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Original Research Article

Growth and survival of red Tilapia (*Oreochromis aureus x Oreochromis mossambicus*) fry fed on corn and soy meal, peanut meal and fishmeal enriched with spirulina (*Arthrospira platensis*)

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In order to promote the feed production of Tilapia in Senegal, three diets were produced from animal raw materials, agricultural by-products and spirulina at rates of 0%, 17%, and 32 %. In order to evaluate their effects on growth performance, survival, feed efficiency and carcass composition , three diets were composed of 25% protein and 8.62% lipid R1, 30% protein and 8.31% lipids R2 and 35% protein and 8.62% lipids R3. A total of 60 hybrid red Tilapia fry with an initial mean weight of 0.6 g were distributed in an isolated system consisting of 80-liter plastic tanks with a density of 10 fish per tank. The present study was carried out at the Ouakam hatchery. After 8 weeks of experimentation, the results revealed that for all treatments studied, the mean temperature was around 23.94°C. The final mean weight varied between 1.41 g and 3.29 g according to the treatments. The best growth parameters and feed efficiency studied, such as absolute mean weight gain, relative mean weight gain, specific growth rate, daily individual growth, feed conversion rate and protein efficiency rate were obtained in the diet R3 composed of 35% protein and 32% spirulina. The best survival rate 97% was recorded at control diet R1 containing 0% spirulina.The protein content of the carcass is higher in fish subjected to the different R1 (59.77), R2 (60.24), R3 (60.77) diets than in the initial fish (48.64). The fat content of the initial fish recorded the highest rate (33.83) compared to the R1, R2, R3 diets respectively 26.54, 23.36 and 24.79 which decreased. Finally, for the dry matter content, it increased slightly in the experimental diets R2 (96.55) R3 (96.50), except for the diet R1 (94.93) which recorded a lower rate than the initial fish (95.37). Results obtained at the end of this study suggest that spirulina can supplemented with fish meal in diet of hybrid red tilapia fry

Key words: Growth, food, tilapia, rate, diet, feed, survival.

INTRODUCTION

The fish-farming sector has not yet reached a viable economic dimension in Africa, either in terms of volume or in terms of the place of this activity in other production systems (Mustafa and Nakagawa, 1995). The use of fishmeal as the primary source of protein in aquaculture feeds is at the cost of these foods (Tacon et al., 2006).

Table 1. Feed formulation

	Diets		
INGREDIENTS (g)	**R1**	**R2**	**R3**
Fish meal	250	210	180
Spirulina	0	170	320
Peanut cake	100	100	100
Corn flour	300	300	300
Corn flour	270	140	20
Natural binder (Lalo)	30	30	30
Palm oil	30	30	30
Vitamin mix	10	10	10
Mineral mix	10	10	10
TOTAL (g)	1000	1000	1000

Tilapia is the second most cultivated in the world (6.67 million tonnes respectively) after carp and consumes about 3% of the world's fishmeal supply (Tacon and Metian, 2015). Fishmeal is rich in Essential Amino Acids (AAE) whose profile corresponds remarkably to the needs of fish (Azaza et al., 2005). FAO has reserved unicellular products, including algae, as potential alternatives to fishmeal and terrestrial vegetable protein in fish diets (Habib et al., 2008; Ahmadzadenia, 2011). Algae have great potential as an effective supplement for fish feed and protein source (Habib et al., 2008). Spirulina species are the most frequently used (Mustafa and Nakagawa, 1995) and have been specifically selected by FAO as an area of focus given its full nutritional profile (Habib et al., 2008). Its protein is excellent quality since it contains all the essential amino acids and is easily assimilated by the body and very rich in vitamins (A, B1, B2, B12, E) and assimilable iron (Pierlovisi, 2008). It also contains calcium, phosphorus, magnesium in a quantity comparable to cereals and cow's milk (Pierlovisi, 2008). This study was conducted to test the zootechnical performance of a diet based on corn and soy meal, peanut cake and fishmeal enriched with spirulina.

MATERIALS AND METHODS

The study was carried out at the premises of the aquaculture station of Cheikh Anta Diop University in Senegal located in the West Corniche, in the enclosure of the fishermen's house.

Biological material

Red tilapia fry were used as biological material for experimental purposes including hybrids from a cross between *O. aureus* and *O. mossambicus*. They are considered omnivorous fish because they are able to feed on benthic algae and litter (Dempster et al., 1993; Azim et al., 2003). Spirulina powder (*A. platensis*), a 0.3 mm long aquatic bacterium, was used as plant material for experimental purposes. It contains in dry weight up to 70% of proteins, 15 to 25% of carbohydrates, to 11% of lipids. Spirulina also contains vitamins, minerals (mainly trace elements), chlorophyll and phycobiliprotein.

Food manufacturing method

Feeds were formulation by used ingredients including fishmeal, corn flour, palm kernel oil, fonio flour, peanut cake, spirulina, vitamin, binder, water.

Food manufacturing procedure

Three regimes differentiated by the spirulina incorporation rate and the protein level were produced: a control R1 diet (without spirulina) and two regimes R2 and R3 respectively containing 17% and 32% spirulina. The different proportions of ingredients (Table 1) are formulated for each 1 kg of feed. The raw materials are weighed and mixed with the vitamins, minerals, binder and oil so as to obtain a homogeneous mixture. Water was then added at 30% dry matter. The passage of the latter in a reel made it possible to obtain spaghetti filaments 2 mm in diameter. These filaments are subsequently dried in the sun, fragmented and crushed using a grinder to finally obtain a powder stored in glass jars and intended for feeding the fry.

Livestock management

Overall, sixty red tilapia fry were distributed in six 80-liter trays, or 10 individuals per tray. The initial biomass in each bin was 6g and the average individual weight was 0.6g. Each food has been tested on 2 bins (in duplicate). During 8 weeks of experimental, the temperature is raised before siphoning of the tanks. This siphoning, to clean the waste accumulated in the breeding tanks, is performed twice a day; in the morning and afternoon before feeding. In each tank, the siphoning water is replaced. The daily ration distributed corresponds to 15% of the live weight of the fish during the first two weeks. For the rest of the experiment, the ration decreased to 10%, 8% and 6% respectively in the 4th week, 6th week, 8th week. The distribution of the feed was carried out manually and offered at, a rate of 3 meals per day (9h, 13h, and 17h).

Table 2. Parameters of Growth, Survival and feed Efficiency

Growth parameters	Diets R1	R2	R3
Initial average weight (g	0.6	0.6	0.6
Final average weight (g)	1.41	2.48	3.29
Average absolute weight gain (g	0.81	1.88	2.69
Relative weight gain (%)	134	313	448
TCS (%pc/day)	1.41	2.36	2.84
CIJ	0.01	0.03	0.5
TCA	5.17	2.49	1.95
CEP	0.64	1.23	1.52
Survival rate (%)	97	93	72

Every two weeks, measures of growth parameters from (weight gain and survival) are made to evaluate the nutritional quality of feed.

Parameters of growth, survival and feed efficiency

The absolute average weight gain (GPmA in g): this parameter tells us about the total growth of the fish during the breeding period. It is calculated from the formula:

$$GPmA(g) = \text{final average weight} - \text{initial average weight}$$

Relative weight gain (GPr in%): this parameter makes it possible to evaluate the weight growth of the fish during a given time. It is calculated from the following this formula:

$$GPr(\%) = \frac{\text{final average weigh} - \text{initial average}}{(\text{initial average weight})} x\ 100$$

Specific growth rate (TCS %pc / day): This coefficient is used to estimate the weight gained per day per fish, as a percentage of live weight.

$$TCS(in\ \%pc/day) = \frac{\ln(\text{final average weight}) - \ln(\text{initial average weight})}{\text{duration of experience/day}} x\ 100$$

Daily individual growth (CIJ): Individual daily growth is an index used to express the daily gain in weight of each individual throughout the duration of the breeding. It is calculated according to the following formula:

$$CIJ = \frac{Pmf - Pmi}{\text{Duration of breeding}} x100$$

with Pm = average weight

Food conversion rate (TCA): This coefficient is used to characterize the efficiency of use of the feed.

$$TCA = \frac{\frac{\text{Amount of feed distributed}}{\text{Fish}}}{\text{weight gain}}$$

Coefficient of Protein Efficiency (CEP):CEP is defined as the ratio of protein intake in g to body weight of fish. It is a means used to determine the ability of the species to use dietary protein.

$$CEP = \frac{GPA}{Qx\ Cx\%(\text{protein of the feed})} x100$$

Survival rate (TS in%): it is the ratio between the number of fish at the end and at the beginning of the experiment, according to the relation:

$$TS(\%) = \frac{\text{Final number of fish}}{\text{number of initial fish}}$$

Data analysis

The data obtained was entered and calculated with Microsoft Excel. The analysis of some data was performed with the XLSTAT subjected to analysis of variance (ANOVA). The Tukey test was used to compare significant differences between treatments. The differences among means at 5% significance level (Differences were regarded as significant when $P < 0.05$).

RESULTS

Parameters of growth, survival and feed efficiency

During the experiment, different growth parameters were determined to evaluate the fish growth of each treatment. Overall results of growth and survival parameters versus diets on survival and growth of red tilapia are obtained after 8 weeks of experimental period (Table 2).

Weight gain

The batch of fish fed with the diet R3 receiving a proportion of 32% spirulina has the best average weight gain (2.69 g) followed by the batch R2, diet containing 17% (1.88g) and finally the fish fed with the diet R1 containing 0% Spirulina

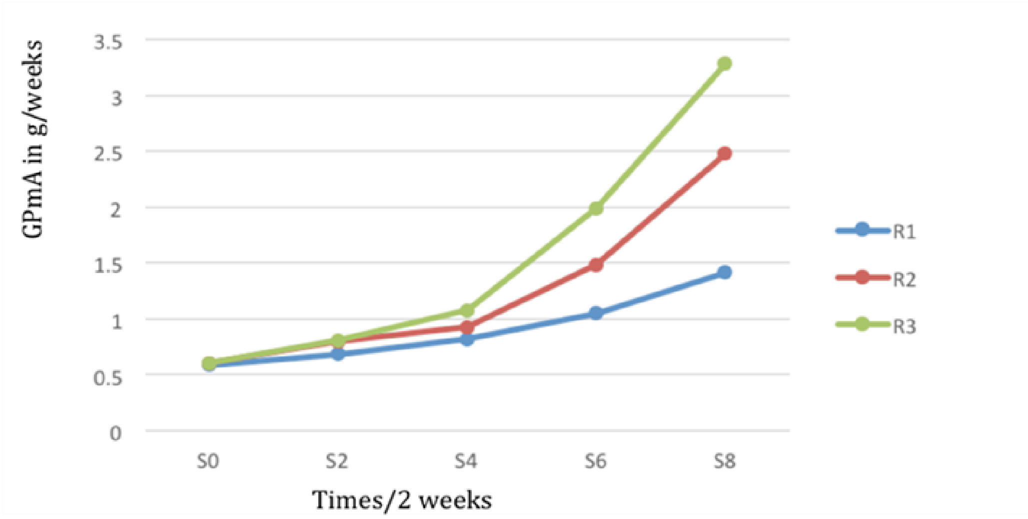

Figure 1: Evolution of fry weight as a function of time (during 8 weeks)

Table 3. Evolution of absolute average weight according to treatments and time

Treatment	S0	S2	S4	S6	S8
Farine (R1)	0	0.06±0.0647	0.1111±0.1058	0.5±0.1553	0.9444±0.2924
Spirulina 17% (R2)	0	0.1667±0.0665	0.3889±0.1058	1.0588±0.1598	2±0.3009
Spirulina 32% (R3)	0	0.1±0.0631	0.6316±0.1030	1.611±0.1553	2.8235±0.3009
P	0.203	0.0038	0.0002	0.0001	0.0001

(0.81g). For the relative weight gain we get the same performance (Figure 1). Table 3 shows the variations in average weights for different treatments over the duration of the experiment. The results obtained (Tukey test) show a low variation in the average absolute weight in the first two weeks (P = 0.203). Beyond the second week the variations were highly significant (S4: P = 0.0002, S6: P = 0.0001, S8: P = 0.0001).

Specific growth rate

As can be seen the specific growth rate (Figure 2), the best growth performances are obteined in the fish fed with the R3 diet containing 32% spirulina followed by the R2 diet containing 17% Spirulina and finally R1 containing 0%.

Specific growth rate

With regard to the specific growth rate, the best growth performance are observed in the fish fed with the R3 diet containing 32% spirulina followed by the R2 diet containing 17% Spirulina and finally R1 containing 0% (Figure 3).

Survival rate

During the whole period of the experiment, the survival rate was various between diets with the range of 72- 97% and 72%. The highest value of 97% is obtained in fish fed with the R1 diet, followed by 93% in the fish fed with the R2 diet and finally the lowest value, 72%, is obtained in fish fed with the R3 diet containing 32% spirulina (Figure 4).

Food conversion rate (TCA)

Statistically, there is a significant difference between the diet (R3) that has the best TCA and the other 2 diets (R1 and R2). On the other hand, there is no significant difference between the feed R1 and R2, which contain 0% and 17% of Spirulina (Figure 5).

Protein Efficiency Coefficient (CEP)

For the protein efficiency coefficient, the best results are obtained with regimes R2 (1.23) and R3 (1.52) without significance difference between them. However the R1 regime (0.64) showed a significant difference (Figure 6).

Bromatological composition of fish flesh

Analyzes of the bromatological composition of fish flesh (protein, dry matter and fat) determine the composition of fish flesh at the beginning and end of the experiment (Table 4).

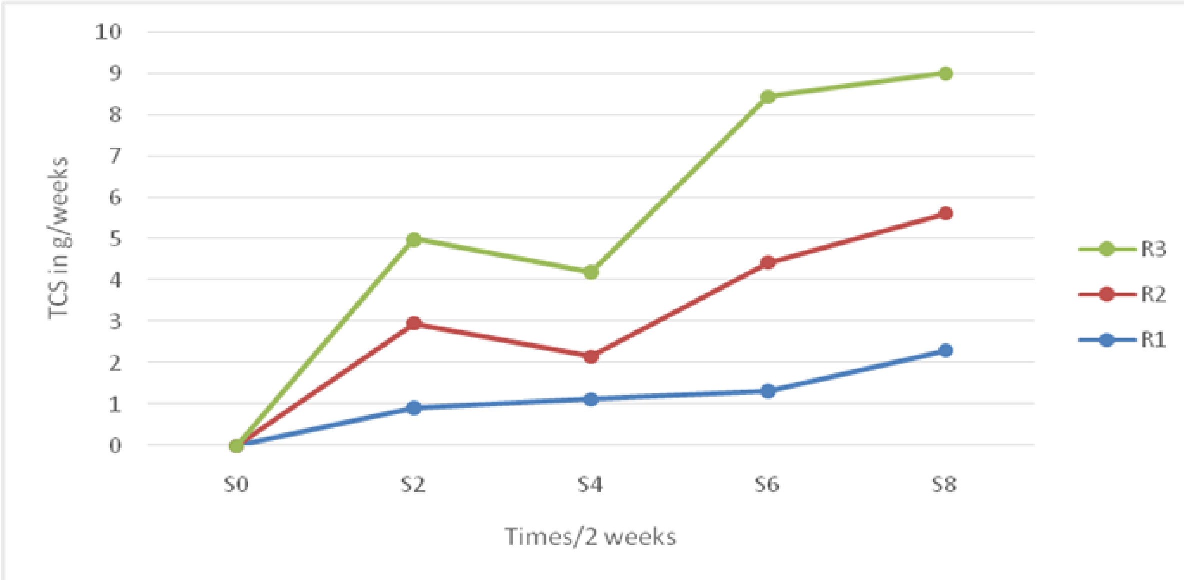

Figure 2: Evolution curve of the TCS as a function of time (8 weeks)

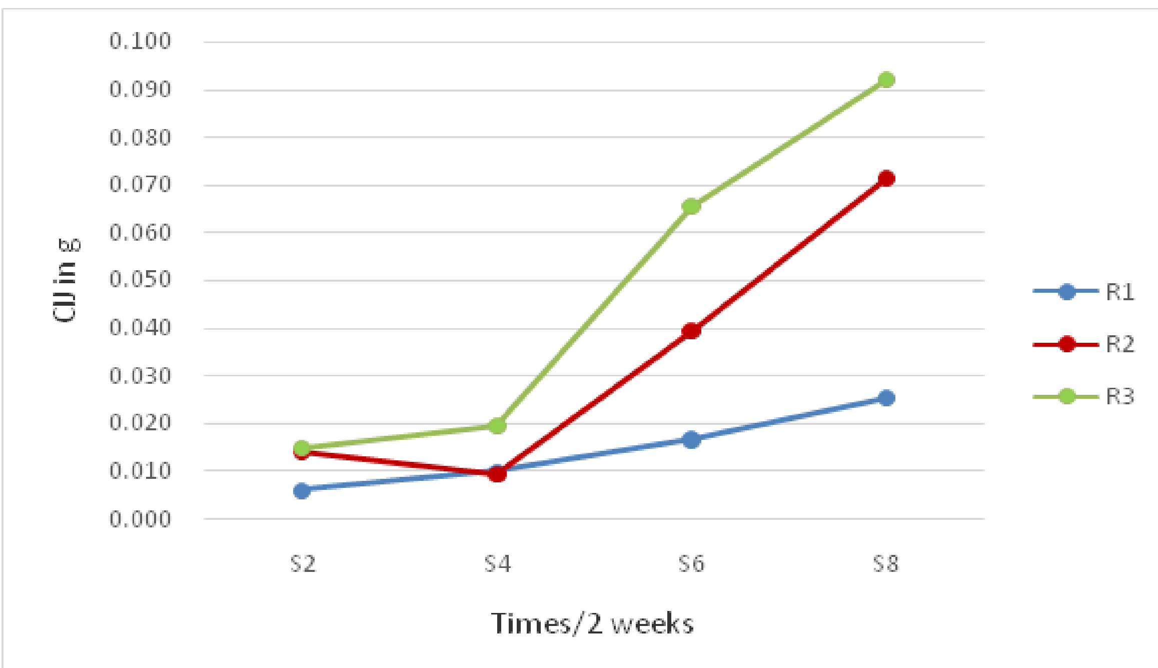

Figure 3: Curve of evolution of the CIJ as a function of time (8 weeks)

The results showed that the protein content of the initial fish (48.64) is lower than that of the final diet R1 (59.77), R2 (60.24) and R3 (60.77). In addition, the best fat content was obtained at the level of the initial fish (33.83%) with those of the other diets significantly lower R1 (26.54), R2 (23.36), R3 (24.79). Finally dry matter levels increased slightly at R1 (94.93), R2 (96.55), R3 (96.50) compared to the initial fish (95.37).

DISCUSSIONS

Parameters of growth, survival and food efficiency

The inclusion of spirulina in diets, R2 and R3 respectively containing 17% and 32% spirulina, tested on red tilapia fry (*Oreochromis* sp) during the experimental phase showed

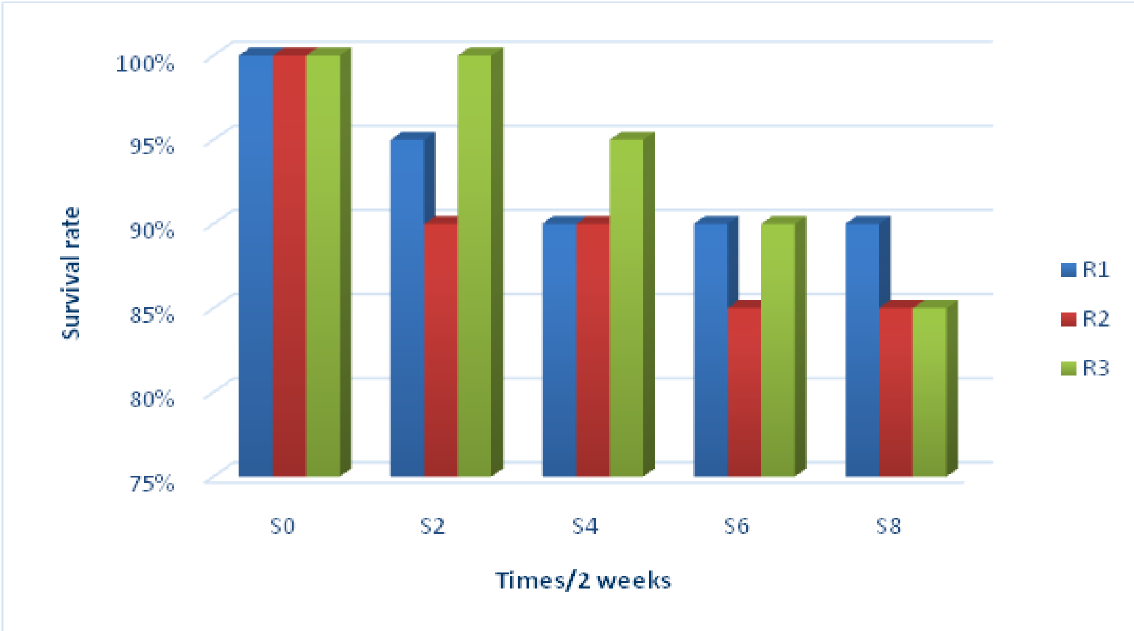

Figure 4: Curve evolution of the survival rate as a function of time (8 weeks)

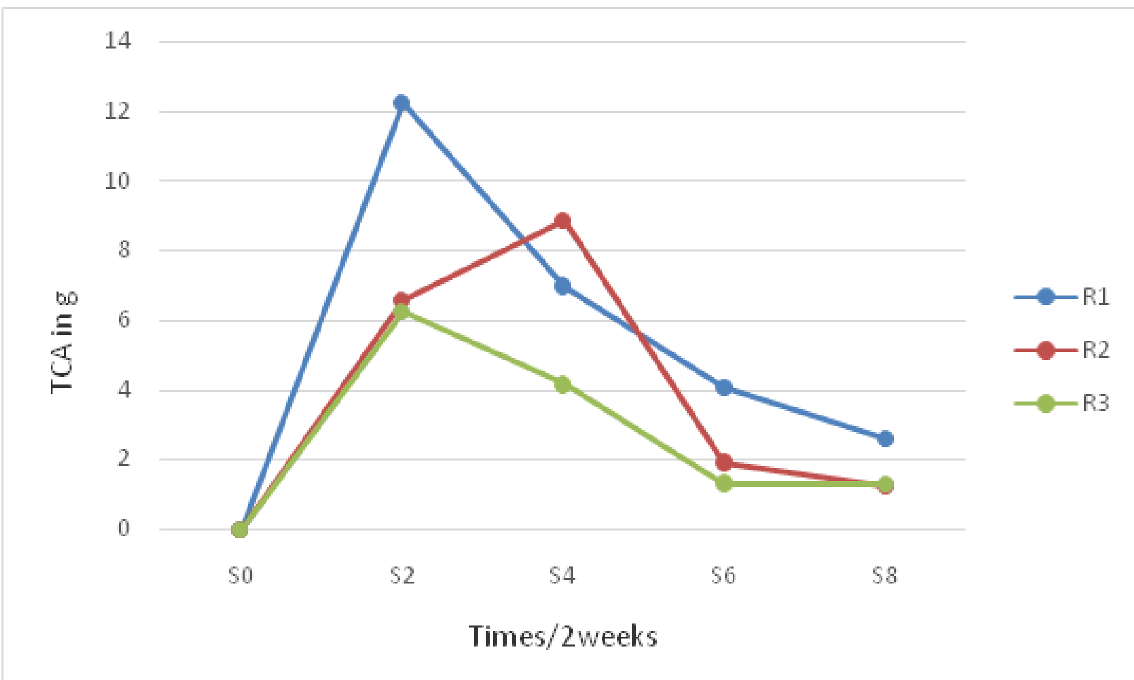

Figure 5: TCA evolution curve as a function of time (8 weeks)

good growth performance. On the other hand, the best survival rate was observed at the level of the R1 diet.

Weight gains

For the relative weight gain and the absolute average weight gain, the best results were observed in the batch of fish fed the diet R3 (containing 32% spirulina).

In fact, concerning the average absolute weight gain, the batch of fish fed with the R3 diet receiving a 32% proportion of spirulina has the best average absolute weight gain (2.69 g) followed by the R2 batch, fish fed with

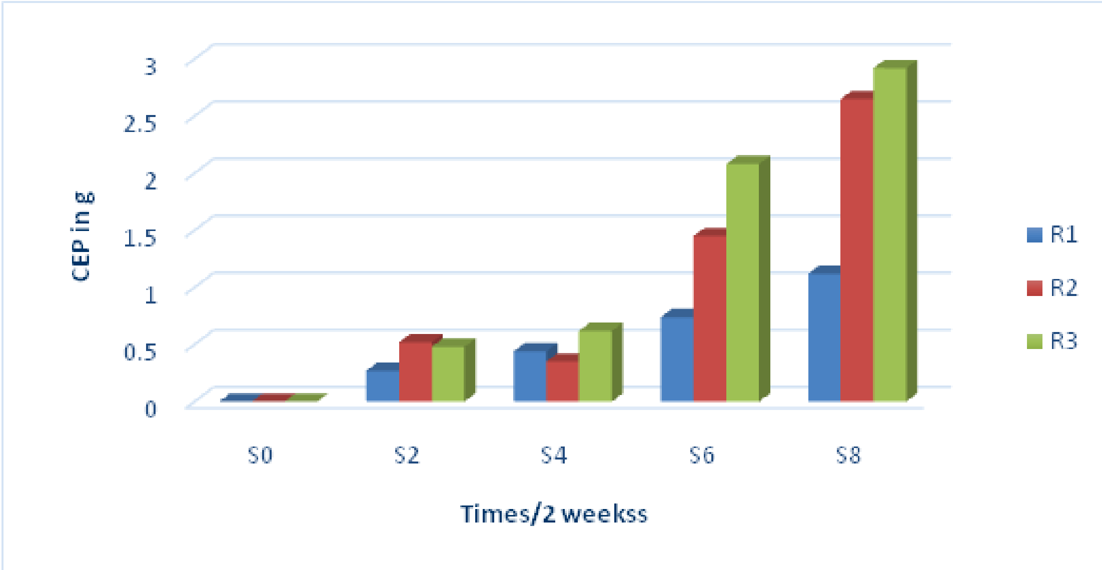

Figure 6: Curve of evolution of the CEP as a function of time (8 weeks)

Table 4. Bromatological composition of fish flesh at the beginning and end of the experiment (%DM basis)

		DIETS		
Composition	**Initial**	**R1**	**R2**	**R3**
Protein %	48.64	59.77	60.24	60.77
Fat %	33.83	26.54	23.36	24.79
Dry matter %	95.37	94.93	96.55	96.50

diet containing 17% Spirulina, (1.88g) and R1, control diet containing no spirulina, (0.81g). The difference in growth performance recorded between the R3, R2 and R1 diets would result from the better degree of convertibility of the ingredients incorporated in these feed (Ahmad et al., 2012; Hajiahmadian et al., 2012). On the other hand, the feed used in the R3 diet would be more digestible and easily assimilated by fish than the feed R1. According to Köprücü and Özdemir (2005), the digestibility of feed depends on the nature of the ingredients used. The observed growth gap could be related to the nature of the ingredients used as highlighted by (Burel et al., 2000; Köprücü and Özdemir, 2005; Iga-Iga, 2008). This increase could possibly be due to the improvement of the food intake and the digestibility of the nutrients consequently the microalgae A. platensis has improved the growth of these fry. These results are identical with those obtained by Dawah et al. (2002), who found that adding algae to fish diets improved the growth of Nile tilapia (*O. niloticus*). (Nandeesha et al., 1998) also reported that the body weight gain of Nile tilapia (*O. niloticus*) increased linearly with increasing algae levels in the diet of fish.

However, other studies revealed that the high inclusion of Spirulina leads to a depressed growth rate. Sharma and Panta (2012) and El Sayed (1994) suggest that inclusion of Spirulina above 30% is detrimental to fish growth. Similarly, Olvera-Novoa et al. (1998) reported high growth rates in diets containing 10% and 20% protein Spirulina, but halved growth rates in diets containing more than 40% Spirulina. The relative weight gain in turn shows that the best results were still recorded with the R3 diet containing 32% spirulina or 448%, followed by the control containing 17% spirulina (313%) against 134% at the R1 diet containing 0% % spirulina.

Specific growth rate

For the specific growth rate, the best results were obtained with regimes R2 and R3 respectively containing 17% and 32%. The specific growth rate increases according to the high spirulina rate, therefore the protein level of the feed. Many authors have obtained similar results in their studies on tilapia nutrition. El-Sheekh et al. (2014) in their study had the best TCS in diets containing 20% and 30% spirulina. However, Allen (2010) obtained TCS that decrease with the high rate of spirulina incorporated in these foods. For 15%; 30% ; and 45% he gets TCS respectively 1.29; 0.99; and 0.93.

If we analyze the TCS from the point of view of protein content we will clearly see that the best TCS was obtained in the R3 diet containing the highest content of Protein. Siddiqui et al. (1988) report an optimal requirement of 40% for fingerlings of *O. niloticus* (initial weight 0.838g), and 30% for juveniles (initial weight, 40g). (Jauncey 1982, Teshima et al., 1992; Faye et al., 2018) reported that for rearing fry require 40% protein for normal growth. Kaushik et al. (1995) observed a maximum growth rate and feed efficiency at 35% of dietary protein for the same species. Diyaware et al. (2009) also support our conclusion by revealing that the best growth rates of hybrid catfish, *Heterobranchus bidorsalis* and *Clarias anguillaris* fry are obtained with a 40% crude protein content. Sotolu (2010) obtained a better weight gain, a specific growth rate and a feed conversion rate with a 40% dietary protein content in *Clarias gariepinus*. Adewolu and Adoti (2010) reported that fish fed continuously with 35% protein diets significantly resulted in the best weight gain, specific growth rate (Dernekbasi et al., 2010; Sarr et al., 2015).

CONCLUSION

The objective of this study was to determine among different spirulina levels incorporated in feed formulated for better growth and survival of red tilapia fry by a high performance feed formulation. At the end of this study, encouraging results, although preliminary, were obtained. Given the growth performance obtained in the various diets, we can say, in the current state of our knowledge that the R3 diet (containing 32% spirulina that is to say 35% protein) is the diet the more interesting in terms of quality, because the best feed witch is the one that best covers the nutritional needs of fish. The feed used in this study consists mainly of spirulina, fishmeal and agricultural by-products. This work carried out in an above ground structure should therefore be taken up in ponds, where natural productivity could contribute to improving the results. Knowing the potential of tilapia to benefit from various dietary sources in the natural environment, fish-mediated plankton or benthos organisms could, to some extent, solve the problem of deficient nutrients. Also, it would be interesting to integrate the study of the immune system of fish fed with Spirulina because the latter is able to increase the resistance of humans and animals.

Conflict of interests

The authors declare that they have no conflicting interests

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