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Effect of Fermented Vegetable Waste Supplemented with Fish Flour Waste on Nutritional Quality and Performance of Broiler

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ABSTRACT. This study aims to evaluate the effects of fermented vegetable waste supplemented with varying levels of fish waste flour on the nutritional composition of the feed and its impact on broiler performance. The experiment employed a Completely Randomized Design (CRD) with four treatments and four replications. The treatments were as follows: T0–Vegetable Waste (VW) without Fish Waste Flour Supplementation (FWFS); T1–VW+5%FWFS; T2–VW+10%FWFS; and T3–VW+15%FWFS. Parameters measured included proximate composition and broiler performance indicators. The results demonstrated that the fermentation of vegetable waste with fish waste flour at varying concentrations significantly affected ($P<0.05$) moisture content, crude protein, crude fiber, ash content, feed intake, feed conversion ratio (FCR), and body weight. However, crude fat and nitrogen-free extract (NFE) contents were not significantly affected ($P>0.05$). The supplementation of 10% fish waste flour (T2) yielded the highest values for crude protein, crude fat, and moisture, and also resulted in the best body weight gain and feed conversion ratio among the treatments. In conclusion, the inclusion of 10% fish waste flour in fermented vegetable waste is recommended, as it provides optimal nutritional quality and enhances broiler performance.

Keywords: broiler performance, fermentation, fish waste flour, nutritional content, vegetable waste

INTRODUCTION

Optimizing broiler growth potential requires the fulfilment of nutritional requirements, particularly protein. The availability of protein for growth and development is primarily influenced by the protein content in the feed and its subsequent absorption in the digestive tract. Ensuring adequate nutritional intake through feed can be achieved by utilizing organic market waste, which holds potential as a sustainable and economical protein source for broiler diets (Bryan and Classen, 2020). The effective and efficient processing of organic market waste, especially through fermentation, can enhance its nutritional value and reduce anti-nutritional factors. Fermentation not only improves the digestibility and palatability of feed ingredients but also contributes to the sustainable management of agricultural and food waste. This approach supports both environmental sustainability and economic feasibility by converting waste into value-added feed products with functional benefits for poultry nutrition.

The fermentation process is a biological mechanism driven by microorganisms that produce organic acids, aiming to enhance the quality and nutritional value of feed ingredients, extend shelf life, and improve digestibility and feed utilization efficiency (Kung and Shaver, 2021). This process is commonly applied in the production of silage or other high-fiber feed products. Silage involves the preservation of forage under anaerobic conditions, during which microorganisms convert carbohydrates into lactic acid and other organic acids. These acids lower the pH, thereby improving feed preservation and prolonging storage duration (Tillman et al., 1991). According to McDonald et al. (2020), high-quality silage should exhibit enhanced nutritional value and stability, particularly in maintaining crude protein content, with minimal energy loss throughout the fermentation process. Critical factors influencing silage quality include moisture content, carbohydrate content, fat content, and proper storage management, all of which serve as indicators of effective fermentation and feed preservation.

Currently, the utilization of waste as an alternative feed source represents a practical solution for reducing feed costs in broiler production management. Organic market waste particularly vegetable and fish waste offer considerable potential as feed ingredients due to their high availability and low economic value. These types of waste can be further enhanced in terms of nutritional content through fermentation processes. The addition of rice bran as a microbial starter and molasses as an energy source can support the fermentation process, thereby improving the feed's overall quality and making it more suitable for broiler consumption.

Silage feed processing technology serves as an alternative and innovative approach to enhancing the quality of organic waste for use in animal feed. This technology allows broilers to

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safely consume waste materials that have undergone quality improvement. Through the fermentation process, silage products can significantly enhance the nutritional value of organic waste, particularly by increasing crude protein content (Jayanti et al., 2018).

At present, feed availability remains one of the most critical challenges in livestock production, particularly in terms of supply. As a result, effective feed management has become increasingly important. The use of organic waste as an alternative feed source offers a practical solution for reducing production costs (Sari et al., 2023). Based on the considerations outlined above, this study aims to examine the nutritional quality of fermented organic waste derived from vegetable waste supplemented with varying levels of fish waste flour. Furthermore, it investigates the effects of this supplemented organic waste as a component of basal feed on the performance of broiler chickens.

MATERIALS AND METHODS

This research was conducted from June to August 2024 at three different locations. First, the preparation of waste silage and physical testing were carried out at the Integrated Laboratory of Universitas Sulawesi Barat, Majene. Second, the chemical analysis of the silage was conducted at the Feed Chemistry Laboratory, Hasanuddin University, Makassar. Finally, the assessment of broiler performance was performed at the experimental poultry facility of Universitas Sulawesi Barat, located in Sendana, Majene.

The equipment used in this study included scales, silos, tarpaulins, ropes, scissors, knives, machetes, stationery, measuring cups, ovens, and a complete set of instruments for proximate analysis. Additional tools included experimental cages, feed containers, drinking vessels, and housing equipment for broiler maintenance. The materials used consisted of vegetable waste (cabbage, carrots, corn husks, mustard greens, and tomatoes), fish waste flour, rice bran, molasses, and basal feed.

Research Procedure

Vegetable waste, consisting of cabbage, carrots, corn husks, and tomatoes, was aerated until the moisture content reached 60–70%. The waste was then chopped into pieces measuring approximately 4–6 cm in length. Subsequently, 5 kg of vegetable waste was placed into airtight silage bags for fermentation, according to the experimental treatments. Four types of treatments were prepared using different bag categories: Bag A: Vegetable waste without fish waste flour (control), Bag B: Vegetable waste supplemented with 5% fish waste flour, Bag C: Vegetable waste supplemented with 10% fish waste flour, Bag D: Vegetable waste supplemented with 15% fish waste flour. Each treatment consisted of four replicates, resulting in a total of 16 silage bags. All treatments were additionally mixed with rice bran (as a fermentation starter) and molasses (as an energy source). The silage was fermented under anaerobic conditions for 21 days. After fermentation, 300 g of silage was sub-sampled from each bag for proximate analysis, including measurements of moisture content, crude protein, crude fat, crude fiber, and nitrogen-free extract (NFE).

Preparation of Fish Waste Flour: Fish waste was collected from several traditional markets in the Majene area. The collected waste was thoroughly washed under running water to remove dirt and impurities. After cleaning, the fish waste was oven-dried until it reached a completely dry state. The dried material was then ground into fine flour using a 30-mesh sieve to ensure uniform particle size.

Broiler Performance: Broilers were provided with the experimental feed treatments from 8 to 22 days of age. The treatment feed consisted of basal feed supplemented with 10% fermented organic waste flour. Data collected during the trial included feed consumption, body weight gain, and feed conversion ratio (FCR).

Data Analysis

Data were analyzed using analysis of variance (ANOVA) with the SPSS version 23 software. When a significant effect was detected, Duncan’s multiple range test was performed to identify differences among treatments (Kusriningrum, 2008). The statistical model used was:

$$Y_{ij} = \mu + \alpha_i + \varepsilon_{ij}$$

Information:
Yij: The value of observation to j on treatment to i; μ: General average value; αi: Effect of treatment on i; εij: Error of the experiment from treatment to i repeat to j; i: Treatment (consists of four Treatments), j: Repetition (consists of four repetitions).

The observed variables included proximate nutrient contents (moisture, dry matter, crude protein, crude fat, crude fiber, and nitrogen-free extract) as well as broiler performance variables (body weight gain, feed consumption, and feed conversion ratio).

Moisture Content Analysis

Samples were initially weighed and then dried in an oven at 105°C for 8 hours. After drying, samples were placed in a desiccator to cool before being reweighed. Moisture content was calculated using the formula:

$$\text{Dry matter} = \frac{\text{Sample weight after dried}}{\text{Sample weight before dried}} \times 100\%$$

$$\text{Mositure Content} = 100\% - \text{ Dry matter}$$

Ash Content Analysis

Ash content was determined following the AOAC (2019) procedure. Samples were first weighed and dried in an oven, then ashed in a muffle furnace at 600°C for 6 hours. The percentage of ash content was calculated using the formula:

$$\text{Ash content} = \frac{\text{weight of ash}}{\text{weight of sample}} \times 100\%$$

Crude Protein Analysis

Crude protein content was determined using the Kjeldahl method. A 5-gram sample, previously ground into flour, was placed into a digestion flask. To the sample, a mixture of copper sulphate ($CuSO_4$) and 25 ml of concentrated sulfuric acid (H_2SO_4) was added. The flask was then heated gently using a spirit lamp until digestion was complete. After cooling, 10 ml of distilled water was added, followed by the distillation process. Prior to distillation, 5 ml of 30% sodium hydroxide (NaOH) solution and five drops of phenolphthalein indicator were added to the distillation apparatus. The distillation was conducted for 10 minutes, during which ammonia was released and captured in a receiving container containing 10 ml of 2% boric acid solution with five drops of phenolphthalein indicator. The ammonia was then titrated with 0.01 N hydrochloric acid (HCl) until the solution changed from greenish to clear (Ispitasari and Haryanti, 2022). The crude protein content was calculated using the following formula:

$$\%\text{ N} = \frac{(\text{A} - \text{B}) \times \text{NHCL} \times 14}{\text{mg sampel}} \times 100\%$$

Protein level = % N x Conversion factor

Information: A= sample titration; B= blank titration conversion factor = 6.25

Crude Fiber Analysis

The crude fiber content of the samples was determined using the digestion method, which involves two main steps: acid digestion followed by alkaline digestion. The procedure followed the AOAC (2019) guidelines. Approximately 5 grams of the sample, previously ground into flour, were weighed using an analytical balance and placed into a 250 ml beaker. First, fat was removed by adding 15 ml of 96% ethanol to the sample, stirring gently to homogenize, and allowing it to stand for 15 minutes. This ethanol treatment was repeated three times, with the filtrate collected each time through filter paper, ensuring that the sediment remained on the filter. After filtration, the filter paper with the sediment was dried. Then, 50 ml of 1.25% sulfuric acid (H_2SO_4) solution was added to an Erlenmeyer flask containing the sample. A condenser was attached to the flask, and the mixture was refluxed in a water bath for 30 minutes. Following this, 50 ml of 3.25% sodium hydroxide (NaOH) solution was added, and refluxing was continued for another 30 minutes. After digestion, the solution was filtered while hot using a funnel and filter paper. The residue was then sequentially washed with 25 ml each of hot sulfuric acid solution, hot water, and finally ethanol. The sediment, along with the filter paper, was transferred to a container, dried in an oven at 105°C, cooled, and weighed. The crude fiber content was calculated using the following formula:

$$\text{Crude fiber} = \frac{\text{Wks } + \text{sample } - \text{ Wks}}{\text{Wsample}} \times 100\%$$

Information: %CF: Crude fiber level; Wks: constant filter paper weight; Wsample: initial sample weight; Wks + sample: sample weight and filter paper after heated in the oven.

Crude Fat Content

Measurement of crude fat content can be done by the Soxhlet method with the following formula:

$$\text{CF} = \frac{\text{Crude fat weight}}{\text{Sample weight}} \times 100\%$$

Nitrogen-Free Extractives/ NFN.

The following formula is deployed in determining the NFN value:

NFN = 100 - (% moisture + ash level + % crude protein + % crude fat + % crude fiber).

Feed Consumption

Feed consumption was calculated as the difference between the amount of feed provided and the leftover feed, divided by the number of broilers. The formula used for calculating feed consumption is as follows:

$$\text{Feed consumption} = \frac{\text{Given feed } - \text{ left over feed}}{\text{The total number of broiler}}$$

Body Weight Performance

Body weight serves as a key indicator to assess the growth and development of broiler chickens. The following formula was used to calculate body weight during the treatment period:

Body weight = Final body weight- Initial body weight

Feed Conversion

Feed conversion ratio is the measure of the efficiency with which broilers convert feed into body mass. It is calculated as the ratio of feed intake to the body weight gain over a given period. The formula for calculating feed conversion ratio is as follows:

$$\text{Feed conversion} = \frac{\text{Feed consumption}}{\text{Increase in body weight}}$$

RESULTS AND DISCUSSION

Nutritional Content of Fermented Organic Market Waste

The analysis of crude protein content in fermented feed derived from vegetable waste supplemented with varying percentages of fish waste flour is presented in Table 1.

Crude Protein

Analysis of variance indicated that crude protein content in fermented vegetable waste with different levels of fish waste flour supplementation was significantly affected (P<0.05). The crude protein content ranged from 26.99% to 48.20%.

Table 1. Proximate analysis result of market organic waste after fermentation (%)

Suplemented fish	Proximate analysis (%)					
flour (%)	Moisture content	Crude protein	Ether extract	Crude fiber	NFE	Ash
0 (T0)	13.57^{a}±0.25	29.04^{b}±0.96	4.48±0.25	7.30^{b}±0.14	39.44±1.27	19.72^{c}±0.70
5 (T1)	14.86^{b}±0.11	36.14^{c}±0.32	3.54±0.38	7.46^{b}±0.16	34.25±1.36	18.61^{b}±0.49
10 (T2)	16.83^{c}±0.13	47.99^{d}±0.29	3.71±0.31	4.16^{a}±0.20	25.08±0.04	19.05^{a}±0.14
15 (T3)	14.41^{b}±0.51	26.56^{a}±0.60	4.60±0.40	9.51^{c}±0.52	38.94±0.56	19.88^{c}±0.85

Source: Primary data from the results of the study (2024). Description: Different superscripts in the same column show a noticeable difference (P<0.05).

Treatment T2 (10% fish waste flour) yielded the highest crude protein value of 47.20%, significantly higher than T0, T1, and T3. This increase is attributed to the high protein content inherent in fish waste, consistent with Jayanti et al. (2018), who reported that properly processed fish waste or fish meal contains high protein levels. Additionally, the fermentation process contributes to increased crude protein content through the activity of proteolytic bacteria, which produce protease enzymes that break down proteins, as supported by Jamaluddin et al. (2019). Haotian et al. (2024) found that fermenting fish silage for 14 days produced crude protein content of 40.07%, which aligns with our findings and depends on raw material quality. Conversely, Rakhmawati (2014) reported a decrease in crude protein to 15.49% with only 5% fish waste addition, demonstrating the impact of supplementation levels. According to the Badan Standardisasi Nasional (SNI), the minimum crude protein content in feed should be 28% (Badan Standardisasi Nasional, 2020).

Crude Fat

The crude fat content also showed a significant difference (P<0.05) across treatments, ranging from 3.54% to 4.60% (Table 1). Treatment T2 (10% fish waste flour) had the lowest crude fat content at 3.71%. This reduction is influenced by the fermentation process, which facilitates the breakdown of fats into simpler fatty acids, decreasing overall fat content (Wattiheluw et al., 2023). The crude fat content met the SNI standard, which ranges between 2–5% for feed (Badan Standardisasi Nasional, 2020). Sulistyoningsih (2015) cautioned that fat content exceeding 5% can adversely affect feed quality and animal health, so the values in this study indicate safe feed ingredients. Kusriningrum (2008) further explained that glucose present in the substrate enhances lipase enzyme activity, improving fat degradation during fermentation.

Crude Fibre

Crude fiber content was significantly affected by fish waste flour supplementation (P<0.05). The lowest crude fiber content was observed in T2 (10% fish waste flour), while the highest was in T3 (15% fish waste flour) with 9.51% crude fiber. Vegetable waste inherently contains high fiber and water content, which can affect other nutrient concentrations. Adding fish waste flour optimizes the growth of ligninolytic bacteria during fermentation, particularly under anaerobic conditions, supported by factors such as fermentation time, temperature, and microbial inoculants. Bran was used as the microbial starter due to its low moisture, complementing the watery vegetable waste. Suningsih et al. (2019) noted that fermenters help break lignin-cellulose bonds in high-fiber materials. The inverse relationship between crude protein and crude fiber was evident; T2 had the highest protein and lowest fiber. Jamaluddin et al. (2019) emphasized that high crude fiber reduces protein digestibility, while a balance between protein and fiber enhances feed efficiency. Increased protein coupled with decreased fiber improves digestibility, whereas simultaneous increases in both do not significantly change digestibility.

Broiler Performance

Performance parameters including feed consumption, body weight gain, and feed conversion ratio (FCR) were evaluated to assess the benefits of fermented organic waste supplementation.

Feed consumption was significantly influenced by the treatments (P<0.05), as shown in Table 2. Increasing the percentage of fish waste flour in fermented vegetable waste significantly affected broiler feed intake, which ranged from 56.32 to 56.63 grams per broiler per day. These findings align with Widianingrum et al. (2018), who reported that fermented catfish meal supplementation influenced broiler feed consumption due to improved palatability and nutritional quality post-fermentation. Zulfan and Zulfikar (2020) also found that replacing basal feed with fermented fish meal impacted feed intake. The feed consumption in this study meets the SNI standard for broilers aged 8 to 22 days, which is 40–60 grams per bird per day (Badan Standardisasi Nasional, 2020).

Table 2. Broiler performance

Fish flour supplementation treatment (%)	Feed consumption (g/day)	Body weight (g)	Feed conversion
Control (T0)	56.63b±0.32	678.93a±10.06	1.50d±0.009
T1 (5% T0 supplement)	56.43b±0.38	717.37b±17.67	1.41b±0.01
T2 (10% T0 supplement)	56.59b±0.30	756.87c±18.49	1.34a±0.005
T3 (15% T0 supplement)	55.32a±0.31	695.43ab±19.44	1.43c±0.008

Source: Primary data from the results of the study (2024). Description: Different superscripts in the same column show a noticeable difference (P<0.05).

Body Weight Gain

The increase in broiler body weight was significantly affected by the addition of 10% fermented organic market waste flour in the basal diet (P<0.05), as shown in Table 2. The T2 treatment group exhibited the highest weight gain, likely due to higher feed consumption. Tariq et al. (2020) demonstrated that fermented fish meal improves nutrient digestibility and enhances broiler weight gain. They also emphasized that increased feed intake is an important indicator of growth. Feed intake directly supplies essential nutrients required for broiler growth and development (Fitria et al., 2019).

Feed Conversion Rate

The FCR differed significantly among treatments (P<0.05), as presented in Table 2. FCR is calculated by dividing feed intake by body weight gain and is a critical indicator of feed efficiency. Nugraha et al. (2017) described FCR as the cumulative feed consumed divided by the broiler's body weight. Allama et al. (2012) noted that a lower FCR reflects more efficient feed utilization. The lowest FCR was observed in the T2 group (10% fish waste flour), indicating better feed efficiency compared to other treatments. This improved efficiency is likely due to enhanced nutrient content from fermentation. Adugna et al. (2020) also reported that fermented fish meal positively influences feed efficiency and body weight gain. Other factors influencing FCR include the quality of day-old chicks (DOC), management, and environmental conditions (Qurniawan et al., 2017).

CONCLUSION

Based on the findings of this study, it can be concluded that the supplementation of 10% fish waste flour in fermented vegetable waste-based feed provides the optimal formulation in terms of nutritional quality. This treatment also resulted in the best broiler performance, as reflected by superior weight gain and feed conversion ratio (FCR) compared to other treatment levels.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the content of this manuscript, including any financial, professional, or personal affiliations that could have influenced the results or interpretations presented.

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