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Evaluating the Use of Marlin Fish (*Istiompax indica*) By-product Meal in the Ration on Carcass and Organ Yields of Broiler Chickens

Zulfan*, Muhammad Daud, Herawati Latif, Novia Khairunnisa, and Tantri Anggraini

Animal Husbandry Department, Faculty of Agriculture, Syiah Kuala University, Banda Aceh, 23111, Indonesia

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* Corresponding author:
E-mail: zulfan_pet@yahoo.co.id

ABSTRACT

This study aimed to examine the effect of marlin fish (*Istiompax indica*) byproduct meal (MFBM) mixed with some other feed ingredients such as yellow corn (YC), rice bran (RB), broken rice (BR), and top mix (TM) as a mixture feed (MF) in replacement fractionally a commercial ration (CR) on carcasses and organs of broiler chickens. As a comparison, commercial local fish meal (CLFM) was used instead of MFBM in the MF. A total of 100 DOCs, strain MB 202, were raised for 35 days of age to feed the experimental rations. The experimental rations were: CR= 100% CP511/512 (control), $MFBM_4$= 80% CP511/512 + 20% MF_1 containing 4% MFBM, $MFBM_8$= 80% CP511/512 + 20% MF_2 containing 8% MFBM, $CLFM_4$= 80% CP511/512 + 20% MF_3 containing 4% CLFM, and $CLFM_8$= 80% CP511/512 + 20% MF_4 containing 8% CLFM. The research used a completely randomized design (CRD) with five treatments, four replications, and two subsamples. Data were analyzed by Analysis of Variance (ANOVA) and continued by Duncan's multiple range taste (DMRT) only if the results detected a significant difference. This study showed that at 4% usage within the MF, using MFBM did not indicate a significant difference in the whole carcass and cuts-up weights than using CLFM. However, at the level of 8% within an MF, the former was significantly higher ($p<0.05$) on the whole carcass and breast weight than the latter. In conclusion, marlin fish byproduct meal (MFBM) could be used up to 8% to produce better whole carcass and breast weight compared to commercial local fish meal (CLFM) without adverse effects on the internal organs of broilers.

Keywords: Broiler, Carcass, Fish meal, Organs, Marlin (*Istiompax indica*)

Introduction

Fish meal is a common animal protein source in poultry. The protein in fish meal has a high biological value in animal rations. It is rich in essential amino acids (EAA), particularly lysine and sulfur amino acids, the major elements such as calcium, phosphorus, sodium chloride, and magnesium, and the trace elements such as iron, zinc, and selenium, as well as the B-group vitamins especially B and choline (Barlow, 2003). The pivotal role of fish meal in the ration is almost changeable. However, in recent years, fish meal has been limited in broiler rations due to less uniformity and higher cost relative to plant sources (Frempong *et al.*, 2019). Providing fish meals at a lower price may be possible by exploring the raw materials available locally in extraordinary numbers and continuity. Therefore, looking for an alternative fish meal at a lower price may be a good choice for small farmers to replace the role of commercial fish meal within their broiler feed.

There are numerous fish-cutting byproducts generated from traditional fish markets and commonly discarded, causing increased environmental pollutants. They are composed of miscellaneous fish species, and principally cut residuals still contain high nutrition. These are potential raw sources for making fish meal. Fish byproducts such as viscera, fins, head, and skin contain protein, vitamins, and minerals, so these can be utilized as a feed supplement in the ration (Afreen and Ucak, 2020). According to Petricolena (2014), the chemical composition of fish highly varies among species and from one individual fish to another. Hence, it is better to separate them into specific species to produce fish meals of relatively constant quality.

Most earlier studies reported that fish byproduct meals from a single fish species contained high protein and supported bird performance and carcass. In their study, Miranti *et al.* (2019) reported fish waste (head and bone) of *Sardinella lemuru* meal had 40.68±0.42% protein. Zulfan *et al.* (2020; 2022) reported a *leubim* fish (*Canthidermis maculata*) waste meal (LFWM) had 49.24% protein in the whole discards, 55.84% in the discard without skin, and 46.72% in its skin. All parts of the waste can be included in fish meal, and their use in the rations improves broiler carcass without adverse effects on the broiler's internal organs. Another fish species mostly available in traditional fish markets is marlin fish.

The black marlin (*Istiompax indica*) is a fish species found in the warm waters of the Indian and Pacific Oceans (Whitehouse, 2020). Marlin is one of the biggest size fish and is commonly sold in traditional fish markets in cuts-up rather than in the whole fish, causing loads of inedible parts. So far, we have not found studies using marlin byproduct fish meal (MFBM) in broiler rations. This disposal likely has a better replacement for commercial fish meal utilization in the poultry rations to produce broiler carcasses at lower feed cost. Internal organs were fundamentally thought about as functions because they were highly influenced by what the birds eat. Tough digest and any possible poisons contained in the feed ingredients can cause either enlargement or deterioration of internal organs, which was unexpected. Since marline wastes were collected from the leftovers of fish markets, they were susceptible to pollution. Therefore, this study aimed to examine the effect of using marlin fish by-product meal (MFBM) in replacing commercial local fish meal (CLFM) within broiler rations on carcass and non-carcass broilers. This study is expected to explore the high presence of fish waste originating from traditional fish markets to serve an alternative fish meal at a lower price, safely use it in the ration, and reduce pollutants.

Materials and Methods

Materials and equipment

This research used 100 broiler chicks, strain MB 202 unsex, merchandized by PT Japfa, North Sumatera ordered through PT Indojaya Agrinusa, Aceh Besar. Broiler commercial rations of CP511 and CP512 fabricated by PT Charoen Pokhpand, North Sumatera, were used as basal rations. Feed ingredients composted to mixture feed (MF) consisted of broken rice (BR), yellow corn (YC), top mix (TM), rice bran (RB), commercial local fish meal (CLFM), and marlin fish byproduct meal (MFBM). The feed ingredients were bought from Poultry Shop Tungkop, Aceh Besar, and the CLFM from DA Shop, while the MFBM was self-produced in this study. Other materials were disinfectant agents, litter, lime, ND and IBD vaccines, vita chicks, vita stress, and medicines such as neobro and Trimezyn-s.

This research established twenty experimental units with a size of 100 x 100 cm per unit, each completed by a heating lamp, drinker, and feeder. The equipment processing marlin by-products was a scale, pan, stove, dryer, and disk mill. Collecting carcasses and organs of broilers were equipped with killing cones, processing knives, bone scissors, a scalder, a de-feathering machine, scales, and a chiller.

The trial rations

The commercial rations of CP511 (starter) and CP512 (finisher) were used as base rations. The control (CR) was feeding the broiler with 100% CR. The trials substituted 20% of the CR with mixture feeds, including 4 and 8% of marlin fish by-product meal, to perform the $MFBM_4$ and $MFBM_8$ rations. As a comparison with the MFBM, commercial local fish meal (CLFM) was used at the same level as the MFBM usage to perform the $CLFM_4$ and $CLFM_8$. Each $MFBM_4$ and $CLFM_4$ were mixed with 5% YC+ 5.5% BR + 5% RB + 0.5% TM, and each $MFBM_8$ and $CLFM_8$ were mixed with 2.5% YC+ 6.5% BR + 2.5% RB + 0.5% TM to reach 20% mixture feeds each. The nutritional requirements of the trial rations were kept under the recommendation of the NRC (1994). The feed composition and nutrient contents of the trial rations are given in Table 1, and the nutrient contents of MFBM and CLFM are given in Table 2.

The trial rations were constituted as follows:

CR = 100% commercial CP511/512 (control)

$MFBM_4$ = 80% CP511/512 + 20% MF_1 (15.0% YC + 5.5% BR + 5.0% RB + 0.5% TM + 4.0% MFBM)

Table 1. Feed composition and nutrient contents of experimental rations

Feed ingredients	0−3 weeks (Starter)					3−5 weeks (Grower/Finisher)				
	CR	$MFBM_4$	$MFBM_8$	$CLFM_4$	$CLFM_8$		$MFBM_4$	$MFBM_8$	$CLFM_4$	$CLFM_8$
			--- (%) ---					--- (%) ---		
CP511[1]	100	80.00	80.00	80.00	80.00	0.00	0.00	0.00	0.00	0.00
CP512[1]	0.00	0.00	0.00	0.00	0.00	100	80.00	80.00	80.00	80.00
Yellow corn[2]	0.00	5.00	2.50	5.00	2.50	0.00	5.00	2.50	5.00	2.50
Broken rice[2]	0.00	5.50	6.50	5.50	6.50	0.00	5.50	6.50	5.50	6.50
Rice bran[2]	0.00	5.00	2.50	5.00	2.50	0.00	5.00	2.50	5.00	2.50
Top mix	0.00	0.50	0.50	0.50	0.50	0.00	0.50	0.50	0.50	0.50
MFBM[3]	0.00	4.00	8.00	0.00	0.00	0.00	4.00	8.00	0.00	0.00
CLFM[4]	0.00	0.00	0.00	4.00	8.00	0.00	0.00	0.00	4.00	8.00
Total	100	100	100	100	100	100	100	100	100	100
Nutrient contents based on computation										
Protein (%)	22.00	21.59	23.29	21.23	22.58	20.00	19.99	21.69	19.63	20.98
Crude fat (%)	5.00	5.59	5.62	5.43	5.28	5.00	5.59	5.62	5.43	5.28
Crude fiber (%)	5.00	4.91	4.96	4.97	4.77	5.00	4.91	4.96	4.97	4.77
Ca (%) (min)	0.90	1.02	1.31	0.83	0.92	0.90	1.02	1.31	0.83	0.92
P (%) (min)	0.60	0.72	0.82	0.77	0.91	0.60	0.72	0.82	0.77	0.91

[1]Marked label CP 511 Bravo: 21-23% protein, 5% crude fat, 5% crude fiber, 0.9% Ca, and 0.6% P; CP 512 Bravo: 19-21% protein, 5% crude fat, 5% crude fiber, 0.9% Ca, and 0.6%.
[2]Hartadi *et al.* (2005).
[3]Laboratory of Balai Standarisasi dan Pelayanan Jasa Industri (BSPJI) Banda Aceh, 2023.
[4]Utomo *et al.* (2013) for crude fat and crude fiber; DA Shop for protein; and Sihite (2013) for Ca and P.

Table 2. Nutrient contents of MFBM and CLFM

Nutrients	Marlin fish byproduct meal (MFBM)[1]	Commercial local fish meal (CLFM)[2]
Crude protein (%)	46.13	55.00[2a]
Crude fiber (%)	1.61	2.98[2b]
Crude fat (%)	10.78	6.54[2b]
Ca (%)	7.26	2.46[2c]
P (%)	3.41	4.60[2c]

[1]Laboratory of Balai Standarisasi dan Pelayanan Jasa Industri (BSPJI) Banda Aceh, 2023.
[2]a= DA Shop; b= Utomo *et al.* (2013); c= Sihite (2013).

$MFBM_8$ = 80% CP511/512 + 20% MF_2 (2.5% YC + 6.5% BR + 2.5% RB + 0.5% TM + 8.0% MFBM)
$CLFM_4$ = 80% CP511/512 + 20% MF_3 (5.0% YC + 5.5% BR + 5.0% RB + 0.5% TM + 4.0% CLFM)
$CLFM_8$ = 80% CP511/512 + 20% MF_4 (2.5% YC + 6.5% BR + 2.5% RB + 0.5% TM + 8.0% CLFM)

Experimental design

This study was established into a Completely Randomized Design with Sub-sampling consisting of 5 treatments, four replications, and two subsamples. Replication was an experimental unit, living five birds each. A mathematic model for this study was $Y_{ijk}= \mu + \tau_i + \varepsilon_{ij} + d_{ijk}$ in which Y_{ijk}= observation value, μ= an overall mean, τ_i= an effect due to treatment, ε_{ij}= a sampling error, and d_{ijk}= a subsampling error (Steel and Torrie, 1991).

Research procedures

Preparation: a postal house and the equipment were cleaned and disinfected with disinfectant agents. The 20 pens, 1 x 1 m per unit, were established as experimental units, limed, and finally sowed the litter. Each unit was equipped with a brooder, a feeder, and a drinker, and then the house was left empty for two weeks. The experimental diets were prepared by formulating the diets. The commercial rations and feed ingredients were bought from a poultry shop, while MFBM was made by collecting the raw materials from traditional fish markets. The commercial rations CP511/512 were crumbled, and the feed mixture was mashed. Experimental diets were mixed weekly based on the composition of each treatment.

Feeding experimental rations: The chickens were fed experimental rations *ad libitum* by adding feed twice/day for up to five weeks. Drinking water was supplied *ad libitum* and replaced with clean water daily. Vita chicks were given 0-1 week and continued by vita stress 1-4 weeks. The ND vaccine was offered on the 3rd day via eye drops and repeated on the 21st day via intramuscular injection. The IBD vaccine was offered on the 12th day via mouth drops.

Collecting the data: At the end of the 35th day, all chickens were weighed to determine the average final body weight (FBW). Two chickens were taken from each experimental unit, and the criteria was that the average body weight was close to the average body weight of the experimental unit. The following process was slaughtering the chicken, bleeding, scalding, and de-feathering. Subsequently, the head, neck, and shanks were cut off, and the internal organs were pulled out of the chicken body cavity. Abdominal fat was removed and then weighed. The whole carcass was weighed, and then its parts were cut off, and each part (breast, wings, thighs, and back) was weighed. Internal organs (heart, liver, pancreas, and spleen) were released from attached tissues and weighed individually. The crop was cut off at the end of the esophagus and the base of the proventriculus. Afterward, the crop was emptied of its content and weighed. The gizzard was sliced to remove its content and then weighed. The intestine was cut out at the base of gizzard, cleaned its content, and weighed.

Procedures for making MFBM

The procedures for making MFBM were as follows: The components of unwanted marlin fish resulted from fish cuttings in Fish Market, Aceh Besar were gathered and then separated into two parts based on size. The bigger and more complex segments, such as tails, bones, and fins, were minimized up to 10 cm/piece and then remixed and rinsed with clean water. Afterward, all the materials were transferred into a pan containing hot water and heated for 30 minutes. The stuff was next dried while drained under sunrise and then moved into a dryer. The last step was to mill byproducts to become a marlin fish byproduct meal (MFBM). As much as 500 g of meal was sampled and posted to the Laboratory of Balai Standarisasi dan Pelayanan Jasa Industri (BSPJI) Banda Aceh to determine its nutrient contents.

Parameters

This study collected the parameters: weight and percentage of the whole carcass, commercial carcass parts, non-carcass external organs, internal organs, and abdominal fat. Every organ was weighed individually. The percentage of the whole carcass was obtained by dividing carcass weight by live weight (LW), and the percentages of commercial carcass parts were obtained by dividing the weight of each cut-up by the whole carcass weight. The percentage of every internal and external organ and abdominal fat was computed by dividing each organ's weight by LW.

Data analyses

The data were tabulated and then analyzed using Analysis of Variance (ANOVA). If the results of the ANOVA detected the treatments significantly affecting the parameter's, analyzing data was continued by a Duncan's Multiple Range Test (DMRT) to determine the significant differences among the treatments (Steel and Torrie, 1991).

Results and Discussion

Weight and percentage of the whole carcass

The weights and percentages of broiler's whole carcasses collected at the end of the fifth week of age of all treatments are shown in Table 3. The use of marlin fish byproduct meal (MFBM) mixed with broken rice (BR), yellow corn (YC), rice bran (RB), and top mix (TM) in the ration had a significant effect (p<0.05) on whole carcass weight of five-week-old broilers. The whole carcass weight of broilers fed the ration containing 8% MFBM ($MFBM_8$) was equivalent to that of those fed the 100% commercial ration (CR) but significantly higher than that of those fed the 8% CLFM ($CLFM_8$). At the level of 4% usage, both $MBFM_4$ and $CLFM_4$ base rations had an equal carcass weight. At the level above 4%, the CLFM base rations caused a reduced carcass weight compared to the CR, but it did not occur by the $MFBM_4$ evenly at the level of 8%, a carcass weight increased. It indicated that the MFBM was better than the CLFM to produce a higher carcass weight at the 8% usage.

The difference in carcass weight was due to the impact of live weight (LW) where the chickens fed the $MFBM_8$ and the CR had a significantly higher LW (p<0.05) than those fed the $CLFM_8$. This finding was associated with Jadhav *et al.* (2015), who say that, in general, carcass weight directly relates to LW in which carcass weight increases proportionally with increasing LW. Olawumi (2013) found a statistically significant (p<0.01) positive phenotypic correlation (r= 0.987) between live weight and carcass weight. Carcass weight from the broilers fed the $MFBM_8$ was 1,651 grams, which was higher than those fed *leubim* waste fish meal (LFWM) as reported by Zulfan *et al.* (2022), i.e. 1,487 grams because the LW of broilers achieved in the recent study was higher. The carcass and live weight of broilers at the end of the fifth week of age are described in Figure 1.

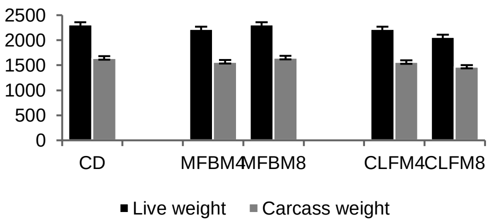

Figure 1. Live weights and whole carcass weights of broilers fed MFBM-based rations vs CLFM-based rations at 4% and 8% usage CR= control; $MFBM_4$= marlin fish byproduct meal 4%; $MFBM_8$= marlin fish byproduct meal 8%; $CLFM_4$= commercial local fish meal 4%; $CLFM_8$= commercial local fish meal 8%.

These results indicated that MFBM should have better nutritional content than the CLFM, even though its materials came from fish-cutting waste. The results of the analysis of the Center for Standardization & Industrial Services (BSPJI), Banda Aceh (2023) revealed 46.13% protein content in the MFBM that was not much different from the LFWM (49.24%) as reported by Zulfan *et al.* (2020) and was estimated to contain relatively good amino acids. This result agreed with Hendalia *et al.* (2019), who found that trash fish meal (TFM) has 43.77-45.81% crude protein and has complete essential amino acids, especially methionine. The same finding reported by Karimi (2006), the protein in fish meal contains high biological value in animal rations because it contains high levels of essential amino acids (EAA), especially lysine and methionine. The MFBM was also so palatable that birds' feed intake will furnish tremendous nutrients from the MFBM to support chicken growth.

Relative to LW, there was no significant difference (p>0.05) in carcass percentages among all treatments ranging from 70.31-71.37% because the increase in LW was linear with the increase in carcass weights of all groups. The carcass percentage of broilers fed the MBFM-based rations was equal to that of those fed the LFWM-based rations (71.41%) found by Zulfan *et al.* (2022). Substitution of partial commercial rations with MF composed of up to 8% MFBM produced a carcass percentage similar to the CR or the $CLFM_8$.

Commercial carcass parts

The weights and percentages of broiler's commercial carcass parts collected at the end of the fifth week for all treatments are shown in Table 4. ANOVA showed that the use of MBFM significantly affected (p<0.05) the weight of the broiler's carcass cuts-up, i.e., breast weight, while thigh, wing, and back weight had no significant effect (p>0.05). Broilers fed the ration containing 8% MFBM had significantly higher breast weight than those fed the 4% CLFM. Meanwhile, there was no significant difference in breast weight between the $CLFM_4$ and $CLFM_8$. The chickens from the 8% MFBM treatment had higher carcass weight than those from the 4% CLFM treatment. According to Olawumi (2013), there is a statistically significant (p<0.01) positive phenotypic correlation between live weight and the weights of carcass parts: breast (r= 0.889), thigh (r= 0.981), back (r= 0.964), and drumstick (r= 0.915). Then, carcass weight also has a significant positive phenotypic correlation with the weight of its parts: breast (r= 0.921), thigh (r= 0.957), back (r= 0.960), and drumstick (r= 0.921). The positive and significant

Table 3. The weights and percentages of whole carcasses of broilers

Live weight and whole carcass		CR	Marline fish byproduct meals		Commercial local fish meals	
			4% ($MFBM_4$)	8% ($MFBM_8$)	4% ($CLFM_4$)	8% ($CLFM_8$)
Live weight	(g)	2.311 ± 108.9^b	2.226 ± 141.4^b	2.314 ± 191.9^b	2.224 ± 126.1^b	2.064 ± 142.1^a
Whole carcass	(g)	1.645 ± 83.2^b	1.568 ± 92.7^{ab}	1.651 ± 137.4^b	1.563 ± 71.8^{ab}	1.470 ± 97.6^a
	(%)	71.20±1.49	70.45±1.03	71.37±2.10	70.31±2.17	71.21±1.54
Noncarcass	(g)	665.50±49.01	658.13±55.35	663.13±78.78	661.88±78.15	594.88±59.31
	(%)	28.80±1.49	29.55±1.03	28.63±2.10	29.69±2.17	28.79±1.54

[a,b] The numbers in the same row with different superscripts meant significant differences (P<0.05).

Table 4. Weights and percentages of cuts-up carcasses of broilers

Carcass parts		CR	Marline fish byproduct meals		Commercial local fish meals	
			4% ($MFBM_4$)	8% ($MFBM_8$)	4% ($CLFM_4$)	8% ($CLFM_8$)
Breast	(g)	$643.63±36.71^{b}$	$618.75±52.70^{ab}$	$657.50±80.62^{b}$	$585.63±19.54^{a}$	569.38±50.6
	(%)	39.15±1.66	39.44±1.87	39.75±2.36	37.52±1.29	38.71±1.73
Thighs	(g)	495.00±35.25	476.88±49.35	490.00±31.17	476.25±56.68	426.88±45.82
	(%)	30.11±1.77	30.43±2.89	29.78±2.21	30.45±2.91	29.00±1.62
Wings	(g)	172.13±19.97	154.38±16.35	175.00±14.39	168.13±9.61	160.63±15.68
	(%)	10.48±1.29	9.85±0.88	10.66±1.18	10.77±0.64	10.94±0.90
Back	(g)	334.25±49.89	317.50±43.51	328.75±52.29	332.50±49.93	312.63±36.23
	(%)	20.26±2.27	20.28±2.83	19.82±1.73	21.27±2.90	21.35±2.81

[a,b] The numbers in the same row with different superscripts meant significant differences (P<0.05).

correlated relationship between carcass traits and breast girth indicates that breast girth can be used as an indirect selection criterion for carcass traits in broiler chickens (Sam, 2019). Olawumi (2013), in his study, supposed this correlation could result from the pleiotropic effects of genes and linkage effects that operate on these traits.

The highest weight of commercial carcass parts was found in the broilers fed the $MFBM_8$ and those fed the control ration. It means that the MFBM was better than the CLFM in producing carcass cuts-up. The MFBM might contain the nutrients better than the CLFM. As reported by Hendalia *et al.* (2019), the trash fish is a potential source of protein and methionine. The head and bones of the marlin fish had attached meat, and the characteristics of its skin were soft and gelatinous. This agreed with Asrat *et al.* (2023), the eviscerated carcass yield, breast, and drum-thigh weight are significantly better (p<0.05) in FWM treatment groups compared to the control group. Naswa and Suprayitno (2019) studied salmon fish skin and found that this fish skin contains high glycine but low L-tyrosine. It was shown that the breast and thigh weights of the MFBM were higher than those of the CLFM. According to Scheuermann *et al.* (2003), genetic and gender-related variations in breast muscle yield of broiler chickens may be attributed to differences in the number and size of muscle cells (myofibers).

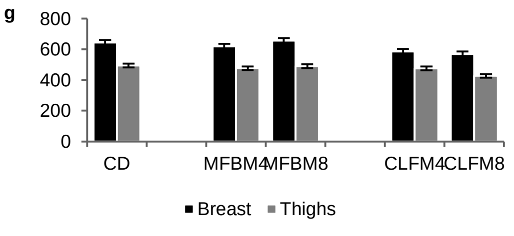

Figure 2. Breast and thigh weights of broilers fed MFBM-based rations and CLFM-based rations at 4% and 8% usage. CR= control; $MFBM_4$= marlin fish byproduct meal 4%; $MFBM_8$= marlin fish byproduct meal 8%; $CLFM_4$= commercial local fish meal 4%; $CLFM_8$= commercial local fish meal 8%.

The nutrients that exist in the MFBM could support the development of breast muscles. According to Wen *et al.* (2017), growth performance and breast muscle yield are very responsive to dietary methionine, especially in fast-growing broilers, and are often used to estimate the methionine requirement of broilers. Relative to the whole carcass, there was no significant difference (p>0.05) in the percentage of all cuts-up from all treatments. It indicated that employing either the MFBM or the CLFM did not reduce the percentage of cuts-up. It means that both MFBM and CLFM could convert feed into carcasses. The breast is the most valuable portion of the chicken carcass in the market. For this reason, the broiler industry is constantly interested in evaluating the performance of the commercially available strain cross, considering the weight and yield of the breast meat as the most important variables (Scheuermann *et al.*, 2003).

External organs

The weight and percentage of non-carcass external organs of broilers collected at the end of the fifth week of all treatments are presented in Table 5. ANOVA indicated using MFBM mixed with BR, YC, RB, and TM had no significant effect (p>0.05) on the weight and percentage of feathers, head, neck, and shanks of broilers. There were no significant differences in the weights and percentages of these external organs of broilers fed the commercial rations partially substituted with MF containing the MFBM or CLFM. Employing the MFBM in the ration did not produce a broiler with significantly higher non-carcass external organs. External non-carcasses commonly had low value. Therefore, their low percentages were preferable.

The percentage of head and neck of the broilers in this study was close to what was reported by Suni *et al.* (2020): 2.22-2.59% of the head and 3.43-3.87% of the neck. In contrast, the percentage of feathers found in this study was higher than in the previous study, 5.25-5.76 vs. 2.66-3.60%, probably influenced by different strains of broilers. The recent study used MB 202, while Suni *et al.* (2020) used CP 707.

Internal organs

The weight and percentage of non-carcass internal organs of broilers collected at the end of the fifth week of all treatments are presented in Table 6. ANOVA did not detect any significant differences (p>0.05) in all internal organ weights of broilers fed the experimental rations. There was no indication broilers ate the MBFM-based rations, which caused adverse effects on their internal organs such as crop, gizzard, intestine, liver, pancreas, spleen, and heart. Similarly reported by Zulfan *et al.* (2022), there are no found significant differences in all internal organs of broiler fed the ration containing LFWM with the percentages the LFWM: CLFM: control as follows: liver 2.25-2.27: 2.48: 2.23%, heart 0.35-0.37: 0.41: 0.38%, spleen

Table 5. Weights and percentages of external organs of non-carcasses of broilers

Non-carcass external organs		CR	Marline fish byproduct meals		Commercial local fish meals	
			4% ($MFBM_4$)	8% ($MFBM_8$)	4% ($CLFM_4$)	8% ($CLFM_8$)
Feathers	(g)	121.50±19.29	118.13±17.10	133.75±29.25	121.25±34.38	113.13±15.10
	(%)	5.25±0.75	5.33±0.94	5.76±1.01	5.48±1.63	5.50±0.82
Head	(g)	52.25±4.68	50.50±4.41	49.75±6.78	49.63±6.35	46.13±3.52
	(%)	2.26±0.22	2.27±0.16	2.14±0.14	2.22±0.18	2.25±0.28
Neck	(g)	55.63±17.43	59.38±5.66	62.38±9.96	58.38±15.26	50.75±10.18
	(%)	2.40±0.72	2.68±0.31	2.73±0.59	2.62±0.65	2.45±0.41
Head+neck	(g)	88.38±26.91	71.38±20.69	74.38±21.51	70.50±30.23	62.50±23.96
	(%)	3.85±1.22	3.24±1.02	3.26±1.05	3.15±1.32	3.04±1.19
Shanks	(g)	72.13±7.83	66.63±7.67	71.88±7.62	74.38±15.56	62.13±8.53
	(%)	3.12±0.27	2.99±0.18	3.11±0.24	3.32±0.52	3.00±0.25

0.13-0.15: 19: 13%, pancreas 0.15-0.17: 17: 15%, and gizzard 1.71-1.97: 1.75: 1.29%.

Internal organs could be used as information by the producers in the evaluation of feed safety for their broilers. The excessive increase in size of several internal organs, such as livers, heart, and spleen, may indicate a bird has swallowed a poison feed (Ressang, 1998). Feed ingredients processed from the discards, such as marline byproducts, were easily contaminated by hazardous compounds, such as heavy metals, coli, and other pathogenic microbes. Heating raw materials will minimize these agents, but it is pivotal to examine the internal organs to ascertain that they are free from infections. All internal organs of broilers in this study appeared in usual sizes, referring to Putnam (1991): heart 0.42-0.70%, liver 1.7-2.3%, and spleen 0.14-0.17%. The percentage of blood was close to reports by Suni *et al.* (2020), 3.51-3.52%. It means the MFBM was safe to be exposed to up to 8% in the feed formulation.

Abdominal fat

The average weight and percentage of abdominal fat of broilers are shown in Table 7. ANOVA indicated using MFBM had no significant effect ($p>0.05$) on abdominal fat. Broilers fed the rations either composted of the CLFM or MFBM had equal abdominal fat weight to the CR. On a statistical point, this finding was not in line with Asrat *et al.* (2023), who found a significant decline ($p<0.05$) in abdominal fat in the FWM rations compared to the control group. However, these values were not considered relatively high in the 28.25-30.75 g fat deposited in the broilers fed the MFBM-based rations.

Relative to LW, the abdominal fat of broilers from all treatments was relatively the same. It means the MFBM did not cause high-fat accretion within the broiler's body. The dietary fat could influence fat deposit (Tůmová and Teimouri, 2010; Fouad and El-Senousey, 2014). The results of the analyses of the Center for Standardization & Industrial Services (BSPJI), Banda Aceh (2023) revealed the MFBM used in this research contained 10.78% fat, higher than the CLFM (6.54%) (Table 2). Feeding the broiler on the MFBM up to 8% within the ration did not cause a significant increase in dietary fat. Fat content in the rations of this study was not more than 10% so as not to cause excessive fat accumulation in the body. The percentage of abdominal fat on the broilers from this study ranged from 1.27-1.45%, which was very lack. According to Tůmová and Teimouri (2010), the abdominal fat tissue constitutes approximately 2-3% of the broiler's live weight. Fish meal or fish byproduct meal is a good source of methionine and lysine. Fouad and El-Senousey (2014), explain that methionine, lysine, and also arginine lead to a significant decline in body fat content by regulating

Table 6. Weights and percentages of internal organs of broilers

Internal organs		CR	Marline fish byproduct meals		Commercial local fish meals	
			4% ($MFBM_4$)	8% ($MFBM_8$)	4% ($CLFM_4$)	8% ($CLFM_8$)
Crop	(g)	4.25±1.49	3.88±0.83	4.00±0.92	4.00±0.76	3.50±0.53
	(%)	0.18±0.07	0.17±0.04	0.17±0.04	0.18±0.03	0.17±0.02
Gizzard	(g)	38.13±3.23	34.50±2.20	34.25±2.49	37.13±5.03	34.75±3.73
	(%)	1.65±0.18	1.55±0.04	1.49±0.16	1.67±0.19	1.69±0.21
Instestine	(g)	49.13±5.54	51.50±5.61	46.00±73.82	52.13±6.60	45.75±8.76
	(%)	2.12±0.19	2.32±0.26	1.99±0.17	2.34±0.21	2.24±0.55
Liver	(g)	44.75±4.49	41.38±7.03	45.13±6.81	43.25±5.70	40.13±6.08
	(%)	1.94±0.19	1.86±0.33	1.95±0.27	1.95±0.27	1.95±0.35
Pancreas	(g)	4.75±0.71	3.88±1.25	3.75±1.28	3.63±1.06	4.38±0.74
	(%)	0.21±0.04	0.17±0.05	0.16±0.07	0.16±0.05	0.21±0.04
Spleen	(g)	2.88±0.99	2.25±1.39	2.75±1.16	2.63±0.74	2.88±1.13
	(%	0,12±0,04	0.10±0.06	0.12±0.05	0.12±0.03	0.14±0.05
Heart	(g)	9.00±1.51	8.75±2.5	8.00±1.31	10.25±2.12	8.38±2.07
	(%	0.39±0.05	0.39±0.09	0.35±0.05	0.44±0.06	0.42±0.09
Blood	(g)	73.25±15.54	83.13±18.11	74.38±19.17	70.63±21.12	69.38±20.26
	(%	3.15±0.54	3.72±0.65	3.18±0.58	3.15±0.84	3.35±0.85

Table 7. Weights and percentages of abdominal fat of broilers

Fat		CR	Marline fish byproduct meals		Commercial local fish meals	
			4% ($MFBM_4$)	8% ($MFBM_8$)	4% ($CLFM_4$)	8% ($CLFM_8$)
Abdominal fat	(g)	33.38±9.29	28.25±4.40	30.75±4.59	32.13±5.28	28.50±5.37
	(%)	1.45±0.53	1.27±0.20	1.34±0.26	1.44±0.21	1.37±0.19

the body fat content by reducing the activity of fatty acid synthase (FAS, lipogenesis) and increasing the activity of hormone-sensitive lipase (HSL, lipolysis).

Conclusion

It can be concluded that using marlin fish waste up to 8% mixed with corn, broken rice, rice bran, and top mix as a substitute for some commercial rations produces whole carcass and breast weights better than using commercial local fish meal up to 8%. However, relative to live weight, these yields were not significantly affected by the difference in fish meals. Marlin fish waste meal did not cause excessive accumulation of abdominal fat in the body.

Conflict of interest

There is no conflict of interest with any financial organization regarding the materials discussed in the manuscript.

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Author's contribution

Khairunnisa and Anggraini performed data collection and wrote the draft. Daud and Latif performed data analyses and reviewed the draft. Zulfan performed conceptualization, research design, validation, writing, and overall review. All authors agreed with the contents of this manuscript.

Ethics approval

The research has complied with all relevant national regulations and institutional policies and has been approved by the authors's institutional review board.

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