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Growth performance and carcass quality of river catfish *Hemibagrus nemurus* fed salted trash fish meal

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A B S T R A C T

The objective of the study was to examine the substitution effect of fish meal by salted trash fish meal in the diet on the growth performance and carcass quality of river catfish *Hemibagrus nemurus*. Four diets (34% protein and 3.25 kcal g-1 digestible energy) were tested; the control diet contained fish meal without salted trash fish meal (FM), and the other diets were salted trash fish meal diets with fish meal, which was reduced and proportionally replaced by salted trash fish meal 50% (STFM-50), 75% (STFM-75), 100% (STFM-100); and a commercial diet (CD), containing 31.79% protein and 2.94 kcal digestible energy, was used as a reference diet. The juvenile catfishes (with average in body weight 50 ± 2.26 g) were stocked into 2 m × 2 m × 2 m floating net cages at a density of 50 fish cage^{-1}, and fed experimental diets at satiation, twice a day at 7.00 AM and 17.00 PM for 12 weeks. The results showed that the substitution of fish meal by salted trash fish meal up to 75% did not give significant effect on pelleted diet water stability, growth performance (survival rate, weight gain, specific growth rate, feed efficiency, protein efficiency) and carcass quality (body proximate composition, amino acid profile, edible flesh, dress-out percentage, carcass waste and sensory quality) of the fish ($P > 0.05$). However, complete substitution (100%) reduced protein retention and fish body protein ($P < 0.05$). Compared to commercial diet, the substitution of fish meal by salted trash fish meal up to 75% produced higher protein retention, fish body protein and sensory quality of the fish ($P < 0.05$). Therefore, it is concluded that the salted trash fish meal can be included in the diet of river catfish *H. nemurus* up to 75%.

Introduction

The demand for farmed raised river catfish *Hemibagrus nemurus* has continued to increase as the supply of the fish from the wild decreased due to overfishing and habitat destruction (Hasan et al., 2016a). Although the artificial breeding and aquaculture techniques of the species have been developing (Muchlisin et al., 2004; Muchlisin and Siti-Azizah, 2009; Abidin et al., 2006); the production cost is higher than the other farm-raised catfish as the fish requires high dietary protein (34–42%) for its optimum growth (Khan et al., 1993; Hasan et al., 1999; Abidin et al., 2006; Hasan et al., 2016a).

Fish meal is the most preferable and digestible protein source in the diet for most farmed fish including river catfish *H. nemurus* (Tacon, 1993; Eguia, 1998; Khan et al., 1993; Hasan et al., 1999; Abdelghany, 2003; Hasan et al., 2016a). However, this material is expensive, and its production is limited and scarcely available in local market; therefore, it is not economical for local farmers. Since local demand for fish meal continue to grow, its production is expected to remain constant (New and Wijkstrom, 2002; Borgeson et al., 2006; Rana and Hasan, 2009; Ayhan and Emir, 2015). Hence, the exploring of local materials as alternative protein sources to replace fish meal in the fish diet is necessary to be studied.

Trash fish from marine by-catch is a potential alternative for fish meal in the fish diet due to its high protein content, 14.4–20.8% of wet weight (Castro-Gonzalez et al. 1998; Li et al., 2004; Hasan et al., 2016b) and abundant supply, which is estimated to be more than 4.392.000 tons per year or equal to 62.6% of the total annual marine catch in Indonesia (Davies et al., 2009; Anon., 2010). However, most trash fish production is scattered among small-scale fishermen in remote fishing grounds. The fish is highly perishable while refrigeration methods are expensive and scarcely available. Thus, the most practical and cheapest preservation methods for utilizing the fish are acid (silage) and salt preservation. The use of trash

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fish silage for fish meal alternative in the fish diets has been studied by several researchers (Hasan et al., 2001; Cavalheiro et al., 2007; Hernández et al., 2011; Goosen et al., 2014); but there is almost no information on salted trash fish meal. Our direct observation in the field showed that the fish farmers in Riau Province, Indonesia, have added the salted trash fish meal as protein source up to 30% in the diet for pangasius (*Pangasius hyphopthalmus*) and tilapia (*Oreochromis niloticus*), but there was no scientific information on its effects on fish growth and body composition as well as carcass quality.

Our previous feeding study on juvenile river catfish *H. nemurus* for 8 weeks also revealed that the salted trash fish meal could be included in fish diets up to 50% replacing fish meal without the negative effect on growth, food efficiency and nutrient utilization (Hasan et al., 2016b). However, the application of these findings in the practical culture system, especially its effects on fish carcass quality, remains unevaluated. Hence, this paper reports the effect of the substitution of dietary fish meal from salted trash fish on the growth performance and carcass quality of the river catfish *H. nemurus* in the culture system.

Material and methods

Diet preparation and analysis

Dried salted trash fish of marine by-catches, fish meal, soybean meal, and rice bran were purchased from a local feedstuff supplier. Before inclusion in the diet, the salted trash fish, which comprised various species, were desalted in boiling water for 15 min (1 kg trash fish: 2 L water) and pressed to reduce its salt concentration, then they were oven-dried and grounded. The salted trash fish meal and other ingredients were analyzed for proximate and salt concentration (Table 1).

The Completely Randomized Design (CRD) with three replications were used in this study. Four diets were formulated to contain 34% protein and 3.25 kcal g^{-1} digestible energy (DE). A control diet was formulated by the inclusion of fish meal without salted trash fish meal (FM); and the remaining three diets were prepared by reducing fish meal and proportionally replacing it with salted trash fish meal 50% (STFM-50), 75% (STFM-75) and 100% (STFM-100). A commercial pelleted diet (CD) containing 31.79% crude protein and 2.94 kcal g^{-1} DE, but with unknown ingredients, was used as a reference diet (Table 2).

The formulated diets were pelleted, dried and analyzed for salt concentration, proximate and amino acid composition, as well as their stability in the water. Salt concentration and proximate composition analyses were performed based on AOAC method (AOAC, 2005). The salt concentration was determined by titration with $AgNO_3$ 0.1 N after incineration at 500 °C. Moisture was determined after the sample was oven-dried at 105 °C for 24 h until constant in weight. Ash was determined after the sample was incinerated at 500 °C for 5 h. Crude protein was analyzed by micro-Kjeldahl procedure and crude protein was estimated as N × 6.25, where N is total nitrogen (g), and 6.25 is a protein factor. Crude lipid was determined after the sample was Soxhlet-extracted with petroleum ether. The NFE was calculated by difference, 100 – crude protein – crude lipid – ash – moisture (Merrill and Watt, 1973). The DE of the diets was estimated using published DE values for channel catfish, protein = 3.5 kcal g^{-1}, lipid = 8.1 kcal g^{-1} and NFE = 2.5 kcal g^{-1} (NRC, 1993). The amino acids analyses were conducted by HPLC using Pico-tag method (Waters, USA) based on Cohen (1989). The amino acid profile was determined after being hydrolyzed under nitrogen in 6 N HCl at 110 °C for 24 h; and amino acids were calculated in 100 g^{-1} of sample.

Pellet stability in the water was determined by the method recommended by Fagbenro and Jauncey (1995) and Hasan et al. (2001). Triplicate samples containing 50 g of the pelleted diets were placed on the sieve and slowly immersed in 40 L aquarium containing distilled water at room temperature for 10 and 30 min. The sieves were removed to dry for 1 min, oven-dried at 105 °C for 2 h, then cooled in a desiccator and reweighted. Water stability was calculated as the percentage difference in weight after reweighting and expressed as the loss percentage of dry matter (% LDM).

Feeding trial and fish analysis

River catfish *H. nemurus*, averaging 50 ± 2.26 g in weight, were collected from a local private fish hatchery in Kampar, Indonesia. They were acclimated to the experimental conditions for two weeks before the feeding trial. During acclimation, the fish were fed commercial pellet. A total of 1250 fish were randomly stocked to triplicate 2 m × 2 m × 1.20 m experimental floating net cages at a density of 50 fish per cage, and fed the experimental diets for 12 weeks. The fish were fed at satiation twice daily at 7.00 AM and 5.00 PM. All the fish were weighted at the beginning and at the end of the experiment. Twenty fish at the beginning of the experiment and ten fish of each cage at the end of the experiment were taken randomly for body proximate and amino acid composition analyses.

The other ten fish of each cage were evaluated for carcass quality (edible flesh, dress-out percentage, carcass waste, sensory, and overall quality). The growth performance, edible flesh, dress-out percentage, carcass waste and hepatosomatic index were calculated by the following formulas:

$$\text{Weight gain}(g) = (\text{Final fish weight} - \text{Initial fish weight})$$

$$\text{Specific growth rate}\left(\%\text{day}^{-1}\right) = [(\text{Ln final weight} - \text{Ln initial weight})/\text{days of trial}] \times 100$$

$$\text{Survival rate}(\%) = (\text{Total final survived fish})/(\text{Total initial fish}) \times 100.$$

$$\text{Food consumption}\left(\text{g fish}^{-1}\right) = (\text{Total food consumed per fish})$$

Table 1
Proximate composition of feed ingredients.

Ingredients	Proximate composition (% dry basis)[a]					
	Dry matter	Protein	Lipid	Ash	NFE[b]	Salt
Fish meal	91.52 ± 0.08	57.12 ± 0.78	11.86 ± 0.17	20.50 ± 0.64	10.52 ± 1.59	2.84 ± 0.02
Salted trash fish meal	90.24 ± 0.55	55.37 ± 1.02	5.27 ± 0.06	27.19 ± 0.82	12.17 ± 1.81	13.19 ± 0.12
Soybean meal	90.10 ± 0.25	36.96 ± 1.52	21.27 ± 1.59	4.81 ± 0.29	36.96 ± 2.15	–
Rice bran	93.17 ± 0.09	12.11 ± 0.27	8.51 ± 0.08	12.52 ± 0.59	66.85 ± 0.76	–

[a] Values are means of triplicate ± S.E.
[b] NFE was calculated by difference (100 – crude protein – crude lipid – moisture – ash).

Table 2
Formulation, proximate and salt concentration of experimental diets.

Materials	Diets (%)					
		FM[a]	STFM-50	STFM-75	STFM-100	CD[b]
Fish meal		36	18	9	0	–
Salted trash fish		0	18	27	36	–
Soybean meal		28	24	24	24	–
Rice bran		38.5	39	39	38.5	–
Palm oil		1	0.5	0.5	1	–
Vitamin and mineral mix[c]		0.5	0.5	0.5	0.5	–
Proximate composition by analysis (% dry basis)[d]						
Dry matter		89.79 ± 0.46	87.90 ± 0.34	88.08 ± 0.46	87.21 ± 0.06	90.39 ± 0.51
Protein		34.09 ± 0.42	34.04 ± 0.20	33.57 ± 0.26	33.75 ± 0.29	31.79 ± 0.46
Lipid		13.15 ± 0.37	13.19 ± 0.20	13.11 ± 0.23	13.08 ± 0.18	6.71 ± 0.73
Ash		13.74 ± 0.30	13.79 ± 0.20	14.17 ± 0.11	14.77 ± 0.57	8.62 ± 0.08
NFE[e]		39.03 ± 0.49	38.98 ± 0.34	39.15 ± 0.06	38.39 ± 0.78	52.88 ± 0.35
Energy (kcal DE g^{-1})[f]		3.23 ± 0.01	3.24 ± 0.02	3.22 ± 0.01	3.20 ± 0.02	2.94 ± 0.03
Salt (NaCl)		1.12 ± 0.10	3.09 ± 0.01	4.37 ± 0.01	5.22 ± 0.02	0.57 ± 0.02
A/E ratio of the experimental diets and Hemibagrus nemurus (% protein)[g]						
Essential amino acid	*Hemibagrus nemurus*					
Arginine	7.72	7.15	6.34	7.03	6.78	5.80
Histidine	7.10	7.81	8.01	8.01	7.49	8.69
Isoleucine	14.02	12.34	13.62	11.72	13.72	13.89
Leucine	17.48	18.54	17.78	17.75	17.39	17.63
Lysine	13.88	17.79	15.17	15.65	14.95	15.93
Methionine	6.54	7.05	6.95	6.89	7.207	5.82
Alanine	7.61	5.05	6.33	6.67	6.63	6.76
Phenylalanine	8.15	7.33	7.73	7.77	7.91	7.92
Threonine	9.68	9.03	9.61	9.52	9.92	8.77
Valine	7.82	7.90	8.43	8.99	7.99	8.78
Tryptophane	ND[h]	ND	ND	ND	ND	ND

[a] FM = Fish meal; STFM = Salted trash fish meal; CD = Commercial diet.
[b] CD = Commercial diet, unknown ingredients.
[c] Vitamin and mineral mix. Vit A. 2750 IU; Vit D. 550.000 IU; Vit E. 25.000 IU; Vit K. 5.000 mg; Choline. 250.000 mg; Niacin. 50.000 mg; Riboflavin. 10.000 mg; Pyridoxine. 1[illegible]00 mg; Calcium D-pantothenate. 25.000 mg; Biotin. 50 mg; Folacin. 2.500 mg; Cyanocobalamin. 10 mg; Ascorbic acid. 50.000 mg; K_2HPO_4. 30%; KCl. 8.4%; $MgSO_4$. 14.8%; $CaHPO_4{\cdot}2H_2O$ 27.4%; $FeCL_3$. 1.4%; $MnSO_4{\cdot}7H_2O$ 0.2%; $CaCO_3$. 16.8%.
[d] Values are means of triplicate ± S.E.
[e] NFE was calculated by difference (100 – crude protein – crude lipid – moisture – ash).
[f] Energy (kcal DE g^{-1}) was calculated based on protein = 3.5 kcal g^{-1}, lipid = 8.1 kcal g^{-1}, NFE = (2.5 kcal g^{-1}).
[g] A/E = % Essential amino acid/Total essential amino acid.
[h] ND = Not determined.

$$\text{Food conversion ratio} = (\text{Food consumed, g})/(\text{Weight gain, g})$$

$$\text{Protein efficiency ratio} = (\text{Weight gain, g})/(\text{Protein consumed, g})$$

$$\text{Protein retention}(\%) = (\text{Protein gain, g})/\text{Protein consumed, g}) \times 100$$

$$\text{Edible flesh}(\%) = (\text{Flesh weight}/\text{Whole body weight}) \times 100$$

$$\text{Dress} - \text{out percentage}(\%) = (\text{Whole body weight} - \text{head} - \text{fins} - \text{skin} - \text{viscera})/(\text{Whole body weight})$$

$$\text{Carcass waste}(\%) = [\text{Waste weight}(\text{head} - \text{born} - \text{fins} - \text{skin} - \text{viscera})/(\text{Whole body weight})] \times 100$$

$$\text{Hepatosomatic index}(\%) = (\text{Liver weight, g}) \times 100/(\text{Whole body weight, g})$$

Sensory quality was evaluated for fresh fillets, except for flavor, the fillets were steamed before evaluation. The assessment was made by six trained panelists, which were comprised of teaching staffs of the Department of Fish Processing Technology, Riau University who were very familiar with quality characteristics of this species. Before evaluation, the sensory attributes and scores were discussed and agreed by the panelists. The attributes were appearance: intensity of reddish whiteness and lightness in color; texture: elasticity and softness; odor: intensity of fresh specific odor and off-odor (earthy musty odor, oily and waste odor); flavor: intensity of fresh specific flavor and off-flavor (earthy musty flavor, oily and waste flavor) and overall quality. The sensory quality assessment was made using a 9-1 fresh fish quality score sheet; score 9 was the highest which was indicated by appearance (very intense of reddish whiteness and lightness in color; solid and elastic in texture); odor (very intense of fresh odor and no off-odor); flavor (very intense of fresh flavor and no off-flavor); and 1 was the lowest, which was characterized by appearance (very intense discoloration and darkness); texture (very intense softness and darkness); odor (very intense off-odor); flavor (very intense off-flavor).

Data analysis

The data were subjected to a one-way Analysis of Variance (one-way ANOVA) using SPSS software version 17 (SPSS, 2008). The Least Significant Difference (LSD) test was used to determine the differences among the treatments.

Results and discussion

The salted trash fish meal contained 55.37% crude protein, 5.27% crude lipid, 8.19% ash, 12.17% nitrogen-free extract (NFE) and 13.19% NaCl (Table 1). The crude protein and lipid contents of the salted trash fish meal were of lower values as compared to conventional fish meal, but crude ash, NFE, as well as salt (NaCl), were higher for salted trash fish meal than for conventional fish meal. Trash fish from marine by-catch are usually lower in protein and similar or higher in lipid than conventional fish meal (Li et al., 2004; Hasan et al., 2001). However, lower crude lipid of trash fish meal in this study may be due to the lipid lost (washing and leaching) during the desalting process, as the salted trash fish before being formulated into the feed diet was boiled and pressed for reducing its salt concentration (desalting). Reducing lipid in the salted trash fish meal as a result of boiling and pressing during desalting was also reported in our previous study (Hasan et al., 2016b). In addition, higher ash content of the salted trash fish meal, which reached 13.19%, may be caused by high salt concentration in the product.

Formulation and proximate composition of the experimental diets were shown in Table 2. Protein and energy contents of each formulated diet (FM and STFM diets) were maintained at 34% and 3.25 kcal g^{-1} DE respectively; and palm oil was used as a lipid source to maintain energy balance in the diets. Commercial diet (CD) was composed of unknown ingredients. Protein, fat, ash, NFE and energy composition of the formulated diets were similar, except for CD, which was lower in protein, fat, ash and energy but higher in NFE. Salt concentration of the formulated diets was increased as the amount of salted trash fish meal increased in the diets; and their concentrations were 1.12%; 3.09%; 4.37%; and 5.22% respectively for FM, STFM-50, STFM-75 and STFM-100. The amino acid profiles of the salted trash fish meal and control diets were similar. The A/E ratio (% essential amino acid content/total amino acid) of *Hemibagrus nemurus*, which was considered as an indicator for amino acid balance in the fish diets, was also similar between salted trash fish meal diets and control diet. As the nutritional values of the salted trash fish meal and control diets were similar, consequently, salt concentration was the only component differentiating salted trash fish meal diets and control diets composition.

The water stability of pelleted diets was measured by the percentage loss of dry matter (LDM) after 10 and 30 min in the water, and the best water stability was the feed with a minimum loss in dry matter. The LDM values in this study (Table 3) were not different between salted trash fish pelleted diets and control pelleted diet (P > 0.05), indicating that the inclusion of salted trash fish meal in the diet did not significantly affect water stability of the pelleted feed. The LDM values of the control diet and salted trash fish meal diets were 2.02–2.04% for 10 min and 6.37–6.38% for 30 min. According to Wood et al. (1985) and New (1987), these values were considered very stable as a minimum LDM value for catfish feed was <10% for 5 min.

The feeding trial indicated that the substitution of the conventional fish meal by salted trash fish meal in the fish diets up to 75% (Table 4) did not affect survival rate, weight gain, specific growth rate, food consumption, food conversion, protein efficiency ratio and hepatosomatic index as compared to the control diet (P > 0.05). The replacement of conventional fish meal by salted trash fish meal in the diet up to 75% (Table 5) neither affected body proximate composition and amino acid profile of the fish as compared to those fed the control diet (P > 0.05). The acceptability of salted trash fish diets in this study was higher than our previous feeding study on the same species of smaller size for 8 weeks, where the inclusion of salted trash fish more than 50% in the fish diet gave negative effects on growth and feed utilization (Hasan et al., 2016b). The reason for the higher acceptability of the salted trash fish meal diets in this study may be due to the bigger experimental fish size used and longer feeding trial (12 weeks as compared to 8 weeks in the previous study), so the fish became more adaptable to the salted diets.

However, complete replacement of conventional fish meal with salted trash fish meal (STFM-100) decreased protein retention and body protein composition of the fish (P < 0.05). An optimal essential amino acid (EAA) profile is a prerequisite for fish protein retention (Luo et al., 2006; Peres and Oliva-Teles, 2009; Baki et al., 2017). The contents of the EAA, especially the lysine, methionine and threonine, are generally the limiting amino acids' content in economical alternative protein sources; and a deficiency in one EAA will lead to poor utilization of the provided dietary protein (Wilson, 2002).

In the present study, the A/E ratio of *Hemibagrus nemurus*, which was considered as an indicator for amino acid balance in the fish diets (Khan et al., 1993; Hasan et al., 2001; Mai et al., 2006; Hu et al., 2013) was similar between salted trash fish meal diets and control diet. Therefore, the reason for reducing protein retention and fish body protein composition as the increasing of salted trash fish in the diets up 100% may correlate with reducing the protein utilization due to high concentration of salt in the salted trash fish diets. The negative effects on protein utilization due to higher salt concentration of the diet was also reported in our feeding trial on the same species of smaller size (Hasan et al.,

Table 3
Water stability of pelleted feed diets for 10 and 30 min.

Pelleted Diets	Water Stability (% LDM)	
	LDM-10 Minutes	LDM-30 Minutes
FM	2.04 ± 0.07[a]	6.38 ± 0.07[a]
STFM-50	2.02 ± 0.13[a]	6.38 ± 0.05[a]
STFM-75	2.03 ± 0.05[a]	6.37 ± 0.05[a]
STFM-100	2.03 ± 0.08[a]	6.37 ± 0.06[a]

Values (means of triplicate ± S.E.) in the same columns with the same superscript are not significantly different (P < 0.05).

Table 4
The effect of salted trash fish meal diets on fish growth, food consumption and utilization.

Parameters	Diets				
	FM[a]	STFM-50	STFM-75	STFM-100	CD
Initial weight (g)	45.67 ± 2.57	47.00 ± 2.55	46.23 ± 2.51	44.44 ± 1.04	44.67 ± 2.70
Final weight (g)	119.04 ± 9.23	121.06 ± 7.24	118.35 ± 5.00	115.67 ± 3.05	136.07 ± 7.84
Survival rate (%)	94.67 ± 6.11[a]	83.33 ± 11.02[a]	92.67 ± 9.24[a]	96.12 ± 2.01[a]	87.82 ± 9.49[a]
Weight gain (g)	73.37 ± 7.97[a]	74.06 ± 5.85[a]	72.12 ± 7.31[a]	71.23 ± 2.12[a]	91.40 ± 6.61[b]
Specific growth rate (%)	1.06 ± 0.07[a]	1.05 ± 0.05[a]	1.04 ± 0.10[a]	1.05 ± 0.01[a]	1.24 ± 0.06[b]
Food consumption (g/fish)	165.06 ± 12.25[a]	166.85 ± 9.57[a]	163.24 ± 4.25[a]	161.16 ± 8.69[a]	177.53 ± 16.72[b]
Food conversion ratio	2.26 ± 0.12[a]	2.27 ± 0.31[a]	2.28 ± 0.26[a]	2.20 ± 0.16[a]	1.94 ± 0.08[a]
Protein efficiency ratio	1.30 ± 0.08[a]	1.31 ± 0.18[a]	1.32 ± 0.15[a]	1.31 ± 0.09[a]	1.62 ± 0.05[b]
Protein retention (%)	20.79 ± 1.61[a]	20.13 ± 3.26[a]	20.07 ± 3.08[a]	15.92 ± 1.30[b]	14.55 ± 0.56[b]
Hepatosomatic Index (%)	1.14 ± 0.06[a]	1.19 ± 0.04[a]	1.23 ± 0.07[a]	1.12 ± 0.18[a]	1.09 ± 0.09[a]

Values (means of triplicate ± S.E) in the same rows with the same superscript are not significantly different (P < 0.05)

Table 5
The effect of salted trash fish meal diets on proximate composition and amino acid profile of fish.

Proximate composition	Proximate composition (% weight basis, triplicate samples)				
	FM	STFM-50	STFM-75	STFM-100	CD
Protein	16.30 ± 0.04[c]	15.89 ± 0.03[c]	15.87 ± 0.01[c]	14.04 ± 0.23[b]	11.37 ± 0.34[a]
Lipid	12.05 ± 0.57[a]	12.11 ± 0.32[a]	12.26 ± 0.40[a]	12.41 ± 0.24[a]	13.85 ± 0.56[b]
Moisture	68.98 ± 0.29[a]	70.25 ± 0.38[a]	69.68 ± 0.82[a]	68.69 ± 0.33[a]	68.55 ± 0.57[a]
Ash	0.48 ± 0.05[a]	0.33 ± 0.01[a]	0.47 ± 0.09[a]	0.39 ± 0.06[a]	0.35 ± 0.05[a]
Amino acid (% sample)					
Aspartic acid	2.15 ± 0.01	2.01 ± 0.29	1.92 ± 0.08	1.89 ± 0.25	1.98 ± 0.26
Glutamic acid	3.55 ± 0.07	3.25 ± 0.02	3.23 ± 0.56	3.48 ± 0.31	3.37 ± 0.14
Serine	0.59 ± 0.10	0.64 ± 0.08	0.59 ± 0.11	0.58 ± 0.02	0.59 ± 0.03
Glycine	2.09 ± 0.52	1.97 ± 0.35	2.01 ± 0.19	1.98 ± 0.10	1.98 ± 0.11
Proline	1.57 ± 0.02	1.69 ± 0.13	1.64 ± 0.30	1.71 ± 0.16	1.87 ± 0.26
Tyrosine	0.86 ± 0.04	0.84 ± 0.03	0.74 ± 0.21	0.76 ± 0.11	0.78 ± 0.14
Cysteine	0.72 ± 0.01	0.75 ± 0.06	0.69 ± 0.10	0.74 ± 0.05	0.69 ± 0.10
Histidine	2.08 ± 0.24	1.95 ± 0.17	2.04 ± 0.17	2.01 ± 0.08	1.98 ± 0.18
Arginine	1.32 ± 0.28	1.25 ± 0.20	1.32 ± 0.13	1.28 ± 0.19	1.33 ± 0.22
Alanine	0.59 ± 0.10	0.55 ± 0.14	0.56 ± 0.12	0.54 ± 0.28	0.51 ± 0.19
Valine	0.72 ± 0.07	0.66 ± 0.13	0.71 ± 0.04	0.63 ± 0.04	0.62 ± 0.09
Methionine	0.60 ± 0.01	0.60 ± 0.07	0.66 ± 0.09	0.60 ± 0.01	0.63 ± 0.04
Threonine	0.83 ± 0.01	0.55 ± 0.25	0.62 ± 0.25	0.76 ± 0.01	0.55 ± 0.26
Isoleucine	1.04 ± 0.01	1.06 ± 0.20	1.00 ± 0.12	0.98 ± 0.05	1.01 ± 0.14
Leucine	1.55 ± 0.03	1.61 ± 0.02	1.52 ± 0.14	1.57 ± 0.02	1.56 ± 0.06
Phenilalanine	0.65 ± 0.04	0.80 ± 0.08	0.77 ± 0.12	0.72 ± 0.11	0.76 ± 0.11
Lisine	1.39 ± 0.01	1.30 ± 0.14	1.31 ± 0.27	1.39 ± 0.09	1.22 ± 0.06
Total	22.31 ± 0.81	21.45 ± 0.75	21.34 ± 0.76	21.62 ± 0.78	21.44 ± 0.78

Values (means of triplicate ± S.E.) in the same rows with the same superscript are not significantly different ($P < 0.05$).

Table 6
The effect of salted trash fish diets on carcass quality of fish.

Carcass quality	Diets				
	FM	STFM-50	STFM-75	STFM-100	CD
Edible flesh	38.89 ± 3.89[a]	38.35 ± 2.38[a]	38.10 ± 1.24[a]	39.72 ± 1.29[a]	38.07 ± 1.08[a]
Dress-out percentage	53.36 ± 1.48[a]	53.28 ± 1.56[a]	53.20 ± 1.49[a]	53.95 ± 0.38[a]	54.15 ± 2.75[a]
Carcass waste	58.27 ± 3.15[a]	58.65 ± 0.51[a]	58.27 ± 0.71[a]	58.63 ± 1.30[a]	58.45 ± 0.34[a]
Sensory quality					
Appearance	8.61 ± 0.19[b]	8.78 ± 0.19[b]	8.72 ± 0.10[b]	8.67 ± 0.00[b]	7.50 ± 0.17[a]
Texture	8.28 ± 0.25[b]	8.44 ± 0.10[b]	8.50 ± 0.00[b]	8.22 ± 0.10[b]	7.67 ± 0.00[a]
Odor	8.67 ± 0.17[b]	8.78 ± 0.10[b]	8.72 ± 0.10[b]	8.61 ± 0.10[b]	7.72 ± 0.10[a]
Flavor	8.39 ± 0.25[b]	8.67 ± 0.00[b]	8.61 ± 0.19[b]	8.33 ± 0.17[b]	7.78 ± 0.10[a]
Overall	8.56 ± 0.10[b]	8.72 ± 0.10[b]	8.72 ± 0.19[b]	8.50 ± 0.00[b]	7.72 ± 0.10[a]

Values (means of triplicate ± S.E.) in the same rows with the same superscript are not significantly different ($P < 0.05$).

2016b) and flounder juvenile, *Paralichthys olivaceus* (Park et al., 2000).

Compared to the commercial diet (CD), the diets containing salted trash fish meal up to 75% (STFM-75) gave higher protein retention and fish body protein composition but lower weight gain, specific growth rate, feed consumption and fish body lipid ($P < 0.05$). This is probably due to the salted trash fish meal diets containing 34% protein, which retained higher protein levels in the fish body. While the commercial diet contained lower protein level (31.79%), which may be below the optimum requirement for the fish growth (Ng et al., 2001; Jayant et al., 2018), so the fish consumed more feed to meet its protein requirement, and high intake of low protein diet increases body lipid which was reported by García-Romero et al. (2014); Martínez et al. (1992); Rueda et al. (1997); and Shearer (1994).

Edible flesh, dress-out percentage, carcass waste and sensory quality of the fish (Table 6) were not affected by the substitution of fish meal by salted trash fish meal in the diet ($P > 0.05$), and the values were also comparable between the fish fed salted trash fish meal diets and commercial diet. However, there was a better sensory quality value of the fish fed salted trash fish meal diets as compared to that fed commercial diet ($P < 0.05$). The better sensory quality of the fish fed salted trash fish diets in this study may correlate with higher protein concentration of the trash fish diets as compared to commercial diet. The better sensory quality of river catfish *H. nemurus* fed higher protein diet was also reported by Hasan et al (2016a).

Conclusion

The conventional fish meal can be replaced by salted trash fish meal in the diet of river catfish up to 75% without negative effect on pellet water stability, growth performances and carcass quality of the river catfish *H. nemurus*.

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