Original Research Article

A comparison between chicken viscera and housefly maggot cultured from this by-products for Nile tilapia diets : growth performances, feed utilization and whole body composition

ABSTRACT

Aims : The feeding trial was conducted to compare the effects of partial fishmeal replacement by two different animal protein sources on growth performance, feed utilization efficiency, and body composition of juvenile Nile tilapia.
Place and Duration of Study : The study was carried out at the Aquaculture Research Center, Department of Zoology, Faculty of Sciences and Technics, University of Abomey-Calavi for a period of 84 days.
Methodology : Three isonitrogenous and isoenergetic diets were formulated to containing fishmeal (CD), chicken viscera meal (CVM) and housefly maggot meal (HMM), as partial fishmeal replacement. Commercial diet Skretting (SK) was used as reference diet. Monosex male *O. niloticus* with an average initial body weight of 8.65 g were fed thrice a day to apparent satiety. Each treatment was randomly attributed to three replicates.
Results : Fish fed all experimental diets showed no effects (*P>.05*) on survival rate (91.33-96.00 %), condition factor (1.85-1.9), protein efficient ratio (2.05-2.37) and feed conversion ratio (1.21-1.40), although higher values were observed with control diets. Final mean weight and daily wheight gain of fish fed HMM diet (88.31 g ; 0.95 g. $days^{-1}$) were not significantly different from those fed control diets C (88.54 g ; 0.95 g/j) and Sk (87.59 g ; 0.94 g/j) respectively. Growth performances significantly decreased (*P<.05*) in CVM group (75.09 g ; 0.75 ± g/j). Whole-body protein contents were similar in all groups, whereas lipid content was highest in those fed CVM.
Conclusion : The results indicated that 200 g fishmeal per kilo diet can be successfully replaced with 250 $g.Kg^{-1}$ of HMM without adverse effect on growth and feed utilization whereas CVM inclusion did not perform also well.

Keywords: animal protein sources, carcass compostion, growth, feed utilization, tilapia.

1. INTRODUCTION

Fish meal is an important protein source in aquafeed due to its high protein content, balanced amino acid composition, essential fatty acids and high palatability [1, 2]. However, because of increasing prices, scarcity and poor quality locally, it has become the principal limiting factor of aquaculture development. In addition, according to forecasts, its availability is expected to wane and the cost will greatly increase [3]. It is imperative to minimize diet cost by searching cheaper alternative sources of protein that would enable aquaculture to be

left economically and environmentally sustainable in fish diets [4]. Therefore, research for fishmeal substitutes has been a important challenge [5]. Nowadays, a large number of studies explored various feed ingredients including both animal protein and plant protein sources. Plant protein sources have limitations, such as low palatability, presence of anti-nutritional factors, low concentrations of sulfur amino acids, and high proportions of fiber and non-starch polysaccharides [6,7]. In animal protein sources, both poultry by-product and insects larvae have received wide attention as a potential source of protein to produce feed for aquaculture industry, because of their high protein contents, availability and low price [8]. These ingredients are considered to be of higher quality than feedstuffs of plant origin, mainly because of their higher-level of indispensable amino acids [9].

Insects rise and spawn readily, have high feed conversion efficiency, and can be raised on biowastes [10]. Insect larvae are part of the natural diet sources for many animals included some fish [11,12]. Housefly *Musca domestica* maggot is considered as a good alternative protein source for fish due to its high protein content and essential amino acid content [4]. Larvae of fly are able to convert low valued organic waste into protein rich biomass [13]. There have been many studies on the replacement effects of housefly (*Musca domestica*) maggot meal in diets for many fish species, such as Gibel carp *Carassius auratus gibelio* and darkbarbel catfish *Pelteobagrus vachelli* [14], African catfish *Clarias gariepinus* [15,16,17,18], Vundu Catfish *Heterobranchus Longifilis* [19,20], Barramundi *Lates calcarifer* [21] and Nile tilapia *Oreochromis niloticus* [22,23].
On the other hand, in poultry processing, viscera are mostly considered as a waste product and disposal of these by-products is becoming a major problem for industries causing wastage of precious proteins source and environmental contamination [24]. Poultry by-products such as chicken viscera has significant potential as feed ingredients in fish feed [25,26,27]. Chicken viscera has high protein content, balanced amino acids profile, total digestible dry matter and total energy [28]. It's less expensive animal protein source as compared to fishmeal [29].

Tilapia culture is extensively ~~extensivily~~ practiced in tropical and subtropical regions with an annual growth rate of 12% due to their high growth rate, disease resistance, and low trophic feeding levels [30]. Nile tilapia *O. niloticus* is by far, the most important farmed tilapia species in the world, ranked second in terms of global farmed fish production in 2013, only after carp, with annual production achieving beyond 3.7 million tons in 2012 [31]. Thus, it is important to evaluate ~~evaluates~~ the potential of further feed ingredients for this species in the context of sustainability, concerning ~~with respect to the~~ needs of both the aquaculture and feed manufactured industry. To our acquaintance, no study has been made to compare both chicken viscera meal and housefly maggot meal as a fishmeal replacement in a single growth experiment. The main objective of this investigation was therefore to compare the effects of partial fishmeal replacement with chicken viscera meal and maggot meal in the diet of Nile tilapia (*Oreochromis niloticus*) juveniles on their growth performance, feed utilization efficiency and body composition.

2. MATERIAL AND METHODS

2.1. Fish and experimental design

The feeding trial was conducted at the Aquaculture Research Center, Laboratory of Ecology and Aquatic Ecosystem Management, Faculty of Sciences and Technics, University of Abomey-Calavi, Benin. The experiment was carried out in an outdoor recirculation system containing 18 concrete tanks (diameter : 120 cm ; water volume : 1000 L).

Comment [A1]: Sugiro citar alguns trabalhos: e.g.:
Vegetable protein
https://doi.org/10.1016/j.anifeedsci.2019.114379;
https://doi.org/10.1016/j.aquaculture.2015.11.017;
https://doi.org/10.1016/j.aquaculture.2016.06.032.

Animal protein:
https://doi.org/10.1016/j.aqrep.2017.01.001;
https://scialert.net/abstract/?doi=jas.2019.384.391;
https://doi.org/10.1080/00128325.2016.1158898.

Comment [A2]: https://doi.org/10.3390/ani9040181

Comment [A3]: A more recent source than Bhujel (2014) should be given in support of the statement made at the beginning of the paragraph

Monosex male Nile Tilapia (*Oreochromis niloticus*) fingerlings were obtained from a private fish farm (Dieu Exauce, Tori-Bossito, Benin) and transferred to the experimental site. Fish were acclimatized for two weeks. During acclimation period, they were fed with an equal mixture of experimental diets at a rate of 3% of biomass. In all, 900 fish (initial mean body weight of 8.45-8.6g, individually weighed to obtain a homogeneous stock of fish) were randomly distributed in eighteen concrete tanks. At the beginning of the trial, all fish were fasted for 24 h. Experimental *O. niloticus* of equal size were randomly selected, weighed and stocked in each tank. Three tanks were randomly assigned to each diet. Dead fish, if any, were removed from the tank and weighed immediately. Fish in each tank were counted and group weighed every 2 weeks and tanks were cleaned. Before each control, fish were starved for 24 h to avoid inclusion of ingested feed in the measurements of body weight as well as to reduce stress. Water was supplied with through biological filter system before being pumped into each tank at a flow rate of 4 L/min. All tanks were half-covered with racks throughout the experiment in order to prevent large variations in temperature and algal development.

Fish were hand-fed to apparent satiation thrice daily (09 :00 ; 13 :00 h and 17 :00 h). The daily feed supplied was recorded. Twenty fish from each tank (sixty fish per treatment) were randomly sampled to measure individual body weight, body length so as to calculate condition factor (CF).

2.2. Ingredients

2.2.1. Chicken viscera and maggot meal production

Chicken (*Gallus gallus*) viscera were collected from the commercial poultry processing industry “Agrisatch” (Abomey-calavi, Benin) and stored frozen (-20°C). The by-products were precooked on water vapor and dried in oven at 55°C for 48h [25, 32]. The dried-product was grounded and meal was stored in a refrigerator in plastic bag until use.

Maggot meal used in this study was the processed housefly (*Musca domestica*) larvae. Housefly larvae were produced from chicken viscera. Substrate were constitute from chicken viscera spread on sawdust for house flies to lay egg. This substrate (5cm) were watered twice daily morning and evening to maintain the constant humidity required for maggot growth. Larvae were appeared on the second day. They were harvested, washed, weighed, killing in hot water during 15 minutes, afterward oven dried at 60°C for 24 h before being processed into meal. The maggot meal was packed in an air tight container and stored in a refrigerator at 4°C until use.

According to the nutrient requirement of fingerlings Nile Tilapia [33], three isonitrogenous (35% crude protein) and isoenergetic (19KJ/g gross energy) experimental diets were formulated using *Sardinella* fishmeal (CD), chicken viscera meal (CVM), maggot meal (HMM) as major protein source in addition to fish meal and soybean and cotton oilcakes meal (Table 2). In all experimental diets, fish meal was used at the level of 100 g kg^{-1} diet. Maize bran was used as the major carbohydrate source and palm oil was used as lipid source to adjust the required lipid content (80-100 g kg^{-1} diet) in the diets. The commercial diet Skretting is used as reference diet. Nutrient composition of the main ingredients used in the diets is shown in Table 1, and the diet formulations and proximate compositions are shown in Table 2. Diet descriptions are as follows :

Commercial diet Skretting SK

CD- 300g.Kg^{-1} *Sardinella sp* fishmeal protein diet (control)

Comment [A4]: There is lack of concordance between the text citation and the information given in the reference list.

Nile tilapia requirements papers:
Protein:
https://doi.org/10.1016/j.aquaculture.2009.10.027
http://dx.doi.org/10.4025/actascianimsci.v39i4.36122
Energy:
https://doi.org/10.1111/j.1439-0426.1995.tb00029.x
https://doi.org/10.1007/s10499-012-9616-3
https://doi.org/10.1016/j.aquaculture.2017.12.035

CVM- 280g.Kg^{-1} Chicken viscera meal

HMM- 250g.Kg housefly *Musca domestica* maggot meal.

Table 1 : Proximate composition (as % dry matter) of feeds ingredients

Ingredients	Dry matter	Crude protein	Crude lipid	Ash
Fish meal	92.0	66.0	7.88	15.77
Chicken viscera	90.9	35.2	22.0	6.3
Maggot meal	92.7	48.8	21.0	6.25
Soybean oilcake	94.8	30	13.2	3.7
Cottonseed oilcake	90.0	40.5	7.0	8.0
Blood meal	90.9	71.9	1.7	6.4
Maize bran	91.4	6.2	3.1	1.4

All values are mean of triplicate samples.

Table 2 : Ingredients and proximate composition of the experimental diets control (C), Skretting (Sk), HMM (Housefly Maggot Meal) and CVM (Chicken Viscera Meal)

	Price	Dietary treatments			
	(US$.Kg$^{-1)}$	SK^{1}	CD	CVM	HMM

Comment [A5]: C or CD?

Ingredients (g 100 g $^{-1}$)					
Fish meal	2.24		30	10	10
Chicken viscera meal	0.27		–	28	–
Maggot meal	0.44		–	–	25
Blood meal	0.22		7	7	7
Corn bran	0.26		36	15	26
Soybean meal	0.67		14	22	18
Cottonseed meal	0.33		10	15	11
Palm oil	1.38		2	2	2
Salt (NaCl)	0.43		1	1	1
Proximate composition					
Dry matter (%)			90,16	90,10	90,54
Crude protein (% DM)			35,32	35,03	35,13
Crude lipid (% DM)			8,15	13.47	11,88
NFE[2](% DM)			36.42	28.73	31.35
Ash (% DM)			7.95	9.4	6,45
Gross energy[3] (kJ g^{-1})			17.85	18,57	18.58
Diet cost (US$. Kg^{-1})[4]		1.87	1.00	0.65	0.67

1. Proximate composition : Crude protein : 35% ; Crude fat : 9% ; Fibre : 3,4% ; Ash : 6,5%, Calcium : 1% ; Phosphore : 1%, Lysine : 1,5% ; Methionine : 0,5% ; CuSO4 : 5mg/Kg
2. Nitrogen-free-extract (NFE) = 100 - (% moisture + % crude protein + % crude lipid + % ash + % crude fibre).
3. Gross energy was calculated using the factors of 23.7 KJg^{-1}, 39.5 KJg^{-1} and 17.2 KJg^{-1} protein, lipids and NFE respectively [34]
4. Prices in US$, 1 US$= 580.05 FCA at present. Labour and processing costs were included.

2.2.2. Preparation

For diet preparation, dry ingredients were weighed, mixed together for 30 mn using a food mixer, and warm water was added to obtain about 35% moisture level. The resulting dough were then passed through a laboratory pelleting machine (Bosch MFW3640A) with 2 mm die to form 'spaghettis' strands and sun-dried for three days at 30-35°C. After drying, diets were ground manually into pellets of appropriate size.

2.3. Water quality and Biochemical analysis

Water quality were checked three times weekly. Temperature, dissolved oxygen, pH, conductivity and total dissolved solid (TDS) were monitored from each tank at 10 cm depth using multiparameter HANNA HI-9828 v1.04. Nitrite and ammonium were determined by cadmium reduction and phenate methods respectively.

Proximate composition of ingredients, fish samples from each treatment were analysed following standard procedures of Association of Official Analytical Chemists [35]. Prior to analysis, samples were dried and ground to a fine powder. Dry matter was determined by drying the samples in an oven at 105° C for 24 h. Crude protein content was analysed using the Kjeldahl method to measure the nitrogen and calculated as *N*×6.25. Crude lipid was extracted following the method described by Folch *et al.* [36]. Ash content was measured after combustion at 550 °C for 12 h in a muffle furnace. Total ash content was determined by incinerating the sample at 650°C for 6 h.

2.4. Calculations and statistical analysis

At the end of the trial, growth and nutritional indices were calculated as followed :

$$\text{Survival rate } (\%) = \frac{\text{final amount of fish}}{\text{initial amount of fish}} \text{ X } 100$$

$$\text{Weight gain rate } (\text{WGR}, \%) = \frac{(\text{final body weight} - \text{initial body weight})}{\text{initial amount of fish}} \text{ X } 100$$

$$\text{Daily weight gain } (\text{DWG}, \text{g/days}) = \frac{(\text{final body weight} - \text{initial body weight})}{\text{rearing period}}$$

$$\text{Specific growth rate } (\text{SGR}, \%) = \frac{\ln(\text{final weight gain}) - \ln(\text{initial weight})}{\text{rearing period}} \text{ X } 100$$

$$\text{Protein efficiency ratio } (\text{PER}) = \frac{\text{body weight gain}}{\text{total feed consumed protein content in diets}}$$

$$\text{Feed Conversion Ratio } (\text{FCR}) = \frac{\text{total dry feed consumed}}{\text{body weight gain}}$$

$$\text{Condition factor } (\text{CF}) = \frac{\text{final body weight (g)}}{\text{body length (cm)}3} X \text{ } 100$$

$$\text{Yield } (\text{Kg/m3}) = \frac{\text{final biomass per tank (g)} - \text{initial bimass per tank (g)}}{\text{volume (m3)}}$$

$$\text{Production } (\text{Kg/m3/year}) = \frac{\text{Yield x365}}{\text{rearing period}}$$

$$\text{Feed intake } (\text{FI}, \text{g/fish}) = \frac{\text{total amount of the dry feed consumed}}{\text{fish numbers X days}} \text{X } 100$$

Economic conversion ratio (ECR) = Cost of diet x Feed Conversion Ratio (FCR)

Data were expressed as mean ± standard error of the mean (SEM). Prior to the statistical tests, data were examined for homogeneity of variances. Differences between the means were tested by Tukey's multiple range tests. Differences were regarded as significant when $p < 0.05$. The normality and homogeneity of variances among groups were tested and all data were subjected to one-way analysis of variance ANOVA. All analyses were performed using the Statistical Package for Social Sciences (SPSS IBM version 20.0 for windows v8.1, Chicago, Illinois, USA).

3. RESULTS AND DISCUSSION

The present experiment evaluated the potential of CVM and HMM as fishmeal substitutes in diets for Nile tilapia. The results of the study indicated that HMM could be incorporated in diets for juvenile Nile Tilapia up to a level of 250 g/kg, without negative effects on growth and feed utilization. However, CVM, significantly reduced the growth of *O. niloticus* when 200g/kg of *Sardinella* fishmeal protein was replaced by CVM protein (280 g/kg). Maggot meal used in this study had relatively higher protein content (48.8 %), while the chicken viscera had a lower protrein value (35.0 %).

3.1. Water quality

Water quality parameters in all tanks during the experimental period are shown in Table 3. Water temperature values ranged from 29.88 to 30.10 °C, pH from 6.78 to 6.89, dissolved oxygen from 3.11 to 3.18 mg L^{-1}, conductivity from 179.6 to 185.1 µS cm^{-1}, total dissolved solid from 92.5 to 94.63 ppm and salinity from 0.07 to 0.08 psu. These water quality parameters were similar in all treatments (*P>.05*) and were within optimal ranges for Nile Tilapia growth as reported by DeLong *et al.* [37]. The global growth performance and high survival rates in all treatments indicate that all diets were adequate for juvenile Nile Tilapia and fulfill its nutrients requirement. There was no difference in survival rate in this study for any dietary treatments, which ranged from 87% to 96% among treatments. Average survival in the study was higher than other several reports [39,40] several of those studies used green-water culture systems.

Comment [A6]: Not part of "water quality" section.

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Table 3 : Water quality parameters in *O. niloticus* rearing tanks during the experimental period

Parameters	SK	CD	CVM	HMM
pH	6.78 ± 0.29	6.81 ± 0.29	6.78 ± 0.31	6.81 ± 0.31

Temperature (°C)	29.88 ± 0.68	30.08 ± 0.72	30.10 ± 0.70	29.97 ± 0.72
Dissolved oxygen ($mg.L^{-1}$)	3.18 ± 0.86	3.17 ± 0.57	3.13 ± 0.54	3.11 ± 0.64
Conductivity (µS/cm)	179.7 ± 84.1	185.1 ± 86.9	181.4 ± 86.9	179.6 ± 89.1
TDS ($mg.L^{-1}$)	93.06 ± 45.56	94.63 ± 45.22	93.60 ± 45.96	92.50 ± 46.85
Salinity (psu)	0.07 ± 0.08	0.08 ± 0.04	0.08 ± 0.04	0.08 ± 0.04
Nitrite ($mg.L^{-1}$)	0.04 ± 0.01	0.03 ± 0.01	0.03 ± 0.01	0.03 ± 0.01
Nitrate ($mg.L^{-1}$)	2.23 ± 0.38	2.33 ± 0.25	2.30 ± 0.16	2.26 ± 0.18

3.2. Growth performances and feed utilization

The change in mean weight over the trial period is shown in Figure 1. Growth performance, feed utilization and production parameters of *O. niloticus* fed the practical diets is shown in Table 4. Fish mortality was recorded in all replicates of the treatments, but there were no significant differences in survival rates during the entire period of the experiment (86 days) ($P>.05$). The average initial mean weight of *Oreochromis niloticus* fingerlings (8.45 - 8.66g) in all the treatment groups was similar ($P>.05$), indicating that the significant differences observed for the growth parameters were effects of the experimental diets. Juveniles of Nile tilapia attained almost eightfold to tenfold of the initial body weight after 12 weeks. Overall daily weight gain ranged between 0.79 and 0.95 g day^{-1} and percentage weight gain was between 789.0 % and 929.32 % for all the different treatments after 12 weeks of experiment. Fish fed HMM diets had similar final body weight and weight gain compared to the control group SK and CD ($P > .05$). Fish fed the control diet (SK and CD) and experimental diet HMM had significantly ($P < .05$) better daily weight gain (DWG) and SGR than those fed with diet CVM. This was also the case with the feed intake in which an increasing tendancy was observed with control diet and HMM, but only the value found in fish fed with diet CVM was significantly different from all others treatments.

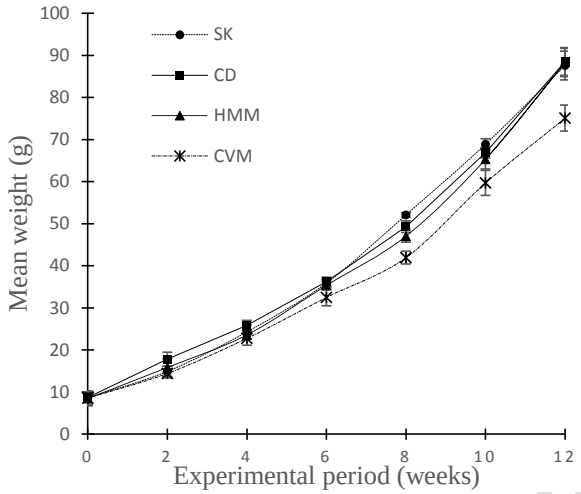

Figure 1 : Change in mean weight of individual *O. niloticus* fed the experimental diets containing chicken viscera meal CVM, housefly maggot meal HMM; Control diet CD and commercial diet Skretting SK (n=3) during the experimental period (12 weeks).

Results obtained from the present study clearly indicate that monosex male Nile Tilapia *O. niloticus* fed Maggot meal diet performed better than those fed chicken viscera meal in terms of growth performances. Fish meal is known as the best protein source in aquafeeds and diets containing fish meal generally produce better growth performance in comparison with other protein sources, including animal and plant meals [40]. However, group fed HMM diet performed equally than those fed control diets. Final weight of the fish fed CVM diet at the end of the trial was significantly lower than those fed conrol diet.

Chicken viscera has been confirmed as an alternative protein source for replacing fishmeal in feeding for several fish species. It was reported that no significant difference in the growth performance and feed efficency was observed in African catfish *Clarias gariepinus* fed diets containing 30% CVM (corresponding to the half of fishmeal replacement) when compared to fish fed control diet [32]. Giri *et al.* [25] indicated that dried chicken viscera could be used as a fishmeal replacement in the diets of *Clarias batrachus* fingerlings without adversely affecting the performances. Tabinda and Butt [41] also recorded best growth for diets containing 22.5% chicken intestine (with 7.5% fishmeal) in grass carp *Ctenopharyngodon idella*. However, in the present study, diet containing 280 g kg^{-1} CVM significantly decreased the growth performance. Because all diets were isonitrogenous and isoenergetic, the diminishing growth performance in group fed CVM diet might be assigned to the low nutritional value and imbalanced amino profile (such as lysine and methionine) of this alternative protein source [42,43]. However, the protein efficiency ratio obtained with CVM diets at the end of this experience was superior to 1.2 obtained by Giri *et al.* [44] in *C. batrachus,* but similar than those (2.7) obtained by Nyina-Wamwiza *et al.* [45] with diet containing of 18% of chicken viscera meal.

Comment [A8]: Tip: standardize units (g kg or %)

According to the present study results, similars growth was observed in terms of percentage WG, SGR and FCR in HMM diet for *Oreochromis niloticus* as compared to the control diets. Similar results were obtained for barramundi *Lates Calcarifer* [21], African catfish *Clarias gariepinus* [15] and turbot *Scophthalmus maximus* [46]. Wang *et al.* [23] indicating that

maggot meal can replace 18% FM protein in the diet of *O. niloticus* with any adverse effect on the growth performance and nutrient utilization. In contrast, Slawski *et al.* [47] showed that Nile tilapia (*Oreochromis niloticus*) fed diets with housefly maggot meal had increased feed conversion and reduced growth performance compared to fish fed control diet. The lower digestibility of maggot meal could be attributed of chitin in the exoskeleton of prepupae which is indigestible to fish [48].

In present study, SGR was significantly higher ($p<0.05$) in SK, CD and HMM as compared to CVM. Similar results were reported by Samocha *et al*. [49]. These authors reported significant difference in SGR at high inclusion of poultry by-product in the diet of *L. vannamei*. Similarly, Shapawi *et al.* [50] also found high SGR with the inclusion of poultry by-product up to 75-100%. The average specific growth rate (SGR) of *O. niloticus* (weighing 8.6 g) fed with the control diet (350 g kg^{-1} crude protein) was approximately 2,77 % per day, which is higher than those (1.12–1.62% per day) reported for Nile Tilapia (initial weighting 2.69–3.21 g) [23,51], because the bigger fish can get lower growth rate than the smaller fish. A relatively high SGR obtained in the current study may be probably assigned to suitable temperature, relatively lower stocking density and suitable water flow. A anterior study in Nile Tilapia (*O. niloticus*) showed it was possible to sustain growth performance with a 27% maggot meal (produced from chicken manure) inclusion diet [22,23]. However, it had been stated that higher dietary inclusion levels of maggot meal had negative impacts negatively survival, growth performance and feed utilization in juvenile Nile tilapia [23]. The increasing costs combined with the growing demand for fishmeal could potentially ensure the use of maggot meals in manufactured fish feed industry. As shown in Table 4, condition fator, protein efficiency ratio, feed conversion ratio and survival rate data in this study also indicated no significant differences among the treatments ($P>.05$).

The use of Chicken viscera and housefly maggot meal in *O. niloticus* diets ensued in decrease of feed cost (cost/kg diet) and economic conversion ration (Table 4). The maximum reduction economic conversion ration was reached with chicken viscera and maggots based-diets. These diets allowed the decreasing of ECR from 59% (HMM) to 60% (CVM) approximatively (*vs* control diet SK).

Table 4 : Growth performance, feed efficiency and annual production of *Oreochromis niloticus* fed the test diets for 12 weeks.

Parameters	SK	CD	CVM	HMM
Initial weight (g)	8.60 ± 0.10	8.66 ± 0.14	8.45 ± 0.10	8.58 ± 0.17
Final weight (g)	87.59 ± 3.42^{a}	88.54 ± 3.30^{a}	75.09 ± 3.09^{b}	88.31 ± 3.37^{a}
Feed intake (g fish^{-1})	94.93 ± 3.20^{ab}	104.84 ± 3.33^{a}	91.86 ± 3.73^{bc}	107.95 ± 3.31^{a}
Survival (%)	96.00 ± 2.00	94.00 ± 2.00	91.33 ± 1.16	92.00 ± 2.00
Weight gain (%)	918.8 ± 41.8^{a}	923.4 ± 54.7^{a}	789.0 ± 28.7^{b}	929.32 ± 20.9^{a}
Daily weight gain (g. days^{-1})	0.94 ± 0.04^{a}	0.95 ± 0.04^{a}	0.79 ± 0.04^{b}	0.95 ± 0.04^{a}
Specific growth rate (% days^{-1})	2.76 ± 0.05^{a}	2.77 ± 0.06^{a}	2.60 ± 0.04^{b}	2.77 ± 0.02^{a}
Feed conversion ratio	1.21 ± 0.09	1.32 ± 0.02	1.40 ± 0.11	1.37 ± 0.09
Protein efficiency ratio	2.37 ± 0.18	2.16 ± 0.04	2.05 ± 0.16	2.09 ± 0.14
Condition factor	1.92 ± 0.09	1.89 ± 0.12	1.95 ± 0.14	1.85 ± 0.09
Yield (Kg.m^{-3})	3.78 ± 0.25^{a}	3.73 ± 0.25^{a}	3.00 ± 0.14^{b}	3.63 ± 0.20^{a}
Production (Kg.m^{-3}.year^{-1})	16.03 ± 1.06^{a}	15.84 ± 1.06^{a}	12.76 ± 0.59^{b}	15.43 ± 0.86^{a}
ECR	2.26 ± 0.18^{a}	1.32 ± 0.02^{b}	0.91 ± 0.07^{c}	0.92 ± 0.06^{c}

3.3. Carcass composition

Whole-body composition of *O. niloticus* fed the experimental diets are showed in Table 5. Dry matter (range : 89.82-91.62 %) and crude protein (range : 59.67-62.45 %) of fish fed all diets were not significantly different (*P>.05*). Lipid deposition (range : 32-38%) in fish fed CVM diets is significantly higher, whereas ash content (9.79-17.43) decreased (*P<.05*). These findings were in agreement with [22,25,32], who related that substitution of FM by CVM and HMM in diets did not affect the body protein content, but increase body lipid content of fish.

Comment [A9]: Fat is related to fish meat quality.
So, I suggest the authors discuss the fat content increases

Table 5 : Proximate composition (%) of whole body of *Oreochromis niloticus* fed the experimental diets. C, diet containing fish meal ; HMM, diet containing housefly maggot meal ; CVM, diet with chicken viscera meal.

		Diets				Anova
Composition	Initial	SK	CD	CVM	HMM	p-values
Dry matter	89.82 ± 0.12	91.51 ± 0.52	91.00 ± 0.24	91.01 ± 0.25	91.62 ± 0.27	0.279
Crude protein	63.14 ± 0.70	61.40 ± 0.44	62.45 ± 0.08	59.90 ± 2.50	59.67 ± 1.54	0.332
Crude lipid	10.76 ± 0.59	32.59 ± 1.86^{b}	33.56 ± 1.66^{ab}	38.64 ± 1.06^{a}	31.68 ± 0.58^{b}	0.025
Ash content	16.52 ± 81.19	14.79 ± 0.68^{a}	17.43 ± 2.37^{a}	9.79 ± 0.48^{b}	14.95 ± 0.26^{a}	0.016

Values with different superscripts within the same row are significantly different ($p<0.05$). Values are mean ± SE (n = 10 fish/treatment).

4. CONCLUSION

This study indicate the utility of HMM to partially replace fishmeal in practical diets for tilapia juveniles up to 25 %, as no negative effects on growth performance or body composition were observed. However, the inclusion of 28 % CVM appears to induce reduction on growth performance and decreasing fish feed intake. Further research is required to evaluate the influence of CVM at various levels of fishmeal substitution in *O. niloticus* diets. Nevertheless, we suggest the use of these by-products which are available free of cost so far in order to reduce the cost of Nile tilapia feed.

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COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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