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Research Article

Utilization of Industrial Waste (Fish Meal Oil Sludge and Cassava Dregs) as an Alternative to Commercial Broiler Feed

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Abstract | This research aims to determine the effect of using a mixture of fish meal oil sludge and cassava dregs as a substitute for commercial feed on the production performance of broiler chickens. The study involved 168 broiler chickens, fish meal oil sludge, cassava dregs, and commercial feed. The research used an experimental method with a Completely Randomized Design (CRD), consisting of 7 treatments, 4 replications, and 6 chickens in each replication. The treatments involved reducing the use of commercial feed proportionally and replacing it with a substitute feed in the form of a mixture of fish meal oil sludge and dregs, as follows: R0 (100% commercial feed), R1 (95% commercial feed + 5% substitute feed), R2 (90% commercial Feed + 10% substitute feed), R3 (85% commercial feed + 15% substitute feed), R4 (80% commercial feed + 20% substitute feed), R5 (75% commercial feed + 25% substitute feed), R6 (70% commercial feed + 30% substitute feed). The parameters observed were feed consumption, body weight gain, Feed Conversion Ratio, carcass percentage, abdominal fat percentage, organic matter digestibility, and nitrogen digestibility. The data were analyzed using analysis of variance. The results of the study showed that the replacement of commercial feed with a mixture of fish meal oil sludge and cassava dregs had a significant effect ($P<0.05$) on the performance of broiler chickens, including increasing feed consumption, body weight gain, carcass percentage, and organic matter digestibility, while decreasing Feed Conversion Ratio, abdominal fat percentage, and nitrogen digestibility at the optimal level of 10% feed substitution (R2).

Keywords | Industrial waste, Fish meal oil sludge, Cassava dregs, Feed substitute, Broiler chicken

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INTRODUCTION

The poultry farming industry in Indonesia has been experiencing significant growth, driven by the rising demand for animal protein. To sustain this growth, it is essential to ensure an adequate supply of feed ingredients, which are a critical factor in poultry production. However, conventional feed ingredients such as soymeal and fishmeal are costly and heavily reliant on imports, creating challenges for local farmers in maintaining cost efficiency (Natsir *et al*., 2019). This situation underscores the need for alternative feed ingredients that are affordable, locally available, and nutritionally adequate.

The search for alternative feed sources has gained significant attention as a means to address these challenges (Bist *et al*., 2024). The utilization of industrial and agricultural by-products, such as fish meal oil sludge and cassava dregs, offers a promising solution to these challenges. Fish meal oil sludge is one of the industrial wastes produced during fish meal processing. It originates from the liquid that emerges during the pressing process of fish meal production and this liquid consists of oil, dissolved solids (oil sludge), and water (Shepherd and Jackson, 2013). It contains high protein that can be categorized as high-quality animal feed material, which has the potential to enhance the growth of poultry, especially broiler chickens (Barua *et al*., 2017). Unfortunately, the handling of fish meal oil sludge in some fish meal processing industries are underutilized and simply discarded.

Cassava dregs, which also commonly known as gamblong in Indonesia, is a waste product from the process of making tapioca flour. It has low protein content but high carbohydrates and is easily digestible (starch), making it suitable as an energy source in poultry feed (Ginting, 2022). The important components found in cassava dregs are organic substances in the form of starch and crude fiber (Erviana *et al*., 2020), with crude fiber content at 14.93% (Ramadhanti *et al*., 2024). While these by-products have been individually explored as feed ingredients, limited research has investigated their combined use and synergistic effects on broiler chicken production.

Addressing this gap, this study focuses on the effect of a mixed diet of fish meal oil sludge and cassava dregs as a substitute for commercial broiler feed. Unlike previous studies that have primarily assessed individual by-products, this research evaluates the nutritional feed efficiency and production performance of broiler chickens fed with this alternative feed. This novel approach aims to contribute to sustainable agriculture by utilizing waste materials and minimizing reliance on imported feed ingredients. Additionally, this research also seeks to find alternative animal feed sources that do not compete with human food needs.

MATERIALS AND METHODS

The materials used in this research were industrial waste from fish meal production, specifically fish meal oil sludge, obtained from the Muncar Banyuwangi fish meal company, and cassava dregs in the form of flour from the Turen Malang Tapioca Factory. The commercial feed used in this research, produced by Japfa Comfeed, served as the basal feed. The study involved 168 broiler chickens, housed in battery cages, along with feeding and drinking equipment and supporting facilities.

The research method used in this study was an experimental approach employing a Completely Randomized Design (CRD) with a homogeneous experimental unit, consisting of 7 treatments, 4 replications, with each replication having 6 chickens. The feed provided was commercial feed produced by Japfa Comfeed. The treatments were applied by gradually reducing the usage of commercial feed proportionally, as follows:

R0: 100% Commercial Feed
R1: 95% Commercial Feed + 5% Fish Meal Oil Sludge and Cassava Dregs Mixture
R2: 90% Commercial Feed + 10% Fish Meal Oil Sludge and Cassava Dregs Mixture
R3: 85% Commercial Feed + 15% Fish Meal Oil Sludge and Cassava Dregs Mixture
R4: 80% Commercial Feed + 20% Fish Meal Oil Sludge and Cassava Dregs Mixture
R5: 75% Commercial Feed + 25% Fish Meal Oil Sludge and Cassava Dregs Mixture
R6: 70% Commercial Feed + 30% Fish Meal Oil Sludge and Cassava Dregs Mixture

The mixed feed of fish meal oil sludge and dregs was formulated based on the protein content of the commercial feed. The feed and water were provided ad libitum. Feeding broiler chickens using the ad libitum method operates on the principle of providing feed continuously, allowing chickens to consume feed according to their physiological needs. This method is designed to give chickens the freedom to choose their feeding times without specific time restrictions, thereby supporting optimal growth and reducing stress that might arise from feed scarcity (Muhammad *et al*., 2023; Folorunso *et al*., 2014). The treatment feed was replenished periodically, typically twice a day, in the morning and evening. However, if feed consumption increases, particularly during the intensive growth phase, additional feeding at midday can be performed to prevent empty feeders (Muhammad *et al*., 2023). Observations on production performance was conducted for 42 days.

The observed parameters included production performance indicators such as feed consumption (FC= Total Feed Provided - Feed Left Over), Body Weight Gain (BWG= Final Body Weight–Initial Body Weight), Feed Conversion Ratio (FCR= Total Body Weight Gain (kg) / Total Feed Consumed (kg)), abdominal fat percentage (Body Weight (g) / Weight of Abdominal Fat (g)) ×100), organic matter digestibility ((1 – rest of OM/weight of OM) ×100) (OMD%), and Apparent Nitrogen Digestibility (AND%).

Statistical Analysis

All collected data were analyzed using Analysis of Variance (ANOVA) according to a Completely Randomized Design (CRD). When significant differences were found ($P<0.05$), means were compared using the Least Significant Difference (LSD) test. Statistical analyses were performed using SPSS version 29.0 (IBM Corp., Armonk, NY, USA).

RESULT AND DISCUSSION

Based on the research findings and analysis of variance regarding the use of a mixture of fish meal oil sludge and

Table 1: Mean feed consumption, body weight gain, and feed conversion ratio.

Parameter	Treatment						
	R0	R1	R2	R3	R4	R5	R6
FC (gr/chicken)	3458.41 ±1.47[c]	3489.24±0.73[d]	3562.99±0.99[e]	3412.64±1.22[bc]	3391.88±1.05[abc]	3349.58±0.69[ab]	3330.95±0.75[a]
BWG(gr/chicken)	1877.49±0.63[cde]	1831.11±0.91[de]	1904.17±0.80[de]	1818.82±0.45[bcd]	1793.54 ±0.68[bc]	1724.98±1.14[ab]	1712.83±0.41[a]
FCR (kg)	1.95± 0.20[c]	1.92± 0.32[bc]	1.79± 0.95[a]	1.84± 0.85[ab]	1.88± 0.35[bc]	1.94± 0.10[c]	1.94± 0.02[c]

a,b,c,d,e Different superscripts in the same row indicate significant differences (P<0.05).

dregs as a substitute for commercial feed, significant effects (P<0.05) were observed on feed consumption, body weight gain, and feed conversion ratio in broiler chickens with the most optimal results were obtained in the R2 treatment (90% Commercial feed + 10% Fish Meal Oil Sludge and Cassava Dregs Mixture). The detailed results can be found in Table 1.

Feed Consumption

Based on the analysis of the least significant difference, it was found that the feed consumption of broiler chickens in each treatment, where commercial feed was replaced with a mixture of fish meal oil sludge and dregs in the diet, showed significant differences (P<0.05) as can be seen in Table 1. The variations in feed consumption among these treatments can be attributed to the form of fish meal oil sludge and cassava dregs, which are in the form of flour and thus are bulky. As a result, the animals are unable to consume large quantities of feed due to their limited crop capacity. Additionally, the increased metabolic energy content in the feed may contribute to the reduced feed intake. As the energy content in the animal's diet increases, it influences the amount of feed consumed (Nassar *et al*., 2019).

Body Weight Gain

Based on the analysis, it was found that the body weight gain of broiler chickens in each treatment, where commercial feed was replaced with a mixture of fish meal oil sludge and dregs in the diet, showed significant differences (P<0.05). The variations in body weight gain when replacing commercial feed with the mixture of fish meal oil sludge and cassava dregs can be attributed to the different nutritional content of each treatment's diet.

The use of a mixture of fish meal oil sludge and cassava dregs in the commercial feed provides nutrients such as protein, carbohydrates, fats, minerals, and vitamins that can be digested and absorbed better in the animal's body. Both absorbed amino acids and carbohydrates in the form of starch (NFE) can be utilized by the body for energy, fulfilling the energy requirements (Moore, 2018). This condition occurs because the influence of both feed ingredients comes from a source of animal protein (fish meal oil sludge) and a source of energy (cassava dregs), allowing for the fulfillment of essential amino acids, especially critical amino acids (Morgan and Choct, 2016; Chirwa and Lebitso, 2012). Animal protein sources in feed are superior to plant protein sources due to their relatively good protein quality (Beski *et al*., 2015). Additionally, animal feed sources provide higher levels of calcium and phosphorus and contain vitamin B12, which is only found in animal feed sources (Natsir *et al*., 2018).

Feed Conversion

The analysis of the least significant difference revealed significant differences (P<0.05) in the feed conversion ratio of broiler chickens across treatments, where commercial feed was substituted with a mixture of fish meal oil sludge and cassava dregs in the diet. These variations in feed conversion ratio can be attributed to the supplementation of fish meal oil sludge and cassava dregs, which contributed to a more balanced nutrient profile. This supplementation ensures an adequate supply of essential amino acids and linoleic acids from animal protein, enhancing the nutritional value of the feed and improving the overall diet quality (Cardoso *et al*., 2019). Linoleic acid in fish waste oil is present in varying amounts from 4% up to 20% based on factors such as fish species, processing methods, and the specific parts of the fish used (Selim *et al*., 2021). However, specific data on linoleic acid content in fish meal oil sludge is limited.

The quality of the feed affects feed consumption and body weight gain, which in turn determines the feed conversion ratio. Factors such as body weight gain, feed consumption, gender, health, and other factors can influence the feed conversion ratio (Suwarta, 2014). Based on the research findings and analysis of variance regarding the use of a mixture of fish meal oil sludge and cassava dregs as a substitute for commercial feed, significant effects (P<0.05) were observed on carcass percentage and abdominal fat percentage in broiler chickens. The detailed results can be found in Table 2.

Carcass Percentage

Based on the analysis of least significant difference, it was found that the carcass percentage of broiler chickens in each treatment, where commercial feed was replaced with a mixture of fish meal oil sludge and cassava dregs in the diet, showed significant differences (P<0.05). The variations in carcass percentage in treatments using the replacement of commercial feed with a mixture of fish meal oil sludge and cassava dregs can be attributed to the use of animal protein from fish meal oil sludge, which is rich in essential amino acids, particularly methionine and lysine (Chirwa and Lebitso, 2011). This allows for optimal digestion of protein in the diet. Animal protein is superior to plant protein for both humans and monogastric animals, as animal protein is more balanced in its essential amino acid composition. These essential amino acids cannot be synthesized by the body and must be obtained through diet (van Hue *et al.*, 2022).

Table 2: Mean values of carcass percentage and abdominal fat percentage.

Parameter	Treatment						
	R0	R1	R2	R3	R4	R5	R6
Carcass (%)	70.16± 0.84[ab]	71.13± 0.44[bc]	72.07± 0.29[c]	70.83 ±0.53[bc]	69.96± 1.47[ab]	68.93 ±0.95[a]	68.75 ±0.32[a]
Abdominal Fat(%)	2.35± 0.57[bc]	2.26± 0.32[b]	2.09± 0.19[a]	2.21± 0.31[b]	2.26± 0.68[bc]	2.32± 0.60[bc]	2.36± 0.59[c]

a, b, c Different superscripts in the same row indicate significant differences (P<0.05).

The essential amino acids include arginine, lysine, histidine, leucine, isoleucine, valine, methionine, threonine, tryptophan, and alanine. Among them, lysine, methionine, cysteine, and tryptophan are considered critical amino acids because they are the most difficult to obtain in balanced amounts, requiring special attention to meet their needs when formulating the diet (de Borja Reis *et al.*, 2022). With a balanced amino acid profile in the diet, optimal digestion occurs, leading to increased protein utilization in the body and higher carcass percentages.

Abdominal Fat Percentage

Based on the analysis of least significant difference, it was found that the abdominal fat percentage of broiler chickens in each treatment, where commercial feed was replaced with a mixture of fish meal oil sludge and cassava dregs in the diet, showed significant differences (P<0.05). This indicates that fish meal oil sludge and cassava dregs have good quality protein content, and their amino acid composition is more complete due to the higher quality of animal protein compared to plant protein. As a result, the protein in the diet is digested optimally, leading to a higher protein digestibility and reduced fat accumulation (Shabani *et al.*, 2019). Additionally, the energy content in the mixture of fish meal oil sludge and dregs can also affect the abdominal fat percentage. When the energy content in the diet is high, the feed consumption tends to decrease, resulting in a reduced intake of protein (Hudiansyah *et al.*, 2015).

Furthermore, crude fiber also influences the abdominal fat percentage because it can interfere with protein digestion, leading to incomplete protein digestion. Crude fiber cannot be digested but can carry undigested food substances from other feed ingredients in the feces (Suariani *et al.*, 2021). The growth and feed efficiency will decrease with an increase in cellulose content in the diet (Saelan and Sulasmi, 2021).

Based on the research findings and analysis of variance regarding the use of a mixture of fish meal oil sludge and cassava dregs as a substitute for commercial feed, significant effects (P<0.05) were observed on organic matter digestibility and nitrogen digestibility in broiler chickens. The detailed results can be found in Table 3.

Organic Matter Digestibility

Based on the analysis of least significant difference, it was found that the organic matter digestibility of broiler chickens in each treatment, where commercial feed was replaced with a mixture of fish meal oil sludge and cassava dregs in the diet, showed significant differences (P<0.05). The variations in organic matter digestibility in treatments using the replacement of commercial feed with a mixture of fish meal oil sludge and cassava dregs can be attributed to the different nutritional content, especially the organic components, of each treatment's diet. These differences in organic components are a result of the varying quality of the feed ingredients in each treatment's diet.

Providing a mixture of fish meal oil sludge and cassava dregs, a significant amount of easily digestible carbohydrates (NFE) is supplied due to the presence of cassava dregs in the diet. Additionally, the mixture provides different qualities of protein in the diet, allowing for variations in the quantity and balance of essential, semi-essential, and non-essential amino acids in the diet (Suthama dan Wibawa, 2018). Moreover, cassava dregs content in the mixture introduces varying levels of crude fiber in each treatment's diet, leading to differences in the digestibility of each diet (Broch *et al.*, 2017). Higher crude fiber content can reduce the digestibility of carbohydrates, protein, fats, and vitamins (Zaksena *et al.*, 2022).

Table 3: Mean values of organic matter digestibility, and nitrogen digestibility.

Parameter	Treatment						
	R0	R1	R2	R3	R4	R5	R6
Organic Matter Digestibility (%)	82.83±0.71[b]	83.35±0.75[bc]	84.45±0.52[e]	84.02±0.57[d]	83.60±0.45[cd]	83.02±1.01[abc]	82.71±1.26[a]
Nitrogen Digestibility (%)	59.63±0.91[b]	63.87±0.93[c]	66.33±0.79[e]	64.95±0.88[d]	63.94±0.74[c]	61.33±0.88[b]	58.16±0.92[a]

a, b, c Different superscripts in the same row indicate significant differences (P<0.05).

Nitrogen Digestibility

The analysis of nitrogen digestibility in broiler chickens fed diets containing a mixture of fish meal oil sludge and cassava dregs reveals significant differences in digestibility across treatments, primarily attributed to variations in protein quality. This difference in protein quality may be influenced by the quantity and balance of essential, semi-essential, and non-essential amino acids in each diet which ultimately affects their absorption rates. Research indicates that proteins of differing quality yield amino acids with varying absorption efficiencies, which can be critical in animal nutrition (Schaafsma, 2005).

Factors affecting the absorption of amino acids include (1) the physical properties of feed ingredients that hinder digestion, (2) the physicochemical properties of the proteins, and (3) the chemical interactions between amino acids and carbohydrates present in the diet (Adedokun *et al*., 2011). The differences in nitrogen digestibility are also caused by the varying fiber content in the experimental diets, which could lead to differences in digestibility among the treatments. The higher the fiber content, the lower the digestibility of carbohydrates, proteins, fats, and vitamins (Gilani *et al*., 2005).

CONCLUSIONS AND RECOMMENDATIONS

Based on the research results, replacing commercial feed with a mixture of fish meal oil sludge and cassava dregs at a 10% level provides optimal results in terms of weight gain, feed conversion ratio, nitrogen digestibility, carcass percentage, and abdominal fat. It is recommended to use this mixture at a 10% inclusion rate as a substitute for commercial feed to improve broiler performance. Further research is encouraged to investigate the effect of this alternative feed mixture on other poultry species.

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NOVELTY STATEMENTS

The findings highlight a practical application of circular economy principles in poultry farming by transforming industrial waste into nutritionally valuable feed ingredients, contributing to both environmental sustainability and reduced reliance on imported feed sources.

AUTHOR'S CONTRIBUTIONS

Badat Muwakhid and Usman Ali, conceptualization, collecting data, interpreting data, supervision, and drafting the original manuscript; Rifa'i and Primasatya Nugraha, drafting the original manuscript, analyzed and interpreted the data.

Conflict of Interest

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

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