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### RESEARCH ARTICLE

#### EFFECTS OF PARTIAL SUBSTITUTION OF FISHMEAL BY SEA CLAM (*SENILIA SENILIS*) MEAT MEAL ON GROWTH PERFORMANCE, FEED EFFICIENCY, SURVIVAL, AND WHOLE-BODY COMPOSITION OF THE NILE TILAPIA (*OREOCHROMIS NILOTICUS*, L.1758)

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#### Abstract

The present study assessed the effects of incorporating sea clam (*Senilia senilis*) meat meal as a partial replacement for fishmeal on the growth performance, survival and whole-body composition of Nile Tilapia *Oreochromis niloticus* fry (0.2 g). Three iso-proteins (26%) and iso-caloric (11%) diets where fishmeal was substituted with clam meat meal at 0% diet A, 10% diet B, and 15% diet C were prepared. The experiment was conducted for 12 weeks. The stocking density was 15 fish per tank in an isolated system consisting of 9 plastic tanks of 80L each. Each treatment was administered in triplicates, and fish were fed three times per day (09 :00h, 13 :00h, and 17 :00h). The daily ration corresponded to 10% of the fish's live weight during the first month and was reduced to 8% and then 6% for the second and last month of the trial period. The results of this study showed that the incorporation of clam meat meal in the diet of Nile Tilapia fry has benefited growth in fish fed the tested diets. The best growth performance was obtained in the fish fed with diet B containing 10% clam meat meal: 10.57g for absolute mean weight gain; 4.75% /d for SGR; 0.82 for FCR; 2.14 for PER, followed by diet A. Diet C has the lowest growth performance: 8.37g for weight gain, 4.44%/d for SGR, 0.99 for FCR, and 1.75 for PER. The best survival rate was obtained by diet C (93.33%), followed by diet B (80%), and the lowest by diet A (71.11%). The protein contents of the tested fish were moderately higher than that of the initial fish. No big difference was observed among the tested diets. The ash content is reduced sharply after two months feeding. The lipid content of the tested fish decreased slightly in comparison to the initial fish. At the end of the study, fish fed with diet B showed the best

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growth performance among other diets. These results indicate that clam meat meal can be included up to 15% in the tilapia diet without affecting the nutritional quality of the feed.

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## Introduction:-

Global fisheries have declined considerably since the early 1970s, mainly due to overexploitation of leading stocks of economic interest. Senegal is not an exception to this global phenomenon of overfishing of species of economic importance. The demand for fisheries products is becoming increasingly essential and is manifested at both internal and external markets. Per capita, fish consumption has soared from 10 kg in the 1960s to 19.7 kg in 2013 (FAO 2016). The huge augmentation of per capita fish consumption is due to significant contribution of aquaculture to the total fish production. As the global production of farmed fish for human consumption was estimated at 80 million metric tons in 2016, up from 1.6 million metric tons in 1960 (FAO, 2018). The sustainable development of aquaculture requires easy access to high-quality, high-performance feed. The growth of aquaculture worldwide is reflected in the increasing use of compound feeds, whose protein content is mainly provided by fishmeal.

The high cost and shortage of fishmeal have led to the use of other protein sources such as earthworms, insects, snail, mussels, periwinkle, maggot, and plants in fish feeds (Ugwumba *et al.*, 2001; Akinwande *et al.*; 2002, Omoyinmi *et al.*, 2005).

Meyers (1987) stated that crustaceans and mollusks have attractants containing nitrogen compounds such as amino acids, peptides, nucleotides, and chitin, which promote feed consumption, resulting in increased growth. Marine invertebrates could serve as alternatives to fishmeal in fish feeds.

Bivalvia mollusk (herein referred to as mollusk or shellfish) production shares an important sector of the global aquaculture industry. In 2018, total mollusks production increased to over 16.1 million metric tons. There are certain regions around the world with a high prevalence of mollusks aquaculture. Today, the Sereer Niominka people of the Saloum Delta (Senegal) continue to collect and trade shellfish using traditional methods. There is a lack of information on the nutrient composition of sea clam, *Senilia senilis*, which could be very useful for its utilization as a fish feed ingredient.

The study aimed to investigate the nutritional potential of sea clam (*Senilia senilis*) meat meal as an alternative ingredient to fishmeal in the diet of *O. niloticus* fry

## Material and Methods:-

### Clam meat meal preparation

Fresh mature clams (*Senilia senilis*) harvested from mudflats in the Saloum Delta (Senegal) have been cleaned with cold water and then cooked at 100°C for 10 min in a kettle. After cooking, the flesh separated from its shell was washed and sun-dried. The product obtained was ground, sieved, and packaged in a glass jar until use.

### Diets preparation

To evaluate the effects of partial dietary replacement of fishmeal with a clam meat meal, three different feeds were formulated using Diet formulator software. The following ingredients were used: clam meat meal, fishmeal, rice bran, peanut cake meal, mixture of *Corchorus leaves meal*, and *Sterculia gum* meal. The protein and lipid contents of these three feeds are 26% and 11% respectively.

**Table 1:-** Diets Composition.

Ingredients	Diets		
	A	B	C
Clam meat meal <sup>a</sup>	0	10	15
Fishmeal <sup>b</sup>	35	33	31
<i>Corchorus</i> leaves flour	20	12	9
Rice bran meal	12	12	12
Peanut cake meal	20	20	20

<i>Sterculia</i> gum meal	2	2	2
Yeast meal	4	4	4
Vitamins premix <sup>c</sup>	1	1	1
Minerals premix <sup>d</sup>	1	1	1
Crude protein (%)	26	26	26
Crude lipid (%)	11	11	11

<sup>a</sup>Clam meat meal: 20.26% crude protein and 0.89% crude lipid

<sup>b</sup>Fishmeal : 56% crude protein and 10.5% crude lipid

<sup>c</sup>VitA250000UI;VitD<sub>3</sub> 250000UI;VitE5000mg;VitB<sub>1</sub> 100mg;VitB<sub>2</sub> 400mg;Niacine1000mg;PantothenateCa2000mg;VitB<sub>6</sub> 300mg;VitK<sub>3</sub> 1000g;VitC5000mg;Biotine15mg;Choline100 g; BHT 1000 mg.

<sup>d</sup>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 attapulgit q.s 1000 mg; Fluoride 1.5%.

For diet manufacturing, each ingredient was sieved and weighed according to the formulation in Table 1. Each diet's ingredients were mixed in a plastic tank and water was added and further mixed to dough. The doughs were run in a meat grinder (Moulinex) to obtain spaghetti like filaments. The wet filaments were dried in an electric dryer at 36°C for 8 h and then ground into powder.

### Culture conditions

The tilapia fry used in this study came from the Graduate School of Fisheries and Aquaculture's experimental unit at the University of Cheikh Anta DIOP of Dakar, Senegal. They were less than a month old. For the experiment, 135 Nile tilapia fry were weighed and fasted for 24 hours before starting the experiment. The stocking density was 15 fish per tank. They had an initial average weight of 0.2g and were distributed in 9 plastic tanks of 80l capacity. The experiment lasted 12 weeks, and each diet was tested in triplicate. The daily ration at the beginning of the experiment was 10% and at the end 6%. The daily ration was divided into three equal meals (09h, 13h, and 17h). Every two weeks, growth parameters, feed efficiency, and survival rates were measured and the daily feed ration adjusted. The siphoning was done in the morning and evening to maintain good water quality. The temperature was taken every day, morning and evening, with a multi-parameters device.

### Calculation of Growth, feed efficiency and survival parameters

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

RWG (%) = (final average weight - initial average weight)/(initial average weight)×100

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

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

PER= Mean weight gain (g) / Mean protein intake (where mean protein intake = feed supplied x % protein of diet)

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

### Biochemical analysis of whole fishbody

Fish samples were taken before and after the experiment and subjected to biochemical analysis for dry matter, ash, crude protein, and crude lipid contents at the ENSA laboratory in Thiès, Senegal, using the standard methods of the AOAC (1984). Due to high cost of chemical analysis in Senegal, fish samples from the same treatment were put together as one and analyzed. In that regard, the parameters of the body composition were not statistically compared.

### 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) P=0.05 was taken as the level of significance. Duncan's test was used to compare significant differences between treatments.

## Results And Discussion:-

### Results

#### Physical and chemical parameters

The temperature was measured every day, morning and evening, with a multi-parameter device. The results show that the temperature varied from 24.93 °C to 30.75 °C, and the average value is 26.46 °C.

### Growth, survival, and feed efficiency parameters

Data on absolute average weight gain (AWG), relative average weight gain (RWG), specific growth rate (SGR), feed conversion rate (FCR), protein efficiency ratio (PER), and survival rate (SR) are recorded in table 2:

**Table 2:-** Growth performance, feed efficiency and survival rate.

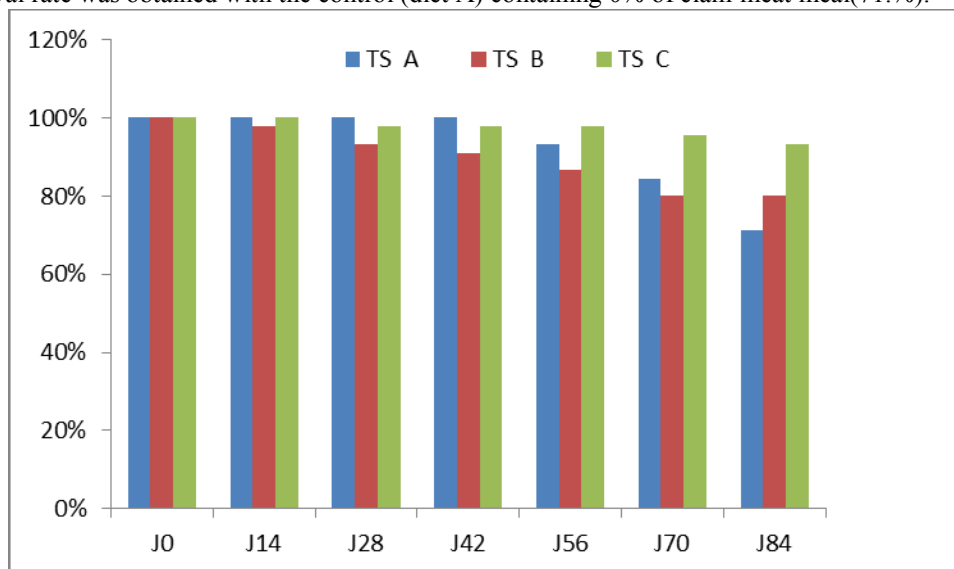
Parameters	A (0%)	B (10%)	C (15%)	STDEVA
IAW(g)	0.20	0.20	0.20	± 0.00
FAW (g)	9.01	10.77	8.58	±1.16
AWG (g)	8.81 <sup>ab</sup>	10.57 <sup>a</sup>	8.37 <sup>b</sup>	±1.16
RWG (%)	4405.00 <sup>ab</sup>	5286.67 <sup>a</sup>	4188.33 <sup>b</sup>	±581.76
SGR (%/d)	4.53 <sup>ab</sup>	4.75 <sup>a</sup>	4.44 <sup>b</sup>	±0.16
FCR	0.92 <sup>a</sup>	0.82 <sup>a</sup>	0.99 <sup>a</sup>	±0.09
PER	1.92 <sup>a</sup>	2.14 <sup>a</sup>	1.75 <sup>a</sup>	±0.20
SR (%)	71.11 <sup>c</sup>	80.00 <sup>b</sup>	93.33 <sup>a</sup>	±11.18

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

The results showed that incorporating clam meat meal into the diet of Nile tilapia benefited fish growth to some extent. Although there was significant difference ( $p < 0.05$ ) among the treatment groups, there was no statistical difference between the control (diet without clam meat meal) and diets with clam meat meal with respect to growth and feed efficiency parameters (AWG, RWG, SGR, FCR, PER). However, there was a significant difference ( $p < 0.05$ ) between diet B (10% clam meat meal) and diet C (15% clam meat meal) treatments with regard to only growth parameters (AWG, RWG, SGR) but not feed efficiency parameters (FCR, PER). Indeed, the best growth performance was obtained in fish fed with diet B containing 10% of the clam meat meal.

### Survival rate (SR)

Fish survival rate ranged from 71 % to 93 % (Table 2). The best survival rate was obtained in fish fed diet C containing 15% of clam meal (93.3%) followed by the fish fed diet B, containing 10% of the clam meal (80%). The lowest survival rate was obtained with the control (diet A) containing 0% of clam meal (71.1%).



**Figure:-** Pattern of evolution of survival rate during the experiment.

**Absolute average weight gain (AWG)**

Fish fed diet B containing 10% of clam meat meal had a higher AWG of 10.57g compared to those fed diets A (0%) and B (15%) that had AWG of 8.81 g and 8.37g, respectively.

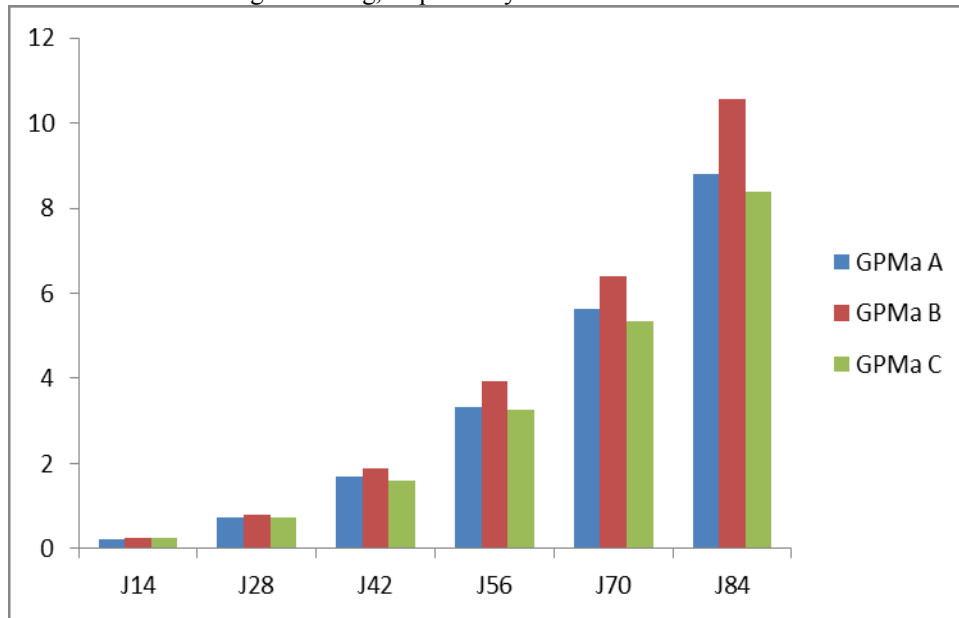


Figure:- Evolution chart of absolute average weight gain during the experiment.

**Specific growth rate (SGR)**

Similar trends have been observed with the specific growth rate. Diet B has the highest SGR (4.75 g/d), followed by the control diet A (4.53g/d) and C (4.44g/d).

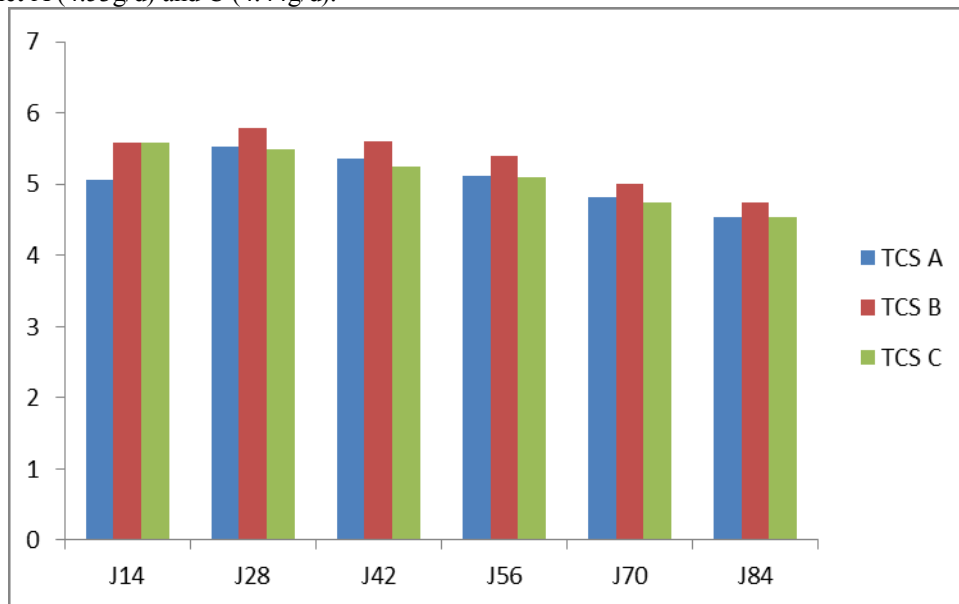


Figure:- Pattern of change in the specific growth rate during the experiment.

**Feed conversion ratio (FCR)**

The lowest feed conversion ratio was achieved with Diet B (0.82) followed by diet A (0.92) and diet C (0.99), respectively.

### Protein efficiency ratio (PER)

The best PER was obtained with fish fed diet B containing 10% of clam meat meal (2.14) followed by diet A containing 0% of clam meat meal (1.92) and diet C containing 15% of clam meat meal (1.75).

Composition	Diets			
	Initial fish	A (0%)	B (10%)	C (15%)
Proteins (%)	20.76	28.09	27.88	28.242
Ash (%)	21.42	8.07	8.61	7.37
Lipids (%)	7.88	3.33	3.71	4.14

**Table 3:-** Proximate composition of wholefish body at the end of the 12 weeks (N=1).

### Biochemical analysis of the whole fish body

The body composition results are presented in table 3. At the end of the three months feeding, the whole body protein content increased moderately, ash decreased tremendously while lipid decreased slightly comparing the body composition of initial and final fish. There was no big difference in whole- fish body protein, ash, and lipid contents among all the treatments.

### Discussion:-

The average temperature (26.46 °C) in this study is within the range (24-28°C) stated by Balarin and Hatton (1979) in the laboratory environment.

In this study, the growth performance of tilapia fry revealed that clam meat meal could replace 15% of fishmeal in the diet. Chimsung and Tantikitti (2013) even reported that the replacement of fishmeal protein with minced snail meal at 50 % is recommended in the diet of sex-reversed red tilapia (*Oreochromis niloticus* x *O. mosambicus*). The present result may be justified by the statement of Kelli *et al.* (2017) who revealed that the inclusion of sea clam (ocean quahog *Arctica islandica*) by-products, particularly dried clam fines, improved the intake of the reduced fish meal feeds by juvenile sunshine bass (female White Bass *Morone chrysops* × male Striped Bass *M. saxatilis*) grown in tanks. Similarly, some fish have shown high tolerance to mollusk meals in their diets. Some authors reported 25% inclusion of garden snail meat in *C. gariepinus* fingerlings diets for optimum growth and nutrient utilization (Sogbesan *et al.*, 2006; Ovie and Adejayan, 2010). Okanlawon and Oladipupo (2010) demonstrated that snail offal could replace fishmeal in the fish diet at a 50% inclusion rate, reducing the cost of feeding and promoting successful aquaculture. Oyelese (2007) reported that snail meal is best used in supplementation for conventional fishmeal at a ratio of 60% snail meal and 40% fishmeal in the diet of *Clarias gariepinus*.

In this study, the highest SGR was obtained with the fish fed the diet B (10%) with a value of 4.75 (g/d). These results are different from those of Okanlawon *et al.* (2010), who obtained the best SGR with the control diet containing only fishmeal in their study on the effects of replacing fishmeal with snail offal meal at 0, 25, 50, 75 and 100%. In contrast, Ugwumba *et al.* (2006) recorded a specific growth rate (0.71%/d) in fish fed with 25% garden snail meat diet of *Clarias gariepinus* fingerlings.

The survival rate of this study ranged from 71 % to 93 %. These results are close to those of Okanlawon *et al.* (2010), who obtained a survival rate of 83 to 98% in their work on the effects of replacing fishmeal with snail offal in *Clarias gariepinus* fingerlings growth performance. In contrast, Suresh (2007) obtained 100% survival rates in her study on giant African snail meat as a source of animal protein for common carp (*Cyprinus carpio* var. *communis* Linn.). The high survival rates recorded in the present study indicated that feeding tilapia on a diet containing clam meat meal did not have any negative effect on fish survival. This could probably be due to better feed conversion and utilization, as well as higher fish growth in clam-based diets, especially at lower inclusion levels (15%).

The lowest feed conversion ratio was obtained with Diet B (0.82) followed by Diet A (0.92) and Diet C (0.99). These results are better than those of Okanlawon *et al.* (2010), who obtained the best FCR of 2.01 with the diet containing 25% snail slime in their study on the effects of replacing fishmeal with snail offal meal at 0, 25, 50, 75 and 100%. Furthermore, Ugwumba *et al.* (2006) found that the best FCR of 1.2 was obtained in the fish fed a 25% garden snail meat diet with *Clarias gariepinus* fingerlings.

The best protein efficiency ratio (PER) of 2.14 was obtained with fish fed with diet B containing 10% of the clam meal. Suresh (2007) recorded a smaller PER in the diet containing more fishmeal than snailmeal with a value of 1.25 in their study on the effects of replacing fishmeal with snailmeal on common carp. Ugwumba *et al.* (2006) obtained a higher PER of 3.69 in the diet 25% on their study on the use of garden snail (*Limicolaria aurora*) meat meal in the diet of *Clarias gariepinus* fingerlings.

Biochemical analysis of the whole fish body determines the levels of dry matter, proteins, and lipids of the entire fish body at the pre and post-experiment. Studies have shown that exogenous factors (feed composition, temperature, oxygen, etc.) and endogenous factors (size, sex, sexual maturity stage, etc.) can influence the body composition of farmed species (Hepher, 1990).

The proximate compositions of tilapia whole body were not greatly affected by the replacement of fishmeal protein by clam meal protein in the present study. The results of this study showed that the protein content of the initial fish is lower than the values obtained after two months feeding. The quality of the tested diets may justify this result. Also, this result could be explained by the protein intake provided by the incorporation of clam meal in the diets. Clam meal is rich in essential amino acids. For the dry matter content, there is no big difference between the initial fish and after two months feeding.

The fat content of the initial fish is higher than the values of those subjected to the different experimental diets. This could mean that the fish subjected to the diets spent a lot of energy during the exploratory phase to cope with their living environment conditions, hence a low percentage of lipids in the whole body of fish. On the other hand, this low percentage of lipids in the fish fed on the diets A, B and C may be caused by poor digestion of the fat present in the test feed. Indeed, lipids, generally when well digested, allow fish to have lipid deposits. These play a significant role in the supply of energy, which is all the more critical in fish as the majority of them do not digest complex carbohydrates well (Guillaume *et al.* 1999).

In conclusion, the present study revealed that clam (*Senilia senilis*) meal could replace up to 15% of fishmeal protein in the diet for tilapia fry without any adverse effect on growth performance.

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