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EVALUATING BROILER GROWTH AND MEAT QUALITY WITH FERMENTED OIL PALM MEAL DIETS

Farhan Ali Laghari [1], Imdad Hussain Leghari [2], Shoaib Ahmed Pirzado [2], Abdul Sattar Shahani [2], Sahar Khan [2], Asmatullah Sahito [3], Fareeda Marri [4], Abdul Sami Solangi [2], Bilawal [3], Gordhan[3], Naseeb Ullah Marri [2], Abdul Kabir*

[1]Department of Livestock and fisheries Poultry Wing sindh
[2]Department of poultry Husbandry Sindh Agriculture University Tandojam
[3]Department of livestock and fisheries Animal husbandry wing sindh
[4]Institute of Biochemistry University of Balochistan Quetta
[5]Department of Veterinary Microbiology, Faculty of Animal Husbandry and Veterinary Sciences, Sindh Agriculture University, Tandojam, Pakistan
Corresponding author: Abdul Kabir*, Naseeb Ullah Marri *
Kabirvet32@gmail.com: *+923455975319*

Abstract

The study investigated the effects of substituting soybean with fermented oil palm meal on broiler chickens by dividing 180 chicks into three groups: Group A (control, fed a basal diet), Group B (15% fermented palm kernel meal), and Group C (15% non-fermented palm kernel meal). Group B showed superior growth performance, with the highest live body weight (2200.00 g), feed intake (3391.66 g), and the best feed conversion ratio (FCR) of 1.54, compared to Groups A and C. Carcass weight and dressing percentage were also highest in Group B (1543.33 g and 66.10%, respectively). Organ weights, including the thymus, spleen, bursa, heart, and liver, were all maximized in Group B.Group B also demonstrated better meat quality, including the highest breast muscle weight (347.13 g) and leg muscle weight (173.36 g), with the least cooking loss (20.97%) and highest water-holding capacity (70.16%). The lowest pH (5.41), highest protein content (22.73%), fat (2.59%), and ash (1.75%) were also observed in Group B, indicating improved meat quality. Overall, Group B, with 15% fermented palm kernel meal, performed better in terms of growth, carcass characteristics, and meat quality compared to the other groups.

Keyword: Fermented Palm Kernel Meal, Broiler Growth Performance, Feed Conversion Ratio, Meat Quality

INTRODUCTIN

The poultry sector in Pakistan is a significant contributor to the economy, employing about 45 million people in the domestic sector and 68 million in commercial operations (GoP, 2021-22). Pakistan ranks 11th among the world's largest poultry producers. The industry thrives due to several factors, including the healthy image of poultry products with high protein content, low fat, balanced polyunsaturated fatty acids, and low cholesterol. Additionally, the ease of processing poultry meat, its lower cost compared to red meat, and the absence of cultural or religious restrictions contribute to its popularity. Despite these advantages, Pakistan's per capita production of chicken meat and eggs lags behind developed countries, necessitating the expansion of current resources and the exploration of alternative, cost-effective feed sources (Hussain et al., 2008).

Feed costs represent 60-70% of total poultry production expenses. Thus, identifying cheaper, locally available feed ingredients is crucial. Poultry, being monogastric, struggles with fibrous by-products due to the lack of fiber-degrading enzymes required to break down complex carbohydrates. This necessitates innovative methods to incorporate fibrous substances like agro-industrial by-products into poultry diets without compromising bird health and productivity (Thirumalaisamy et al., 2016). For marginal farmers, the increasing cost of traditional feed ingredients adds financial strain, making low-cost poultry farming essential (Kim & Lillehoj, 2019). Incorporating locally available by-products into poultry feed can reduce overall production costs, making poultry meat and eggs more affordable, particularly in rural India (Swain et al., 2014).

The ability to maintain broiler performance on low-energy diets paves the way for the inclusion of alternative feeds and by-products. While there is a trade-off between reduced growth rates and production costs, this approach can be the most economical in many regions (Farrell et al., 2005). Evaluating the potential of multipurpose trees and their by-products is essential for sustainable poultry production (Al Boushi et al., 2016).

poultry farms employ advanced technologies, diverse diets, and efficient farming methods to produce high-quality poultry products. (Zaboli et al., 2019). Palm kernel cake (PKC), a by-product of palm kernel oil extraction, is an example of an agro-industrial by-product used in poultry feed. PKC is rich in non-starch polysaccharides (NSPs), such as β-mannan, which can inhibit its nutritional value (Sundu et al., 2006). To enhance its use, strategies like enzyme supplementation and fermentation with cellulolytic microorganisms have been explored (Alshelmani et al., 2014). PKC can be a cost-effective substitute for more expensive feed ingredients like soybean meal and yellow corn, reducing feed costs without compromising bird health and growth performance (Azizi et al., 2021). Properly formulated broiler diets incorporating PKC can optimize its use, enhancing poultry nutrition while lowering production costs (Alagwani et al., 2021). This approach supports the poultry industry's goal of sustainable and cost-effective production, ensuring access to affordable poultry products for both rural and urban consumers

Materials and Methods

This research was conducted at the Department of Poultry Husbandry, Faculty of Animal Husbandry and Veterinary Sciences, Sindh Agriculture University Tandojam.

Collection and Preparation of Ingredients

Palm oil fruits (Elaeis guineensis) were collected from Latif Farm, Tandojam, in collaboration with Dalda (Pvt) Pakistan. The palm oil was extracted using a mechanical process involving a screw or hydraulic press, which separates the oil from the palm oil cake (palm kernel meal) and other solids.

Oil Palm Meal Solid State Fermentation

The fibrous residue left after oil extraction, known as palm oil mesocarp fiber (POMF), was shredded and ground to enhance surface area and support microbial growth. A microbial inoculum consisting of a specific strain of bacteria, fungi, or both was prepared and propagated in a liquid medium or separate solid substrate.The inoculated POMF was then transferred to fermentation chambers under controlled conditions, including temperature, pH, and aeration, to optimize the growth of desirable microorganisms and inhibit undesired ones. The fermentation process lasted for 15 days, with ongoing monitoring and adjustments as needed. Once fermentation was complete, the fermented substrate was harvested, dried (using hot air or sun drying), ground into a fine powder, and packaged as oil palm meal.

Feed Formulation for Broilers

To formulate broiler feed, nutritional requirements for protein, energy, vitamins, minerals, and amino acids were first established according to broiler growth stages. The nutritional composition of both soybean meal and palm kernel meal (PKM) was analyzed, focusing on protein content, amino acid profiles, and energy levels to determine suitable inclusion levels for PKM. Based on nutritional analysis, the maximum inclusion level of PKM was determined, taking into account the quality of PKM, broiler age, and specific nutrient needs. Adjustments were made to compensate for PKM's lower protein and lysine levels compared to soybean meal by supplementing additional protein sources such as fish meal or synthetic amino acids.

Energy sources were balanced, considering PKM's energy content, with adjustments made using corn or other grains to achieve optimal energy levels. Essential nutrients, including vitamins and minerals, were supplemented as needed to ensure a balanced feed formulation.After formulation, laboratory tests and small-scale trials were conducted to assess the nutritional content, pellet quality, and broiler performance, including growth rates, feed intake, and feed conversion ratios.

Experimental Design

A total of 180 day-old Ross broiler chicks were purchased from a commercial hatchery near Hyderabad. The chicks were initially weighed and divided into three groups, Group A: Control basal diet,Group B: Fermented 15% palm kernel meal,Group C: Non-fermented raw 15% palm kernel meal. Each group was further divided into subgroups based on chemical treatments. carcass weight, meat quality, water holding capacity, pH, cooking loss, drip loss, appearance, and proximate analysis of meat.

Statistical Analysis

Data were analyzed using one-way ANOVA (SAS 9.0, SAS Institute Inc., Cary, NC) and expressed as mean ± SD. Differences between means were evaluated by Tukey's test at $P < 0.05$.

RESULTS

Growth Performance

Live bodyweight

The effect of fermented palm kernel meal had statisticallysignificant resultsfor the live body weight (g) obtainable in Table 4.1. The maximum live body weight (2200.00 g) was detected from group B followed by group A resulted (2166.67 g). Whereas decreased live body weight (1515.67 g) was observed from group C. Our statistical analysis shows that there was significant distinction among all these three groups ($P<0.05$).

Table 1 Effectofsubstitutingsoybeanwithfermentedpalmkernelmealonlivebody weight (g)

Groups	A	B	C	**P-value**
Livebody weight	Control	Fermented 15%palmkernel meal	Nonfermented15% palm kernel meal	
	2166.67^{a}±44.10	2200.00^{a}±115.47	1515.67^{b}±60.09	0.0014

Feed intake (g)

Table 4.2 show the effect of fermented palm kernel meal had statistically significant results for the feed intake (g). The maximum feed intake (3391.66 g) was observed from group B followed by group A resulted (3391.66 g). Whereas the minimum feed intake (2814.33 g) was observed from group C. Our statistical analysis shows that there was significant distinction among these all three groups (P<0.05).

Table 2 Effectofsubstitutingsoybeanwithfermentedpalmkernelmealonfeedintake (g)

Groups	A	B	C	P-value
Feed intake	Control	Fermented 15% palm kernel meal	Nonfermented15% palm kernel meal	
	3391.66^{a}±51.94	3391.66^{a}±189.08	2814.33^{b}±26.31	0.0225

FCR

The effect of fermented palm kernel meal had statistically significant results for the FCR presented in Table 4.3. The better FCR (1.54) was observed from group B followed by group A resulted (1.56). Whereasthe maximum FCR (1.85) was observed from group C. Our statistical analysis shows that there was significant distinction among these all three groups (P<0.05).

Table4.3 Effect of substituting soybean with fermented palm kernel meal on FCR

Groups	A	B	C	P-value
FCR	Control	Fermented 15% palm kernel meal	Nonfermented15% palm kernel meal	
	1.56^{b}±0.0110	1.54^{b}±0.0080	1.85^{a}±0.0581	0.0008

Carcass weight(g)

The effect of fermented palm kernel meal had statistically significant results for the carcass weight (g) presented in Table 4.4. The maximum carcass weight (1543.33 g) was observed from group B followed by group A resulted (1433.33 g). Whereas the minimum carcass weight (1000.00g) was observed from group C. Our statistical analysis shows that there was significant distinction among all these three groups (P<0.05).

Table 4.4 Effect of substituting soybean with fermented palm kernel meal on carcass weight (g)

Groups	A	B	C	**P-value**
Carcass weight(g)	Control	Fermented 15% palmkernel meal	Nonfermented15% palm kernel meal	
	1433.33^{a}±58.119	1543.33^{a}±88.192	1000.00^{b}±57.735	0.0033

Dressing%

Table 4.5 shows the effect of fermented palm kernel meal had statistically significant results for the dressing (%). The maximum dressing (66.10 %) was observed from group B followed by group A resulted (65.21 %). Whereas the minimum dressing (59.47 g) was observed from group C. Our statistical analysis shows that there was significant distinction among all these three group groups (P<0.05).

Table4.5 Effect of substituting soybean with fermented palm kernel meal on dressing(%)

Groups	A	B	C	P-value
Dressing %	Control	Fermented 15% palmkernelmeal	Nonfermented15% palm kernel meal	
	65.21^{a}±0.8153	66.10^{a}±0.7612	59.47^{b}±0.5238	0.0012

Thymus weight(g)

The effect of fermented palm kernel meal had statistically significant results for the thymus weight(g)presentedinTable4.6. Themaximumthymus weight(3.86g) was observed fromgroupB followed by group A (2.88 g). Whereas the minimum thymus weight (2.51 g) was observed from group C. Our statistical analysis shows that there was significant distinction among all these three groups (P<0.05).

Table 4.6 Effect of substituting soybean with fermented palm kernel meal on thymus weight (g)

Groups	A	B	C	P-value
Thymus weight(g)	Control	Fermented 15% palmkernel meal	Nonfermented15% palm kernel meal	
	$2.88^{b}\pm0.1673$	$3.86^{a}\pm0.1167$	$2.51^{b}\pm0.1386$	0.0014

Spleen weight(g)

Table 4.7 show the effect of fermented palm kernel meal had statistically significant results for the spleen weight (g). The maximum spleen weight (1.15 g) was observed from group B followed bygroupA resulted(1.09g). Where as the minimum spleen weight(0.76g)was observed from group C. Our statistical analysis shows that there was significant distinction among all three groups (P<0.05).

Table4.7Effectofsubstitutingsoybeanwithfermentedpalmkernelmealonspleenweight(g)

Groups	A	B	C	P-value
Spleen weight(g)	Control	Fermented 15% palmkernelmeal	Non fermented 15%palmkernel meal	
	$1.09^{b}\pm0.0705$	$1.15^{a}\pm0.0808$	$0.76^{b}\pm0.0578$	0.0162

Bursa weight(g)

The effect of fermented palm kernel meal had statistically significant results for the bursa weight (g) presented in Table 4.8. The maximum bursa weight (1.72 g) was observed from group B followed by group A resulted (1.67 g). Whereas the minimum bursa weight (0.86 g) was observed from group C. Our statistical analysis shows that there was significant distinction among all these three groups (P<0.05).

Table4.8 Effect of substituting soybean with fermented palm kernel meal on bursa weight (g)

Groups	A	B	C	P-value
Bursa weight(g)	Control	Fermented 15% palmkernelmeal	Non fermented 15%palmkernel meal	
	$1.67^{a}\pm0.0589$	$1.72^{a}\pm0.0669$	$0.86^{b}\pm0.0409$	0.0001

Heart weight(g)

Table 4.9 shows the effect of fermented palm kernel meal statistically non-significant results for the heart weight(g). The maximum heart weight(8.51 g)was observed from group B followed by group A resulted (8.30 g). Whereas the minimum heart weight (8.15 g) was observed from group C. Our statistical analysis shows that there was significant distinction among all these three groups (P<0.05).

Table4.9Effect of substituting soybean with fermented palm kernel meal on heart weight (g)

Groups	A	B	C	P-value
Heart	Control	Fermented 15% palm kernel meal	Non fermented 15%palmkernel meal	
	$8.30^{a}\pm0.0033$	$8.51^{a}\pm0.0338$	$8.15^{a}\pm0.0057$	0.6583

Liver weight (g)

The effect offermented palm kernel meal had statistically non-significant results for the liver weight (g) presented in Table 4.10. The maximum liver weight (37.76 g) was observed from group B followed by group A (36.83 g). Whereas the minimum liver weight (35.26 g) was observed from group C. Our statistical analysis shows that there was significant distinction among all these three groups (P<0.05).

Table4.10 Effect of substituting soybean with fermented palm kernel meal onliver weight (g)

Groups	A	B	C	P-value
Liver wight(g)	Control	Fermented 15% palmkernelmeal	Nonfermented15% palm kernel meal	

	$36.83^{a}\pm0.5174$	$37.76^{a}\pm0.4667$	$35.26^{a}\pm0.5147$	0.6223

Meat quality

Breast muscle weight

The effect of fermented palm kernel meal had statistically significant results for the BMY presented in Table 4.16. The maximum breast muscle weight (347.13) was observed from group B followed by group A resulted (343.41). Whereas the minimum breast muscle weight (284.76) was observed from group C. Our statistical analysis shows that there was significant distinction among all these three groups (P<0.05).

Table4.11Effectofsubstitutingsoybeanwithfermentedpalmkernelmealonbreast muscle weight (g)

Groups	**A**	**B**	**C**	**P-value**
Breast muscle weight	**Control**	**Fermented 15% palmkernelmeal**	**Non fermented 15%palmkernel meal**	
	$343.41^{a}\pm7.8156$	$347.13^{a}\pm7.0430$	$284.76^{b}\pm9.2821$	0.0027

Leg muscle weight(g)

Table 4.17 shows the effect of fermented palm kernel meal statistically significant results for the live body weight (g) presented in Table 4.17. The maximum leg muscle weight (173.36) was observed from group B followed by group A resulted (168.75). Whereas the minimum leg muscle weight (144.92) was observed from group C. Our statistical analysis shows that there was significant distinction among all these three groups (P<0.05).

Table 4.12 Effect of substituting soybean with fermented palm kernel mealon leg muscle weight (g)

Groups	**A**	**B**	**C**	**P-value**
LMY	**Control**	**Fermented 15% palmkernel meal**	**Nonfermented15% palm kernel meal**	
	$168.75^{a}\pm7.8598$	$173.36^{a}\pm3.5844$	$144.92^{b}\pm3.6258$	0.0205

Abdominal fat weight(g)

The effect of fermented palm kernel meal had statistically significant results for the AFY presented in Table 4.18. The maximum abdominal fat weight (12.02) was observed from group B followed by group A resulted (11.92). Whereas the minimum abdominal fat weight (11.61) was observed from group C. Our statistical analysis shows that there was significant distinction among all these three groups (P<0.05).

Table4.13Effectof substituting soybean with fermented palm kernel meal on abdominal fat weight (g)

Groups	**A**	**B**	**C**	**P-value**
AFY	**Control**	**Fermented 15% palm kernelmeal**	**Nonfermented15% palm kernel meal**	
	$11.92^{ab}\pm0.0902$	$12.02^{a}\pm0.0800$	$11.61^{b}\pm0.0560$	0.0210

Cooking loss

The effect of fermented palm kernel meal had statistically significant results for the cooking loss presented in Table 4.19. The minimum cooking loss (20.97) was observed from group B followed by group A resulted (21.18). Where as the maximum cooking loss (27.15) was observed from group C. Our statistical analysis shows that there was significant distinction among these all three groups (P<0.05).

Table4.14 Effect of sub stituting soybean with fermented palm kernel meal on cooking loss

Groups	**A**	**B**	**C**	

CL	Control	Fermented 15% palm kernel meal	Nonfermented15% palm kernel meal	P-value
	27.15^{a}±0.1071	20.97^{c}±0.1556	21.18^{b}±0.1338	0.0001

Driploss

The effect of fermented palm kernel meal had statistically significant results for the drip loss presented in Table 4.20. The maximum drip loss (3.59) was observed from group C followed by group A resulted (2.23). Whereas the minimum drip loss (2.12) was observed from group B. Our statistical analysis shows that there was significant distinction among these all three groups(P<0.05).

Table4.15Effect of substituting soybean with fermented palmkernel meal on driploss

Groups	A	B	C	P-value
DL	Control	Fermented 15% palmkernelmeal	Nonfermented15% palm kernel meal	
	2.23^{b}±0.0529	2.12^{b}±0.0606	3.59^{a}±0.2642	0.0011

Water holding capacity

Table4.21shows the effect of fermented palm kernel meal had statistically significant results for the water holding capacity. The maximum water holding capacity (70.16) was observed from group B followed by group A resulted (69.67). Whereas the minimum water holding capacity (63.01) was observed from group C. Our statistical analysis shows that there was significant distinction among all these three groups (P<0.05).

Table4.16Effect of substituting soybean with fermented palm kernel meal on water holding capacity

Groups	A	B	C	P-value
WHC	Control	Fermented 15% palmkernelmeal	Nonfermented15% palm kernel meal	
	69.67^{a}±0.1708	70.16^{a}±0.1217	63.01^{b}±0.0926	0.0001

PH

The effect of fermented palm kernel meal had statistically significant results for the pH presented in Table 4.22. The lowest pH (5.41) was observed from group B followed by group C resulted (5.43). Whereas the highest pH (5.53)was observed from group A. Our statistical analysis shows that there was significant distinction among all these three groups (P<0.05).

Table4.17Effectofsubstitutingsoybeanwithfermentedpalmkernelmeal on driploss pH

Groups	A	B	C	P-value
Ph	Control	Fermented 15% palmkern elmeal	Nonfermented15% palm kernel meal	
	5.53^{a}±0.0145	5.41^{b}±0.0145	5.43^{a}±0.0318	0.0171

protein

The effect of fermented palm kernel meal had statistically significant results for the CP presented in Table 4.23. The maximum crude protein (22.73) was observed from group B followed by group A resulted (22.70). Whereas the minimum crude protein(21.54)was observed from group C. Our statistical analysis shows that there was significant distinction among all these three groups (P<0.05).

Table4.18Effectofsubstitutingsoybeanwithfermentedpalmkernelmealoncrude protein

Groups	A	B	C	P-value
CP	Control	Fermented 15% palmkernelmeal	Non fermented 15%palmkernel meal	
	22.70^{a}±0.0731	22.73^{b}±0.0868	21.54^{a}±0.0952	0.0001

Fat

The effect of fermented palm kernel meal had statistically non-significant results for the fat presented in Table 4.24. The maximum fat (2.59) was observed from group B followed by group A resulted (2.53). Whereas the minimum fat (2.44) was observed from group C. Our statistical analysis shows that there was significant distinction among three groups (P<0.05).

Table4.19 Effect of substituting soybean with fermented palmkernel meal on fat

Groups	**A**	**B**	**C**	**P-value**
FAT	**Control**	**Fermented 15% palmkernelmeal**	**Non fermented 15%palmkernel meal**	
	$2.53^{a}\pm0.0981$	$2.59^{a}\pm0.0504$	$2.44^{a}\pm0.0648$	0.4368

Ash

The effect of fermented palm kernel meal had statistically non-significant results for the ash presented in Table 4.25. The maximum ash (1.75) was observed from group B followed by group A resulted (1.69).Whereas the minimum ash(1.53)was observed from group C. Our statistical analysis shows that there was significant distinction among all these three groups (P<0.05).

Table4.20 Effect of substituting soybean with fermented palmkernel meal on ash

Groups	**A**	**B**	**C**	**P-value**
ASH	**Control**	**Fermented 15% palm kernelmeal**	**Non fermented 15%palmkernel meal**	
	$1.69^{ab}\pm0.0284$	$1.75^{a}\pm0.0608$	$1.53^{b}\pm0.0529$	0.0463

DISCUSSION

Soybean meal (SBM) is widely used in broiler diets as a primary source of protein and essential amino acids, such as lysine, tryptophan, threonine, isoleucine, and valine. These nutrients are crucial for the rapid growth and metabolism of broilers. However, SBM contains anti-nutritional factors (ANFs) like protease inhibitors, antigenic proteins, and phytic acid, which can reduce nutrient bioavailability and digestibility. This can affect broiler growth and health by causing undigested proteins to enter the hindgut, leading to harmful compound formation (e.g., ammonia, polyamines) and increasing the risk of enteric diseases like coccidiosis and necrotic enteritis (NE).

There is a growing trend to find alternative protein sources to replace soybean meal and corn in monogastric animal diets. Many developing countries produce large quantities of agricultural by-products, which could serve as suitable alternative feedstuffs. However, these by-products may contain non-starch polysaccharides (NSPs) and other anti-nutritional elements that could potentially hinder broiler growth (Alshelmani et al., 2017a; Aftab and Bedford, 2018). This study explored the effect of substituting soybean with fermented palm kernel meal (PKM) on the growth and meat quality of broilers. The results showed that both fermented and non-fermented palm oil meals provided better growth performance than the control group, which aligns with previous research by Alshelmani et al. (2021).

The significant increase in live body weight observed in Group B, which was fed fermented PKM, suggests that this alternative feed source positively influences broiler growth. Improved feed intake and a favorable feed conversion ratio (FCR) in Group B further support this conclusion. In contrast, the higher FCR in Group C, which received non-fermented PKM, may indicate suboptimal nutritional balance or digestibility issues associated with the non-fermented meal. Previous studies have indicated that palm kernel cake (PKC) can be included up to 20% in poultry diets (Ugwu et al., 2008; Anaeto et al., 2009). However, some researchers have reported negative effects on body weight gain and FCR when PKC is included at levels of 10-15% in broiler diets (Solton, 2009; Alshelmani et al., 2016, 2017a). These mixed results highlight the need for careful formulation and processing methods, like fermentation, to optimize the use of PKM in broiler nutrition.

The differences in organ weights between groups highlight the effects of dietary interventions. Group B, which received fermented PKM, showed higher weights for the thymus, spleen, bursa, and intestine, suggesting potential immunomodulatory effects. However, there were no significant changes in the weights of the heart, liver, gall bladder, gizzard, pancreas, and proventriculus. This indicates that these organs were not significantly affected by the dietary changes. Sundu et al. (2006) suggested that up to 40% PKC could be safely included in poultry diets if nutrient balance is maintained. However, achieving such a high proportion is challenging, even with the use of NSP enzymes, as it may increase digesta viscosity and affect nutrient utilization (Sulabo et al., 2013; Putra et al., 2014; Alshelmani et al., 2016). Therefore, careful formulation is essential to ensure overall organ health and nutrient utilization.

The higher yields of breast and leg muscles in Group B indicate that fermenting PKM positively impacts muscle growth. This aligns with the overall improved growth performance observed in this group. Slightly higher abdominal fat yield (AFY) in Group B suggests that fermented PKM might affect fat metabolism. The lower cooking and drip loss observed in Group B indicate improved meat quality due to enhanced water holding capacity (WHC), which contributes to better sensory attributes and nutritional value. The higher WHC in Groups A and B also indicates better water retention, contributing to juiciness and tenderness. In contrast, non-fermented PKM (Group C) had lower WHC, suggesting potential water retention issues. Higher crude protein content in Group B suggests better protein utilization, enhancing muscle growth. These findings align with Novriadi et al. (2017), who found no significant differences among treatments in crude protein, moisture, fat, ash, and WHC.

Overall, fermenting PKM positively influenced muscle growth, improved meat quality, and enhanced protein utilization in broilers. These findings provide valuable insights into the potential benefits of incorporating fermented PKM in poultry diets for better performance and meat quality. Further research is needed to optimize inclusion levels and processing methods for PKM in poultry nutrition.

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