



The Effects of Replacing Fish Meal with Skipjack Tuna Offal Meal on the Growth Performance and Carcase Quality OF Local Chickens

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Abstract | The aim of this research was to evaluate the impact of using steamed skipjack fish offal meal (SSFO) as a substitute for fishmeal in feed on the production performance and carcass quality of local chickens. The research method was a field experiment with a completely randomized design (CRD) with 5 treatments and 5 replications, resulting in 25 treatment units. A total of 25 pen units, each measuring 1 m × 0.5 m × 0.5 m, were used. Each pen was equipped with a feed and water bunk, and 250-day-old chicks (DOCs) of local chickens were used to assess body weight variability and were randomly assigned to the prepared pen units. During the experiment, the temperature ranged from 32°C in the first few weeks and was reduced to 27°C, with a humidity ranging from 77–78%. The treatments were as follows: T0 (10% fish meal + 0% SSFO in feed); T1 (7.5% fish meal + 2.5% SSFO in feed); T2 (5% fish meal + 5% SSFO in feed); T3 (2.5% fish meal + 7.5% SSFO in feed); and T4 (0% fish meal + 10% SSFO in feed). The observed variables were feed consumption, body weight gain, feed conversion, IOFC value, carcass weight, carcass percentage, meat protein content, and meat fat content of local chickens. The results indicated that substituting fish meal with SSFO significantly increased the final body weight and carcass weight ($P < 0.01$) while reducing the feed conversion ratio ($P < 0.01$). The best performance was observed with the T2 treatment (5% SSFO in feed). These findings suggest that SSFO can effectively replace up to 5% of fish meal in poultry feed, offering a cost-effective alternative that could reduce feed costs and increase profitability in the poultry industry. Furthermore, the use of SSFO, a byproduct, promotes sustainability and resource efficiency within the industry.

Keywords | Carcase quality, Growth performance, Local chicken, Skipjack tuna

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INTRODUCTION

Local chickens are usually bred in the backyards of rural households, often in small quantities of approximately 24 hens, primarily for egg production (Laihad *et al.*, 2019).

Some farmers rear native chickens for meat consumption, bartering, or selling, providing an extra income source for the household. Experts note that the population of native chickens in the country remains comparable to that of hybrid or commercially bred stocks (Laihad *et al.*, 2019). In

the poultry industry, reducing the import of feed ingredients serves as a method to decrease greenhouse gas emissions, as sea freight is a significant contributor to these emissions (Adli *et al.*, 2020; Sjofan *et al.*, 2021; Sohn and Ohshima, 2010). Indonesia imported approximately 115.2 thousand tonnes of fish meal, along with approximately 268.3 thousand metric tonnes of fisheries products (Stamista, 2023). According to data from the Central Statistics Agency (BPS) for Gorontalo Province, the production of skipjack tuna catches reached 13,333 tonnes in 2020, compared with 147.25 tonnes in 2017.

Skipjack fish offal, consisting of the intestines, stomach, liver, heart, lungs, and eggs, is a byproduct of skipjack fish (*Katsuwonus pelamis*) processing. This offal has considerable potential due to its nutrient content, which is beneficial for poultry. Zainudin *et al.* (2024) reported that steamed skipjack-offal meal consists of 18.24% protein, 6.71% fat, 5.99% crude fibre, 2826.80 kcal/kg metabolizable energy, 0.79% calcium, and 0.29% phosphorus. In Gorontalo, skipjack fish offal is abundantly produced and readily available. However, its drawback is that it spoils quickly, making it less suitable for direct use in livestock feed. The use of skipjack fish offal in native chicken feed is still limited, with varying results in some studies. Therefore, there is a need to address specific gaps regarding the optimal inclusion levels of this offal in feed to increase production performance and carcass quality. The hypothesis of this study is that incorporating steamed skipjack fish offal at specific levels can improve the production performance and carcass quality of local chickens. The aim of this research was to evaluate the optimal level of processed skipjack fish as an alternative feed ingredient to replace fish meal in feed, thereby enhancing the production performance and carcass quality of native chickens.

MATERIALS AND METHODS

ETHICAL APPROVAL

Ethical approval for the study was given by the Animal Care and Use Committee, University of Islam Kalimantan Muhammad Arsyad Al Banjary, No. 2-KEP-UNISKA. PPJ-2024. The approval outlined several key measures to ensure animal welfare beyond basic housing and feeding. These included health monitoring. Regular health checks were conducted to monitor the wellbeing of the chickens throughout the study. Environmental enrichment: Measures were taken to provide a stimulating environment for the chickens, including appropriate lighting, ventilation, and space to allow for natural behaviours. Stress Minimization: Efforts were made to minimize stress, such as reducing noise levels and handling the chickens gently during the study. Humane Endpoints: Clear criteria were established for humane endpoints to ensure that any chickens showing signs of severe distress or illness would be promptly and

humanely euthanized. Veterinary Care: Access to veterinary care was available to address any health issues that arose during the study. Training for Personnel: All personnel involved in the study received training on proper animal handling and welfare practices to ensure humane treatment of the chickens. These measures were designed to ensure that the study adhered to high standards of animal welfare and ethical research practices.

EXPERIMENTAL DESIGN

FEEDING PROGRAM: T0 (10% fish meal + 0% SSFO in feed); T1 (7.5% fish meal + 2.5% SSFO in feed); T2 (5% fish meal + 5% SSFO in feed); T3 (2.5% fish meal + 7.5% SSFO in feed); and T4 (0% fish meal + 10% SSFO in feed). The chicken feed formulation was formulated following the AOAC (2005) method and included maize, rice bran, soybean meal, fish meal, premix, and CaCo3, as presented in Table 1 and 2.

Table 1: Nutrient Composition of formulated feed for 2-5 weeks.

	T0	T1	T2	T3	T4
Nutrient Composition (%)					
Maize	51.00	51.00	51.00	51.00	51.00
Soya Bean Meal	19.50	19.50	19.50	19.50	19.50
Rice Bran	17.50	17.50	17.50	17.50	17.50
Fish Meal	10.00	7.50	5.00	2.50	0.00
Steamed skipjack tuna offal meal	0.00	2.50	5.00	7.50	10.00
Limestone	1.00	1.00	1.00	1.00	1.00
Premix	1.00	1.00	1.00	1.00	1.00
	100.00	100.00	100.00	100.00	100.00
Proximate composition					
CP	20.10	20.32	20.54	20.75	20.97
Fat	3.29	3.29	3.28	3.28	3.27
CF	6.37	6.52	6.68	6.83	6.99
Ca	0.99	0.89	0.80	0.70	0.61
P	0.50	0.47	0.44	0.40	0.37
ME (Kcal / Kg)	2904.87	2939.81	2974.76	3009.71	3044.65

CP: crude protein; CF: crude fat; GE: gross energy; Nutritional content of ingredients was analyzed at the animal feed and chemistry laboratory, faculty of animal husbandry, hasanuddin university, unhas, makasar.

A total of 25 pen units, each measuring 1 m × 0.5 m × 0.5 m, were used. Each pen was equipped with a feed and water container. The pens and feeding equipment are cleaned and disinfected beforehand. Each pen unit is labelled according to the treatment and fitted with an electric bulb for heating. To assess body weight variability, a total of 250-day-old chicken (DOC) local chickens were randomly assigned to the prepared pen units (Figure 1). The experimental pens are placed inside a closed building equipped with lighting and heating. Each pen unit is labelled according to the type

of feed given. Thermometers and hygrometers are installed in the building to measure the temperature and humidity. During the experiment, the temperature ranged from 32°C in the first few weeks and was reduced to 27°C, with a humidity ranging from 77–78%. From the first day, the livestock were given the treatment feed so that the effects could be observed from the beginning. Feed and water were provided twice daily at 07:00 and 15:00 WITA on an *ad libitum* basis. Observations were made from the first day until the 60th day. Vaccinations are administered at 4 and 21 days to prevent Newcastle disease (ND) or tetelo, and Gumboro vaccination is given at 14 days.

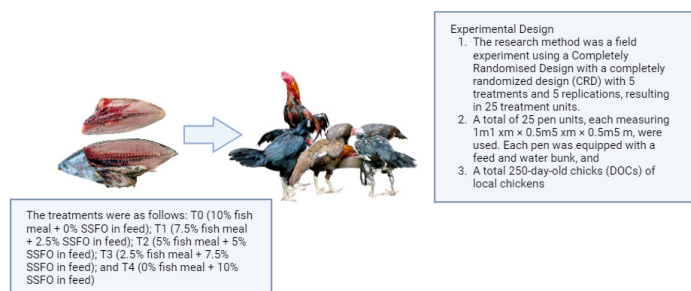


Figure 1: The experimental design of the effects of replacing fish meal with skipjack tuna offal meal on the growth performance and carcass quality of local chickens.

SKIPJACK TUNA OFFAL MEAL PREPARATION: The processing of skipjack tuna is carried out at the Integrated Laboratory of the Faculty of Agriculture, Gorontalo State University (UNG). The samples were procured from local markets situated in Gorontalo. Specifically, only large, reputable stores were selected for sampling. First, the processing procedure involves cleaning 1 kg of fresh skipjack tuna innards with running water, draining them, and then cutting them into small particles.

Fresh skipjack tuna innards were steamed in boiling water (100°C) for 30 minutes, followed by drying under the sun for 2–3 days. After that, the samples were placed in an oven at 60–70°C for 8 hours if weather conditions were needed. After drying, they are ground into flour via a grinding mill.

GROWTH PERFORMANCE AND CARCASS QUALITY

The body weight gain (BWG) of local chickens was determined by the difference in weight between the initial and subsequent weeks. The feed intake was routinely calculated by measuring the difference between the feed offered to the ducks and the remaining feed each week, accounting for any mortalities within the current experiment. The feed conversion ratio (FCR) was determined by dividing the feed intake by the body weight gain of the local chickens during the experiment. Mortalities were recorded per pen and expressed as a percentage from the beginning to the end of the experiment (Sjofjan *et al.*, 2021).

At the end of the study, 75 native chickens aged 60 days from each treatment group were randomly selected and slaughtered to collect data on carcass quality, meat quality, and internal organs. Samples of the pectoral major muscle (breast meat) are cut into cubes measuring 2x2x1 cm for analysis of meat protein content and meat fat content. After processing, the remaining carcass was weighed. This should include the meat, skin, and bones but exclude the organs, head, feet, and feathers. The carcass percentage is determined by dividing the weight of the processed chicken (meat, skin, and bones) by the weight of the chicken before slaughter and then multiplying by 100. Moreover, the breast meat percentage was calculated as the weight of the breast meat divided by the weight of the processed chicken carcass multiplied by 100 (Soren and Biswas, 2020).

Table 2: Nutrient Composition of formulated feed for 2-5 weeks.

	T0	T1	T2	T3	T4
Nutrient Composition (%)					
Maize	57.00	57.00	57.00	57.00	57.00
Soya Bean Meal	13.50	13.50	13.50	13.50	13.50
Rice Bran	17.50	17.50	17.50	17.50	17.50
Fish Meal	10.00	7.50	5.00	2.50	0.00
Steamed skipjack tuna offal meal	0.00	2.50	5.00	7.50	10.00
Limestone	1.00	1.00	1.00	1.00	1.00
Premix	1.00	1.00	1.00	1.00	1.00
	100.00	100.00	100.00	100.00	100.00
Proximate composition					
CP	18.14	18.36	18.57	18.79	19.01
Fat	3.09	3.09	3.08	3.08	3.07
CF	6.31	6.46	6.62	6.62	6.93
Ca	0.98	0.88	0.79	0.79	0.59
P	0.48	0.44	0.41	0.41	0.34
ME (Kcal / Kg)	2901.81	2936.75	2971.70	3006.65	3041.59

CP: crude protein; **CF:** crude fat; **GE:** gross energy; Nutritional content of ingredients was analyzed at the animal feed and chemistry laboratory, faculty of animal husbandry, hasanuddin university, unhas, makasar.

Therefore, the protein content of meat is determined on the basis of the total nitrogen content via the wet chemical (Kjeldahl) method (Soren and Biswas, 2020). Proteins contain approximately 16% nitrogen on average, leading to the use of the calculation $N \times 6.25$ ($1/0.16 = 6.25$) to convert nitrogen content into protein content. A factor of 6.25 was also employed to convert the total nitrogen in the meat to the total protein content of the meat. The Kjeldahl method involves a digestion step where nitrogen is converted into ammonium (NH_4^+) and an analytical step where NH_4^+ is quantified via titrimetry, colorimetry, or an ion-specific electrode (Soren and Biswas, 2020). Moreover, the fat con

Table 3: The effects of replacing fish meal with skipjack tuna offal meal on the growth performance of local chickens.

Parameters	Treatments				
	T0	T1	T2	T3	T4
Feed intake (g/head)	1747.64 ^b	1747.46 ^b	1725.06 ^b	1661.86 ^a	1623.97 ^a
Body weight (g/head)	434.99 ^b	465.18 ^c	482.08 ^d	435.04 ^b	432.38 ^a
Feed conversion ratio (FCR)	4.02 ^c	3.76 ^b	3.58 ^a	3.82 ^b	3.76 ^b
IOFC (IDR)	11.302,82	12.862,43	13.959,66	12.607,55	12.937,28

tent of the meat was determined via Soxhlet extraction. During this process, the solvent accumulated in the extraction chamber for 5–10 minutes, completely surrounding the sample, before being siphoned back into the boiling flask. The fat content is measured either by the weight loss of the sample or by the weight of the fat extracted (Soren and Biswas, 2020).

STATISTICAL ANALYSIS

The first experiment utilized descriptive analysis, whereas the second experiment focused on digestibility and employed statistical analysis via analysis of variance via GraphPad 9.5.1, with errors depicted as the standard error of the mean (SEM). The probability values were subsequently subjected to the Duncan multiple range test. The applied model is adapted from Ardiansyah *et al.* (2022).

$$Y_{ij} = \mu + T_i + e_{ij}$$

Where;

Y_{ij} : represents the observed parameters.

μ : is the overall mean.

T_i : indicates the difference in skipjack tuna meal effects.

e_{ij} : is the error term.

The treatments were as follows: T0 (basal feed), T1 (basal feed with 10% fresh skipjack tuna offal meal), T2 (basal feed with 10% steamed skipjack tuna offal meal), and T3 (basal feed with 10% fermented skipjack tuna offal meal). To compare the means of nutrient digestibility, one-way analysis of variance (ANOVA) was used, with a significance threshold of $p < 0.05$. The analysis involved six replications, and significance was determined at the 5% level ($p < 0.05$). The probability values were subsequently subjected to the Duncan multiple range test (DMRT).

RESULTS AND DISCUSSION

EFFECTS OF TREATMENTS ON THE GROWTH PERFORMANCE OF LOCAL CHICKENS

The average feed intake of local chickens during the study is presented in Table 3 and ranged from approximately 1623.97 g/bird to 1747.64 g/bird. The analysis of variance indicated that the use of steamed skipjack fish offal meal as a substitute for fish meal in the feed significantly differed ($P < 0.01$) in terms of the feed intake of local chickens.

The highest feed intake was observed in the T0 treatment (1747.64 g/bird), which was not significantly different from that in the T1 (1747.46 g/bird) and T2 (1725.06 g/bird) treatments (Figure 1). Duncan's multiple range test indicated that substituting fish meal with 2.5% (T1) and 5% (T2) processed steamed skipjack fish offal meal did not significantly differ from the control, although there was a tendency for feed consumption to decrease as the level of processed steamed skipjack fish offal meal increased. Compared with T0, T1, and T2, replacing fish meal with 7.5% (T3) and 10% (T4) processed steamed skipjack fish meal significantly reduced feed intake. By using Duncan's multiple range test, researchers were able to determine which specific levels of skipjack offal fish meal substitution significantly affected feed intake, providing clear and actionable insights into the effectiveness of the different treatments.

The feed intake of chickens can be influenced by palatability, digestibility, and the nutritional composition of the feed, particularly the energy and protein contents. The processed steamed skip jack offal fish meal had a high protein content (60.70%) and gross energy (5694.00 kcal/kg), as well as a low crude fibre content (0.78%). Therefore, the use of processed steamed skip jackmeal can affect the nutritional composition of the feed, especially by increasing its protein and energy contents. Abdelfatah and Fargh (2016), reported that the maintenance of broiler chickens with coloured feed significantly affected body weight and weight gain. The analysis of variance results revealed that the inclusion of steamed skipjack fish offal meal as a replacement for fish meal in the feed had a significant effect ($P < 0.01$) on the body weight of local chickens. The highest average body weight was observed in T2 (482.08 g/bird), followed by T1 (465.18 g/bird), both of which were significantly greater than those in T0 (434.99 g/bird), T3 (435.04 g/bird), and T4 (432.38 g/bird) (Figure 2).

The analysis of variance results revealed that the inclusion of steamed skipjack fish offal meal as a replacement for fish meal in the feed significantly ($P < 0.01$) reduced the feed conversion ratio (FCR) compared with that of the control feed (T0) (Figure 3). These findings indicate that the use of steamed skipjack fish offal meal is more efficient than the use of the control feed (T0). As shown in Table 3, the FCR varied, with T2 having the lowest value (3.58) among the treatments, suggesting that the optimal level of steamed

skipjack fish offal meal is 5%. Increasing the level of steamed skipjack fish offal meal to 7.5% and 10% increased the FCR. The high FCR observed in this study is likely influenced by the environmental temperature at the research location, Gorontalo, where temperatures range from 23–33°C and sometimes reach 34–35°C. It is believed that this high temperature affected the nutrients consumed by the chickens, which were predominantly used for maintenance rather than production due to heat stress. Compared with the results of the study by Ologhobo *et al.* (2012), the use of offal meal did not significantly differ among the treatments and the controls.

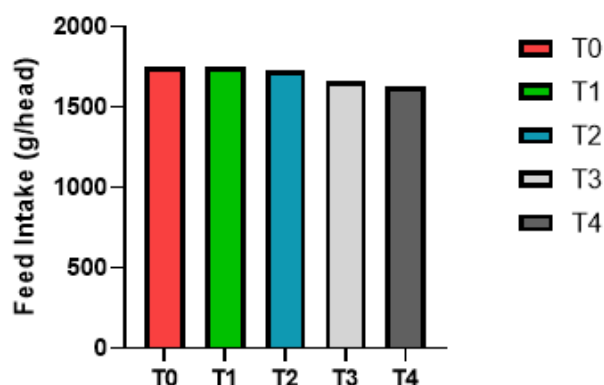


Figure 2: The effects of replacing fish meal with skipjack tuna offal meal on the feed intake of local chickens; **T0:** (10% fish meal + 0% SSFO in feed); **T1:** (7.5% fish meal + 2.5% SSFO in feed); **T2:** (5% fish meal + 5% SSFO in feed); **T3:** (2.5% fish meal + 7.5% SSFO in feed); **T4:** (0% fish meal + 10% SSFO in feed).

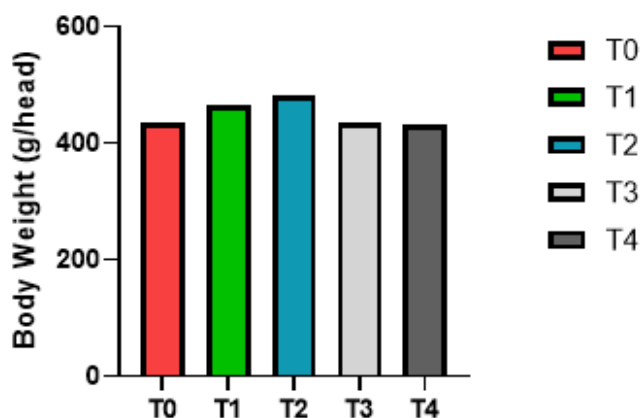


Figure 3: The effects of replacing fish meal with skipjack tuna offal meal on the body weight of local chickens; **T0:** (10% fish meal + 0% SSFO in feed); **T1:** (7.5% fish meal + 2.5% SSFO in feed); **T2:** (5% fish meal + 5% SSFO in feed); **T3:** (2.5% fish meal + 7.5% SSFO in feed); **T4:** (0% fish meal + 10% SSFO in feed).

Bhaskar and Mahendrakar (2008), stated that an FCR not aligning with standard values might be due to the feed consumed being used more for maintaining body temperature in response to the environmental temperature rather than

for production. The FCR obtained in this study (approximately 3.58–3.82) was lower than the results reported by Eleroğlu *et al.* (2013), who studied native chickens fed skipjack fish offal meal, with an FCR ranging from approximately 6.91–7.39. A lower FCR indicates better feed efficiency, whereas a higher FCR suggests that more feed is needed. The use of steamed skipjack fish offal meal at levels of 2.5%–10% in the feed was more efficient than the use of feeds containing fish meal or skipjack fish waste meal. Moreover, Leke *et al.* (2015a) reported that the method of processing skipjack tuna offal meal significantly affects ($P < 0.01$) weight gain. Compared with the control and boiling methods, the steaming method of processing skipjack fish waste results in greater weight gain, as it enhances the availability of nutrients in the broiler chickens digestive tract. Weight gain is closely related to both the quantity and quality of the feed. Quality is linked to feed consumption, and any disruption in feed consumption will adversely affect growth (Leke *et al.*, 2015b). In addition, a study by Kim *et al.* (2012) reported that incorporating up to 6% tuna fish silage in the diet had no significant effects. The optimal results were observed at 4% tuna fish silage, particularly in terms of final body weight, carcass percentage, and meat protein conversion in broiler chickens. In contrast, a study by Bagau *et al.* (2016) in which fishbone skipjack from tuna fish was used did not successfully influence the growth performance of laying hens.

EFFECTS OF TREATMENTS ON THE CARCASE QUALITY OF LOCAL CHICKENS

The analysis of variance results indicate that the provision of steamed skipjack fish offal meal as a replacement for fish meal in feed had a significant effect ($P < 0.01$) on carcass weight (Table 4). This means that the use of 2.5%–10% steamed skipjack fish offal meal in the feed results in differences in the carcass weights of chickens. According to Duncan's multiple range test, carcass weight was significantly greater in the T2 treatment group (352.27 g/bird) than in the T0 (311.72 g/bird), T3 (322.53 g/bird), and T4 (312.93 g/bird) groups (Figure 4). Furthermore, the carcass weight was significantly lower in the T0 and T4 groups than in the other groups, and the carcass weight did not differ significantly from that in the T3 group. The use of 2.5%–10% steamed skipjack fish offal meal increased the protein and energy contents of the feed. The protein and energy contents of the feed affect feed consumption in chickens. High protein content in feed increases feed consumption, leading to increased body weights. Conversely, chickens will limit their feeding activity if the feed contains high energy. High protein-energy concentrations in the feed do not always improve weight gain, and similarly, feed with low protein-energy concentrations cannot support maximal weight gain owing to limitations in meeting protein-energy requirements (Kezhavars and Austic, 2004). As expected, the muscle fillet lost mass during heating.

Table 4: The effects of replacing fish meal with skipjack tuna offal meal on the carcass of local chickens.

Parameters	Treatments				
	T0	T1	T2	T3	T4
Carcase weight (g/head)	311.72 ^a	336.80 ^{bc}	352.27 ^c	322.53 ^{ab}	312.93 ^a
Carcase Percentage (%)	62.81 ^{ab}	64.95 ^b	65.06 ^b	62.41 ^a	62.36 ^a
Breast meat (g/head)	83.23 ^a	87.13 ^{ab}	92.67 ^b	84.07 ^a	81.73 ^a
Breast meat percentage (%)	26.88	25.86	26.41	26.23	26.13
Protein meat(%)	22.01 ^a	22.07 ^a	21.46 ^a	21.57 ^a	20.94 ^a
Fat meat (%)	5.25 ^a	4.36 ^b	4.70 ^{ab}	4.77 ^{ab}	5.47 ^a

G: gram; **IDR:** Indonesia rupiah; **IOFC:** income over feed cost; **T0:** (10% fish meal + 0% SSFO in feed); **T1:** (7.5% fish meal + 2.5% SSFO in feed); **T2:** (5% fish meal + 5% SSFO in feed); **T3:** (2.5% fish meal + 7.5% SSFO in feed); **T4:** (0% fish meal + 10% SSFO in feed).

The rates of mass change over time were calculated to understand the effects of cooking temperature on muscle changes (Bell *et al.*, 2001).

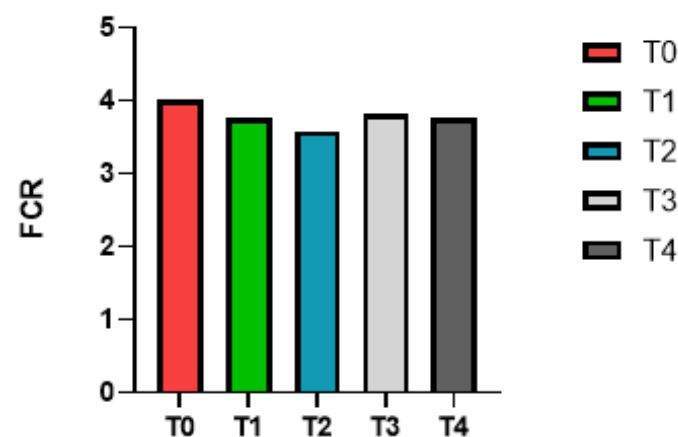


Figure 4: The effects of replacing fish meal with skipjack tuna offal meal on the FCR of local chickens; **T0:** (10% fish meal + 0% SSFO in feed); **T1:** (7.5% fish meal + 2.5% SSFO in feed); **T2:** (5% fish meal + 5% SSFO in feed); **T3:** (2.5% fish meal + 7.5% SSFO in feed); **T4:** (0% fish meal + 10% SSFO in feed).

The analysis of variance results indicate that the use of steamed skipjack fish offal meal as a substitute for fish meal in feed significantly affects ($P < 0.05$) the percentage of free-range chickens. Duncan's multiple range test revealed that the carcass percentage in the T1 (64.95%) and T2 (65.06%) treatments, which contained 2.5% and 5% steamed skipjack fish offal meal, respectively, was significantly greater ($P < 0.05$) than that in the control treatment (T0) (Table 4) (Figure 5). However, there was no significant difference between T1 and T0. The percentage of carcasses in treatments T3 (62.41%) and T4 (62.36%), which contained 7.5% and 10% steamed skipjack fish offal meal, respectively, was significantly lower ($P < 0.05$) than that in T2, but both treatments (T3, T4) were not significantly different from or relatively similar to T0 (Table 4) and Figure 6. The variation in carcass percentage can be influenced by carcass weight, as each treatment's carcass percentage

aligns with the achieved carcass weight. Additionally, the carcass percentage can be affected by handling during the slaughtering process, such as the removal of body parts such as the head, neck, feet, internal organs, feathers, and blood.

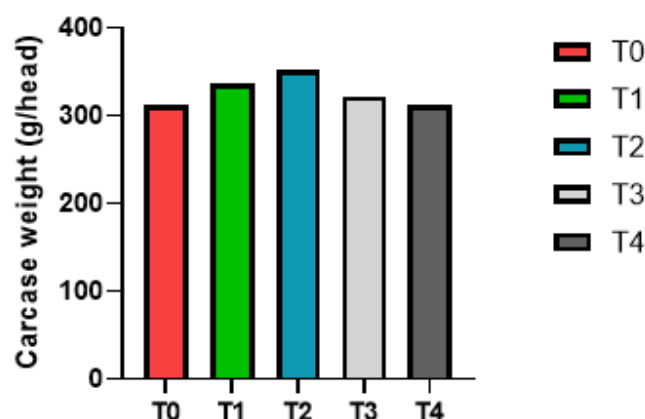


Figure 5: The effects of replacing fish meal with skipjack tuna offal meal on the carcass weight of local chickens; **T0:** (10% fish meal + 0% SSFO in feed); **T1:** (7.5% fish meal + 2.5% SSFO in feed); **T2:** (5% fish meal + 5% SSFO in feed); **T3:** (2.5% fish meal + 7.5% SSFO in feed); **T4:** (0% fish meal + 10% SSFO in feed).

The analysis of variance and Duncan's multiple range test results indicate that the use of steamed skipjack fish offal meal as a substitute for fish meal does not have a significant effect ($P > 0.05$) on the percentage of local chickens with breast carcass. These findings suggest that there are no significant differences or relatively similar results among the five treatments in terms of the percentage of breast carcasses. This lack of difference may be due to the chest muscle growth of the chickens in this study having already reached its maximum. However, the percentage of breast carcass in the treatment groups tended to be lower than that in the control group (T0) (Table 4). The variation in the breast carcass percentage is strongly influenced by the carcass weight; if the carcass weight is high, the breast

carcase percentage will also increase. The size of the breast carcass can be used as a measure to compare breast meat quality in chickens. The breast carcass percentage in this study ranged from 26.13% to 26.88%, which is higher than the results of Wang *et al.* (2009), who reported a breast muscle percentage of 18.8%, with a carcass percentage of 68.26% in Chinese free-range chickens. Compared with other carcass cuts, breast muscle is a standard indicator of successful broiler chicken rearing, as the breast carcass cut has the highest meat yield.

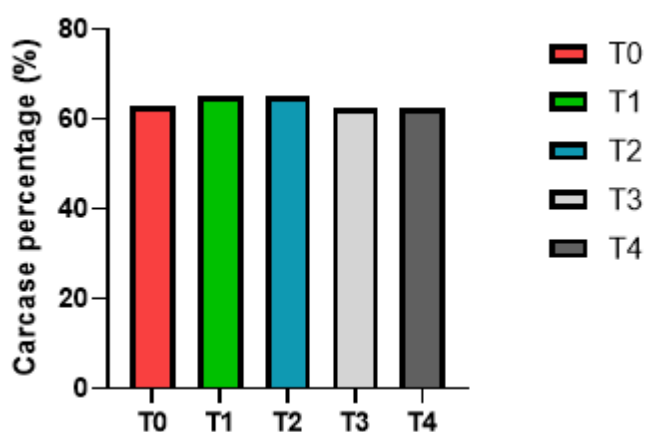


Figure 6: The effects of replacing fish meal with skipjack tuna offal meal on the carcass percentage of local chickens; **T0:** (10% fish meal + 0% SSFO in feed); **T1:** (7.5% fish meal + 2.5% SSFO in feed); **T2:** (5% fish meal + 5% SSFO in feed); **T3:** (2.5% fish meal + 7.5% SSFO in feed); **T4:** (0% fish meal + 10% SSFO in feed).

As shown in Table 4, the average protein content of the local chicken meat obtained in this study ranged from 20.95% to 22.07%. The analysis of variance revealed that replacing fish meal with skipjack tuna meal did not significantly affect ($P > 0.05$) the protein content of chicken breast meat. The use of 2.5% - 10% processed steamed skipjack fish offal meal in the feed (T1, T2, T3, T4) produced protein content in the breast meat comparable to that of the control feed (T0). The analysis of variance revealed a significant effect ($P < 0.05$) of using steamed skipjack fish meal as a substitute for fish meal in feed on the fat content of the breast meat of local chickens (Table 4). The average fat content of the chicken breast meat in this study ranged from 4.36% to 5.47%, which is within the normal range of 1.2–12% according to Aberle *et al.* (2001). Table 3 shows an increase in fat content with increasing levels of steamed skipjack fish offal meal in the feed (T1, T2, T3, and T4). However, this increase remained below that of the control feed (T0), except for that of treatment T4, which was numerically greater than that of T0. The increase in fat content is likely influenced by increased energy consumption. Compared with a single study from Lengkey *et al.* (2011), the average abdominal fat content

ranged from 1.85% to 1.92%. The highest abdominal fat content, 1.92%, was associated with the 6% skipjack tuna bone meal, whereas the lowest, 1.85%, was associated with R0, the basal diet without skipjack tuna bone meal. This finding indicates that adding skipjack tuna bone meal to rations increases the amount of abdominal fat in broilers (Lengkey *et al.*, 2011).

CONCLUSIONS AND RECOMMENDATIONS

This study demonstrated that steamed skipjack fish offal meal can be effectively used as a replacement for 5% fish meal in the feed of local chickens, positively influencing growth performance and tending to reduce the meat cholesterol content. Specifically, the inclusion of 5% processed steamed skipjack fish offal meal resulted in the highest average body weight (482.08 g/bird) and the lowest feed conversion ratio (FCR) (3.58), indicating optimal efficiency at this level. The findings also suggest significant economic and practical implications for poultry farming. By reducing reliance on traditional fish meal, which is often more expensive and less sustainable, farmers can lower feed costs and enhance sustainability. Additionally, the use of skipjack fish offal, a byproduct, promotes waste utilization, contributing to more environmentally friendly farming practices. Future research should explore additional treatment variations, long-term impacts, and validation of these findings across different environmental conditions and chicken breeds. It is also essential to investigate the effects of environmental factors, such as temperature, on nutrient utilization and overall performance. The high temperatures observed during the study period likely influenced feed efficiency due to heat stress, which warrants further investigation. In summary, steamed skipjack fish meal can replace 5% of the fishmeal in the feed of local chickens, providing both economic and environmental benefits. Further research should aim to validate these findings, explore broader applications, and optimize feed formulations for various poultry farming contexts.

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NOVELTY STATEMENT

The novelty of this research is the use of three treatments

of skipjack tuna fish on local chickens. There is a lack of information on this fish. This novel approach is quite applicable among developed countries.

AUTHOR'S CONTRIBUTIONS

Srisukmawati Zainudin played a role in collecting the data, conducting the nutritional analysis, analysing the data, and preparing the manuscript. Hartutik, Edhy Sudjarwo, and Osfar Sjofoan contributed to the design of the research, provided supervision, and participated in revising the manuscript. All the authors have read and approved the final version of the manuscript submitted to the journal.

CONFLICT OF INTEREST

No potential conflicts of interest relevant to this article are reported.

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