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Biology and Growth Performance for Fry Red Tilapia Feed With Spirulina

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Abstract

The use of fish feed with nutrient deficiency is common in present aquaculture practice and it causes the highest fish mortality and economic loss in this industry. Microalgae (*Spirulina*) is known to have good nutritional and chemical compositions that are good for fish feed. An experimental study was carried out to determine the nutritional composition of *Spirulina*, the biology and growth performance of red tilapia when feed with different ratio of *Spirulina*. Twelve cages sizes 1x1x0.9m and built with netlon and polyvinyl chloride were used and arranged in concrete tanks to culture the fish. The fish feed was prepared with own grown spirulina. The fish was fed with different ratios (0%, 1%, 3%, 5%, and 7%) of *Spirulina* for 13 weeks. The results show that locally grown Spirulina are far better than those from other countries in performance. The 3% Spirulinar ration gave the best fish weight growth, total length, fish appearance and gonad weight. Thus, the locally grown *Spirulina* fish feed was found to be good for supplementation in fish feed with 3% given the overall growth performance to red tilapia and it is considered to be a potential candidate to replace the fish meal and feed formulation.

Keywords**:** Red Tilapia; *Spirulina* feed; Aquaculture; Experimental study**.**

المستخلص

يعد استخدام أعلاف الأسماك التي تعاني من نقص المغذيات أمرًا شائعًا في ممارسة الزراعة المائية الحالية وهو يسبب أعلى معدل وفيات للأسماك وللخسارة الاقتصادية في هذه الصناعة. من المعروف أن الطحالب الدقيقة (سبيرولينا) لديها تركيبة غذائية وكيميائية جيدة لتغذية الأسماك. أجريت دراسة تجريبية لتحديد التركيبة الغذائية للسبيرولينا وحياتها وتطور النمو على البلطي الأحمر عند تغذيته بنسب مختلفة من سبيرولينا. تم استخدام 12 قفص بحجم 1 x 1 x 0.9 متر بنيت من نيتلون وكلوريد البوليفينيل في خزانات خرسانية لتربية الأسماك. تم إعداد أعلاف الأسماك باستخدام سبيرولينا. تم تغذية الأسماك بنسب مختلفة (0 ٪ ، 1 ٪ ، 3 ٪ ، 5 ٪ ، و 7 ٪) من سبيرولينا لمدة 13 أسبوعا. أظهرت النتائج أن سبيرولينا المزروعة محليا مناسبة في جودة الأداء. أعطت نسبة سبيرولينا 3٪ أفضل نمو لوزن الأسماك ، وطولها الكلي ومظهر الأسماك ونشاطها ووزن الغدد التناسلية وبناء عليه فإن أعلاف سمكة سبيرولينا المزروعة محليا جيدة لإضافتها في أعلاف الأسماك بنسبة 3 ٪ نظرا لارتفاع أداء النمو الكلي للبلطي الأحمر وهي لذلك تعد مرشحا محتملا لتحل محل وجبة الأسماك وفي صياغتها.

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Introduction

Tilapia is among three genera species of economic importance.It has been cultured for the last 2,500 years (Chapman, 2000). There has been a steady increase in the global production of tilapia during the period 1991 to 2002, with annual production of 1.5 million tones per year when the global fish production was almost 51.4 million tons (Ramnarine, 2005).

Nutrition for fishmeal in aquaculture promotes optimal fish growth and health. When fish are cultured in a system without natural foods, for example, trout raceways, or when the contribution of natural foods is only marginal with regard to nutrition, like intensively stocked catfish ponds, there is a need for the feed to be nutritionally adequate (Lovell, 1989). Fishmeal is currently the main source of protein utilized to feed the fish. However, because of the expansion of aquaculture systems based on the use of fishmeal as a major ingredient for aqua feeds, the meal is becoming unsustainable. As such, many studies have focused on the search for alternative protein sources suitable for use in aqua feeds, which might reduce the dependency on fishmeal. Alternative protein source that meets some important requirements, such as high protein content, adequate fatty acid profiles, secured supplies, as well as affordable costs are, thus, investigated (Nagel et al., 2012).

Plant protein meals such as soybean meal, rapeseed meal, corn gluten meal or wheat gluten have been used successfully as ingredients for fish feeds (Cabral et al., 2011, Nagel et al., 2012 and Santigosa et al., 2008; Silva et al., 2010, Cruz-Suárez et al., 2009, and Tibaldi et al., 2006). However, plant protein sources contain a wide range of anti-nutritional factors, and hence, high inclusion level of these ingredients can induce negative effects on growth and on digestive enzyme activities (Santigosa et al., 2008). Therefore, protein sources of plant origin do not represent an ultimate alternative to fishmeal, and hence, the need to find new aqua feed ingredients remains currently a challenging goal. Accordingly, microalgae appear as a promising alternative to enhance the nutritive value of conventional feeds, and to be used, at least partially, as a substitute for fishmeal (Lupatsch, 2009). Microalgae consist of high levels of beneficial carbohydrates, proteins, lipids and antioxidants making them an essential food source in the rearing of all stages of marine bivalve molluscs (clams, oysters, scallops), the larval stages of some marine gastropods (abalone, conch), larvae of several marine fish species, penaeid shrimp and zooplankton (Muller-Feuga et al., 2000). It is also capable of producing omega-3 and omega-6 (long-chain) poly-unsaturated fatty acids known to be required in human nutrition. Partial substitution of fishmeal by microalgae biomass can induce positive effects on growth, feed utilization, lipid metabolism, body composition, meat quality, and resistance to stress and diseases.

This study deals with the biology and growth performance in Fry Tilapia feed with Spirulina. In order to achieve this goal, the study will focus ondetermining the nutritional composition of Spirulina grown in fish tank and, 2) Determination of fish growth fed with different ration of Spirulina 1%, 3%,5% and 7% in terms of length and weight, growth rate and FCR.

Materials and Methods

A total of twelve cages were used and arranged in a concrete tank with dimensions of 4.7m x 4.2m at the hatchery, TPU, UP Malasysia. The cages were built of netlon and polyvinyl chloride (PVC) supplied commercially. Each cage was 1m x 1m and 0.9m deep. The concrete tanks were equipped with a complete aeration system (Fig. 1).

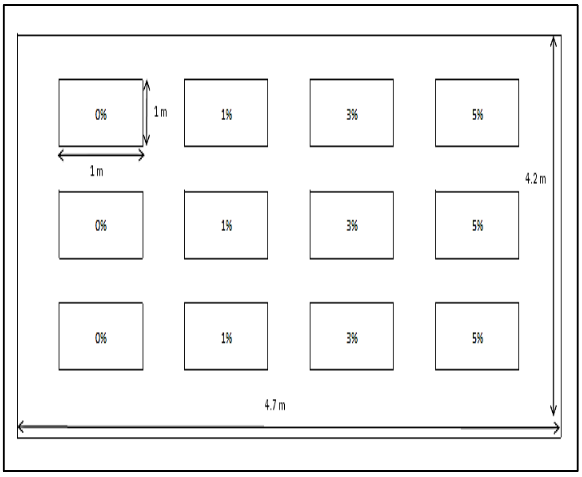

Fig. 1. Layout of the cages (left) and phot of cages built with netlon and PVC (right).

The red tilapia fingerlings used were obtained from a local farmer (SA Agromax Enterprise, Puchong). They were subjected to an acclimatization period of 2 weeks (Li et al., 2015) and fed with control diet free of spirulina. Fingerlings with an average weight of 1.23g and 4.0cm length, were randomly selected and placed into the cages with capacity of 24 fish per cage and total of 72 fish per trearment. Groundwater was used in the system and 1/3 of the water volume in the concrete tank was replaced once every two weeks in order to offset evaporation loss. The tank was cleaned once a month.

The fish feed was prepared by addition of commercial Spirulina with a ground commercial fish feed obtained locally. It conisits of home-grown dried Spirulina powder. Feed formulation was determined according to the feeding rations of 0%, 1%, 3% and 5%. The fish sample were fed twice a day (at 10.00 a.m. and 05.00 p.m.) till adlibtum for 90 days using feeding trays that were prepared to assist in fish feeding (Table 1).

The proximate analyses of the Spirulina, commercial fish feed, and a mixture of Spirulina with fish feed were done according to the AOAC method at the Faculty of Agriculture, University Putra Malysia. They were all measured based on the composition of crude protein (Kjedahl protein), crude lipid, crude fiber, ash and moisture.

Water quality monitoring was done once every two weeks based on five different parameters; ammonia-nitrogen, nitrate, dissolved oxygen (DO), pH and water temperature. The water temperature, DO and pH readings were observed in the morning hours using the multi-probe before fish sampling. For moisture content was measured according AOAC; section930.15 recommendations and Ash was determined by standard procedures outlined in the AOAC procedures section 942.05.

Following the method of Kjedhal (1833) described by the AOAC in section 954.05 crude protein is analyzed. 10ml of H_2SO_4 acid and a tablet of Kjeldahl catalyst were added into the digestion tube. The latter is inserted into a digester and heated to 720°C for one hour afterwhich the temperature is increased to 420°C for another hour. The tube was then allowed to cool for 4 hours and crude protein was analysed using protein analysing machine (Kjaltex). The result was automatically calculated by the instrument in percentage.

Feed crude fat was determined using the AOAC method suggested in section 920.39. Three grams of feed sample were weighed and transferred into the extraction thimble. The mouth of thimble was covered with coton wool and then inserted into Soxhlet apparatus. The aluminum cap was weighed and 200ml of petroleum ether added. The Soxhlet apparatus is fixed to the aluminum cap and attached to the condenser. Gentle water flow was started through the apparatus which was then heated gradually at 60°C until finish. After heating the aluminum cap was detached and the solvent was drained from the Soxhlet apparatus and the aluminum cap was placed in the oven to dry at 100°C for 30 minutes. After draining it was taken out and cooled in the dessicator before being weighed, recorded and fat content calculated.

Results and Discussion

Commercial Fish Feed

Immediate analysis has been done to determine the nutritional composition of commercial fat for fish feed used. The chemical properties content in the feed consist of 12.5% moisture, 6.8% ash, 27.9% crud protein, 8.9% crude lipid and 5.4% crude fiber. The content was compatible with the composition stated on the commercial fish feeds' package.

The nutritional condition stimulates the fish immune system (Oliva-Teles, 2012). Protein is an essential for amino acids which is the important defense mechanism in the fish body (Li et al., 2007). In this study crude protein in the supplied feed was ca. 63% as apposed to the initial commercial percentage of ca. 28%. This is consistent with Tokusoghu and Unal (2003) who reported the use of protein content of spirulina ca. 60 to 64% on different types of fish. The carbohydrate and lipid play an important role in optimizing the efficiency of protein utilization by protein sparing effect (Johnston et al., 2003).

Nutritional Composition of Feed

Different ratios of spirulina, ranging from 1% to 7% were added to the fish feed. A proximate analysis result shows that the properties increase with increasing ratio except for ash which decreases and crude fiber as well as crude lipid in some cases. The 7% formulated ratio of spirulina shows highest protein with 29.98 and moisture 13.01% as well as crude lipid 8.98 while lowest in ash with 4.24 compared to 0%, 1%, 3% and 5%. For crude fiber, 0% has the highest with 5.40 compare to others.

The formulation of fish feed with 1%, 3%, 5% and 7% ratios of spirulina used was done to observe their effect towards the red tilapia growth and survival. This protocol was conducted with different ratio of spirulina species (e.g. Vasudevan et al.,2006; Teimouri et al., 2013; Nakagawa and GomezDiaz, 1995 and Ramakrishnan et al., 2008). All the studies yielded positive results when compared with feed with absence of spirulina.

Effect of Spirulina Ratios on Fish Growth Weight

Result of different ratios of spirulina feed for red tilapia show positive increase in the fish mean weight across the weeks at different ratios with 3% and 1% ratios showing higher growth weight (Table 1). A remarkable increase in the mean weight was noticed in week 6 and week 8 at all the ratios. This may be due to the adaptability to the feed nutritional content while at week 10 and 13 the rate exhibits decline, which may be due to fish metabolism and water quality decline. One-way ANOVA test between group analyses, showed no significant difference between the spirulina ratios at P> 0.05 level with [F(4,100) = 1.436, P = .228].

Table 1. Mean of Red Tilapia Growth Weight (g)

Spirulina concentration	Weight (g) week 2	Weight (g) week 4*	Weight (g) week 6	Weight(g) week 8	Weight(g) week 10	Weight(g) week 13*
Control	2.6±0.82^{ab}	4.9±0.45^{b}	8.7±0.60^{c}	17.2±1.87^{d}	18.4±1.35^{d}	27.0±1.17^{e}
1%	2.99±0.35^{ab}	5.8±0.28^{b}	10.6±0.51^{c}	18.6±1.17^{d}	23.7±1.89^{e}	36.4±1.14$^{.f}$
3%	2.8±0.68^{ab}	5.6±0.70^{b}	12.0±0.60^{c}	22.6±1.74^{d}	33.2±1.08^{e}	40.6±1.45^{f}
5%	3.1±0.88^{ab}	5.8±0.49^{b}	11.6±0.20^{c}	27.4±1.48^{d}	35.6±1.02^{f}	30.00±1.64 e
7%	2.9±0.80^{ab}	5.5±0.84^{b}	13.0±0.09^{c}	30.6±1.31^{d}	37.6±1.73f	25.5±1.12^{e}

*Note: Means within rows with different superscripts are significantly different.

The fish growth weight displays an increase in the first phase of the experiment (week 2 and 4) from 2.6g to 5.8g were 0% spirulina increases from 2.6g at the first two weeks (15 days) to 4.9g at 4th week (29 days) while 1% and 5% increased from 2.99g to 5.8g and 3.1g to 5.8g (Fig. 1a). However, high increase in fish growth weight was noticed in the second phase of the experiment with 7% having the highest increase from 13.0g at week 6 to 30.6g at week 8 compared to the control (0%) with increase from 8.7g at the week 6 to 17.2g at the week 8 (Fig. 1b).

The third phase of the experiment exhibited slow growth pattern (week 10 to 13) with decline in some cases. A high decline was observed at 7% from 37.6g at week 10 to 25.5g at week 13 and slow increase in growth was observed in 3% f rom 33.2g at week 10 to

40.6g at week 13 (Fig. 2), nevertheless, cumulatively it has the highest performance. This may be due to the excess utilization of spirulina dietary which was reported to cause negative impact on fish growth in striped jack, *Pseudocaranxdentex* and red tail prawn, *Penaeuspenicillatus* (Nakagawa and Gomez-Diaz,1995). The results are consistent with feed with high ration of spirulina in high fish (Vasudevan et al., 2006) and in juvenile common crap (Ramakrishman et al., 2008). ANOVA test showed significant difference in fish weight (at $P< 0.05$ level) between different ratios across the three phases of the experiment with [$F(9,20) = 55400.000$, $P = .000$] for phase one (week 2 to 4), [$F(9,20) = 1688536.667$, $P = .000$] for phase two (week 6 to 8), [$F(14,30) = 1716748.571$, $P = .000$] for phase three (week 10 to 13).

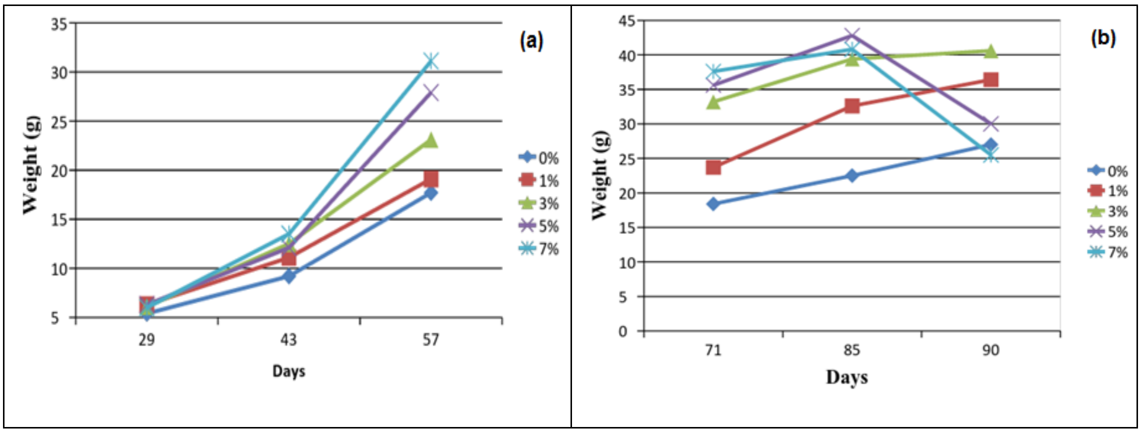

Fig. 1. Fish growth weight at (a) phase one (week 1 to 4) and (b)phase two (week 4 to 8).

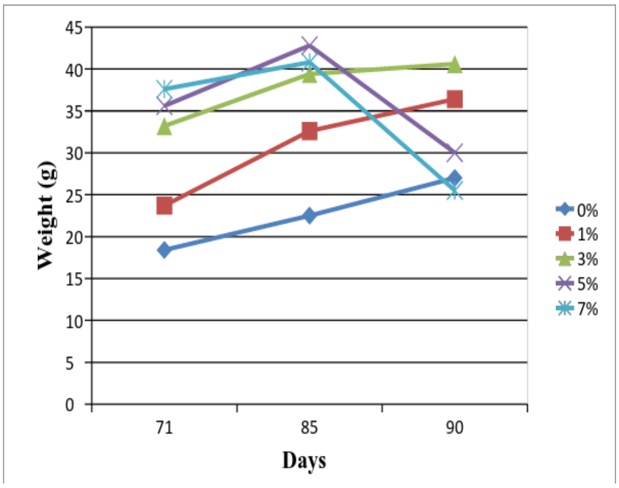

Fig.2 Fish growth weight at the phase three (week 10, 12 & 13).

Table 2 illustrates the ANOVA result. This was further supportrd by Turkey HSD post-hock test which was performed to identify where the differences occur. The result shows a significant difference between all the ratios across the weeks in all the three phases of the experiment except in some cases.

Table 2. ANOVA test of week`s weight on different ratio of spirulina.

Variables	N	Mean	SD	df	F	P
Phase 1 (weeks 2&4)				9	55400.000	.000
Week 2 0%	3	2.60	.01	20		
Week 4 0%	3	4.90	.01			
Week 2 1%	3	4.00	.01			
Week 4 1%	3	5.80	.01			
Week 2 3%	3	2.80	.01			
Week 4 3%	3	5.60	.01			
Week 2 5%	3	3.10	.01			
Week 4 5%	3	5.80	.01			
Week 2 7%	3	2.90	.01			
Week 4 7%	3	5.50	.01			
Phase 2 (weeks 6 & 8)				9	1688536.667	.000
Week 2 0%	3	8.70	.01	20		
Week 4 0%	3	17.20	.01			
Week 2 1%	3	10.60	.01			
Week 4 1%	3	18.60	.01			
Week 2 3%	3	12.00	.01			
Week 4 3%	3	22.60	.01			
Week 2 5%	3	11.60	.01			
Week 4 5%	3	27.40	.01			
Week 2 7%	3	13.00	.01			
Week 4 7%	3	30.60	.01			
Phase3(weeks10&13)				14	1716748.571	.000
Week 2 0%	3	18.40	.01	30		
Week 4 0%	3	27.00	.01			
Week 2 1%	3	23.70	.01			
Week 4 1%	3	36.40	.01			
Week 2 3%	3	33.20	.01			
Week 4 3%	3	40.60	.01			
Week 2 5%	3	35.60	.01			
Week 4 5%	3	30.00	.01			
Week 2 7%	3	37.60	.01			
Week 4 7%	3	25.50	.01			

Effect of Spirulina ratios on Fish Growth Length

Fish growth length (Table 3) shows positive increase in the fish mean length for all spirulina ratios across the weeks. The 3% ratio, however, have the highest growth length of 12.9cm. A remarkable increase was noticed in weeks 6 and 8 at all ratios, as it increases from the mean average of 6cm in week 4 to 8cm in week 6. This may be due to the adaptability to the feed nutritional content. While at weeks 10 and 13 the increase pattern returns back to its previous trend which may also be due to the fish metabolism and/or water quality decline. One way ANOVA analysis shows no significant difference in fish weigh between the spirulina ratios at P> 0.05 level with [F(4,100) = .303, P = .875].

Table 3. Mean of Red Tilapia Growth Length (cm).

Spirulina concentration	Length (cm) week 2	Length(cm) week 4*	Length(cm) week 6	Length(cm) week 8	Length(cm) week 10	Length(cm) week 13
Control	5±0.67^{b}	6.1±0.71^{c}	7.6±0.11^{d}	9.5±0.16^{e}	11.4±0.54^{e}	11.6±0.99^{f}
1%	5.2±0.58^{b}	6.5±0.89^{c}	8.1±0.96^{d}	9.8±0.10^{e}	10.8±0.24^{f}	12.7±0.11^{g}
3%	5.1±0.57^{b}	6.5±0.71^{c}	8.6±0.58^{d}	10.2±0.79^{e}	11.5±0.79^{f}	12.9±0.80^{g}
5%	4.9±0.46^{b}	6.5±0.64^{c}	8.4±0.89^{d}	10.9±0.4^{e}	11.6±0.49^{f}	12.5±0.88^{g}
7%	5.2±0.48^{b}	6.5±0.75^{c}	8.8±0.92^{d}	11.1±0.79^{e}	11.8±0.83^{f}	11.8±0.57^{g}

*Note: Means within rows with different superscripts are significantly different

At the first phase of the experiment (week 2 and 4) the length growth pattern was slow with 3% having the highest 5.1cm at week 2 (15 days) compared to other ratios. At week 4, however, the growth pattern becomes uniform at 6.5cm except for 0%; 6.1cm (Fig.3a). The growth length increasing pattern changed in the second phase weeks 6 and 8 with high relative increase. The 7% ratio shows the highest increase from 8.8cm at week 6 to 11.1cm at week 8 while 0% have the lowest increase from 7.6cm at week 6 to 9.5cm at week 8 (Fig. 3b).

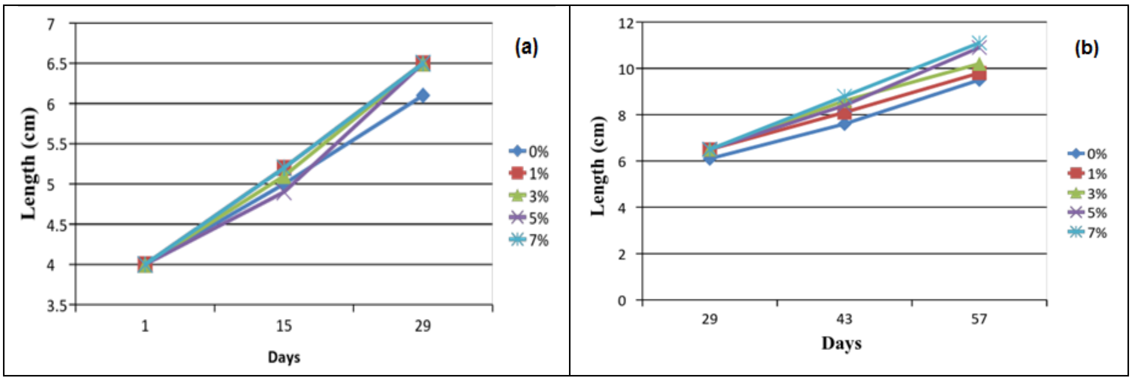

Fig. 3. Fish length at (a) phase one (week 1 to 4) and (b) phase two (week 4 to 8).

The growth pattern in third phase (week 10 to 13) was back to initial pattern of the first phase. (Fig. 4). The decline in the growth pattern may be due to the excess utilization of spirulina dietary. A case reported by Nakagawa and Gomez-Diaz (1995) in striped jack, *Pseudocaranxdentex* and red tail prawn, *Penaeuspenicillatus*.

Similar results in cultures fed with high rations of spirulina were reported by Vasudevan et al. (2006) and Ramakrishman et al. (2008). A one way ANOVA (Table 4) imbetween group analysis shows significant difference in fish length (at P< 0.05 level) between different ratios across the three phases of the experiment with [F(9,20) = 15616.667, P = .000] for phase one (week 2 to 4), [F(9,20) = 42600. 000, P = .000] for phase two (week 6 to 8), [F(14,30) = 53.559, P = .000] for phase three (week 10 to 13).

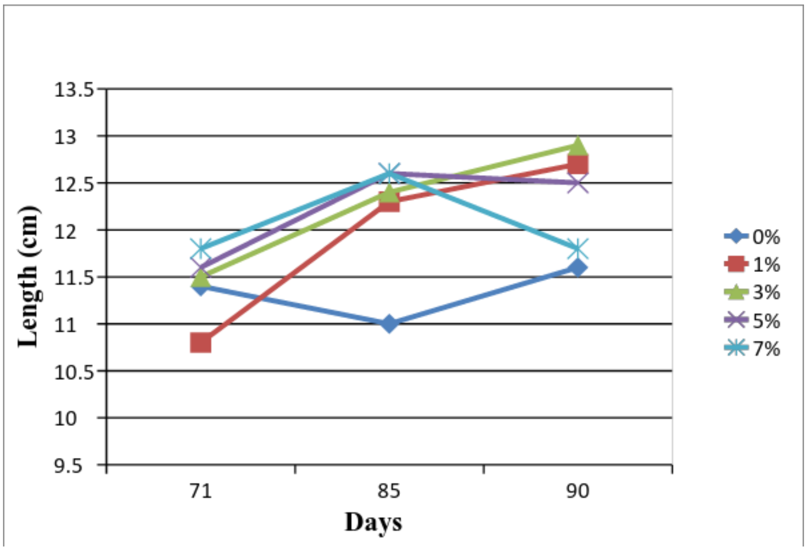

Fig. 4 Fish growth weight at the phase three (week 10, 12 &13).

The relationship between fish length and weight in different ratios of spirulina was investigated using Pearson product-moment correlation coefficient, to ensure no violation of the assumptions of normality and linearity. The result shows strong positive correlation between the length and weight of all spirulina ratios with r = .987, n = 21, p< 0.005 at 1%, r .988, n = 21, p< 0.005 at 3%, r = .948, n = 21, p< 0.005 at 5% and r = .986, n = 21, p< 0.005 at 7% (Table 5). The relationship helps to estimate the fish length and weight biomass as well as isometric growth of the fish (Nehemia et al., 2012). This study exhibits positive isometric growth where the fish appear to be stouter and became heavier as body length increased.

Effect of Feed Diet Consumption on Growth Performance

Total feed consumed was calculated and 7% ratio treatment was found to consume the highest amount of feed compared to other treatments (Table 6). This may be due to the increase of fish appetite and consequently improvement of the growth (Aly et al., 2008). However, it has no impact on the fish growth compared with 3% which shows higher growth (13 weeks). Feed consumption ratio (FCR) shows the amount of feed required to produce one unit of weight (Amoah, 2012). It also identifies the feed performance on fish health and the cost effectiveness. At the first phase of the experiment, 1% spirulina supplement feed shows lowest FCR with 0.178g and highest feed intake of 0.809g as well as body weight gain of 4.537g compared to other treatments (Table 7). At the second phase of the experiment treatment, with 7%, spirulina supplement shows lowest FCR with 0.145 and highest feed intake 3.66g as well as body weight gained 2 5.1g compared with other other treatments.

Table 4. ANOVA test of week`s length on different ratio of spirulina.

Variables	N	Mean	SD	df	F	P
Phase 1 (weeks 2&4)				9	15616.667	.000
Week 2 0%	3	5.00	.01	20		
Week 4 0%	3	6.10	.01			
Week 2 1%	3	5.20	.01			
Week 4 1%	3	6.50	.01			
Week 2 3%	3	5.10	.01			
Week 4 3%	3	6.50	.01			
Week 2 5%	3	4.90	.01			
Week 4 5%	3	6.50	.01			
Week 2 7%	3	5.20	.01			
Week 4 7%	3	6.50	.01			
Phase 2 (weeks 6 & 8)				9	42600.000	.000
Week 2 0%	3	7.60	.01	20		
Week 4 0%	3	9.50	.01			
Week 2 1%	3	8.10	.01			
Week 4 1%	3	9.80	.01			
Week 2 3%	3	8.60	.01			
Week 4 3%	3	10.20	.01			
Week 2 5%	3	8.40	.01			
Week 4 5%	3	10.90	.01			
Week 2 7%	3	8.80	.01			
Week 4 7%	3	11.10	.01			
Phase3(weeks10&13)				14	53.559	.000
Week 2 0%	3	11.40	.01	30		
Week 4 0%	3	11.60	.01			
Week 2 1%	3	10.80	.01			
Week 4 1%	3	12.70	.01			
Week 2 3%	3	11.50	.01			
Week 4 3%	3	12.90	.01			
Week 2 5%	3	11.60	.01			
Week 4 5%	3	12.50	.01			
Week 2 7%	3	11.80	.01			
Week 4 7%	3	11.80	.01			

However, at the third phase of the experiment the treatment with 7% spirulina supplement also shows lowest FCR with -0.16 and highest feed intake of 16.1g with lowest body weight gain of -5g compared with other treatments. This indicates the impact of higher spirulina diet feed consumption as it may negatively affect the body weight as suggested by Nakagawa and Gomez-Diaz (1995).

Table 5. Pearson product-moment correlation matrix between length and weight of spirulina ratios.

	W 0%	W 1%	W 3%	W 5%	W 7%	L 0%	L 1%	L 3%	L 5%	L 7%
W 0%	1									
	21									
W 1%	.987**	1								
	.000									
	21	21								
W 3%	.981**	.988**	1							
	.000	.000								
	21	21	21							
W 5%	.905**	.901**	.948**	1						
	.000	.000	.000							
	21	21	21	21						
W 7%	.847**	.825**	.893**	.986**	1					
	.000	.000	.000	.000						
	21	21	21	21	21					
L 0%	.963**	.942**	.976**	.945**	.918**	1				
	.000	.000	.000	.000	.000					
	21	21	21	21	21	21				
L 1%	.987**	.982**	.987**	.933**	.881**	.977**	1			
	.000	.000	.000	.000	.000	.000				
	21	21	21	21	21	21	21			
L 3%	.979**	.965**	.981**	.935**	.895**	.988**	.996**	1		
	.000	.000	.000	.000	.000	.000	.000			
	21	21	21	21	21	21	21	21		
L 5%	.970**	.945**	.968**	.954**	.929**	.985**	.987**	.993**	1	
	.000	.000	.000	.000	.000	.000	.000	.000		
	21	21	21	21	21	21	21	21	21	
L 7%	.940**	.911**	.948**	.963**	.953**	.977**	.967**	.980**	.994**	1
	.000	.000	.000	.000	.000	.000	.000	.000	.000	
	21	21	21	21	21	21	21	21	21	21

**. Correlation is significant at the 0.01 level (2-tailed).

Effect of Spirulina Diet on Fish Appearance and Activity

Color score was the determinant of red tilapia appearance in the experiment. At the end of the experimental period the fish in with 3% spirulina showed the most intense and attractive color among the treatments with orange color when compared with fish in 0% spirulina; the least attractive color. Teimouri et al. (2013) reported similar results. The dietary carotenoids content in spirulina supplement feeds may be the cause of fish color appearance as well as their skins and fins shiny (Vasudevan et al., 2006).

The activity score determined at the end of the experimental period showed also that fish with 3% spirulina treatment are the most active, based on the struggle when handled.

The least active was found, as expected, in 0% spirulina. The most active isclearly attributable to the massive weight gained by the treatment.

Table 6. Cumulative Feed Given (g) to Red Tilapia.

Week	Cumulative feed given (g)				
	0%	1	3	5	7
1	0.062	0.062	0.062	0.062	0.062
2	0.062	0.062	0.062	0.062	0.062
3	0.312	0.36	0.336	0.372	0.348
4	0.312	0.36	0.336	0.372	0.348
5	0.49	0.70	0.67	0.70	0.66
6	0.49	0.70	0.67	0.70	0.66
7	0.78	0.95	1.08	1.04	1.17
8	0.78	0.95	1.08	1.04	1.17
9	1.55	1.67	2.03	2.47	2.75
10	1.55	1.67	2.03	2.47	2.75
11	1.7	2.1	3	3.2	3.4
12	1.7	2.1	3	3.2	3.4
13	1.8	2.608	3.152	3.424	3.8

Water Quality Effect on Culture

At the beginning of the experimental study, up to week 9, the water quality was stable. Deterioration in the water quality was observed from week 10 to 13 (Table 8) which may have contributed to the decline in fish growth (Amoah, 2012).

The water pH ranged 7.26 to 7.59 up to week 9, where it rises to 8.72 at week 10 though it is slightly higher than the FAO (2016) recommendation of 6.5 to 8.5 for aquaculture. Water temperature within the weeks of 0 to 9 was within the range of 25.0 to 30.9°C. It is rises to 32.1°C at week 10, which may had affected the fish health, as it causes greater fish metabolism (FAO, 2016). The DO in water declined towards the end of the experiment (weeks 10 and 13). This may be due to the high temperature, fish metabolism or fish overcrowdings. The latter may lead to increase in fish respiration which exerts high demand for DO (FAO, 2016) and that may be the curse for poor fish growth (Amoah, 2012). High ammonia nitrogen and nitrate were also noticed in weeks 10 and 13 that further indicates water quality deteriorationand consequently affect the fish growth and health (FAO, 2016). Nitrate concentration in the water is attributable to ammonia concentration as it promotes nitrification process in the water column.

Effect of Spirulina Concentration on Gonadal Development

The Gonad somatic index (GSI) which correlates to fish weight is a vital parameter in studying the fish reproduction. A sample of five fish was taken from the experimental set-up at each spirulina concentration. After measuring the fish weight, the gonad weight was also taken to determine the effect of spirulina concentration on Gonadal development.

Table 7. Feed Conversion Rate for phase one.

Treatment	Body weight gained (g)	Feed intake (g)	FCR
Phase 1:			
0%	3.60	0.764	0.211
1%	4.537	0.809	0.178
3%	4.410	0.800	0.181
5%	4.530	0.888	0.196
7%	4.3	0.824	0.191
Phase 2:			
0%	12.367	2.540	0.205
1%	12.860	3.062	0.238
3%	16.920	3.292	0.195
5%	21.630	3.233	0.149
7%	25.1	3.66	0.145
Phase 3:			
0%	9.760	8.221	0.842
1%	17.726	10.233	0.577
3%	18.077	13.189	0.730
5%	2.970	14.755	4.968
7%	-5	16.1	-0.16

Table 8.General water quality measurements for the experimental period.

Parameter	Week 0	Week 2	Week 4	Week 6	Week 8	Week 10	Week 13
PH	7.59	7.58	7.41	7.41	7.26	8.72	7.63
Temp	30.9	29.4	28.9	29.6	25.0	32.1	31.8
DO (mg/l)	4.78	5.09	5.34	5.10	6.51	4.03	4.25
Ammonia-Nitrogen(mg/)	0.10*	0.04**	0.03**	0.04**	0.02**	0.17***	0.15***
Nitrate (mg/l)	1.3*	0.5**	0.3**	0.4**	0.2**	2.5***	2.4***

*Water clear and low algae population
**Water green and high algae population
***Water cloudy and very low algae

The result shows that 3% spirulina concentration with high body weight of 40.9g has the highest gonad weight of 0.22g and highest gonad index of 0.54 with 0% spirulina concentration exhibiting the lowest gonad weight and index (Table 9).

Table 9. Mean of fish weight Gonad weight and Gonad index (± SD).

Treatment	Fish weight (g)	Gonad weight (g)	Gonad Index (GSI)
0%	25.9± 0.77	0.09± 0.05	0.35
1%	36.1± 0.21	0.16± 0.03	0.44
3%	40.4± 0.32	0.22± 0.06	0.54
5%	29.9± 0.08	0.11±0.01	0.37
7%	25.0± 0.31	0.13± 0.03	0.52

Conclusions and Recommendations

The nutritional feed sources (spirulina) were shown to help in fish growth performance as well as product quality. Among the different ratios of spirulina used in the study, 3% shows remarkable performance in fish growth rate compared to the blank. The rest of the ratios, however, also performed better but below that of 3%. The FCR conducted shows that the feed intake with spirulina is more efficient in output compared to commercial fish feed. Water quality seems to be very important factor in influencing fish growth.

We therefor, concur with previous studies in recommending Spirulina supplement feed for improving the aquaculture as it yields higher productivity due to its rich nutrients.

It is also recommended that spirulina ratios in fish feed should be carefully formulated as excess feed utilization leads to decline in productivity. Hence a ratio between 1% to 3%, should be used in order to accomplish higher performance in all the aquaculture management process provided that water quality is carefully monitored to avoid deterioration.

Authors' Resposibility

The authors substantially contributed to the conception and design of the study, acquisition, analysis and interpretation of data. All authors are responsible for the intellectual content of the manuscript and approved the final version of the article to be published.

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