

CARCASS QUALITY OF RAW AND SMOKED FISH FILLETS PREPARED FROM CAGE RAISED RIVER CATFISH (*Hemibagrus nemurus* Valenciennes, 1840) FED HIGH PROTEIN-LOW ENERGY AND LOW PROTEIN-HIGH ENERGY DIETS

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Graphical abstract



Abstract

The purpose of this study was to evaluate the effect of high protein-low energy and low protein-high energy diet on carcass quality of raw and smoked river catfish fillets. Two diets containing high protein-low energy (40 % protein, 2.75 kcal g⁻¹ energy, diet A) and low protein-high energy (34 % protein, 3.00 kcal g⁻¹ energy, diet B) which produced the best growth in our previous feeding trial were fed to river catfish. The fish, 40.14 g to 42.64 g in weight were stocked in commercial fish cage at density of 50 fish per m³ and fed the experimental diets for 90 d. At the end of the experiment, all fish was weighed for weight gain, 20 fish were evaluated for carcass quality and other 20 fish were filleted and hot smoked. Smoked fillets were assessed for smoking yield, proximate composition, sensory quality and overall acceptability. Edible flesh, dressing percentage and flesh water holding capacity of the fresh raw were higher for the fish fed diet A; but carcass waste was higher for the fish fed diet B. Protein composition was higher for the fish fed diet A; however, fat composition was higher for the fish fed diet B. In terms of smoking yield and overall acceptability of smoked fish, there was no difference between smoked fillets prepared from the fish fed the two diets, while appearance and texture were higher for the smoked fillets prepared from fish fed diet A; and odor as well as flavor were higher for smoked fillets prepared from fish fed diet B.

Keywords: Carcass quality, diets, river catfish (*Hemibagrus nemurus* Valenciennes, 1840), smoking yield, sensory quality

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1.0 INTRODUCTION

Hot-smoked river catfish (*Hemibagrus nemurus* Valenciennes, 1840) is a traditional fish product of considerable economic importance in Riau Province, Indonesia. The product is usually prepared from fish caught in the wild, but the catch in the wild now is decreasing due to overfishing and environmental damage, thus the latter supply of the fish will depend on aquaculture production. However, the cultured fish is usually lower in quality than that wild fish [1–3], so improvement quality of

the raw is important to produce high quality of smoked fish.

The quality of farm-raised fish is affected by nutritional quality of the fish diet. Low protein and high energy in the diet cause fat deposition in the fish body, resulting in low edible flesh and high carcass waste, soft flesh, oily flavor and short storage life [4–7]. Fatty fish is difficult to fillet; and when hot-smoked, the body fat liquidify and the final product is low in yield and sensory quality [3]. River catfish requires 34 % to 40 % dietary protein and 2.70 kcal g⁻¹ to 3.25 kcal g⁻¹ energy for optimum growth [8, 9]; however,

the farmers feed their fish with lower dietary protein and higher energy than recommended, thus the low quality of the raw and smoked fish quality must be due to low protein and high energy level in the fish diet.

The recent study on growth performance of river catfish fed diets containing two dietary protein and two dietary energy levels at a laboratory scale revealed that the diets containing 40 % protein, 2.75 kcal g⁻¹ energy and 34 % protein, 3.00 kcal g⁻¹ energy resulted in the best growth [9]. However, the diets producing good quality of raw and smoked fillet have not yet been investigated. This research therefore was proposed to evaluate carcass quality of raw and smoked fish prepared from harvested cultured catfish fed diets containing 40 % protein, 2.75 kcal g⁻¹ energy (high protein-low energy diet) and 34 % protein, 3.00 kcal g⁻¹ energy (low protein-high energy diet) at a commercial culture scale.

2.0 EXPERIMENTAL

2.1 Feeding Trials

River catfish, ranging from 40.14 g to 42.64 g in size were stocked in two triplicate commercial floating cages at a density of 50 fishes per m³ (Figure 1); and fed the diets containing high protein-low energy (40 % protein and 2.75 kcal g⁻¹ energy, diet A) and low protein-high energy (34 % protein and 3.00 kcal g⁻¹ energy, diet B) (Table 1) for 90 d.

Table 1 Formulation and proximate composition of the experimental diets

Composition	Diets (%)	
	A	B
Fishmeal	55	33
Soybean meal	17	30
Rice bran	26	32.5
Palm oil	0	2.5
Vitamin mix	1	1
Mineral mix	1	1
Proximate composition by analyses		
Dry matter	94.49	94.88
Protein	40.96	34.83
Fat	7.31	6.95
Ash	16.9	13.91
Fiber	6.99	8.78
FE	25.84	31.03
Estimated Digestible Energy (kcal · g ⁻¹)	2.78	3.04



Figure 1 Experimental fish

At the end of experiment, the fish were weighed for weight gain. Forty fishes from each cage were randomly sampled; 20 fishes were slaughtered and calculated for carcass quality; and other 20 fishes were filleted and made for hot smoked fillets.

The fillets were smoked in a smoke kiln using stratified temperatures, 50 °C to 60 °C at initial step for drying, 80 °C to 90 °C at a further step for cooking, and 50 °C to 60 °C at final step for product finishing [3]. The smoking process was stopped after the fillets were cooked and turned golden yellow to brown in color.

2.2 Raw Carcass and Smoked Fish Fillet Quality Analysis

Carcass quality of raw was calculated for edible flesh, dressing percentage, carcass waste, water holding capacity and flesh chemical composition. Smoked fish quality was evaluated for smoking yield, chemical composition, sensory value and overall acceptability. Water holding capacity was analyzed by a centrifugation method [10]; and the value was expressed as the percentage of water lost after centrifugation for 5 min at 1 500 rpm (1 rpm = 1/60 Hz) (Centurion Scientific K3 Series, K241R). Edible flesh, dressing percentage, carcass waste, water holding capacity and smoking yield was calculated using the following formulas.

$$\begin{aligned} \text{Weight gain} &= (\text{Final weight} - \text{Initial weight}) / (\text{Initial weight}) \times 100 \\ \text{Edible flesh (\%)} &= (\text{Flesh weight} / \text{Body weight}) \times 100 \\ \text{Dressing percentage (\%)} &= (\text{Body weight} - \text{head} - \text{fins} - \text{skin} - \text{viscera}) / (\text{Body weight}) \times 100 \\ \text{Carcass waste (\%)} &= (\text{Fish waste weight} / \text{Body weight}) \times 100 \\ \text{Water Holding Capacity} &= (\text{Flesh mince weight} - \text{Flesh mince weight after centrifuge}) / (\text{Flesh mince weight}) \times 100 \\ \text{Smoking yield} &= (\text{Fillet weight after smoking} / \text{Fillet weight before smoking}) \times 100 \end{aligned}$$

Chemical composition of raw and smoked fish fillet was analyzed for moisture, protein and fat composition using AOAC method [11]. Moisture was determined after oven-drying at 105 °C until the

sample weight was constant; protein content was analyzed using Kjeldahl procedure; and crude protein was estimated as $N \times 6.25$. Crude fat was determined after soxhlet extracted using petroleum ether.

Sensory quality was evaluated by six trained panelists comprising of teaching staffs of Fish Processing Technology Department. The sensory quality assessment was made using a 9-1 smoked fish quality score sheet recommended by Hasan and Edison [12]; score 9 was the highest and 1 was the lowest. The sensory quality attributes included appearance (smoothness, fat secretion, translucent, hue, and color intensity); odor (specific smoked catfish odor); flavor (specific smoked catfish flavor); texture (elasticity, oiliness and juiciness). Overall acceptability were evaluated by 50 untrained panelists using a nine-point hedonic scale, 9 = like extremely and 1 = dislike extremely.

2.3 Data Analysis

Triplicate data of carcass characteristics and smoked fish fillets quality prepared from fish fed two different diets were analyzed using t-test [13].

3.0 RESULTS AND DISCUSSION

3.1 Weight Gain and Carcass Quality Characteristics of Raw

There was no difference in weight gain (Table 2) between fish fed diet A and B, but edible flesh, dressing percentage and flesh water holding capacity were higher for fish fed diet A than B. Carcass waste was higher for the fish fed diet B than A. Improving carcass quality of harvested fish as a result of increasing protein in fish diet has also been proved by other workers in other species [7, 14, 15, 16, 17].

Flesh composition of harvested fish differed between fish fed diet A and diet B, except for moisture. Protein composition was higher for fish fed diet A than B, however, fat composition was higher for fish fed diet B than A. Edible flesh, dressing percentage and flesh water holding capacity of harvested fish in this study showed a parallel relationship with body protein but inverse relationship with body fat. Dietary protein with sufficient energy in the diet will be metabolized completely to body protein; however an excess of energy in the diet will be converted to body fat which are devoted in skin and visceral cavity, thus reducing edible flesh and dressing percentage as well as flesh water holding capacity. Increasing protein level in the diet improves body protein and decreases body fat was also reported in many species of fish such as chinook salmon (*Oncorhynchus tshawytscha*) [18], bagrid catfish (*Pseudobagrus fulvidraco*) [16], Grass Carp (*Ctenopharyngodon idella*) [19], rainbow trout (*Salmo gairdneri*) [20, 21], channel catfish (*Ictalurus*

punctatus) [23-26] and clarias catfish (*Clarias macrocephalus* × *Clarias gariepinus*) [7].

Table 2 Carcass quality characteristics of harvested fish fed high protein-lowenergy diet (A) and low protein-high energy diet (B)

Carcass quality characteristics	Composition (%)	
	Diet A	Diet B
Weight gain	276.76 ^a	272.67 ^a
Edible flesh	43.45 ^b	41.20 ^a
Dressing percentage	53.71 ^b	51.99 ^a
Carcass waste	46.29 ^a	48.52 ^b
Water holding capacity	11.77 ^a	14.73 ^b
Moisture	70.08 ^a	69.66 ^a
Protein	17.95 ^b	15.75 ^a
Fat	9.57 ^a	11.43 ^b

Note: Data in the same rows indicated by the same latter were not significantly different ($P > 0.05$)

3.2 Smoking Yield and Chemical Composition of Smoked Fillets

There was no difference in yield of smoked fillets prepared from diet A and B (Table 3), indicating that the difference in body protein and fat of raw fish did not affect smoking yield. Smoking yield, the most economic importance of smoked fish industry, is usually correlated with fat and other component lost during smoking.

In cold smoking method, the smoking yield usually increased with increasing fat content of the raw [27]; but in hot-smoking method, smoking yield decreased with increasing fat content of the raw as some of the body fat melted during smoking [3]. Smoking yield was also affected by water holding capacity, the ability of muscle to resist water and fat of the raw fish [28-30].

Table 3 Smoking yield and chemical composition of smoked fillets prepared from fish fed diet A and B

Chemical composition (%)	Diets	
	A	B
Smoking yield	35.31 ^a	36.68 ^a
Moisture	11.73 ^a	14.06 ^b
Protein	48.07 ^b	43.21 ^a
Fat	18.72 ^a	22.67 ^b

Note: Data in the same row indicated by the same latter were not significantly different ($P > 0.05$)

The fact that the smoking yield did not differ between the two smoked fillets prepared from fish of different fat and protein content in the present study was probably associated with smoking method in this study, which used low temperature 50 °C to 60 °C at initial smoking step for drying the fish fillet. The gradual increase in temperature 80 °C to 90 °C at further step to cook the fish might be capable of

minimizing excessive loss of fat of the fatty fillets during smoking. Other reason was because moisture composition of smoked fish prepared from fish fed low dietary protein-high energy diet was still fairly higher since increasing drying temperature would defact and liquidify the body fat. Higher protein in smoked fish prepared from fish fed diet A, and higher fat in smoked fish prepared from fish fed diet B (Table 3) was proportional to protein and fat composition of the raw. The similar results were also demonstrated by hot-smoked *Pangasius catfish* (*Pangasius hypophthalmus*) prepared from fish of different sizes [3].

3.3 Sensory Quality and Overall Acceptability

There was no difference in overall acceptability of smoked fish (Table 4) between the two smoked fish; however, appearance and texture values were higher for smoked fillets prepared from fish fed diet A; and flavor as well as odor values were higher for the smoked fillets prepared from fish fed diet B. A better appearance and texture of smoked fillets prepared from fish fed high protein diet was probably due to the fish body protein composition and water holding capacity which were higher in fish fed high protein diet. This reason was in accordance with findings reported by Rora et al. [27] and Eien et al. [31]. Moreover, a better odor and flavor of smoked fillet may be correlated to fish body fat composition which was higher in the fish fed low protein diet. Fish body fat at a certain amount improving odor and flavor of smoked fillet was also consistent with our previous study on sensory quality characteristics of smoked fish prepared from *Pangasius catfish* (*Pangasius hypophthalmus*) of different sizes [3].

Table 4 Sensory quality and overall acceptability of smoked fillets prepared from fish fed diet A and B

Sensory quality	Diets	
	A	B
Appearance	9.00 ^b	7.80 ^a
Texture	8.27 ^b	7.67 ^a
Odor	8.20 ^a	9.00 ^b
Flavor	8.20 ^a	9.00 ^b
Overall acceptability	8.61 ^a	8.56 ^a

Note: Data in the same row indicated by the same latter were not significantly different ($P > 0.05$)

4.0 CONCLUSION

There was no difference in weight gain and body moisture of the raw between fish fed the two diets, but edible flesh, dressing percentage, flesh water holding capacity and body protein were higher for the fish fed diet A, and body fat was higher for fish fed diet B. Smoking yield and overall acceptability of the smoked fish prepared from fish fed the two diets were similar, however protein composition,

appearance and texture values were higher for smoked fillets prepared from fish fed diet A; while fat, moisture, odor and flavor values were higher for smoked fillets prepared from fish fed diet B. As high protein diet is expensive while weight gain, smoking yield and overall acceptability of smoked fish are not different between fish fed the two diets, diet B therefore may be recommended for better raw and smoked fillet quality.

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