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Influence of Varying Dietary Lipid Levels on Growth, Feed Conversion and Chemical Composition of Meat and Liver of the Juvenile Blackfin Sea Bream, *Acanthopagrus berda* (Forsskal 1775)

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Abstract.- This paper reports the effects of different dietary lipid concentrations on growth, food conversion and product (meat) quality of blackfin sea bream *Acanthopagrus berda* (mean body weight 10.2±0.5 g) juveniles which were collected from Sonari channel, Hawksbay, Karachi and were brought to the laboratory. Fish were acclimatized for 10 days. Subsequently, they were placed in rectangular glass tanks (150 liters each). Six fish were stocked in each tank with three replications. Fish were fed four isonitrogenous (42% protein) diets of different lipid levels (15%, 20%, 25% and 30%) for 60 days. Fish fed diet of 20% lipid showed considerable weight gain, high specific growth rate (SGR) and low feed conversion ratio (FCR) values. Fish body protein concentration remained consistent though liner relationship was found between body lipid and lipid level in the diets. The hepatosomatic index (HSI) was directly proportional to the concentration of lipid in diets. Generally, the nutrients like protein, lipid and ash in the fish meat were not significantly influenced by the lipid levels. No substantial changes in total quantity of saturates were noted in liver of the fish. Similarly, the monounsaturated fatty acid were only partially affected. No important differences were shown in total monoenes. The over-all poly unsaturated fatty acids (PUFAs) were significantly increased as lipid level increased. The n-3/n-6 was found to be reduced from 5.4 to 2.3 among fish fed diets of 15% and 30% lipid levels. Based on the biological data, it was estimated that optimal level of lipid for *A. berda* weighing from 10.2 g and 56.3 g was 20%.

Key words: Lipid level, sea bream *Acanthopagrus berda*, meat and liver composition, growth, feed conversion.

INTRODUCTION

Sea breams (*Acanthopagrus* spp.) are considered as commercially important food fishes for aquaculture throughout several regions of the world such as China, South-east Asia, Africa, UK and USA (Oh *et al*., 2013; Mongile *et al*., 2014). According to FAO (2012) world production from aquaculture and capture fisheries in 2011 remained as 154 million tons. Of this production, sea bream's contribution which totaled less than 50,000 tons in the early 1990s, reached 150,000 tons in 2011 following a significant addition to 180,000 tons in the production in 2012. In Pakistan, the capture fisheries production of sea breams topped 1676 metric tons in 2012 (Anonymous, 2012). Among these, blackfin sea bream is highly prized as a food fish and establishes a main demersal fish source of the northern Arabian Sea (Anonymous, 2012). Though, there is a considerable commercial fishery, its demand has increased to such a level that the aquaculture of this fish is imperative for the expansion of its industry (Abbas and Siddiqui, 2013). Preliminary trials (Sarwat, 2014) showed that blackfin sea bream is an important candidate for aquaculture because of its large size, resistance to extreme environmental conditions and fast growth, as commonly observed for different species of sea bream (Sa *et al.*, 2006; Rigos *et al.*, 2011).

The growth that signifies an upsurge in fish meat protein content is imperative for the economic

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sustainability of an aquaculture set-up and is affected by the nutrient stable feed, which consequently characterizes the aquaculture budget. The amount of nutrients in feed formulation is the foundation for decreasing this budget. Since lipids are costly constituent of fish feed, it is important to know its lowest amount which will be useful for optimum growth of fish (EL-Husseiny *et al.,* 2013). However, the addition of lipid in surplus of the best rations will cause more fat deposition and cannot more improve growth (Mongile *et al*., 2014). Furthermore, deposition of lipid in the visceral organ may be harmful regarding fish health. Therefore, optimization of dietary lipid level is necessary because excess of lipid in feed will accumulate the fats in fish body and consequently fatty fish have low economic value (Han *et al.,* 2014). Requirement of lipids for various groups of fish are different and depend on many factors like climate, feeding mechanism and life cycle (Sa *et al.,* 2006; Rigos *et al.,* 2011; Mongile *et al*., 2014). Data on the dietary nutrient requirements of different species of sea bream is available to some extent. The dietary lipid requirement of these fish has been stated to be between 20%-28 % (Zakeri *et al.,* 2009; Mohammad *et al.,* 2010). Nothing has so far been documented on the effect of nutritional lipid level of blackfin sea bream juvenile reared in intensive aquaculture system. Therefore, the current research was planned to study the impact of lipid concentration on growth, food utilization and meat quality including lipid contents deposited in the liver of juvenile *A. berda* cultured at 26^{o}C for 60 days.

MATERIALS AND METHODS

Experimental diet

Four iso-nitrogenous (42% protein) test diets were prepared in one batch (g per 100 g dry diet) to contain different lipids levels of 15%, 20%, 25% and 30% (Table I). Fish meal was added as source of protein, and tapioca was used as source of carbohydrate. Cod liver oil was used as source of lipid and energy. Minerals and vitamins were also included in the diets. All ingredients were weighed, ground and mixed mechanically to realize homogeneity. Water (150 ml/kg) was added to the mixture and was remixed. Thus soft dough was pelleted by 2mm die. The pellets of diet were then dried under shade for 10 hours. The experimental diets were then stored at -4^{o}C for subsequent use.

Experimental design and feeding fish

Juvenile blackfin sea bream, *A. berd*a (mean body weight 10.2±0.5 g) were collected from Sonari channel, Hawksbay, Karachi and were brought to the Aquaculture Laboratory of the Centre. They were acclimatized for 10 days and were randomly placed in rectangular glass tanks (6 fish per tank) with three replications in March 2014. The water carrying capacity of each tank was 150 liters and oxygenation was provided by aerators. All the tanks were supplied with sand-filter and aerated seawater continuously. All the fishes were placed in similar light with photoperiod of 12L:12D. Fish were fed at ration of 2% body weight three time a day (09.00, 1:00 and 6:00). After 2 h of each feeding, uneaten food was collected for the estimation of feed intake. Fish length and weight were measured fortnightly.

Chemical analysis and measurement

After the completion of 60-day trial, three fishes were caught from each experimental tank, killed and then dissected to calculate the weight of liver so as to determine the hepatosomatic index (HSI). After that, these fishes were frozen and stored for chemical analysis at -20^{o}C. Samples of the back muscle and liver were dried at room temperature and ground into powder form for chemical composition (AOAC, 2000). Gas-liquid chromatography technique was applied in fatty acid methyl ester (FAME) separation and quantification. With the help of oven (Labostar-LG122 Tabia Espec, Osaka, Japan) the moisture was estimated at 105^{o}C for 24h. Crude lipid was estimated by Soxhlet extraction method (Folch *et al.,* 1957). The Kjeldahl method (N×6.25) was applied for the determination of protein content by means of automatic Kjeldahl system (Buchi 430/323, Switzerland). Ash was obtained from muffle furnace at 550^{o}C. Energy in each treatment was determined with the help of bomb-calorimeter. The data were reported on wet weight basis (mg/100 g of edible portion).

Calculations and statistical analysis

Fish weight gain (WG), condition factor (CF), feed intake (FI), specific growth rate (SGR), protein productive value (PPV), feed conversion ratio (FCR), protein growth rate (PGR), hepatosomatic index (HSI) and protein efficiency ratio (PER) were determined at the end of each sampling by the following formulae:

1. WG, % of initial weight =100 × [final W – initial W/initial W.
2. CF =100 × weight / length^3
3. FI = diet given as % body wt. – remaining diet pellets.
4. SGR =100 × (ln final W – ln initial W /period).
5. PPV =100 × amount of N (protein) gain/amount of N (protein) intake.
6. FCR = diet given / WG)
7. PGR = 100 × (ln final N×6.25 of fish – ln initial N×6.25 of fish) / number of days.
8. HSI = wet of liver (g)/empty fish weight (g) ×100: total of initial was1.24%.
9. PER = wet WG / N×6.25 intake.

The data on growth parameters and carcass nutrients were statistically evaluated (Zar, 1996).

RESULTS

Water quality

Dissolved oxygen concentration remained up to 6.5±0.4 ml/l and pH was generally alkaline with slight variations among the tanks; pH values were around 7.3±0.2 throughout the study period. Water temperature was consistent at 26.0±0.3ºC. Ammonia and nitrites were not more than 0.01±0.002 ml/l. Salinity was usually between 15-16 ‰.

Chemical composition of the test diets

Four formulated diets contained 15%, 20%, 25% and 30% of cod liver oil. The proximate analysis showed that all experimental diets contained approximately 42.5% protein, 15.1-30.1% lipid, 14-15% ash and 7.4-7.6% moisture, 23.6-29.4 kJ/g energy (Table I). The inclusion of cod liver oil with different concentrations caused in substantial variations in the FA conformations of the diets as given in Table II. The diet with

Table I.- Fish feed ingredients and chemical composition of test diets.

	Lipid level (% DM)			
	15	**20**	**25**	**30**
Fish meal	37.5	37.5	37.5	37.5
Tapioca flour	13.6	13.6	13.6	13.6
Lupine seed meal	6.8	6.8	6.8	6.8
Corn gluten meal	10.5	7.5	4.5	1.5
Wheat flour	14	12	10	8
Vitamin-mineral premix[1]	2.6	2.6	2.6	2.6
Cod liver oil	15	20	25	30
Proximate composition[2]				
Moisture	7.5±0.8	7.6±0.5	7.4±0.9	7.5±0.4
Crude protein[3]	42.6±2.9	42.1±2.3	42.0±2.6	42.2±1.9
Crude lipid	15.1±1.2	20.0±1.0	25.2±1.1	30.1±1.7
Crude fiber	3.5±0.4	3.4±0.7	3.3±0.5	3.2±0.3
Ash	13.9±0.7	13.6±0.9	15.0±0.9	14.0±0.5
Carbohydrates[4]	24.9±1.9	20.9±1.6	14.5±1.7	10.5±1.5
Energy (kJ/g)	23.6±2.1	25.2±1.9	27.5±2.7	29.4±2.8

[1]Abbas and Siddiqui (2013).
[2]Dry matter (%): number of samples = 5.
[3]Measured as N × 6.25.
[4]Carbohydrates = 100 – (%protein + %fat + %ash + %fiber).

Table II.- The effects of fat levels on FA composition of test diets.

	Lipid level (% DM)			
	15	**20**	**25**	**30**
14:0	7.5±0.6	5.2±0.1	3.7±0.4	1.7±0.5
16:0	14.3±1.3	19.1±1.5	30.0±1.1	37.0±1.5
18:0	4.3±0.7	4.8±0.5	6.3±0.4	6.3±0.3
16:1n-7	8.4±0.1	6.4±0.1	5.6±0.2	3.2±0.1
18:1n-9	12.1±1.4	21.1±1.5	25.2±1.2	36.3±2.3
18:1n-7	2.5±0.1	2.3±0.1	2.0±0.2	1.1±0.1
20:1n-9	6.2±0.3	4.4±0.6	3.4±0.6	1.4±0.1
22:1	8.4±0.8	5.4±0.3	3.5±0.4	1.5±0.1
24:1n-9	1.5±0.2	2.2±0.1	2.3±0.2	2.0±0.1
18:2n-6	6.7±0.4	9.1±1.0	10.1±1.0	12.8±1.2
20:2n-6	0.4±0.03	0.3±0.01	0.2±0.01	0.1±0.02
20:3n-6	0.1±0.01	0.1±0.02	0.1±0.02	0.1±0.01
20:4n-6	0.5±0.01	0.3±0.01	0.2±0.03	0.1±0.01
18:3n-3	2.1±0.01	2.0±0.002	1.8±0.002	0.4±0.002
18:4n-3	2.7±0.2	1.7±0.2	1.5±0.1	0.3±0.1
20:4n-3	0.5±0.001	0.2±0.001	0.2±0.003	0.1±0.00
20:5n-3	8.1±1.0	5.4±0.8	4.2±1.1	1.0±0.01
22:5n-3	1.4±0.03	0.6±0.003	0.5±0.002	0.3±0.002
22:6n-3	10.2±1.1	7.8±0.3	6.3±0.5	2.6±0.3
Saturates	26.4±1.6^a	29.3±2.0^a	40.2±2.3^b	45.2±2.3^b
Monoenes	39.6±2.3^a	42.3±3.0^a	42.4±2.7^b	46.0±3.1^b
n-6 PUFA	8.0±0.1^a	10.0±1.0^b	10.7±1.1^b	13.1±1.6^c
n-3 PUFA	25.5±2.4^c	18.0±1.1^b	15.0±0.6^b	5.0±0.4^a
PUFA	33.7±3.1^c	28.1±2.8^b	25.7±1.4^b	18.1±2.0^a
n-3/n-6	3.1±0.6^c	1.7±0.03^b	1.3±0.01^b	0.4±0.02^a

Similar superscripts indicate no statistical difference among treatments.

lower lipid level (15%) contained 39.6% monoenes (mainly 18:1n-9, but also significant amounts of 16:1n-7, 22:1 and 20:1n-9, 26.4% saturated fatty acids, of which more than half was 16:0, 25.5% n-3 PUFA (polyunsaturated FA) mainly 22:6n-3 (DHA; docosahexaenoic acid) and 20:5n-3 (EPA; eicosapentaenoic acid), and 8.1% n-6 (PUFAs) largely in the form of 18:2n-6. Graded inclusion of cod liver oil resulted in increased 16:0, 18:1n-9 and 18:2n-6 (2-fold, 3-fold and 2-fold between 15% and 30% lipid levels, respectively). Total saturated, monoenes and n-6 PUFA also increased. On the other hand, 14:0, most of the monoenes, 20:2n-6, ARA and all the total n-3 PUFAs, EPA and DHA, decreased drastically (9-fold and 6-fold between 15% and 30% lipid levels, for EPA and DHA, respectively).

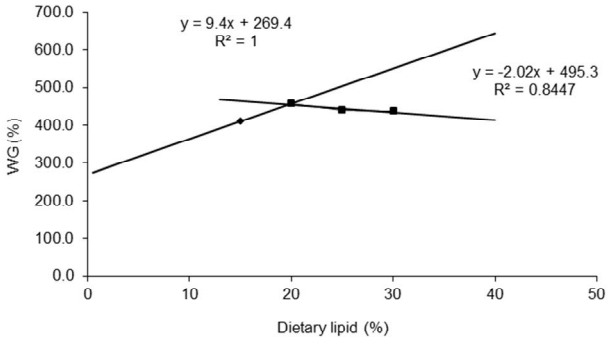

Fig. 1. Dietary lipid requirement of *A. berda* as estimated by broken line regression model.

Growth, feed conversion and condition indices

No pathological symptoms and mortality were observed during the trail. Highest gain in weight and body growth were found in the fish nourished with diet of 20% lipid level (Table III; Fig. 1). Weight gain increased up to a level of lipid 20%, but above this level no important increase ($P>0.05$) was noticed. Feed containing 20% and 25% lipid level showed less FCR value than the remaining diets (Table III). Specific growth rate (SGR) of juvenile blackfin sea bream fed diet with 20% and 25% lipid were better than the fish fed with 15% lipid level. Protein efficiency ratio (PER) was similar among all treatments (Table III). The hepatosomatic index (HSI) increased as lipid level increase from 15% to 30% in the diets (Table III). Protein growth rate (PGR) was directly proportional to the dietary lipid level among treatments. Protein productive valve (PPV) remained consistent throughout the study period (Table III).

Table III.- Growth and food utilization of *A. berda* fed with diets at different lipid levels.

	Lipid level (% DM)			
	15	**20**	**25**	**30**
Final wt. (g)	53.6±0.14^{a}	56.3±0.56^{b}	55.6±0.49^{b}	54.8±0.28^{b}
WG[1] (%)	410.4±1.42^{a}	457.4±0.61^{b}	439.8±0.92^{b}	44.2±0.49^{b}
SGR[2]	2.77±0.41^{a}	2.85±0.53^{b}	2.83±0.31^{a}	2.80±0.50^{a}
FI[3]	23.9±0.14^{a}	24.1±0.42^{a}	25.1±0.21^{b}	25.2±0.63^{b}
FCR[4]	0.054±0.04^{a}	0.053±0.02^{a}	0.057±0.02^{b}	0.06±0.04^{b}
PER[5]	0.53±0.56^{a}	1.03±0.08^{b}	0.84±0.04^{b}	0.81±0.56^{b}
CF[6]	3.27±0.21^{a}	3.07±0.74^{a}	3.03±0.34^{a}	3.1±0.35^{a}
HSI[7]	1.8±0.14^{a}	2.1±0.35^{ab}	3.2±0.42^{c}	4.3±0.14^{d}
PPV[8]	26.1±0.28^{a}	25.7±0.35^{a}	25.2±0.07^{a}	25.1±0.14^{a}
PGR[9]	3.7±0.28^{a}	3.2±0.07^{a}	3.3±0.03^{a}	3.4±0.07^{a}
Survival (%)	100	100	100	100

Similar superscripts indicate no statistical difference among treatments; initial fish weight is 10.2±0.5 g.
[1-7]Formulae of each parameter are given in materials and methods section.

Table IV.- Whole body composition of *A. berda* fed with diets of different lipid levels.

	Lipid level (%)			
	15	**20**	**25**	**30**
Moisture (%)	72.6±0.21^{a}	71.8±0.07^{a}	71.9±0.07^{a}	72.1±0.28^{a}
Protein[1] (%)	17.1±0.28^{a}	16.5±0.14^{a}	15.2±0.07^{a}	15.4±0.35^{a}
Lipid (%)	7.9±0.77^{b}	7.5±0.14^{b}	7.2±0.07^{a}	7.1±0.14^{a}
Ash (%)	3.4±0.07^{a}	3.2±0.06^{a}	3.1±0.06^{a}	3.1±0.63^{a}

Similar superscripts indicate no statistical difference among treatments.
Chemical composition of stocking fish: moisture = 72 %, protein = 53.4 %, lipid = 35.0 %, ash = 12.8 %.
[1]Measured as nitrogen × 6.25.

Body composition

Prior to start the trial, proximate composition of fish meat was 72.0% moisture, 19.4% protein, 9.0% lipid and 5.1% ash (Table IV). After 60 days, the moisture was approximately 72.1%, protein 17.0%, lipid 7.2% and ash 3.2%. Generally, chemical constituents of fish meat was not affected by the graded inclusion of fish oil. The liver fatty acid compositions, and the changes arising from the

Table V.- The Effects of fat levels on the liver FA composition of *A. berda* fed with diet of 42% protein concentration.

	Lipid level (%)			
	15	20	25	30
Total lipids	35.7±2.0[a]	49.6±2.3[a]	45.1±2.0[a]	36.7±1.8[a]
14:0	3.0±0.1[a]	3.2±0.2[a]	2.8±0.1[a]	2.4±0.2[a]
16:0	21.3±1.0[a]	20.5±1.2[a]	21.4±1.1[a]	22.2±1.6[a]
18:0	7.0±0.3[a]	6.5±0.2[a]	6.8±0.3[a]	7.0±0.5[a]
16:1n-7	4.1±0.2[a]	4.4±1.0[a]	3.7±0.2[a]	3.7±0.1[a]
18:1n-9	11.6±1.1[c]	14.3±1.2[b]	16.8±1.1[b]	19.5±1.1[a]
18:1n-7	2.1±0.2[ab]	2.5±0.1[a]	2.0±0.1[ab]	1.3±0.1[b]
20:1n-9	3.0±0.3[a]	3.4±0.2[a]	3.3±0.1[a]	3.7±0.2[a]
22:1	1.4±0.2[a]	1.0±0.1[b]	0.8±0.3[b]	0.3±0.2[c]
24:1n-9	1.3±0.1[a]	0.6±0.2[ab]	0.6±0.2[ab]	0.4±0.1[b]
18:2n-6	3.2±0.3[b]	4.3±1.1[ab]	4.2±0.3[ab]	6.1±1.0[a]
20:2n-6	0.4±0.01[b]	0.8±0.02[b]	0.7±0.02[b]	1.7±0.3[a]
20:3n-6	1.2±0.02[b]	1.2±0.01[b]	1.1±0.02[b]	1.6±0.01[a]
20:4n-6	1.8±0.02[a]	1.3±0.01[a]	1.6±0.02[a]	1.7±0.01[a]
18:3n-3	00.3±0.002[a]	00.3±0.002[a]	00.3±0.001[a]	00.2±0.002[a]
18:4n-3	00.5±0.01[a]	00.7±0.02[a]	00.3±0.02[a]	00.2±0.02[a]
20:4n-3	00.4±0.001[a]	00.3±0.001[a]	00.3±0.002[a]	00.1±0.00[c]
20:5n-3	02.1±1.0[a]	01.7±0.7[ab]	1.3±0.2[b]	1.0±0.02[b]
22:5n-3	01.1±0.01[a]	00.6±0.01[b]	00.5±0.02[c]	00.1±0.001[d]
22:6n-3	32.0±2.2[a]	31.5±2.6[a]	30.1±2.5[a]	31.5±3.1[a]
Saturates	31.3±1.6[a]	30.5±2.0[a]	31.1±2.4[a]	31.7±2.2[a]
Monoenes	23.7±2.2[c]	26.6±3.0[bc]	27.7±2.6[ab]	29.6±2.0[a]
n-6 PUFA	6.8±0.1[c]	8.0±1.0[b]	8.1±1.2[b]	11.3±1.4[a]
n-3 PUFA	37.7±2.5[a]	34.5±1.2[a]	32.7±0.6[ab]	25.9±0.8[b]
PUFA	44.6±3.1[a]	42.6±2.5[ab]	32.4±1.3[ab]	38.7±2.0[b]
n-3/n-6	5.4±0.6[a]	4.2±0.03[b]	4.0±0.01[b]	2.3±0.02[c]

Similar superscripts indicate no statistical difference among treatments.

dietary inclusion of fish oil with different concentration are presented in Table V. The total saturated fatty acids ranged from 30.5%, 31.7% while 16:0 had the highest proportion (approximately 22.2%) of all saturated fatty acids. No substantial changes in any of the single saturated fatty acid, or in the total saturated fatty acid were noted. Similarly, the monounsaturated fatty acid were only partially affected. Specifically, when fish oil was included in the diets at different levels 18:1n-9 was significantly increased by 2-fold (11.6% vs. 19.5%, for 15% and 30%, respectively) and 18:1n-7 and 24:1n-9 were significantly decreased, while no important differences were shown in any of the other monoenes or the entire monoenes. The n-6 PUFAs, including the overall n-6 PUFAs, were significantly increased with graded inclusion of fish oil. 18:2n-6 was increased 2-fold, from 3.32 to 6.1% for 15% and 30%, respectively. 20:2n-6 increased almost 3-fold and 20:3n-3 5-fold between 15% and 30%, while arachidonic acid 20:4n-6 (ARA) was unaffected by the dietary treatments (approximately 1.4%-1.8%). Lastly, the n-3/ n-6 was reduced from 5.4 to 2.3 among fish supplied with diets containing 15% to 30% levels of lipid.

DISCUSSION

In the present investigation, lipid concentration of 20% (25.2 kJ per gram digestible energy) was suitable for the fish to enhance both the WG and the FCR in blackfin sea bream juveniles cultivating from 10.2g to 56.3g. Similar findings have been stated in some fishes like yellowfin sea bream, *Acanthopagrus latus* (Zakeri *et al.,* 2009), white sea bass, *Atractoscion nobilis* (Lopez *et al*., 2006), blackspot seabream, *Pagellus bogaraveo* (Silva *et al*., 2006), gilthead seabream, *Sparus aurata* (Rigos *et al*., 2011; El-Husseiny *et al.,* 2013; Mongile *et al.,* 2014), which have shown that feed conversion and growth rates increase when fish were given diets containing low lipid levels. In this study, the lipid requirements for the growth of blackfin sea bream appeared similar to other marine fish species (NRC, 1993). In some studies on gilthead seabream (Mohammad *et al.,* 2010) and Japanese sea bass, *Lateolabrax japonicus*, Cuvier **(**Ai *et al*.**,** 2004) the optimum lipid level was suggested as 20% to 30% for the best growth performance. In this study, when lipid concentration in diet was above 20%, mean percent WG decreased significantly. This indicates that WG maxima may be identified in a range of dietary lipid concentration from 20% to 30% as suggested by El-Husseiny *et al.* (2013) and Mongile *et al.* (2014). Similar trend was observed in haddock (Kim and Lall, 2001) and blackfin sea bream in the present study. FCR and PER decreased as lipid level in the diets was increased (Han *et al.,* 2014). This shows that an upsurge in lipid energy of the fish feed could be useful in nutrient utilization than increasing dietary protein energy. These results are advocated by the findings of Mohammad *et al.* (2010), Oh *et al*. (2013) and Han *et al.* (2014). In this research, fish fed with diets of 15% lipid level showed high PER and low SGR values. This shows that the sea bream can efficiently utilize the diets with low lipid level for lipid synthesis, therefore PER value increased suggesting a compensatory mechanism (Zakeri *et al.,* 2009).

Fat contents are generally known as the criterion constituents for determining the quality of fish flesh (EL-Husseiny *et al.,* 2013). In this study, fat contents in meat was considerably higher for the fish given diets of 15% and 20% lipid levels than that of 25% and 30% lipid levels. As dietary lipid concentration increased, fat content decreased as in other fishes (Zakeri *et al.,* 2009; Mohammad *et al.,* 2010; Oh *et al*., 2013. EL-Husseiny *et al.,* 2013; Mongile *et al*., 2014; Han *et al.,* 2014). They observed that the fat contents of fish appeared to be influenced by feeding rhythm with age; correlation among them was positively significant. Similar strong correlation was also observed in the findings of this study. This relationship suggests that as the fish grows its weight increases and proportionately most of this increase is present in the form of fat in fish (Al-Asgah, 1992). In the current study, no statistically significant differences in moisture and crude lipid contents were found among fish fed with diets 15% to 30%, though moisture content showed a clear inverse relationship with crude fat contents (Rigos *et al.,* 2011; Oh *et al*., 2013; EL-Husseiny *et al.,* 2013; Mongile *et al*., 2014; Huang *et al*., 2014; Han *et al.,* 2014).

The relationship between protein and water contents in different fish species has been found to some extent. Salam and Ali (2001) and Han *et al.* (2014) for example, observed that in non-fatty fish, as protein is removed from the muscle, the moisture content rises steadily. Oh *et al*. (2013) found that water content decreased when lipid content was increased. This clearly indicates a reverse relationship among lipid and water content appearing a tool for homeostasis of fish tissue mass as also found in the present investigation. The protein content remained constant as lipids are considered for protein sparing action in the fish. (EL-Husseiny *et al.,* 2013; Mongile *et al*., 2014; Huang *et al*., 2014).

The HSI increase with increase in lipid content due to deposition of fats in the liver of fish was similar with the findings of Miller *et al.* (2005) and Oh *et al*. (2013). In this study, whole body composition including EPA and DHA remained consistent and similar to the recommended values (Tocher, 2003; Mourente and Bell, 2006; Morkore, 2006; Karalazos *et al*., 2011 FAO, 2012). In this study, the combined values of DHA and EPA are higher than the requirement reported for pomfrets, *Pampus argenteus* (Hossain *et al.,* 2011).

Since lipid and protein contents are known as costly component of fish diet and their excess amount in the feed are counterproductive (Oh *et al*., 2013). Therefore, lipid and protein concentration when developing nutritionally balanced diet must be decreased to a lowest level as suggested by Mongile *et al*. (2014). In the current research juvenile blackfin sea bream fed diets of 20% lipid with P/E (16.7 mg protein per kJ^{-1} DE) showed the highest SGR (2.85%). Similar P/E ratio (18.0 mg protein kJ^{-1}) was reported for other fish fed with diet containing 20% lipid (Sa *et al.,* 2006; Huang *et al*., 2014; Rigos *et al.,* 2011; Oh *et al*., 2013). Finally, this study suggests that blackfin sea bream, *A. berda* juvenile can perform well on 42% protein diet with 20% lipid level under the available laboratory conditions.

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