Available online at http://www.ifgdg.org

Int. J. Biol. Chem. Sci. 16(5): 2330-2339, October 2022

ISSN 1997-342X (Online), ISSN 1991-8631 (Print)

International Journal of Biological and Chemical Sciences

Original Paper http://ajol.info/index.php/ijbcs http://indexmedicus.afro.who.int

Utilization of marine fish viscera in African snakehead fish fingerlings (*Parachanna obscura*, Gunther, 1861) feeding: Zootechnical parameters and body composition

Diane N.S. KPOGUE[1,2*] Juste Vital VODOUNNOU[1,2], Saidatou SANOUSSI[1], Elie MONTCHOWUI[1] and Emile Didier FIOGBE[2]

[1] Research Unity in Aquaculture and Fisheries Management (URAGeP) of Aquaculture School (EAq) of National University of Agriculture (UNA), BP 95 kétou, Republic of Benin.
[2] Research Laboratory on Wetlands (LRZH) of Abomey-Calavi University (LRZH/FAST/UAC) 01 BP 526 Cotonou, Republic of Benin.
[*] Corresponding author; E-mail: senami_diane@yahoo.fr

Received: 03-09-2021 Accepted: 10-09-2022 Published: 31-10-2022

ABSTRACT

The Marine Fish Viscera (MFV) are a protein source can be used in aquaculture feed. In fact, MFV are considered that waste in the fresh fish market. This study investigated on the utilization of MFV for substitute the fish meal in African snakehead fish fingerlings (*Parachanna obscura*, Gunther, 1861) feeding. The aim of the study was to evaluate the effect of Marine Fish Viscera Meal (MFVM) on the zootechnical parameters, feed utilization and carcass composition of *P. obscura*. For the study, 750 fingerlings (mean weight 1.05 ± 0.06 g) of *P. obscura* in 15 rectangular concreted tanks have been used for 6 weeks. *P. obscura* fries fed on several diets with 25% arithmetic progression of Fish Meal (FM) replacement by MFVM (T_1:0%, T_2: 25%, T_3: 50%, T_4: 75%, T_5: 100%). At the end of study, significant differences ($P < 0.05$) in relation to the zootechnical parameters considered were observed. The best FBW (141.66 ± 1.66 g), SGR (2.20 ± 0.02%), FCR (1.39 ± 0.02), PER (1.88 ± 0.02) and PPV (10.44 ± 0.60) were obtained with treatment T5. We notice that the more FM substitution rate by MFVM increase, the more zootechnical performances, feed utilization and flesh quality improve. The different treatments didn't impact significantly ($P > 0.05$) the survival rate. There was no mortality recorded in study.

Keywords: Fish meal, marine fish viscera meal, *P. obscura*, zootechnical parameters, body composition.

INTRODUCTION

Fish meal is a fundamental ingredient in fish feeding composition (Medale and Kaushik, 2009). Due to its richness in essential amino acids, vitamins and minerals, it supplies necessary elements for fish to grow and to be healthy (Hernandez et al., 2004). But regarding negative effects of climate changes and population growth, a decrease in fisheries products was noticed throughout the world (FAO, 2018), that results to the unavailability and expensiveness of fish meal (Soltan et al., 2008). This was a matter of great reflection for African researchers to solve the food self-

DOI: https://dx.doi.org/10.4314/ijbcs.v16i5.40

sufficiency issue in general and especially the issue related to aquaculture development. As live prey production is not considered for human consumption and enables to value slaughterhouse wastes is also a solution to reduce the use of fish meal in fish feed (Sogbesan et al., 2007; Abou et al., 2010; Alofa et al., 2015 ; Vodounnou et al., 2016a ; Vodounnou et al., 2016b ; Djissou et al., 2016). Thus, marine fish viscera represent a good protein source to be valued in aquaculture (Oke et al., 2016). In Benin, marine fish viscera are considered as fishery wastes and collecting them contribute to the environment sanitation (Oke et al., 2016). Marine fish viscera are highly nutritional elements rich and its protein rate can be compared to that of fish meal used in fish feed (Oke et al., 2016). Several studies were carried out on the use of fish viscera in fish feeding. In aquaculture, studies on marine fish viscera valuation were realized on fish species such as tilapias and catfishes in order to reduce the production cost (Oke et al., 2016).

In the past, there was no such a study on *Parachanna obscura*, an African (especially in Central and West Africa) fish species belonging to channidae family and in Asia with Channa (Kpogue et al., 2012a; Vodounnou et al., 2017; Vodounnou et al., 2018). In fact, *Parachanna obscura* is a carnivorous fish that gives birth 09 months over 12 in one year (Isangedighi and Umoumoh, 2011**)**. Its meat is very appreciated by Benin population with a high economic value. Some studies were carried out to determine its nutritional needs in protein for larvae: 45 and 55.5%; for juveniles 42.5 and 53.5% (Kpogue et al., 2012b), for lipid:7%, for glucide :12 % (Vodounnou et al., 2018, Kpogue et al., 2018a), for feeding rate :5.01 (fish biomass) $^{-0.23}$ (Kpogue et al., 2012c), for feed distribution frequency :3 times / day (Kpogue et al., 2018b) and for stocking density (Kpogue et al., 2012d).

Aquaculture is expanding in Africa, especially in Benin where fish production is daily increasing (Abou et al., 2007; FAO, 2018). In spite of this expansion, some difficulties regarding feed and resulting from the use of great quantity of fish meal in fish feed has been encountered (Samocha et al., 2004; Zhou et al., 2010). The use of marine fish viscera in aquaculture aims to find a new protein source replacing fish meal due to its nutrient elements profile close to the fish meal. It’s with this logic that the current study entitled utilization of marine fish viscera in African snakehead fish fingerlings (*Parachanna obscura*, Gunther, 1861) feeding: Zootechnical endpoint and flesh quality has been carried out. The aim of this study was to evaluate the effect of marine fish viscera on the zootechnical parameters, feed utilization and carcass composition of *P. obscura*.

MATERIALS AND METHODS

Marine Fish Viscera collect and treatment

Marine Fish Viscera (MFV) were collected in fishing port of Cotonou in economic capital of Benin. MFV collected were from fish caught the same day. After collection, the scales, gills and fins have been emptied to the MFV. Then, the MFV were washed and drained. The MFV used didn’t have to undergo any degradation. After their first cooking by fire at about 90˚C in interest for innocuousness and for also eliminate the germ, they were drained again.

Drying and grinding of MFV

After their first cooking with fire at about 90˚C with water, and after draining they were put in oven for drying. The drying temperature was 60 ˚C with laboratory oven Model: NL-9023A. Marine Fish Viscera dried were ground for obtaining of meal.

Essential Amino-Acids composition of main ingredients

After the production of Marine Fish Viscera Meal, the composition of Essential Amino-Acids of MFVM and the others main ingredients have been calculated (Figure 1).

Diet formulation

On nutrient data base of others ingredients and the MFVM, the diets were formulated and the proximate composition in protein, lipid carbohydrate and ash of the diets was determined (table 1).

Experimental design of MFVM in *P. obscura* fingerlings diet

For the study, 750 fingerlings of *P. obscura* (mean weight 1.05 ± 0.06 g) were used. The study was carried out for 6 weeks on the stock farm located at Dangbo town in Ouémé areas in Bénin. Rectangular concrete tanks were used for the five diets (each diet was tested in triplicate) and were half covered by straw device to prevent sun light prevention. Each concreted tank containing 100 L of water and 50 fingerlings of *P. obscura*. Acclimate period of one week of *P. obscura* fingerlings was observed before experiment. The biomass and the total length of each fish were measured before experiment start up. The five isocaloric experimental diet were formulated (Table 1) and the fish were fed with 5.01(fish biomass)$^{-0.23}$rate (Vodounnou et al. 2018). Fish meal in diet was replaced with MFVM at the inclusion level of 0 (T_1), 25 (T_2), 50 (T_3), 75 (T_4) and 100 (T_5) (Table 1). The feeding frequency of fingerlings reared is three times daily (Kpogue et al., 2018).

Experiment monitoring

The physico-chemical parameter such as dissolved oxygen, pH and temperature, were monitored three times daily. These parameters were monitored with an oxygen meter, a pH meter and thermometer respectively. Control growth was carried every 7 days. All ponds were washed and the fishes were counted and weighted. At the experiment end, biomass, total number of the fishes, weight and individual length were measured in each pond.

Zootechnical parameters and feed utilization

Many parameters were calculated at the end of experiment:

Feed Efficiency: $\mathrm{FE} = \frac{(\text{Final Biomasses}+\text{Dead fish Biomass})-\text{Initial Biomasses}}{\text{Feed Distributed}}$

Specific Growth Rate: $\mathrm{SGR} = \frac{[\text{Ln (Final Body Weight (g))} - \text{Ln (Initial Body Weight (g))}]}{\text{Duration (days) of the experiment}} \times 100$

Feed Conversion Rate: $\mathrm{FCR} = \frac{1}{FE}$

Survival Rate: $\mathrm{SR} = \frac{\text{Final Number}}{\text{Initial Number}} \times 100$

Protein Productive Value: $\mathrm{PPV} = \frac{\text{Final Protein in fish} - \text{Initial Protein in Fish}}{\text{Total Feed Intake per Fish x Dietary Protein}} \times 100$

Protein Efficiency Ratio: $\mathrm{PER} = \frac{\text{Final Biomasses} - \text{Initial Biomasses}}{\text{Feed Distributed x Dietary Protein}}$

Data manipulation

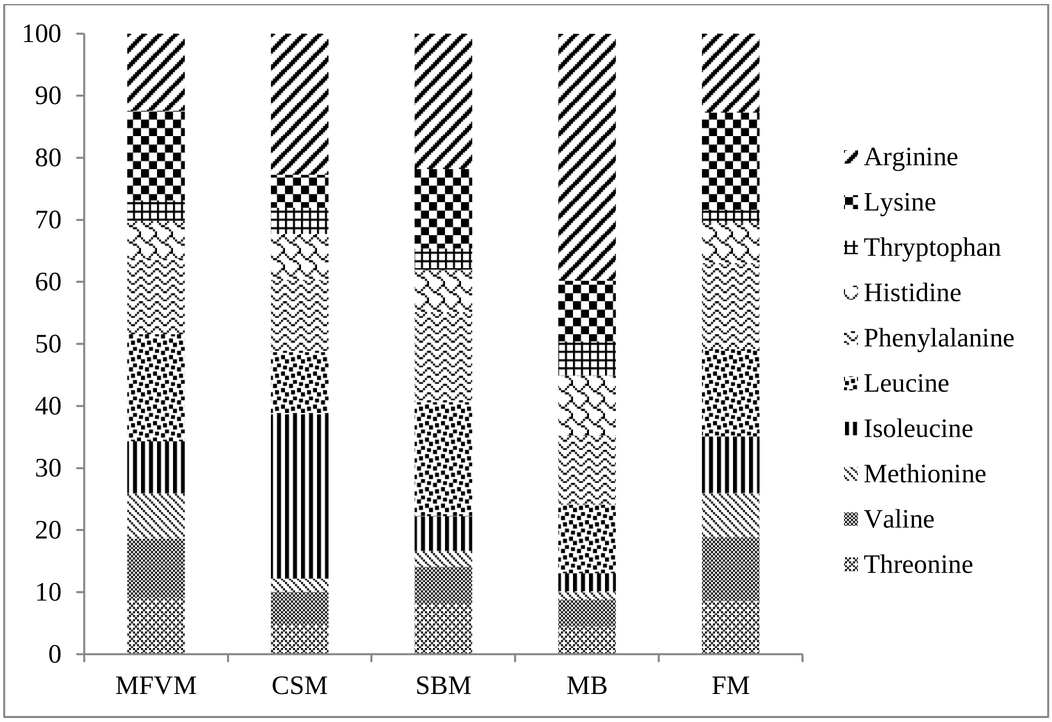
After data collect and statistical analysis, different zootechnical parameters, physico-chemical parameters and feed utilization parameters have been calculated. Mean and range of each parameter were calculated and graphs were drawn. The data were analyzed using a one-way analysis of variance (ANOVA) with the facilities of STATVIEW version 5.01 software, after the verification of variance homogeneity, using Hartley's test. Significant differences among means were determined using Fisher's test P = 0.05 significance level.

Table 1: Formulation and proximate composition of experimental diet.

Traitements	T1	T2	T3	T4	T5
Maize Bran (%)	14	12	15	15	16
Fish Meal (%)	46	34.5	23	11.5	0
Marine Fish Viscera Meal (%)	0	11.5	23	34.5	46
Soy Bean (%) Meal	17	16	15	15	17
Cotton Seed Meal (%)	17	20	18	18	15

***Complex Mineral Vitamin (%)**	2.5	2.5	2.5	2.5	2.5
Iron Sulfate (%)	0.5	0.5	0.5	0.5	0.5
Palm Oil (%)	2	2	2	2	2
Carboxymethylcellulose(%)	1	1	1	1	1
Total	100	100	100	100	100
Proximate analyses					
Crude protein	44.05	44.10	44.65	45.44	46.09
Crude lipid	6.14	6.23	6.44	6.86	7.02
Carbohydrate	12.74	12.81	13.01	13.23	13.56
Ash	9.28	9.32	9.31	9.29	9.34

*****contains (‰):Vitamin A 4 000 000 U.I; Vitamin D 800 000 U.I; Vitamin E 40 000U.I; Vitamin K_3 1600 mg; Vitamin B_1 4 000 mg; Vitamin B_2 3 000 mg; Vitamin B_6 3 800 mg; Vitamin B_{12} 3 mg; Vitamin C 60 000 mg; Biotin 100 mg; Inositol 10 000 mg Pantothenic acid 8 000 mg; Nicotinic acid 18 000 mg; Folic acid 800 mg; Cholin chloride 120 000 mg; Colbat carbonate 150 mg; Ferrous sulphate 8 000 mg; Potassium iodide 400 mg; Manganese oxide 6 000 mg; Cuivre 800 mg; Sodium selenite 40 mcg; Lysine 10 000 mg ; Methionin 10 000 mg ; Zinc sulphate 8 000 mg.



MFVM: Marine Fish Viscera Meal, CSM: Cotton Seed Meal, SBM: Soy Bean Meal, MB: Maize Bran, FM: Fish Meal

Figure 1: Composition of Essential Amino-Acids of main ingredients in EAA % / EAA.

RESULTS

Water quality

The water physico-chemical parameters were recorded and the means were calculated each week. The evolution of these parameters was observed by week during experiment. pH during experiment ranged from 6.57 ± 0.05 and 6.93 ± 0.03 (Figure 2). Water temperature varied between 28.92 ± 0.14 °C and 29.52 ± 0.11 °C (Figure 3). Dissolved oxygen in water varied between 6.32 ± 0.15 and 6.98 ± 0.15 (Figure 4).

Zootechnical parameters, feed utilization and survival rate

Final Biomass varied in relation to treatment. Treatment T5 (141.66 ± 1.66) presented the highest final biomass (Figure 5). The lowest final Biomass was obtained with treatment T1 (106.66 ± 1.76) (fig 5). Significant differences were observed between all treatments ($P < 0.05$). More the incorporation of MFVM by FM increase, zootechnical parameters also improve.

Specific Growth Rate obtained during experiment varied in relation to treatments. Significant differences ($P < 0.05$) were observed between the treatments (Table 2). The highest SGR was obtained with treatment T5: 2.20 ± 0.02 and the lowest SGR were obtained with T1: 1.57 ± 0.04. The same tendency was observed in relation to Final Biomass variation.

Feed Conversion Rate presented significant differences ($P < 0.05$). T5 treatment presented the highest FCR (1.39 ± 0.02) (fig 6) and T1 treatment presented the lowest FCR (1.85 ± 0.06) (fig 6). More the incorporation of the MFVM by FM increases, the more Feed Conversion Rate parameter. No significant differences ($P > 0.05$) were observed between the T2 and T3 and T3 and T4 treatments.

Survival rate

During experimental period, there was no mortality recorded in the all treatments. No significant differences ($P > 0.05$) were observed between treatments. Survival Rate observed in the all treatments during experiment period was 100.00 ± 0.00 (Table 2)

Body composition

The body composition of carcass showed that the diets impacted the quality of carcass in protein. Protein Efficiency Ratio showed significant differences ($P < 0.05$) between treatments. The lowest PER was observed in T_1: 0.89 ± 0.01. Significant differences ($P < 0.05$) were observed between all treatments. The highest PER was observed in T_5: 1.88 ± 0.02 treatment. Productive Protein Value showed also significant differences ($P < 0.05$) between treatments. It showed same tendency with PER in relation with significant differences. The lowest PPV was observed in diet T_1: 4.11 ± 0.10 and the highest PPV were observed in diet T_5: 10.44 ± 0.60.

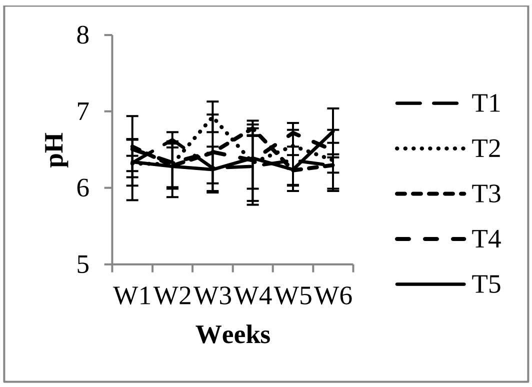


Figure 2: pH variation.

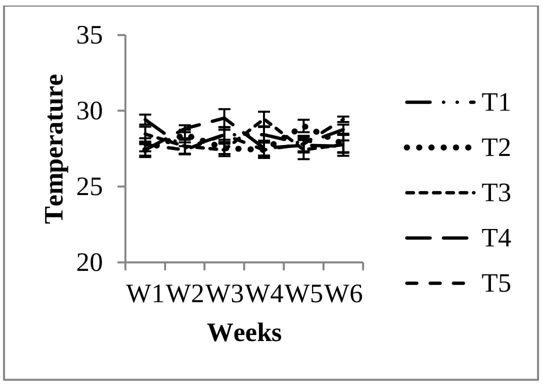


Figure 3: Temperature variation.

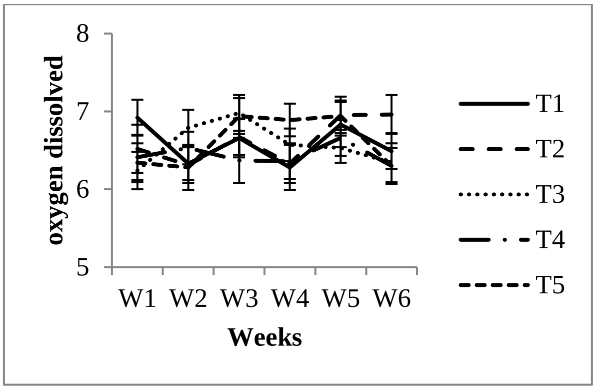


Figure 4: Dissolved oxygen variation.

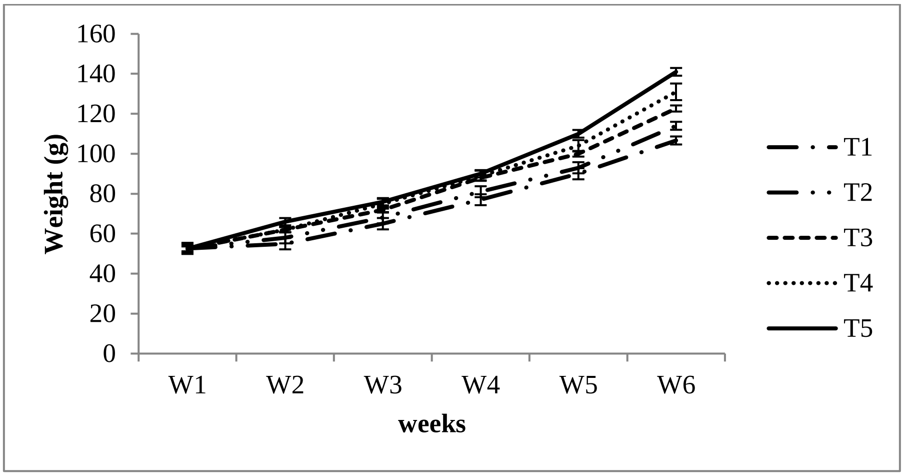


Figure 5: Biomass evolution during experiment.

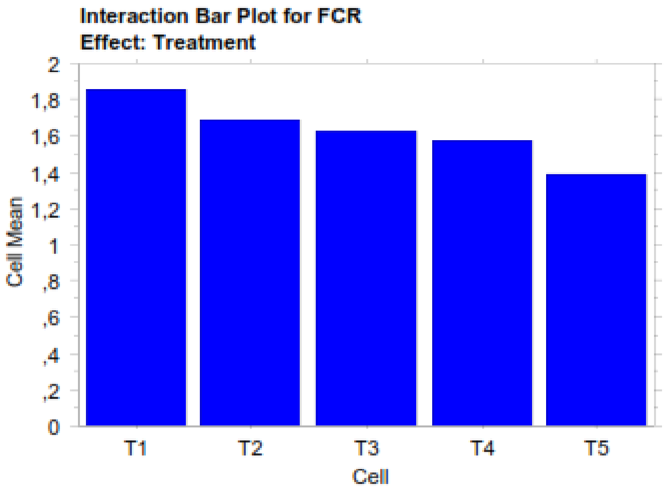


Figure 6: Feed conversion rate during experiment.

Tableau 2: Zootechnical parameters, feed utilization, survival rate, body composition of *P. obscura* fingerlings reared with experimental diet.

Parameters	**T_1**	**T_2**	**T_3**	**T_4**	**T_5**
Initial Biomass	52.60 ± 0.36[a]	52.67 ± 0.74 [a]	52.40 ± 1.22 [a]	52.53 ± 0.25 [a]	52.50 ± 1.32 [a]
Final Biomass	106.66 ± 1.76[a]	114.00 ± 1.00 [b]	122.66 ± 1.45 [c]	131.00 ± 0.55 [d]	141.66 ± 1.66 [e]
Specific Growth Rate	1.57 ± 0.04[a]	1.71 ± 0.04 [b]	1.89 ± 0.04 [c]	2.03 ± 0.01 [d]	2.20 ± 0.02 [e]
Protein Efficiency Ratio	0.89 ± 0.01 [a]	0.97 ± 0.01 [b]	1.28 ± 0.02 [c]	1.61 ± 0.01[d]	1.88 ± 0.02 [e]
Protein Productive Value	4.10 ± 0.10 [a]	6.18 ± 0.12 [b]	9.67 ± 0,72 [c]	10.07 ± 0.66 [d]	10.44 ± 0.6 [d]
Survival Rate (SR)	100.00 ± 0.00 [a]	100.00 ± 0.00 [a]	100.00 ± 0.00 [a]	100.00 ± 0.00 [a]	100.00 ± 0.00 [a]

DISCUSSION

Water quality

The pH value ranging from 6.57 ± 0.05 and 6.93 ± 0.03 recorded is closed to the optimum threshold slightly acid that is accepted by *P. obscura* in natural environment (Kpogue et al., 2012a). The water temperature varied from 28.92 ± 0.14°C and 29.52 ± 0.11°C. This temperature is the limit supported by *P. obscura* in the wild (Bolaji et al., 2011). Regarding dissolved oxygen rate, it ranged between 6.32 ± 0.15 and 6.98 ± 0.15 mg/L. This rate is acceptable to *P. obscura* that is a less dissolved oxygen requiring species. Indeed, *P. obscura* possesses accessories organs enabling aerial respiration and surviving in low oxygen media (Bolaji et al., 2011).

The evaluation of MFVM on the zootechnical performances of *P. obscura* fries fed on several diets with 25% arithmetic progression of FM replacement by MFVM showed significant differences in relation to the zootechnical parameters considered. The biomass progression showed T5 that received 100 % FM substitution by MFVM provided the best final biomass 141.66 ± 1.66. We noticed significant difference between this treatment and others. This result could be explained by bad quality of fish meal or the fish species though meal is used. SGR also presents the same trend. The highest SGR is also recorded in T_5: 2.20 ± 0.02 and show significant differences with the other treatments. We notice that the more FM substitution rate by MFVM increase, the more zootechnical performances and feed utilization improve. This shows that the marine fish viscera used in the experiment are richest in nutritive elements than fish meal used. These results don't corroborate with those of Vodounnou et al. (2016b) during the substitution of fish meal by earthworm meal. This could be explained by the difference between the nutritional value of earthworm meal and MFVM. The FCR showed significant differences in relation to treatments. As the treatment T_5 is total FM substitution by MFVM, it shows the best FCR: 1.39 ± 0.02. But there was no significant difference between treatments T_2 and T_3 on the one hand and T_3 and T_4 on the other hand. These results are not similar also to those of Vodounnou et al. (2016b) during the substitution of fish meal by earth worm meal. Marine fish viscera used in the current study are then more nutritionally valued than earth worm meal for the growth of *P. obscura* fries. The results of Oke et al. (2016) on the use of marine fish viscera in *Clarias gariepinus* fries feeding didn't show significant differences in term of zootechnical parameters and feed utilization until 50% substitution of FM by MFVM. This difference between our study and that of Oke et al. (2016) can be due to the difference of fish species used in experiment and to the quality of fish meal.

The different treatments didn't impact significantly the survival rate. There was no mortality recorded in treatments. These results prove good water quality. It's also important to mention that *P. obscura* is naturally rustic and able to live difficult conditions. The mean survival rate during the current experiment is 100.00 ± 0.00%. Similar results were obtained during nutritional studies on the same species (Vodounnou et al., 2018). The use of marine fish viscera in fish feed didn't have impact on the survival rate of other species such as Carpe (Tabinda et al., 2013); *Clarias gariepinus* (Oke et al., 2016).

PER shows that treatments impacted significantly carcass composition. The highest was recorded in T_5: 1.88 ± 0.02 and the lowest in T_1: 0.89 ± 0.01. We notice significant difference among treatments. The initial protein rate in carcass differs from the final protein rate in relation to treatments. This difference could be explained by proteins digestibility and utilization by fish in relation to the substitution rate of fish meal by MFVM in the feed. Many study substituting fish meal by other animal or vegetal genuine protein sources led to the modification of bromatological composition of carcass (Adesina, 2012; Vahid et al., 2018). PPV also show that carcass composition vary according to treatments. The lowest is recorded in T_1: 4.10 ± 0.10 and the highest in T_5: 10.44 ± 0.6. We notice significant difference among treatments except T_4 and T_5 that didn't show significant difference. The same trend was noticed with PER where difference recorded with final protein rates led to significant difference in PPV.

Conclusion

This study proved that the Marine fish viscera meal is a good ingredient that can be used in *P. obscura* diet. It can substitute the fish meal to 100%. But this substitution must consider the quality of fish meal used and the good transformation process of marine fish viscera in marine fish viscera meal.

COMPETING INTERESTS

The authors declare that they have no competing interests.

AUTHORS CONTRIBUTIONS

All authors, DNSK, JVV, SS, EM and EDF, have made adequate effort on all parts of the work necessary for the development of this manuscript according to his/her expertise. All authors read and approved the final manuscript.

ACKNOWLEDGEMENTS

We thank the Research Unity in Aquaculture and Fisheries Management (URAGeP) of Aquaculture School (EAq) of National University of Agriculture.

REFERENCES

AbouY, Fiogbe ED, Micha JC. 2007. Effects of stocking density on growth, yield and profitability of farming Nile tilapia, *Oreochromis niloticus* L., fed Azolla diet, in earthen ponds. *Aquaculture Research,* **38**: 595-604.

Abou Y, Houssou E, Fiogbé ED. 2010. Effets d'une couverture d'Azolla sur les performances de croissance et de production de Clarias gariepinus (Burchell) élevé en étangs. *International Journal of Biological and Chemical Sciences,* **4**: 201-208.

Adesina AJ. 2012. Comparability of the proximate and amino acids composition of maggot meal, earthworm meal and soybean meal for use as feedstuffs and feed formulations. *Elixir Applied Biology*, **51**:10693–10699.

Alofa CS, Oke V, Abou Y. 2015. Effect of replacement of fish meal with broiler chicken viscera on growth, feed utilization and production of African catfish *Clarias gariepinus* (Burchell, 1822). *International Journal of Fisheries and Aquatic Studies,* **4**(6): 182-186.

Bolaji BB, Mfon TU, Utibe DI. 2011. Preliminary study on the aspects of the biology of snakehead fish Parachanna obscura (Gunther) in a Nigerian wetland. *African Journal of Food, Agriculture, Nutrition and Development,* **11**: 4708-4717. DOI: https://doi.org/10.4314/ajfand.v11i2.65923

Djissou ASM, Adjahouinou DC, Koshio S, Fiogbe ED. 2016. Complete replacement of fish meal by other animal protein sources on growth performance of *Clarias gariepinus, International Aquaculture Research*, **8**: 333–341.

FAO. 2018. World Review of Fisheries and Aquaculture. Rome. 237 pp.

Hernandez CJ, Sarmiento P, Gonzalez-Rodriguez B, Parra AI. 2004. Replacement of fish meal with co-extruded wet tuna viscera and corn meal in diets for white shrimp (*Litopenaeus vannamei*), *Aquaculture Research*, **35**: 1153-1157.

Isangedighi IA, Umoumoh OE. 2011. Some aspects of the reproductive biology of African snakehead - *Parachanna obscura* in itu-cross river system. *Nigerian Journal of Agriculture, Food and Environment*, **7**(4): 19-30.

Kpogue DNS, Mensah GA, Fiogbe ED. 2012a. A review of biology, ecology and prospect for aquaculture of *Parachanna obscura*, *Review of Fish Biology Fish*, **23**: 41-50. DOI: 10.1007/s11160-012-9281-7.

Kpogue DNS, Gangbazo H, Fiogbe ED. 2012b. A preliminary study on the dietary protein requirement of *Parachanna obscura* (Günther, 1861) larvae. *Turkish Journal of Fisheries and Aquatic Sciences*, **13**: 111-117. DOI: doi.org/10.4194/1303-2712-v13_1_14

Kpogue DNS, Fiogbe ED. 2012 c. Feeding rate requirements for *Parachanna obscura* fry reared under controlled environmental conditions. *Journal of Applied Biosciences*, **55**: 3962-3972. http://m.elewa.org/JABS/2012/55/3.pdf

Kpogue DNS, Fiogbe ED. 2012d. Optimum stocking density for *Parachanna obscura* larvae fed at its optimum ration. *International Journal of Biological and Chemical Sciences*, **6**(3): 1293-1302. DOI: doi.org/10.4314/ijbcs.v6i3.32

Kpogue DNS, d'Almeida FMA, Odjo I, Fiogbe ED. 2018a. Utilisation des glucides chez les alevins de *Parachanna obscura* élevés en milieu contrôlé. *International Journal of Biological and Chemical Sciences*, **12**(1): 286-293. DOI: https://doi.org/10.4314/ijbcs.v12i1.23

Kpogue DNS, Gangbazo HK, Vodounnou DSJV, Mensah GA, Fiogbe ED. 2018b. Optimal feeding frequency for African sneakhead fish (*Parachanna obscura*, Gunther, 1861) fingerlings reared in captivity. *International Journal of Aquaculture*, **8**(22): 161-167. DOI: 10.5376/ija.2018.08.0022

Medale F, Kaushik S. 2009. Les sources protéiques dans les aliments pour les poissons d'élevage. *Cahier d'Agriculture*, **18**:103–111.

Oke V, Abou Y, Adité A Kabré JAT. 2016. Growth Performance, Feed Utilization and Body Composition of *Clarias gariepinus* (Burchell 1822) Fed Marine Fish Viscera-based-diet in Earthen Ponds. *Fish and Aquaculture Journal*, **7** (4): 1-7. DOI: 10.4172/2150-3508.1000183

Samocha TM, Davis DA, Saoud IP, DeBault K. 2004. Substitution of fish meal by co-extruded soybean poultry by-product meal in practical diets for the Pacific white shrimp *Litopenaeus vannamei*. *Aquaculture*, **231**: 197-203.

Sogbesan OA, Ugwumba AAA, Madu CT, Eze SS, Isa J. 2007. Culture and utilization of earthworm as animal protein supplement in the diet of *Heterobranchus longifilis* fingerlings. *Journal of Fisheries and Aquatic Science*, **2**: 375-386.

Soltan MA, Hanafy MA, Wafa MIA. 2008. An Evaluation of Fermented Silage Made from Fish By-Products as a Feed Ingredient for African Catfish (*Clarias grariepinus*). *Global Veterinaria*, **2**: 80-86.

Tabinda AB, Ghazala R, Yasar A, Ashrah M. 2013. Utilization of chicken intestine as an alternative protein source in the diet for fingerlings of *Cirrhinus mirigala. Journal of Animal and Plant*, **23**(6)-1603-1608.

Vahid Y, Shamsaie M, Baboli MJ, Yadollahi F, Hajivar EN, Moëzzi F. 2018. Replacement of Soybean Meal with Guar Meal in the Diet of Rainbow Trout, *Oncorhynchus mykiss* (Walbaum 1792): Biological Parameters and Flesh Quality. *Asian Fisheries Science*, **31**:181–190.

Vodounnou DSJV, Kpogue DNS, Tossavi CE, Mensah GA, Fiogbe ED. 2016 a. Effect of animal waste and vegetable compost on production and growth of earthworm (*Eisenia fetida*) during vermiculture. *International Journal of Recycling and Organic Wastes for Agriculture*, **5**: 87-92. DOI 10.1007/s40093-016-0119-5

Vodounnou DSJV, Kpogue DNS, Tossavi CE, Mensah GA, Fiogbe ED. 2016 b. Culture of earthworm (*Eisenia fetida*), production, nutritive value and utilization of its meal in diet for *Parachanna obscura* fingerlings reared in captivity, *International Journal of Fish and Aquatic Studies*, **4**: 1-5.

Vodounnou DSJV, Kpogue DNS, Akpo Y, Lagnika M, Fiogbe ED. 2017. Determination of sexual dimorphism of African snakehead (*Parachanna obscura*): morphometric and meristic parameters, weight-length relationship and condition factor. *International Journal of Biology and Chemical Sciences*, **11**(4): 1742-1752. DOI: https://doi.org/10.4314/ijbcs.v11i4.26

Vodounnou DSJV, Kpogue DNS, Zounon J, Sintondji W, Fiogbe ED. 2018. Nutrient requirement of African sneakhead fish (*Parachanna obscura*, Gunther 1861): a review. *International Journal of Aquaculture*, **8**(21): 156-160. DOI: 10.5376/ija.2018.08.0021

Zhou P, Zhang W, Davis DA, Lim C. 2010. Growth Response and Feed Utilization of Juvenile Hybrid Catfish Fed Diets Containing Distiller’s Dried Grains with Soluble to Replace a Combination of Soybean Meal and Corn Meal. *North American Journal of Aquaculture*, **72**: 298-303.