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Evaluation of the Performances and IOFCC of Broilers Fed the Whole, the Skinless, and the Skin of *Leubim* Fish Waste Meals Based Partial Replacement Feed of Commercial Diets

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ABSTRACT

This study aimed to evaluate the performances of broilers fed the commercial diet CP511 (CCP) partially substituted with *leubim* fish waste meal (LFW) processed into different parts i.e. whole *leubim* fish waste meal (LFW_W), skinless *leubim* fish meal (LFM_{-S}), and *leubim* fish waste skin meal (LFW_S), each mixed with yellow corn (YC) and top mix (TM). This research was conducted at the Field Laboratory of Animal Husbandry (LLP), Syiah Kuala University from March 17 to April 21, 2021. This study used 100 DOC broiler chickens strain CP 707 and commercial local fish meal (CFM). The study used a completely randomized design (CRD) consisting of 5 treatments and 4 replications. The treatment was CCP= 100% CP511 (control+) and the CCP replaced with: CFM (control-), LFW_W, LFM_{-S}, and LFW_S with the equal amount of 8% each and the addition of 8% YC + 0.5% TM each. The results showed that although statistically no significant differences (P>0.05), the inclusion of LFW meals in the form of LFW_W, LFM_{-S}, or LFW_S plus YC + TM each to substitute partially CCP tended to have higher body weight gain (BWG), final body weight (FBW), feed intake, and better feed conversion ratio (FCR), and protein efficiency ratio (PER), while protein intake (PI) significantly increased (P<0.05). The inclusion of LFW-based diets reduced feed cost and increased income over feed & chick cost (IOFCC). The LFW_{-S} diet did not result in better broiler performances than the LFW_W diet. In conclusion, LFW meals processed as a whole, without the skin, and the only skin added with yellow corn and top mix as a partial replacement for the commercial diet increased BWG, FBW, PI, FI, and improved FCR, reduced feed cost, and generated better profit. It was suggested not to dispose of the skin out of the waste since the whole *leubim* fish waste meal carried out more advantages.

Keywords: *Canthidermis maculata, Leubim*, Fish skin, Performances, IOFCC, Broiler

Introduction

Most broiler producers have been noticing to pay extra attention to produce broilers with lower cost. In certain areas, in which the feed ingredient sources are so rare, feeding the broilers by own diet constituted of restricted local feedstuffs may not result in desired marked weight. On the other hand, feeding them by their broiler diet composted of mostly imported feed ingredients may get successfully in broiler performances but the potential increased production cost over a revenue makes it useless. Therefore, in this situation, it might be better to look for the commercial diet but few of this were exchanged with our alternative feeds.

Initial study on *leubim* fish waste (LFW) meal reported by Zulfan *et al.* (2020a) used experimental base diets formulated with mostly local feeds resulted in not optimal broiler final body weights (FBW). Unfortunately, even though, there were significantly increased performances, the LFW meal has been also suspected of having a contribution to unsatisfying FBW. In a further study, Zulfan *et al.* (2020b) attempt to proceed the LFW meal by the fermentation treatment and to convince the LFW meal role by performing the replacement feeds based on a commercial diet. The result was an increased significantly performance with an optimal FBW of broilers fed the LFW-based diets. Subsequently, the LFW meal was challenged to exclude its skin/scales and then running it into the present study.

The replacement feeds should have an impact in lowering costs such as by employing several alternative feed sources. For a long period, in Indonesia, fish meal has been accused as one of the causes of high diet costs due to frequently imported. Unfavorably, local fish meal has been intensely thought of in poor quality. Nowadays, the latter should be disputed because this country has rich marine resources. Thus, it needs to investigate the potential supplies of fish raw materials, for instance, *leubim* fish (*Canthidermis maculata*) waste meal originated from many places of fish processings or fish markets in Aceh.

The replacement feed does not create merely into a low cost but it should also equalize to dietary nutrients close to the removal feed. This may involve conventional feeds and one or more new sources of feedstuffs. When a balanced diet is fractionally removed to change with new feeds, some feed concentrates within this diet consequently diminish. Therefore, the feed ingredients-based industrial diet or equal ones should bring back into this diet in the form of substitution feed mixtures with the advantages of saving cost without harmful the dietary nutrients. This important feed may include yellow corn.

Yellow corn has been extensively used as the main source of calories in the feeding of poultry. Its carbohydrate is highly digestible (99%) due to its low crude fiber content (Dei, 2017). Its oil has a good composition of fatty acids with high content of linoleic acid (omega 6) and oleic acid (omega 9) (Carrillo *et al.*, 2017). This feed is also palatable and does not contain antinutritional factors. The nutrients available within the corn are believed to have a good complement to those within the fish meal. Hence, by copying the earlier study, in the present study yellow corn also has been utilized to accompany LFW meal in struggling to resettle the dietary replacement feed, mainly metabolizable energy (ME) existing comparable to the dietary removal feed. Nevertheless, placing the newer corn back into the balanced diet could not promise to hold all loosen micronutrients predominantly minerals and vitamins, and also some essential amino acids (EAA) that have flowed out of this diet. Consequently, it should be better to recovery those into the fabricant diets in the form of such feed supplements. According to Thirumalaisamy *et al.* (2016), using unconventional feed ingredients in feed formulation requires more supplementation of nutrients such as amino acids, toxin binders, micronutrients, etc.

One of the feed supplements regularly added into the poultry diets was a top mix. Top mix is a commercial feed supplement containing 12 vitamins, and 6 minerals, and 2 essential amino acids (methionine and lysine). The results of the previous study (Zulfan *et al.*, 2020b) indicated that mixing *leubim* fish waste meal with yellow corn + top mix improved the performances of broilers.

Today, in some places in Aceh, *leubim* fish waste has been utilized by small farmers to introduce into their animal diets resulting in lessening disposal problems. Unpleasantly, only the waste with no skin was collected and the skin of *leubim* was still seen as a terrible feature then the processing fish sellers have to discard this fake unused component. Earlier studies have proved that the inclusion of the entire *leubim* fish meal including *leubim* skin/scales within the diets enhanced the performances of the birds but an enthusiastic purpose has been questioned concerning a bad perception on its body covering fractions. Therefore, this study has been established to determine an effect taking the skin/scales out of the whole *leubim* fish waste and looking for the possible skin exclusively processed into the fish meal.

This study aimed to evaluate the performances of broilers fed the commercial diet CP511 (CCP) partially substituted with *leubim* fish waste meal (LFW) processed into different parts i.e. whole *leubim* fish waste meal (LFW_W), skinless *leubim* fish meal (LFM_{-S}), and *leubim* fish waste skin meal (LFW_S), each mixed with yellow corn (YC) + top mix (TM). The expectation of this study was the completely *leubim* fish waste including its nasty skin/scales invented from fish markets would be potentially explored in poultry diets so that resulted in zero waste.

Materials and Methods

This research was conducted at the Animal Field Laboratory, Animal Husbandry Department, Faculty of Agriculture, Syiah Kuala University from March 17 to April 21, 2021.

Materials and equipment

This research used 100 DOC broiler chickens unsex strain CP 707. Other materials consisted of commercial diet CP511, yellow corn, top mix, commercial local fish meal purchased from North Sumatera, whole *leubim* fish waste meal, skinless *leubim* fish waste meal, *leubim* fish waste skin meal, ND and IBD vaccines, primaticol, and vita stress. The equipment included 20 units of 1 x 1 m cages, scales, heating light bulbs, disk mills, boilers, drainers, stoves, feeders, and drinkers.

Experimental diets

The commercial diet of CP511 was used as a based diet to perform a positive control diet (CCP). As much as 16.5% of CCP were removed then incorporated with 8% yellow corn (YC) + 0.5 top mix (TM) + 8% fish meal. The first fish meal was the commercial local fish meal to perform a negative control diet (CFM). The rest fish meals were whole *leubim* fish waste meal including skin (LFW_W), *leubim* fish waste meal excluding skin (LFW_{-S}), and *leubim* fish waste skin meal (LFW_S). The nutritional requirements refer to the recommendations of the NRC (1994). The composition and nutritional content of the experimental rations were presented in Table 1, while the nutritional content of each trial fish meal was presented in Table 2. The experimental diets were:

CCP = 100% CP511(control +)
CFM = 83.5% CP511 + 8% YC+ 0.5% TM + 8% CFM (control-)
LFW_W = 83.5% CP511 + 8% YC+ 0.5% TM + 8% LFW_W

LFW_{-S} = 83.5% CP511 + 8% YC+ 0.5% TM + 8% LFW_{-S}
LFW_{S} = 83.5% CP511 + 8% YC+ 0.5% TM + 8% LFW_{S}

Making *leubim* fish waste meal

The entire *leubim* fish waste was collected from Lampulo Fish Market, Banda Aceh. Then, the waste was separated into two parts; the first part was the whole *leubim* fish waste included its skin and the second part was excluded its skin resulting in *leubim* fish waste skin and skinless *leubim* fish waste. Each waste was transferred into different boilers containing boiling water then heated for 45 minutes. Afterward, the wastes were drained and dried at sunrise. The dry wastes then were milled to produce three kinds of fish meal, *i.e*. whole *leubim* fish waste meal (LFW_{W}), *leubim* fish waste meal without skin (LFW_{-S}), and *leubim* fish waste skin meal (LFW_{S}). A total of 200 g of LFW_{-S} and LFW_{S} samples each were sent to the Examine Laboratory of Baristand, Banda Aceh for analyzing their nutritional content. *Leubim* fish and its cutting waste, as well as 3 kinds of leubim fish waste meal products, were presented in Figure 1.

Research procedures

The research was initiated by the preparation of the cages and diets. The former included washing and disinfecting the cages and equipment as well as liming the cages. The cages were constructed into 20 experimental units 1 x 1 m each, sowed the liters, and installed incandescent light bulbs. The diet preparation included feed formulation, the *leubim* fish waste meal processing, and the diet mixture. The experimental diets were mixed weekly based on each treatment for 5 weeks. Raising chickens was carried out for five weeks of which those fed the experimental diets ad libitum with the addition twice a day. Drinking water also was supplied ad libitum and replaced with fresh water every day. Vita stress was offered through the drinking water during the first fourth week. Body weight and feed consumption were collected at the end of each week. Bodyweight was obtained by weighing the chickens, while feed consumption was obtained by reducing the number of rations given by the number of remaining rations.

Experimental design

This study used a completely randomized design (CRD) consisting of 5 treatments and 4

Table 1. Composition and nutrient content of experimental diets

Feed ingredients	Experimental diets (%)				
	Commercial diet CP511 (CCP)	Commercial fish meal (CFM)	Whole *leubim* fish waste meal (LFW_{W})	Skinless *leubim* fish waste meal (LFW_{-S})	*Leubim* fish skin waste meal (LFW_{S})
CP511 Bravo[1]	100	83.5	83.5	83.5	83.5
Yellow corn[2]	0	8	8	8	8
Fish meal					
CFM[3]	0	8	0	0	0
LFW_{W}[4]	0	0	8	0	0
LFW_{-S}[5]	0	0	0	8	0
LFW_{S}[5]	0	0	0	0	8
Top mix	0	0.5	0.5	0.5	0.5
Total	100	100	100	100	100
Calculated nutritional contents:					
Protein (%)	21–23	22.76–24.43	22.30–24.08	22.83–24.50	22.10–23.77
Crude fiber (%)	5.0	4.59	5.28	4.48	4.43
Ether extract (%)	5.0	5.26	4.65	4.79	4.57
Ca (%)	0.9	0.95	1.60	0.78	0.78
P (%)	0.6	0.89	1.02	1.36	1.86

1 Market label CP511 Bravo: CP 21-23%, CF 5%, EE 5%, Ca 0,9%, and P 0,6%
2 Hartadi *et al.* (2005)
3 Dian Aquatic; Utomo *et al.* (2013); Sihite *et al.* (2013)
4 Zulfan *et al.* (2020[a])
5 Analyzed in the Examine Laboratory of Baristand, Banda Aceh

A = *leubim* fish; B = whole *leubim* fish waste; C = *leubim* fish waste skin; D = meat attached bones, skinless *leubim* fish waste, E = skin attached head, abdomen, and etc, skin in the head removed when processed into skinless *leubim* fish waste, F = skinless *leubim* fish waste meal, *leubim* fish waste skin meal, whole *leubim* fish waste meal (doc. Zulfan et al., 2021)

Figure 1. *Leubim* fish, its cutting waste, and three kinds of *leubim* fish waste meal products.

Table 2. Nutritional contents of different kinds of fish meals

Nutrients	Commercial fish meal (CFM)[1]	Whole *leubim* fish waste meal (LFW_W)[2]	Skinless *leubim* fish waste meal (LFW_{-S})[3]	*Leubim* fish skin waste meal (LFW_S)[3]
Moisture (%)	15.04[1b]	7.50	5.00	6.07
Crude protein (%)	55.00[1a]	49.24	55.84	46.72
Ether extract (%)	6.54[1b]	1.61	3.64	0.95
Crued fiber (%)	2.98[1b]	11.33	1.67	1.01
Ca (%)	2.46[1c]	10.46	0.27	0.34
P (%)	4.60[1c]	6.21	10.5	16.78

[1a] Dian Aquatic; [1b] Utomo *et al.* (2013); [1c] Sihite *et al.* (2013).
[2] Zulfan *et al.* (2020a).
[3] Analyzed in the Examine Laboratory of Baristand, Banda Aceh.

replicates. Replicate was an experimental unit placed 5 birds each. The model for this CRD refers to Ott (1991): Yij = µ + ai + eij where Yij= the jth sample measurement selected from population i, µ= an overall mean, ai= an effect due to population i, and eij = a random error associated with the response on diet i, replicate j.

Parameters and data analysis

The parameters observed in this research were broiler performances at 5 weeks of age and income over feed and chick cost (IOFCC). The performance included final body weight (FBW), body weight gain (BWG), feed intake (FI), protein intake (PI), feed conversion ratio (FCR), and protein efficiency ratio (PER). The FBW was recorded by weighing all birds individually at the end of the 5^{th} week, then the average weekly BWG by substracting FBW by DOC weight. The FI was computed by subtracting the amount of given feed by the amount of residual feed, while the PI was resulted from multiplying the mean dietary protein by the FI. The FCR was determined by comparing the average FI by the average BWG, while the PER by comparing the BWG by the PI. The IOFCC was counted by subtracting the revenue by the feed and chick cost.

The data on birds' performances were analyzed by an Analysis of Variance (AOV). The significant differences in the data were continued by Duncan's Multiple Range Test (DMRT) to detect the significant differences among the treatments.

Results and Discussion

Feed intake and protein intake

Total feed intake (FI) and protein intake (PI) of the birds from all treatments were presented in Table 3. The results of AOV revealed the use of different parts of *leubim* fish waste meal (LFW) i.e. LFW_W, LFW_{-S}, and LFW_S each added with corn and top mix, respectively in substitution to the commercial CP diet (CCP), had no significant effect (P>0.05) on feed intake. The use of the LFW-based diets did not depress feed intake and seem broilers fed these diets tended to promote it than those fed full CCP. This was evidence that the LFW meal was so palatable. The result of this study was in line with those reported by Zulfan *et al.* (2020b), the use of LFW meal + corn + top mix tended to increase feed intake.

The inclusion of the LFW_S did not show a significant decrease in feed intake. This result was not in suspecting that the hard and stiff texture of *leubim* skin/scales considerably composed of collagen, keratin, and chitin was assumed to greatly decline feed intake. Hussain *et al.* (2018) said that scales from the fish industry are waste protein, which is neither eaten by the animals nor easily degraded by the scavenger microbes, thus required appropriate treatments such as hydrolyzed into source material for the construction of rechargeable protein batteries. In the present study, the LFW_S was treated by boiling water generating in softening the skin texture then likely degraded the bound compounds. As reported by Zhang *et al.* (2019), the protein recovery of hydrothermally treated fish scales was approximately 4.5 times higher than that of the conventionally treated samples. This result also shown removing the skin out of the *leubim* fish waste (LFW_{-S}) could not be able to significantly increase feed intake over the whole *leubim* fish waste (LFW_w). Distinctly, all components of cooked *leubim* fish bodies were favored by the chickens. The birds fed all substituted diets with the inclusion of either commercial local fish meal (CFM) or the LFW tended to have higher feed intake compared to those fed a full CCP. Adding fish meal into the diet

Table 3. Broiler performances

Parameters	Commercial diet CP 511 (CCP)	Commercial fish meal (CFM)[1]	Whole *leubim* fish waste meal (LFW_W)[2]	Skinless *leubim* fish waste meal (LFW_{-S})[3]	*Leubim* skin waste meal (LFW_S)[3]
FBW (g $bird^{-1}$)	1887±112	1991±149	2062±45	2029 ±85	1996 ±103
Weekly BWG (g $bird^{-1}$ $week^{-1}$)	368±22	389±30	403±9	397±17	390±21
Total FI (g $bird^{-1}$)	3256±152	3389±181	3304±130	3338±110	3298±132
Weekly FI (g $bird^{-1}$ $week^{-1}$)	651±30	683±36	661±26	668±22	660±26
Daily FI (g $bird^{-1}$ day^{-1})	93.02±4.34	96.82±5.16	94.39±3.73	95.38±3.14	94.22±3.77
Daily PI (g $bird^{-1}$ day^{-1})	20.46±0.95^a	22.84±1.22^b	21.89±0.86^{ab}	22.57±0.74^b	21.61±0.86^{ab}
FCR (g FI g BWG^{-1})	1.77±0.04	1.75±0.12	1,64±0,04	1.68±0,05	1.70±0.11
PER (g BWG g PI^{-1})	2.57±0.07	2.43±0.17	2.63±0.06	2.51±0.08	2.58±0.17

^{a,b} Different superscripts indicated a significant difference (P<0.05).

improved feed intake by the birds. Agree with Solangi *et al.* (2002), fish meal increased feed consumption.

Birds fed LFW-based diets did not show higher feed intake than those fed the CFM-based diets. This result was not the same as reported by Zulfan *et al.* (2020a), broilers fed the LFW-based diet had significantly higher feed intake (P<0.05) than those fed the CFM-based diet. This contrast was due to the different sources of CFM used. In this study, the CFM had better quality based on the favor, color, and texture purchased from North Sumatera. According to Raza *et al.* (2015), different sources of fishmeal affected feed consumption.

The result of AOV indicated there was a significant difference (P<0.05) in protein intake among the groups. Birds fed the CFM and the LFW_{-S} diets significantly consumed protein higher than the other groups. It seems that all the diets with the inclusion of fish meal whether CFM or LFW meals were consumed protein higher than the CCP diet. Protein intake was subjected to the feed intake and the dietary protein. The substituted diets contained slightly higher protein than the CCP diet (Table 1). Increased feed intake of the birds fed the substituted diets caused to increase in protein intake.

It was not supposed to increased FI due to the lack of ME in fish meal-based diets. Unfortunately, the dietary ME could not be able to calculate since very little information on the ME content of the CFM and the LFW. The CFM used in this study was *'tepung ikan rucah',* a fish meal made up of miscellaneous unmarketable fish. The ME content in a fish meal may vary in a wide range depending on fish kinds or their cutting by-products. Therefore, to calculate the dietary MEs by imitating the ME contents in different fish meals would not present these precisely. It was suggested to establish further research to study ME contents of the various local fish meal including the LFW meal. Estimation of the ME from the gross energy (GE) would not serve properly since different feeds vary in digestibility.

Despite this, the potential reduced ME in replacement diets have been anticipated by employing corn. Remove 16.5% CCP caused loss of approximately 531.2 kcal/kg ME. The combination of fish meal and corn was assumed to meet the equal ME. Adding 8% of the newer corn (3,862 kcal/kg ME refers to Hartadi *et al.*, 2005) donated up to 308.96 kcal/kg ME. Adding 0.5% top mix contributed none to ME. In an assumption the ME contents within the common fishmeal were at least 2,800 kcal/kg, then adding 8% fish meal furnished at least 224 kcal/kg ME. Hence, the total supplied ME from both would be approximately 532.96 kcal/kg that was very close to ME lost, and this was not enough evidence to support the increased FI due to lack of ME in fish meal-based diets. Therefore, the increased palatability of fish meal-based diets should not be more debatable. It has been widely accepted that fishmeal is the most palatable feed for poultry.

In approximated dietary isocaloric, the daily ME intake was supposed at 2,977; 3,100; 3,020; 3,054, and 3,017 kcal/kg for CCP, CFM, LFW_W, LFW_{-S}, and LFW_S, respectively. The energy protein ratio (EPR) was considered in the range of 129–142, 127–136, 126–136, 125–134, and 127–137 for CCP, CFM, LFW_W, LFW_{-S}, and LFW_S, respectively, all represented in the proper EPR. The formulated experimental diets have been thought to meet this.

BWG and FBW

The results of AOV indicated that BWG and FBW did not show any significant differences (P>0.05) among all groups. The use of different parts of the LFW meal resulted in similar BW among these groups. Despite this, when those were compared to the CCP group, birds fed the LFW_w-based diet produced 175 grams of average BW over the latter. This result proved the previous study reported by Zulfan *et al.* (2020b), substituting a partially commercial diet with the LFW meal mixed with yellow corn and top mix resulted in higher BWG and FBW rather than using 100% of the commercial diet. The increased BWG and FBW of broilers fed the CFM and the LFW-based diets were highly supposed due to the increased protein intake. The increased protein intake of the birds fed the LFW-based diets over those fed the CCP diet stimulated the achievement of better FBW and BWG. This result agreed with the previous study reported by Zulfan *et al.* (2020b), the increased BWG and FBW broilers fed the LFW-based diet closely were due to the increased protein intake.

The increased FBW and BWG were not the only impressed by the amount of protein consumed but the quality of the dietary protein should be notable as well. This was strongly the notion that the LFW meal has valuable nutrition. *Leubim* fish waste meal contained high protein and was presumed as a good source of amino acids. This became obvious that the protein in a fish meal has a high biological value because of rich in essential amino acids, mainly lysine and sulfur amino acids (Karimi, 2006). In addition, fat in fish meal contains the long-chain omega-3 (n-3) polyunsaturated fatty acids (LC n-3 PUFA) and is an important factor in the animal diet contributing to good health (Pike, 1999).

The protein content increased 49.24 to 55.84% as the LFW_W was excluded the skin (LFW_{-S}), while the protein content in the LFW_S was somewhat lower 46.72% (Table 2). The latter was also lower than that reported by Zhang *et al.* (2019) analyzing in tilapia scales and found 55.87% crude protein and 36.48% ash on a dry basis. This difference could be due to the differences in fish kinds, processing methods, and other treatments. Although rather higher protein, the inclusion of the LFW_{-S} did not produce BWG and FBW better than the LFW_W even tended to quite lower. On the other side, the LFW_S did not produce lower BWG and FBW, but there was a tendency rather lower than the LFW_W. This study indicated that the *leubim* fish waste should not need to remove its skin when processed into the meal because the LFW_{-S} did not support relatively better BWG and FBW. The nutrients within the *leubim* skin and other parts of its body might have been complementing each other. Fish skin is an ample supply of gelatin and collagen (Abuine *et al.*, 2019; Abdullah, 2019). Naswa and Suprayitno (2019) examined the salmon skin and found 15 amino acids contained in gelatin (*Oncorhynchus sp*.) of this fish skin with the highest and the lowest EAA were determined in L-arginine (8.45%) and L-isoleucine (0.92%), respectively while the highest and the lowest non-EAA found in glycine (28.36%) and L-tyrosine (0.33%), respectively. The most plentiful amino acids making up collagen are glycine, proline, and hydroxyproline, while that constructing keratin is cysteine (Osborn, 2019).

A suspect that the protein content in the skin/scales of *leubim* fish waste would be tough digest then suppressing the growth of the chickens when used in the diet was not proven. An incredible result was shown in this study that the inclusion of the LFW_S added with corn and top mix in substitution to the partial commercial diets was able to meet BWG and FBW comparable to the CFM diet even somewhat higher than the CCP diet. Although there was a little decrease in BWG and FBW at the LFW_S diets compared to those at the LFW_W and the LFW_{-S} diet, the difference was not statistically different. According to Abdullah (2019), fish scales are the waste products produced by fisheries production that have high nutritional value but less attention by the human. The unknown factors, such as hormones, etc., within the LFW meals, may involve promoting performances either directly or indirectly. Fish scales accumulate cortisol, the major stress hormone in fishes (Sadoul and Geffroy, 2019) playing a pivotal role in aerobic and anaerobic metabolism, stimulating several aspects of intermediary energy metabolism, elevating oxygen uptake, increasing gluconeogenesis, and inhibiting the synthesis of glycogen synthesis (Kalamarz-Kubiak, 2017). The possible presence of natural hormonal factors in fish skin/scales meal has been debated in a seminar forum suggesting to include it in addition to nutritional aspects thought having responsibility in contribution to birds' performances. Unfavorably, the latter should be further discussed.

Fish scales are composed of a surface layer containing hydroxyapatite, Calcium carbonate, and a deeper layer made up of mostly collagen type I (Harikrishna *et al.*, 2017), approximately 80–98% (Abdullah, 2019). Similar to collagen is keratin, both are fibrous proteins highly found in the skin. Collagen is a protein that is made up of three polypeptide chains and many units of hydroxyproline, proline, and glycine residues forming a helical structure, while keratin is a tough fibrous protein that occurs as an α or β type and always has a lot of cysteine residues with many disulfide bonds, present in the molecular structure (Osborn, 2019). This has led to the assumption that the use of LFW_S would greatly reduce the BWG and FBW of the chickens. Those were supposedly decomposed during the boiling process. In this study, the waste was heated for a longer time (± 45 minutes) causing the bonds within these compounds to be likely destroyed. Zhang *et al.* (2019) reported the hydrothermal process is a promising technology for the recovery of fish scale protein free of catalysts or any other chemical resulting in secondary pollution. The results of this study showed that the skin of *leubim* fish can also be used for making a meal without distressing the BWG and FBW of broilers with a note that it should go through the heat process first. The average daily PI and FBW of the birds from all treatments were described in Figure 2.

FCR and PER

The results of AOV showed the use of LFW meal plus yellow corn and top mix as in substitution to the commercial diet had no significant effect (P>0.05) on FCR. However, broilers fed the LFW-based diets tended to have better FCR than those fed the CCP. This was due to the rate of the increased feed intake of the birds fed the formers under the rate of its increased BW compared to those fed the latter. It meant the LFW-based diets were more efficient to utilize by the birds to perform yields. This was similarly reported by Zulfan *et al.* (2020b).

This result indicated that the LFW meal processed wholly fractions, without the skin, and only with the skin mixed with yellow corn and top mix each improved the diet quality. It signaled that the nutrients containing in all parts of the body *leubim* fish waste were quite perfect. The FCR at the CFM diet was equivalent to that at the CCP

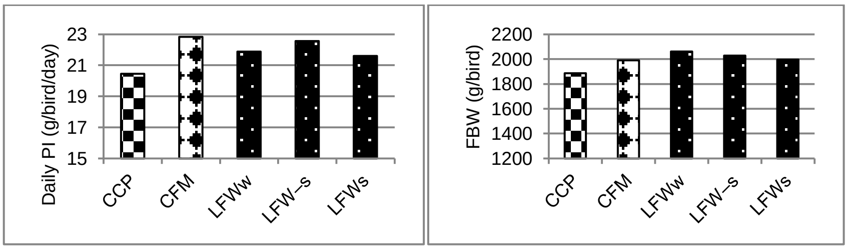

Figure 2. Average daily Protein Intake (PI) and Final Body Weight (FBW) CCP= Commercial diet CP 511; CFM= Commercial fish meal; LFW_W= Whole *leubim* fish waste meal; LFW_{-S}= Skinless *leubim* fish waste meal; LFW_S= *Leubim* fish skin waste meal.

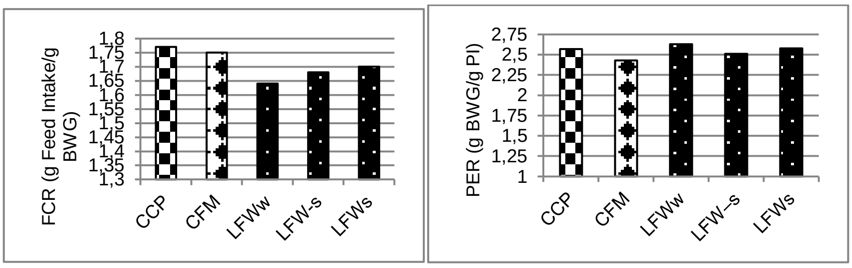

Figure 3. Average Feed Conversion Ratio (FCR) and Protein Efficiency Ratio (PER) CCP= Commercial diet CP 511; CFM= Commercial fish meal; LFW_W= Whole *leubim* fish waste meal; LFW_{-S}= Skinless *leubim* fish waste meal; LFW_S= *Leubim* fish skin waste meal.

diet. This showed that the commercial local fish meal drawn into this study was not inferior. Agree with North and Bell (1990), the adequacy of dietary nutrients affected feed conversion for which the lower FCR the better feed quality. In a basic of achievement on FBW, the CFM could be used to replace a few of CCP but no better assessment could be given yet at this point until the economic value has been completedly counted for all diet treatments.

There was no significant difference (P>0.05) on PER among the groups. The partly replaced commercial diet with animal protein sources derived from *leubim* fish waste meal seemed successfully maintain the dietary protein. This result was in line with reported by Zulfan *et al.* (2020b). Even though, statistically no significant difference, the LFW-based diet tended to have PER higher than the CFM diet. It designated that the protein in all locations of the body of *leubim* fish waste meal more superior than it in the CFM. The best protein quality was observed in the whole *leubim* fish waste meal. Regrettably, PER was criticized in the assessment of protein quality since many factors were involved (Lamb and Harden, 1973). In the previous study, the increased performance was supposed due to the increased protein intake and likely any supplementary effects between LFW meal and yellow corn + top mix and other feed ingredients available in the commercial diet, unwillingly the role of the LFW meal solely was still distrusted. The average daily FCR and PER of the birds from all treatments were described in Figure 3. The result of the present study became evidence that the LFW meal seems to retain excellent sources of nutrients. The only performance was not sufficient enough to decide whether a new feed source was permissible or not to introduce into the poultry diet. It should pass over the economic value as well and so the feed cost and at least the IOFCC should also bear in mind.

Cost and IOFCC

The revenue, cost, and Income over Feed and Chick Cost (IOFCC) of raising broilers from all treatments were presented in Table 4. The highest revenue was obtained at the LFW_W diet, while the lowest was recorded at the CCP diet. Alternating partially of the CCP with the CFM or with three different kinds of LFW (LFW_W, LFW_{-S}, and LFW_S) for which each added with yellow corn and top mix resulted in higher revenue than using of full commercial diet (CCP diet). The LFW-based diets had higher revenue than the CFM diet too. The total revenue is related to the FBW. Statistically, the use of all types of fish meal had no significant effect (P>0.05) on the FBW. Yet, the difference in FBW affected the amount of earned money. Broilers fed the commercial diet partially substituted with the LFW-based diets had higher FBW so that their revenue was higher too. The CFM diet also had higher FBW than the CCP diet creating a higher revenue as well. The higher the selling weight, the higher the return obtained. The only revenue cannot be drawn to describe the efficiency of raising broilers. Therefore, the costs must be calculated.

The results of cost analyzes showed that the highest cost was found at the CFM diet while the lowest was at the LFW_S diet. This was subjected to the highest and the lowest feed cost found at these diets, respectively. Using the LFW-based diets in substitution to fractionally the CCP

Table 4. Revenue, cost, and income over feed and chick cost (IOFCC)

Parameters	Commercial diet CP 511 (CCP)	Commercial fish meal (CFM)[1]	Whole *leubim* fish waste meal (LFW_W)[2]	Skinless *leubim* fish waste meal (LFW_{-S})[3]	*Leubim fish* skin waste meal (LFW_S)[3]
			--- (Rp bird^{-1}) ---		
Revenue[1]	45,288.00	46,329.18	49,493.40	47,969.70	47,270.07
Costs					
Feed cost[2]	29,299.95	30,480.73	28,220.44	29,025.86	27,492.91
Chick cost	8,613.86	8,613.86	8,613.86	8,613.86	8,613.86
Other variable cost	5,761.26	5,761.26	5,761.26	5,761.26	5,761.26
Total variable cost	43,675.07	44,855.85	42,595.56	43,400.98	41,868.03
Total fix cost[5]	335.17	335.17	335.17	335.17	335.17
Total cost	44,010.24	45,191.02	42,930.73	43,736.15	42,203.20
IOFCC	7,374.19	7,234.59	12,659.10	10,329.98	11,163.30
Total income	1,277.76	1,138.16	6,562.67	4,233.55	5,066.87

[1] Broiler price based on the market price when this research conducted Rp24,000.00/kg live weight

[2] Feed ingredient price/kg: CP511 Bravo= Rp9,000.00, YC= Rp5,000.00, TM= 40,000.00, CFM= Rp11,000.00, LFWw = Rp5,340.00, LFW_{-S} = Rp7,2480.50, LFW_S = Rp2,780.00.

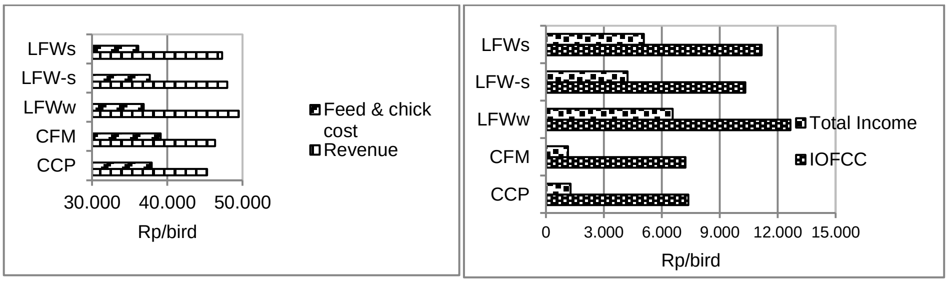

Figure 4. Revenue, feed & chick cost, IOFCC, and total income CCP= Commercial diet CP 511; CFM= Commercial fish meal; LFW_W= Whole *leubim* fish waste meal; LFW_{-S}= Skinless *leubim* fish waste meal; LFW_S= *Leubim* fish skin waste meal.

diet reduced feed cost and increased IOFCC. However, using the CFM did not reduce feed cost. Feed cost was associated with the diet price and feed intake. The price of the CCP diet was Rp9000.00/kg, then replacing partially it with 8% CFM + 8% YC + 0,5% TM (CFM diet) only reduced as much as Rp5,00/kg diet. The diet price extremely declined if the local feed sources (LFW_W or LFW_{-S}) were included instead of the CFM resulting in Rp8542.20 or Rp8694.88 per kg diet, respectively. This could be depressed until Rp8337.40 per kg diet when the LFW_S was employed instead of the CFM. The differences in diet prices of different kinds of the LFW meal were due to the different prices of raw materials of this waste. The original *leubim* fish waste was paid for Rp20.000 per bag (50 kg) each as compensation for collecting or packaging the wastes. Until now very rare ones looking for *leubim* waste skin, therefore, the fish-cutting sellers undergoing to confront any setback to dispose of this trash would be allowable to people who are pursuing it (Rp0,00 raw material). So far, exploring the LFW meal into the poultry diet reduced feed cost. This was under Thirumalaisamy *et al.* (2016), using unconventional feed ingredients available locally to formulate the least-cost feed formulation were found to be a reduction in the cost of poultry feeds.

Low diet price does not always carry out to low diet cost depending on how much the diet has been spent by the birds. The CFM diet reduced diet price, but the birds consumed highly this diet causing the increased diet cost over than the CCP diet. This circumstance was also found in the LFW-based diets, even though increased feed intake, the diet prices mostly decreased so that the diet cost also decreased. Relatively to the total cost, the percentages of the feed cost were very close among all treatments with the range of 65.14–67.45%. This was related to Thirumalaisamy *et al.* (2016), feed comprised around 60–70% of the total expenditure of broiler production.

In the present study, it has been shown replacing partially the CCP with all kinds of fish meals increased revenue. Despite this, when the CFM was used, the IOFCC was not better due to an increased total cost. The IOFCC could be higher at whatever LFW meal was used. The highest IOFCC was recorded at the LFW_W diet, the *leubim* fish waste including its skin because this diet produced the highest FBW and the second-lowest of total cost. The LFW produced without its skin (LFW_{-S}) did not result in better income contrasted to the whole *leubim* fish waste meal (LFW_W) but still better than the full commercial diet (CCP). It was unbelievable that the LFW_S diet could result in better income than either the CCP or CFM diet. This was supported by the higher FBW with a lower cost of the birds fed the LFW_S diet than those fed the latter. Hence, the skin alone was profitable to treat into the fish meal without lowering IOFCC. The amount of revenue, feed and chick cost, IOFCC, and total income of the birds from all treatments were described in Figure 4.

Conclusions

In conclusion, *leubim* fish waste meal whether processed completely, without skin, or the skin alone mixed with yellow corn and top mix exceedingly could be used to replace partially commercial diet with the advantages in better final body weight and feed conversion, lower feed cost, and higher Income over Feed and Chick Cost (IOFCC) of raising broilers. Broilers fed the commercial diets partially substituted with the feed mixture containing the skinless *leubim* fish waste meal did not result in better performance and income than those fed the whole *leubim* fish meal. Therefore, the recommendation should be disseminated to the farmers that *leubim* fish waste need not remove its skin when processed into the meal for generating zero pollutants. However, this was still a mystery so that further research was suggested to contemplate the skin waste of *leubim* fish.

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