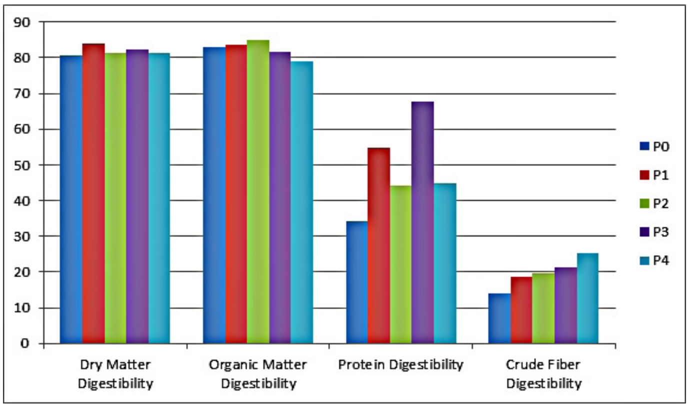

Figure 4: Average digestibility of dry matter, organic matter, protein and crude fiber of Goroho banana peel feed (*Musa acuminafe sp*) in super native chickens.

The data results obtained that the digestibility of dry matter was P0 (80.67), P1 (84.11), P2 (81.31), P3 (82.21) and P4 (81.43%), from the results of the values not significantly different (P> 0.05) which means that the provision of feed containing fermented Goroho banana peels (P1-P4) does not have a negative effect on the digestibility of super native chickens and the digestibility of feed containing fermented banana peels was on average higher than feed without Goroho banana peels (P0: 80.67%). The fermentation process can reduce the value of various anti-nutrients in feed, there is an increase in the protein value of banana peels by 37.91% (P3) during fermentation, as reported (Koni *et al*., 2024) by 74.35% and a decrease in crude fiber by 31.45%, so that this can increase the digestibility of dry matter. Wenda *et al*. (2020) reported an increase in dry matter digestibility of fermented Raja banana peel by 71.66 in broiler chickens. Rompas *et al*. (2016) stated that dry matter digestibility is influenced by the components of the dry matter content of the feed itself such as protein, carbohydrates (NFE and Crude Fiber), fat and ash.

Organic Material Digestibility

Organic materials consist of carbohydrates, proteins, fats, vitamins closely related to inorganic materials (ash). Organic material digestibility can be affected by ash content. If the ash content is high, it will result in lower organic material content. Boangmanalu *et al*. (2016) stated that the organic material digestibility of a feed indicates the quality of feed digested by the body. The results of the analysis of variance showed that the use of Goroho banana peels at a level of 10% in feed for super native chickens had no significant effect (P>0.05) on the digestibility of organic materials. This proves that the use of fermented Goroho banana peels in feed does not cause a decrease in the digestibility of organic materials and the best digestibility in treatment 2; 85.06% (fermentation using rumen fluid). The average digestibility of organic materials tends to be the same P0 (82.95%), P1 (83.79%), P2 (85.06%), P3 (81.70%), and P4 (78.97%). Research by Wenda *et al.* (2020) on the use of fermented Raja banana peels increased the digestibility of organic matter by 73.01% in broiler chickens. Zulfikar (2017) stated that the factors that affect the digestibility of organic matter are the crude fiber and mineral content of the feed.

The digestibility of organic matter is the amount of nutrients contained in a feed such as carbohydrates, proteins, fats and vitamins that can be digested by the body, in Rahmawati *et al.* (2021) stated that the digestibility value of organic matter and dry matter of feed is high because it is followed by the high nutrient content in the feed used to meet the needs of livestock. The digestibility of organic matter and the digestibility of dry matter will always be directly proportional because organic matter is part of the dry matter so that the results will tend to follow the dry matter. The digestibility of dry matter and the digestibility of organic matter of feed will always be directly proportional because organic matter is one part of the dry matter so that the size of the digestibility of dry matter obtained will affect the size of an organic matter.

Protein Digestibility

The results of the analysis of variance showed that the protein digestibility of feed using Goroho banana peels from the highest to the lowest averaged at P3 (67.74), P1 (54.90), P4 (44.72), P2 (44.24) and P0 (34.25%). The results of the research on the digestibility of protein in the treatment feed (P1-P4) had an average value higher than the research results of Has *et al.* (2017) who used banana peels (Musa paradisiaca) fermented with tempeh yeast, resulting in protein digestibility of 43.06% in native chickens in the Grower phase. The increase or decrease in the protein digestibility of a feed ingredient is influenced by factors such as the protein content of the feed ingredient and the amount of protein that enters the livestock's digestive tract. Another factor is because in Goroho banana peels (P3) using starter formula 1 (Ma-11 1 liter + Molasses 1 liter + water 2.5 liters + bran 0.5 kg + rotten tempeh ¼ kg) the activity of the microorganisms contained in it is more optimal and effective in breaking down complex protein bonds into simpler ones, so that they enter the digestive tract of super kampung chickens and with the help of digestive enzymes it becomes easier to digest and absorb by the digestive organs. The same condition also applies to P1, P4, P2 compared to P0.

Crude Fiber Digestibility

Crude fiber contains cellulose, lignin and hemicellulose depending on the species and growth phase of the plant material. Green fodder is a source of crude fiber that can stimulate the growth of digestive organs in growing livestock. High levels of crude fiber can reduce microbial decomposition. Based on the results of the analysis of variance, it shows that the use of goroho banana peel silage feed with a provision level of 10% in the ration has a very significant effect ($P < 0.05$) on crude fiber digestibility. Based on the results of the average value of crude fiber digestibility of the study from each treatment is P0 (14.10%), P1 (18.57%), P2 (19.76%), P3 (21, 28%), and P4 (25.35%). The crude fiber digestibility value obtained was lower than that reported by Suariani *et al.* (2023) that the use of fermented banana peel flour as feed for free-range chickens resulted in crude fiber digestibility of 45.12%. The highest crude fiber digestibility was found in the P4 treatment and the lowest was found in the P0 (control) treatment. The crude fiber digestibility value of the P4 treatment feed was significantly higher than that of the other treatments (P0, P1, P2, P3). This is due to the low fiber content in the P4 treatment. The low crude fiber content will facilitate the penetration of rumen microbes (bacteria, protozoa, and fungi) to digest feed nutrients. This means that the lower the crude fiber content in the feed, the higher the crude fiber digestibility.

The low crude fiber digestibility value, especially in the P0, P1, P2, and P3 treatments, is due to the high cellulose content in the feed given, this is in line with the statement of Pangestu *et al.* (2018) that poultry have difficulty digesting cellulose because poultry do not have cellulase so that crude fiber digestion occurs in the cecum with the help of microorganisms. Crude fiber plays a good role in poultry, crude fiber in feed can reduce pathogenic microorganisms (Jangiaghdam *et al.*, 2022), the level of crude fiber in the ration greatly affects the performance and growth of livestock. Crude fiber is needed by livestock to stimulate digestive tract movements, but excessive amounts of crude fiber can also reduce feed digestibility. Crude fiber is a component of plant cell walls that is difficult for poultry to digest and contains little nutritional value, but its presence in the ration is very important because crude fiber has a physiological function for poultry.

CONCLUSIONS AND RECOMMENDATIONS

Fermentation of Goroho banana peel P1 to P4 increased the content of water, crude protein, crude fat, crude fiber, calcium, phosphorus, cellulose and can reduce the content of NFE, gross energy, hemicellulose and lignin. The digestibility of dry matter and digestibility of organic matter in all treatments using Goroho banana peel feed in super kampung chickens gave results that were not significantly different. The highest increase in protein digestibility was in treatment 3 (67.745%) and the highest digestibility of crude fiber was in treatment 4 (25.35%). The use of fermented Goroho banana peel in animal feed not only enhances nutritional value but also facilitates long-term storage, thereby saving time for livestock farmers. Fermented Goroho banana peels have the potential to be an important feed ingredient for poultry, providing advantages such as increased feed efficiency, gut health, and meat quality. However, potential challenges and limitations must be addressed such as nutritional variability, anti-nutritional factors, palatability, storage and handling to ensure their safe and effective use in commercial poultry farming.

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The authors contributed equally to this work.

NOVELTY STATEMENT

Previous studies on the nutritional and digestibility of fermented Goroho banana peel have been conducted. However, there has been no research on the nutritional quality of goroho banana peel using the fermentation method with the addition of 4% Ma-11 starter, 4% rumen fluid, 4% formula 1 starter (1 liter of Ma-11 + 1 liter of molasses + 2.5 liters of water + 0.5 kg of bran + 250 grams of decomposed soybean product), and 4% formula 2 starter (1 liter of rumen fluid + 1 liter of molasses + 2.5 liters of water and 0.5 kg of bran) and its use as feed to determine the digestibility value in super native chickens.

AUTHOR'S CONTRIBUTIONS

Sri Suryaningsih Djunu, Syukri I. Gubali and Samsul Bahri: Idea and design.
Laode Sahara, Syahruddin Syahruddin, Ellen J. Saleh, Arlan Igirisa and Prandi R. Mohamad: Material sample collection and lab analysis.
Sri Suryaningsih Djunu, Srisukmawati Zainudin, Safriyanto Dako and Anisa Ekaputri Lestari Mustafa: Write the manuscript.
Sri Suryaningsih Djunu: Revision

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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