International Journal of Education, Vocational and Social Science
https://e-journal.citakonsulindo.or.id/index.php/IJEVSS
E-ISSN : 2963 4954
IJEVSS

Production Performance, Lipid Profile, And Economic Value Of Kub Chicken Feed Substituting Fish Meal With Chicken Head Meal

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Abstract

This study aimed to analyze the effect of substituting fish meal with chicken head meal on production performance, meat lipid profile, and economic efficiency of the kampung unggul balitbangtan chicken, as well as to determine the optimal substitution level. The study employed an experimental method using a completely randomized design consisting of five treatments and four replicates with varying levels of chicken head meal substitution. The treatments applied were: A0 = base diet, A1 = base diet + 15% fish meal, A2 = base diet + 10% fish meal + 5% chicken head meal, A3 = base diet + 5% fish meal + 10% chicken head meal, and A4 = base diet + 15% chicken head meal. The observed parameters included feed intake, body weight gain, feed conversion ratio, meat fat and cholesterol content, as well as economic analysis using the income over feed cost approach. The results showed that treatments A1, A2, A3, and A4 had a highly significant effect (P<0.01) on increasing feed intake compared to A0, with feed intake values of (A0 = 751.95 g/bird, A1 = 1,319.7 g/bird, A2 = 1,315.9 g/bird, A3 = 1,315.6 g/bird, A4 = 1,310.2 g/bird). The body weight gain of KUB chickens in treatments A1, A2, A3, and A4 showed a highly significant effect (P

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< 0.01) compared to the control group, with body weight gain values of (A0 = 116.5, A1 = 428.95, A2 = 412.1, A3 = 4019.1, A4 = 355.1). The feed conversion ratio of KUB chickens in treatments A1, A2, A3, and A4 showed a highly significant effect (P < 0.01) compared to the control, with conversion ratios of (A0 = 6.51, A1 = 3.08, A2 = 3.18, A3 = 3.23, and A4 = 3.72). However, the treatments had no significant effect (P > 0.05) on fat content, but had a significant effect (P < 0.05) on the cholesterol content of KUB chicken meat, with respective IOFC values (A0 = Rp 21,572, A1 = Rp 48,721, A2 = Rp 48,504, A3 = Rp 48,733, and A4 = Rp 45,493). Thus, it can be concluded that substituting fish meal with chicken head meal can improve production performance and IOFC values and affect meat cholesterol levels without altering the fat content of KUB chicken meat; however, the use of chicken head meal at high levels without fish meal tends to reduce production performance and IOFC values.

Keywords: KUB Chicken; Chicken Head Meal; Production Performance; Lipid Profile; IOFC.

INTRODUCTION

The supply of animal protein, particularly chicken meat, is a strategic pillar in supporting food security and the quality of human resources in Indonesia. The kampung unggul balitbangtan chicken (KUB) has emerged as a promising genetic innovation because it offers higher productivity, feed efficiency, and adaptability compared to ordinary native chickens. However, the development of smallholder poultry farming remains constrained by high production costs, with the feed sector accounting for 60%–70% of total costs, primarily due to reliance on imported fishmeal, whose prices are volatile.

The use of chicken head waste as a substitute for fish meal is an innovative solution that supports the principles of the circular economy. Chicken head waste contains 41% crude protein, offering significant potential to reduce feed costs without compromising nutritional value. Although its effectiveness has been demonstrated in commercial broiler chickens, the implementation of chicken head meal in KUB chickens requires further in-depth study, given the differences in growth characteristics and specific nutritional requirements of KUB chickens.

This study is crucial because it comprehensively examines the effects of various levels of chicken head meal substitution (5%, 10%, and 15%), ranging from production performance to meat lipid profiles. Focusing on fat and cholesterol levels is important as consumer health awareness regarding food products increases. Through the integration of biological technical analysis and economic analysis, this study is expected to provide practical solutions for efficient

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alternative feed that is profitable for farmers and sustainable for the national livestock industry.

RESEARCH METHODOLOGY

The study was conducted in Pauwo Village, Kabila Subdistrict, Bone Bolango Regency, Gorontalo Province, from December 2025 to February 2026. This was an experimental quantitative study using a completely randomized design (CRD) with five treatments and four replicates. Each replicate consisted of five chickens, resulting in a total of 100 KUB chickens used in the study. This study used 100 one-day-old KUB chicks (DOC), 20 battery cages, starter feed, chicken head meal, feeders, water containers, disinfectant, vaccines, a digital scale, and a notebook.

Table 1. Base diet composition

Feed ingredients	Proportion (%)
- Corn	50
- Rice bran	19
- Coconut meal	9.5
- Soybean meal	15
- Premix	1.5
Total	100

Table 2. Composition of the treatment diets

Feed ingredients	Teratment				
	A0	A1	A2	A3	A4
	Proportion (%)				
- Corn	55	50	50	50	50
- Rice bran	19	15	15	15	15
- Coconut meal	9.5	8.5	8.5	8.5	8.5
- Fish meal	0	15	10	5	0
- Chicken head meal	0	0	5	10	15
- Soybean meal	15	10	10	10	10
- Premix	1.5	1.5	1.5	1.5	1.5

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International Journal of Education, Vocational and Social Science
https://e-journal.citakonsulindo.or.id/index.php/IJEVSS
E-ISSN : 2963 4954
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Total	100	100	100	100	100

Description: A0 = base diet, a1 = base diet + 15% fish meal, a2 = base diet + 10% fish meal + 5% chicken head meal, a3 = base diet + 5% fish meal + 10% chicken head meal, a4 = base diet + 15% chicken head meal.

Table 3. Nutritional content of the treatment diet

Nutritional content	Treatment				
	A0	A1	A2	A3	A4
	------ Proportion (%) ------				
- PK (%)	20,41	20,08	19,74	19,41	16,70
- LK (%)	5,67	6,30	6,93	7,56	5,94
- SK (%)	3,89	3,73	3,57	3,41	3,62
- EM (Kkal/Kg)	3180,62	3175,97	3171,32	3166,67	3189,82
- Ca (%)	1,0	1,01	1,03	1,04	0,27
- P (%)	0,96	0,90	0,84	0,78	0,64

Source: Results of the analysis by the Laboratory of Animal Nutrition and Feed Technology, Faculty of Agriculture, Gorontalo State University

Table 4. Nutritional content of feed ingredients

Feed ingredients	Nutritional content					
	PK (%)	SK (%)	LK (%)	Ca (%)	P (%)	EM (Kkal/kg)
Corn	9,42[a]	2,15[a]	5,17[a]	0,22[a]	0,60[a]	3182[a]
Rice bran	13,2[a]	6,35[a]	6,07[a]	0,19[a]	0,73[a]	2878[a]
Coconut meal	24,7[a]	15,02[a]	9,36[a]	0,11[a]	0,47[a]	3498[a]
Fish meal	48,61[b]	5,36[b]	4,67[b]	5,10[b]	2,80[b]	3262[b]
Chicken head meal	41,88	2,15	17,31	5,36[b]	1,60[b]	3169[b]
Soybean meal	49,0[a]	2,27[a]	8,26[a]	0,32[a]	0,58[a]	3910[a]
Premix				5,38[a]	1,44[a]	

Sources: a. Pesik et al., (2016). b. Usman et al., (2022). c. Results of laboratory analysis by the Department of Animal Nutrition and Feed Technology, Faculty of Agriculture, Gorontalo State University

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Treatment Design

This study is an experimental study using a completely randomized design (CRD) with four treatments, each consisting of five replicates. Each replicate consisted of 5 chickens, resulting in a total of 100 KUB chickens used in the study.

The treatment design applied was as follows:

P0: Base diet + 0% conventional fish meal + 0% chicken head meal
P1: Base diet + 15% conventional fish meal + 0% chicken head meal
P2: Base diet + 10% conventional fish meal + 5% chicken head meal
P3: Base diet + 5% conventional fish meal + 10% chicken head meal
P4: Base diet + 0% conventional fish meal + 15% chicken head meal

Observed Variable

Feed intake is the amount of feed consumed by livestock over a specific period of time. Feed intake is calculated by subtracting the amount of feed remaining from the amount of feed provided, then dividing the result by the number of animals. Feed intake is expressed in grams per head (g/head) (Silalahi et al., 2019).

$$\text{Feed intake} = \frac{\text{Amount given} - \text{Amount remaining}}{\text{Number of livestock}}$$

Daily weight gain is the increase in the weight of broiler chickens measured at one week of age. Daily weight gain is calculated by subtracting the initial body weight from the current body weight and is expressed in grams per bird (Urfa et al., 2017).

$$\text{Weight gain} = \frac{\text{Final weight} - \text{DOC weight}}{\text{Number of livestock}}$$

Feed conversion ratio is a measure of how efficiently livestock utilize feed; in other words, it indicates how many kilograms of feed are required to gain one kilogram of body weight in chickens. The feed conversion ratio is calculated by dividing the amount of feed consumed by the animal's body weight (Nova et al., 2002).

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$$\text{Feed Conversion} = \frac{\text{Feed intake}}{\text{Weight gain}}$$

Fat content was determined using the Soxhlet extraction method based on the AOAC standard procedure (2005). The principle of this method is to dissolve all fat components in a non-polar organic solvent, typically petroleum ether or n-hexane, so that the fat can be separated from the non-lipid components. This method is widely used because it is capable of extracting total lipids with a high degree of accuracy (Lee et al., 1995). The percentage of fat content is calculated using the formula:

$$\text{Fat content (\%)} = \frac{(\text{flask weight} + \text{sample}) - \text{flask weight}}{\text{sample weight}} \text{ x } 100\%$$

Cholesterol levels were analyzed using the saponification and solvent extraction methods, followed by measurement via enzymatic spectrophotometry. The principle of this method involves hydrolyzing cholesterol esters into free cholesterol through a strong base reaction (KOH in ethanol), after which the resulting free cholesterol is extracted using a nonpolar solvent such as n-hexane. The extracted cholesterol is then measured using cholesterol oxidase and peroxidase enzyme reagents, which produce a colored compound whose intensity is proportional to the cholesterol content in the sample (Grundy, 2004). The color reaction in this analysis follows an enzymatic reaction:

$$\text{Cholesterol} + \text{O}_2 \xrightarrow{\text{perokxidase}} \text{Cholesterol} - 4 - \text{en} - 3 - \text{on} + \text{H}_2\text{O}_2$$

$$\text{H}_2\text{O}_2 + \text{Fenol} + 4 - \text{AAP} \xrightarrow{\text{peroxidase}} \text{Quinonimin} + \text{H}_2\text{O}$$

The resulting quinonimine compound is pink in color, and its intensity is measured spectrophotometrically (Hasibuan et al., 2021). Based on the absorbance values, total cholesterol levels are calculated using the following formula:

$$Cholesterol\ ({}^{mg}/_{100\ g}) = \frac{A_s}{A_{st}}\ x\ C_{st}\ x\ \frac{V_t}{W_s}$$

Description:

A_s = Sample absorbance

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A_{st} = Cholesterol standard absorbance
C_{st} = Chlesterol standard concentration (mg/mL)
V_t = Total extract volume (mL)
W_s = sample weight (g)

Income Over Feed Cost is an economic indicator in the livestock industry that reflects the difference between revenue earned and feed costs incurred (Satriawan et al., 2021).

IOFC = Revenue – Feed Costs

Data Analysis

The data obtained were analyzed using Analysis of Variance (ANOVA) at a 5% significance level. If there were significant differences between treatments, a post-hoc test least significant difference (LSD) was conducted to identify which treatments differed significantly.

Yij=μ+τi+ϵij

Description:

- Yij = observed value-j in the treatment of-i
- μ= grand mean
- τ_i= effect of treatment-i
  ϵ_{ij}= assumed random error $\epsilon_{ij} \sim N(0, \sigma^2)$

RESULT AND DISCUSSION

Table 5. Research Findings

Variable	Treatment				
	A0	A1	A2	A3	A4
Feed intake (g/head)	751.95±18.02 b	1319.7±20.80 a	1315.9±23.97 a	1315.6±4.64[a]	1310.2±5.17[a]
Weight gain (g/head)	116.5±12.43[c]	428.95±19.02 a	412.1±7.63[a]	409.1±35.11[a]	355.1±27.88[b]
Feed convertion	6.51±1.11[a]	3.08±0.22[c]	3.18±0.11[bc]	3.23±0.43[bc]	3.72±0.43[b]

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Meat fat (%)	13.5±1.29	14±1.83	140±0.82	14.5±1.29	15±0.82
Cholesterol in meat (mg/dL)	112.5±33.04[a]	132.5±22.17[a]	145±19.15[ab]	150.8±25.47[ab]	192.5±55.0[b]
IOFC (Rp.)	21.572±5.947 b	48.721±1.239 a	48.504±612[a]	48.733±2.292 a	45.493±2.242 a

Description: A0 = base diet, a1 = base diet + 15% fish meal, a2 = base diet + 10% fish meal + 5% chicken head meal, a3 = base diet + 5% fish meal + 10% chicken head meal, a4 = base diet + 15% chicken head meal.

Different letters on the same line indicate a clear difference

Production Performance

Feed intake is the amount of feed consumed by livestock over a specific period of time. Feed intake is calculated by subtracting the amount of feed remaining from the amount of feed provided, then dividing the result by the number of animals. The feed intake results from this study are presented in Table 5.

Based on the results of the analysis of variance, the administration of various combinations of fish meal (FM) and chicken head meal (CHM) had a highly significant effect ($P < 0.01$) on the feed intake of KUB chickens. These results indicate that the nutrient density and aroma characteristics of the treated diets elicited a significantly better feeding response compared to the control diet. Post-hoc LSD test revealed that all treatment groups (A1 = 1319.7 g/bird, A2 = 1315.9 g/bird, A3 = 1315.6 g/bird, and A4 = 1310.2 g/bird) were not significantly different ($P > 0.05$); however, all four treatments were significantly higher ($P < 0.01$) than the control treatment (A0 = 751.95 g/bird). The average feed intake in this study aligns with the findings of Hubulo et al. (2022), who reported that the average feed intake for KUB chickens ranged from 21.00 g/bird to 22.99 g/bird, indicating that the use of high-quality alternative feed ingredients remains capable of maintaining nutritional intake stability at an optimal level, as required for KUB chickens from the starter to the grower phase.

The inclusion of animal protein in the diet significantly improves diet acceptability by stimulating the birds' sense of smell and taste (Saelan et al., 2023). The distinctive aroma of fish meal and the fat content in chicken head meal act as natural attractants that stimulate the appetite of KUB chickens more effectively than a basic plant-based diet (Nurain et al., 2020).

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Increased feed intake is driven by the relatively high crude fat content in chicken head meal (17%), where fat in poultry feed serves not only as an energy source but also as a palatability-enhancing agent capable of improving feed texture, making it more appealing (Prayogi, 2007). Physiologically, the presence of fat and animal aromatic compounds acts as a chemical mediator that stimulates the olfactory nerves to increase pecking frequency (Wahju, 2004).

The high feed intake in the treatment group indicates that the use of chicken head waste does not have a negative effect on palatability but rather maintains the stability of energy intake required for basal metabolism (Erwan et al., 2023). The stability of intake in treatment A4 indicates that the use of chicken head meal up to 15% remains capable of meeting the biological requirements of the livestock; this is supported by the fact that chicken head meal has a sufficiently high crude protein profile of 41%, thereby enabling it to substitute for fish meal in maintaining the balance of essential amino acids in the diet (Tifiany, 2021). This aligns with the principle that chickens will consume feed to meet their daily metabolic energy requirements, where feed with the appropriate nutrient density will promote the achievement of an optimal satiety point without reducing appetite (Lupita et al., 2017). Furthermore, feed intake in KUB chickens is directly proportional to the feed's nutrient content (Huwani et al., 2023).

Daily weight gain is the increase in the weight of broiler chickens measured at one week of age. Daily weight gain is calculated by subtracting the initial weight from the current weight. The daily weight gain of KUB chickens in this study is presented in Table 5.

Based on the results of the analysis of variance, the administration of various combinations of fish meal (FM) and chicken head meal (CHM) had a highly significant effect ($P < 0.01$) on the body weight gain of KUB chickens. Further LSD analysis indicated that treatments A1 (428.95 g/bird), A2 (412.1 g/bird), and A3 (409.1 g/bird) produced the highest body weight gains and were not statistically significantly different ($P > 0.05$), while all three treatments were significantly higher ($P < 0.05$) than treatment A4 (355.1 g/bird), and all four treatments were significantly higher ($P < 0.05$) compared to the control A0 (116.5 g/bird). The body weight gain of chickens in treatments A1 to A3 in this study aligns with Hubulo et al. (2022), who reported that the body weight gain of KUB chickens ranged from 6.52–7.62 g/bird/day, and exceeded the average body weight gain reported by Saelan et al. (2023), which was 370.5 g/bird. This demonstrates that the synergy of animal proteins from fish meal and chicken head meal provides a more responsive growth rate compared to plant-based diets as reported by Saelan et al. (2023).

The high rate of weight gain in the treatment group indicates that the combination of feed ingredients used was able to optimally support the body's anabolic processes, a finding supported

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by evidence that the use of chicken head meal as a substitute for fish meal was shown to maintain the anabolic rate in KUB chickens due to its adequate protein and mineral content for tissue formation (Tirajoh et al., 2022). This support for anabolism correlates directly with the crude protein content of chicken head meal at 41% and fish meal at 48.61%, which provide essential nitrogen for muscle protein retention (Tifiany, 2021). High nitrogen retention from animal protein sources is a key factor that accelerates muscle tissue cell division (hyperplasia) during the grower phase (Lupita et al., 2017).

The success of treatments A2 and A3, which were comparable to A1, indicates a complementary effect, whereby mineral deficiencies in fish meal were offset by minerals from chicken head meal, thereby optimizing skeletal development to support muscle mass (Sartika et al., 2013). This is consistent with the findings of Syahruddin et al., (2022) that the use of local animal by-products such as intestinal meal can substitute for fish meal in increasing the percentage of chicken carcass, which indirectly increases the weight of KUB chickens.

The decline in performance in treatment A4 (355.1 g/bird) compared to treatments A1 through A3 suggests that a saturation point has been reached in the use of chicken head meal alone. Biochemically, chicken head meal has a relatively high crude fat content of 17%. The high fat concentration in treatment A4 caused the energy density of the diet to increase significantly, which, according to Wahju (2004), can cause chickens to reach the energy satiety threshold (chemostatic satiety) earlier before the protein requirement for tissue deposition is maximally met. Additionally, the use of chicken head meal without fish meal in treatment A4 is suspected to trigger deficiencies in limiting essential amino acids such as methionine and lysine, which are more abundant in fish meal (Sidadolog et al., 2011). This phenomenon reinforces Liebig's law of the minimum, where growth rate will cease at the level of the most limiting nutrient, in this case the limiting amino acid (Ihsan et al., 2024).

Collectively, the difference in growth between the treatment and control (A0) groups demonstrates the superior biological value of animal protein in stimulating the growth hormone IGF-1 (Insulin-like Growth Factor-1) compared to plant protein (Rajulani et al., 2022). The low weight gain in the control group, at only 116.5 g/bird, confirms that the basal diet without animal protein supplementation suffers from a severe protein precursor deficit, thereby inhibiting the genetic potential of KUB chickens to grow optimally (Urfa et al., 2017).

Feed conversion ratio is a measure of how efficiently livestock utilize feed; in other words, it indicates how many kilograms of feed are required to gain one kilogram of body weight in chickens. The feed conversion ratio is calculated by dividing the amount of feed consumed by the

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animal's body weight. The feed conversion ratios from this study are presented in Table 5.

Based on the results of the analysis of variance, the administration of various combinations of fish meal (FM) and chicken head meal (CHM) had a highly significant effect ($P < 0.01$) on the feed conversion ratio of KUB chickens. A post-hoc LSD test indicated that treatment A1 had the lowest feed conversion ratio (most efficient) at 3.08, which was not statistically significantly different ($P > 0.05$) from treatments A2 (3.18) and A3 (3.23), but was significantly lower ($P < 0.05$) than treatment A4 (3.72). Treatment groups A1–A4 were statistically significantly lower ($P < 0.05$) compared to control A0, which reached 6.51. The feed conversion ratios in treatments A1, A2, and A3 in this study align with the findings of Ihsan et al. (2024), who reported that the FCR for KUB chickens ranges from 3.2 to 3.5. This indicates that the use of a combination of animal proteins in the form of fish meal and chicken head meal provides better digestibility for KUB chickens (Saelan et al., 2023).

The low feed conversion ratio in the treatment group reflects the high efficiency of feed nutrient utilization in converting to muscle mass. This phenomenon is supported by the nutritional profile of the diet, in which chicken head meal has a crude protein content of 41% and fish meal of 48.61% (Tifiany, 2021). The high availability of animal protein facilitates more complete absorption of essential amino acids compared to plant protein, allowing the metabolism of KUB chickens to work more efficiently in tissue deposition (Lupita et al., 2017).

Conversely, the very high FCR value in the A0 control treatment indicates inefficient utilization of nutrients due to the poor physiological quality of the diet. The control diet, which did not contain animal protein, caused deficiencies in essential amino acids such as lysine and methionine, so that the body's protein synthesis process—particularly muscle tissue formation—did not proceed optimally (Mateos et al., 2012). Consequently, the consumed nutrients were used more for basic survival needs than for growth, resulting in very low body weight gain. This condition is exacerbated by the dominance of plant-based feed ingredients, which have lower digestibility and higher crude fiber content, which can accelerate the rate of digestion and reduce nutrient absorption efficiency in the digestive tract (Beski et al., 2015).

Furthermore, the imbalance between energy and protein in the control diet prevents the available energy from being efficiently utilized for tissue growth, even though the fat content—as a source of energy—is relatively high. Energy from fat will not be optimally utilized for muscle tissue synthesis if it is not balanced with sufficient essential amino acids, resulting in a mismatch between energy supply and the body's protein synthesis requirements. Under these conditions, excess energy tends to be used for basal metabolic activities or even dissipated as heat, thus

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having no effect on body weight gain in chickens (Leeson et al., 2005).

A combination of amino acid deficiencies, low protein content, and an imbalance between energy and protein leads to nutritional stress, in which the chicken's body is unable to utilize nutrients efficiently for growth. Additionally, the dominance of plant-based feed ingredients in the diet also contributes to low nutrient digestibility, resulting in suboptimal nutrient absorption. Consequently, the feed consumed does not contribute to body weight gain but merely meets basic survival needs, leading to a high FCR (Hu et al., 2021).

Lipid Profile

Fat content refers to the amount or percentage of fat present in chicken meat; it is expressed as a percentage. The fat content of KUB chicken meat in this study is presented in Table 5.

Based on the results of the analysis of variance, the inclusion of various levels of fish meal and chicken head meal combinations showed no significant effect ($P > 0.05$) on the fat content of KUB chicken meat; this indicates that substituting fish meal with chicken head meal up to a level of 15% did not significantly alter the composition of fat deposition in muscle tissue. The average fat content of the meat across all treatments was within a relatively uniform range. This indicates that although there were differences in the sources of animal protein in the diet, the lipogenesis process in KUB chicken meat tissue remained stable. This finding is consistent with the report by Hidayah et al. (2019), which stated that KUB chicken meat has distinctive nutritional characteristics, wherein its meat fat content tends to remain stable even when fed various different diet formulations.

The absence of significant differences in meat fat content is likely due to the relatively balanced energy and protein densities across all treatment groups. Physiologically, meat fat or intramuscular fat is more influenced by genetic factors and slaughter age than by short-term dietary manipulation. This is supported by the findings of Wiranti et al., (2023), who explained that the lipid profile in poultry, including its deposition in muscle tissue, is strongly influenced by the metabolic efficiency of each individual animal. Furthermore, Suwarta et al. (2024) emphasize that the supplementation of alternative feed ingredients, as long as it remains within the biological tolerance limits of native chickens, will not adversely affect the chemical quality of the meat, including its fat content.

Although chicken head meal has a relatively high crude fat content of 17%, research findings indicate that this fat intake is primarily utilized as a source of metabolic energy for activity

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and growth rather than being deposited as body fat. This phenomenon aligns with the energy metabolism mechanism described by Hasanah et al., (2023), which states that poultry have the ability to regulate body fat homeostasis through fatty acid oxidation pathways to meet daily energy requirements. This effect is also observed in the use of other local feed ingredients, where Kenedi et al. (2020) reported that certain nutritional interventions are often more effective at influencing blood lipid profiles or abdominal fat than drastically altering intramuscular fat levels.

The total cholesterol content of chicken meat is the total amount of cholesterol present in the chicken meat tissue; total cholesterol content is expressed in milligrams (mg). The total cholesterol content of KUB chicken meat in this study is presented in Table 5.

Based on the results of the analysis of variance, the inclusion of various combinations of fish meal and chicken head meal had a significant effect ($P<0.05$) on the cholesterol content of KUB chicken meat. The results of the post-hoc LSD test showed that treatments A0–A3 did not differ significantly from one another ($P>0.05$), but differed significantly ($P<0.05$) from treatment A4. The results of the study indicate that increasing the substitution level of chicken head meal in the diet tends to increase the cholesterol content of KUB chicken meat. The average cholesterol levels in the meat were A0 = 112.5 mg/dL, A1 = 132.5 mg/dL, A2 = 145 mg/dL, A3 = 150.8 mg/dL, and A4 = 192.5 mg/dL. These results are consistent with the study by Rakhmawati et al. (2023), which reported an average cholesterol level of 183 mg/dL in native chickens.

Differences in cholesterol levels among treatments are closely related to variations in fat content and fatty acid profiles in the diet. Chicken meal has a relatively higher fat content compared to fish meal. Additionally, fats from poultry by-products are generally dominated by saturated fatty acids, which can increase the activity of the HMG-CoA reductase enzyme in the liver, thereby stimulating endogenous cholesterol synthesis (Dinh et al., 2008).

Unlike chicken head meal, fish meal is known as a source of unsaturated fatty acids (particularly omega-3) that have a cholesterol-lowering effect by inhibiting cholesterol synthesis and increasing cholesterol excretion via bile. Thus, a reduction in the level of fish meal in the diet leads to the loss of the hypocholesterolemic effect, causing the balance of lipid metabolism to shift toward increased cholesterol levels in tissues (Simopoulos, 2000). Age and genetic factors also influence cholesterol levels, where an increase in the age of chickens is accompanied by an increase in fat deposition, which is directly related to cholesterol levels in muscle tissue (Kenedi et al., 2020).

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IOFC Analysis

Income over feed cost is an approach used to assess the feed cost efficiency of a business by comparing the costs incurred with the revenue generated. The analysis in this study focuses on feed cost efficiency as a key component in chicken production. Feed costs are calculated by multiplying the feed price by the feed conversion ratio (FCR), yielding the feed cost per kilogram of chicken body weight. The analysis of the poultry farm's profitability is presented in Table 5.

The results of the statistical analysis indicate that substituting fish meal with chicken head meal had a highly significant effect ($P < 0.01$) on the IOFC value of KUB chickens. Furthermore, based on the LSD post-hoc test, treatments A1, A2, A3, and A4 were not significantly different ($P > 0.05$), and all four treatments were significantly higher ($P < 0.01$) compared to the control treatment A0. Descriptively, treatments A1, A2, and A3 had relatively lower feed costs compared to the other treatments. Treatment A1 resulted in a feed cost of Rp. 26,279/kg body weight with an FCR of 3.08, indicating better feed utilization efficiency compared to treatment A4, which had a higher FCR. Although the feed price in treatment A4 was lower, the increase in the FCR value caused the feed cost to be higher, namely Rp. 29,507/kg of body weight.

The income over feed cost (IOFC) is used as an indicator of feed efficiency, defined as the difference between revenue from chicken sales and feed costs, as reported by Leeson et al. (2005). Based on the research results, treatment A1 showed the highest IOFC value of Rp. 48,721/kg of body weight, followed by A3 and A2. This indicates that biological efficiency, as reflected by the FCR value, has a more dominant influence than feed prices in determining livestock business profits.

In contrast, treatment A0 showed a very high FCR (6.51), resulting in feed costs of Rp. 53,428/kg of body weight, a low IOFC, and significant feed cost losses for farmers. This indicates that diets without added animal protein, such as chicken meal or fish meal, have very low production performance and are economically inefficient. A high FCR reflects the animals' poor ability to convert feed into muscle, thereby significantly increasing production costs.

Thus, substituting fish meal with chicken head meal at a certain level can still maintain feed efficiency and remain economically viable. However, at excessively high substitution levels, feed efficiency tends to decline, leading to increased feed costs and a decrease in the IOFC value.

CONCLUSION

Based on the background and description of the research results, it can be concluded that substituting fish meal with chicken head meal at various levels has a highly significant effect ($P <$

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0.01) on feed intake, body weight gain, feed conversion ratio, and income over feed cost for KUB chickens. Furthermore, substituting fish meal with chicken head meal had a significant effect ($P < 0.05$) on the cholesterol content of the meat but no significant effect ($P > 0.05$) on the fat content of KUB chicken meat.

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