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Effects of Supplementary Moringa Leaf Meals on Growth and Serum Contents of Pla-Mong Fish (*Pangasius bocourti* Sauvage, 1880)

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Four treatments of four levels of Moringa leaf meals of 0, 50, 100 and 150 gkg^{-1} added to the feed diets as to attain constant amounts of crude protein of 30 % and Gross energy of 400 Kcal per 100g diet, i.e. the variation of Moringa leaf meals to achieve similar amount of protein and energy in all four treatments. The experiment was conducted at the Department of Fisheries, Khon Kaen University, Khon Kaen, Thailand during June to December 2014. The experiment consisted of four treatments and was carried out in a Completely Randomized Design with four replications. Pla-mong *(Pangasius. bocourti)* fish were chosen and cultured for 20 weeks. The average initial weight of fish ranged from 83.83 – 86.55 g fish^{-1}. The objectives of this study include determinations on growth performance, survival rate, serum biochemical and carcass quality. The results showed that the body weight, weight gained, average daily gained, specific growth rate, feed conversion ratio and feed conversion efficiency were not significantly found. However, The highest body weight, weight gain, average daily gain, specific growth rate at 100 gkg-1 diet were 243.98 g, 160.01 g fish-1, 1.14 g fish-1day-1 and 0.76 % fish^{-1}day^{-1}, respectively. For fish health, it was found that the biochemical parameters in serum such as total protein, albumin, globurin and aspartate aminotransferase were statistically significant *(*p<0.05*).* The Moringa rate of 100 g kg^{-1} was the best and other higher rates were not of significant value. This rate gave better growth performance and had no adverse effects on digestibility and serum-biochemistry.

Keywords: growth performance, protein from moringa leaves, pla-mong (*Pangasius bocourti*), serum contents

INTRODUCTION

In aquaculture, different fish species have been used for fish culture in order to produce adequate amount of fish production for markets both domestic and overseas. The fish species of Pla-mong (*Pangasius bocourti* Sauvage, 1880) is one of them. This type of fish receives a high demand from the markets. Apart from the selected fish species to be used in aquaculture, a high quality of feed diet is one of the most important factors to be taken into account for aquaculture production. Thus, research activities for some alternative protein sources is of a tangible value to be used in producing fish production. There are many types of plants that possess high nutritious values, particularly protein contents in leaves and they had been used in many diets for fish such as Sweet potato (Adewalu, 2008), *Amaranthus spinosus*)Adewolu and Adamson, 2011), Moringa leaves)Yuangsoi and Masumoto, 2012(, White

Popinac leaves)Leucaena leucocepphala(and others where plant dried leaves had been commonly used in feed rations)Amisah et al., 2009). Cassava dried leaves)Manihot esculenta(had also been used for fish culture by Hassan et al.)2017(. Furthermore, some seeds of Sesbania grandiflora leguminous crop had also been used in feed diet for fish culture)Olvera et al., 1988(.

Some workers in North Africa carried out some experiments with the use of dried leaves of Leucaena and cassava plants for catfish (*Clarias gariepinus*) culture, e.g., Amisah et al. (2009); Bichi and Ahmad (2010). With a case study on agronomic value of drumstick tree (*Moringa oleifera*), this fast-growing plant possesses some economic importance in feed manufacturing industry and also being used as a medicinal substance for man (Foidl et al., 2001). Some crop seeds are rich in oil and protein contents and some of them can be used for water cleaning process whilst leaves and pods can be used as a source of protein for man and animals (Makkar and Becker, 1997). Many plant species can provide protein, vitamin C, calcium and potassium and some could provide natural antioxidant substances e.g., ascorbic acid, flavonoids, phenolics and carotenoids (Moyo et al., 2011). Furthermore, some plant species are rich in starch, minerals, iron, sulfur, vitamins A, B and C, and calcium including some amount of essential amino acids such as methionine and cysteine (Foidl et al., 2001). Moringa leaves normally possess low level of tannin but high in crude saponin (5 %) where this substance may possess anti-nutritional effects in animal (Makkar and Becker, 1996). The residues derived from the solvent extraction of leaves of Moringa appear to be a good source of protein for fish after the removal of some anti-nutritional properties. Yuangsoi and Charoenwattanasak (2011) carried out experiment with the use of dried leaves of Moringa added to their feed diet at levels of 0, 5, 10 and 15 % for a culture of Nile tilapia (*Oreochromis niloticus*). They reported that the best result on growth performance was found with a level of 10 % dried leaves whilst other higher levels gave a decrease in growth performance.

Pla-mong fish is a native species of the Mekong and Chao Phraya basins. This fish species can also be found in other rivers in Northeast Thailand, e.g., the Mun River and also some other smaller rivers in northeastern region such as the Chi River and others. (Roberts and Vidthayanon,1991, Rainboth,1996). The flesh of this type of fish has a high palatability taste hence it is popularly accepted by a large number of the Thai people apart from the many overseas consumers. There is a high demand for this type of fish around the world such as the USA and the European countries (Jones and Young, 1996). The consumers normally demanded a large amount of filets for their cooking recipes and the price of the filets could be relatively high. The price for the Thai markets could be varied according to its individual fresh weight, e.g., 0.7-1.0 kg for 50 Baht kg^{-1} (1 US Dollar = 33 Baht) and the weights of 1.5 to 2.0 kg for 150 Baht kg^{-1} and the filets of this type of fish had been exported overseas in the 2004 with a figure of 120,000 metric tons (Prasertwattana et al., 2003; Imslip, 2005).

The objective in carrying out this work lied mainly on an evaluation of Moringa dried leaf meals added to the feed rations in substitution to other four expensive ingredients (soybean meal, broken rice, full fat soybean and wheat) where the work aimed to cut cost of investment but with a relatively high fish production. The work also aimed to establish data on growth performance, survival rate, serum contents and carcass quality of the Pla-mong fish.

MATERIALS AND METHODS

Fish, Diets and Feeding Protocol

The experiment was conducted at the Department of Fisheries, Khon Kaen University, Khon Kaen Province, Thailand during June to December 2014. Juvenile fish of Pla-mong (*P. bocourti*) were acclimatized under a cleaned fresh water unit for four weeks in a 1,000 L fiber tank. They were fed with a 40 % protein content of a commercial feed diet. After a period of four weeks, a feed diet of 30% protein was used and the fish were allowed to grow for another 8 weeks. Feeding protocol was started at the beginning of the 9^{th} week of rearing. A Completely Randomized Design (CRD) with four replications was used. Ten fish were used in each replicated tank (with a mean value of live weight ranged from 83.83 – 86.55 g $fish^{-1}$). An aquarium tank with a dimension of 60 x 150 x 60 cm in width, length and height, respectively was used for each replication. An amount of cleaned water of approximately 450 L was used for each aquarium. That is 16 tanks were used for the four treatments. Water quality parameters such as dissolved oxygen (6.55±0.48 mg L^{-1}), temperature (22.98±0.89°C) and pH (7.57±0.37) were maintained daily throughout the experimental period. The formulated feed diet was

carried out to maintain approximately 30 % crude protein with gross energy of approximately 400 Kcal per 100g feed diet for each of the four treatments after added individually with four levels of Moringa dried leaf meals. To obtain the denoted levels of protein and gross energy as mentioned earlier, thus different levels of each of the four ingredients (soybean meal, broken rice, full fat soybean and wheat) were carried out where soybean meal levels were 176.00, 158.00, 137.00 and 115.00 g kg^{-1} feed diet for T1 up to T4, respectively.

Table 1. Ingredients and its nutritional values being used in mixing with four levels of Moringa dried leaf meals to form four treatments for use in Pla-mong fish culture.

Ingredients (%crude protein)/Treatments	Levels of Moringa leaf meals in feed diet (g kg^{-1})			
	0 (T1)	50 (T2)	100 (T3)	150 (T4)
Fish meal(54.97)	310.00	310.00	310.00	310.00
Soybean meal(43.47)	176.00	158.00	137.00	115.00
Broken rice (6.47)	211.00	205.00	193.00	173.00
Rice bran(12.77)	11.00	11.00	11.00	11.00
Corn meal (7.23)	94.00	94.00	94.00	94.00
Full fat soybean (34)	70.16	61.16	54.16	49.16
Wheat (10.00)	75.20	58.20	48.20	45.20
Moringa leaf meal(26.16)	0	50.00	100.00	150.00
Soybean oil	45.00	45.00	45.00	45.00
Vitamin and Mineral mixture[1]	7.637	7.637	7.637	7.637
Proximate composition on dry matter basis (%)				
Crude protein	30.27	29.78	30.15	30.44
Moisture	6.19	5.58	6.54	6.23
Fat	8.97	9.05	9.14	9.27
Crude fiber	1.72	1.88	2.15	2.40
Crude ash	8.33	8.63	8.91	9.23
Nitrogen free extract (NFE)	44.52	45.08	43.11	42.43
Gross Energy (GE); Kcal/100 g diet[2]	438.37	438.67	433.51	433.58

[1]Vitamin and mineral mixture (g) : retinyl acetate (100 IU.g-1) 0.03 g,Cholecalciferol (20IU.g-1) 0.03 g, D,L-α-tocopherol acetate 0.009 g, menadione 0.00525 g, thiamine nitrate 0.00375 g, riboflavin 0.006 g,Pydroxinehydrochlorite, 0.006 g, D-calciumpantothenate 0.015 g, Niacin 0.015 g, Folic acid 0.0015 g,Cyanocobalamin 0.00045 g,ascorbyl acetate 0.03 g, $CaCO_3$ 6.00 g.$MgSO_4$:$7H_2O$ 1.00 g, $ZnSO_4$:$7H_2O$ 0.60 g, $FeSO_4$:$7H_2O$ 0.03 g, $CuSO_4$:$5H_2O$ 0.06 g and KI 0.001 g

[2]Gross Energy = (%crude protein x 5.64) + (% NFE x 4.11) + (%fat x 9.44); NRC (1993)

Broken rice levels were 211.00, 205.00, 193.00, and 173.00 g kg^{-1} of feed diet for T1 up to T4, respectively. Full fat soybean levels were 70.16, 61.16, 54.16 and 49.16 g kg^{-1} feed diet for T1 up to T4, respectively. Wheat levels were 75.20, 58.20, 48.20 and 45.20 g kg^{-1} feed diet for T1 up to T4, respectively. The Moringa leaf meal levels being used were 0, 50, 100, and 150 g $kg^{-1}$of feed diet for T1 up to T4, respectively. Therefore, four feed diets with a similar level of 30 % crude protein and a gross energy of 400 Kcal per 100g of feed diet were established (Table 1). The four treatments were analyzed for protein, moisture, fat, fiber and ash contents with the use of the method described by the AOAC (1990). Phytochemicals of all treatments were determined with the use of a Spectrophotometric method. Total phenolic content was determined by the method of Folin-Ciocalteu assay (Singlrton et al., 1999) where the calculations were carried out with the use of a Gallic acid standard curve. The total

amount of tannin content was determined using the method described by the AOAC (2000), where a tannic acid standard curve was used. The phytic acid content was carried out using a modified procedure of Talamond et al., (1998). The calibrated values were determined with the use of a standard phytic acid solution by the application of calcium phytate.

Feeding was given as ad-libitum by hand twice daily (08:00 am and 03:00 pm). Feeding process was taken place throughout the experimental period of 20 weeks. Feed consumption was weekly recorded and the fish from each replicated tank was weighed out individually for live weights at two week intervals for growth performance and feed utilization determinations.

Growth performance and feed utilization calculations

The collected data on weight gained (WG), average daily gained (ADG), specific growth rate (SGR), feed conversion ratio (FCR), feed conversion efficiency (FCE), survival rate (SR) were calculated with the use of the following formulae where appropriate:

WG (g) = Final weight-initial weight

ADG (g day^{-1}) = (final weight-initial weight)/duration of experiment

SGR (% day^{-1}) = (Ln final weight - Ln initial weight)/No. of days x100

FCR = Total feed intake (g)/Total wet weight gained (g)

FCE (%) = Total wet weight gained (g)/Total feed intake (g) x100

Survival rate (%) = [(Final fish number)/(Initial fish number)]x100

Serum biochemistry and carcass quality assay

At the end of the experimental period, after starving the fish for 12 hours, two fish per tank were randomly taken and then anesthetized. Blood samples were collected from caudal vein then kept in non-heparinized tubes. Hematocrit was determined using a micro-hematocrit centrifuge. The serums were separated into aliquots and analyzed for serum biochemistry. Serum was analyzed for total protein (TP), albumin (ALB), total bilirubin (BT), globulin (GLOB), alanine aminotransferase (ALT), aspartate aminotransferase (AST) and alkaline-phosphatase (ALP). The serum biochemical indices were determined with an automatic biochemical analyzer (BS-200; Mindray, Shenzhen, China). Then the fish were dissected and simultaneously took out the liver and the inner organs were determined and then calculated for the carcass quality, i.e., they included hepatic somatic index (HSI), visceral somatic index (VSI), visceral fat index (VFI) and muscle ratio (MR) where the following equations were used. They include:

HSI (%) = [Liver mass (g)/body mass (g)]× 100

VSI (%) = [total inner organ mass (g)/body mass (g)]× 100

VFI (%) = [Visceral fat mass (g)/body mass (g)]× 100

MR (%) = [muscle mass (g)/body mass (g)] × 100

Statistical analysis

The obtained data were subjected to one-way analysis of variance (ANOVA) for least significant differences (LSD) of the Duncan's Multiple Range Test (DMRT) with the use of a computer programme (SAS, 1998).

RESULTS

Nutritive values and Phytochemical contents in the diet

The results on nutritive value of the four treatments showed that crude protein ranged from 29.78 to 30.44 % for T2 and T4, respectively (Table 2). Moisture contents ranged from 5.58 to 6.54 % for T2 and T3, respectively. Fat contents ranged from 8.97 to 9.27 % for T1 and T4, respectively. Crude fiber values ranged from 1.72 to 2.40 %, for T1 and T4, respectively. Crude ash values ranged from 8.33 to 9.23 % for T1 and T4, respectively. Nitrogen free extract values ranged from 42.43 to 45.08 % for T4 and T2, respectively. Gross energy values ranged from 433.58 to 438.67 (Kcal/100 g feed diet) for T4 and T2, respectively.

Growth performance

Initial live weights of the Pla-mong fish ranged from 83.83 to 86.55 g for T2 and T4, respectively (Table 3). Final live weights ranged from 217.55 to 243.98 g for T2 and T3, respectively. Weight gained values ranged from 133.72 to 160.01 g for T3 and T4, respectively. Average daily gained weights ranged from 0.96 to 1.14 g day^{-1} for T2 and T3, respectively. Specific growth rate values ranged from 0.68 to 0.76 % for T2 and T3, respectively and feed conversion ratio ranged from 2.04 to 2.21 for T3 and T2, respectively. Feed conversion efficiency ranged from 45.53 to 49.19 % for T2 and T1, respectively. Survival rate

(%) was 100 % for all treated fish.

Hematocrit and serum biochemical parameters

Hematocrit percentages (Hct) of the fish ranged from 29.50 to 32.00 % for T4 and T3, respectively (Table 4). Total bilirubin (BT) values ranged from 0.492 to 0.858 mg dl^{-1} for T2 and T1, respectively. Total protein (TP) values ranged from 3.150 to 3.817 g dl^{-1} for T4 and T1, respectively. The difference was large and statistically significant ($p < 0.05$).

Table 2. Phytochemicals of four Moringa feed meal levels added to the feed diets of the Pla-mong fish culture.

Phytochemicals/Treatments	Levels of Moringa leaf meals in diets (g kg^{-1})				*p*-value
	0 (T1)	50 (T2)	100 (T3)	150 (T4)	
Total Phenolic (%)	0.481^{c}	0.535^{c}	0.760^{b}	0.871^{a}	0.0001
Total tannin (%)	0.262^{c}	0.293^{c}	0.413^{b}	0.461^{a}	0.0001
Phyticacid (%)	0.0037	0.0038	0.0042	0.0041	0.682

Letter(s) of the same row indicated least significant differences of Duncan's Multiple Range Test (DMRT) at probability (p) <0.05.

Table 3. Growth performance and feed utilization of the Pla-mong fish as influenced by four levels of Moringa leaf meal tested for a period of 20 weeks.

Parameters/Treatments	Levels of Moringa leaf meal in diet (g kg^{-1})				p-value
	0 (T1)	50 (T2)	100 (T3)	150 (T4)	
Initial weight (g)	86.19	83.83	83.97	86.55	0.751
Final weight (g)	236.08	217.55	243.98	234.74	0.338
Weight gained (g)	149.89	133.72	160.01	148.20	0.296
Average daily gained (g day^{-1})	1.07	0.96	1.14	1.06	0.305
Specific growth rate (% day^{-1})	0.72	0.68	0.76	0.71	0.300
Feed conversion ratio	2.05	2.21	2.04	2.14	0.453
Feed conversion efficiency (%)	49.19	45.53	49.09	46.88	0.463
Survival rate (%)	100	100	100	100	-

Table 4. Hematological and serum biochemical parameters of the fish of Pla-mong (*P. bocourti*) as influenced by the four feed diets carried out for 20 weeks.

Parameters/Treatments	Levels of Moringa leaf meal in diet (g kg^{-1})				*p*-value
	0 (T1)	50 (T2)	100 (T3)	150 (T4)	
Hct (%)	31.50	30.33	32.00	29.50	0.505
BT(mg dl^{-1})	0.858	0.492	0.613	0.580	0.175
TP(g dl^{-1})	3.817^{b}	3.683^{b}	3.300^{ab}	3.150^{a}	0.004
ALB(g dl^{-1})	1.400^{c}	1.350^{bc}	1.283^{ab}	1.233^{a}	0.020
GLOB(g dl^{-1})	2.433^{b}	2.317^{b}	2.017^{ab}	1.933^{a}	0.004
AST(U l^{-1})	75.833^{b}	68.500^{ab}	58.333^{a}	77.500^{b}	0.047
ALT(U l^{-1})	6.500	7.167	7.000	8.333	0.784
ALP(U l^{-1})	ND	ND	ND	ND	-

Note: ND = not detected

: Hematocrit (Hct), Total bilirubin (BT), Total protein (TP Albumin (ALB), Globulin (GLOB), Aspartate aminotransferase (AST), Alanine aminotransferase (ALT), and Alkaline phosphatase (ALP)

Letter(s) within the same row indicated least significant differences (LSD) of the Duncan's Multiple Range Test (DMRT) at probability (p)<0.05.

Table 5. Carcass quality of the fish of Pla-mong (*P. bocourti*) as affected by the four levels of Moringa leaf meal in feed diets tested for 20 weeks duration.

Parameters/Treatments	Levels of Moringa leaf in diet (g kg^{-1})				*p*-value
	0 (T1)	50 (T2)	100 (T3)	150 (T4)	
HSI (%)	2.20	1.90	2.10	2.12	0.362
VSI (%)	14.47	13.09	14.13	14.22	0.406
VFI (%)	6.62	6.23	6.15	6.22	0.969
MR (%)	31.45	32.07	32.32	30.23	0.411

Albumin (ALB) values ranged from 1.233 to 1.400 g/dl for T4 and T1, respectively. The difference was large and statistically significant ($p < 0.05$). Globulin (GLOB) values ranged from 1.933 to 2.433 g dl^{-1} for T4 and T1, respectively. The difference was large and statistically significant ($p < 0.05$). Aspartate aminotransferase (AST) values ranged from 58.333 to 77.500 U l^{-1} for T3 and T4, respectively. The difference was large and statistically significant ($p < 0.05$). Alanine amiotransferase (ALT) values ranged from 6.500 to8.333 U l^{-1} for T1 and T4, respectively and Alkaline phosphatase (ALP) was not detected.

Carcass quality

The carcass quality of hepatosomatic index (HSI) ranged from 1.90 and 2.20 % for T2 and T1, respectively (Table 5). Vesicle somatic index (VSI) ranged from 13.09 to 14.47 % for T2 and T1, respectively. Vesicle fat index (VFI) ranged from 6.15 to 6.62 % for TT3 and T1, respectively and muscle ratio (MR) ranged from 30.23 to 32.32 for T4 and T3, respectively. There were no statistical differences found in all carcass quality items of the Pla-mong fish.

DISCUSSION

The results on proximate composition based on dry matter basis revealed that crude protein % were more or less similar in all treatments being used and did with that of the gross energy percentages. The results suggested that the fish should have received a similar level of protein and energy for growth except that of the crude fiber where T4 attained the highest followed by T3 and least with T1 (control). The results on total phenolic percentages showed that the higher amount of Moringa feed meal added to the diet significantly increased phenolic contents of T3 and T4. The difference was large and statistically significant. This must be attributable to the effect due to Moringa feed meal. That is the higher the Moringa added the diet the higher the total phenolic percentages. A similar result as that of the phenolic % was found with that of the total tannin %. That is the higher the amount of Moringa being added to the ration diet the higher the tannin contents in the feed diet. Giner-Chavez (1996) reported that tannin percentages in the diet from 0.5 to 2.0 % significantly decreased growth rate and acute death of animals when the content was exceeded 5.0 % in the diet. Similarly, the use of the condensed tannin level more than 2 % in the diet resulted in the decrease in growth rate (Francis et al., 2001). And the phytic acid content found in this experiment ranged from 0.0037 to 0.0042 %. They did not provide negative effect in fish because phytic acid content in experimental diet was lower than that of the previous work. The rates of feed diets of phytic acid content of 5-6 g Kg^{-1} gave low growth rate in rainbow trout (*Salmo gairdneri*) (Spinelli et al., 1983) and common carp (*Cyprinus carpio*)

(Hossain and Jauncey, 1993). Similary, Satoh et al. (1989) reported that diets containing phytic acid more than 2.2 % resulted in low growth rate in channel catfish (*Ictalurus punctatus*). However, the feed diets with phytic acid of 1.5 % did not give any impact on fish growth (Gatlin III and Phillips, 1989; Satoh et al.,1989). A high dose of phytic acid caused low utilization of mineral and also low level of protein digestibility (Francis et al., 2001). Therefore, the selection of raw materials in animal feeds is important and should be considered as an anti-nutritional factor (ANFs) when use as raw materials in animal feed diets (Siddhuraju et al., 2000).

The growth performance and feed utilization of Pla-mong (*P. bocourti*) when fed with diets containing Moringa leaf meal at different levels for 20 weeks did not indicate significant differences ($p>0.05$) but fish fed with Moringa leaf meal at a rate of 100 g kg^{-1} gave maximum growth performance when compared with fish in other groups which was disclosed by Yuangsoi and Charoenwattanasak **(**2011**)** they reported that utilization of Moringa **(***Moringa oleifera* Lam**.)** leaf on growth performance and protein digestibility in Tilapia **(***Oreochromis niloticus* L**.)** when cultured at the rates of 0, 50, 100 and 150 g kg^{-1} for 60 days**.** It was found that growth performance such as weight gain and specific growth rate; feed utilization such as feed conversion ratio and feed efficiency were not significantly found in all groups **(**p>0**.**05**)** of the fish**.** In addition, Richter *et al***.**, **(**2003**)** reported that use of Moringa **(***Moringa oleifera Lam***.)** as an alternative protein source for Nile tilapia **(***Oreochromis niloticus L***.)** being cultured at 10**%**, 20**%** and 30**%** for 7 weeks reported that Nile tilapia fed with 10**%** of Moringa in diet gave the best growth performance, however the growth performance of Nile tilapia was reduced when fed with higher percentages of Moringa of 20 and 30 **%.** A similar result was reported by Afuang et al**.** **(**2003**)** they found that 13 **%** of Moringa **(***Moringa oleifera Lam***.)** leaves in feed diet significantly affected growth performance and feed utilization in Nile Tilapia **(***Oreochromis niloticus L***.)**.

The hematocrit assay is normally used as a general indicator of fish health (NRC,1993). Hematocrit of fish from all groups of this work were within a normal range and did not significantly differed from one another ($p>0.05$). This similar result was consistently found with the study of Yuangsoi and Charoenwattanasak (2011**)**, they reported that hematological parameters of Nile tilapia **(***Oreochromis niloticus L***.)** when fed with Moringa leaf meal supplemented in the diets at 0, 5, 10 and 15 %. It showed that hematocrit was not significantly different ($p>0.05$). In the other study, Soltan et al.., (2008) used a mixture of plant protein substituted as fish meal protein in Nile tilapia diets that was led to the lower hematocrit levels, they claimed that it could be attributable to the binding of phytate to minerals (iron) and/or to be amine group of amino acids causing the low availabilities in the body and gave an increase in erythrocyte fragility. This study indicated that Moringa leaf meal levels in the feed diets affected the changes in total protein, albumin and globulin. Among the blood protein, albumin and globulin are the major proteins, which play a significant role in the immune response. Total serum protein concentration is a measurement of all of the different proteins in plasma with an exceptional of those consumed in clot formation such as fibrinogen and the clotting factors (Racicot et al., 1975). From this study, it showed abnormality of the fish liver that caused a decrease in total protein albumin and globulin (Kaneko et al., 1997). From the results of this study, it showed that total protein, albumin and globulin in the serum of the fish decreased with an increase in Moringa leaf meal level where it indicated the effect due to the interaction between phenolic compound with protein resulted in soluble and insoluble complex formation (Hagerman,1989; Naczket al.,2006;Kosiriska et al., 2011). In addition, the similar amounts of total bilirubin indicated that the liver gave a similar performance due to higher amounts of bilirubin where it showed liver malfunction (Kaneko et al., 1997). Furthermore, the hepatic enzymes comprising of AST, ALT and ALK were also studied where they detected high levels of ALP, ALT and AST in blood where it gave information on the damage of organs particularly in liver cells. The study also showed AST of the fish fed with the Moringa leaves supplemented at a rate of 100 g kg^{-1} gave the lowest. The amount of AST and ALT enzymes indicated a malfunction of liver. These two enzymes normally synthesized by the liver, so when the liver is disordered, both enzymes will be released into the bloodstream more than that of a normal liver. Hepatosomatic index, Viceral somatic index, Viceral fat index and muscle ratio were not significantly differences ($p>0.05$). The results agreed with the study of Yuangsoi and Charoenwattanasak **(**2011**)** where they reported

that the utilization of Moringa **(***Moringa oleifera* Lam**.)** leaf diet in Tilapia **(**Oreochromis niloticus L**.)** with the rates of 0, 50, 100 and 150 g kg^{-1}**.** It was found at the end of the experimental work, the hepatosomatic index (HSI) was not statistically significant ($p>0.05$) in all groups.

CONCLUSION

To sum up, this study indicated that Moringa leaf meal can be efficiently used as a plant protein source yet the amount to be used should not be exceeded 100 g kg^{-1} in any supplementary diets for Pla-momg culture and it could be significantly aided in growth performance, hematological, and serum biochemistry parameters in the catfish**.**

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

PN designed and performed the experiments, data analysis and also wrote the manuscript**.** SD and SC designed experiments and reviewed the manuscript**.** All authors read and approved the final version**.**

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