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Effect of Feeding *Arthrospira platensis* (*Spirulina*) on Growth and Carcass Composition of Hybrid Red Tilapia (*Oreochromis niloticus x Oreochromis mossambicus*)

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Abstract

The present study was designed to evaluate the use of *Spirulina*, *Arthrospir platensis* as a protein source for hybrid red tilapia fries (*Oreochromis niloticus x Oreochromis mossambicus*) with average weights of 206±11 mg. *Spirulina* was incorporated into diets at 0, 50, 75, and 100% of the fishmeal-based diet. The test diets were fed to the fish at 12% body weight three times a day for consecutive 65 days at 24±2°C. The final weight gain, specific growth rate, feed conversion ratio (FCR) and survival rate of fish were evaluated. The present study suggests that up to 75% of *Spirulina* can be substituted for fishmeal in a fishmeal-based diet for hybrid red tilapia with increased feed conversion ratio and protein productive value in carcass proximate composition. Also higher immunity can be observed than other treatments, where white blood cells were 4.08 x10^3 mm. In conclusion, the results of this study indicate the possibility of using *Arthrospira platensis* as commercial nutrient source for large scale culture of fish in general and tilapia in particular.

Keywords: Fish nutrition, *Spirulina platensis, Oreochromis niloticus,* growth performance, fish meal replacement, carcass proximate composition.

Introduction

Spirulina, Arthrospir platensis is a freshwater blue-green filamentous alga, and it is receiving increasing attention for its bioactive components such as vitamins (especially vitamin A and B12), minerals, polyunsaturated fatty acids, carotenes and other pigments that have antioxidants activity (Madhava *et al*., 2000; Lin *et al*., 2007).

Spirulina contains also high protein contents (up to 70% in dry weight) and lipids (7–16%) (Vonshak 1997a). These nutritional elements make *Spirulina* as a potential food items for persons suffering from coronary illness and obesity. *Spirulina* is suitable for animal feeding (Cohen, 1997) and also as supplement nutrients for humans (Qureshi *et al*., 1995). In addition *Spirulina* is considered one of the most concentrated natural sources for nutrition to both terrestrial and aquatic animals. Therefore, *Spirulina* could be an excellent source of useful nutrients (Glombitza and Koh, 1989) as well as a good energy source that can be used as crucial component for animal feeding (Kishimoto *et al*., 1994; Kim *et al*., 2013). FAO fisheries statistics showed a clear increase in production of *Spirulina* species over the recent years. For example, production in China was first recorded at 16483 tons in 2003 and rose sharply to 66920 tons in 2007, worth around US $6.59 and 30.78 million, respectively (FAO, 2009).

Fish are considered as a main source of dietary protein for human consumption and essentially helps in improving the malnutrition in Egyptian increasing population. Therefore, aquaculture activities now have good potential to increase the productivity to ameliorate the gab in animal protein. Several approaches were applied to improve the aquaculture conditions to yield fish species. For instance, Tilapia (*Oreochromis niloticus)* is widely cultured in the world. They tolerate a wide range of water quality conditions and could develop resistant to many diseases (Magouz, 1990). Searching for a suitable source of fish foods that can replace the conventional fishmeal in the aqua-culture consider one of the important approaches in this field. This work was focused on replacing high protein feed ingredient such as fishmeal on diet of red tilapia fingerlings with dried *Spirulina* as a source of high protein content. The success of this diet replacement would save feed costs, improvement the growth performance, feed conversion ratio, survival rate and increased immunity of fish.

Materials and Methods

Experimental Fish

Fries of red tilapia, *Oreochromis niloticus* x *Oreochromis mossambicus* were obtained from Hatchery Unit of El-Max Research Station, Alexandria (NIOF) as natural hatchery during summer 2010. Fish were transported in oxygenated cellophane bags to the laboratory. Fishes were randomly distributed in 12 glass aquaria of 33-litre size. Each aquarium contained 10 fishes.

The fish biomass in the aquaria was about 2.5 g/aquarium. Fishes of each aquarium were group-weigh to avoid handling stress to determine their average weight. Each aquarium was equipped with a biological filter containing high porosity filter sponge which was washed thoroughly every two-days and cleaned regularly.

Aquarium water was oxygenated through the biological filter. Fishes were kept for one week to acclimate to the laboratory conditions. Ten fishes with more or less similar initial weights (206±11 mg /aquarium) were selected and randomly allotted to each experimental aquarium.

Experimental Diets

Four experimental diets were formulated to replace 0, 50, 75, and 100% of fishmeal with *A. platensis*. All experimental diets incorporated into isonitrogenous (36% CP) and isocaloric diets (473 kcal/100 g diet). Three replicate aquaria were assigned to each of the dietary treatments as presented in Table 1. The diets were prepared by mixing the dry ingredients with water meat mincer with a 1 mm diameter. The pellets were air dried and stored at -20°C until used. The pellet feed were slightly broken into particles during the experimental diets.

Feeding Regime

The feeding rate was 12% of live body weight for a period of 65 days. Fishes were fed twice a day ($09.^{00}$ and $18.^{00}$ h) and daily feed intake was recorded. Fries were weighed weekly and amounts of feed were adjusted according to the new weight. The water of the aquaria was changed daily to remove unused feed and fecal materials, then cleaned dissolved oxygen was measured using dissolved oxygen meter (Jenway Model 9070 waterproof meter) and continuous aeration was provided by air pumps. Dissolved oxygen was ranged from 7-8 mg L^{-1} during experiments period. Fish were exposed to natural light regime (14 h light: 10 h dark) at 24±2°C.

Analytical Methods

Diets and fish samples were analyzed according to AOAC (1990) for dry matter, crude protein, ether extract, crude fiber, nitrogen free extract (NFE) and ash. The gross energy contents of the diets and fish

Table 1. Ingredients and proximate composition of experimental diets on dry weight basis

Ingredient (%)	Diet			
	Control	50%	75%	100%
Fish meal	25	12.5	6.5	0
Soybean meal	27	27	27	27
Algae	0	14	22.5	28
Wheat bran	15	15	15	15
Yellow corn	15	15	15	15
Wheat milling	11	9.5	7	8
Sun flower oil	5	5	5	5
Vitamins and minerals mix[1]	2	2	2	2
Chemical analysis (%)				
Dry matter	89.64	89.5	90.44	90.46
Crude protein	35.7	36.3	35.7	35.8
Ether extract	8.5	8.05	7.71	7.45
Crude fiber	2.61	2.57	2.42	2.26
Ash	7.12	6.0	5.91	5.56
Nitrogen free extract (NFE)[3]	46.07	47.08	48.26	48.93
Gross energy (GE) (kcal/100g dite)[4]	471.37	474.75	472.82	473.77
Digestabale energy kcal/100g diet	404	406	405	406
P/E ratio	88.37	89.44	88.15	88.16

[1]Vitamin mixture (g/100 g) was 960000 IU, 160000 IU, 0.8 g, 80 mg, 0.32 g, 0.12 g, 0.8 g,, 0.8 mg 1.6 g, 80 mg, 4 mg, 40 g. of vitamin A, D3, E, K, B1, B2, B6, Pantothenic acid, B12, Niacin, Folic acid Biotin, Choline chloride, respectively.

[2]Mineral mixture (g\100g) was 12.75, 72.85, 0.55, 0.25, 0.02, 5, 2.5, 0.08, 0.05, 0.01 and 6 mg of $MgSO_4.7H_2O$, $CaHPO_4. 2H_2O$, $ZnSO_4. 7H_2O$, $MnSO_4. 4H_2O$, $CaI_2.O_6. 6H_2O$, KCl, $FeSO_4. 7H_2O$, $CuSO_4. 5H_2O$, $CoSO_4. 7H_2O$, $CrC_3. 6H_2O$ and NaCl, respectively.

[3]Nitrogen free extract = 100 - (protein + lipid + fiber +ash)

[4]Gross energy (GE) was calculated as 5.65, 9.45 and 4.11 kcal/g for protein, lipid and NFE, respectively NRC, (1993).

samples were calculated using factors of 5.65, 9.45 and 4.11 kcal/g of protein, lipid and carbohydrate, respectively (NRC, 1993).

Measurement of Growth Performance and Utilization Parameters

Weight Gain (WG) = final fish weight (g) – initial fish weight (g).

Weight Gain % (WG %) = Gain of fish (g) x 100/ initial weight of fish (g).

Average daily gain (ADG) = Gain (g) / time (day).

Specific growth rate (SGR %) = 100 X {(In W_2 – In W_1) / T}

where W_2 is the final weight of fish (G), W_1 is the initial weight of fish (G), In is natural log and T is the period in days.

Feed conversion ratio (FCR) = feed intake (g) / Weight gain (g).

Feed efficiency percent (FE %) = Weight gain (g) X 100 / feed intake).

Protein efficiency ratio (PER) = Weight gain (g) / Protein intake (g).

Protein productive value (PPV %) = {(Retained protein (g)) / (protein intake (g))} X 100.

Energy utilization (ER %) = { (Energy gain (kcal)) / GE intake (kcal))} X100.

Incident cost (IC) = cost of feed consumed / kg fish produced.

Profit index (PI) = Price of fish produced / price of feed consumed.

Hematological Parameters

Blood samples were taken from the caudal vein of an anaesthetized fish by sterile syringe using EDTA solution as anticoagulant agent. Part of blood samples were used for the differential count of the white blood cells as immunity indicator (Dacie and Lewis 1984).

Red blood cells count (R.B.Cs×10^6 mm) and white blood cells count (W.B.Cs×10^3 mm) were quantified on a bright- line Hemocytometer model (Neubauer improved, Precicolor HBG, Germany) using a commercial kits (Ranox company, Germany) according to the method described by Stoskopf, (1993).

Hemoglobin concentration (Hb g/dl) was quantified according to the method of Zinkl (1986).

Packed cell volume (PCV %) was estimated by the microhaematocrite method described by Dacie and Lewis (2006). Mean cell hemoglobin concentration (MCHC), mean cell hemoglobin (MCH), and Mean cell volume (MCV) were calculated using the formulae.

MCHC (%) = Hb / Ht x 100

MCH (pg) = Hb / RBC x 10

MCV (μ^3) = Ht / RBC x 10

Differential leukocyte count: the relative and absolute count was estimated according to Van Kampen, and Zijlstra (1961).

Statistical Analysis

Results were presented as mean ±SD (standard deviation) for three replicates. The statistical analyses were carried out using SAS program (1989-1996) version 6.12. Data obtained were analyzed statistically to determine the degree of significance between treatments using one way analysis of variance (ANOVA) at $P \leq 0.05$ level of significance.

Results

Growth Performance and Feed Utilization

Significant effects (P<0.001) of the dietary replacement of fish meal with *A. platensis* dried meal on the growth performance of red tilapia (Table 2). Use of *A. platensis* dried meal gave higher final weight (FW), weight gain (WG), average daily gain (ADG), and specific growth rate (SGR) than the control diet. However, increasing replacement level of *A. platensis* resulted in an increase of above nutritional parameters until 75% level. Total replacement of fish meal by *Artrospira platensis* (*Spirulina*) dried meal has positive effect in growth performance when compared with their counterparts. The results showed that SGR values were 4.9 and 4.59 %/day/fish for 100% *A. platensis* diet and control group, respectively.

Interestingly, red tilapia fed with partial replacement of fish meal with 75% dried *A. platensis* showed the highest FW, WG, ADG, SGR and SR%; where (7.22±0.23 g, 6.99±0.22 g, 108±3.0 mg/fish/day, 5.3±0.033% /day, and 100%, respectively). These values were higher than those obtained in fish group fed on diet containing 100% of *A. platensis*. In contrast, the lowest values were obtained in red tilapia group fed on a diet containing partial replacement with 50% of fish meal by *A. platensis* where it showed FW, WG, ADG, SGR and SR% (5.06±0.25 g/fish, 4.82±0.26 g/fish, 74±4.0 mg/fish/day, 4.67±0.161% and 83.3% respectively). (Table 2).

The survival rate was decreased in fish group fed on diet containing 0% of dried micro algae (control group) and fish group fed with diet containing 50% of dried *A. platensis*. Interestingly, no mortalities were recorded in red tilapia group fed on a diet 75% and 100% replacement of fish meal (SR 100%).

Feed intake, feed conversion ratio and nutrient utilization values are shown in Table 3. The values of protein utilization are expressed as the protein efficiency ratio (PER%) and productive protein value (PPV%). The results showed that the highest feed intake value (7.77±0.231 g/fish) was recorded in the fish group fed with the diet with partial replacement of 75% *A. platensis* followed by other groups with slight variation in the feed intake values. These results were significant different ($P<0.05$) than the control group which scored (5.72±0.87 g/ fish).

The results showed that FCR values ranged between 1.0 and 1.18 g/g with no different among the tested diets. This finding indicates that total replacement of fish meal with *A. platensis* meal gave similar feed conversion ratio. The feed conversion ratio (FCR%), protein efficiency ratio (PER%) and productive protein value (PPV%) indicated that the best results were recorded in the fish group fed with the diet which have partial replacement with 75% of *A. platensis* (1.0, 3.32 and 46.30%, respectively) followed by diet which have complete replacement (100%) of dried *A. platensis* (1.04, 3.11, 45.08 % respectively). In contrast, the lowest values were obtained in the fish group fed on the diet with partial 50% replacement of *A. platensis* (1.11, 2.78 and 41.11%, respectively). These values were significantly different than those of the control group which scored (1.18, 2.63 and 37.06% respectively).

Chemical Composition of Tilapia Body Carcass

The chemical composition of red tilapia fingerlings at the end of feeding experiments is presented in Table 4. The results showed that among groups that fed in diets supplemented with the *A. platensis*, carcass dry matter (DM) content and the crude protein values (CP) were higher in fish groups fed on the diet with 75% replacement of *A. platensis* (26.9% and 64.2%, respectively) followed by fish groups fed on diet with complete replacement with *A. platensis* which scored (26.01% and 63.6 %

Table 2. Growth performance of red tilapia fed diet containing *Arthrospira platensis* (*Spirulina*) for 8 weeks

.Items	I. B. W (g/fish)	F.B.W (g/fish)	W.G (g/fish)	A.D.G (mg/fish/day)	SGR (%)	SR (%)
Control	0.23^{a}±0.01	4.55^{c}±0.82	4.32^{c}±0.81	66^{c}± 12.0	4.59^{b}±0.266	90^{b}
50%	0.24^{a}±0.015	5.6^{bc}±0.25	4.82^{bc}±0.26	74^{b}± 4.0	4.69^{b}±0.161	83.3^{c}
75%	0.23^{a}±0.011	7.22^{a}±0.23	6.99^{a}±0.22	108^{a} ± 3.0	5.3^{a}±0.033	100^{a}
100%	0.24^{a}±0.015	5.8^{b}±0.28	5.56^{b}±0.29	86^{b}± 4.5	4.9^{b}±0.141	100^{a}

Each value is the mean of three readings ± standard deviation.
Means has the different letters in the same column are significantly different at P≤ 0.05.

Table 3. Feed intake, feed conversion ratio and nutrient utilization of red tilapia fed diet containing *Arthrospira platensis* (*Spirulina*)

Items	Dry matter Feed intake (FI) (g/fish)	Feed conversion ratio (FCR %)	Protein efficiency ratio (PER %)	productive Protein value (PPV %)	Energy retention %
Control	5.72^{b}±0.878	1.18^{a}±0.037	2.63^{c}±0.092	37.07^{b}±1.88	23.89^{b}±1.25
50%	6.22^{b}±0.455	1.11^{ab}±0.11	2.78^{c}±0.2	41.11^{b}±6.33	24.57^{b}±1.3
75%	7.77^{a}±0.231	1.0^{b}±0.005	3.32^{a}±0.025	46.30^{a}±1.28	29.86^{a}±0.58
100%	6.4^{b}±0.306	1.04^{b}±0.036	3.32^{b}±0.117	45.08^{a}±2.30	28.73^{a}±0.90

Each value is the mean of three readings ± standard deviation.
Means has the different letters in the same column are significantly different at P≤ 0.05.

Table 4. Carcass chemical composition of red tilapia fed diet containing dried *Arthrospira platensis* (*Spirulina*) on dry matter basis

Chemical composition	Treatments				
	Dry matter (%)	Crude protein (%)	Ether extract (%)	Ash (%)	Kcal/100g fish
Control	24.9^{a} ± 0.94	62.9^{b}±0.20	25.1^{a}±0.2	10.3^{a}±0.02	950
50%	25.4^{a}± 2.017	61.7^{a}±0.56	25.6^{c}±0.104	10.8^{a}±0.59	932
75%	26.9^{a} ± 0.5	64.2^{a}±0.32	23.3^{b}±0.055	10.1^{a}±0.55	969
100%	26.01^{a}± 0.83	63.6^{c}±0.37	24.1^{a}±0.712	10.7^{a}±0.51	960

Each value is the mean of three readings ± standard deviation.
Means has the different letters in the same column are significantly different at P≤ 0.05.

respectively). The lowest values obtained from the fish group fed on the diet with 50% replacement with *A. platensis* which scored (61.7 and 25.6%, respectively).

The results also showed that the ether extract (EE) and ash content of fish carcass were low in fish groups fed on diet with 75% replacement with *A. platensis* (23.3 and 10.1%, respectively) followed by 100% replacement of *A. platensis* which scored (24.1 and 10.76%, respectively). The highest EE and ash content values were recorded in fish groups that fed on diet with 50% replacement of *A. platensis* (25.6 and 10.8%, respectively).

Cost-Benefit Analysis of Red Tilapia Fed Diet Containing *Spirulina*

The use of *A. platensis* meal in red tilapia feed resulted in decrease of feed cost (cost/kg feed) and incidence cost as well as increase profit index (Table 5). The maximum reduction IC was achieved with diet containing 75% *A. platensis* meal and caused maximum profit.

Hematological Profile

The results of hematological parameters (W,B.Cs, R.B.Cs, Hb, P.C.V, M.C.V, M.C.H, M.C.H.C and Differential leucocytes count) of fish fed diets containing various levels of dried *A. platensis* were presented in Table 6 and Table 7. The results showed that the highest value of W.B.Cs, R.B.Cs and P.C.V were recorded in fish groups that fed on diet with 75 replacements of dried *A. platensis.* The highest values of Hb and MCHC were obtained of fish groups that fed on diet with 50% replacement of dried *A. platensis*. The results indicated that there were no significant (P>0.05) differences among all treated groups and control group.

MCV and MCH were higher in fish groups that fed on the diet with 100% replacement of *A. platensis*; the differences were highly significant among all treated groups and control group (Table 6). Interestingly, fish group fed with the diet which has partial replacement with 75% of dried *A. platensis* showed a high value of lymphocytes with a highly significant difference. Of note, as shown in table 4,

Table 5. Cost-benefit analysis of red tilapia fed diet containing (*Spirulina*) *Arthrospira platensis*

Diet	control	50%	75%	100%
Cost per kg feed	4.01	3,43	3.19	2.84
Change %	100	85.53	79.55	70.82
Incidence cost[1]	83.21	63.7	41.28	46.21
Change %	100	76.55	49.60	55.53
Profit index[2]	.11	.14	.22	.19
Change %	100	127.27	200	172.73

Incidence cost = feed cost to produce 1 kg fish
Profit index = value of fish /cost of feed consumed, 1 kg fresh fish equals 6 LE

Table 6. Hematological values of red tilapia fed on the experimental diets containing different levels of *Arthrospira platensis* (*Spirulina*)

Items	WBCs (10^3 mm)	RBCs (10^6 / mm)	Hb (g/dl)	PCV (%)	MCV	MCH	MCHC
Control	$3.24^b±0.25$	$1.9^c±0.14$	$8.63^b±0.38$	$28.8^a±1.67$	$146^a±5.56$	$44.3^a±2.05$	$30.3^a±1.89$
50%	$3.88^a±0.06$	$2.49^b±0.12$	$9.13^a±0.15$	$26.7^a±0.32$	$107^b±4.17$	$36.7^b±1.22$	$32.8^a±2.93$
75%	$4.08^a±0.13$	$2.77^a±0.04$	$8.87^b±0.21$	$28^a±0.68$	$101^b±1.16$	$32.1^c±1.24$	$31.7^a±1.59$
100%	$3.16^b±0.25$	$1.83^c±0.11$	$8.83^b±0.12$	$27.3^a±0.11$	$149^a±9.47$	$48.3^a±3.49$	$32.4^a±0.32$

Each value is the mean of three readings ± standard deviation.
Means has the different letters in the same column are significantly different at P≤ 0.05.

Table 7. Differential leucocytes count of red tilapia

Items	Lympho leucocytes %	Mono leucocytes %	Hetero Leucocytes %	Eosino leucocytes %
Control	$60.3^b±1.53$	$9^a±1.0$	$24.7^c±0.58$	$6.0^a±1.00$
50%	$63.3^a±1.15$	$6^b±1.0$	$27.7^b±0.58$	$3.0^c±1.00$
75%	$64^a±0.0$	$5.67^b±0.58$	$26.7^b±0.58$	$3.33^c±0.58$
100%	$58.3^c±0.58$	$8.33^a±0.58$	$28.7^a±0.58$	$4.67^b±0.58$

Each value is the mean of three readings ± standard deviation.
Means has the different letters in the same column are significantly different at P≤ 0.05

the leucocytes were recorded the higher numbers in fish groups that fed on the diet with complete replacement of dried *A. platensis*. Interestingly, is the higher values in monocytes, and eosinophils were recorded in control group with a significant difference (P≤0.05).

Discussion

Spirulina are multicellular and filamentous blue-green microalgae belonging to two separate genera *Spirulina* and *Arthrospira* and consists of about 15 species. However, the recent nomenclature considers *Spirulina* as *Arthrospira*. Of these, *Arthrospira platensis* is the most common and widely available *Spirulina* and most of the published research and public health decision refers to this specific species. It grows in fresh water, can be harvested and processed easily and has significantly high nutritional contents (Habib *et al.*, 2008).

The results of the current study showed that growth performance (FW, WG, ADG and SGR) increased with increasing *A. platensis* (*Spirulina*) replacement up to 75% replacement. This increase could possibly due to the improved feed intake and nutrient digestibility. The lower values of these parameters were recorded in fish that fed with 50% replacement of dried *A. platensis* but theseresult is higher than results which recorded by control group these means that dried micro algae *A. platensis* improved growth. These results were in agreement with those obtained by Dawah *et al.* (2002) who found that the addition of algae in fish diets improved growth performance of Nile tilapia (*Oreochromis niloticus*). Furthermore, our results are in agreement with that obtained by Dernekbasi *et al*., (2010) who evaluated the use of *Spirulina* in guppy diet and they found that increasing level of *Spirulina* in diet provided better growth comparing to the other commercial feeds.

Nandeesha *et al*. (1998) reported that body weight gain of Nile tilapia (*O. niloticus*) increased linearly with increasing the level of algae in fish diet.

In the present study *A. platensis* could improve growth rate and reduce the mortality rate in red tilapia group which fed with a diet 75% and 100% replacement for fish meal (SR 100%). The survival rate was decreased in fish group fed with diet containing 0% of dried *A. platensis* (control group) (SR 90%). These results agreed with Vonshak (1997a), who showed that *S. platensis* improves growth rate and reduce mortality. The highest feed intake value had been recorded in fish group fed with the diet composed of 75% of dried *A. platensis*. The better feed intake in *A. platensis* supplemented diets may have been due to the increased fish appetite and flavor resulting in improving the growth rate, FCR, PER% and PPV%. While the lower values of FCR, P--ER% and PPV% obtained from the fish group fed with the diet which containing with 50% of dried *A. platensis*. These results agree with those obtained by Dawah *et al*. (2002) who found that food conversion ratio and protein efficiency ratio were better when the fish were maintained on artificial diets with 10% and 20% dried algae. The *A. platensis* replacement significantly affected the whole-fish body composition and changes the protein and lipid contents in fish body. These changes could be linked with changes in their synthesis, deposition rate in muscle and/or different growth rate (Abdel-Tawwab *et al.*, 2008).

The growth performance, feed utilization, and crude protein rate in chemical composition carcass increased depending on the increasing *A. platensis* meal content, and the best growth appeared with fish group which fed with the diet supplemented with 75% dried *A. platensis*. These results are in agreement with El-Sayed, (1994) who recorded that dried *Spirulina maxima* is an excellent substitute for fishmeal in silver sea bream diets, even at a high substitution level (75%), because it is rich in proteins, vitamins, minerals, essential amino acids and fatty acids.

While fish group which fed with the diet supplemented 100% of dried *A. platensis* give growth lower than fish group fed with the diet supplemented 75% of dried *A. platensis* and this agree with Takeuchi *et al*. (2002) who found that juvenile tilapia fed solely on the alga show a lower feed efficiency and protein efficiency ratio than commercial diet.

In the present study fish fed on diets containing *A. platensis* exhibited higher RBCs and WBCs counts, as compared with fish fed the control diet. These results proved the improvement of fish health when fed *A. platensis*-supplemented diets so that survival rate increased with diet containing *A. platensis*. Watanuki *et al*. (2006) reported that *S. platensis* activated the functions of leucocytes, such as phagocytosis and production of superoxide, and cytokines production in common carp, *Cyprinuscarpio*. The results indicated that highest value of W.B.Cs, R.B.Cs and P.C.V scored by fish groups fed with the diet which replacement for 75% of dried *A. platensis*. Our results agree with Promya and Chitmant (2011) who reported that fingerlings which received feed 5% *A. platensis*+ basal diets had higher values for red and white blood cell counts and immunity stimulating capacity. The increase in red and white blood cells and immunity stimulating capacity due to the presence of C-phycocyanin in *Spirulina*, which can help build the immunity capacity (Vonshak, 1997b).Our results were in agreement with Qureshi *et al*. (1996) who reported that *Spirulina* could stimulate the immune system via increasing the phagocytic and the natural killer activities and with Bermejo *et al*. (2008) who reported that most antioxidant capacities of *Spirulina* protein extract are attributable to the biliproteins contained in this microalga, such as phycocyanin so that we can use

Spirulina to improve the immunity capacity of the animals which consume it.

The present study concludes that *A. platensis* positively improved growth performance and feed efficiency of red tilapia as well as increased immunity stimulating capacity. In addition, this study found that the optimum rate of *A. platensis* in the fish practical diet is 75% replacement for fish meal in a fishmeal-based diet for red tilapia without any adverse effects on fish growth and proximate composition of carcasses. In accordance with our results, Ibrahem *et al*. (2013) obtained a significant increase in the growth performance parameters and survival rates of *Oreochromis niloticus* in *Spirulina*-suplemented groups at concentration level of 10g/kg. The use of *A. platensis* in the diet can thus reduce the amount of incorporated fishmeal, which presently is the main protein source for the culture of most fish species.

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