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Evaluation of Fermented Islamic Boarding School Food Waste using *Rhizopus Oligosporus* as a Superior Local Feed on the Performance of Broiler Chickens

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ABSTRACT

This study aimed to evaluate the use of fermented Islamic boarding school food waste with *Rhizopus oligosporus* as feed on the performance of broiler chickens. The study used 200 day-old chicks (DOC) of the Arbor Acres (AA) CP-707 broiler strain produced by PT Charoen Pokphand TBK Indonesia, which were reared for 7 weeks. The research employed an experimental method using a Completely Randomized Design (CRD) consisting of 5 treatments and 4 replications. The treatment variations were the inclusion levels of Rhizopus oligosporus-fermented Islamic boarding school food waste in broiler feed: A (0% FIBSFW), B (10% FIBSFW), C (20% FIBSFW), D (30% FIBSFW), and E (40% FIBSFW). The observed variables included feed intake (g/bird), final body weight (g/bird), and feed conversion ratio (FCR). The results showed that the inclusion of fermented Islamic boarding school food waste with *Rhizopus oligosporus* had a significant effect ($P<0.05$) on feed intake, final body weight, and feed conversion ratio. It was concluded that fermented Islamic boarding school food waste can be used up to 30% in the feed, reducing the use of corn without negatively affecting broiler performance.

Key words: Broiler chickens, Fermentation, Feed, Food waste, Performance, *Rhizopus oligosporus*

INTRODUCTION

The broiler poultry industry in Indonesia has experienced rapid growth in line with the increasing demand for chicken meat as an affordable source of animal protein. One of the primary challenges in broiler farming is the high cost of feed, which can account for over 70% of total production costs (Maulana et al. 2025). Dependence on conventional feed ingredients such as corn and soybean meal, which are primarily imported, leads to price fluctuations and limited availability of raw materials. Therefore, efforts to identify alternative, locally based feed sources that are economical, sustainable, and do not compete with human food needs are crucial (Febrina et al. 2022).

Islamic boarding school food waste is a potential alternative feed source that has not been optimally utilized. Boarding schools with a high number of resident students (santri) produce significant amounts of food waste daily. The nutritional composition of this waste is relatively high, containing 20.17% crude protein, 16.76% crude fat, 5.90% crude fiber and 7.44% ash (Hidayat et al. 2024). Organic waste from hotels and restaurants has also been reported to contain 3,006.75kcal/kg of metabolizable energy, 16.58% crude protein, 7.37% crude fat, and 10.86% crude fiber (Febrina et al. 2024). Given its abundant availability and nutritional value, this waste holds promise as a local feed ingredient (Rusfidra et al. 2025).

However, the direct use of food waste in broiler diets is limited due to its high moisture content, perishability, potential microbial contamination and the presence of anti-nutritional factors. Therefore, processing technologies such as fermentation are needed to improve its safety, nutritional

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quality, and shelf life. Fermentation has been shown to reduce anti-nutritional compounds and enhance the digestibility and nutrient profile of feed ingredients (Predescu et al. 2024).

Rhizopus oligosporus, a fungus commonly used in tempeh production, produces various enzymes such as protease, amylase, and lipase that help break down complex compounds in food waste, making nutrients more available for absorption (Djulardi et al. 2023). Additionally, fungal fermentation, as shown in other organic substrates like coconut endosperm and black soldier fly larvae, also enhances feed functionality and stability (Wong et al. 2021).

Based on this background, fermentation using *Rhizopus oligosporus* is a promising approach to improve the nutritional value of pesantren food waste. However, its impact on broiler performance must be evaluated. Therefore, this study aims to investigate the potential of *Rhizopus oligosporus*-fermented Islamic boarding school food waste as a functional local feed ingredient for broilers. The results are expected to contribute to the development of innovative, sustainable feed alternatives for poultry.

MATERIALS AND METHODS

Ethical Approval

This research was conducted after receiving ethical approval under the Minister of Agriculture Decree No. 306/KPTS/TN.330/4/1994, which was approved by the Animal Research Ethics Committee of Andalas University, Padang, Indonesia, required for the use of experimental animals in research and teaching.

Materials

This study utilized 200-day-old broiler chicks (DOC) of the Arbor Acres (AA) CP-707 strain, produced by PT Charoen Pokphand TBK Indonesia. The chickens were raised for 7 weeks in litter cages measuring 120 x 120 x 100cm, with a total of 20 boxes. The feed was formulated using basic ingredients such as ground corn, meat meal, soybean meal, fish meal, fine rice bran, coconut oil, and top mix, with partial substitution of energy sources using Islamic boarding school food waste fermented with *Rhizopus oligosporus*. Drinking water was provided *ad libitum* using clean, potable water. Table 1 displays the nutrient contents of feed ingredients.

The rearing cages were equipped with brooders, feeders, drinkers, a digital scale for measuring body weight and feed intake and a drying oven for moisture content analysis. Nutritional analysis of the feed ingredients was carried out at the feed nutrition and chemistry laboratory to determine the nutrient composition of the waste before and after fermentation. All treatments and animal handling were conducted in accordance with ethical research protocols and animal welfare standards.

Methods

This study employed an experimental method using a Completely Randomized Design (CRD) with 5 treatments and 4 replications. The treatment variations involved the inclusion of *Rhizopus oligosporus*-fermented Islamic boarding school food waste (FIBSFW) in broiler feed as follows:

A: 0% FIBSFW, B: 10% FIBSFW, C: 20% FIBSFW, D: 30% FIBSFW and E: 40% FIBSFW

Fermentation Process of Islamic Boarding School Rice Waste using *Rhizopus Oligosporus*

The fermentation of Islamic boarding school rice waste with *Rhizopus oligosporus* was carried out to improve the nutritional quality and safety of the material before its use as broiler feed. The process began with the collection of leftover rice waste from the boarding school kitchen. The waste was sorted to remove foreign objects such as plastic, bones, or metal and then chopped into smaller pieces to increase the surface area of the substrate.

The material was fermented under limited aerobic conditions. A fermentation starter in the form of tempeh yeast containing *Rhizopus oligosporus* spores was added at a dosage of 3–5% of the fresh weight of the substrate. The mixture was then placed in a clean container (such as a bucket or perforated plastic bag) and allowed to ferment for 72 hours at room temperature (28–32°C). Tables 2 and 3 present the composition of feed ingredients and the nutrient content (%) of the treatment feeds.

Statistical Analysis

All collected data were analyzed using analysis of variance (ANOVA). If significant differences among treatments are detected, Duncan's multiple range test ($P<0.05$) will be applied for further comparison (Steel et al. 1991).

RESULTS & DISCUSSION

Feed Intake

Table 4 illustrates the impact of incorporating fermented Islamic boarding school food waste (FIBSFW) into the diet of broiler chickens raised for 7 weeks. The feed intake of broiler chickens fed fermented Islamic boarding school food waste with *Rhizopus oligosporus* ranged from 5925.88±40.99 to 6057.00±51.27g/head.

Table 1: Nutrient content of feed ingredients

Feed Ingredients	Crude protein (%)	Crude fat (%)	Crude Fiber (%)	Calcium (%)	Phosphorus (%)	Metabolizable energy (kcal/kg)*
Ground Corn[a]	8.96	2.76	2.93	0.58	0.39	3350.00
Fish Meal[a]	55.65	4.34	2.01	3.45	2.37	2550.00
Fine Rice Bran[a]	9.50	5.09	15.00	0.69	0.26	1630.00
Soybean Meal[a]	43.33	2.39	3.25	0.83	0.53	2280.00
Coconut Oil[a]	0.00	100.00	0.00	0.00	0.00	8650.00
Top Mix[b]	0.00	0.00	0.00	5.38	1.44	0.00
FIBSFW[a]	19.38	15.06	7.68	3.84	2.67	3050.00
Meat Meal[a]	54.15	5.98	3.45	3.870	1.87	2200.00

a: Research analysis results, 2024; b: Packaging label of PT. Medion Indonesia; and c: (Scott et al.1982).

Table 2: Composition of feed ingredients (%)

Feed Ingredients	Treatment				
	A	B	C	D	E
Ground Corn	57.00	49.00	42.00	36.00	27.00
Meat Meal	10.00	10.00	10.00	10.00	10.00
Soybean Meal	19.00	17.00	14.00	10.00	9.00
Fish Meal	5.00	5.00	5.00	5.00	5.00
Fine Rice Bran	7.00	7.00	7.00	7.00	7.00
Coconut Oil	1.50	1.50	1.50	1.50	1.50
Top Mix	0.50	0.50	0.50	0.50	0.50
FIBSFW	0.00	10.00	20.00	30.00	40.00

Table 3: Nutrient content (%) of treatment feeds

Nutrient contents	Treatments				
	A	B	C	D	E
Crude protein	22.20	22.57	22.59	22.27	22.98
Crude fat	4.70	5.94	7.18	8.42	9.66
Crude fiber	3.78	4.25	4.72	5.18	5.65
Calcium	1.12	1.44	1.76	2.08	2.40
Phosphorus	0.65	0.88	1.10	1.33	1.55
Metabolizable energy (kcal/kg)	2934.05	2925.45	2927.55	2940.35	2921.05

The nutrient contents of the treatment feeds were obtained from Tables 1 and 2.

Statistical analysis showed that the inclusion of *Rhizopus oligosporus*-fermented food waste had a significant effect ($P<0.05$) on feed intake. Treatments A, B, C, and D did not differ significantly ($P>0.05$), but all differed significantly ($P<0.05$) from treatment E.

The highest feed intake was observed in treatment A (control) at 6057.00±51.27g/head, although statistically it was not different from treatments B, C, and D. This indicates that the fermented ingredient was still acceptable to the chickens in terms of taste (palatability) and did not interfere with their feeding behavior. Palatability is one of the key factors influencing feed intake (Nuraini et al. 2022). The fermentation process can improve feed palatability (Septinova et al. 2019). Flavor can be enhanced during fermentation, leading to a better taste of the feed (Trisna et al. 2019). The fermentation process can increase glutamic acid, which plays a role in enhancing flavor (Maslami et al. 2018).

The results of the study show that broiler chickens continued to consume feed in relatively the same amount, even though a portion of the commercial feed was replaced by Islamic boarding school food waste that had undergone fermentation with *Rhizopus oligosporus*. Fermented feed can replace commercial feed (Septinova et al. 2019) and with fermentation technology, a larger quantity of fermented feed can be provided to poultry (Mirnawati et al. 2021). In this study, the fermentation of food waste with *Rhizopus oligosporus* successfully maintained broiler feed intake at a 30% substitution level, thus preventing a reduction in feed consumption.

The decrease in feed intake observed in treatment E, with a value of 5925.88±40.99g/head, indicates that the broiler chickens began to reject the feed, likely due to changes in physical or organoleptic characteristics such as a strong odor, altered texture, or unfamiliar taste. Changes in organoleptic characteristics of the feed, particularly in terms of aroma, taste, and color, were noted. At high substitution levels, the fermentation process with *Rhizopus oligosporus* tends to produce a sharper or more pungent aroma, such as a strong acidic smell. The taste of the feed also became more sour or bitter due to the metabolites produced by the microbes during fermentation. The darker or uneven color of the feed could also have a visual effect that is less appealing to the chickens, which are naturally sensitive to visual changes in their feed (Kusumorini et al. 2021).

Final Body Weight

The final body weight of broiler chickens fed with *Rhizopus oligosporus*-fermented Islamic boarding school food waste ranged from 2867.06±2830 to 3069.88±45.11g/head. Statistical analysis indicated that the inclusion of *Rhizopus oligosporus*-fermented food waste had a significant effect ($P<0.05$) on final body weight. The final body weight of treatments A, B, C and D did not differ significantly ($P>0.05$), but differed significantly ($P<0.05$) from treatment E.

The highest body weight was observed in treatment A (control) at 3069.88±45.11 g/head, although statistically, it was not different from treatments B, C, and D. This condition shows that substituting part of the commercial feed with fermented food waste up to certain levels (treatments B, C, and D) still supports optimal broiler growth, comparable to the control group that used 100% commercial feed. The fermentation of food waste with *Rhizopus oligosporus* has enhanced the nutritional value of the feed by breaking down complex compounds into more digestible forms, increasing the soluble protein content, and reducing anti-nutritional factors, especially phytic acid and tannins. Tannins are anti-nutritional compounds that can bind to proteins and inhibit digestive enzymes (Setiarto et al. 2016). Phytic acid is a form of phosphorus storage in plants that is not efficiently digestible by poultry (Toor et al. 2021).

Fermentation of feed with *Rhizopus oligosporus* has the advantage of improving nutritional value by lowering anti-nutritional factors, especially phytic acid and tannins (Toor et al. 2021). The fermentation process increases nutritional content due to the breakdown of complex compounds into simpler forms (Maulana et al. 2021; Ciptaan et al. 2022; Maulana 2023). The degradation of complex compounds into simpler forms during fermentation occurs due to enzymes produced by microorganisms present in the

Table 4: Feed intake (g/head), final body weight (g/head), and feed conversion ratio of broiler chickens

Treatments	Feed intake (g/head)	Final body weight (g/head)	Feed conversion ratio
0% FIBSFW	6057.00±51.27^{a}	3069.88±45.11^{a}	1.97±0.02^{b}
10% FIBSFW	6019.06±70.22^{a}	3033.56±92.37^{a}	1.99±0.05^{b}
20% FIBSFW	6011.19±80.75^{a}	3013.25±74.78^{a}	2.00±0.05^{b}
30% FIBSFW	5950.94±37.71^{a}	2964.75±51.53^{a}	2.01±0.04^{b}
40% FIBSFW	5925.88±40.99^{b}	2867.06±2830^{b}	2.07±0.01^{a}
SE	29.31	31.32	0.02
P-value	*	*	*

FIBSFW=Fermented Islamic boarding school food waste; Values (mean+SE) bearing different alphabets in a column differ significantly ($P<0.05$).

fermentation substrate (Trisna et al. 2019). *Rhizopus oligosporus* can produce enzymes such as amylase, protease, lipase, phytase, tannase, cellulase, and hemicellulase. *Rhizopus oligosporus* can reduce anti-nutritional factors, especially tannins and phytic acid, through the action of tannase and phytase enzymes produced during fermentation (Toor et al. 2021).

The reduction in final body weight of broiler chickens occurred at the highest substitution level, which was 40% (treatment E). This is likely related to the decrease in feed intake in treatment E. The decline in feed palatability due to changes in organoleptic characteristics (such as aroma, taste, and color) may lead to suboptimal nutrient intake. Feed palatability is influenced by organoleptic properties such as aroma, taste, and color, which directly impact feed intake and body weight gain in poultry (Jang et al. 2019). Excessive substitution of conventional feed ingredients with fermented organic waste can negatively impact broiler performance (Allaily et al., 2024). This is due to the accumulation of excess organic acid fermentation metabolites.

Feed Conversion Ratio

The feed conversion ratio (FCR) of broiler chickens fed with *Rhizopus oligosporus*-fermented Islamic boarding school food waste ranged from 1.97±0.02 to 2.07±0.01. Statistical analysis indicated that the inclusion of *Rhizopus oligosporus*-fermented food waste had a significant effect ($P<0.05$) on feed conversion ratio. The FCR of treatments A, B, C, and D did not differ significantly ($P>0.05$), but it differed significantly ($P<0.05$) from treatment E.

The best feed conversion ratio in this study was observed in treatment A (control), which was 1.97±0.02, although statistically, it was not different from treatments B, C, and D. This indicates that the use of *Rhizopus oligosporus*-fermented food waste as a substitute in the feed up to 30% can still efficiently support broiler growth, similar to broilers fed 100% commercial feed. Feed conversion efficiency depends on the balance of nutrients in the diet, particularly protein content, energy, and digestibility of feed ingredients (Adrizal et al. 2021). Fermentation of feed ingredients with *Rhizopus oligosporus* can reduce crude fiber content, thus improving digestibility and feed conversion efficiency in poultry (Ndego et al. 2023).

The feed conversion ratio for treatment E was 2.07±0.01, indicating lower efficiency. The increase in the feed conversion ratio is most likely due to reduced feed intake caused by changes in the sensory characteristics of the feed (such as aroma, taste, and color), as well as a possible imbalance in nutrients due to the high proportion of fermented ingredients. Excessive use of fermented products can cause an imbalance in the composition of the diet and decrease palatability, which ultimately negatively affects feed conversion ratio (Allaily et al. 2024). Sensory characteristics of feed, such as aroma, color and taste, greatly influence palatability (Kusumorini et al. 2021).

Conclusion

From this study, it is concluded that the use of *Rhizopus oligosporus*-fermented Islamic boarding school food waste can be incorporated up to 30% in the feed, reducing the use of corn without negatively affecting performance. Under these conditions, the broiler performance achieved was feed intake of 5950.94±37.71g/head, final body weight of 2964.75±51.53g/head, and feed conversion ratio of 2.01±0.04.

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Conflict of Interest: The authors declare that they have no competing interests.

Data Availability: The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics Statement: All authors confirm adherence to ethical standards, including those concerning plagiarism, consent for publication, research misconduct, data fabrication, duplicate publication, and redundancy.

Author's Contribution: Rusfidra was responsible for the conceptualization, methodology, data analysis, and the original draft writing of the manuscript. Fajri Maulana supervised the project, reviewed and edited the manuscript, and handled project administration. Satri Yusasra Agasi contributed to data collection and formal analysis, while Fadhli Fajri was involved in data collection and investigation. Heppy Setya Prima assisted with visualization and provided resources for the study. Malikil Kudus Susalam was responsible for validation.

Generative AI Statement: The authors declare that no Gen AI/DeepSeek was used in the writing/creation of this manuscript.

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