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Possible Benefits of Using Two Dietary Crude Protein Levels And Two Fat levels From Three Sources in Feeding Tilapia

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ABSTRACT

This study was conducted during the summer season (June- October) 2018 in fish farm at Al-Manzala city for 150 days. A total number of 750 mono-sex Nile tilapia with an average initial body weight of 52.6 ± 0.40 g were used in five experimental treatments (150 fish/hapa/treatment, 10 fish/m^3) to evaluate two dietary crude protein levels (25 and 30%) and two crude fat levels (2 and 6%) from three fat sources (corn oil, imported fish oil, and a new local commercial source of fatty acids named Aquafat-omiga). Fish were stocked into net hapas, each hapa has the dimensions 3 x 5 x 1 m. **Conclusively**, from the obtained results and due to the view point of the producers, 2 % fish oil supplemented diet (25 % protein) is the most economic diet (lowest feed intake, best feed conversion and feed efficiency) followed by that (25 % protein) supplemented with 2 % Aquafat-omiga. But from the view point of the consumers, 30 % crude protein diet plus 6 % addition corn oil gave best body gain and fish carcass protein, boneless meat and lean meat besides lowest fat and ash in fish body and lowest serum cholesterol, uric acid, and cortisol. So, it could recommend using the first diet containing 30 % crude protein and supplemented with extra 6 % corn oil. Particularly, fish oil is rear, unavailable, imported, and expensive.

INTRODUCTION

Mono-sex Nile tilapia has many attributes that make them an ideal candidate for aquaculture especially in developing countries (Abdelhamid, 2019a). Fish are cheap priced and high biological valued animal protein source. Fish are rich in protein, polyunsaturated fatty acids, minerals and vitamins; consist of 60% of total protein consumption of the Egyptian people (Abdelhamid, 2019b&c).

Egypt, a country where the farming of tilapia has its roots (Stickney, 2006) produces 12% of the world farmed tilapia (FAO, 2007). The objective of the present study was to evaluate effects of lowering the dietary crude protein from 30 % to 25 % with the addition of two fat levels (being 2 and 6 %) from three sources (corn oil, Aquafat-omiga®, and fish oil) in a field study for 150 days on growth performance, feed and nutrients utilization, body composition, blood profile, and economic efficiency with all male mono-sex Nile tilapia.

MATERIALS AND METHODS

This study was conducted in fish farm at Al-Manzala (General Authority for Fish Resources Development, Ministry of Agriculture). The study lasted for 150 days throughout June - October 2018.

The experimental management:

A total number of 750 mono-sex Nile tilapia with an average initial body weight of 52.6 ± 0.40 g were used in five experimental treatments (150 fish / hapa (treatment), 10 fish / m3) to evaluate two dietary crude protein levels (25 and 30 %) and two crude fat levels from three fat sources as illustrated in Table 1. Al-Manzala Powdered Feed (30% crude protein, 25% crude protein, 6.7% crude fat, 7.7% crude fibers and 2567 Kcal gross energy/kg feed) was used as a basal ration. All diets were re-pelleted by a manufacturing machine (pellets diameter 3 mm). Fish were stocked into net hapas, each hapa has the dimensions 3 x 5 x 1 m. The tested Aquafat–omiga contained calcium salt of linoleic acid, oleic acid, linolenic acid, palm fatty acid distillate (PFAD) and fish which manufactured and analyzed by Norel Animal Nutrition–Misr Company, 24 Aden St., P.O.B. 2 El-Agoza, Mohandessin, Giza, Egypt. The Aquafat-omiga formula was comprised of crude fat 84 %, ash 12.5 %, calcium 8 %, moisture 3.5 % and BHT 0.01 % (Antioxidant). The Aquafat-omiga contains 64.2 % unsaturated fatty acids and 35.8 % saturated fatty acids. The fish oil used herein was imported from Pakistan contained 99 %fish oil and maximum 7 % free fatty acids plus carotenoids 5 – 20 ppm. Fish fed the experimental diets at a daily feeding rate of 3% of their live body weight six days a week. Experimental diets were handily introduced two times daily at 8 a.m. and 2 p.m.

Table 1: Details of the experimental treatments

Treatment	Details
T1	30 % protein + 6% corn oil
T2	25 % protein + 6% corn oil
T3	25 % protein + 2% corn oil
T4	25 % protein + 2 % Aquafat-omiga
T5	25 %protein + 2 % fish oil

Chemical analysis of the experimental diet and fish carcass:

At the end of the experiment, the fish was sampled from each hapa and kept frozen until chemical analysis. The chemical analysis of the experimental diets and the whole body fish (at the start and the end of the experimental period), was carried out according to the AOAC (2000). Gas chromatograph with FID detector was used for fatty acids profile differentiation in fish muscles according to AOAC (2000), which carried out in the fatty acid laboratory of the Regional Center for Foods and Feeds, Agricultural Research Center, Ministry of Agriculture, Giza.

Criteria studied:

Some water quality parameters were measured in all hapas at the start and the end of the experiment according to Abdelhamid (1996). Body weight of individual fish of sample from each hapa was measured biweekly to point feed quantity at the actual body weight of fish and to calculate growth performance and feed utilization (Abdelhamid, 2003). At the end of the experiment, blood samples were collected from the fish caudal peduncle of the different experimental groups. Blood samples from 5 fish / hapa were taken randomly which were received in clean plastic tubes. Adequate amounts of whole blood in small plastic vials containing heparin were used for the determination of hematological parameters (Stoskopf, 1993 and Dacie

and Lewis, 1995). Other blood samples were collected and transferred by centrifugation for 20 minutes at 3500 rpm to obtain blood serum. Serum samples were kept at -20 ºC in a deep freezer till the biochemical analysis (Tietz, 1995) using commercial kits from Diagnostic System Laboratories INC, USA. At the end of the present study, economic efficiency parameters (total outputs, total costs, net return and economic efficiency) of each experimental hapa were calculated according to local market prices at the time of study in Egypt (2018).

Statistical analysis:

The obtained data were statistically analyzed using (SAS, 2006) procedures for personal computer. When F-test was positive, least significant difference by (Duncan, 1955) was calculated for the comparisons among means for all hapas.

RESULTS

Fish rearing water criteria:

Some water quality criteria were measured throughout the entire experimental period in different experimental Hapas. The water temperature ranged between 32.8 and 21.1 ºC, whereas the pH values took the range 7.15 – 8.5. Concerning dissolved oxygen concentration in different experimental Hapas, it ranged from 7.14 to 8.31 mg / L without specific effect due to sampling neither time nor dietary treatments.

Fish growth performance criteria:

Table 2 shows no significant (P>0.05) differences among treatments in IW (50.7 – 52.7 g) and SGR (1.44 – 1.58 %/d), whereas the first treatment (Hapa A, 30 % CP) reflected significantly (P≤0.05) the highest FW (294.8 g), TWG (243.55 g), ADG (3.48 g), and RGR (475.22 %) than the other treatments (Hapas). The condition factor was lowest (P≤0.05) by E-treatment (25 % CP + 2 % fish oil).

Table 2: Growth performance of the experimental fish as affected by the experimental treatments throughout the experimental period (means ± standard errors)

Treatments	Initial	FW	TWG	ADG	RGR	SGR	Kt
A	51.25	294.80^{a} ±0.46	243.55^{a} ±0.46	3.48^{a} ±0.01	475.22^{a} ±0.89	1.46 ±0.00	1.79^{b} ±0.04
B	50.9	282.53^{c} ±0.36	231.63^{c} ±0.36	3.31^{c} ±0.01	455.07^{d} ±0.70	1.53 ±0.10	1.90^{a} ±0.02
C	52.7	274.17^{d} ±0.35	221.47^{d} ±0.35	3.16^{d} ±0.00	420.25^{e} ±0.66	1.58 ±0.13	1.93^{a} ±0.01
D	51.3	287.28^{b} ±0.33	235.98^{b} ±0.33	3.37^{b} ±0.00	460.00^{c} ±0.64	1.44 ±0.00	1.80^{b} ±0.02
E	50.7	287.01^{b} ±0.85	236.31^{b} ±0.85	3.38^{b} ±0.01	466.09^{b} ±1.67	1.44 ±0.00	1.72^{c} ±0.02

a – d: means in the same column superscripted with different letters differ significantly (P≤0.05). IW: initial body weight, g; FW: final body weight, g; TWG: total body weight gain, g; ADG: average daily gain, g: RGR: relative growth rate, %; SGR: specific growth rate, %/d, and Kt: condition factor (by total length).

Feed and nutrients utilization: As shown from Table 3, treatment-A reflected the highest (P≤0.05) FI, whereas the treatment-E (25 % CP + 2 % fish oil) had the beast

(P≤0.05) FCR, FE, and PER. Treatment-D (25 % CP + 2 % Aquafat-omiga) gave the best (P≤0.05) PPV, EU, and LR.

Table 3: Feed and nutrients utilization of the experimental fish as affected by the experimental treatments throughout the experimental period (means ± standard errors).

Treatments	FI	FCR	FE	PER	PPV	EU	LR
A	448.90^{a} ±0.35	1.84^{a} ±0.00	54.26^{b} ±0.08	1.58^{c} ±0.00	30.99^{b} ±0.05	397.73^{b} ±0.95	40.06^{e} ±0.06
B	427.23^{c} ±0.20	1.84^{a} ±0.00	54.22^{b} ±0.07	1.69^{b} ±0.00	31.00^{b} ±0.04	352.94^{d} ±0.65	42.57^{d} ±0.07
C	406.83^{e} ±0.66	1.84^{a} ±0.00	54.44^{b} ±0.08	1.69^{b} ±0.00	33.68^{a} ±0.04	348.28^{e} ±1.02	45.88^{c} ±0.08
D	433.08^{b} ±0.42	1.84^{a} ±0.00	54.49^{b} ±0.08	1.70^{b} ±0.00	33.69^{a} ±0.05	408.87^{a} ±0.66	50.79^{a} ±0.06
E	417.46^{d} ±0.58	1.77^{b} ±0.00	56.60^{a} ±0.14	1.76^{a} ±0.00	31.08^{b} ±0.07	356.57^{c} ±1.69	49.13^{b} ±1.15

a – e: means in the same column superscripted with different letters differ significantly (P≤0.05). FI: feed intake, FCR: feed conversion ratio, FE: feed efficiency, PER: protein efficiency ratio, PPV: protein productive value, EU: energy utilization, and LR: lipid retention.

Boneless meat and proximate chemical analysis of the fish carcass: Table 4 shows that lean meat (LM) and boneless meat (BM) percentages were significantly higher in A-treatment than all other treatments, perhaps for its higher CP content. Table 5 illustrates the chemical analysis of the whole fish body at the start and at the end of the experiment. In general, there was an increment in DM, CP, NFE, and energy contents by ageing. But the ash content had decreased by age ingoing. The highest (P≤0.05) DM was registered for D-treatment (25 % CP + 2 % Aquafat-omiga), the highest CP and lowest EE and ash in A-treatment (P≤0.05) fish fed with 30 % CP. The fish in E-treatment (25 % CP + 2 % fish oil) contained the highest (P≤0.05) energy content.

Table 4: Lean meat and boneless meat percentages of the fish as affected by the experimental treatments throughout the experimental period (means ± standard errors)

Criteria	Treatments				
	A	B	C	D	E
Lean meat	2.66^{a} ±0.01	2.56^{bc} ±0.01	2.60^{b} ±0.01	2.54^{c} ±0.01	2.53^{c} ±0.01
Boneless meat	35.10^{a} ±0.36	33.76^{bc} ±0.17	33.21^{c} ±0.11	34.56^{ab} ±0.18	34.53^{ab} ±0.35

a – c: means in the same column superscripted with different letters differ significantly (P≤0.05).

Table 5: Proximate chemical analysis of the fish carcass as affected by the experimental treatments throughout the experimental period (means ± standard errors).

Treatments	DM, %	CP, %	EE, %	Ash, %	NFE, %	Energy, Kcal/100 g
Initial	26.47	56.78	20.85	22.18	0.19	517.84
A	28.97^{ab} ±0.93	64.95^{a} ±0.14	18.30^{d} ±0.10	16.49^{b} ±0.13	0.26 ±0.12	540.12^{bc} ±0.46
B	28.46^{b} ±0.43	62.48^{b} ±0.28	19.61^{c} ±0.24	17.43^{a} ±0.24	0.48 ±0.23	539.45^{bc} ±2.47
C	29.78^{ab} ±0.90	63.33^{b} ±0.27	19.66^{c} ±0.27	16.42^{b} ±0.23	0.59 ±0.19	545.22^{ab} ±1.30
D	31.02^{a} ±0.50	61.22^{c} ±0.43	20.73^{b} ±0.16	17.44^{a} ±0.26	0.61 ±0.23	543.46^{ab} ±1.91
E	28.27^{b} ±0.21	60.84^{c} ±0.06	21.44^{a} ±0.16	17.52^{a} ±0.09	0.21 ±0.11	546.34^{a} ±1.24

a – d: means in the same column superscripted with different letters differ significantly (P≤0.05). DM: dry matter, CP: crude protein, EE: ether extract, and NFE: nitrogen free extract.

Fatty acids of the fish flesh:

Table 6 presents the relative distribution of different fatty acids of the experimental fish muscles as affected by the dietary treatments. Fish muscles of the first treatment (A) fed high CP (30%) plus 6% corn oil contained the highest percentages of both EPA and DHA than the other treatments.

Table 6: Relative distribution (% dry matter basis) of different fatty acids in the experimental fish muscles as affected by the dietary treatment.

Fatty acids	Name	Diets				
		A	B	C	D	E
C 14:0	Myristic acid	4.73 –	3.83 –	3.52 –	3.64 -	3.64
C 15:0	Pentaenoic acid	0.68 –	0.51 –	0.48 –	0.49 -	0.46
C 16:0	Palmitic acid	18.9 –	23.0 –	21.7 –	22.1 -	20.9
C 16:1(t)7	Palmitoleic acid	5.29 –	5.16 –	0.06 –	5.12 -	5.01
C 16:1(t)5		0.23 –	0.17 –	0.15 –	0.14 -	0.18
C 17:0	Heptadecanoic acid	0.62 –	0.63 –	0.65 –	0.67 -	0.61
C 16:2(t)4		0.88 –	0.51 –	0.48 –	0.50 -	0.45
C 16:3(t)4	Hexagonic acid	0.44 –	0.33 –	0.31 –	0.32 -	0.32
C 16:4(t)1		0.24 –	0.12 –	0.13 –	0.12 -	0.14
C 18:0	Stearic acid	3.38 –	4.63 –	4.86 –	5.14 -	3.97
C 18:1(t)9	Oleic acid	19.3 –	26.1 –	27.0 –	27.0 -	26.6
C 18:1(t)7	Vaccinic acid	3.29 –	3.11 –	2.93 –	2.98 -	2.78
C 18:1(t)5	Octadecosaenoic acid	0.31 –	0.19 –	0.17 –	0.18 -	0.88
C 18:2(t)6	Linoleic acid	8.19 –	0.50 –	0.58 –	12.7 -	12.5
C 18:3(t)6	Gamma linolenic acid	0.29 –	1.05 –	0.98 –	0.55 -	0.56
C 18:3(t)3	Linolenic acid	1.19 –	0.75 –	0.73 –	1.08 -	1.05
C 18:4(t)3	Octadecatetertranoic acid	1.44 –	0.24 –	0.26 –	0.75 -	0.76
C 20:0	Arachidic acid	0.19 –	0.44 –	0.41 –	0.27 -	0.28
C 20:1(t) 11	Eicosaenoic acid	0.84 –	3.54 –	2.91 –	0.42 -	0.35
C 20:1(t) 9	Gadoleic acid	5.90 –	0.17 –	0.15 –	3.22 -	1.89
C 20:1(t) 7	9-eicosaenoic acid	0.25 –	0.46 –	0.52 –	0.18 -	0.13
C 20:2(t) 6		0.34 –	0.36 –	0.41 –	0.53 -	0.50
C 20:3(t) 6	Eicosatrienoic acid	0.19 –	0.84 –	0.91 –	0.39 -	0.25
C 20:4(t) 6	Arachidonic acid	0.69 –	0.25 –	0.21 –	0.87 -	1.07
C 20:4(t) 3	Eicosatatrienoic acid	0.38 –	2.34 –	2.18 –	0.23 -	0.22
C 20:5(t) 3	Eicosatatrienoic acid (EPA)	5.27 –	3.44 –	2.86 –	2.25 -	2.16
C 22:1(t) 11		7.34 –	0.35 –	0.29 –	3.17 -	2.72
C 22:1(t) 9	Eicosatatrienoic acid (EPA)	0.75 –	0.64 –	0.57 –	0.52 -	0.27
C 22:5(t) 3	Docosenoic acid	7.62 –	3.87 –	3.53 –	3.76 -	3.81
Non identified fatty acids	Erucic acid	0.84 –	0.91 -	0.94 –	0.92 -	0.93

Blood analysis of the experimental fish:

Concerning the haematological parameters, the significant ($P \leq 0.05$) differences were calculated only in MCH, MCHC, and WBCs, where D-and C- treatments (25 % CP + 2 % Aquafat-omiga and 2 % corn oil, respectively) reflected the significantly ($P \leq 0.05$) highest values comparing with the other treatments (Table 7). The significantly ($P \leq 0.05$) best treatment in most biochemical parameters (globulin, albumin/globulin, ALT, AST, and AST/ALT) was E- and D-treatments containing diets with 25 % CP + 2 % fish oil and 2 % Aquafat-omiga, respectively (Table 8). Treatment-B (25 % CP+ 6 % corn oil) was the best significantly ($P \leq 0.05$) concerning (Table 9) creatinine and triglyceride levels, treatment-A (30 % CP + 6 % corn oil) also the best significantly concerning cholesterol, uric acid and cortisol concentrations. Treatment-C (25 % CP+2% corn oil) the best in high density lipoprotein level. The D-treatment (25 % CP + 2 % Aquafat-omiga) was significantly the best in low density lipoprotein.

Table 7: Hematological parameters of fish at the end of the experimental period as affected by the experimental treatments (means ± standard errors).

Trea.	Hb	RBCs	HCT	MCV	MCH	MCHC	PLT	WBCs	Lymp.	Mono.	Eosin.
A	7.88	2.14	27.79	155.41	36.40^{ab}	25.60^{b}	10.00	103.63^{b}	92.50	10.00	1.00
	±0.23	±0.0.18	±0.58	±1.05	±0.30	±0.70	±3.00	±1.13	±0.50	±0.00	±0.00
B	7.40	2.39	28.01	161.75	36.00^{ab}	26.35^{ab}	9.50	108.63^{ab}	94.50	11.00	1.00
	±0.56	±0.27	±3.86	±7.51	±0.40	±0.95	±0.50	±4.38	±1.50	±1.00	±0.00
C	7.43	2.36	29.67	148.79	35.45^{b}	28.65^{a}	11.00	113.60^{a}	95.00	11.50	1.00
	±0.46	±0.38	±2.31	±3.42	±0.25	±0.05	±2.00	±2.40	±0.00	±0.50	±0.00
D	8.11	2.11	29.07	149.83	36.20^{ab}	28.60^{a}	10.00	115.65^{a}	93.50	10.50	1.00
	±0.15	±0.22	±2.58	±0.51	±0.10	±0.70	±2.00	±1.05	±0.50	±0.50	±0.00
E	8.13	2.63	29.24	153.05	36.80^{a}	28.15^{a}	12.00	111.10^{ab}	92.50	9.50	1.00
	±0.78	±0.22	±0.63	±2.30	±0.10	±0.35	±0.70	±1.20	±0.50	±0.50	±0.00

a – b: means in the same column superscripted with different letters differ significantly (P≤0.05). Trea.: treatment; Hb: hemoglobin, g/dl; RBCs: red blood cells, x106/µl; HCT: hematocrit, %; MCV: mean corpuscular volume, fl; MCH: mean corpuscular hemoglobin, pg; MCHC: mean corpuscular hemoglobin concentration, %; PLT: platelets, X 103/µl; WBCs: white blood cells, X 103/µl; Lymp.: lymphocytes, %; Mono.: monocytes, %; Eosin.: eocinocytes, %.

Table 8: Biochemical parameters of fish at the end of the experimental period as affected by the experimental treatments (means ± standard errors).

Treatments	TP	AL	GL	AL/GL	ALT	AST	AST/ALT
A	4.70	3.80^{a}	2.10^{ab}	1.26^{c}	84.50^{ab}	355.50^{ab}	5.22^{a}
	±0.50	±0.10	±0.10	±0.01	±0.50	±0.50	±0.00
B	4.50	3.00^{b}	2.20^{a}	1.42^{bc}	83.50^{b}	354.00^{b}	4.79^{ab}
	±0.70	±0.20	±0.10	±0.15	±0.50	±1.00	±0.44
C	4.30	2.75b^{c}	1.85^{b}	1.57^{ab}	84.00^{ab}	353.50^{ab}	4.35^{b}
	±0.50	±0.15	±0.05	±0.01	±0.00	±0.50	±0.01
D	5.20	2.35^{c}	2.30^{a}	1.73^{a}	84.50^{ab}	354.00^{ab}	5.18^{a}
	±0.50	±0.05	±0.10	±0.01	±0.50	±1.00	±0.00
E	5.05	2.50^{c}	2.30^{a}	1.69^{a}	85.00^{a}	357.00^{a}	5.26^{a}
	±0.35	±0.10	±0.10	±0.05	±0.00	±1.00	±0.07

a – c: means in the same column superscripted with different letters differ significantly (P≤0.05). TP: total protein, g/dl; AL: albumin, g/dl; GL: globulin, g/dl; AL/GL, ratio; ALT: alanine aminotransferase, u/l; AST: aspartate aminotransferase, u/l; and AST/ALT, ratio.

Table 9: Biochemical parameters of fish at the end of the experimental period as affected by the experimental treatments (means ± standard errors).

Treat.	Creatin.	Trigly.	Chole.	UA	HDL	LDL	Glucose	Cortisol
A	0.07^{ab}	220.50^{a}	182.00^{b}	1.45^{b}	35.13^{b}	160.32^{cd}	85.50	6.50^{b}
	±0.05	±0.50	±3.00	±0.01	±0.01	±0.00	±0.50	±0.30
B	0.02^{b}	185.00^{c}	197.00^{b}	1.79^{ab}	36.61^{ab}	161.51^{bc}	83.50	7.10^{ab}
	±0.01	±5.00	±8.00	±0.32	±1.49	±1.19	±1.50	±1.20
C	0.10^{ab}	200.00^{b}	222.50^{a}	2.11^{a}	38.16^{a}	162.72^{b}	82.50	8.80^{a}
	±0.04	±5.00	±12.50	±0.00	±0.00	±0.00	±.050	±0.40
D	0.18^{a}	152.00^{d}	236.50^{a}	2.25^{a}	33.43^{c}	158.60^{d}	83.50	7.85^{ab}
	±0.02	±2.00	±1.50	±0.02	±0.01	±0.00	±0.50	±0.05
E	0.10^{ab}	161.50^{d}	242.50^{a}	2.23^{a}	33.99^{bc}	168.98^{a}	84.50	7.20^{ab}
	±0.02	±1.50	±2.50	±0.01	±0.55	±0.37	±0.50	±0.30

a – d: means in the same column superscripted with different letters differ significantly (P≤0.05). Creatin.: creatinine, mg/dl; Trigly.: triglycerides, mg/dl; Chole.: cholesterol, mg/dl; UA: uric acid, mg/dl; HDL: high density lipoprotein, mg/dl; and LDL: low density lipoprotein, mg/dl.

Economic efficiency:

Table 10 presents the calculated economic efficiency of using the experimental diets with tilapia. The fifth treatment (basal diet with 25 % CP + 2 % fish oil) was the best economically (it realized the highest net return) comparing with the other four treatments.

Table 10: Economic efficiency parameters at the end of the experiment

Treatment	Total outputs[1]	Total feed costs[2]	Net return[3]	Economic efficiency[4] (%)
(1) 30 % protein + 6% corn oil	905.18	602.11	303.07	**50.33**
(2) 25 % protein + 6% corn oil	859.75	571.68	288.07	**50.48**
(3) 25 % protein + 2% corn oil	824.00	544.05	279.95	**51.55**
(4) 25 % protein + 2 % Aquafat-omiga	876.75	577.26	299.49	**51.97**
(5) 25 % protein + 2 % fish oil	865.50	556.83	308.67	**55.43**

Total outputs per treatment (LE/Kg fish) = fish price X total fish production*, * Total fish production per treatment (hapa). 2-Total feed costs per treatment (LE/Kg diet) = feed costs per one kg diet X feed intake. 3- Net return per treatment (LE) = total outputs – total feed costs. 4- Economic efficiency per treatment (%) = (net return/ total feed costs) X 100.

DISCUSSION

Firstly, the experimental treatments did not alter the rearing water quality, since values of all tested parameters were within the suitable ranges for Nile tilapia culture as given by Abdelhakim *et al*. (2002) and Abdelhamid (2019). Using the 30 % CP diet (treatment A) was responsible for the significantly highest FW, TWG, DWG, RGR, fish body CP, serum albumin, and triglycerides, and the significantly lowest fish body EE and ash as well as lowest serum cholesterol, uric acid, and cortisol. This means that the high-protein diet reflected best growth performance, body composition, blood serum biochemical parameters, and immunity against stress.

Dietary inclusion of fish oil led to significant effects, i.e. lowest Kt, FI, and FCR, the highest fish body EE, energy, ash, MCH, AST, ALT, AST/ALT, globulin, AL/GL, cholesterol, and LDH. It was the best in FE, PER, and economically among the tested diets. Aquafat-omiga addition to the 25 % CP diet was significantly the best diet concerning PPV, EU, LR, fish body DM, WBCs, globulin, Al/Gl, triglycerides, and LDL. It caused also highest uric acid, and creatinine concentrations and lowest HDL; yet, it was the best treatment economically after the fish oil diet. However the lowest growth performance (FW, TWG, DWG, and RGR) and highest Kt, HDL, and cortisol levels were obtained with the 25 % CP diet with 2 % corn oil.

In this connection, Gaber (1994) came to the conclusion that as the dietary crude protein level and nitrogen consumption increased, nitrogen excretion and retention are increased. Moreover, El-Houssiny *et al*. (1999) found that dietary crude protein level (20, 25, and 30 %) and feeding regime (daily feeding rates 3 and 5 %, twice or three times daily) had affected the humoral immune response of Nile tilapia.

In the same trend, Shehata and Goda (2000) found that dietary lipid levels and sources affect the immune response of Nile tilapia broodstock in winter season. Attalla (2009) concluded too that oil extracts can promote growth performance and improve the physiological activities of blue tilapia (*Oreochromis aureus*). Additionally, El-Kasheif *et al*. (2011) concluded that Nile tilapia diet with 3-9 % supplemented fish oil is sufficient without any negative effects on growth performance, body composition and hematological measurements.

The situation in fish regarding the relationship between dietary levels of n-3 PUFAs and immunosuppression is contradictory. Studies comparing the effects of high dietary levels of n-3 fatty acids versus high dietary levels of n-6 fatty acids have

shown variation in the immunomodulatory properties of the different fatty acids. Nevertheless, there appear to be more reports of immunosuppression associated with high dietary n-3 fatty acid content than with high n-6 fatty acid content. Channel catfish fed diets with high levels of n-3 fatty acids had enhanced immune function (especially phagocytic capacity) at low temperatures, while fish fed high dietary levels of n-6 fatty acids had enhanced disease resistance factors at higher temperatures. The importance of n-3 fatty acids for maintaining immune function was demonstrated, as antibody production and macrophage killing activity were decreased in rainbow trout fed diets deficient in n-3 fatty acids (Lim *et al*., 2003).

However, fish is low in total fat and saturated fat (Wood *et al*., 2004) but it is a rich source of omega-3 and omega-6 polyunsaturated fatty acids (Hu, *et al*., 2002). Moreover, fat of the fish contained eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) as omega -3, linoleic acid and arachidonic acid as omega-6 besides oleic acid as omega-9 which has health benefits (Minarny *et al*., 2014).

Additionally, Kolanowski *et al*. (2005) reported that omega-3 is converting into docosahexaenoic acid (DHA) in the human bodies as the essential nutrient for development of nerves and brain cells. Omega-3 fatty acid inhibits the synthesis of low density lipoprotein and increase the synthesis of high density lipoproteins (Steffens and Wirth, 2005). Furthermore, it lower the total blood serum cholesterol level (Simopoulos, 1991). Generally, these fatty acids are essential in human nutrition and have proven to be involved in many metabolic functions; e.g. they have anti-inflammatory effects, decrease platelet aggregation and are essential parts in the cell membranes, cardiovascular system, brain, and nervous tissue (Tilami and Sampels, 2017).

The negative relationship between CP and EE percentages of fish carcass composition found in the present study was registered too by Abdelhamid and Soliman (2013), Gabr *et al*. (2013), and Abdelhamid *et al.* (2015a). Abdelhamid *et al.* (2014a&b) presented hematological and immunological effects due to different levels and sources of dietary feed additives for African catfish (*Clarias gariepinus*) and Nile tilapia (*Oreochromis niloticus*), respectively. Such physiological responces were found too by Abdelhamid *et al.* (2015b) with different fish species (Nile tilapia, common carp, and African catfish) when fed a dried sewage sludge.

Alsamarae (2015) recommended the replacement of 1 % corn oil by Aquafat-omiga in tilapia diets to improve their growth performance, feed utilization, body composition, blood profile, reproductive performance, economic efficiency, and fish health in general. Although the limited improvements obtained in the present study by using 2 % Aquafat-omiga in diets of all mal mono-sex Nile tilapia, Refaey *et al*. (2018) fed hybrid red tilapia diets containing Aquafat-O®, as an additional source of fatty acids. They proved that this dietary addition led to significant improvements in the parameters of growth performance, feed utilization, and hematology, by increasing the additive levels. Yet, the addition of 6% Aquafat-O® reduced each of fish-carcass lipid content, serum glucose, total cholesterol, triglyceride, and hepatic lipid peroxidase. So, they recommended the dietary addition of 6% Aquafat-O®. The conflicted results may be due to fish species and level of addition, besides they did not refer to the economic efficiency of their high level of addition.

Global aquaculture production is increasing year by year and it is the fastest and reliable sector to fulfill the animal protein deficiency on the human tables around the world. Nutrition and feeding are the significant criteria should be focused for economical and sustainable aquaculture. Like terrestrial animals, around 40 essential

nutrients (among them are fatty acids) are required for aquatic organisms (Prabu *et al*., 2017). However, dietary fats provide essential fatty acids (EFA) needed for normal growth and development of fish that cannot synthesize these fatty acids. Freshwater fish require a dietary source of linoleic acid and linolenic acid. Till now, there are no clear standard levels for essential fatty acid requirements of all known fish species (NRC, 1993 and Parker, 2011).

Blubberlip Snapper (*Lutjanus rivulatus*) are the high commercial value fish species in Sri Lanka. In its lipid fraction, most abundant fatty acids were: C16:00, C18:00, C18:1 (n-9), C22:6 (n-3) and C20:4 (n-6). The total of saturated, monounsaturated and polyunsaturated fatty acids were 50.44%, 22.29%, 24.19% for male and 48.67%, 23.27%, 23.82% for female, respectively. The omega-3: omega-6 ratio equal to 0.86 for male and 1.05 for female. It can be concluded that these fish are the potential source of fatty acids and good food fish in Sri Lanka (Jayasinghe *et al*., 2018).

Generally, Anon. (2019) mentioned that high fat foods remain in the stomach longer than low fat foods and lipid digestion begin in the stomach by gastric lipase. In the small intestine, bile is released, triggered by cholecystokinin, where bile acts as emulsifier. Pancreatic lipase major enzyme involves which hydrolyzes the ester linkages between glycerol and fatty acids.

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ARABIC SUMMARY

الفوائد الممكنة من استخدام مستويين بروتين خام ومستويين دهن من ثلاث مصادر مختلفة فى عليقة البلطى

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تم عمل تجربة تغذية حقلية فى هابات مزروعة فى حوض ترابى للاستزراع السمكى بالمجمع السمكى بالمنزلة دقهلية، والتابع لهيئة تنمية الثروة السمكية، وذلك لمدة ١٥٠ يوما، فاستخدمت ٧٥٠ سمكة بلطى نيلى وحيد الجنس بوزن أولى تقريبا ٥٣ جم وُزعت على ٥ مجاميع، وغُذيت على علائق تحتوى ٢٥ أو ٣٠ % بروتين خام مع مستويين (٢ و ٦%) من ٣ مصادر مختلفة من الزيوت (أكوافات-أوميجا، زيت أذرة، زيت سمك). من النتائج المتحصل عليها يمكن **استخلاص** أنه من وجهة نظر المُنتجين فإن العليقة (٢٥ % بروتين) المضاف إليها ٢ % زيت سمك كانت هى الأكفأ اقتصاديا (انخفاض استهلاك العلف، مع أفضل تحويل غذائى وكفاءة غذائية)، يليها العليقة (٢٥ % بروتين) المضاف إليها ٢ % أكوافات-أوميجا. ولكن من وجهة نظر المستهلكين فإن عليقة الـ ٣٠ % بروتين مع إضافة ٦ % زيت أذرة أعطت أفضل زيادة فى الوزن، وبروتين جسم، وتشافى ولحم خالى الدهن، وأقل دهن ورماد فى الجسم، وأقل تركيزات فى كوليسترول السيرم، وحمض اليوريك، والكورتيزول. لذا يمكن التوصية باستخدام العليقة الأولى ذات الـ ٣٠ % بروتين خام مضافا إليها زيادة ٦ % زيت أذرة. خاصة وأن زيت السمك أصبح نادر الوجود أو غير مُتاح، فهو مستورد ومُكلف.