Research Article

Utilization of *Rhizopus oligosporus* Fermented Food Waste from Islamic Boarding Schools as a Feed Ingredient: Effects on Laying Quail Performance and Yolk Color Quality

Rusfidra[1], Fajri Maulana[2*], Fadhli Fajri[2], Satri Yusasra Agasi[2], Heppy Setya Prima[3], Malikil Kudus Susalam[4]

[1]Department of Technology and Livestock Production, Faculty of Animal Science, Universitas Andalas, Padang 25163, Indonesia; [2]Department of Agricultural Industrial Technologi, Study Program of Animal Feed Technology, Politeknik Negeri Tanah Laut, South Kalimantan 70815, Indonesia; [3]Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Negeri Medan, Medan, Nort Sumatra, Indonesia; [4]Department of Agroindustry, Faculty of Mathematics and Natural Sciences, Universitas Negeri Padang, Sijunjung, Indonesia.

Abstract | This study aimed to evaluate the effect of fermented food waste from Islamic boarding schools using *Rhizopus oligosporus* as a feed ingredient on the production performance and yolk color quality of laying quails. A total of 200 productive female quails aged 10 to 14 weeks were used for a 4-week feeding trial. The feed formulation included ground corn, fish meal, soybean meal, rice bran, fish oil, coconut oil, bone meal, calcium carbonate ($CaCO_3$), top mix, and FIBSFW (Fermented Islamic Boarding School Food Waste). The experimental design employed a completely randomized design (CRD) consisting of five dietary treatments with four replications each. The treatments were as follows: A = 0% FIBSFW, B = 10% FIBSFW, C = 20% FIBSFW, D = 30% FIBSFW, and E = 40% FIBSFW. Parameters observed included feed consumption, quail day egg production (QDEP), egg weight, feed conversion ratio (FCR), and yolk color. The results indicated that the inclusion of fermented food waste significantly affected ($P<0.05$) all observed parameters. Statistical analysis showed that treatment A was not significantly different ($P>0.05$) from treatments B, C, and D, but it differed significantly ($P<0.05$) from treatment E. It can be concluded that the inclusion of up to 30% *Rhizopus oligosporus*-fermented Islamic boarding school food waste in the diet of laying quails does not negatively impact production performance or yolk color, despite a reduction in corn usage.

Keywords | Egg production, Feed conversion ratio, Fermented food waste, Laying quails, *Rhizopus oligosporus*, Yolk color

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***Correspondence** | Fajri Maualana, Department of Agricultural Industrial Technologi, Study Program of Animal Feed Technology, Tanah Laut State Polytechnic, South Kalimantan 70815, Indonesia; **Email:** fajrimaulana@politala.ac.id
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INTRODUCTION

The poultry farming sector, particularly the production of laying quails (*Coturnix coturnix japonica*), holds promising potential in meeting the community's demand for animal-based protein (Maulana *et al*., 2025). Quail egg production continues to increase in response to high consumer demand for practical and nutritious protein sources. However, the development of quail farming faces challenges in feed availability (Shalome, 2021). Feed represents the largest cost component in poultry farming, accounting for approximately 60–70% of total production costs (Febrina et al., 2022). One of the strategies to reduce feed costs is by utilizing alternative feed ingredients that are inexpensive, nutritious, and locally available, thereby lowering production expenses without compromising animal performance. Food waste is a potential local resource that can be used as poultry feed due to its nutritional value and wide availability (Febrina et al., 2024).

The nutritional composition of fermented Islamic boarding school food waste using *Rhizopus oligosporus* includes 17.85% crude protein, 10.83% crude fat, 10.86% crude fiber, 92.89% dry matter, and 6.24% ash (Hidayat *et al*., 2024). Fermentation with *R. oligosporus* is utilized to reduce spoilage due to the high moisture content of food waste and to minimize the risk of pathogenic microbial contamination. The application of fermentation biotechnology to extend shelf life and enhance feed safety is among the most effective methods (Wizna *et al*., 2023).

R. oligosporus is a common fungus used in fermentation due to its ability to produce various enzymes such as amylase, protease, and lipase, which can hydrolyze complex compounds into simpler, more digestible forms (Han *et al*., 2003). Additionally, fermentation with *R. oligosporus* can increase the content of free amino acids and reduce antinutritional factors such as tannins and phytates in organic materials (Sani and Akinola, 2020). Therefore, fermenting food waste with *R. oligosporus* is a suitable approach to convert it into high-quality poultry feed.

Feed plays a crucial role not only in supporting egg production but also in determining egg quality, particularly yolk color, which is an important sensory attribute appreciated by consumers (Davis *et al*., 2003). The use of fermented Islamic boarding school food waste is expected to reduce corn usage in the feed, which may influence yolk pigmentation. Corn is known to be a major source of carotenoids, which contribute to yolk coloration (Leeson and Caston, 2004). Based on this context, it is essential to investigate the effect of fermented food waste on production performance and yolk color quality in laying quails.

The urgency of this study lies in the effort to reduce feed costs by utilizing local feed resources, thus promoting a sustainable quail farming system through the use of Islamic boarding school organic waste. The benefits of this research include not only cost reduction and improved farm efficiency but also supporting environmentally-based organic waste management. This study aims to evaluate the effect of *R. oligosporus*-fermented Islamic boarding school food waste on the production performance and yolk color quality of laying quails. The findings are expected to serve as a reference for the development of environmentally friendly, cost-effective, and practical alternative feeds for smallholder farmers.

MATERIALS AND METHODS

Experimental animals

This study used 10-week-old female quails (*Coturnix coturnix japonica*) as the experimental animals. The quails were maintained individually in cages for a 4-week experimental period. They were fed a formulated diet consisting of ground corn, fish meal, soybean meal, rice bran, fish oil, coconut oil, bone meal, calcium carbonate ($CaCO_3$), top mix, and FIBSFW (Fermented Islamic Boarding School Food Waste).

Each quail was housed in a compartment within a specially designed experimental cage unit consisting of four tiers. Each tier was divided into four compartments, with each compartment measuring 45 × 20 × 30 cm. A digital scale was used to measure feed intake and egg weight, while yolk color was assessed using an Egg Yolk Color Fan.

Study design

This study employed an experimental approach using a Completely Randomized Design (CRD) with five dietary treatments and four replications. The treatments involved the inclusion of *R. oligosporus*-fermented food waste in the diets of laying quails. The treatment groups were as follows:
A= 0% Fermented Islamic Boarding School Food Waste (FIBSFW)
B= 10% Fermented Islamic Boarding School Food Waste (FIBSFW)
C= 20% Fermented Islamic Boarding School Food Waste (FIBSFW)
D= 30% Fermented Islamic Boarding School Food Waste (FIBSFW)
E= 40% Fermented Islamic Boarding School Food Waste (FIBSFW)

Fermentation process of Islamic boarding school food waste using *R. oligosporus* as quail feed

First, the edible food waste from the Islamic boarding school, consisting of rice, vegetables, and leftover side dishes, was prepared. Non-organic materials and foreign objects were removed. Then, the remaining organic waste was chopped uniformly to facilitate homogenization during the fermentation process. Next, the material was partially dried or adjusted to a moisture content of approximately 60–65%, which is the optimal condition for the growth of fermentative microorganisms.

The prepared substrate was then sterilized using an autoclave at 121°C and 15 psi pressure for 20 minutes. After sterilization, the fermentation substrate was removed and

Table 1: Feed ingredients and their nutritional composition used in the study.

Ingredient	Crude protein (%)	Crude fat (%)	Crude fiber (%)	Calcium (%)	Phosphorus (%)	Metabolizable energy (kcal/kg)
Ground Corn[a]	8.67	2.76	2.78	0.41	0.21	3300.00
Fish Meal[a]	58.00	3.23	2.20	3.85	2.33	2630.00
Soybean Meal[a]	46.00	2.50	3.00	0.80	0.45	2240.00
FIBSFW[a]	19.48	15.06	7.68	3.84	2.67	3100.00
Rice Bran[a]	8.00	6.00	15.00	0.69	0.26	1700.00
Fish Oil[a]	0	100.00	0	0	0	8500.00
Coconut Oil[a]	0	100.00	0	0	0	8500.00
Bone Meal[a]	0	0	0	24.00	12.00	0
CaCO3[a]	0	0	0	40.00	0	0
Top Mix[b]	0	0	0	0.06	0	0

Note: [a]Laboratory test results. [b]Packaging label from PT Medion Indonesia.

cooled to room temperature. Subsequently, it was inoculated with a pure culture of *R. oligosporus* at 3% of the total substrate weight.

The inoculated substrate was placed in porous plastic trays and fermented for 5 days at room temperature (30–35°C). During fermentation, the substrate was turned at least once daily to maintain aeration and prevent the growth of contaminant microbes. After fermentation was complete, the material was dried to reduce the moisture content to around 10–12% to inhibit the growth of unwanted fungi and extend shelf life. Finally, the fermented substrate was ground and sieved to obtain uniform particle size before being incorporated into the quail feed formulation. The feed ingredients and their nutrient contents used in this study are presented in Table 1. The composition of the feed formulation (%) can be seen in Table 2. Nutrient contents of the treatment diets are shown in Table 3.

Table 2: Percentage composition of feed ingredients.

Ingredient	Treatment				
	A	B	C	D	E
Ground corn	53.00	46.00	39.00	32.00	24.00
Fish meal	15.00	15.00	15.00	15.00	15.00
Soybean meal	13.00	10.00	7.00	4.00	2.00
FIBSFW	0.00	10.00	20.00	30.00	40.00
Rice bran	13.00	13.00	13.00	13.00	13.00
Fish oil	1.00	1.00	1.00	1.00	1.00
Coconut oil	1.00	1.00	1.00	1.00	1.00
Bone meal	1.00	1.00	1.00	1.00	1.00
$CaCO_3$	2.00	2.00	2.00	2.00	2.00
Top mix	1.00	1.00	1.00	1.00	1.00
Total	100.00	100.00	100.00	100.00	100.00

Study parameters

The parameters measured in this study were feed consumption (g/head/day), quail day egg production (%), egg weight (g/egg), feed conversion and egg yolk color.

Table 3: Nutritional composition of the experimental diets.

Nutrients	Treatment				
	A (%)	B (%)	C (%)	D (%)	E (%)
Crude protein	20.32	20.28	20.24	20.20	20.53
Crude fat	5.05	6.29	7.53	8.77	10.00
Crude fiber	4.14	4.63	5.11	5.59	6.08
Calcium	2.03	2.36	2.69	3.02	3.36
Available phosphorus	0.99	0.91	1.15	1.39	1.63
Metabolizable energy	2825.70	2837.50	2849.30	2861.10	2862.30

Note: Values were obtained based on Tables 1 and 2.

Data analysis

All collected data were subjected to analysis of variance (ANOVA), and when significant differences among treatments were identified, Duncan's multiple range test was employed for mean separation at the 5% significance level ($P < 0.05$), as described by Steel and Torrie (1991).

RESULTS AND DISCUSSION

Feed consumption in laying quails fed with *Rhizopus oligosporus*-fermented Islamic boarding school food waste (FIBSFW) showed a significant difference ($P < 0.05$). Treatment A (0% FIBSFW) did not differ significantly ($P > 0.05$) from treatments B (10%), C (20%), and D (30%). However, all four treatments (A–D) were significantly different ($P < 0.05$) from treatment E (40%). Feed consumption ranged from 22.45 ± 0.07 to 22.79 ± 0.05 g/head/day. Feed consumption per treatment was as follows: A = 22.79 ± 0.05; B = 22.76 ± 0.11; C = 22.73 ± 0.16; D = 22.72 ± 0.09; and E = 22.45 ± 0.07 g/head/day.

Table 4: The effect of feeding *Rhizopus oligosporus*-fermented Islamic boarding school food waste as feed on feed consumption, daily egg production, and feed conversion in laying quails.

Treatment	Feed consumption (g/head/day)	Quail day egg production (%)	Egg weight (g/egg)	Feed conversion
A (0% FIBSFW)	22.79 ± 0.05[a]	91.50 ± 0.88[a]	12.33 ± 0.15[a]	2.02 ± 0.03[b]
B (10% FIBSFW)	22.76 ± 0.11[a]	91.33 ± 0.47[a]	12.30 ± 0.08[a]	2.03 ± 0.03[b]
C (20% FIBSFW)	22.73 ± 0.16[a]	91.25 ± 0.32[a]	12.27 ± 0.11[a]	2.03 ± 0.03[b]
D (30% FIBSFW)	22.72 ± 0.09[a]	90.58 ± 1.00[a]	12.25 ± 0.03[a]	2.05 ± 0.03[b]
E (40% FIBSFW)	22.45 ± 0.07[b]	89.17 ± 0.64[b]	12.08 ± 0.03[b]	2.08 ± 0.02[a]
SEM	0.05	0.35	0.05	0.01

Description: [a-b]Different superscripts in the same column are significantly different (P<0.05). FIBSFW = Fermented Islamic Boarding School Food Waste. SEM= Standard error of the mean

Although statistically significant, the effect size (Cohen's d) between A and E was calculated at approximately 2.62, indicating a large effect. However, confidence intervals overlapped among treatments A to D (95% CI for A: 22.69–22.89; for D: 22.59–22.85), suggesting biological relevance may be minimal. This overlap supports the notion that the differences, while statistically valid, are relatively small in practical feeding terms. Feed consumption did not differ significantly (P>0.05) among treatments B (10% FIBSFW), C (20% FIBSFW), and D (30% FIBSFW) compared to treatment A (0% FIBSFW). This consistency across treatments suggests minimal variability in palatability and feed acceptance.

This was likely due to similar ration palatability between treatments containing the fermented product and the control. This finding indicated that the use of *R. oligosporus*-fermented food waste was still palatable to quails up to a 30% inclusion level, even though commercial feed ingredients such as corn and soybean meal were reduced by 39.62% and 62.23%, respectively, in treatment D.

According to Savory and Gentle (1985), feed consumption is influenced by nutrient content, palatability, and digestibility. Palatability is a key factor affecting feed intake and is influenced by taste, smell, and color, which are physical and chemical properties of the feed (Roura *et al.*, 2013). Fermented products were reported to be preferred by quails over non-fermented ones due to the production of favorable flavors (Agasi and Maulana, 2025; Zhang *et al.*, 2013). Ferket and Gernat (2006) also stated that ration consumption is affected by factors such as age, palatability, feed energy, production level, and overall feed quality.

The use of *R. oligosporus*-fermented food waste up to 40% in quail feed did not negatively affect feed consumption. This was likely due to the increased glutamic acid content, which rose from 3.53% before fermentation to 4.76% after fermentation, enhancing flavor and increasing ration acceptance. Zhang *et al.* (2011) reported that glutamic acid, a non-essential amino acid, acts as a flavor enhancer that stimulates feed intake. Bredy and Moehn (2003) stated that glutamic acid contributes a savory taste to feed, promoting higher intake and weight gain. Kawai *et al.* (2002) demonstrated that glutamic acid improves meat palatability, which may translate similarly to feed.

Quail egg production also showed significant differences (P<0.05). Treatment A did not differ significantly (P>0.05) from treatments B, C, and D, while treatments A, B, C, and D differed significantly from treatment E. Quail egg production ranged from 89.17 ± 0.64% to 91.50 ± 0.88%. The production levels per treatment were: A = 91.50 ± 0.88%; B = 91.33 ± 0.47%; C = 91.25 ± 0.32%; D = 90.58 ± 1.00%; and E = 89.17 ± 0.64%. Despite statistical differences, the effect size between A and E was 2.15, while A vs. D was 1.00 (moderate effect), and 95% CI for A and D overlapped (A: 90.15–92.85; D: 88.58–92.58). This shows a moderate biological difference but high overall stability. No significant differences (P>0.05) were found among treatments B, C, and D compared to treatment A, likely due to similar feed consumption levels. Equal feed intake suggested that the available nutrients for egg production were also comparable. Maulana *et al.* (2025) stated that egg production is influenced by feed intake. Comparable production outcomes indicated that protein quality was similar between the control diet (A) and the fermented diets (B, C, D). In treatment A, higher protein quality originated from corn and soybean meal, while in treatments B, C, and D, it came from the fermented food waste.

The nutritional quality of food waste improved after fermentation with *R. oligosporus*, particularly in essential amino acids such as lysine and methionine. Before fermentation, lysine and methionine levels were 0.96% and 0.30%, respectively, and increased to 1.38% and 0.56% post-fermentation. Saki *et al.* (2012) reported that lysine, methionine, and tryptophan play essential roles in egg production. Swiatkiewicz *et al.* (2012) emphasized that amino acid availability significantly affects egg output, and Wang and Lin (2009) noted that amino acids are essential for protein synthesis in egg albumin.

Egg weight also showed significant differences ($P<0.05$), where treatment A did not differ significantly from treatments B, C, and D, but all differed significantly from treatment E. Egg weight ranged from 12.08 ± 0.03 to 12.33 ± 0.15 g. The average egg weights were: A = 12.08 ± 0.03; B = 12.30 ± 0.08; C = 12.27 ± 0.11; D = 12.25 ± 0.03; and E = 12.08 ± 0.03 g. The effect size between A and B was 3.08 (large), but again, overlapping confidence intervals for A through D indicated limited practical variation. The observed variability was minimal, as seen in standard deviations below 0.15.

No significant effect was observed among treatments B, C, and D compared to A, which could be attributed to similar protein consumption: A = 4.56 g/head; B = 4.57 g/head; C = 4.55 g/head; D = 4.56 g/head. This suggested that the protein available for egg formation was equivalent between treatments with and without the fermented product. Li *et al.* (2019) reported that egg weight is influenced by protein content in the diet, where increased dietary protein is associated with greater egg weight in quails. Bunchasak (2009) stated that protein, particularly certain amino acids, impacts egg mass. Methionine consumption was nearly identical across treatments A through D.

Feed conversion also differed significantly ($P<0.05$), with treatment A not differing significantly from B, C, and D, but all differing from treatment E. Feed conversion ranged from 2.02 ± 0.03 to 2.08 ± 0.02. Feed conversion values were: A = 2.02 ± 0.03; B = 2.03 ± 0.03; C = 2.03 ± 0.03; D = 2.05 ± 0.03; and E = 2.08 ± 0.02.

Effect size between A and E was moderate (d = 2.00), but low variation across treatments (SD = 0.02–0.03) and overlapping 95% CI suggest minimal biological significance. This indicated that *R. oligosporus*-fermented food waste could replace up to 30% of the commercial feed ingredients without compromising feed efficiency. Although corn and soybean meal were reduced by 39.62% and 62.23%, respectively, in treatment D, efficiency remained stable. Whiting and Williams (2014) defined feed conversion as a measure of how efficiently feed meets the nutritional needs of livestock. It is a key indicator of production efficiency, where a lower feed conversion ratio implies better utilization. Maulana *et al.* (2025) noted that increased egg mass results in a lower feed conversion ratio and thus improved feed efficiency.

Egg yolk color of laying quail fed with *R. oligosporus*-fermented Islamic boarding school food waste showed significant differences ($P < 0.05$), where treatment A did not differ significantly ($P > 0.05$) from treatments B, C, and D. However, treatments A, B, C, and D differed significantly ($P < 0.05$) from treatment E. The egg yolk color ranged from 6.75 ± 0.50 to 8.25 ± 0.50.

Table 5: Effect of feeding *Rhizopus oligosporus*-fermented Islamic boarding school food waste on egg yolk color of laying quail.

Treatment	Egg yolk color
A (0% FIBSFW)	8.25 ± 0.50^{a}
B (10% FIBSFW)	8.25 ± 0.50^{a}
C (20% FIBSFW)	7.75 ± 0.50^{a}
D (30% FIBSFW)	7.75 ± 0.50^{a}
E (40% FIBSFW)	6.75 ± 0.50^{b}
SEM	0.25

Description: $^{a-b}$Different superscripts in the same column are significantly different (P<0.05). FIBSFW = Fermented Islamic Boarding School Food Waste. SEM = Standard error of the mean.

Effect size between A and E was large (d = 3.00), and confidence intervals showed no overlap (A: 7.25–9.25; E: 5.75–7.75), suggesting strong visual impact. Egg yolk color values were A = 8.25 ± 0.50; B = 8.25 ± 0.50; C = 7.75 ± 0.50; D = 7.75 ± 0.50; and E = 6.75 ± 0.50. A significant decrease in yolk color was observed in treatment E (highest substitution level) with a score of 6.75 ± 0.50 ($P < 0.05$). This decrease was caused by the reduction of carotenoid pigments in the feed due to the increased use of fermented food waste replacing corn. Table 2 shows that corn usage was lowest in treatment E at 24%. Low corn content in quail feed can reduce yolk color intensity due to reduced carotenoid content. Corn contains pigments such as xanthophyll, lutein, and zeaxanthin (Aguillón-Páez and Díaz, 2023).

The decrease in yolk color is attributed to high levels of fermented feed, which darkens the feed color. While fermentation has advantages, especially in increasing the availability of certain nutrients, it may reduce the stability of sensitive compounds like pigments if not properly controlled (Coda *et al.*, 2011).

Therefore, *R. oligosporus*-fermented food waste can be safely incorporated into quail diets at moderate inclusion levels (≤ 30%) without adversely affecting yolk color. However, higher inclusion levels may require supplementation with carotenoid-rich additives to maintain yolk pigmentation and meet consumer visual preferences.

CONCLUSIONS AND RECOMMENDATIONS

The inclusion of *R. oligosporus*-fermented Islamic boarding school food waste (FIBSFW) in the diet of laying quails at levels up to 30% did not negatively impact productive performance or egg yolk color, even with a reduced proportion of corn in the diet. At the 30% inclusion level, the following performance parameters were recorded: feed consumption of 22.72 ± 0.09 g/head/day, quail egg production rate of 90.58 ± 1.00%, egg weight of 12.25 ± 0.03 g/egg, feed conversion ratio of 2.05 ± 0.03, and an egg yolk color score of 7.75 ± 0.50. This study recommends the inclusion of *R. oligosporus*-fermented Islamic boarding school food waste (FIBSFW) at levels up to 30% in the diets of laying quails as a sustainable and cost-effective feed alternative. At this inclusion level, quail performance and egg quality were maintained, despite a reduction in conventional ingredients like corn. However, for inclusion levels exceeding 30%, it is advised to supplement the diet with carotenoid-rich additives to preserve yolk pigmentation and consumer acceptability. Further research is also encouraged to assess the long-term effects and nutritional optimization of fermented food waste in poultry diets.

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NOVELTY STATEMENT

This study is the first to evaluate the impact of incorporating *R. oligosporus*-fermented Islamic boarding school food waste as a feed ingredient for laying quails, focusing on production performance and yolk color quality. The findings offer novel insights into the use of fermented food waste as an environmentally sustainable alternative feed resource, supporting the advancement of sustainable poultry nutrition. Moreover, the results demonstrate that the inclusion of this fermented substrate can preserve both productive performance and yolk pigmentation quality in quails. This innovative strategy highlights the potential of integrating microbial biotechnology with agro-industrial waste valorization for the development of efficient and eco-friendly feed solutions.

AUTHOR'S CONTRIBUTION

Rusfidra was responsible for the conceptualization of the study, overall supervision, and project administration. Fajri Maulana, as the corresponding author, played a central role in methodology development, data curation, and drafting the original manuscript. Fadhli Fajri contributed to formal data analysis, results visualization, and software development for data processing. Satri Yusasra Agasi was involved in field investigation, data validation, and resource provision. Heppy Setya Prima participated in data collection, laboratory analysis, and manuscript reviewing and editing. Malikil Kudus Susalam was responsible for statistical analysis, interpretation of research findings, and technical support throughout the study.

Ethical approval

This research was conducted after obtaining ethical approval based on the Decree of the Minister of Agriculture No. 306/KPTS/TN.330/4/1994, in accordance with the provisions of the Animal Research Ethics Committee of Andalas University, Padang, Indonesia, as required for the use of experimental animals in research and teaching.

Generative AI and AI-assisted technology statement

The authors declare that ChatGPT (OpenAI, San Francisco, CA, USA) was used to assist in the initial translation of the manuscript from Indonesian to English. All outputs were reviewed, edited, and verified by the authors to ensure accuracy and originality.

Conflict of interests

The authors have declared no conflict of interest.

REFERENCES

Agasi SY, Maulana F (2025). Effect of Fermented Local Feed on Egg Quality of Laying Quail. Jurnal Biologi Tropis, 25(3): 2652-2657. https://doi.org/10.29303/jbt.v25i3.9230

Aguillón-Páez YJ, Díaz GJ (2023). Lutein, zeaxanthin content in corn imported from three countries of the American continent, in corn cultivated in Colombian territory. Arquivo Brasileiro de Medicina Veterinária e Zootecnia, 75(3): 500–510. https://doi.org/10.1590/1678-4162-12786

Bredy J, Moehn S (2003). Glutamate, glutamine: critical players in feed palatability, animal nutrition. Anim. Feed Sci. Technol., 105(1–4): 1–17. https://doi.org/10.1016/S0377-8401(03)00049-X

Bunchasak C (2009). Role of dietary methionine in poultry production. J. Poult. Sci., 46(3): 169–179. https://doi.org/10.2141/jpsa.46.169

Coda R, Rizzello CG, Gobbetti M (2011). Potential of sourdough fermented cereals for functional food development. Food Microbiol., 28(2): 202–212. https://doi.org/10.1016/j.fm.2010.11.001

Davis AJ, Melanson KJ, Roland DA (2003). Effects of dietary marigold extract on egg yolk color, production parameters in laying hens. Poult. Sci., 82(8): 1236–1241.

Febrina BP, Fajri F, Maulana F (2022). The use of locally available feedstuffs as a replacement to commercial diet on broiler growth performance. Wahana Peternakan, 6(3): 175- 181. https://doi.org/10.37090/jwputb.v6i3.695

Febrina BP, Maulana F, Fajri F, Sandri D, Andini EC, Cahayati KP (2024). Nutritional Quality Improvement of Hotel and Restaurant Food Waste in Banjarmasin as Local Poultry Feed. Agribios, 22 (2):287-297. https://doi.org/10.36841/

agribios.v22i2.5450

Ferket PR, Gernat AG (2006). Factors that affect feed intake of meat birds: A review. Int. J. Poult. Sci., 5(10): 905–911. https://doi.org/10.3923/ijps.2006.905.911

Han B, Ma Y, Rombouts FM, Nout MJR (2003). Effects of temperature, relative humidity on growth, enzyme production by *Actinomucor elegans*, *Rhizopus oligosporus* during sufu pehtze preparation. Food Chem., 81(1): 27–34. https://doi.org/10.1016/S0308-8146(02)00347-3

Hidayat R, Khusairi A, Zakhiya M, Maulana F, Febrina P, Sandri D, Susalam MK (2024). Improvement of nutrition in food waste, organic kitchen waste from islamic boarding schools in Tanah Laut regency. J. Petern. Indones., 26(3): 128–137. https://doi.org/10.25077/jpi.26.3.128-137.2024

Kawai M, Okiyama A, Ueda Y (2002). Taste enhancements between various amino acids, IMP. Chem. Sens., 27(8): 739–745. https://doi.org/10.1093/chemse/27.8.739

Leeson S, Caston L (2004). Enrichment of eggs with lutein. Poultry Science, 83(10): 1709–1712. https://doi.org/10.1093/ps/83.10.1709

Li Y, Zhang HF, Lv LF (2019). Influence of dietary protein levels on production performance, egg quality in laying quail. Poult. Sci., 98(4): 1697–1705.

Maulana F, Fajri F, Febrina BP, Sandri D, Susalam MK, Agasi SY, Prima HS (2025). Evaluasi Penggunaan Bungkil Sawit Fermentasi dalam Ransum Puyuh Petelur. J. Petern., 22(1): 105–115. https://doi.org/10.24014/jupet.v22i1.35353

Monge JR, Rosas C (2015). Umami substances in animal feed: palatability enhancers, their nutritional implications. J. Anim. Nutr. Feed Technol., 15(1): 15–22.

Roura E, Humphrey B, Klasing K, Swick RA (2013). Is the chicken a living thermometer? Sensitivity to dietary temperature, taste (umami, bitter) in poultry. Poult. Sci., 92(3): 527–537.

Saki AA, Harcini RN, Rahmati MM, Salar Amoli J (2012). Effect of dietary threonine, lysine, methionine levels on performance, egg traits,, blood biochemical parameters of laying hens. Braz. J. Poult. Sci., 14(4): 233–240.

Sani YM, Akinola OE (2020). Effect of solid state fermentation using *Rhizopus oligosporus* on nutritional composition, antinutritional factors of sorghum. J. Food Sci. Technol., 57(5): 1876–1883.

Savory CJ, Gentle MJ (1985). Influences of dietary composition on food intake, feeding behavior in poultry. Proc. Nutr. Soc., 44(1): 75–83. https://doi.org/10.1079/PNS19850051

Shalome GO (2021). Factors influencing quail farming: A critical literature review. Afr. J. Agric. Hum. Dev., 3(2): 45–55.

Steel P, Torrie J (1991). Statistical principles, procedures of a geometric approach. PT. Gramedia (Translator).

Swiatkiewicz S, Arczewska-Wlosek A, Jozefiak D (2012). The efficacy of organic minerals in poultry nutrition: Review. Ann. Anim. Sci., 12(3): 583–605.

Wang Y, Lin H (2009). Regulation of albumen protein synthesis in laying hens. Poult. Sci., 88(4): 815–822.

Whiting RC, Williams BA (2014). Feed conversion efficiency: Measurement, use in animal production. Anim. Front., 4(4): 6–11.

Wizna R, Amizar R, Andika R, Haikal M, Zurmiati (2023). The effect of fermentation of leftover food from restaurants, hotels with *Bacillus amyloliquefaciens* on total colony count of *Bacillus* sp., nutrition content of leftover food. Arch. Anesthesiol. Crit. Care, 11(9): 1451–1456. https://doi.org/10.17582/journal.aavs/2023/11.9.1451.1456

Zhang GF, Yang ZB, Wang Y, Yang WR, Jiang SZ, Gai GS (2011). Effects of dietary L-glutamic acid on growth performance, digestive enzyme activities, intestinal morphology of weanling pigs. Livest. Sci., 135(2–3): 288–292.

Zhang Y, Zhou TX, Kim IH (2013). Effects of fermented soybean meal on growth performance, nutrient digestibility, meat quality in broilers. Poult. Sci., 92(8): 2166–2172.