P-ISSN: 2304-3075; E-ISSN: 2305-4360
International Journal of Veterinary Science
www.ijvets.com; editor@ijvets.com

Research Article https://doi.org/10.47278/journal.ijvs/2024.231

The Effect of Using a Fermented Mixture of Palm Kernel Cake and Cassava Byproduct Combined with Turmeric in Feed on Broiler Carcass Performance

Nurhayati [1]*, Chandra Utami Wirawati [2] and Dwi Desmiyeni Putri [1]

[1]Department of Animal Science, State Polytechnic of Lampung, Jl. Soekarno-Hata no.10 Bandar Lampung, Indonesia 35145
[2]Department of Agricultural Technology, State Polytechnic of Lampung, Jl. Soekarno-Hata no.10 Bandar Lampung, Indonesia 35145
***Corresponding author:** nurhayati1970@polinela.ac.id

Article History: 24-552 Received: 03-Jul-24 Revised: 01-Aug-24 Accepted: 18-Aug-24 Online First: 04-Sep-24

ABSTRACT

This study aimed to evaluate the impact of different inclusion levels of a fermented mixture of palm kernel cake (PKC) and cassava byproduct (CB), combined with turmeric in feed, on broiler carcass performance, including body weight, carcass percentage, abdominal fat percentage, meat fat content, and blood cholesterol levels. The research was designed using a Completely Randomized Design with a 4x2 factorial pattern, where the first factor was the level of fermented product usage in feed (0, 10, 20, and 30%), and the second factor was the inclusion of turmeric (without and with 2.5% turmeric of total feed). The results showed an interaction effect between the level of fermented product usage and the inclusion of turmeric on blood cholesterol levels, with the combination of 30% fermented product usage and turmeric resulting in the lowest cholesterol level (110.5mg/dL). The level of fermented product usage affected body weight, abdominal fat percentage, and blood cholesterol levels but did not affect carcass percentage or meat fat content. On the other hand, including turmeric in feed reduced blood cholesterol levels and tended to increase carcass percentage. Based on these findings, it is suggested that the dosage of turmeric be increased in the feed so that the combined effect of mixed fermentation products of PKC and CB with turmeric can significantly influence all investigated variables.

Keywords: Fermentation products, Palm kernel cake, Cassava byproduct, Turmeric, Broiler carcass

INTRODUCTION

The use of antibiotic growth promoters (AGP) in poultry feed for a long time can cause pathogenic bacteria to become resistant to antibiotics, which can harm livestock and humans. One way to replace AGP is by using natural antibiotics such as probiotics, prebiotics, and phytobiotics in poultry feed. In raising poultry without AGP, efforts are made to ensure that the livestock have high immunity, making them less susceptible to diseases. Providing quality feed (such as fermented products containing probiotics and prebiotics) and using herbal ingredients (such as turmeric containing phytobiotics) is expected to boost immunity (Arslan et al. 2017) and improve poultry performance (Nurhayati 2007).

The mixture of palm kernel cake (PKC) and cassava byproduct (CB) fermented with *Aspergillus niger* is a fermentation product with potential as a non-conventional alternative feed ingredient for poultry. Using this fermented product in broiler feed can improve feed palatability and broiler performance (Nurhayati 2007). This is because the fermentation product contains probiotics (Nurrady et al. 2018) that help maintain the health of the broiler's digestive tract. Additionally, the fermentation product also contains prebiotics (mannan oligosaccharides or MOS), which function to suppress pathogenic microorganisms in the digestive tract, aiding in their elimination through feces, thereby enhancing the balance of microorganism composition and improving profile (Nurhayati et al. 2021; Nurhayati et al. 2018).

Turmeric is an herbal plant that contains phytobiotics/active compounds called curcuminoids. Curcuminoids act as antioxidants, antivirals, anti-inflammatories, anticancer agents, radioprotectives, and neuroprotectives (Amalraj et al. 2017). Curcumin has also been shown to improve the activity of digestive enzymes in the digestive tract, thereby enhancing the digestion and absorption of feed nutrients. Additionally, curcumin has

Cite This Article as: Nurhayati, Wirawati CU and Putri DD, 2024. The effect of using a fermented mixture of palm kernel cake and cassava byproduct combined with turmeric in feed on broiler carcass performance. International Journal of Veterinary Science x(x): xxxx. https://doi.org/10.47278/journal.ijvs/2024.231

response of broilers and help prevent infections (Aderemi and Alabi 2023; Saleem et al. 2024). Using turmeric extract as a feed additive can enhance the activity of pancreatic enzymes (amylase, protease, lipase, and protein enzyme activity) (Purwanti et al. 2015; Chowdhury et al. 2021; Yang et al. 2022; Jamil et al. 2024).

Based on the beneficial characteristics and advantages of the mixed fermentation products of PKC and CB, as well as turmeric, this research aimed to combine the use of these fermented products and turmeric in broiler feed to achieve a synergistic effect that maximizes carcass performance. Therefore, this study aimed to determine the effect of the usage levels of fermentation products synergized with turmeric in feed on broiler carcass performance (body weight, carcass percentage, abdominal fat percentage, meat fat content, and blood cholesterol levels).

MATERIALS AND METHODS

Research materials and tools

This research was conducted at the Livestock Pen of the Lampung State Polytechnic. The materials used were 192 a-day-old broilers chicks, a fermented product mixture of palm kernel cake (PKC) (75%) and cassava byproduct (CB) (25%), concentrate, corn, rice bran, vegetable oil, and turmeric. The experimental feed compositions are presented in Tables 1 and 2.

Table 1: Composition of broiler experimental feed during starter and finisher periods

Feed ingredients	Treatments			
	P0	P1	P2	P3
Starter treatment feed (%)				
Concentrate feed	46	40	34	28
Corn	54	50	46	42
Fermentation product	0	10	20	30
Total	100	100	100	100
Finisher treatment feed (%)				
Concentrate feed	36	30	24	18
Corn	51.5	47.5	43.5	39.5
Rice bran	10	10	10	10
Fermentation product	0	10	20	30
Vegetable oil	2.5	2.5	2.5	2.5
Total	100	100	100	100

Note: P0, P1, P2, and P3 = successive usage levels of fermentation product at 0%, 10%, 20%, and 30% in feed.

Table 2: Nutrient content of feed during starter and finisher periods in each treatment

Period/Treatments	Nutrient contents			
	CP (%)	CF (%)	ME (kcal/kg)	EE (%)
Starter period				
P0	23.26	4.11	3229.13	3.908
P1	22.856	4.528	3212.63	3.880
P2	22.452	4.946	3196.12	3.852
P3	22.048	5.364	3179.62	3.824
Finisher period				
P0	20.185	4.2475	3223.55	4.468
P1	19.781	4.6655	3207.05	4.35
P2	19.377	5.0835	3190.55	4.322
P3	18.973	5.5015	3174.04	4.294

Note: CP = crude protein, CF = crude fiber, ME = metabolizable energy, EE = Ether extract

The equipment employed in this experiment included litter cages, feeding, and drinking devices, and digital scales with capacities of 210g (precision: 0.001g) for measuring mineral and DOC scale and 5kg (precision: 0.001g) for body weight, carcass weight, and ration scales. Additional tools comprised lighting, a thermometer, a hygrometer, cage cleaning instruments, an oven, and wooden slats and plastic nets for compartmentalizing the cages.

Research methods

Day-old chicks (DOCs) were raised in litter cages partitioned according to needs, each measuring 1x1.5m² for 24 compartments. Initially, the DOCs were weighed and randomly divided into 24 equal groups. These groups were then randomly allocated into 4x2 treatment groups with 3 replications, with each replication consisting of 8 birds.

The treatment groups included levels of fermented product usage (P0 = 0%, P1 = 10%, P2 = 20%, and P3 = 30% of total feed) and the addition of turmeric powder (T0 = 0% and T1 = 2.5% of total feed). Broilers were raised for 5 weeks with ad libitum feeding and drinking. Feed provided differed for broilers aged 0-3 weeks (starter period) and 4-5 weeks (finisher period). At the end of the fifth week, 3 broilers per experimental unit x 3 replications were slaughtered to observe carcass percentage, abdominal fat, meat fat content, and blood cholesterol. Body weight was averaged per compartment or replication. The observed variables were body weight, carcass percentage (%), abdominal fat percentage (%), meat fat content (%), and blood cholesterol level (mg/100mL).

The variables observed in this study consisted of body weight, carcass percentage, abdominal fat percentage, meat fat content and blood cholesterol levels. The research was designed using a completely randomized design factorial pattern of 4x2, with the first factor being 4 levels of fermented product usage: 0 (P0), 10 (P1), 20 (P2), and 30% (P3) of total feed, and the second factor being 2 levels of turmeric powder addition: 0 (T0) and 2.5% (T1) of total feed. Each treatment was replicated 3 times.

Data analysis

All data obtained were analyzed using variance analysis with a 4x2 factorial design and three replications. When interactions between treatments were detected, a simple effect analysis was performed on each treatment combination. If no interactions were found, the main effects of each factor were evaluated. Post hoc tests for simple or main effects were conducted using Duncan's Multiple Range Test (DMRT). Data analysis was carried out with the assistance of the R program (Dakhlan 2019; R Core Team 2023).

RESULTS AND DISCUSSION

The effect of fermentation product level and turmeric in feed, and their interaction on broiler body weight

Body weight (BW) represents the manifestation of growth achieved during the study. The average body weight in each treatment combination over the course of the study (5 weeks) is presented in Table 3 and Fig. 1.

The data in Table 3 show that the highest BW of broilers was observed in treatment combination P1T1 (1713.58g), while the lowest was in treatment combination P3T1 (1299.81g). Analysis of variance results indicated

Table 3: The effect of fermentation product level and turmeric in feed, and their interaction on body weight (g)

Tumeric	Level of fermentation product				Tumeric Average
	P0	P1	P2	P3	
T1	1565.77	1713.58	1359.67	1299.81	1484.71
T0	1631.35	1631.22	1483.32	1398.94	1536.21
Average of fermentation product	1598.58b	1672.40b	1421.50a	1349.38a	

Note: T1 = with turmeric and T0 = without turmeric; P0, P1, P2, and P3 = successive usage levels of fermentation product at 0%, 10%, 20%, and 30% in feed; Different letters within the same row indicate significant differences (P<0.05).

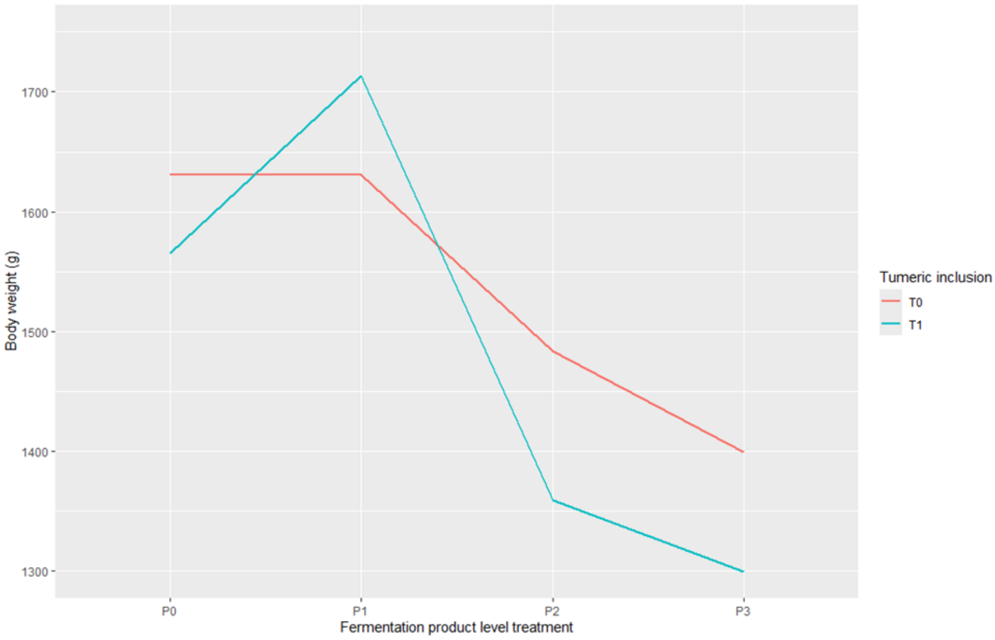

Fig. 1: Body weight of broilers fed with different level of fermentation product and with and without turmeric inclusion in feed

no interaction between fermentation product level and turmeric on broiler BW. The research also revealed that the fermentation product level in the feed significantly influenced body weight (P<0.05). Body weight in treatments P1 and P0 did not differ significantly (P>0.05), but both were higher (P<0.05) than treatments P2 and P3. Treatments P2 and P3 did not differ significantly (P>0.05).

Feeds containing fermentation products up to 10% tended to increase broiler BW, while above 10%, they tended to decrease BW. The highest increase in broiler BW was observed in treatment P1 compared to other treatments. This is attributed to the nutritional availability in treatment P1 (especially CP content and energy), which is not significantly different from treatment P0. Additionally, the feed-in treatment P1 contained fermentation products that help supply probiotics and prebiotics, which aid in improving the digestion process and nutrient absorption, ultimately maximizing broiler BW achievement. This finding is consistent with Nurrady et al. (2018), who reported that continuous administration of probiotics AKBIS Prob (a mixture of soybean pulp and PKC fermented with *Aspergillus niger*) in feed can increase the amount of *Aspergillus niger* in broiler digestive tracts over time. Lin et al. (2020) and Saleh et al. (2011) reported that probiotic supplementation with *Aspergillus niger* at 1-1.25% in feed can improve intestinal microflora and morphology, as well as growth performance. Adugna and Belete (2020) stated that the administration of probiotics, including Aspergillus niger has a potential effect on the modulation of intestinal microflora and pathogen inhibition. Meanwhile, Nurhayati et al. (2021) reported that prebiotic supplementation from extracted fermentation products of PKC and CB in feed can increase probiotic bacteria, suppress pathogenic bacteria, and improve villi and intestinal mucosa area in broilers. Barros et al. (2015) stated that MOS is beneficial in stimulating enzyme activity in the intestinal mucosa, which leads to reduced intestinal viscosity and more effective and efficient nutrient absorption. Furthermore, fermented products addition in feed can reduce oxidative stress levels, improve palatability, digestive health, immune function and livestock performance (Chang et al. 2022; Fu et al. 2023; Zhu et al. 2023; Lian et al. 2024). Additionally, Azizi et al. (2023) concluded that the addition of fermented products (fermented palm kernel cake) in broiler feed can help improve gut health and nutrient digestibility and improve the health and overall performance of broilers.

On the other hand, the decrease in BW in treatments P2 and P3, which were lower compared to P0, was attributed to decreasing energy and protein content and increasing fiber content in the diet (P2 and P3), resulting in insufficient nutrient supply on broilers to achieve maximum BW, so that the performance of probiotics and prebiotics in fermented products becomes ineffective and inefficient in supporting maximum BW increase.

The influence of fermentation product levels and turmeric in feed and their interaction on carcass percentage

Carcass percentage is the ratio between carcass weight and live weight multiplied by 100%. The carcass percentage data is presented in Table 4 and Fig. 2.

The data in Table 4 and Fig. 2 show that the highest carcass percentage is in the P0T0 treatment combination (65.18%) and the lowest is in the P2T0 treatment (62.26%).

Table 4: The influence of fermentation product levels and turmeric in feed, and their interaction on carcass percentage (%)

Tumeric	Level of fermentation product				Tumeric Average
	P0	P1	P2	P3	
T1	64.20	64.91	64.68	62.33	64.03
T0	65.18	65.09	62.26	62.61	63.78
Average of fermentation product	64.69	65.00	63.47	62.47	

Note: T1 = with turmeric and T0 = without turmeric; P0, P1, P2, and P3 = successive usage levels of fermentation product at 0%, 10%, 20%, and 30% in feed.

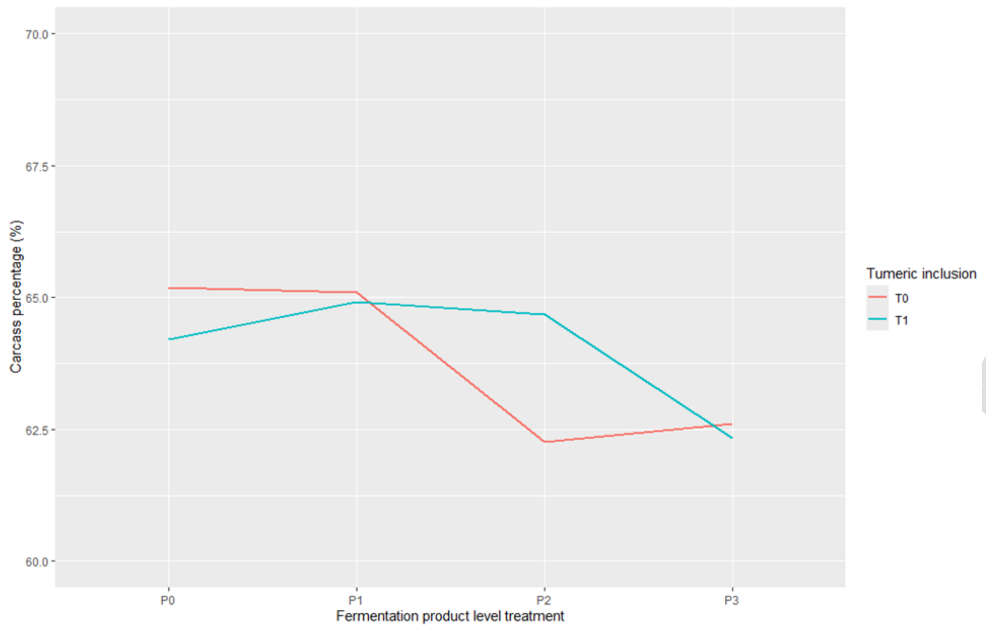

Fig. 2: Carcass percentage of broilers fed with different level of fermentation product and with and without turmeric inclusion in feed

The variance analysis results indicate that there is no interaction between the levels of fermentation product and turmeric in the feed on the carcass percentage. The study results also show that each factor did not significantly affect (P>0.05) the carcass percentage.

The carcass percentage values for treatments P0 to P3 are consistent with the BW obtained during the study. The carcass percentage in P1 and P0 is higher compared to P2 and P3, with P1 having the highest carcass percentage compared to other treatments. The reason for the highest carcass percentage in P1 is that the P1 feed contains energy and protein levels similar to P0, along with probiotics and prebiotics that help maintain digestive health, enhance feed nutrient digestibility and absorption, making it more effective and efficient for conversion to carcass.

Turmeric addition in the feed did not affect the carcass percentage but tends to result in higher T1 values than T0. This is suspected to be due to the low dosage of turmeric, resulting in insignificant carcass values. This study's results align with those of Nouzarian et al. (2011), Wang et al. (2015), Yesuf et al. (2017), Choudhury et al. (2019) and Aldiyanti et al. (2022). The carcass percentage of T1 is higher than T0, although T1's BW is lower than T0's. This indicates that turmeric supplementation positively affects feed nutrient conversion to carcass.

The influence of fermentation product levels and turmeric in feed, and their interaction on abdominal fat percentage

Abdominal fat percentage is the ratio of fat weight (fat surrounding the gizzard and the layer adhering between abdominal muscles and the small intestine) to live weight multiplied by 100%. The abdominal fat percentage data from this study is presented in Table 5 and Fig. 3.

The data in Table 5 and Fig. 3 show that the highest average abdominal fat percentage is in the P0T1 treatment combination (2.77%) and the lowest is in the P2T1 treatment (1.49%). The variance analysis results indicate no interaction between the levels of fermentation product and turmeric in the feed on the abdominal fat percentage; however, the level of fermentation product usage in the feed affects the abdominal fat percentage (P<0.05). The abdominal fat percentage in treatments P1, P2, and P3 is not significantly different (P>0.05), and all three tend to be lower (P<0.05) than in treatment P0. This is due to the progressively decreasing energy and fat content in the feed from P0 to P3, which decreases abdominal fat deposition from P0 to P3. Additionally, the inclusion of fermentation products containing the probiotic *Aspergillus niger* in the feed is suspected also to reduce the abdominal fat percentage. This is supported by previous studies, such as Nurhayati (2008), which showed that using fermentation products without turmeric decreased the abdominal fat percentage in broilers. Similarly, Saleh et al. (2010) found that the inclusion of the probiotic *Aspergillus niger* up to 0.1% reduced the abdominal fat content in broilers compared to the control. Nikmah et al. (2021) reported that including 10% fermentation product in the feed combined with a probiotic plus acidifier (1:1) at 0.3% in the feed reduced the abdominal fat percentage.

Prebiotics (MOS) in the fermentation product can increase non-pathogenic bacteria (Lactobacillus) in the digestive tract of broilers (Nurhayati et al. 2018). This condition can also impact the reduction of abdominal fat deposition. Toghyani et al. (2011) stated that although there is no clear mechanism reporting that prebiotics are

Table 5: The influence of fermentation product levels and turmeric in feed, and their interaction on abdominal fat percentage (%)

Tumeric	Level of fermentation product				Tumeric Average
	P0	P1	P2	P3	
T1	2.77	1.50	1.49	1.67	1.86
T0	2.26	1.91	1.75	1.50	1.85
Average of fermentation product	2.5125b	1.7025a	1.6175a	1.58a	

Note: T1 = with turmeric and T0 = without turmeric; P0, P1, P2, and P3 = successive usage levels of fermentation product at 0%, 10%, 20%, and 30% in feed; Different letters within the same row indicate significant differences (P<0.05).

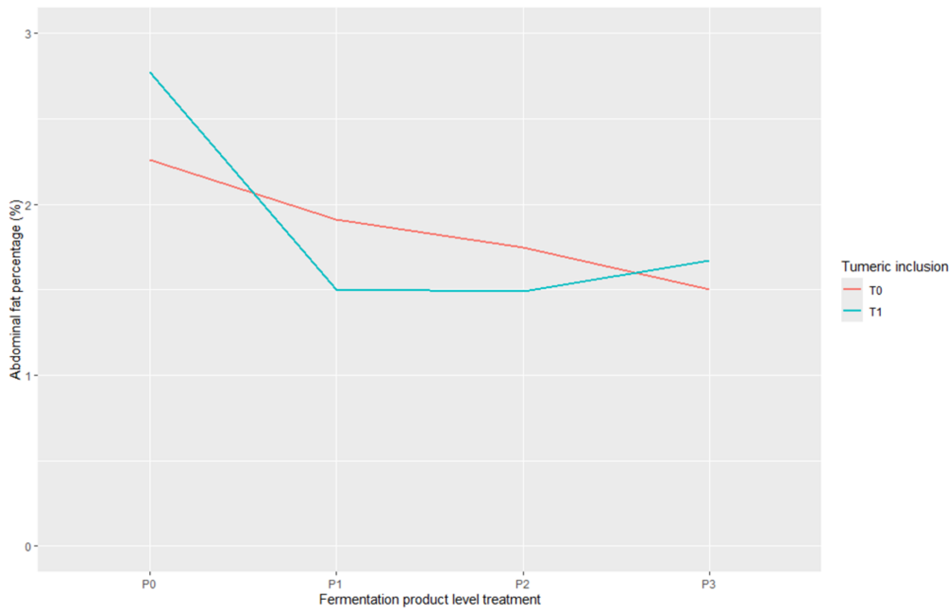

Fig. 3: Abdominal fat percentage of broilers fed with different level of fermentation product and with and without turmeric inclusion in feed

responsible for reducing lipid synthesis, the lipid reduction is suspected to be due to the increase in non-pathogenic bacteria in the digestive tract (Lactobacillus), which can reduce the activity of acetyl-CoA carboxylase, an enzyme that stimulates the rate of fatty acid synthesis.

The influence of fermentation product levels and turmeric in feed and their interaction on meat fat content

The meat fat content data is obtained from the analysis of the fat content in chicken breast meat. The meat fat content data from this study is presented in Table 6 and Fig. 4. The data in Table 6 shows that the highest average fat content in meat is found in the P0T1 combination (1.04%) and the lowest is in the P3T1 treatment combination (0.48%). Analysis of variance results indicate that there is no interaction between the levels of fermented product and turmeric in the feed on meat fat content (P>0.05). The study also shows that each factor does not significantly affect (P>0.05) the meat fat content.

The meat fat content tends to decrease with the increased use of fermented products in the feed. The fat content in the P1, P2, and P3 treatments tends to be lower compared to the control. This is due to the lower energy and fat content in treatment diets of P1, P2, and P3 compared to the control, as a result of the increased use of fermented products, leading to lower fat deposition in the broiler meat of the three treatments (P1, P2, and P3) compared to the control.

The influence of fermentation product levels and turmeric in feed and their interaction on blood cholesterol

Cholesterol is a type of sterol (zoosterol) commonly found in animal tissues. Cholesterol in the body comes from food (exogenous cholesterol) and from synthesis within the body (endogenous cholesterol). The blood cholesterol data from this study is presented in Table 7 and Fig. 5.

The data in Table 7 and Fig. 5 show that the highest average blood cholesterol is found in the P0T1 treatment combination (129.00mg/dL), while the lowest is in the P3T1 treatment combination (110.5mg/dL). Analysis of variance results indicate that there is an interaction between the levels of fermented product and turmeric in the feed on blood cholesterol levels (P<0.05). Based on the average blood cholesterol data, it shows that the addition of fermented products tends to reduce blood cholesterol levels. This is due to the effect of *Aspergillus niger* as a probiotic in the fermented product, which inhibits the enzyme 3-hydroxy-3-methylglutaryl-CoA reductase, thereby inhibiting cholesterol synthesis (Saleh et al. 2011). Meanwhile, Reis et al. (2017) stated that propionic acid produced by non-pathogenic microorganisms (probiotics) can inhibit the activity of the enzyme hydroxymethyl-3-glutaryl-CoA reductase. The decrease in cholesterol levels in this study is in line with Lin et al. (2020), who found that the administration of *Aspergillus niger* as a probiotic in feed can significantly reduce blood cholesterol levels in broilers.

Furthermore, the provision of fermented products containing prebiotic MOS also contributes to the reduction of blood cholesterol levels in broilers. Mannooligosaccharides are fermented by non-pathogenic microorganisms in the intestines, producing SCFA, one of which is propionic acid. Propionic acid can inhibit the activity of the enzyme hydroxymethyl-3-glutaryl-CoA reductase, which plays a role in cholesterol synthesis. Samal and Behura (2015) stated that prebiotics lower cholesterol by reducing the activity of all lipogenic

Table 6: The influence of fermentation product levels and turmeric in feed, and their interactions on meat fat content (%)

Tumeric	Level of fermentation product				Tumeric Average
	P0	P1	P2	P3	
T1	1.04	0.87	0.75	0.48	0.78
T0	0.81	0.85	0.70	0.76	0.78
Average of fermentation product	0.93	0.86	0.73	0.62	

Note: T1 = with turmeric and T0 = without turmeric; P0, P1, P2, and P3 = successive usage levels of fermentation product at 0%, 10%, 20%, and 30% in feed.

Table 7: The influence of fermentation product levels and turmeric in feed, and their interaction on blood cholesterol (mg/dL)

Tumeric	Level of fermentation product				Tumeric Average
	P0	P1	P2	P3	
T1	129c	116.5b	116b	110.5a	115a
T0	117b	117b	119b	118.75b	118b
Average of fermentation product	123c	116.75ab	117.5b	114.625a	

Note: T1 = with turmeric and T0 = without turmeric; P0, P1, P2, and P3 = successive usage levels of fermentation product at 0%, 10%, 20%, and 30% in feed; Different letters in the same row or column of main effect indicate significant differences (P<0.05); different letter across row and column of simple effect (treatment combination) indicate significant differences (P<0.05).

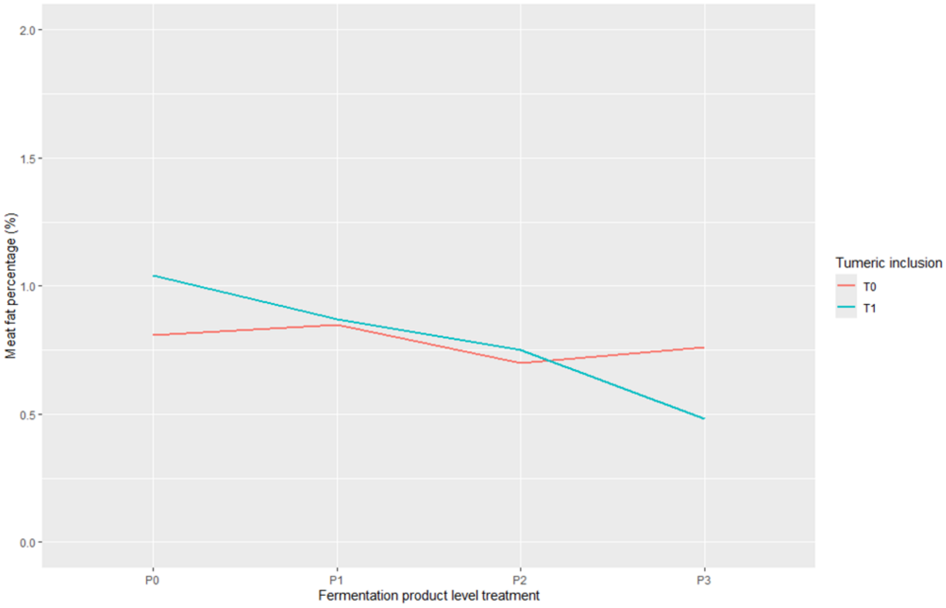

Fig. 4: Meat fat percentage of broilers fed with different level of fermentation product and with and without turmeric inclusion in feed.

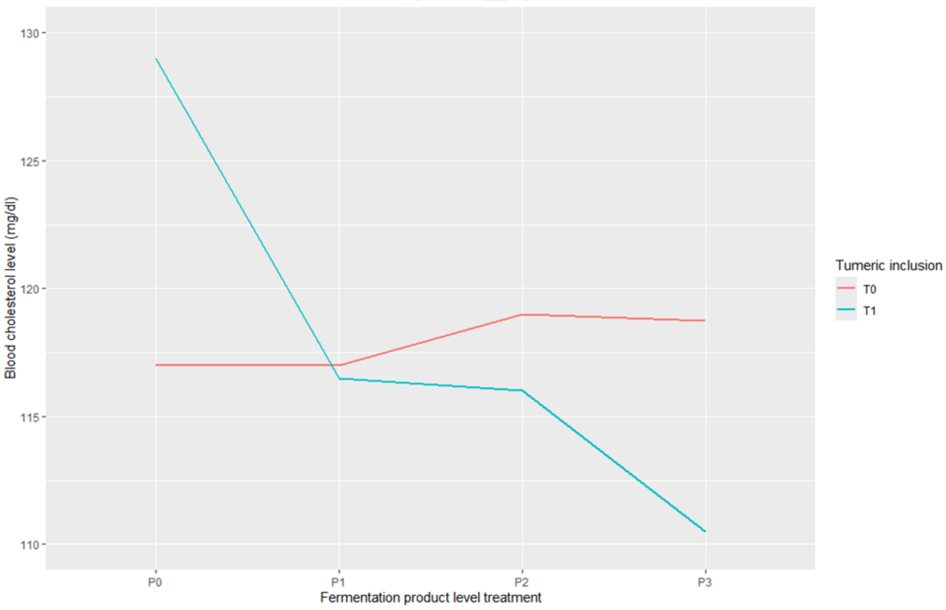

Fig. 5: Blood cholesterol level of broilers fed with different level of fermentation product and with and without turmeric inclusion in feed

enzymes such as acetyl-CoA carboxylase, fatty acid synthase, malic enzyme, ATP citrate lyase, andglucose-6-phosphate dehydrogenase. Additionally, prebiotics can increase bile acid deconjugation, thereby increasing bile acid excretion and lowering cholesterol. The decrease in cholesterol levels in this study was consistent with the findings of Maddahian et al. (2015), Ghazalah et al. (2021), and Youssef et al. (2023), who stated that the provision of prebiotic MOS tends to lower cholesterol compared to the control.

Meanwhile, based on the average blood cholesterol data, it shows that the provision of turmeric affects the reduction of cholesterol levels. This is due to the curcumin in turmeric, which can lower cholesterol levels. The effect of turmeric on reducing blood cholesterol levels in broilers in this study is consistent with the findings of Nouzarian et al. (2011) and Arslan et al. (2017). Curcumin reduces cholesterol by inhibiting the activity of the liver enzyme (3-hydroxy-3-methylglutaryl-CoA reductase (HMGCR)), which is responsible for cholesterol synthesis in the liver (Al-Sanjary et al. 2023). Additionally, Saraswati et al. (2013) stated that curcumin can interfere with cholesterol reabsorption in the intestinal tract, thereby reducing cholesterol reabsorption.

Based on the cholesterol data, it is proven that there is a synergistic effect from the combined use of fermented products and turmeric in the feed in reducing blood cholesterol levels in broilers, even though this interaction is not yet visible in variables other than cholesterol levels. This condition encourages further research to increase the dosage of turmeric in the feed, so the synergistic effect of using fermented products and providing turmeric can significantly impact all research variables.

Conclusion

Based on the results and discussion above, it can be concluded that there is an interaction between the levels of fermented product use and the provision of turmeric on blood cholesterol levels. The combination of a 30% level of fermented product use and turmeric resulted in the lowest cholesterol level (110.5mg/dL). The treatment level of fermented product use affects body weight, abdominal fat percentage, and blood cholesterol levels, but does not affect carcass percentage and meat fat content. On the other hand, the treatment of providing turmeric only affects blood cholesterol levels and tends to increase the carcass percentage. The suggestion related to the results of this study is to increase the dosage of turmeric in the feed. This is expected to enhance the effect of the treatment level of using the fermented product mix of palm kernel cake and cassava byproduct combined with turmeric, thereby significantly affecting all the variables studied.

Acknowledgment

The authors express their heartfelt gratitude to the Directorate General of Higher Education under the Ministry of Education, Culture, Research, and Technology of the Republic of Indonesia for funding this research.

Author's contribution

N: responsible for conceptualization, drafting the original manuscript, and conducting statistical analyses. CUW: managed methodology and supervision. DDP: carried out review and manuscript editing. All authors approved the final version of the manuscript.

Conflict of interest

The authors have declared that there is no conflict of interest.

REFERENCES

Aderemi FA and Alabi OM, 2023. Turmeric (Curcuma longa): an alternative to antibiotics in poultry nutrition. Translational Animal Science 7: txad133. https://doi.org/10.1093/tas/txad133

Adugna W and Belete Y, 2020. Review on effects of probiotic in chicken feed. Advances in Biotechnology & Microbiology 15(3): 555913. https://dx.doi.org/10.19080/AIBM.2020.15.555913

Aldiyanti A, Tugiyanti E and Hartoyo B, 2022. Blood profile and carcass production of broiler chickens given nucleotides and turmeric extract in feed. Buletin Peternakan 46 (4): 235-242. https://doi.org/10.21059/buletinpeternak.v46i4.76789

Al-Sanjary AK, Hamid SM and Ibrahim AM, 2023. Effect of adding turmeric and vitamin C in broiler diets on some biochemical and blood characteristics. Fifth International Conference for Agricultural and Environment Sciences. IOP Conf. Series: Earth and Environmental Science 1158:052015. https://doi.org/10.1088/1755-1315/1158/5/052015

Amalraj A, Pius A, Gopi S and Gopi S, 2017. Biological activities of curcuminoids, other biomolecules from turmeric and their derivatives - A review. Journal of Traditional and Complementary Medicine 7: 205-233. https://doi.org/10.1016/j.jtcme.2016.05.005

Arslan M, Ul-Haq A, Ashraf M, Iqbal J and Mund MD, 2017. Effect of turmeric (*Curcuma longa*) supplementation on growth performance, immune response, carcass characteristics and cholesterol profile in broilers. Veterinaria 66(1):16-20.

Azizi MN, Loh TC, Foo HL and Teik Chung EL, 2023. Is palm kernel cake a suitable alternative feed ingredient for poultry? Animals 11: 338. https://doi.org/10.3390/ani11020338

Barros VRSM, Lanag RQ, Lana SRV, Lana AMQ, Cunha FSA and Neto JVE, 2015. β-mannanase and mannan oligosaccharides in broiler chicken feed. Ciência Rural 45(1): 111-117. http://dx.doi.org/10.1590/0103-8478cr20131544

Chang YH, Omer SHS, Lig Q, Lian HS and Liu YL, 2022. Research advance on application of microbial fermented fodder in broilers production: A Short Review. Open Journal of Animal Sciences 12: 200-209. https://doi.org/10.4236/ojas.2022.122015

Choudhury D, Mahanta JD, Sapcota D and Saikia BN, 2019. Effect of dietary supplementation of turmeric (*Curcuma longa*) powder on the carcass quality of commercial broiler chicken. International Journal of Food Science and Nutrition 4(1): 27-31.

Chowdhury DK, Sahu NP, Sardar P, Deo AD, Bedekar MK, Singha KP and Maiti MK, 2021. Feeding turmeric in combination with ginger or garlic enhances the digestive enzyme activities, growth and immunity in *Labeo rohita* fingerlings. Animal Feed Science and Technology 277: 114964. https://doi.org/10.1016/j.anifeedsci.2021.114964

Dakhlan A, 2019. Experimental design and data analysis using R.graha Ilmu. Yogyakarta.

Fu Z, Ao N, Liang X, Chen J, Wang Y, Wang Q, Fu J, Liu C and Lu L, 2023. Effects of fermented feed on growth performance, serum biochemical indexes, antioxidant capacity, and intestinal health of lion-head goslings. Frontiers in Veterinary Science 10: 1284523. https://doi.org/10.3389/fvets.2023.1284523

Ghazalah AA, Fouad El-Manylawi MA, Motawe HFA, Khattab MS and Youssef YI, 2021.growth performance, nutrient digestibility, biochemical properties, hematological traits, and intestinal histopathology of broiler chicks fed mannan oligosaccharides. World's Veterinary Journal 11(4): 621-633. https://dx.doi.org/10.54203/scil.2021.wvj79

Jamil M, Abdullah S, Abbas A, Ihsan F, Talib F and Mustafa S, 2024. Ameliorative effect of dietary turmeric supplementation in fish. In: Khan A, Mohsin M, Khan AMA and Aziz S (eds), Complementary and Alternative Medicine: Chinese/Traditional Medicine. Unique Scientific Publishers, Faisalabad, Pakistan, pp: 180-86. https://doi.org/10.47278/book.CAM/2024.151

Lian X, Shi M, Liang Y, Lin Q and Zhang L, 2024. The effects of unconventional feed fermentation on intestinal oxidative stress in animals. Antioxidants 13: 305. https://doi.org/10.3390/antiox13030305

Lin H, Ding B, Chen L, Zhang Z, He H, Wang J, Wang X, Zhang L, Ni X and Fronte B, 2020. The effect of *Aspergillus niger* as a dietary supplement on blood parameters, intestinal morphology, and gut microflora in Haidong chicks reared in a high altitude environment. Veterinary World 13(10): 2209-2215. www.doi.org/10.14202/vetworld.2020.2209-2215

Maddahian A, Sadeghi AA, Shawrang P and Aminafshar M, 2015. The impacts of prebiotic and feed restriction on serum biochemical parameters of broilers under microbial stress caused by *Salmonella enterica*. Acta Scientiae Veterinariae 43: 1314.

Nikmah A, Ridhana F, Fitri I and Hikmah, 2021. Effects of fermentated feed and probiotic + acidifier supplements on glucose levels and abdomen chicken fat broiler. Budapest International Research in Exact Sciences (BirEx) Journal 3(2): 126-134. https://doi.org/10.33258/birex.v3i2.1871

Nouzarian R, Tabeidianlo SA, Toghyani M, Ghalamkarilg and Toghyanil M, 2011. Effect of turmeric powder on performance, carcass traits, humoral immune responses, and serum metabolites in broiler chickens. Journal of Animal and Feed Sciences 20: 389-400.

Nurhayati, 2007. The effect of usage level of fermented palm kernel cake-cassava byproduct mixture in ration on broiler performance. Journal of the Indonesian Tropical Animal Agriculture 32(1): 28-32.

Nurhayati, 2008. The effect of usage level of palm kernel cake-cassava byproduct mixture fermented by *Aspergillus niger* in ration on weight and component of carcass of broiler. Animal Production 10(1): 55-59.

Nurhayati, Hartutik, Sjofjan O and Widodo E, 2018. Production of mannan oligosaccharides (MOS) extracted from fermented palm kernel cake and cassava by-product mixture and its efficacy as prebiotic. Livestock Research for Rural Development 30: 179.

Nurhayati, Hartutik, Sjofjan O and Widodo E, 2021. The effect of using mannan oligosaccharides extracted from fermented palm kernel cake and cassava by-product mixture in ration on broiler gut profile. Livestock Research for Rural Development 33(3): 39.

Nurrady CL, Nurliana, Safika S, Ferasyi TR, Ismail and Muttaqin, 2018. The effect of AKBIS probiotic adding that fermented in fodder toward the total of *Aspergillus niger* of broiler'sgastrointestinal tract. Jurnal Medika Veterinaria 12 (2):1 17-123. https://doi.org/10.21157/j.med.vet.v1 1i1.4065

Purwanti S, Zuprizal, Yuwanta T and Supadmo, 2015. Phytobiotic utilization as feed additive in feed for pancreatic enzyme activity of broiler chicken. Animal Production 17(3): 154-160.

R Core Team, 2023. _R: A language and environment for statistical computing_. R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org/

Reis SA, Conceição LL, Rosa DD, Siqueira NP and Peluzio MCG, 2017. Mechanisms responsible for the hypocholesterolaemic effect of regular consumption of probiotics. Nutrition Research Reviews 30: 36–49. https://doi.org/10.1017/S0954422416000226

Saleh AA, Eid YZ, Ebeid TA, Amber K, Badawi N and Hayashi K, 2010. Effect of *Aspergillus niger* on broilers performance. Egyptian Poultry Science 30(IV): 1017-1029.

Saleh AA, Eid YZ, Ebeid TA, Kamizono T, Ohtsuka A and Hayashi K, 2011. Effects of feeding *Aspergillus awamori* and *Aspergillus niger* on growth performance and meat quality in broiler chickens. Japan Poultry Science 48: 201-206. https://doi.org/10.2141/jpsa.011019

Samal L and Behura NC, 2015. Prebiotics: An emerging nutritional approach for improving gut health of livestock and poultry. Asian Journal of Animal and Veterinary Advances 10 (11): 724-739. https://doi.org/10.3923/ajava.2015.724.739

Saraswati TR, Manalu W, Ekastuti DR and Kusumorini N, 2013. The role of turmeric powder in lipid metabolism and its effect on quality of the first quail's egg. Journal of the Indonesian Tropical Animal Agriculture 38(2): 123-130. https://doi.org/10.14710/jitaa.38.2.123-130

Toghyani M, Toghyani M and Tabeidian SA, 2011. Effect of probiotic and prebiotic as antibiotic growth promoter substitutions on productive and carcass traits of broiler chicks. 2011 International Conference on Food Engineering and Biotechnology, Vol 9. ACSIT Press, Singapore.

Wang D, Huang H, Zhou L, Li W, Zhou H, Houg, Liu J and Hu L, 2015. Effects of dietary supplementation with turmeric rhizome extract on growth performance, carcass characteristics, antioxidant capability, and meat quality of Wenchang broiler chickens. Italian Journal of Animal Science 14(3): 3870. https://doi.org/10.4081/ijas.2015.3870

Yang J, Hong J, Fu Z and Ma Z, 2022. Effects of dietary curcumin on growth and digestive physiology of *Seriola dumerili*. Frontiers in Marine Science 9: 862379. https://doi.org/10.3389/fmars.2022.862379

Yesuf KY, Mersso BT and Bekele TE, 2017. Effects of different levels of turmeric, fenugreek and black cumin on carcass characteristics of broiler chicken. Journal of Livestock Science 8: 11-17.

Youssef IM, Khalil HA, Jaber FA, Alhazzaa RA, Alkholy SO, Almehmadi AM, Alhassani WE, Al-Shehri M, Hassan H, Hassan MS, Abd El Halim HS, Abd El-Hack ME, Youssef KM and Abo-Samra MA, 2023. Influence of dietary mannan-oligosaccharides supplementation on hematological characteristics, blood biochemical parameters, immune response and histological state of laying hens. Poultry Science 102: 103071. https://doi.org/10.1016/j.psj.2023.103071

Zhu X, Gao K, Qi Y, Yangg and Liu H, 2023. Enzymolytic soybean meal improves growth performance, economic efficiency and organ development associated with cecal fermentation and microbiota in broilers offered low crude protein diets. Frontiers in Veterinary Science 10: 1293314. https://doi.org/10.3389/fvets.2023.1293314

Saleem H, Naz A, Sandhu AS, Fatima M, Tahir O, Zafar MJ, Rusho MA, Iqbal D, Riaz T and Kanwal R, 2024. Pharmacological and therapeutic values of turmeric. In: Khan A, Mohsin M, Khan AMA and Aziz S (eds), Complementary and Alternative Medicine: Chinese/Traditional Medicine. Unique Scientific Publishers, Faisalabad, Pakistan, pp: 77-84. https://doi.org/10.47278/book.CAM/2024.383