Iranian Journal of Fisheries Sciences 19(4) 1828-1839 2020
DOI: 10.22092/ijfs.2018.117179

Growth performance and carcass composition of African catfish, *Clarias gariepinus* fed different protein and energy levels

Rency Siagian E.[1]; Agung Nugroho R.[1*]

Received: July 2017 Accepted: November 2017

Abstract

A feeding trial was conducted to evaluate the effects of dietary crude protein and energy levels on the live weight (LW), daily weight gain (DWG), feed conversion rate (FCR), feed efficiency (FE), protein efficiency rate (PER), survival rate (SR), specific growth rate (SGR), thermal growth coefficient (TGC) and carcass composition of catfish (*Clarias gariepinus*). In this trial a group of 80 catfish were randomly assigned per tank in 3 replicates and fed different levels combination of crude protein and energy, *viz*: three levels of crude protein (CP) (32; 34; and 36%) with digestible protein (DP) (27; 39; and 41%) and three levels of digestible energy (DE) (11.9; 12.4; and 13.3%) for 8 weeks. At the end of experiment, the results showed that the highest LW, DWG, SGR and TGC were found in fish fed 34% CP: 39% DP: 12.4% DE. The better FCR was reached in fish fed 36% CP: 41%DP: 12.4% DE whereas highest PER was in fish fed 34% CP: 39% DP: 13.3% DE. Meanwhile, fish fed 36%CP: 41% DP: 12.4% DE resulted in significantly higher FE. However, the SR of fish was not affected by any combination of CP: DP: DE. This finding indicated that 34% CP: 39% DP: 12.4% DE was the optimum combination in enhancing the growth of catfish.

Keywords: *Clarias gariepinus*, Digestible protein and energy, Growth

1-Animal Physiology, Development and Molecular Laboratory, Department of Biology, Faculty of Mathematics and Natural Sciences, Mulawarman University, Samarinda, East Kalimantan, Indonesia

*Corresponding author's Email: rudysatriana@yahoo.com

Introduction

African catfish (*Clarias gariepinus*) is increasingly becoming a pivotal commercial species in Africa, Europe and part of Asia especially in Indonesia. It is also one of the most important fish species that is currently being cultured both within and outside its natural range of tropical and subtropical environments (Sousa *et al.*, 2013; Yakubu *et al.*, 2014). The catfish's resistance to diseases, high fecundity and easy production in captivity make it of commercial importance (Haylor and Mollah, 1995; Noor El-Deen *et al.*, 2014; Ljubobratovic *et al.*, 2015).

In formulating diets for fish, it is relevant to meet all requirements of nutrients, such as protein, carbohydrate, lipid, vitamin and lipid to achieve optimum growth. Lack of good quality feed for economic production adversely affects growth rates, disease outbreak and total harvest of fish (Fakunle *et al.*, 2013). Fish like all other animals, require energy to sustain life. The dietary protein to energy ratio in fish is a great importance aspect to be considered in formulating fish diet. Levels of dietary protein and energy not only influence the growth and body composition but also digestive enzymes activities and plasma metabolites in various fishes (Yamamoto *et al.*, 2006). Providing adequate energy through dietary lipids can minimize the use of more costly protein as an energy source (Gatlin, 2010).

According to Cho (2011), the energy gain is primarily dependent on the protein or energy ratio in the diet. An effective utilization of energy requires a relatively high proportion of non-protein energy in the diet. High-energy diets can also lead to excessive deposition of carcass lipids and reduced growth rate (Onada *et al.*, 2015). Excess carcass lipid accumulation and reduced growth rate due to increased dietary energy have also been shown for catfish, *C. gariepinu*s (Pantazis, 2005).

To minimize feeding costs in aquaculture, the approach to dietary protein level can be improved by managing protein utilization. Most studies that focused on increasing energy levels or lowering the protein to energy ratio (P/E ratio) have been extensively performed. In addition, to reduce the amount of protein in fish by making changes to dietary lipid, dietary carbohydrate, and dietary protein have been confined mainly to studies of growth performance in *Cyprinus carpio* (Ahmad *et al.*, 2012), *Heterobranchus longifilis* (Otchoumou *et al.*, 2012); *Oreochromis niloticus* (Petrovic *et al.*, 2012); Acehnese mahseer (*Tor tambra*) (Muchlisin *et al.*, 2017) and lemon fin barb hybrid (*Hypsibarbus wetmorei* × *Puntius gonionotus*) larvae (Anizah *et al.*, 2017). Previous studies also revealed that a diet containing 14% fat and 35% protein improved growth performance of juveniles *H. longifilis* and promoted protein-sparing effects of lipid. In addition, most studies reported that the protein requirement of catfish ranged from 35% to 45% (Jamabo and Alfred-Ockiya, 2008). Moreover, dietary protein is considered as the main constituent in fish diets that is required to support growth but can

[DOR: 20.1001.1.15622916.2020.19.4.18.6]

proportionally increase the feed costs (Ahmad *et al.*, 2012).

Dietary energy regulates metabolic activities (McPhee and Janz, 2014), and greatly affects the growth performance (Vikeså *et al.*, 2017) and feed utilization efficiency (Haidar *et al.*, 2016). Dietary protein and energy levels and their ratios may lead to lower fish performance, increase accumulation of lipids and glycogen in the somatic tissues and liver, boost undesirable nitrogenous waste output and enhance cost production. Excessive dietary protein level in relation to energy can also actually reduce growth due to the metabolic demands of nitrogen excretion (Ahmad *et al.*, 2012).

As far as we are concerned, the optimum ratio of dietary protein, crude protein and energy levels on the growth and carcass composition of catfish (*C. gariepinu*s) has never been explored. Therefore, information on the ratio of protein, crude protein and energy levels for optimum growth of the catfish is crucial and it is a prerequisite to finding a cost effective in formulating fish diet. Hence, the objective of the present study was to carry out specifically nutritional research with catfish, *C. gariepinus* by using different levels of dietary protein, crude protein, and energy levels contents for determination of a feed formulation which would result in better growth performance and carcass composition or fish nutrients in *C. gariepinus*.

Materials and methods

Animal and experimental setup

The study was conducted at PT. Suri Tani Pemuka Unit Research and Development, Cianjur, Jawa Barat, Indonesia. Fingerlings of catfish (initial weight 9.12 ± 0.09 g; total length 10 cm) were collected from the fish hatchery of Japfa Comfeed in Subang, West Java and acclimated to the experimental conditions for a week. During this period, fish were maintained on the commercial diet SPLA 3 mm. Two thousand one hundred and sixty fish were randomly distributed into 27 tanks at stocking density of 80 fish per tank with 3 replicates assigned to each of the 9 dietary treatments. Tanks (520 L containing 500 L tap water) were provided with water recirculation system. An electric motor pump (*Grundfos type NS Basic 4-23*) was setup to ensure a constant flow (5.66 L min^{-1}) of well-aerated water. To maintain water quality, water in tanks was replaced at the rate of 30-70%, two times a week using freshwater. The water quality parameters such as temperature, pH, total ammonia nitrate, nitrite, and dissolved oxygen were measured two times a day before the first (at 07.00 am) and after the third feeding (15.30 am), using dissolved oxygen meter and temperature probe (*YSI 550A Clandon, Ohio, USA*), nitrite was measured using *Tetra Kit test* NO_2^- and pH was determined with a pH meter (Eutech Instrument Cyberscan pH 11) to monitor any unusual changes.

[DOR: 20.1001.1.15622916.2020.19.4.18.6]

Pellets preparation and feeding trial

Dry ingredients were mixed for about 30 minutes in a Getra mixer (B20-F volume 20 L Series R10240) to ensure that the mixture was well homogenized and then blended with oil for about 15 minutes. Hot water was added at 20-30% v/w to give a pelletable mixture. A pelleting machine was used to make pellets for catfish feed. An appropriate die was used to form pellets of desired sizes (1.0 to 3.0 mm). Pellets were oven dried (*Getra*) at 56 ^{o}C and stored at 27 ^{o}C throughout the experimental period. Determination of feed composition proximate analysis including dry matter, crude protein, crude lipid, ash, moisture and energy were performed. The compositions of the experimental diets are shown in Tables 1 and 2. The experimental fish were fed at a feeding rate of 6% of the body weight, three times a day at 08.00 am., 11.30 am and 16.00 pm every day for 56 days. To quantify the exact feed intake, refused feed was siphoned out immediately, dried and weighed.

Table 1: Formulation and composition of the experimental diets (g/100 g % dry matter).

Ingredient %	Treatment								
	Diet	**Diet 2**	**Diet 3**	**Diet 4**	**Diet 5**	**Diet 6**	**Diet 7**	**Diet 8**	**Diet 9**
Corn	12.0	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00
Wheat by product	18.0	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00
Soya bean meal	17.8	17.93	18.09	24.06	24.31	24.50	30.77	30.85	31.02
Cassava starch	18.2	16.34	12.56	13.23	11.30	7.54	8.10	6.21	2.42
Animal protein	23.2	23.34	23.46	22.06	22.00	22.06	20.48	20.54	20.67
Fish Meal	6.6	6.60	6.60	6.60	6.60	6.60	6.60	6.60	6.60
Mix oil (Palm olein, fish oil, Soya lecithin)	2.2	4.00	7.50	2.25	4.00	7.50	2.25	4.00	7.50
Vitamin *mix*	0.2	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Mineral *mix*	0.1	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Other additives	1.4	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45
Total %	100.	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 2: Composition of formulated feeds experimented.

Diet	Parameters (%)					
	Dry matter	**Moisture**	**Crude Protein**	**Crude Lipid**	**Ash**	**Energy (cal g^{-1})**
Diet 1	91.4	8.6	33.5	6.2	7.9	4340.4
Diet 2	92.6	7.4	33.3	8.2	8.2	4443.4
Diet 3	92.2	7.8	33.3	11.9	7.8	4571.1
Diet 4	91.8	8.2	35.3	5.5	8.1	4350.5
Diet 5	92.7	7.3	35.8	7.5	8.0	4530.5
Diet 6	92.0	8.0	35.6	11.3	7.7	4631.1
Diet 7	92.2	7.8	37.9	5.3	7.9	4403.5
Diet 8	91.9	8.1	37.7	7.4	7.9	4378.5
Diet 9	92.2	7.8	38.0	11.0	7.8	4668.4

Diet (Crude protein: Digestible protein: Digestible energy), Diet 1= 32% : 27% : 11.9%; Diet 2= 32% : 27% : 12.4%; Diet 3= 32% : 27% : 13.3%; Diet 4= 34% : 39% : 11.9%; Diet 5= 34% : 39% : 12.4%; Diet 6= 34% : 39% : 13.3%; Diet 7= 36% : 41% : 11.9%; Diet 8= 36% : 41%: 12.4%; Diet 9= 36% : 41% : 13.3%.

Sampling and analytical procedure

Body weight (BW) and FCR of fish from each tank were recorded on day 56 of the experiment. At the beginning of the experiment, an initial sample of about 1 kg of fish was taken and kept frozen (-26^{0}C) for subsequent whole-body proximate analysis. Meanwhile, at

[DOR: 20.1001.1.15622916.2020.19.4.18.6]

the end of experiment, weight and length of each fish were recorded and 1 kg fish from each tank were taken immediately and frozen (-26^{0}C) for further determination of whole body composition proximate analysis (AOAC, 1990).

Growth parameters

Live weight, biomass weight, average weekly gain (AWG), daily weight gain (DWG), body weight gain (BWG), feed conversion ratio (FCR), feed efficiency (FE), protein efficiency ratio (PER), survival rate (SR), specific growth rate (SGR) and thermal growth coefficient (TGC) were calculated as follows:

Live weight

Live weight (g)= Fish live weight of the experiment

Daily weight gain (DWG)

DWG=(Final body weight-initial body weight) (g) / number of days

Feed conversion ratio (FCR)

FCR is defined as the feed consumed in dry weight per unit live weight gain.

FCR =Feed consumed (g dry weight)/ Body weight gain

Feed efficiency (FE)

FE = [(Final fish weight (g)+ dead fish weight (g))–initial weight/Feed consumed (g dry weight]×100

Protein efficiency ratio (PER)

PER is defined as fish live weight gain per gram of protein fed.

PER=Body weight gain (g)/feed protein (g)

Survival rate (SR)

SR (%)=(Final number of fish / initial number of fish)×100

Specific growth rate (SGR % / day)

SGR is the average percentage weight change per day between any two weightings provided that the growth curve is exponential in form.

SGR (% / day) = $[(\text{Ln}W_t - \text{Ln}W_0) / (T_2\text{-}T_1)] \times 100$

Where W_0 is the initial fish weight (g) at time T_1 (day) and W_t is the final fish weight (g) at time T_2 (day).

Thermal Growth Coefficient (TGC)

$$\text{TGC} = \frac{\left[W_t^{\frac{1}{3}} - W_0^{\frac{1}{3}}\right]}{[\text{Temperature} \times \text{days experiment}]} \times 100.$$

(Jobling, 1981)

Statistical analysis

Results were expressed as mean±standard error (SE). Proximate analysis and growth data, including live weight, biomass weight, AWG, DWG, BWG, FCR, FE, PER, SGR and TGC were subjected to analysis of variance (ANOVA) using IBM SPSS Statistics 22 (SPSS, Inc., USA). Comparisons among treatment means were carried out by one-way analysis of variance followed by Duncan’s test. Standard Error (±SE) was calculated to identify the range of means. Percentage data were transformed by arc-sine transformation prior to ANOVA and reversed afterwards. All significant tests were at $p<0.05$ levels.

[DOR: 20.1001.1.15622916.2020.19.4.18.6]

Results

Live weight, DWG and PER were found significantly highest (*$p<0.05$*) in fish fed diet 34%CP: 39%DP: 12.4%DE. The FCR ranged between 0.78 and 0.94; and FCR of fish fed diet 32%CP: 27%DP: 11.9%DE was better ($p<0.05$; 0.78±0.01) than that in any other groups. In addition, feed efficiency (FE) varied from 1.07 to 1.27. The FE of group of fish fed diet 36%CP: 41%DP: 12.4%DE was significantly efficient (*$p<0.05$*) compared to any other group. Moreover, there were no significant differences (*$p>0.05$*) in the SR of all groups of fish. SR ranged from 79.54% to 84.83%. The TGC gradually increased, following the increase in levels of crude and digestible protein.

Table 3: Growth parameters of *Clarias gariepinus* sp. fed various levels of protein and energy in the diet for 56 days feeding.

Diet	Live weight (g fish^{-1})	DWG (g fish^{-1} day^{-1})	FCR (feed gain^{-1})	FE (gain Feed^{-1})	PER	SR (%)	SGR (% fish^{-1} day^{-1})	TGC
1	101.40 ± 4.47^{a}	1.64 ± 0.07^{a}	0.94 ± 0.05^{d}	1.07 ± 0.06^{a}	3.16 ± 0.18^{a}	79.54 ± 0.66^{a}	4.33 ± 0.06^{a}	0.16 ± 0.00^{a}
2	106.26 ± 5.39^{abc}	1.73 ± 0.09^{abc}	0.90 ± 0.05^{bcd}	1.11 ± 0.06^{abc}	3.36 ± 0.18^{b}	79.59 ± 1.27^{a}	4.36 ± 0.08^{ab}	0.16 ± 0.00^{abc}
3	103.63 ± 9.72^{ab}	1.68 ± 0.17^{ab}	0.89 ± 0.06^{cd}	1.12 ± 0.07^{ab}	3.40 ± 0.25^{c}	82.74 ± 0.93^{a}	4.30 ± 0.17^{a}	0.16 ± 0.00^{ab}
4	119.33 ±8.36^{bcd}	1.96 ± 0.14 ^{cd}	0.87 ± 0.04^{abc}	1.15 ± 0.05^{bcd}	3.26 ± 0.14^{ab}	84.83 ± 2.68^{a}	4.56 ± 0.14^{bc}	0.17 ± 0.00^{c}
5	129.60 ± 9.09^{d}	2.15 ± 0.16^{d}	0.83 ± 0.05^{abc}	1.21 ± 0.07^{bcd}	3.40 ± 0.23^{c}	80.03 ± 2.38^{a}	4.73 ± 0.12^{c}	0.18 ± 0.00^{c}
6	121.40 ± 12.17^{bcd}	2.00 ± 0.21^{cd}	0.84± 0.06^{ab}	1.20 ± 0.07^{cd}	3.36 ± 0.23^{b}	84.83 ± 2.68^{a}	4.60 ± 0.20^{bc}	0.18 ± 0.01^{c}
7	125.00 ± 9.08^{bcd}	2.06 ± 0.16^{bcd}	0.84 ± 0.05^{abcd}	1.20 ± 0.08^{abc}	3.16 ± 0.23^{a}	82.57 ± 3.69^{a}	4.66 ± 0.12^{bc}	0.18 ± 0.00^{bc}
8	125.96 ± 4.18^{cd}	2.08 ± 0.07^{cd}	0.78 ± 0.01^{a}	1.27 ± 0.02^{d}	3.36 ± 0.06^{b}	82.62 ± 3.82^{a}	4.70 ± 0.05^{bc}	0.18 ± 0.00^{c}
9	129.20 ± 2.30^{cd}	1.94 ± 0.03^{cd}	0.81 ± 0.02^{abc}	1.23 ± 0.03^{bcd}	3.23 ± 0.12^{ab}	84.17 ± 3.20^{a}	4.73 ± 0.03^{bc}	0.18 ± 0.00^{c}

Values are means ± standard error. Means in the same column having different superscript letters (a, b, c, d) indicated significant differences (*$p<0.05$*). Diet (Crude protein: Digestible protein: Digestible energy), Diet 1= 32% : 27% : 11.9%; Diet 2= 32% : 27% : 12.4%; Diet 3= 32% : 27% : 13.3%; Diet 4= 34% : 39% : 11.9%; Diet 5= 34% : 39% : 12.4%; Diet 6= 34% : 39% : 13.3%; Diet 7= 36% : 41% : 11.9%; Diet 8= 36% : 41%: 12.4%; Diet 9= 36% : 41% : 13.3%; DWG = Daily Weight Gain; FCR = Feed Conversion Ratio; FE = Feed Efficiency; PER = Protein Efficiency Rate; SR = Survival Rate; SGR = Specific Growth Rate; TGC = Thermal Growth Coefficient.

The highest percentage of dry matter, crude lipid, and energy of carcass composition was found in the group of fish fed diet 34%CP: 39%DP: 13.3%DE. Meanwhile fish fed 36%CP: 41%DP: 11.9%DE in the diet showed significantly higher moisture and crude protein ($p<0.05$) than other groups of fish; the lowest percentage of ash was found on the fish fed 32%CP : 27%DP : 13.3%DE.

Table 4: Carcass composition (% as is basis) of fingerlings fed on formulated feeds after 56 days.

Diet	Parameter (%)					
	Dry matter	Moisture	Crude Protein	Crude Lipid	Ash	Energy (cal g^{-1})
Diet 1	71.97 ± 0.63^{a}	18.00 ± 0.63^{b}	42.19 ± 1.19^{bc}	34.21 ± 0.10^{ab}	20.82 ± 0.73^{a}	5837.67 ± 90.67^{ab}
Diet 2	74.12 ± 0.72^{ab}	15.84 ± 0.72^{ab}	41.09 ± 0.11^{ab}	36.05 ± 0.66^{bc}	19.46 ± 1.31^{a}	6153.50 ± 23.95^{bcd}
Diet 3	73.55± 1.05^{ab}	16.41 ± 1.06^{ab}	39.58 ± 0.62^{a}	35.88 ± 0.60^{b}	19.38 ± 0.65^{a}	6260.84 ± 27.42^{d}
Diet 4	73.09 ± 0.59^{ab}	16.86 ± 0.59^{ab}	42.79 ± 0.76^{bc}	34.42 ± 0.40^{ab}	21.11± 0.36^{ab}	5844.75 ± 62.02^{abc}
Diet 5	72.54 ± 1.64^{ab}	17.42 ± 1.64^{ab}	42.70 ± 0.70^{bc}	34.57 ± 1.29^{ab}	22.89 ± 1.16^{b}	5992.04± 79.31^{bcd}
Diet 6	75.73 ± 0.90^{b}	14.23 ± 0.90^{a}	40.96 ± 0.28^{ab}	37.90 ± 0.32^{c}	20.49 ± 0.16^{ab}	6264.77 ± 78.44^{d}
Diet 7	71.24 ± 0.45^{a}	18.72 ± 0.45^{b}	43.87 ± 0.26^{c}	33.60 ± 0.64^{a}	21.19 ± 0.75^{ab}	5649.46 ± 235.19^{a}
Diet 8	72.53 ± 1.50^{ab}	17.42 ± 1.50^{ab}	42.90 ± 1.04^{bc}	34.71 ± 0.40^{ab}	20.22 ± 1.17^{ab}	5982.40 ± 68.88^{bcd}
Diet 9	74.40 ± 0.28^{ab}	15.56 ± 0.28^{ab}	41.27 ± 0.40^{ab}	35.74 ± 0.53^{b}	21.98 ± 0.66^{ab}	6164.07 ± 23.13^{cd}

Values are means ± standard error. Means in the same row having different superscripts are significantly different ($p<0.05$) and values in the same row with same superscript are not significantly different ($p>0.05$). Diet (Crude protein: Digestible protein: Digestible energy), Diet 1= 32% : 27% : 11.9%; Diet 2= 32% : 27% : 12.4%; Diet 3= 32% : 27% : 13.3%; Diet 4= 34% : 39% : 11.9%; Diet 5= 34% : 39% : 12.4%; Diet 6= 34% : 39% : 13.3%; Diet 7= 36% : 41% : 11.9%; Diet 8= 36% : 41%: 12.4%; Diet 9= 36% : 41% : 13.3%.

Water quality parameters recorded during the experiments along with their tolerable limits are given in table 5. During the whole experimental period,

[DOR: 20.1001.1.15622916.2020.19.4.18.6]

the water quality parameters were within tolerable limits. *C. gariepinus* can survive in less dissolved oxygen because it has an arborescent organ that helps in water and rapid growth.

Table 5: Water quality parameters recorded during the experiment along with their tolerable limit.

Parameters	Range of parameters recorded	Tolerable limits
Temperature (^{0}C)	25-32	22-32
pH	6.33-7.64	6-9
Dissolved oxygen (mg L^{-1})	0.3-4.84	>0.1
TAN (Total Ammonia Nitrite)	0.01-0.018	<0.1
Nitrite	< 0.3	<0.3

Discussion

Several studies on protein requirements for many species have been reported. However, the optimum ratio of crude protein, digestible protein, and digestible energy requirement in the diet of fish, especially for *C. gariepinus* has never been explored. Based on the current results, the optimum growth performance was reached in fish fed with 34% CP: 39% DP: 12.4% DE. Previous research by Yousif *et al*., (2014) found that the optimum growth of *C. gariepinus* fingerlings (10.89±0.04 g) was achieved at 430 g/kg protein, 21.2 kJ g^{-1} gross energy and P:E ratio of 20.5 mg crude protein kJ^{-1} gross energy. This may suggest that the quantitative protein requirement and the P E^{-1} ratio for the *C. gariepinus* that supported optimum growth and feed utilization were higher than the levels used in the present study. This finding also indicated that the inclusion of different levels of plant and animal by-products to replace the commercial fish meal did not affect the palatability and acceptance of the diets.

Increasing the crude protein content gradually improves fish growth and TGC. Under the present experimental conditions, fish fed the diet containing 34%CP, 39%DP, 12.4%DE had high growth with high FE and low FCR. The FCR obtained (0.83 feed $gain^{-1}$) in the present study was similar to that reported in past research (1.28 feed $gain^{-1}$) in *C. gariepinus* fed 40% protein and 13.76% fat (palm oil) (Kpogue *et al.*, 2013).

Another parameter that can be used to predict growth in fish is TGC. This quantifies and estimates the growth potential of a given species and stock of fish which relates to diet, husbandry, fish size and temperature (Cho, 1992). This inter-relates to SGR that the value of SGR increases following increased temperature. Current findings found that the TGC value was also inter-related to SGR. It was also found that the level of crude and digestible protein affected the TGC value. These results were concomitant with previous research on juvenile Arctic Charr, *Salvelinus alpinus* that showed similar increased SGR and TGC, following increased dietary protein (Amoah, 2012).

Fish meal is a highly digestible protein source, containing all the essential amino acids. The quality and quantity of fish meal corresponding to the fish needs can reach up to 49% for

[DOR: 20.1001.1.15622916.2020.19.4.18.6]

best utilization (Antolović, 2011). The fish fed 34%CP, 39%DP and 12.4%DE can satisfy the growth as indicated by a low feed conversion ratio. Meanwhile, the low feed conversion ratio recorded in fish fed with 32%CP and 27%DP showed low growth performance (DWG and SGR). Moreover, the fish fed 36%CP and 41%DP resulted in significantly decreased PER, showing the bad utilization of dietary protein. The decrease of growth beyond 36% can be due to the fact that the fish cannot use all of the available dietary protein. Excess dietary protein and dietary energy could reduce growth performance because of the energy requirement for metabolism rather than for protein deposition (Jamabo and Alfred-Ockiya, 2008).

The ability of fish to use lipid as a major source of energy has been investigated in many fish species (Raj *et al.*, 2007). From the present result, it was possible to suggest that 5.5-11.9% lipid level with 11.1.9-13.3% digestible energy were suitable for *C. gariepinus*. Lipid requirement of *C. gariepinus, C. isheriensis, C. batrachus, C. macrocephalus, C. fuscus, Heterobranchus longifilis, H. kidorsalis, Heteropneustes fossilis* and *Silurus glanis* ranged between 5% and 10%. Silva and Anderson (1995) revealed that 10% to 20% lipid in fish diet is beneficial for optimum growth without a fatty carcass. In addition, earlier reports on fish such as *Ictalurus punctatus* (Raj *et al.*, 2007), *Salmo gairdneri* (Gatlin, 2010) and *Sciaenops ocellatus* (Robinson and Li, 2008) indicated that the dietary lipid requirement of the fish ranged from 6% to 11%.

The values of FCR ranged between 0.78 and 0.94 and FCR was better among the groups, where the SGR and body weight gain were also high as in diet 5 and diet 9. Based on values, PER ranged from 3.16 to 3.40 among the diets. Increasing dietary lipid level supported elevated values in PER and a similar trend was also noticed in previous research (Silva and Anderson, 1995).

Present results found that the survival rate of fish fed various combinations of CP:DP:DE was not significantly different, ranging from 79.54% to 84.83%. These findings were higher than previous research (66.94%), observed by Yakubu *et al*., (2014) in *Heterobranchus longifilis* and *C. gariepinus* that were fed 45% crude protein and 12% lipid under water recirculation. These aforementioned authors used palm olein (plant oil), fish oil (animal oil) and soya lecithin (plant oil) that also has been used in the current study. In addition, physicochemical variables measured in this experiment were within the recommended ranges for fish culture (Onada *et al.*, 2015). The mortalities might be attributed to handling during the experiment period as observed by Bhatnagar and Devi (2013).

The body composition of fish fed with lipid diets showed the following relationships with protein and lipid content of diets. The body contents of protein, lipid and energy content were observed to increase with increasing protein to energy ratio. High dietary lipid levels generally resulted in low moisture and protein but high energy (Raj *et al.*, 2007). Body lipid contents of 9.2, 9.4 and 13.2% have been reported by Sanjayasari and Kasprijo (2010) for gilthead sea bream, which were given practical diets containing 13-16% lipid from fish meal. In the present study, 33.60-37.90% of body lipid was found in fish which were fed a dietary lipid level of 5.3-11.9%. The positive correlation between body lipids and dietary lipid may indicate that when dietary lipid was supplied in excess, a proportion of this lipid was deposited as fats (Raj *et al.*, 2007).

In conditions that the available dietary protein is less, the lipids seem to support the growth, resulting in depositions in the fish; whereas with 34% protein, the lipids are well metabolized and the fish is not fat. Moreover, the high crude protein rate (36%) combined with a bad utilization of lipids may also lead to the production of fatty fish. The energy value of lipids being higher than that of proteins could support this similarity of the body crude energy between the various batches of fish. The present study therefore concluded that for *C. gariepinus*, a good growth was obtained with diets containing 34% crude protein: 39% digestible protein: 12.4% digestible energy.

The fish diet with 34% CP: 39%DP: 12.4%DE is the optimum ratio in enhancing the growth, feed efficiency and carcass composition for a more profitable and successful culture of catfish. The survival rate of fish was not affected by any combination of CP: DP: DE. Future research needs to be conducted to measure apparent digestibility, digestive enzymes activity and digestive tract histology.

Acknowledgements

The authors would like to thank to JAPFA Comfeed Company Indonesia, Suri Tani Pemuka Company and Mulawarman University, Faculty of Mathematics and Natural Sciences for their support and supervision.

References

Ahmad, M., Qureshi, T.A., Singh, A.B., Manohar, S., Borana, K. and Chalko, S.R., **2012**. Effect of dietary protein, lipid and carbohydrate contents on the growth, feed efficiency and carcass composition of *Cyprinus carpio* communis fingerlings. *Fisheries and Aquaculture,* 4, 30-40.

Amoah, Y.T., **2012**. Effect of dietary protein levels on growth and Protein utilization in juvenile arctic char (*Salvelinus alpinus*) [final project]. 15p

Anizah, M.R., Saad, C.R., Kamarudin, M.S. and Rahim, A.A., **2017**. Effect of dietary protein and protein energy ratio on the growth performance of lemon fin barb hybrid (*Hypsibarbus wetmorei* ×*Puntius gonionotus*) larvae. Iranian *Journal of Fisheries Sciences*, 16, 711-721.

Antolović, N., **2011**. Induced ovulation, development stages and growth of the saddled bream (*Oblada melanura*, Linnaeus, 1758) in captivity, University of Zagreb, Croatia. pp. 1-117

AOAC. **1990**. Official methods of analysis. 15 ed. Association of Official Analytical Chemists, Inc., Virginia, United State of America. pp. 152-164

Bhatnagar, A. and Devi, P., **2013**. Water quality guidelines for the management of pond fish culture. *Journal of Environmental Sciences*, 3, 29.

Cho, C.Y., **1992**. Feeding systems for rainbow trout and other salmonids with reference to current estimates of energy and protein requirements. *Aquaculture*, 100, 107-123.

Cho, S.H., **2011**. Effect of dietary protein and lipid levels on compensatory growth of juvenile olive flounder (*Paralichthys olivaceus*) reared in suboptimal temperature. *Asian-Australasian Journal of Animal Sciences*, 24, 407-413.

Fakunle, J.O., Alatise, S.P., Effiong, B.N. and Tiamiyu, K., **2013**. Effects of replacing soyabeans meal with graded levels of boiled jatropha kernel meal in diets of *Clarias gariepinus* fingerlings. *Bulletin of Environment, Pharmacology and Life Sciences*, 2, 112-117.

Gatlin, D.M., **2010**. Principles of fish nutrition. Southern Regional Aquaculture Center, No.5003, 8 P.

Haidar, M., Groot, R., Hoftijzer, M., Figueiredo-Silva, A., Masagounder, K. and Schrama, J., **2016**. Effect of varying dietary non protein energy level and source on energy utilization efficiency in common carp (*Cyprinus carpio*). http://library.wur.nl/WebQuery/wurpubs/fulltext/406012

Haylor, G.S. and Mollah, M.F.A., **1995**. Controlled hatchery production of African catfish, *Clarias gariepinus*: The influence of temperature on early development. *Aquatic Living Resource*, 8(**4**), 431-438.

Jamabo, N.A. and Alfred-Ockiya, J.F., **2008**. Effects of dietary protein levels on the growth performance of *Heterobranchus bidorsalis* (Geoffroy-Saint-Hilaire, 1809) fingerlings from the Niger delta. *African Journal of Biotechnology*, 7(**14**), 2483-2485.

Jobling, M., **1981**. The influences of feeding on the metabolic rate of fishes: a short review. *Journal of Fish Biology*, 18, 385-400.

Kpogue, D.N.S., Ayanou, G.A., Toko, I.I., Mensah, G.A. and Fiogbe, E.D., **2013**. Influence of dietary protein levels on growth, feed utilization and carcass composition of snakehead, *Parachanna obscura* (Günther, 1861) fingerlings. *International Journal of Fisheries and Aquaculture*, 5, 7.

Ljubobratovic, U., Kucska, B., Feledi, T., Poleksic, V., Markovic, Z., Lenhardt, M., Peteri, A., Kumar, S. and Ronyai, A., **2015**. Effect of weaning strategies on growth and survival of pike perch, *Sander lucioperca*, larvae. *Turkish Journal of Fisheries and Aquatic Sciences*, 15, 327-333.

McPhee, D.L. and Janz, D.M., **2014**. Dietary selenomethionine exposure alters swimming performance, metabolic capacity and energy homeostasis in juvenile fathead minnow. *Aquatic Toxicology*, 155, 91-100.

Muchlisin, Z.A., Nazir, M., Fadli, N., Adlim, M., Hendri, A., Khalil, M. and Siti-Azizah, M.N., **2017**. Efficacy of commercial diets with varying levels of protein on growth performance, protein and lipid contents in carcass of Acehnese mahseer, *Tor tambra*. *Iranian Journal of Fisheries Sciences*, 16, 557-566.

Noor El-Deen, A.I., Mona, S.Z. and Shalby, S.I., **2014**. Increasing catfish production as a try to combat growth crayfish in the river nile and its branches. *Life Science Journal*, 11(**9**), 96-98.

Onada, O.A., Akinwole, A.O., Emmanuel, A. and Kolawole. **2015**. Study of interrelationship among water quality parameters in earthen pond and concrete tank, University of Ibadan, Nigeria. PeerJ PrePrints, 3, p.e845v1. http://dx.doi.org/10.7287/peerj.preprints.845v1

Otchoumou, A.K., Ble, C.M., Etchian, O.A., Alla, Y.L., Sebastien, L., Niamke, and Diopoh, J.K., **2012**. Effects of increasing dietary protein levels on growth, feed utilization and body composition of *Heterobranchus longifilis* (Valenciennes, 1840) fingerlings. *Journal of Biotechnology*, 11, 6.

Pantazis, P.A., **2005**. Protein to energy ratios in african catfish fed purified diets: Is *Clarias gariepinus* (Burchell) an ordinary carnivore. *Archives of Polish Fisheries*, 13, 157-170.

Petrovic, M., Gacic, M., Karacic, V., Gottstein, Z., Mazija, H. and Medic, H., **2012**. Enrichment of eggs in n-3 polyunsaturated fatty acids by feeding hens with different amount of linseed oil in diet. *Food Chemistry*, 135, 1563-1568.

Raj, A.J.A., Haniffa, M.A., Seetharaman, S. and Appelbaum, S., **2007**. Effect of dietary lipid level on survival and growth of the threatened freshwater catfish *Mystus montanus*. *Fisheries and Aquatic Science*, 24, 51-54.

Robinson, E.H. and Li, M.H., **2008**. Replacement of soybean meal in channel catfish, *Ictalurus punctatus*, diets with cottonseed meal and distiller's dried grains with solubles. *World Aquaculture Society*, 39, 521-528.

Sanjayasari, D. dan Kasprijo, **2010**. Estimasi nisbah protein-energi pakan ikan senggaringan (*Mystus nigriceps*) dasar untuk keberhasilan domestikasi. *Jurnal Perikanan dan Kelautan*, 15, 89-97.

Silva, S.S.D. and Anderson, T.A., **1995**. Fish nutrition in aquaculture. First Edition ed. Chapman and Hall, London. 319P

Sousa, S.M.N., Freccia, A., Santos, L.D., Meurer, F., Tessaro, L. and Bombardelli, R.A., **2013**. Growth of nile tilapia post-larvae from broodstock fed diet with different levels of digestible protein and

[DOR: 20.1001.1.15622916.2020.19.4.18.6]

digestible energy. *Revista Brasileira de Zootecnia*, 42, 535-540.

Vikeså, V., Nankervis, L. and Hevrøy, E., **2017**. High dietary energy level stimulates growth hormone receptor and feed utilization in large Atlantic salmon (*Salmo salar* L.) under hypoxic conditions. *Aquaculture Nutrition*, 23(**6**), 1193-1203.

Yakubu, A.F., Nwogu, N.A., Olaji, E.D., Ajiboye, O.O., Apochi, J.O., Adams, T.E., Obule, E.E. and Eke, M., **2014**. A comparative study on growth performance and survival rate of *Clarias gariepinus* Burchell, 1822 and *Heterobranchus longifilis* Valenciesnnes, 1840 under water recirculation system. *Agriculture, Forestry and Fisheries*, 3, 30-33.

Yamamoto, M., McLaughlin, F.A., Carmack, E.C., Nishino, S. and Shimada, K., **2006**. Freshwater budget of the canada basin, arctic ocean from salinity and nutrients. *Journal of Geophysical Research-Ocean*, 113, 1-38.

Yousif, O.M, Krishnankutty, K., Fatah, A.A. and Abdul-rahman, A., **2014**. Growth performance, feed efficiency and carcass composition of african catfish, *Clarias gariepinus* (Picess: Clariidae) fingerlings fed diets composed of agricultural by-products. *International Journal of Biosciences*, 4(**10**), 276-284.