Original article DOI: 10.19027/jai.20.2.130-138

Dietary supplementation of organic selenium to improve growth performance and protein utilization in African catfish fed with different protein level diets

Penambahan selenium organik pada pakan dengan berbagai kadar protein untuk meningkatkan laju pertumbuhan dan pemanfaatan protein pakan ikan lele *Clarias gariepenus*

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(Received September 17, 2018; Accepted October 24, 2018)

ABSTRACT

This study aimed to evaluate the effect of organic selenium supplementation on diet with different protein levels on the growth performance and protein utilization of African catfish juvenile. A randomized 2×3 factorial design with two dietary protein levels (27% and 32%) and three dietary selenium (Se) supplementation levels (0 mg/kg, 3 mg/kg, and 6 mg/kg diet) in triplicates were applied in the study. African catfish juvenile with an initial average body weight and body length of 27.00 ± 0.14 g and 15.0 ± 0.5 cm, respectively, was reared in 18 units of aquarium (141 L) at a density of 142 fish/m^3 for a rearing period of 40 days. Increasing organic Se supplementation level up to 6 mg/kg at high protein feed resulted in higher fish growth and final biomass, lower FCR, and higher protein utilization efficiency than those of other treatments. Furthermore, supplementation of organic Se also resulted in lower lipid and higher Se concentrations in the fish body as well as higher blood protein level compared to those of the control. In conclusion, the result of this study suggested that dietary supplementation of organic Se up to 6 mg/kg could enhance the growth and protein utilization in African catfish fed with both low and high protein diet.

Keywords: African catfish, growth, dietary protein, protein utilization, organic selenium.

ABSTRAK

Penelitian ini bertujuan mengevaluasi pengaruh suplementasi selenium organik pada pakan dengan kadar protein yang berbeda terhadap kinerja pertumbuhan dan pemanfaatan protein pakan ikan lele *Clarias gariepenus*. Penelitian didesain menggunakan rancangan acak lengkap faktorial 2×3 dengan dua tingkat protein pakan (27% dan 32%) dan tiga tingkat suplementasi selenium (Se) pakan (0 mg/kg, 3 mg/kg, dan 6 mg/kg diet) sebanyak tiga ulangan. Ikan lele yang digunakan memiliki bobot awal rata-rata dan panjang tubuh 27 ± 0.14 g dan 15.0 ± 0.5 cm, dipelihara dalam 18 unit akuarium (141 L) dengan kepadatan 142 ekor/m^3 selama 40 hari pemeliharaan. Peningkatan suplementasi Se organik hingga 6 mg/kg pada ikan yang diberi pakan protein tinggi menghasilkan kinerja pertumbuhan ikan dan biomassa akhir yang lebih tinggi, FCR yang lebih rendah, dan efisiensi pemanfaatan protein pakan yang lebih tinggi daripada perlakuan lain. Selain itu, suplementasi Se organik juga menghasilkan kadar lemak yang lebih rendah dan konsentrasi Se tubuh yang lebih tinggi serta kadar protein darah yang lebih tinggi. Kesimpulan dari penelitian ini yaitu suplementasi Se organik pada pakan hingga 6 mg/kg dapat meningkatkan kinerja pertumbuhan dan pemanfaatan protein pakan pada ikan lele yang diberi pakan dengan kadar protein rendah dan tinggi.penelitian ini menunjukkan bahwa pemberian CSP 20% dapat meningkatkan kinerja pertumbuhan ikan nila.

Kata kunci: ikan lele, pertumbuhan, protein pakan, pemanfaatan protein, selenium organik.

INTRODUCTION

Protein is the most costly component in fish feed and thereby would determine the price of aquaculture feed. Thus, protein should be utilized as efficient as possible, so that the production cost of the fish can be minimized. Protein utilization efficiency is determined by the utilization of protein as an energy source and the utilization of protein to synthesize new protein in body tissue. In this regard, the strategy to improve protein utilization efficiency mostly involves the enhancement of non-protein energy utilization and balancing the dietary amino acids composition as the building block of new protein synthesis.

Selenium (Se) is an essential trace element which has an important role in fish physiological functions (Selamoglu, 2017; Labunsky, 2014). Particularly, those mediated through selenoproteins, such as on several enzymes synthesis including thyroid hormone deiodinases, glutathinone peroxidase, thioredoxin reductases, methionine-r-sulfoxide reductase 1, Selenophosphate Synthetase 2 and selenoprotein including W, T, H, and V, P, N, K and S (Labunsky *et al.,* 2014). It has been reported that iodothyronine 5'-deiodinases catalyzed the transformation of thyroxine hormone (T4) to the active thyroid hormone (T3), which is a regulator in hepatic enzyme expression and neutrophil function (Brown & Arthur, 2001). Moreover, Se also demonstrated an insulin-mimetic function which could play a role in carbohydrate metabolism including gluconeogenesis, glycolysis, fatty acid synthesis, and pentose phosphate pathway (Stapleton, 2000; Beckett & Arthur, 2005; Zhou, 2013).

Previous studies showed that Se could be used as a dietary supplement for various aquaculture organism such as rainbow trout (Nazari *et al*., 2016), channel catfish (Gatlin & Wilson, 1984), grouper (Hamzah *et al.*, 2012), barramundi (Ilham *et al*., 2016), crucian carp (Zhou *et al*., 2009), Atlantic salmon (Sele *et al*., 2018), common carp (Ashouri *et al*., 2015), Nile tilapia (Lee *et al.,* 2016; Iqbal *et al.*, 2017), oriental river prawn (Kong *et al.,* 2017), black seabream juvenile (Lee *et al.*, 2008), common barbell (Kouba *et al.*, 2014), and golden pompano (Wang *et al.,* 2016). In this regard, the present study aimed to evaluate the effect of dietary organic selenium supplementation on the growth performance and protein utilization of African catfish juvenile fed with different protein level diets. This study used organic Se as previous report by Nazari *et al.* (2016), Mansour (2017), and Khan (2019) showed that the use of organic Se was more beneficial because of the lower risk of toxicity compared to that of inorganic Se and can act as protector for cell signaling.

MATERIALS AND METHODS

Experimental design

This study apply a randomized 2×3 factorial design with two protein levels, i.e. 27% and 32% (low protein and high protein) as the first variable and three organic Se supplementation levels (0, 3, and 6 mg/kg diet) as the second variable, thus resulting in 6 treatments. Each treatment had three triplications.

Experimental diet

Six isoenergetic and isolipidic experimental diets with 2 different protein levels, i.e. 26% (later denoted as low protein, LP) and 32% (later denoted as high protein, HP), and 3 different organic Se supplementation levels, i.e. 0, 3, and 6 mg/kg diet (later denoted as S0, S3, and S6) for each level of dietary protein were prepared according to the formulation presented in Table 1. The feed ingredients were homogeneously mixed and pelletized.

Fish rearing

A 18 units of glass aquarium with a dimension of 90×45×45 cm (141 L working volume) equipped with two aeration lines per aquarium were used as the fish rearing units. African catfish juvenile with an initial average body weight and body length of 27.00 ± 0.14 g and 15.0 ± 0.5 cm, respectively, was obtained from local fish nursery in Bogor, West Java, Indonesia. The fish was randomly distributed to each experimental unit at a density of 20 fish/aquarium (142 fish/m^3) after being acclimatized in the laboratory condition for 7 days prior to experimentation, during which feeding was performed using LP-S0. Prior to the initiation of the experiment, no feeding was provided to the fish for 24 h. Subsequently the fish was maintained for 40 days and fed with the experimental diets twice a day to apparent satiation. Water quality in the rearing units were maintained by a regular water replacement at a level of 50% and by siphoning out faecal materials every 3 days.

During the experiment water quality monitoring was performed by measuring some water quality parameters including temperature, dissolved oxygen (DO) concentration, total ammoniacal nitrogen concentration and pH. Temperature, DO concentration and pH were measured by using a thermometer, DO meter (Luthron DO-5510) and pH meter (Trans Eco), whereas total ammonia nitrogen was determined according to the standard method for water and wastewater quality (APHA, 1999). During the entire experiment, total ammoniacal nitrogen concentration was in a range of 0.17–1.47 mg/L, whereas temperature, DO concentration and pH were in the range of 29−31°C, 4.8−7.2 mg/L, and 6.8−7.6, respectively.

Sample collection and chemical analysis

At the initiation of the experiment, as many of 3 fish were randomly collected to analyse the whole body composition. After 40 days of culture, the fish were starved for 24 h and all fish was weighed to determine the fish biomass per aquarium. Three fish was collected from each aquarium and analysed for the whole body composition and Se analysis. The proximate composition of the fish whole body and the experimental diets were determined according to Takeuchi (1988). Selenium content in the fish and the diets were determined with Inductively Coupled Plasma-Mass Spectrometry (ICP-MS) method according to manufacturer's protocols.

Table 1. Experimental diet formulation and proximate composition (% dry matter)

	Treatment					
	LP-S0	LP-S3	LP-S6	HP-S0	HP-S3	HP-S6
Ingredient (% dry matter)						
Fishmeal	10.00	10.00	10.00	15.00	15.00	15.00
Soybean meal	20.50	20.50	20.50	22.50	22.50	22.50
Meatbone meal	12.50	12.50	12.50	10.50	10.50	10.50
Wheat pollard	46.00	45.70	45.40	40.00	39.70	39.40
PMC[1]	2.00	2.00	2.00	3.00	3.00	3.00
Fish oil	2.00	2.00	2.00	2.00	2.00	2.00
Corn oil	2.00	2.00	2.00	2.00	2.00	2.00
Premix[2] (without Se)	5.00	5.00	5.00	5.00	5.00	5.00
Organic Se	0.00	0.30	0.60	0.00	0.30	0.60
Proximate composition						
Moisture (%)	8.30	5.75	6.54	5.05	5.58	5.76
Crude protein (%DW)	27.47	27.60	26.45	31.10	32.62	31.67
Crude lipid (%DW)	6.70	7.02	6.91	7.18	7.94	7.72
Ash (%DW)	8.37	7.52	7.48	9.22	9.56	9.86
Crude fibres (%DW)	4.55	8.47	9.34	6.25	6.06	4.15
Nitrogen free extract[3] (%DW)	44.61	43.63	43.28	41.19	38.24	40.84
Gross energy[4] (kcal/100 g DW)	447.1	445.6	448.4	469.2	486.6	456.2
Energy/protein (kcal/100 g)	16.28	16.14	16.95	15.09	14.92	14.40
Se level (mg/kg)	0.25	0.59	0.83	0.29	0.56	0.88

*LP-S0 (26% protein with 0 mg/kg Se); LP-S3 (26% protein with 3 mg/kg Se); LP-S3 (26% protein with 6 mg/kg Se); HP-S0 (32% protein with 0 mg/kg Se); HP-S3 (32% protein with 3 mg/kg Se); HP-S6 (32% protein with 6 mg/kg Se), [1]PMC= Polymethylolcarbamide, [2]Premix composition= Vit A 12.38 mg/kg; Vit D3 0.09 mg/kg; Vit E 0.034 mg/kg; Vit B1 4.50 mg/kg; B2 4.50 mg/kg; B6 2.25 mg/kg; Choline chloride 45.00 mg/kg; Ca-d panthotenate 2.25 mg/kg; Nitonic acid 3.75 mg/kg; Folic acid 0.75 mg/kg; Vit C 225.00 mg/kg; Ca and Cl (as $CaCl_2$) 12.461 mg/kg; Mg (as $MgSO_4.7H_2O$) 4.056 mg/kg; P and K (as KH_2PO_4) 14.499 mg/kg; Na (as NaCl) 1.525 mg/kg; Cu (as $CuSO_4\_5H_2O$) 0.020 mg/kg; I (as KIO_3) 0.002 mg/kg; FE (as $FeSO_4$) 0.082 mg/kg; Mn (as $MNSO_4$) 0.007 mg/kg; Zn (as $ZnSO_4.7H_2O$) 0.088 mg/kg, [3]Nitrogen free extract (NFE) = 100 – (protein% + lipid% + ash% + crude fiber%), [4]Gross energy was calculated according to NRC (1993), with protein, lipid and NFE contain energy of about 5.65, 9.45 and 4.11 kcal/g, respectively.

Blood glucose and protein concentrations were measured by GlucoDr AGM−2100 and Kjehdal method, respectively.

Growth performance

Fish growth performance was determined according to the measurement of fish survival, specific growth rate, final biomass, feed consumption, and feed conversion ratio. Fish survival was the percentage of final fish number after 40 days of culture relative to the initial number of the fish. Specific growth rate was measured according to the following formula.

$$\text{SGR (\%/day)} = \left[\sqrt[t]{\frac{Wt}{Wo}} - 1\right] \times 100$$

SGR = specific growth rate (%/day)
Wt = final average fish body weight (g)
Wo = initial average fish body weight (g)
t = experimental period (day)

The feed is given at satiation by looking at the fish's response to the feed given. The amount of feed consumption is obtained by calculating the difference in the weight of the stock feed before feeding and the weight of the stock feed after feeding.

The feed conversion ratio described that total amount of a feeding is to total fish biomass gain. While, protein and lipid retention determined by ratio in 100 of protein or lipid in final concentration from protein or lipid in initial fish biomass and fish consumed protein or lipid.

Data analysis

Homogeneity and normality were performed by following Levene's test and a Kolmogorov-Smirnov test, respectively. Statistical differences between groups were evaluated by two-way ANOVA followed by Duncan's or least significant difference post hoc test using IBM SPSS statistics version 19.

RESULTS AND DISCUSSIONS

Results

There was no fish mortality observed in the present experiment. Both dietary protein levels and organic selenium supplementation significantly influenced the African catfish growth performance (Table 2) and there was no significant interaction observed between these variables. High protein diet resulted in higher feed consumption and fish growth, and lower feed conversion ratio. Likewise, increasing organic selenium supplementation up to 6 mg/kg resulted in higher growth and lower FCR, regardless the protein level of the diets. In addition, organic Se supplementation seems not to affect the feed consumption.

Both protein and organic Se supplementation levels significantly affected protein utilization efficiency (Figure 1). Protein utilization efficiency was higher at high dietary protein compared with that at low dietary protein level. Similarly. protein utilization efficiency increased with the increase of organic Se supplementation level. This was independent from the protein level of the diet.

Whole body composition of African catfish fed with the experimental diets is presented

Table 2. The growth performance of African catfish fed with diets with low and high protein levels with different organic selenium supplementation levels

Treatment	Initial weight (g)	Final weight (g)	Final biomass (g)	Feed consumption (g)	FCR	SGR (%/day)
LP-S0	27.03 ± 0.04^{a}	52.73 ± 2.73^{c}	1055 ± 55^{c}	1100 ± 97^{c}	2.14 ± 0.04^{a}	1.68 ± 0.13^{d}
LP-S3	27.03 ± 0.17^{a}	58.24 ± 4.91^{c}	1165 ± 98^{c}	1057 ± 108^{c}	1.71 ± 0.16^{b}	1.93 ± 0.22^{cd}
LP-S6	27.03 ± 0.05^{a}	61.50 ± 5.06^{c}	1230 ± 101^{c}	1057 ± 99^{c}	1.54 ± 0.10^{bc}	2.07 ± 0.21^{c}
HP-S0	27.08 ± 0.05^{a}	90.84 ± 6.29^{b}	1817 ± 126^{b}	1830 ± 92^{a}	1.44 ± 0.10^{c}	3.07 ± 0.18^{b}
HP-S3	26.91 ± 0.13^{a}	98.23 ± 7.12^{b}	1965 ± 142^{b}	1580 ± 125^{b}	1.12 ± 0.17^{d}	3.29 ± 0.19^{ab}
HP-S6	27.14 ± 0.30^{a}	110.58 ± 7.48^{a}	2212 ± 150^{a}	1706 ± 76^{ab}	1.03 ± 0.10^{d}	3.57 ± 0.14^{a}

Note : Different superscript in the same column indicates significant difference.
*LP-S0 (26% protein with 0 mg/kg Se); LP-S3 (26% protein with 3 mg/kg Se); LP-S3 (26% protein with 6 mg/kg Se); HP-S0 (32% protein with 0 mg/kg Se); HP-S3 (32% protein with 3 mg/kg Se); HP-S6 (32% protein with 6 mg/kg Se).

in Table 3. Moisture levels of the fish were significantly influenced by both the protein content and organic Se supplementation. Feeding the fish with high protein diet resulted in lower moisture than that fed with low protein diet. Organic Se supplementation resulted in lower moisture; however it seems to be not relating to the supplementation levels. The protein content of the fish was considerably determined by the level of protein in the diet, but not affected by the organic Se supplementation level. In contrast, the lipid content of the fish was significantly influenced by the organic Se supplementation, as it was reduced at treatments with organic Se supplementation. The reduction, however, was independent from the supplementation level. The concentration of Se in fish whole body was significantly affected by both the protein level and organic Se in the diet. Organic Se supplementation resulted in higher Se concentration in the fish body, and the level was increased with the increase of dietary protein level.

Blood protein level was significantly affected by dietary protein and organic Se supplementation (Table 4). High dietary protein and organic Se resulted in higher blood protein. On the other hand, high dietary protein level resulted in lower blood glucose levels. Interestingly, the addition of 3 mg/kg organic Se resulted in significant reduction in blood glucose regardless the dietary protein level. But, increasing the organic Se supplementation to 6 mg/kg diet resulted in significant increase in blood glucose compared with that of the 3 mg/kg Se supplementation diet treatment.

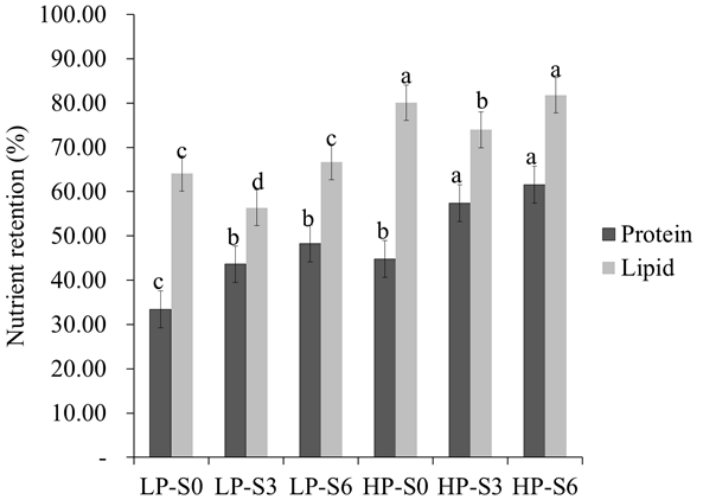

Figure 1. Protein and lipid retention of African catfish fed with diets with low and high protein levels with different organic selenium supplementation levels. Different superscript in the same column indicates significant difference. LP-S0 (26% protein with 0 mg/kg Se); LP-S3 (26% protein with 3 mg/kg Se); LP-S3 (26% protein with 6 mg/kg Se); HP-S0 (32% protein with 0 mg/kg Se); HP-S3 (32% protein with 3 mg/kg Se); HP-S6 (32% protein with 6 mg/kg Se).

Table 3. Whole body composition of African catfish fed with diets with low and high protein levels with different organic selenium supplementation levels

Treatment	Moisture (%)	Protein (%)	Lipid (%)	Ash (%)	Se (µg/g)
LP-S0	73.40 ± 0.71^{a}	14.80 ± 1.02^{b}	7.60 ± 0.22^{a}	3.94 ± 1.03^{a}	0.09 ± 0.00^{d}
LP-S3	71.75 ± 0.72^{b}	15.64 ± 0.50^{b}	6.43 ± 0.09^{b}	5.11 ± 0.66^{a}	0.13 ± 0.01^{c}
LP-S6	72.70 ± 0.69^{ab}	15.47 ± 0.44^{b}	6.65 ± 0.34^{b}	4.05 ± 0.73^{a}	0.13 ± 0.00^{bc}
HP-S0	71.78 ± 0.42^{b}	17.07 ± 0.26^{a}	7.62 ± 0.27^{a}	2.70 ± 0.30^{b}	0.09 ± 0.00^{d}
HP-S3	69.71 ± 0.66^{c}	17.79 ± 0.45^{a}	6.41 ± 0.52^{b}	4.44 ± 0.40^{a}	0.14 ± 0.00^{b}
HP-S6	70.30 ± 0.30^{c}	17.54 ± 0.37^{a}	6.38 ± 0.34^{b}	4.14 ± 0.75^{a}	0.15 ± 0.00^{a}

Different superscript in the same column indicates significant difference. LP-S0 (26% protein with 0 mg/kg Se); LP-S3 (26% protein with 3 mg/kg Se); LP-S3 (26% protein with 6 mg/kg Se); HP-S0 (32% protein with 0 mg/kg Se); HP-S3 (32% protein with 3 mg/kg Se); HP-S6 (32% protein with 6 mg/kg Se).

Discussion

Protein is the most costly component in aquaculture diet. thus the use of protein in aquaculture diet should be highly efficient. Furthermore, inefficient protein level in the diet may also increase the nitrogen excretion and ultimately increased the adverse impact of aquaculture to the environment. The present study tested two isoenergetic diets with different dietary protein levels, i.e. 26 and 32% on African catfish grow out culture. The results showed that the use of low protein diet led to lower growth performance of the fish than that of the high protein diet. This clearly indicates that a dietary protein level of 26% did not meet the basic requirement of protein of African catfish. Indeed, previous studies reported that optimum growth of African catfish at 29°C was obtained at a dietary protein level of about 43–49% and an energy level of about 466–506 kcal/100 g (Henken *et al*., 1986; Ali & Jauncey. 2005). In addition, the present study also shows that increasing dietary protein level significantly reduced the feed consumption, which further adversely affected the growth of the fish.

With its beneficial impact on the growth and health status of aquaculture organisms. selenium as a dietary supplement has been gaining more attention in the development of aquaculture feed. Most of previous studies reported that Se supplementation helps to protect the fish body cells and cellular components from oxidative damage through the activation of selenoenzymes and selenoproteins (Steinbrenner *et al.,* 2016; Schomburg, 2011). However, not many study have been reported on the effect of Se supplementation on the dietary protein utilization. The present study also demonstrated that dietary Se supplementation at both protein levels resulted in some improvement in growth and protein utilization. In particular at low protein diets, Se supplementation up to 6 mg/kg improved the fish growth by 23%. The increase in growth and protein utilization as indicated by protein retention in Se supplemented dietary treatments might be explained by the positive effects of dietary Se on the enhancement of antioxidative capacity, on growth hormone production. and on glucose metabolism as an insulin mimetic. The action of Se on protection cell signaling by maintenance glutathione peroxidase (GPx) (Zoidis *et al.,* 2018). So, Se as supplementary diets for this experiment, it may have increased protein utilization which may act as a protein-sparing effect.

The oxidation of proteins and lipids in metabolic processes generates a considerable production of reactive oxygen species that may cause oxidative stress and induce adverse alterations in gene expression and modifies the cell condition (Khan *et al*., 2016). This leads to the enhancement of antioxidant enzymes as a defense mechanism to anticipate further deleterious impact of the free radicals, such as catalase, superoxide dismutase, peroxide dismutase, glutathione peroxidase and glutathione reductase (Vega *et al.*, 2018; Birben *et al.*, 2012). Selenium has been reported to be an essential trace element for animals including fish, which has an important role in the activation of glutathione peroxidase, an antioxidant enzyme that protects cell membrane from oxidative stress (Ashouri *et al*., 2015). Selenium in the form of selenocysteine is a structural component of the active center of GPx (Ziodis *et al*., 2018; Ashouri *et al*., 2015). In addition, Se has important role in several pathophysiological effect involved synthetized thioredoxin reductase (TR), prevention lipid from oxidative damage, activation of signaling molecule by reducing the transcription factor (Hoffman, 2007). Indeed,

Table 4. Blood protein and glucose concentrations of African catfish fed with diets with low and high protein levels with different organic selenium supplementation levels

Treatment	Blood protein (%)	Blood glucose (mg/100 mL)
LP-S0	8.54 ± 0.51^{d}	62.71 ± 5.59^{a}
LP-S3	10.73 ± 0.74^{bc}	49.93 ± 4.11^{b}
LP-S6	10.48 ± 0.42^{bc}	68.64 ± 5.04^{a}
HP-S0	9.82 ± 0.64^{c}	32.67 ± 1.65^{cd}
HP-S3	11.21 ± 0.31^{ab}	26.35 ± 4.78^{d}
HP-S6	11.99 ± 0.57^{a}	36.89 ± 3.54^{c}

Different superscript in the same column indicates significant difference. LP-S0 (26% protein with 0 mg/kg Se); LP-S3 (26% protein with 3 mg/kg Se); LP-S3 (26% protein with 6 mg/kg Se); HP-S0 (32% protein with 0 mg/kg Se); HP-S3 (32% protein with 3 mg/kg Se); HP-S6 (32% protein with 6 mg/kg Se).

previous studies demonstrated that dietary Se supplementation in some aquaculture species including (among others) common carp (Ashouri *et al*., 2015; Saffari *et al*., 2017), Atlantic salmon (Sele *et al*., 2018), pacu (Takahashi *et al*., 2017), rainbow trout (Fontagné-Dicharry *et al*., 2015), and meagre (Mansour *et al*., 2017) significantly increased the animal's antioxidantion status.

It has been reported that Se as dietary supplementary was associated by protein synthesis in fish (Khan *et al*., 2016). Selenium acts as a substitution for sulphur in the protein synthesis process and is an integral part of the selenoenzymes, which have an important role in the regulation of selenoproteins. These proteins may eventually stimulate and pre-regulate various biological functions. Furthermore, dietary selenium also promotes the body protein content through the production of growth hormones. Seneloproteins has been suggested to involve in the activation of iodothyronine deiodinase enzyme, which catalize the production of thyroid hormones (3,5,3‟-triiodotironin, T3) from tiroxine (T4) (Brown & Arthur, 2001). Thyroid hormones are essential for the stimulation and secretion of growth hormone from the pituitary gland in fish and other vertebrates. In line with Khan *et al*. (2016; 2017) reported that nanoparticles from Se indicated the increasing growth hormone production in juvenile mahseer fish.

Selenium has been reported to have an insulin-mimetic property, which has an action in supporting the entrance of glucose into tissues where the glucose can either be converted into energy or stored for later use (Stapleton, 2000). It has been suggested that Se involves in glucose metabolism via selenoproteins, which possess redox properties and thereby may influence the insulin-dependent metabolic pathways, because both insulin release and insulin signalling are organized by the cellular redox potential (Jablonska *et al*., 2016; Steinbrenner, 2013). The essential role in the regulation of both processes is attributed to hydrogen peroxide. Hydrogen peroxide is reduced to water with the participation of enzymes, such as Se-dependent glutathione peroxidase (GPx) and catalase (CAT) (Lubos *et al*., 2011). However, previous studies also recently reported that upon certain level, dietary supplementation of selenium might bring toxicity effect, i.e. insulin resistance, hyperglycemia, and high low-density lipoproteins. These results correspond to Xiang *et al*. (2017) that additional Se as dietary feeding with high level (5 mg/kg) was high blood glucose, whereas at lower concentration (3 mg/kg) lower blood glucose was observed.

CONCLUSION

Dietary supplementation of organic Se up to 6 mg/kg could enhance the growth and protein utilization in African catfish fed with both low and high protein diet.

ACKNOWLEDGEMENTS

This research was supported by Vocational College. Bogor Agricultural University. The authors wish to acknowledge their support of this project.

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