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EFFECT OF TOTAL REPLACEMENT OF FISHMEAL BY DIFFERENT SOYBEAN MEAL, DRIED AMINO YEAST AND GREEN SEAWEEDS (*Ulva* SP.) COMBINATIONS IN RED TILAPIA (*Oreochromis niloticus* ♀ × *O. aureus* ♂) FRY DIETS ON GROWTH PERFORMANCE AND FEED EFFICIENCY

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***Abstrac*t**

This study was conducted to determine if soybeen meal (SBM) in combination with dried amino yeast (AY) or/and a local seaweed (*Ulva* Sp.) (SW) can replace fishmeal (FM) in the diets of red tilapia (*Oreochromis niloticus* × *O. aureus*) (0.61 ± 0.01g initial body weight). Five isonitrogenous and isocaloric diets were formulated to provide 24% protein and 435 kcal/100 g diet. T_1 (FM-based) diet was formulated to serve as the control. T_2 (SBM-based diet) served as a secondary control. The other three diets were: T_3 (SBM-based + 1% AY), T_4 (SBM-based + 10% SW) and T_5 (SBM-based + 1% AY+ 10% SW). Each diet was used to feed triplicate groups of fish two times a day to satiation for 9 weeks**.** The highest mean final body weight (FBW) (6.68 g fish^{-1}) and the lowest FBW (4.39 g fish^{-1}) were recorded with T_1 and T_5, respectively. The same trend was observed with all other growth performance parameters. The best survival rate (83.33 %) was observed with T_1 while the worst survival rate (70.00%) was found with T_2 and T_4. The best feed conversion value (FCR) was recorded as 1.36 with T_4 and the poorest FCR value was determined as 2.02 with T_5. The highest protein productive value (PPV %) (52.16 %) was noticed when fish were maintained at T_1, followed by T_3 and T_4, while the lowest PPV (36.09%) was found with T_5. The same trend was noticed with all other nutrient utilization parameters. The higher values of body protein content were found with T_1 and T_5 while the lower values appeared with T_2, T_3 and T_4. The highest significantly ($P < 0.05$) body lipid content was found with T_2, while the lower values were observed with T_1, T_4 and T_5. The results obtained in this study suggest that the inclusion of 1% dried amino yeast or 10% green seaweeds (*Ulva* sp.), but not together in all plant-based diets for red tilapia fry improved growth performance and sharply reduced the feed cost without any negative consequences on nutrient utilization or body composition.

Keywords: Red tilapia, fishmeal, soybean meal, amino yeast, seaweeds, *Ulva* sp., growth performance, feed utilization.

INTRODUCTION

Tilapias are the third most important cultured fish group in the world, after carps and salmonids, with an annual growth rate of about 12.2% (El-Sayed, 2006). The "red" tilapia hybrid (female *O. mossambicus* x male *O. niloticus*) has become increasingly popular because of their tolerance, fast growth and attainment of large size as adults under both freshwater and brackish water (Romana-Eguia and Eguia, 1999). Feeding represents over 50% of the operational costs of aquaculture (El-Sayed, 1999). Aquaculture systems currently use 2–5 times more fishmeal (FM) to feed farmed species than what is supplied by the farmed product (Naylor *et al.*, 2000). FM is considered an “ideal protein” for use in aquafeeds because of its high protein density, amino acid balance, and acceptability by cultured fish (Li *et al.*, 2009 and Nguyen *et al.*, 2009). The production of FM has declined gradually since 2005 from an average of around six million tons a year, to just less than five million tonnes in 2008. This has meant prices have reached historic highs (FAO, 2010). FM is one of the most expensive macro-ingredients (used in high percentages) in an aquaculture diet. The scarcity of high quality FM and the wide gap in demand and supply for this resource are boosting its price and may eventually hamper further development of aquaculture (Tacon and Dominy, 1999). Therefore, the reduction of FM dependency by finding suitable and cheap local protein sources as an alternative to FM may provide more economic and environmentally friendly aquaculture (Li *et al.*, 2010). Numerous terrestrial animal- and plant-based proteins have been investigated by aquaculture nutritionists with varying success (Gatlin *et al.*, 2007; Hansen *et al.*, 2007; Li *et al.*, 2009). Plant proteins are often deficient in certain essential amino acids, typicallymethionine, lysine and threonine (Keembiyehetty and Gatlin, 1997), or may have amino acid profiles improperly balanced for maximum growth (Gatlin *et al.*, 2007). Many studies demonstrated that as much as 100% of the FM protein could be replaced by soyabean meal when fish diets were supplemented with a source of amino acids such as *Yucca schidigera* (Gaber, 2006), methionine (El-Saidy and Gaber, 2002).

By identifying alternative protein sources, the authors find that brewer’s yeast is a suitable raw material as FM replacement in feed of tilapia (Ozório *et al.*, 2012). Dried brewer's yeast has a nutritional importance as a feed supplement because it has a high protein and vitamins content. It contains various immunostimulating compounds such as β-glucans, nucleic acids, mannan oligosaccharides and other cell wall components (Oliva-Teles and Gonçalves, 2001; Li and Gatlin, 2005; Ferreira *et al.*, 2010). Many investigations showed that *S. cerevisiae* can positively influence the non-specific immune responses as well as growth performance of some fish species (Oliva-Teles and Gonçalves, 2001; Taoka *et al.*, 2006; He *et al.*, 2009; Abdel-Tawwab *et al.*, 2010). According to the results of these studies, dried baker’s yeast could replace up to 30% of fishmeal protein without adversely affecting fish growth. The supplementation of yeast-based diets with the deficient amino acids was shown to have beneficial effects on fish growth (Mahnken *et al.*, 1980; Murray and Marchant, 1986). Ebrahim and Abou-Seif (2008) concluded that, the biogenic L-carintine (methionine plus lysine) supplementation is useful only when yeast is partially replaced by animal protein.

Seaweeds are considered as rich sources of bioactive compounds as they are able to produce a great variety of secondary metabolites characterized by a broad spectrum of biological activities not only against human pathogens but also against fish pathogens (Liao *et al.*, 2003). Seaweeds contain significant amounts of amino acids (10–30 % of the dry weight), proteins, vitamins A, B_1, B_2, B_6, B_{12}, C and niacin and minerals such as (calcium and iron) essential for nutrition (Jensen, 1993; Noda, 1993; Mabeau and Fleurence, 1993; Oohusa, 1993). The crude protein content of *Ulva* sp. ranged between 10 and 26% of dry weight, while it may reach up to 47% of dry weight in red seaweeds which imply the potential for fish nutrition (Fleurence, 1999).

The aim of this study was to investigate the effect of total fishmeal replacement by soybean meal, dried amino yeast and seaweeds (*Ulva* sp.) combinations in red tilapia (*Oreochromis niloticus* × *O. aureus*) fry diets on growth performance, feed utilization and body composition.

MATERIALS AND METHODS

Fish and Husbandry Conditions:

Red tilapia (*Oreochromis niloticus* ♀ × *Oreochromis aureus* ♂) fry were obtained from the Marine fish hatchery 21 Km, Alexandria. Fish were kept in indoor tank for 2 weeks as an acclimation period to the laboratory conditions. Red tilapia fry with an initial body weight of 0.61 ± 0.01g were randomly divided to 5 groups in triplicate recirculating 100 x 34 x 50 cm aquaria (15 fish per aquarium). A one half water of the aquarium was changed daily to avoid accumulation of the metabolites. Each aquarium was also supplied with air produced by a small electric aerator. During the course of the experiment, all fish from each aquarium were collected every two weeks and collectively weighed. Fish were hand-fed to satiation, twice a day, 6 days/week for 9 weeks. The trials were carried out at the Laboratory of Fish Production, Faculty of Agriculture (Saba-Bacha), Alexandria University, Alexandria, Egypt.

Amino yeast and seaweeds (*Ulva* sp.) Preparation:

The amino yeast used in this study was a commercial formulation produced by New Vetro Vit factory, the industrial zone C 2, 10^{th} of Ramadan city, Egypt of dried active yeast containing: B. Glucan 44.50 g, Rammose (1500.00 mg), Xylose (3000.00 mg), D L- Methionine (10110.00 mg), lysine (2600.00 mg), mannan oligosaccharides (200.00 g.).

Seaweeds (*Ulva sp.*) were collected from nature along the coastal line of Alexandria (attached to rocks) and were prepared as described by El-Tawil (2010) as follow: rinsed with fresh water then distributed on plastic sheets and left in sun to dry then put in drying oven at (60 -70°C) to complete dryness, then crushed and grinded through a food mixer and kept dry until used in the diets formulation.

Experimental Diets:

Five isonitrogenous and isocaloric diets were formulated with natural ingredients to provide 24% protein and 435 kcal/100 g diet (Table 1). Treatments were: T_1 contained both herring fishmeal (FM) and soybean meal (SBM) as the main protein source (FM-based) was formulated to serve as the control. T_2 served as a secondary control (SBM-based) was provided by a diet based on soy bean meal as the main protein source without any additions. The other three treatments were soy bean-based diets with different combinations of dried amino yeast (AY) and seaweeds (SW) as follow: T_3 contained 1% AY (SBM-based +AY), T_4 contained 10% SW (SBM-based +SW) and T_5 contained 1% and 10% AY and SW, respectively (SBM-based +AY+SW). Dietary ingredients were homogeneously ground to 500 μm, thoroughly mixed, and humidified to 50% using boiling water. Moist mixtures were autoclaved with a maximum pressure of 1.2 kg /cm² G for 15 minutes. Vitamins, minerals and amino yeast mixtures were added to the diets after heat treatment. Diets were pelleted through a 1.5 mm die mincer, dried overnight in a forced-air oven (65 °C), crumbled and sieved into 0.5–3.0 mm pellets. All diets were kept frozen (−20 °C) until they are distributed. The chemical analyses of the experimental diets are presented in Table 2.

Table 1. Composition of different experimental diets.

Ingredients	**Experimental diets***				
	T_1	**T_2**	**T_3**	**T_4**	**T_5**
Fish meal	11.5	0	0	0	0
Soybean meal	22	44	44	41	41
Wheat flour	29	21.5	21.5	16	16
Wheat bran	23.2	19	18	15.7	14.7
Yellow corn	12	13.2	13.2	15	15
Ulva sp.	0	0	0	10	10
Amino yeast[1]	0	0	1	0	1
Bone meal	1	1	1	1	1
Vit. & Min Mix[2]	1.3	1.3	1.3	1.3	1.3
Total	100	100	100	100	100

*T_1: fishmeal-based diet (Control $_1$), T_2: soybean-based diet (Control $_2$), T_3: soybean -based diet contained 1% amino yeast, T_4: soybean -based diet contained 10% seaweed and T_5: soybean -based diet contained 1% amino yeast + 10% seaweed.

[1] produced by New Vetro Vit factory, the industrial zone C 2, 10 th of Ramadan city, Egypt of dried active yeast containing: B. Glucan 44.50 g, Rammose (1500.00 mg), Xylose (3000.00 mg), D L- Methionine (10110.00 mg), lysine (2600.00 mg), mannan oligosaccharides (200.00 g.).

[2] Content/kg of Vitamin & minerals mixture (P- Fizer, Cairo, Egypt). Vitamin A, 4.8 MIU; Vitamin D, 0.8 MIU; Vitamin E, 4.0 g; Vitamin K, 0.8 g; Vitamin B_1, 0.4 g; Vitamin B_2, 1.6 g; Vitamin B_6, 0.6 g; Vitamin B_7, 20.0 mg; Vitamin B_{12}, 4.0 g; Folic acid, 0.4 g; Nicotinic acid, 8.0 g; Pantothenic acid, 4.0 g; Colin chloride, 200 g; Zinc, 22 g; Cooper, 4.0 g; Iodine, 0.4 g; Iron, 12.0 g; Manganese, 22.0 g; Selenium, 0.04 g.

Table 2. Proximate analysis of experimental diets.

Proximate analyses%	Experimental diets*				
	T_1	T_2	T_3	T_4	T_5
Dry matter	89.83	89.76	89.37	89.28	89.35
Crude protein	24.25	24.3	24.22	24.32	24.08
Crude fat	7.23	7.12	7.23	7.15	7.28
Crude fiber	3.82	3.83	3.62	4.43	4.81
Ash	8.59	9.22	9.22	9.84	8.61
NFE **	56.11	55.53	55.71	54.26	55.22
GE (kcal/100g)***	435.01	435.06	435.15	435.04	435.10

*T_1: fishmeal-based diet (Control $_1$), T_2: soybean-based diet (Control $_2$), T_3: soybean -based diet contained 1% amino yeast, T_4: soybean -based diet contained 10% seaweed and T_5: soybean -based diet contained 1% amino yeast + 10% seaweed.
**NFE is nitrogen free extract is calculated by difference = 100-(protein+ fat+ fiber+ ash)
***Gross energy (GE) was calculated according to NRC (1993) as 5.65, 9.45, and 4.11 kcal/g of protein, lipid, and carbohydrates, respectively.
Values are average of triplicate analysis (N = 3).

Sampling, Analytical Procedure and Measurements:

Fish were sampled at the beginning and at the end of the trial. A pool of fish sample from each tank was then ground and immediately freeze-dried and stored at −20 °C pending analyses. Diets and carcass samples were submitted to proximate composition analysis according to the standard methods of AOAC (1990) for moisture, protein, fat and ash. Dry matter (4 h, 105 °C) and ash (5 h, 550 °C) were determined on fresh matter basis. Total lipids (petroleum ether extraction, Soxhlet method, 40–60 °C), crude protein (macro-Kjeldahl; N × 6.25), crude fibre was estimated according to Goering and Van Soest (1970) and the nitrogen free extract (NFE) was calculated as:

NFE (%) = 100 − (% crude protein + % crude lipid + % crude fiber +% ash)

Gross energy was calculated according to NRC (1993).

Growth parameters:

Weight gain (WG) = W_1-W_0.
Daily weight gain (DWG) = (W_1-W_0)/T.
Relative growth rate (RGR%) = [(W_1 – W_0) ÷ W_0] × 100.
Specific growth rate (SGR%/day) = [(Ln W_1− Ln W_0)/T] × 100.
Where, Ln = natural log, W_0 = Initial body weight (g), W_1= Final body weight (g) and T= Time (day).

Feed utilization parameters:

Feed conversion ratio (FCR) = feed intake (g)/body weight gain (g).
Protein efficiency ratio (PER) = total weight gain (g)/protein intake (g).
Protein productive value (PPV%) = 100 (protein gain/protein intake).
Energy retention (ER%) = 100 (gross energy gain/gross energy intake).

Statistical Analyses:

Data were submitted to one-way ANOVA and were expressed as the mean ± SD of the replicates. Differences were considered significant if P was less than 0.05. All statistical analyses were performed using SPSS, version 10 (SPSS, Richmond, VA, USA) as described by Dytham (1999). Significant differences ($P \leq 0.05$) among means were tested by the method of Duncan (1955).

Economical evaluation:

A simple economic analysis was conducted for different experimental treatments to estimate the cost of feed required to produce a unit of fish biomass. The estimation was based on local retail sale market price of all the dietary ingredients at the time of the study. These prices (in LE/kg) were as follows: herring fish meal, 11; soybean meal, 3.5; wheat flour, 3; wheat bran, 2.5; yellow corn meal, 2; seaweeds (*Ulva* sp.), 5; amino yeast, 10; bone meal, 2; vitamins & minerals mixture, 7.

RESULTS AND DISCUSSION

Results of growth parameters are shown in Table 3. Experimental fish utilized the five feeds at varying protein sources brought about significant variations ($p<0.05$) in some of the growth parameters considered. It could be noticed that, initial body weight (IBW) did not differ among treatments ($p>0.05$). Differences observed among the experimental groups in FBW were significant ($p<0.05$). The highest mean final body weight (FBW) (6.68 g $fish^{-1}$) and the lowest FBW (4.39 g $fish^{-1}$) were recorded in fish fed FM-based and SBM-based+AY+SW diet, respectively. No significant differences were found in FBW were found when fish were maintained at FM-based diet or SBM-based+AY or SBM-based+SW.

The data indicated that amino yeast and seaweeds can compensate for the lack of amino acids in the all plant diets without any effect on fish growth. The dietary supplementation of amino yeast evaluated in this study resulted in an enhancement of fish growth and feed utilization. This positive effect may be due to the ability of amino yeast to improve the microecological environment of fish digestive (Verschuere *et al.*, 2000), stimulating the immune system development (He *et al.*, 2009), improving fish disease-resistant and anti-stress ability (Abdel-Tawwab *et al.*, 2008). Also it is rich of digestive enzymes, not only help digestion, but also can improve the digestive enzymes activity. Amino yeast can improve feed intake, make fish accept feed as soon as possible, optimize digestive system, improve feed nutrient utilization improve digestion rate and increase weight gain speed (Peulen *et al.*, 2002). The data in this study are in agreement with those obtained by Mahnken *et al.* (1980) who found that, no reduction in the growth of rainbow trout (*Salmo gairdneri*) fed diets without fish meal. Also, they found that, coho salmon (*Oncorhynchs kisutch*) accepted substitution fishmeal by yeast (*Candida sp.*) at a rate of 25 to 50% replacement.

Table 3. Growth performance parameters (means ± SE) of red tilapia (*Oreochromis* sp.) fry fed at diets containing fishmeal and different combinations of soybean meal, dried amino yeast and seaweeds (*Ulva* sp.).

Items	Experimental diets*				
	T_1	T_2	T_3	T_4	T_5
IBW (g)	0.61 ± 0.00	0.60 ± 0.01	0.62 ± 0.00	0.62 ± 0.01	0.62 ± 0.00
FBW (g)	6.68 ± 0.35^a	5.79 ± 0.03^b	5.94 ± 0.02^{ab}	6.49 ± 0.21^{ab}	4.39 ± 0.08^c
WG (g)[1]	6.07 ± 0.35^a	5.19 ± 0.04^b	5.32 ± 0.02^{ab}	5.87 ± 0.21^{ab}	3.77 ± 0.08^c
DWG (g)[2]	0.096 ± 0.006^a	0.082 ± 0.001^b	0.085 ± 0.000^{ab}	0.093 ± 0.003^a	0.060 ± 0.001^c
RGR (%)[3]	994.26 ± 56.56^a	864.50 ± 20.24^a	858.06 ± 3.23^a	946.77 ± 49.95^a	607.26± 12.10^b
SGR[4] %/day	3.80 ± 0.09^a	3.60 ± 0.04^a	3.59 ± 0.01^a	3.48 ± 0.08^a	3.11 ± 0.03^b
Survival rate %[5]	83.33 ± 3.33^a	70.00 ± 3.33^c	73.33 ± 0.00^b	70.00 ± 3.33^c	73.33 ± 6.67^b

*T_1: fishmeal-based diet (Control $_1$), T_2: soybean-based diet (Control $_2$), T_3: soybean -based diet contained 1% amino yeast, T_4: soybean -based diet contained 10% seaweed and T_5: soybean -based diet contained 1% amino yeast + 10% seaweed.

Mean values with the different superscript along the same row are significantly different ($p<0.05$).

[1]Weight gain: W_1-W_0.

[2]Daily weight gain: $(W_1-W_0)/T$.

[3]Relative growth rate: $[(W_1 – W_0) \div W_0] \times 100$.

[4]Specific growth rate : $[(\text{Ln } W_1 - \text{Ln } W_0)/T] \times 100$.

Where, Ln = natural log, W_0 = Initial body weight (g), W_1= Final body weight (g) and T= Time (day).

[5]Survival rate (%) = (Fish No. at the end ÷ Fish No. stocked at the beginning) × 100.

Also, El-Tawil (2010) stated that green seaweeds (*Ulva* sp.*)* supplementation to red tilapia **(***Oreochromis sp***.)** diet at optimum level of 15% improved growth performance. Valente *et al.* (2006) fed juveniles sea bass *Dicentrarchus Iabrax* on diets contain *Ulva sp.* for 10 weeks. They found that maximum fish growth was achieved at 10% seaweeds incorporation in the diet. Moreover, Sancheze Muniz *et al.* (1983) in rainbow trout, they showed that, total replacement fishmeal protein by yeast protein gave the slight growth reduction than those control diet which contained 100% fishmeal protein, though this was slightly improved with addition of methionine.

The weight gain (WG) was least in fish fed SBM-based+AY+SW diet (3.77 g) and highest in fish fed FM-based diet (6.07 g) ($p<0.05$). WG values showed no significant differences ($p>0.05$) among fish groups maintained at SBM-based diet without any supplementations or SBM-based+AY or SBM-based+SW diets. The best daily weight gain (DWG) values were recorded when fish were maintained at FM-based diet and SBM-based diets containing SW or AY. The least DWG values were found when fish were maintained at the SBM-based+AY+SW diet. The highest relative growth rate (RGR), 994.26 % and lowest RGR, 607.26 % were determined in fish fed FM-based diet and SBM-based+AY+SW diet, respectively. No significant differences ($p>0.05$) in RGR were found among fish groups maintained at T_1, T_2, T_3 and T_4 diets. The same trend was found with specific growth rate (SGR). It was highest in fish fed diet T_1 (3.80 %), while it was least in fish fed diet T_5 (3.11 %) ($p<0.05$). The improvement in fish growth parameters with addition of small amounts of dietary seaweeds as feed supplements may be due to the improvement of digestive efficiency of feed, physiological condition, fish vitality, disease resistance (Liao *et al*., 1995). El-Tawil (2010) showed that final body weight, weight gain and specific growth rate (SGR) increased significantly ($P < 0.05$) with increasing *Ulva* level in red tilapia diet up to 15%. Mai and Zhao (2008) found that proper dose (0.25 %) of yeast culture addition is able to improve the growth and health conditions of turbot that fed on the diets containing high level of soybean protein (SBP), and to increase the replacement level fishmeal protein from 30% to 45% by SBP. These results are in agreement with the results obtained by El-Zaeem *et al*. (2012). They indicated that the addition of probiotic and amino yeast in fish diets was effective in stimulating most of the productive performance of red tilapia. Also, they indicated that this stimulation may be due to improvement in intestinal microbial flora balance which in turn will lead to better nutrient digestibility, higher adsorption quality and increased enzyme activities.

The best survival rate (83.33 %) was observed when fish were maintained at FM-based diet (T_1), followed by T_3 and T_5 when fish were maintained at SBM-based+AY diet or SBM-based+AY+SW diet. The worst survival rate 70.00 % was found when fish were maintained at T_2 and T_4. The data of the present work indicated that FM-based diet was better than SBM-based diets in fish survival rate. On the other hand the diet contained amino yeast was better than the diets contained seaweeds in fish survival rate. The utilization of dried yeast at reduced levels may effectively improve non-specific immune responses (He *et al.*, 2009 and Yoshida *et al.*, 1995) in a variety of fish species. As inasmuch, dried yeast is a source of nucleic acids and non-starch polysaccharides, including β-1, 3 glucan, which in high concentrations may play a role of antinutritional factors. Abdel-Tawwab *et al.* (2010) found the same results with Galilee tilapia *Sarotherodon galilaeus*. Fish fed on diets supplemented with live baker's yeast *Saccharomyces cerevisiae* were stronger and healthier. Also, they suggest that yeast supplementation enhanced the resistance of fish against waterborne copper toxicity.

Results of feed and nutrient utilization parameters are shown in Table 4. The highest offered feed were observed in fish fed FM-based diet and diet SBM-based diet, respectively which were significantly higher than those observed for the other diets ($p<0.05$). The best feed conversion value (FCR) was recorded as 1.36 in fish fed SBM-based +SW diet and the poorest FCR value was determined as 2.02 in fish fed diet SBM-based+AY+SW. FCR values of the fish fed diet T_1,T_3 and T_4 did not differ significantly from each other ($p>0.05$).

Table 4. Feed and nutrient utilization parameters (means ± SE) of red tilapia (*Oreochromis* sp.) fry fed at diets containing fishmeal and different combinations of soybean meal, dried amino yeast and seaweeds (*Ulva* sp.).

Items	**Experimental diets***				
	T_1	**T_2**	**T_3**	**T_4**	**T_5**
Offered Feed (g)	8.54 ± 0.23[a]	8.42 ± 0.41[a]	7.75 ± 0.14[b]	7.96 ± 0.18[b]	7.59 ± 0.17[b]
FCR[1]	1.41 ± 0.04[c]	1.63 ± 0.09[b]	1.46 ± 0.03[bc]	1.36 ± 0.04[c]	2.02 ± 0.01[a]
PPV %[2]	52.16 ± 1.60[a]	41.21 ± 3.03[c]	47.36 ± 0.82[b]	49.94 ± 3.14[ab]	36.09 ± 0.43[d]
PER[3]	2.93 ± 0.09[ab]	2.54 ± 0.14[c]	2.84 ± 0.04[b]	3.03 ± 0.18[a]	2.06 ± 0.01[d]
ER %[4]	23.52 ± 1.01[a]	21.82 ± 1.46[b]	23.77 ± 0.50[a]	24.36 ± 1.40[a]	19.03 ± 0.09[c]

*T_1: fishmeal-based diet (Control $_1$), T_2: soybean-based diet (Control $_2$), T_3: soybean -based diet contained 1% amino yeast, T_4: soybean -based diet contained 10% seaweed and T_5: soybean -based diet contained 1% amino yeast + 10% seaweed.

Means with different superscript letters within a row are significantly different ($P<0.05$).

[1]Feed conversion ratio: feed intake (g)/body weight gain (g).

[2]Protein productive value: 100 (protein gain/protein intake).

[3]Protein efficiency ratio: total weight gain (g)/protein intake (g).

[4]Energy retention : 100 (gross energy gain/gross energy intake).

These findings suggested that FCR obtained when fish diets were supplemented with amino yeast or seaweeds only were better than fish diets supplementation with amino yeast and seaweeds together. The data obtained in this study are in agreement with those obtained by Amer and El-Tawil (2011). These results can be partly explained by the lack of palatability of diets containing amino yeast and seaweeds together or the leaching of some dietary constituents of the artificial feeds into water due to the increase in microbial activity of the probiotic in presence of *Ulva* which released the homogenized formulated diet. These occurred losses raised the amount of offered feed without utilization which leads to poor results. Concerning with protein productive value (PPV %), the highest

PPV value (52.16 %) was noticed when fish were maintained at FM-based diet, followed by T_3 and T_4 when fish were fed at SBM-based diet supplemented with AY or SW. The lowest PPV value (36.09 %) was found with SBM-based+AY+SW diet.

Protein efficiency ratio (PER) was highest in fish fed T_4 while it was least in fish fed diet T_5 ($p<0.05$). It could be noticed that, no significant differences ($p>0.05$) observed between fish maintained at T_1 and T_4 in PPV values. The improvement in feed utilization which appear in PER and PPV values when fish diets were supplemented by amino yeast or seaweeds suggesting that protein from amino yeast and *Ulva* sp. was well digested by red tilapia. Wong and Cheung (2000) showed that the protein of green algae (e.g. *Ulva lactuca*) is considered high quality protein, since it contains all the essential amino acids (EAA) and accounted for 42.1- 48.4% of the total amino acids content**.** Our results are in agreement with Olvera-Novoa *et al*. (2002) which observed similar digestibility values in tilapia fed with diet having similar yeast incorporation. Also, Elmorshedy (2010) reported that there were positive trends between protein efficiency ratio (PER) and energy retention (ER %) on one side and seaweeds inclusion levels in the diet up to the level of 14% on the other side. With regard to energy retention (ER %) as shown in Table 4, results indicate that fish maintained at T_1, T_3, and T_4 were significantly ($P < 0.05$) higher than other treatments and the highest value 24.36 % of ER % was observed with fish maintained at T_4 while the worst value was obtained with fish maintained at T_5 with the value of 19.03 %. The same trend was found by Rodrigo *et al.* (2012) when Nile tilapia, *Oreochromis niloticus*, juveniles were fed at various dietary levels (0%, 10%, 15%, 20%, 30% or 40% diet) of dried brewer's yeast. They found that, the digestibility coefficients of protein (78–82%) and lipid (87–94%) were not significantly different with increasing dietary yeast, suggesting that protein from yeast was well digested by tilapia.

The data presented in Table 5 showed that, no significant differences were observed in fish moisture contents ($P > 0.05$) at all treatments. It ranged between 69.53 and 72.67%. On the other side, body protein content increased significantly ($P<0.05$) with addition of both amino yeast and seaweeds in SBM-based diets. The lower values of body protein content were found when fish were maintained at SBM-based diets without any additions or when supplemented with AY or SW. Supplementation of amino yeast and seaweeds in SBM-based diets affected fish body lipid content. Fish maintained at SBM-based diet were significantly the highest ($P < 0.05$) in body lipid content than other treatments, with the value of 8.08%, while the lower values (6.3, 6.72 and 6.08 %) were observed when fish were maintained at T1, T4 and T5, respectively. The results in the present study are in agreement with Olvera-Novoa *et al*. (2002) observed no differences in carcass composition when substituting animal protein with a mixture of plant feedstuffs including 25,30,35,40 and 45% of the protein with torula yeast (*Candida utilis*) in diet for tilapia (*Oreochromis mossambicus*) fry.

Table 5. Means ± standard error (SE) of body composition of red tilapia (*Oreochromis* sp.) fry fed at diets containing fishmeal and different combinations of soybean meal, dried amino yeast and seaweeds (*Ulva* sp.).

Treatments	Moisture %	Protein %	Fat %
T_1	71.98 ± 0.78	17.61 ± 0.03^{a}	6.3 ± 0.18^{c}
T_2	71.76 ± 0.36	16.14 ± 0.29^{b}	8.08 ± 0.03^{a}
T_3	71.83 ± 0.63	16.60 ± 0.07^{b}	7.54 ± 0.06^{b}
T_4	72.67 ± 0.47	16.38 ± 0.05^{b}	6.72 ± 0.07^{c}
T_5	69.53 ± 0.53	17.24 ± 0.12^{a}	6.08 ± 0.05^{c}

*T_1: fishmeal-based diet (Control $_1$), T_2: soybean-based diet (Control $_2$), T_3: soybean -based diet contained 1% amino yeast, T_4: soybean -based diet contained 10% seaweed and T_5: soybean -based diet contained 1% amino yeast + 10% seaweed.

Mean values with the different superscript along the same column are significantly different ($p<0.05$).

Economic evaluation of the experimental diets is shown in Table 6. The data showed that, the addition of 1% amino yeast or 10% green seaweed *Ulva* sp., but not together in all plant- based diets reduced feed cost to produce 1 kg of fish weight gain by 16.051% and 19.07%, respectively compared to the fishmeal-based diet. These findings suggest that the efficiency of inclusion of amino yeast or (*Ulva* sp.) seaweeds in red tilapia diets is economic and sharply reduced the fish feed cost. Previous studies showed that the use of all plant protein diet or using non-fishmeal protein sources in fish diet reduced cost and increased profit in feeds of fish (Nguyen *et al.*, 2009 and Li *et al.*, 2010).

Table 6. Economic efficiency for production of one kg gain of red tilapia fry fed at diets containing fishmeal and different combinations of soybean meal, dried amino yeast and seaweeds (*Ulva* sp.).

Items	**Experimental diets***				
	T_1	**T_2**	**T_3**	**T_4**	**T_5**
Price/ kg feed (L.E)	3.84	3.04	3.11	3.22	3.29
FCR (kg feed/kg gain)	1.41	1.63	1.46	1.36	2.02
Feed cost/kg gain(L.E)	5.41	4.95	4.54	4.38	6.65
Reduction in feed cost/ kg gain %	0.00	8.54	16.05	19.07	-23.00

*T_1: fishmeal-based diet (Control $_1$), T_2: soybean-based diet (Control $_2$), T_3: soybean -based diet contained 1% amino yeast, T_4: soybean -based diet contained 10% seaweed and T_5: soybean -based diet contained 1% amino yeast + 10% seaweed.

The results obtained in this study suggest that the inclusion of 1% dried amino yeast or 10% green seaweeds (*Ulva* sp.), but not together in all plant-based diets for red tilapia fry improved growth performance and sharply reduced the feed cost without any negative consequences on nutrient utilization or body composition, providing additional information for future studies interested in the optimization of a more economic and low-pollution non-fishmeal based diets.

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تأثير الاستبدال الكلى لمسحوق السمك بتوليفات مختلفة من مسحوق فول الصويا و الخميرة الجافة الأمينية و الأعشاب البحرية الخضراء (أولفـا) فى علائق أسماك البلطى الأحمر على النمو وكفاءة الاستفادة من الغذاء

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قسم بحوث تغذية الأسماك- المعمل المركزى لبحوث الثروة السمكية- مركز البحوث الزراعية وزارة الزراعة- مصر.

الملخص العربــى

أجريت هذه التجربة بمعمل إنتاج الأسماك بكلية الزراعة (سابا باشا) جامعة الإسكندرية لدراسة إمكانية الاستبدال الكلى لمسحوق السمك بتوليفات مختلفة من مسحوق فول الصويا و الخميرة الجافة الأمينية و الأعشاب البحرية الخضراء (أولفا) فى علائق أسماك البلطى الأحمر ذات الوزن الابتدائى ٠.٦١ جرام. تم إعداد خمس علائق متساوية فى نسبة البروتين (٢٤٪) و متساوية فى الطاقة (٤٣٥ كيلو كالورى لكل١٠٠ جم غذاء) وكانت المعاملات كالآتى: العليقة الأولى (حيوانية) تحتوى على مسحوق السمك كمصدر للبروتين (كنترول ١)، العليقة الثانية (نباتية) تحتوى على مسحوق فول الصويا كمصدر للبروتين (كنترول ٢)، العليقة الثالثة (نباتية) تحتوى على ١٪ خميرة جافة أمينية، العليقة الرابعة (نباتية) تحتوى على ١٠٪ أعشاب بحرية، العليقة الخامسة (نباتية) تحتوى على كل من ١٪ خميرة جافة أمينية و ١٠٪ أعشاب بحرية. وزعت كل معاملة على ثلاث مكررات، وتمت التغذية مرتين يوميا حتى الإشباع لمدة تسعة أسابيع. وأظهرت النتائج ما يلى: ظهرت أعلى قيم لكل من الوزن النهائى والوزن المكتسب ومعدل النمو النسبى ومعدل النمو النوعى مع العليقة الأولى بينما ظهرت أقل القيم مع العليقة الخامسة. تحققت أعلى نسبة إعاشة ٨٣.٣٣٪ مع العليقة الأولى بينما ظهرت أقل نسبة إعاشة ٧٠٪ مع العليقتين الثانية و الرابعة. كما أفادت النتائج المتحصل عليها أيضا أن القياسات الخاصة بكفاءة استخدام الغذاء قد تأثرت معنويا بالمعاملات. كانت أفضل قيمة لمعامل التحويل الغذائى ١.٣٦ مع العليقة الرابعة بينما ظهرت أسوأ قيمة ٢.٠٢ مع العليقة الخامسة. بالنسبة للقيمة الإنتاجية للبروتين فقد تحققت أعلى قيمة مع العليقة الأولى يليها العليقة الثالثة ثم الرابعة بينما ظهرت أقل قيمة مع العليقة الخامسة. أظهرت قيم لنسبة كفاءة للبروتين و كذلك الطاقة المحتجزة نفس الاتجاه. ظهرت أعلى قيمة معنوية لمحتوى الجسم

من البروتين مع العليقتين الأولى و الخامسة بينما أظهرت العلائق الثانية و الثالثة و الرابعة أقل قيمة لمحتوى الجسم من البروتين. أما بالنسبة لمحتوى الجسم من الدهون فظهرت أعلى قيمة معنوية مع العليقة الخامسة بينما لوحظت أقل قيمة مع العليقة الأولى. تشير النتائج التى تم الحصول عليها فى هذه الدراسة إلى أن إدراج الخميرة الجافة الأمينية بنسبة ١٪ أو الأعشاب البحرية الخضراء (أولفا) بنسبة ١٠٪ دون إضافتهما معاً إلى العلائق النباتية ليرقات البلطى الأحمر تؤدى إلى تحسين أداء الأسماك وخفض تكلفة الغذاء بدون أى آثار سلبية على استفادة الأسماك من الغذاء أو تركيب الجسم.