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Incorporation of *Tagelus adansonii* Bosc 1801 (Bivalvia, Mollusca) meat meal in the diets of Tilapia *Oreochromis niloticus* fry: effects on growth, feed efficiency, survival and flesh composition

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ABSTRACT
Objective: The objective of this study was to investigate whether Tagelus meat meal could completely or partially replace fishmeal in the diet of *Oreochromis niloticus fry without affecting the growth and feed efficiency parameters*. Furthermore, to also check whether the incorporation of Tagelus meat meal in the diet of *Oreochromis niloticus* will pose any significant effect on the body composition or not.
Methodology and results: Fry of *Oreochromis niloticus* (225 individuals) with an initial average weight of 0.013 g were distributed in triplicate in 15 tanks with a density of 15 individuals per tank. They were subjected to five diets with varying levels of protein (33-36%) and lipid (11-13%) containing 0% Tagelus meat meal and 100% fishmeal, R0 (control diet); 25% Tagelus meat meal, and 75% fishmeal, R25 diet; 50% Tagelus meat meal and 50% fishmeal, R50 diet; 75% Tagelus meat meal and 25% fishmeal, R75 diet and 100% Tagelus meat meal and 0% fishmeal, R100 diet for 8 weeks. The results showed that the best growth performance was obtained with the R25 diet, while the lowest was obtained with the R100 diet. Diets R0, R25 and R50 gave similar values for growth parameters measured. The best feed conversion ratio (FCR) was obtained with the R25 diet but there were no statistical differences between it and R0 and R50 diets. In this trial generally, the replacement of fish meal with Tagelus meat meal up to 50% had no major influence on fish whole body composition (DM, CP and CL).
Conclusion and application of results: It can be concluded that Tagelus meat meal could replace fishmeal up to 50% nevertheless, to be at a safer side, the authors recommended 25% fish meal replacement with Tagelus meat meal in the diet of Tilapia (*Oreochromis niloticus*) fry. It was

observed that the high incorporation rate of Tagelus meat meal caused lower growth performance and feed efficiency. Now that it is tested and verified that *Oreochromis niloticus* fry could utilized Tagelus meat meal in their diet, this will help fish farmers and fish feed manufucturers to use it in fish feed. This will attach economic value to Tagelus especially in places where they are not considered as important source of food for humans.
Keywords: fishmeal, Tagelus meat meal, replacement, growth, feed efficiency, survival, flesh composition, *Oreochromis niloticus*

INTRODUCTION

The incorporation of fishmeal in fish feed for intensive fish production has been primarily responsible for the high cost of aquaculture production in many African countries. The scarcity and high cost of fishmeal in formulated feeds have led to the search for other protein sources such as marine invertebrates. Consequently, it has been prescribed that aquaculturists and fish nutrition experts be in continuous search for alternative sources of animal protein, which is affordable and available for the replacement of fishmeal in aquafeed production (Okanlawon and Oladipupo, 2010). Aquaculture is increasingly gaining much importance. It continues to grow at a faster rate than all other sectors producing animal origin food. From the production of less than one million metric tons in the early 1950s to the production of over one hundred million metric tons in 2016 (FAO, 2018) is rather remarkable; however, these spectacular advances in aquaculture are less visible in some areas of the world. This is the case in Senegal, where the sector continues to occupy a minor place despite its natural potential. Indeed, Senegalese aquaculturists lack feed formulas that can ensure a better yield with a low production cost. Among the constraints of aquaculture development is the excessive use of fishmeal, the primary animal protein source in aquaculture feeds. As almost all capture fisheries are overexploited, it is necessary to reduce fishmeal proportion in the feed. Therefore, in order to offer fish farmers suitable solutions, alternative animal protein sources available and cheap, such as local marine aquatic invertebrates should be used. Benthic molluscs are highly diverse and widely distributed in mangrove ecosystems. Among the great diversity of bivalves, only two species are commonly exploited and studied in Senegal's mangrove ecosystems which are *Senilia senilis* and *Crassostrea tulipa* (Diatta, 2018). There is the genus *Tagelus* belonging to the family solecurtidae, and accounting for nearly eleven species throughout the world which is also available in Senegal. *T. adansonii* is a protein-rich mollusc with biochemical composition of 66.92% CP, 3.90% CL, and 1.17% CF. This makes it potentially useful as a substitute for fishmeal in Tilapia diets. The present study was carried out to evaluate the growth performance, feeding efficiency, and survival of Tilapia *Oreochromis niloticus* fry fed with the experimental diets.

MATERIALS AND METHODS

Preparation of Tagelus meat meal : Mature fresh Tagelus harvested from mudflats in the Saloum islands have been cleaned with cold water and then cooked using a kettle at 100 °C for 10 min. After cooking, the flesh was separated from the shell, washed and dried in an electric dryer. The resulting product was ground, sieved, and packaged in a glass jar.

Diets preparation: The formulation of the feeds was carried out according to the dietary requirement of the Tilapia and also the availability and chemical composition of ingredients. Five experimental diets (R0, R25, R50, R75 and R100) were formulated with varying protein levels (33-36%) and lipid (11-13%) levels as shown in table 1.

Table 1: Formulations of experimental diets.

Ingredients	Diets				
	R0	**R25**	**R50**	**R75**	**R100**
Tagelus meal(g)	0	7.5	15	22.5	30
Fish meal (g)	30	22.5	15	7.5	0
Rice bran meal(g)	15	15	15	15	15
Millet bran (g)	20	20	20	20	20
Peanut cake (g)	22	22	22	22	22
Fish oil (g)	5	5	5	5	5
Yeast (g)	4	4	4	4	4
Sterculia gum meal (g)	2	2	2	2	2
Mixed vitamins (g)[a]	1	1	1	1	1
Mixed minerals (g)[b]	1	1	1	1	
TOTAL(g)	100	100	100	100	100

[a]Vit A 250000 UI; Vit D_3 250000 UI; Vit E 5000mg;Vit B_1 100mg;Vit B_2 400mg; Niacine 1000mg; Pantothenate Ca 2000mg; Vit B_6 300mg; Vit K_3 1000g;Vit C 5000mg; Biotine 15mg; Choline 100g; BHT 1000 mg;

[b] Phosphorus 7%; Calcium 17%; Sodium 1.5%; Potassium 4.6%; Magnesium 7.5%; Manganese 738 mg; Zinc 3000 mg; Iron 4000 mg; Copper 750 mg; Iodine 5 mg; Cobalt 208 mg; Calcium and ground attapulgite qs 1000 mg ; Fluoride 1.5%.

Culture conditions: The fish used in the study were fry of Tilapia *Oreochromis niloticus* obtained by semi-artificial reproduction at the IUPA experimental station located at the Faculty of Sciences and Techniques, Department of Animal Biology. Four days after hatching, fry were sorted to have homogeneous sizes. Five experimental diets were studied for 60 days, in triplicate, i.e., 225 individuals with an initial average weight equal to 0.013 g distributed in 15 FRP tanks of 50 liters filled to nine-tenths (3 tanks for the control and 12 for the tested diets) with a density of 15 fish per tank. Throughout the experiment, the fish were fed an amount corresponding to 15% of their biomass in 3 meals per day (09h; 13h; and 17h). The tanks were cleaned every day in the morning and evening by siphoning off the waste and the rest of the uneaten feed accumulated at the tanks' bottom. After siphoning, the water in the tanks was renewed. Every two weeks, the fish were weighed to determine the parameters of growth, feed efficiency, and survival rate; the new biomass was determined, and the daily feed ration distributed readjusted.

Water quality control: The physico-chemical parameters such as temperature, dissolved oxygen, and pH of the water in the tanks were taken every day: morning (7.30 am) and evening (4.30 pm). Afterward, the water was siphoned off and renewed. Before being used, the water was stored in a tank for 48 hours to be de-chlorinated.

Growth parameters, feed efficiency and survival rate

Growth and survival parameters; These parameters highlight some growth elements, namely the absolute average weight gain (AWG), the specific growth rate (SGR), survival rate (SR), and feed conversion ratio (FCR).

Absolute average weight gain (AWG); AWG (g /fish) = final mean weight - initial average weight

Specific Growth Rate (SGR)

SGR (% /d) = ((ln 〖 (final average weight)-ln (initial middleweight) 〗/ (duration of experience/day) x 100

Survival rate (SR)

Survival rate (%) = (Final fish number)/ (Initial number of fish) x 100

Feed Conversion Ratio (FCR)

FCR = (quantity of distributed food/fish)/ (Weight gain)

Biochemical analysis of whole-body of fish: Sample of fishes before and after the experiments were subjected to biochemical analysis for their whole body composition of ash, crude protein, and crude lipid at the ENSA laboratory in Thiès, Senegal, using the standard methods of the AOAC (1995). [4] Crude protein (total Nitrogen x 6.25) was determined using the micro-Kjeldahl method (Kjeltec System 1002 Distilling Unit, Tecator, Hoeganaes, Sweden). Crude lipid was extracted by Soxhlet method. Ash was determined by incineration of samples in a muffle furnace at 550 ^{o}C for 6 h, and dry matter was calculated from the weight difference after oven drying the samples at 105 ^{o}C for 24 h.

Statistical analysis; The data obtained were calculated using Microsoft Excel. The comparison of treatment means for statistical significance was made by one-way analysis of variance (ANOVA) using Statistical Analysis System (SAS-PC) software (Joyner, 1985), [5], P=0.05 was taken as the level of significance. Duncan's test was used to compare significant differences between treatments.

RESULTS

The values of water quality parameters were average temperature 26.5 °C, mean dissolved oxygen 3.67mg/l, and mean pH of 7.71. The crude protein and crude lipid for the fish meal, Tagelus meat meal, and the different diets are showed in table 2.

Table 2: proximate composition of fishmeal, Tagelus meat meal, and the different diets

	Fishmeal	*Tagelus*	R0	R25	R50	R75	R100
CP (%)	58	66.92	33.33	34.00	34.66	35.22	36.00
CL (%)	10.5	3.90	13.82	13.32	12.83	12.33	11.84

CP: crude protein and CL: crude lipid

Different parameters were determined to evaluate the growth, feeding efficiency, and survival rate of fish fed with the diets during the experiment. The results obtained are recorded in table 3.

Table 3: Parameters of growth, feed efficiency, and survival rate

Parameters	R0	R25	R50	R75	R100
IABW(g)	0.013	0.013	0.013	0 .013	0.013
FABW(g)	1.43±0.30^{a}	1.68± 0.44^{a}	1.12± 0.20^{ab}	0.64± 0.94^{b}	0.55± 0.10^{b}
AWG(g)	1 .41± 0.30^{a}	1.67± 0.44^{a}	1.11± 0.20^{ab}	0.63± 0.94^{b}	0.53± 0.10^{b}
FCR	1.03± 0.08^{b}	0.99± 0.15^{b}	1.16± 0.12 ^{ab}	1.4± 0.09^{ab}	1 .56±
SGR(%/d)	8.37 ± 0.35^{a}	8.63 ± 0.50^{a}	7.93± 0.31^{ab}	6 .96± 0.25^{b}	6 .63±
SR (%)	73± 17.95	73± 17.95	76± 10.26	82± 4.04	71± 7.51

Values are means of the triplicates ± SD; values within the same row without a common superscript are significantly different ($p < 0.05$*). IABW = initial average body weight, FABW = final average body weight, AWG = average weight gain, SGR = specific growth rate, FCR = feed conversion ratio, SR = survival rate.*

The results of this study showed that the highest growth rate was obtained in fish fed with the R25 diet containing 25% of Tagelus meat meal. There were no significant differences in the growth of fish fed with R0 diet (control), R25 and R50 diets in terms of FABW and AWG. However, the fish fed with R75 and R100 diets showed the lowest growth performance and there were statistical differences between the two diets and the control diet with respect to growth parameters. The best survival rates were obtained in fish fed with the R75 diet containing 75% Tagelus meat meal (82%) followed by the fish fed with the R50 diet containing 50% Tagelus meat meal (76%). The lowest survival rate was obtained with the R100 diet containing 100% Tagelus meat meal (71%). The best FCR (0.99) was obtained from the fish fed with the R25 diet, which is not significantly different from the fish fed with the R0 diet (1.03) and R50 diet (1.16). The FCR value was higher in the fish fed with the R100 diet (1.57).

TableResults of the biochemical analysis of the whole fish body

	DM (%)	CP (%)	CL (%)
0% Tagelus	25.73	16.58	5.08
25% Tagelus	21.84	14.90	4.21
50% Tagelus	26.07	16.47	6.43
75% Tagelus	30.29	16.35	7.14
100% Tagelus	28.56	16.30	8.34

DM = dry matter, CP = crude protein, CL = crude lipid.

The dry matter content of the flesh of fish fed R0 diet (25.73%) did not differ significantly from that of the flesh of fish fed R50 diet (26.07) and was higher than the dry matter content of the flesh of fish fed R25 diet (21.84). On the other hand, the flesh of tilapia fed R75 and R100 had dry matter contents of30.29 and 28.56 respectively which were higher than the flesh value of fish fed on R0. The fish fed on R25 diet had the lowest dry matter content. In terms of crude protein, fish fed on R25 diet had the lower content (14.90) compared to fish fed with R0 diet (16.58). There were no statistical differences between fish fed the R50 (16.47), R75 (16.35) and R100 (16.30) diets. With regard to lipid content, the lowest value was found in the flesh of fish fed on the R25 diet (4.21), followed by fish on the R0 diet (5.08). The lipid content of fish fed on diets R50, R75 and R100 were higher than that of fish fed on R0 diet.

DISCUSSION

In general, the Physico-chemical parameters of the water in this study were within the recommended optimal range of values. The mean temperature recorded during this experiment was 26.5°C. This temperature is in line with the results of Balarin and Hatton (1979), who stated that in the laboratory, the best growth performance is observed at 24 - 28°C. The mean value of pH of 7.71 obtained in this study shows acceptable physiological activities for normal growth and development of Nile tilapia. Similarly, Kestemont *et al.* (1989) reported that *O. niloticus* could live in water with a pH between 5 and 11. In the present study, the mean DO was 3.67mg/l. This observation agreed with the statements of Kestemont *et al.* (1989) and Mélard (1999), who reported that a DO of more than 3 mg/l is the optimum for good tilapia growth. Fish fed with R25 diet containing 25% Tagelus meat meal showed the best final mean weight (1.68), mean weight gain (1.17 g), relative growth rate (12,844) and specific growth rate (8.63) nevertheless, there were no significant differences among the control, R25 and R50 diets for these growth parameters. This is in line with the findings of Wang *et al.* (2019) who demonstrated that mussel meal is an acceptable alternative animal protein source that can replace 400 g/kg of fishmeal in a low-FM diet for Ussuri catfish without influencing the growth performance. Chimsung and Tantikitti (2014) also reported that the replacement of fishmeal protein with minced snail meal could be at 50 %, however, fermented golden apple snail could even be up to 100 %, but 75 % is recommended. Okanlawon and Oladipupo

(2010) showed that snail offal could replace fishmeal in fish diet at a 50% inclusion rate, thereby reduce the cost of feeding and promotes successful aquaculture.Although there were no significant differences among the control (R0), R25 and R50 diets, value-wise R25 diet is better than R50 diet and therefore is better to limit the substitution to 25%. These results are in line with those of Sogbesan *et al.* (2006), who stated that garden snail meat meal could replace fishmeal in experimental diets of *C. gariepinus* fingerlings. Furthermore, 25% inclusion of garden snail meat meal is preferable by the fingerlings for optimum growth and nutrient utilization. Alatise *et al.* (2005) reported that the freshwater mussel meal at 25% dietary inclusion as a replacement for fishmeal in practical diets appears suitable, particularly in a low-cost diet for *Heterobranchus longifilis*. Ovie and Adejayan (2010) suggested that 25% of garden snails can be efficiently utilized in *C. gariepinus* diets. Some fish have shown a low tolerance inclusion level of mollusk meat meal in their diets. Cho *et al.* (2005) reported that replacement of up to 10% of dietary fishmeal with squid liver meal could be made without reducing growth or deterioration of feed efficiency of juvenile olive flounder. Peralta *et al.* (2010) showed that incorporating oyster meat meal in the tilapia diets gave lower weight gain than the control diet (12.66g). In this study, the replacement of fish meal with Tagelus meat meal above 50% (75 and 100%) showed significant difference between the control diet and R75 and R100 diets. This could presumably be related to the quality of amino acids in the diets containing a high level of Tagelus meat meal. This is in accordance with the results of Alatise *et al.* (2005), who reported that complete replacement of fishmeal by freshwater mussel decreased growth rates and should not be used in *Heterobranchus longifilis* diets. Ovie and Adejayan (2010) revealed that the fish fed with 75% garden snail had a lower growth due to mortality. Contrary to our results, other researchers reported that more than 50% of fish meal could be substituted with mollusk meal without any significant effects. Oyelese (2007) reported that snail meal is best when used in supplementation with conventional fishmeal at a ratio of 60% snail meal and 40% fishmeal in the diet of *Clarias gariepinus*. Peralta *et al.* (2016) indicated that a 17% inclusion rate (equivalent to 64% fishmeal (FM) replacement) of oyster by-product constituted a suitable replacement level for FM. Seira (1998) reported a 75% golden snail meal replacement level for fishmeal without depressing Tilapia growth. Phonekhampheng *et al*. (2009) even concluded that protein from raw and ensiled Golden Apple snails could completely replace fishmeal in diets for African catfish fingerlings under tropical conditions without adverse effects on growth performance and feed utilization. Kotaro *et al.* (1997) also did not obtain a statistically significant difference in growth among all diets in their work on the use of blue mussel as an ingredient in the diet of juvenile Japanese flounder. In this study, the best FCR (0.99) was obtained with the R25 diet containing 25% Tagelus meat meal. These results are similar to those of Sogbesan *et al.* (2006), who obtained the best FCR (1.21) with the diet containing 25% snail meal. Peralta *et al.* (2016), in their study of the oyster *Crassostrea inidalei* as a potential source of protein to replace fishmeal on Tilapia, showed that fish fed with the diet containing 25% oyster by-products gave a statistically significant variation in FCR compared to those fed the control diet. In their study, the best FCR (0.96) was obtained in fish fed with the control diet. The percentage of survival obtained in this study varied between 71% and 82% and there were no significant difference among the treatments. These values are lower than those of Peralta et al. (2016), who obtained 100% survival rates in trials replacing fishmeal with oyster meat meal and those of Kotaro et al. (1997) and Sogbesan et al. (2006) who obtained 100% survival rates. Moreover, the survival rate of sex-reversed red tilapia (*Oreochromis niloticus x O. mosambicus)* diets ranged from 90.74 % to 100 %

(Chimsung and Tantikitti, 2014). Biochemical analysis (protein, lipid and dry matter content) at the end of a feeding trial is frequently used to determine the influence of the feed on fish flesh composition. Data on fish flesh composition allow assessment of the efficiency of nutrient transfer from feed to fish and also contribute to the prediction of nutritional status. Generally, the replacement of fish meal with Tagelus meat meal up to 50% had no major effects on the whole body composition (DM, CP and CL) of the experimental fish. The results of this study show that Tagelus meat meal can replace fishmeal by up to 50%. Nevertheless, fish fed with a diet containing 25% Tagelus meat meal show the best growth performance and feeding efficiency. It seems that the high incorporation rate of Tagelus meat meal caused lower growth performance and feeding efficiency.

CONCLUSION AND APPLICATION OF RESULTS

Partial (50%) replacement of fishmeal with Tagelus meat meal in the diet of *Oreochromis niloticus* fry has no negative effect on the growth performance and feed utilization. On the other hand, complete substitution of fishmeal with Tagelus meat meal did have negative impact on growth performance and feed utilization parameters. Generally, the incorporation of Tagelus meat meal in the diet of *Oreochromis niloticus* fry did not pose any major effect on the body composition of the fish. The results of this study could be used in animal nutrition studies especiallly in fish nutrition. The results will be useful to feed meal plant operators and small-scale fish farmers who make their own feed from locally available ingredients particularly in places where Tagelus is plenty.

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