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Evaluation of *Spirulina* spp. as food supplement and its effect on growth performance of common carp fingerlings

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Abstract
This study was carried out to study the effect of adding different levels of the alga *Spirulina* spp. in fish laboratory of Animal Production Department, Faculty of Agricultural sciences of Sulaimani University, Sulaimani, Kurdistan region, Iraq. Using 72 common carp fingerling weight 45±2 gm, to test the effect of four different levels of the algae *Spirulina* spp. The control treatment T1 with 0% *Spirulina* spp., (T2) adding 1 gm *Spirulina* /kg diet, (T3) with 3 gm *Spirulina* /kg diet, and (T4) with 5 gm *Spirulina* /kg diet. Each treatment in three replicates in which six fingerlings common carp were stocked in each aquarium. Results indicated that forth treatment higher significant than other treatments in weight gain 6.89, Daily growth rate 0.17, Specific growth rate 0.147, Relative growth rate 15.31 and Food conversion ratio 2.14 for the control; while, Food efficiency ratio showed significance in T3 and T4 (62.48 and 62.47) respectively.

Keywords: *Spirulina*, growth performance, common carp fingerlings.

1. Introduction
Fisheries have always played a very significant socioeconomic role in many countries and communities, as a subsistence produce, fish is a vital resource towards poverty reduction and food security for poorer households (FAO, 2010).
To be a viable alternative, a candidate ingredient must possess certain properties such as wide availability and a competitive price, it must also be easy to handle shipping and store, several materials have been tested as alternative protein sources, such as animal by-products, single cell proteins including micro algae, bacterial single cell protein [9, 19].
Declared *Spirulina* as "the best for tomorrow", and it is gaining popularity in recent years as a food supplement [12]. The economic importance of cyanobacteria primarily lies in their agronomic importance as bio fertilizers due to N_2-fixation that helps them to grow successfully in habitats where little or no combined N is available. In recent times, their ability to produce structurally novel and biologically active natural products has been recognised [28, 12, 31].
The use of cyanobacteria as an unconventional source of food and protein increased [11, 27]. Certain cyanobacteria, known as extremophiles, inhabit extreme environments, e.g. *Spirulina* (alkalophilic), because of their special requirements, mass cultures of extremophiles are likely to be free from microbial contamination thus, avoiding a serious problem in outdoor cultures [3].
A number of authors [6, 5, 4] have investigated the utilization of microalgae in the diet of aquaculture species.
Earthrise farms, a commercial producer of *Spirulina* in California, estimate that Japanese fish farmers used about $2.5 million worth of *Spirulina* in 1989 [13]. Their promotional literature lists the key benefits associated with the use of *Spirulina* in aquaculture:

1. Better growth rates are obtained, and less feed is wasted because of the inherent palatability of *Spirulina.* Fish fed with this cyanobacterium have less abdominal fat, the energy being redirected into growth. This hypothesis was tested and verified in feeding trials with cherry salmon

2. Fish fed *Spirulina* have an improved quality in terms of flesh flavor, consistency and color. Henson (1990) [13] reports that sea bream, Mackeral, Yellowtail, and ornamental koi carp exhibited enhanced coloration upon feeding with *Spirulina* supplements.

The aim of present study was to examine the effects of adding *the microalgae Spirulina* to common carp diet on growth performance.

2. Material and Methods

2.1 Experimental animal

The experiment was conducted for 42 days and for this purpose 72 fingerlings common carp *C. carpio* L. (weights ranged between 40-49 g) were brought. The fish were sorted depending on size then weighed and put in experimental plastic aquariums. The fish were acclimated to laboratory conditions and fed with control pellets (31% protein) prior to the feeding trials for 21 days.

2.2 Experimental system and design

Twelve plastic aquariums (100 L) were used in this trial. Each tank was provided with a proper continuous aeration. Each aquarium was stocked with six fish. The numbers of treatments in the trial were four with three replicates for each. The aquaria (replicates) were randomly allocated to minimize differences among treatments. The continuous water flow discharged non-consumed feed and feces particles from the aquaria. In addition, a daily cleaning by siphon method was applied to remove remaining particles from the system.

2.3 Diet formulation

Experimental diets were prepared with the ingredients shown in Table (1). The ingredients were mixed with water to obtain dough. Then, the dough was passed through an electrical mincer for pelleting by using Kenwood Multiprocessors. The pellets were dried at room temperature for a few days and crushed to yield fine particles. Feeding rate was determined to be 3%, fish were individually weighed weekly. The feeding amount was then recalculated according to weekly weights.

Table 1: The structure of experimental diet

Ingredients	Weight in diet (gm/kg)
Fishmeal	150
Soybean	350
Wheat bran	130
Wheat flour	100
Barely	100
Corn	100
Starch	50
Premix	20

2.4 Used Spirulina

Blue green algae tablets as food supplements, the product information as labelled per three tablets contain 1500 mg, their ingredients:

D-Calcium phosphate, microcrystalline cellulose, Anticaking agents (Silicon Dioxide, vegetable sources Magnesium Stearate). Manufactures in the UK to GMP & pharmaceutical standards, Natures Aid Ltd. Preston PR4 2DQ UK.

2.5 Growth parameters

The individual body weight (g) for all fish per treatment were measured twice a week. The feed consumption of each treatment was recorded and readjusted according to the obtained biomass at every treatment weekly. The average body weight gain (ABGW) as (g/fish) was estimated according to the following equation:

Body weight gain (g/fish) = Mean of weight (g) at the end of the experimental period – weight (g) at the beginning of the experimental period

Daily weight gain (DWG) = Gain / experimental period

Relative weight gain (RWG %) = Gain / initial weight x 100

Specific growth rate (SGR) = (In W_1 – In W_0) / T) x 100

W_1: final weight W_0: initial weight T: time between W_1 and

W_0 Feed conversion ratio (FCR) =Total feed fed (g/fish) / total wet weight gain (g/fish)

3. Results and discussion

The primary objective in fish nutrition is to provide a nutritionally balanced mixture of ingredients to support the fish vital functions in an acceptable cost (NRC, 1993). *S. platensis* was reported to improve feed efficiency, carcass quality, and physiological response to stress in several species of fish [18]. None of the previous studies recommended an optimum concentration of dietary *S. platensis* b] ased on graded level study.

Spirulina appeared to be a useful tool to include in the arsenal of disease control and prevention. However, it must not replace good management techniques. The strength of *Spirulina* appears to lie in its ability to improve growth, survival and non-specific immune function against fish pathogens as well as its chemo-protective efficiency. The algae may significantly aid the aquaculture industry.

In the current study, we expanded the *S. platensis* dietary concentration to be 1, 3, and 5 g/kg in order to assess the optimum dietary concentration for common carp using pure whole *S. platensis* in powder form.

Specific growth rate (SGR) is the measuring tools reflecting the fish health status under natural and experimental conditions. In the current study dried *S. platensis* found to be of potential effects on growth at an optimum concentration of 5 g/kg. It's worth mentioned that the mean value level in the group received 5 g/kg is higher in all the tested parameters with significant difference; these results cleared that the optimum dietary level of S. platensis for *C. carpio* is 5 g/kg for studying period (as shown in table 2) to enhance growth performance. (Duncan and Klesius 1996) [8] reported that *Spirulina* alga was a good source of protein for animal feed, being containing high amounts of vitamins and minerals, in addition, (Nakono et al. 2003) [20] recorded that the lack of cellulose from the cellular structure of *Spirulina* render it easily digestible, thus, increase fish appetite, improve feed intake and nutrient digestibility and in turn enhance the health of fish, increasing the ability to fight off infections through the reduction of stress levels. The results of the current study are in accordance with (Takeuchi et al. 2002 and Ibrahem *et al*., 2013) [18, 15] who found that feed supplemented with *S. platensis* powder improved the feed conversion ratio and growth rates in striped jack, *Pseudocaranx dentex* and (*O.*

niloticus. Lu *et al*. 2002) demonstrated that raw *S. platensis* can be an effective uni-feed for larval tilapia at a feeding rate of 30% (on a dry basis) of body weight. Abdel-Tawwab and Ahmed (2009) [1] and Al-Koye (2013) [4] recorded that the growth and feed utilization of *O. niloticus* were obtained at 5.0 g fresh culture of *S. platensis* /kg diet. On the contrary, (Ungsethaphand *et al*. 2010) [33] recorded that the final weight gain, specific growth rate, feed conversion ratio of hybrid red tilapia were not affected by *S. platensis* supplementation. These variations might be attributed to the difference in the *S. platensis* concentration to exert the intended effects, the form of *S. platensis*, raw or dried *S. platensis* or even its products, fish species and size in addition to the rearing conditions.

Table 2: Effect of adding *Spirulina* in some growth parameters for common carp reared from 42 day

Treatments	Weight gain	Daily GR	Specific GR	Relative GR	FCR	FER
T1	5.88 b	0.14 a	0.124 b	12.83 b	2.14 a	46.99 b
T2	3.49 c	0.15 a	0.127 b	10.92 c	1.13 b	49.92 b
T3	5.34 b	0.13 a	0.119 bc	12.23 b	1.62 b	62.48 a
T4	6.89 a	0.17 a	0.147 a	15.31 a	1.07 bc	62.47 a

In addition, certain species of *Spirulina* have no cell wall, which results in improved digestion and absorption [21]. Improvement in growth of fish by dietary inclusion of *Spirulina* has been reported earlier in a number of studies [32, 4]. Growth in fish is primarily due to muscle protein deposition and it therefore follows that the flow of amino acids from food to growing biomass. Fish require some main nutrients such as protein, fat, carbohydrate, vitamins and minerals, but these requirements vary by species, observed improved growth rate (up to 1.5 times), survival rate and feed efficiency under 1-10% *Spirulina* supplementation compared to the basal diet, disease resistance against bacterial infection was also observed (Nose, 1989) [22].

The *Spirulina*-incorporated diets produced better SGR and FCR than the probiotic diets, the PER indicates that supplementing diets with *Spirulina*, followed by yeast and bacteria, significantly improves carp performance [25].

These results showed that *Spirulina* could improve growth, reduction of mortality; overall elements of fish quality, firmness of flesh, brightness of skin color as well as improving the cost/performance ratio of the fish feed. Other researchers (Tongsiri *et al*., 2010; Kiron *et al*., 2012) [32, 16] reported similar results. Use of plant products as protein sources in fish feeds shows considerable application potential for aquaculture worldwide [2, 29, 34]. In sturgeon and *C. carpio*, PER was more favorable in *Spirulina*-based diets than in the control diet [24, 17].

Similar to our results, it has been summarized that many species of fish grow better on algae-enriched diet than on any other fish feeds [14]. The PER and PPV results indicate that supplementing diets with *Spirulina* significantly improves protein utilization in Tilapia. This contributes to optimizing protein use for growth, a significant quality given that protein is the most expensive feed nutrient, the improvement in the biological value of the supplemented diets in these treatments with high population and low dietary protein demonstrated that *Spirulina* supplements performed more efficiently in stress situations [26, 7, 4].

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