# Effect of Black Soldier Fly Larva as a Meal on Proximate Composition and Carcass Quality of African Catfish (*Clarias gariepinus*)

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**Abstract-** The need to substitute the scarce and expensive fishmeal with a cheaper alternative has drawn attention to the use of insect protein in feeds due to their abundance and high nutritional value. In this regard the Black soldier fly (Hermetia illucens) stands out due to its dual ability of recycling organic waste materials into useful biomass for feed. This resulted in several studies that assessed the quality of carcass produced by livestock fed with the larva meal. However, very little studies have been carried out on the effect of this larva meal on the carcass quality of the African catfish (Clarias gariepinus). Here, this study showed that the Black soldier fly larva meal can be used to replace fishmeal in the diet of Clarias gariepinus up to 75% to increase the quality of carcass. Four treatment diets of compounded fish feed were formulated to contain Black soldier fly larva meal replacing fishmeal at different inclusion rates of 0%, 50%, 75% and 100%. The values for condition factor recorded from each treatment were above 1, which imply that the fish were in good physiological state. The values of the hepatosomatic indices observed among the treatment diets indicate that feeding Black soldier fly larva meal to Clarias gariepinus had no negative impact on the liver functionality and no excessive hepatic accumulation of fat or carbohydrate as the values were within the normal range (1–2%). The fillet yield was significantly highest for fish fed 75% larva meal. Meanwhile, the productive potential carcass quality was also noticed to have increased with the increasing rate of larva meal inclusion up to 75%. Our results demonstrate that Black soldier fly larva meal can be used to replace fishmeal in the diet of Clarias gariepinus up to 75% to reduce cost of feeding without compromising the quality of carcass produced.

**Keywords-** black soldier fly larva meal, fishmeal, treatment diet, condition factor, hepatosomatic index, fillet yield, condition factor, productive potential carcass quality factor.

## I. Introduction

The increasing gap between animal protein supply and growing world population has become a global concern [1]. Meanwhile, a major global shift in diets, characterized by increased consumption of animal products and increased demand for feed ingredients, is likely to continue in the near future, and the quest for alternative sustainable animal protein sources is expected to become a considerable issue in the feed market [2], [3], [4]. Insects have recently been identified as an important future source of sustainable raw materials for animal nutrition in many countries around the world. However, insect protein which is required to enhance animal production and supply [5] has for the most part been underutilized [6]. As part of the natural diet of some animal species, insect meets the animals' nutritional needs and feed acceptance [7] which will help to mitigate the low acceptance of direct insect consumption [8] by improving animal production.

Several insects have been tested for animal feeds, with the most promising species being the black soldier fly (*Hermetia illucens*) [9], the yellow mealworm (*Tenebrio molitor*, TM) [10], and the common house fly (*Musca domestica*, MD) [11]. Previous researches have highlighted the possibility of including insect larva/prepupa meal in fish diets as partial or total replacement of conventional protein/fat sources (soybean and fish meals and oils), which are no longer considered sustainable [12], [4], [13].

Several studies have been conducted to determine the effect of insect meal on the carcass quality of fish. One of such studies carried out [14] found that inclusion of Black Soldier Fly Larvae Meal (BSFLM) did not adversely affect the carcass quality parameters of Jian carp (*Cyprinus carpio var. Jian*). The study also found that the inclusion of BSFLM diets of Jian Carp at 100% BSF larvae meal to replace fishmeal led to a decrease in n-3 highly unsaturated fatty acids in Jian carp carcasses thereby suggesting

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that inclusion of the larvae meal can improve on fish carcass quality. Other authors [15] also found that carcass compositions were not affected by the replacement of fishmeal with BSFLM up to 50% in the diet of juvenile Barramundi (*Lates calcarifer*). Renna *et al.*, (2017) [16] reported that a defatted BSFLM can be applied in rainbow trout diets to a maximum of 40% without affecting growth, the survival rate, condition factor, somatic indexes, fillet quality parameters and intestinal morphology. The carcass quality of fish determined by the state of its internal organs which is dependent on the quality of life of the fish. The Fulton's condition factor (K) is used to compare the condition, fatness, or wellbeing of fish, based on the assumption that heavier fish of a given length are in a better condition [17], K values less than one (1) imply that fish are not in good state of well-being within their habitat, while values greater than one (1) imply that fish are in good physiological state of well-being [16]. However, the K value is not a sole determinant of carcass quality [18]. Hepatosomatic Index (HSI) values between 1% and 2% (as obtained in the current study) are indicators of proper liver function [19]. Studies on the fillet yield as reported by several authors indicated that the replacement of fishmeal with BSFLM had not significant change in the fillet yield [20], [21], [22].

Other studies have also shown that there were no significant differences in whole carcass chemical composition especially with regard to percentage crude protein (CP) of trout fed different amounts of BSF larvae meal [23], [24]. As reported in previous studies, the nutrient proximate composition of shrimp carcasses wasn't significantly influenced with the different feeding levels with dietary BSF larvae [25]; also, Zarantoniello *et al.* (2019) [26] reported that rearing of the zebra fish using BSF larvae meal did not negatively affect the proximate composition. The replacement of fishmeal with BSFLM up to 48% in the diets of African Catfish and Yellow did not negatively impact the liver functionality [27], [28]. Ronghua *et al.* (2010) [29] reported no significant differences in the proximate compositions and amino acid contents in the muscle of juvenile grass carp fed diets with partially defatted BSFLM replacing soybean meal up to 100% in the absence of fishmeal.

Similarly, in a recent study [30] it was shown that the use of BSF larvae meal in the rearing of the African catfish at 75% inclusion level did not affect the carcass proximate and quality characteristics. The report showed that the carcass of African catfish reared on BSFL meal had higher quality than that reared on fishmeal in terms of: essential amino acid content which increased with increase in BSF larvae meal substitution, ash content, crude protein content which was highest at 50% and 75% substitution rates and lipid content which increased with increased substitution of BSF larvae meal in the treatment diets. Adeoye *et al.* (2020) [27] also reported that replacing fishmeal with BSFLM up to 50% did not affect the growth, nutritional utilization, survival rate and welfare of *C. gariepinus* fingerlings.

The, present study therefore presents the effect of black soldier fly larva meal diet on the carcass quality of *Clarias gariepinus*.

## II. Materials and Method

### A. Experimental Feed

Black soldier fly larvae used in the experiment were sourced from the wild. Other feed ingredients (Table 1) used were sourced from local suppliers, compounded, mixed and formulated to make a mash as complete fish diets. The diets were formulated to meet optimum feeding standards for Catfish [31], [32] as shown in Table 1. The diets were formulated to partially and wholly replace fishmeal with BSF larvae meal. The control diet (C) contained fishmeal as the protein source without BSF larvae meal. For diets D1, D2, and D3 BSF larvae meal was included to replace fishmeal at inclusion rates of 50%, 75% and 100%.

Table I

FORMULATED TREATMENT DIET (%) COMPOSITIONS USED IN THE STUDY

| Ingredients | C (g/kg) | D1 (g/kg) | D2 (g/kg) | D3 (g/kg) |
|---|---|---|---|---|
| BSF larvae | 0.00 | 70.00 | 105.00 | 140.00 |
| Maize flour | 164.26 | 164.26 | 164.26 | 164.26 |
| Soybean full fat meal | 345.00 | 345.00 | 345.00 | 345.00 |
| Cassava flour | 20.00 | 20.00 | 20.00 | 20.00 |
| Fishmeal | 140.00 | 70.00 | 35.00 | 0.00 |
| Vitamin mineral premix | 5.00 | 5.00 | 5.00 | 5.00 |
| Lysine | 0.50 | 0.50 | 0.50 | 0.50 |
| Methionine | 1.00 | 1.00 | 1.00 | 1.00 |

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| | | | | |
|---|---|---|---|---|
| Salt | 0.29 | 0.29 | 0.29 | 0.29 |
| Bone meal | 1.00 | 1.00 | 1.00 | 1.00 |
| Groundnut cake | 273.00 | 273.00 | 273.00 | 273.00 |
| Palm kernel cake | 50.00 | 50.00 | 50.00 | 50.00 |

*C, Control diet (0% BSF larvae meal and 100% fishmeal); D1, Diet 1 (50% BSF larvae meal and 50% fishmeal); D2, diet 2 (75% BSF larvae meal and 25% fishmeal); D3, diet 3 (100% BSF larvae meal and 0% fishmeal)*

**B. Proximate Analysis of Fish and Experimental Diet**

Proximate composition analysis of both fish and experimental diet was determined by method described by Association of Official Analytical Chemist [33].

**C. Evaluation of Carcass Quality of Fish**

The carcass quality of the experimental fish for each treatment was studied using the following biometric traits.

*i)* *Condition factor (CF)*: $\left[Fish = \frac{Tw}{(Tl \; x \; Tl \; x \; Tl)}\right] x \; 100$

*ii)* *Hepatosomatic index (HIS %)* = $100 \; x \left[= \frac{Lw\;(g)}{Tw(g)}\right]$

*iii)* *Fillet weight (FW %)*= $100 \; x \left[= \frac{Fw\;(g)}{Tw(g)}\right]$

Where;

TL = Total length

TW = Total weight

LW = Liver weight

FW = Fillet weight

The total length was the measurement of the whole length (from the tip of the mouth to the end of the caudal fin) of the fish. Measurements were taken in centimeters (cm) with a fish measurement board.

The total weight was gotten by weighing and taking the weight of whole fish at the end of the experiment. Weight measurements were taken using as sensitive Ming Heng Digital Scale (777 model) with an accuracy of 0.01g.

The liver weight was gotten by measuring the weight of the fish liver carefully collected from each of the slaughtered fish.

The weight of the fillet was gotten by carefully cutting out the edible portions of the carcass (without the bones) by making incision through the mid dorsal part (on each side of the dorsal fin) of the carcass. The edible portions (fillets) were weighed to get the fillet weight.

**D. The Productive Potential Carcass Quality Factor (PPCQF)**

This was determined using the crude protein and fat values obtained from the analysis of the nutrient composition of the fish carcass [18].

PPCQF $= \frac{Crude\ Protein\ (\%) + Crude\ Fat\ (\%)}{100} \;\; x \;\; \frac{Dry\ carcass\ weight}{100}$

**E. Statistical Analysis**

The data collected were subjected to statistical analysis using one-way Analysis of variance (ANOVA)

while the means were separated using Duncan Multiple Range Test [34]. The statistical analysis was carried with IBM SPSS version 23.

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## III. Results

### A. Proximate Analysis of Fish Feed

Result of the proximate analysis of BSF larvae meal and all the feed ingredients used in this study are shown in table 2. The crude protein of fishmeal was 36.13 % while that of BSFLM was in the range of 35.37 – 35.96 %.

Table 2

PROXIMATE ANALYSIS OF FISH FEED AT FOUR DIFFERENT INCLUSION LEVELS OF BLACK SOLDIER FLY LARVA MEAL

| Diet | Crude Protein | Crude Fat | Ash Content | Crude Fiber | Moisture Content |
|---|---|---|---|---|---|
| BSFL | 40.27 | 20 | 15 | 8.5 | 12.5 |
| C | 36.13 | 10.87 | 9.00 | 3.80 | 10.00 |
| D1 | 35.37 | 10.97 | 12.50 | 6.80 | 8.50 |
| D2 | 35.96 | 12.00 | 11.00 | 9.00 | 7.50 |
| D3 | 35.62 | 10.08 | 10.00 | 7.50 | 5.00 |

### B. Proximate Analysis of Fish

The means of proximate analysis of fish fed with the four dietary treatments are shown in table 3.

Fish from all the experimental diets recorded significantly different values for crude protein with D3 recording significantly lower value ($63.700 \pm 0.043^a$) than observed for the rest treatments.

Crude fat recorded showed no significant variations except for treatment C ($11.970 \pm 0.143^a$) which was also not significantly different from that of treatment D1 ($13.500 \pm 0.583^{ab}$).

Treatment C recorded the highest significant value for ash ($6.5470 \pm 0.050^c$).

No significant difference was recorded in terms of moisture content for fish sampled from all treatment units.

Table 3

PROXIMATE ANALYSIS OF FISH REARED WITH DIFFERENT TREATMENT

| Diet | Crude Protein | Crude Fat | Ash Content | Moisture Content |
|---|---|---|---|---|
| C | $65.670 \pm 0.583^b$ | $11.970 \pm 0.143^a$ | $6.547 \pm 0.050^c$ | $11.830 \pm 0.052^a$ |
| D1 | $66.240 \pm 0.572^b$ | $13.500 \pm 0.583^{ab}$ | $6.233 \pm 0.038^b$ | $11.070 \pm 0.575^a$ |
| D2 | $69.180 \pm 0.583^c$ | $13.970 \pm 0.622^b$ | $6.100 \pm 0.058^{ab}$ | $10.750 \pm 0.525^a$ |
| D3 | $63.700 \pm 0.043^a$ | $15.037 \pm 0.402^b$ | $6.010 \pm 0.006^a$ | $11.400 \pm 0.608^a$ |

Values bearing different superscripts in the same column are significantly different ($p < 0.05$).

### C. Carcass Quality

The Condition Factors (K) for the four treatment diets were significantly different ($p < 0.05$). Fish fed on D3 had significantly highest condition factor than the other treatment diets, while the fish fed treatment diet C had the lowest condition factor.

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The Hepatosomatic Index (HIS) was significantly different ($p < 0.05$) for the four treatment diets, with fish fed with treatment diet D3 ($1.796±0.001^d$) having the highest record followed by that of C ($1.758±0.001^c$) and then D1($1.554±0.001^b$). D2 ($1.095±0.001^a$) recorded the lowest HSI.

Fillet yield (FY), represented as the percentage of fillet weight was significantly highest for fish fed on D2 ($53.833±0.001^d$) while the lowest fillet yield was observed in fish fed treatment C ($43.236±0.001^a$). The fillet yield was significantly different ($p < 0.05$) for the four treatment diets.

The values for Productive Potential Carcass Quality Factor (PPCQR) for fish fed on treatment diet D2 recorded the highest value ($0.024±0.001^c$) followed by D1 ($0.018±0.001^b$) while fish fed with treatment diets C and D3 ($0.013±0.001^a$) had no significant difference ($p > 0.05$).

Table 4

CARCASS QUALITY of *C. Garipienus*

| Parameters | K(%) | HSI(%) | FY (%) | PPCQF (%) |
|---|---|---|---|---|
| *C* | $1.034±0.001^a$ | $1.758±0.001^c$ | $43.236±0.001^a$ | $0.012±0.001^a$ |
| *D1* | $1.090±0.001^b$ | $1.554±0.001^b$ | $48.446±0.001^c$ | $0.018±0.001^b$ |
| *D2* | $1.122±0.001^c$ | $1.095±0.001^a$ | $53.833±0.001^d$ | $0.024±0.001^c$ |
| *D3* | $1.187±0.001^d$ | $1.796±0.001^d$ | $46.409±0.001^b$ | $0.013±0.001^a$ |

*Means on the same column having different superscripts are significantly different (p <0.05). K, condition factor, HSI, hepatosomatic index; FY, fillet yield; PPCQF, productive potential carcass quality factor.*

## IV. Discussion

### Proximate Analysis of Fish Feed

The CP levels of the formulated diets as shown in table 2, attained the minimum nutritional requirements of 35-40% for catfish. This is in line with the report of Maina (2020) [29].

### Proximate Analysis of Fish

This study found that the proximate composition of the catfish was significantly influenced by the different dietary treatments of BSF larvae meal.

CP values for fish from all treatment diets were significantly different. Fish from the experimental diet labeled D2 (69.180±0.583) showed the highest significant value for crude protein followed by those of D1 (66.240±0.572) and C (65.670±0.583) both of which were not significantly different from each other. The lowest value for crude protein was recorded for fish samples from D3 (63.700±0.043).

The highest value for CP recorded for D2 agrees with the findings of Maina (2020) [230] who reported that medium inclusion rates (up to 75%) of BSFLM in catfish diet increased carcass protein level.

The crude fat values which were not significantly different across the treatments agrees with the findings of Ronghua *et al.* (2010) [29] which reported no significant difference in fat on whole nutrient components of fish feed with partially defatted BSFLM. However, the observed difference in values could be from the fact that the larva meal used in this study was full fat BSFLM.

The ash content of the fish from the experimental treats showed a downward trend as the inclusion level of BSFLM increased with treatment D3 having the lowest value ($6.010±0.006^a$) while treatment C recorded the highest significant value for ash ($6.5470±0.050^c$). The ash content values for D1 ($6.233±0.038^b$) and D2 ($6.100±0.058^{ab}$) showed no significant differences.

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The moisture content of fish from the different treatments was within the range reported by other authors [32] and showed no significant differences.

*Carcass quality*

The K values reported from this study, independently from each treatment were above 1. The result of this study, though varied significantly across all treatments, is in tandem with that recorded in rainbow trout fed BSFL meal which had K value greater than 1 [16]. The result also showed that K value increased as the level of BSFLM inclusion increased. Therefore, it could be said that feeding BSF to African catfish (*C. gariepinus*) improved the general well-being of African catfish (*C. gariepinus*).

The values of the hepatosomatic indices observed among the three treatment diets (D1, D2 and D3) indicates that feeding BSF to African catfish (*C. gariepinus*) had no negative impact on the liver functionality and no excessive hepatic accumulation of fat or carbohydrate as the values were within the normal range (1–2%). This observation is in accordance with previous findings when fishmeal was replaced with BSF in the diets of African catfish [27] and yellow catfish [28].

Fish fed BSFLM (50-100% inclusion level) had higher fillet yield than fish fed with the control diet (FM). The fillet yield obtained from this study was in the range of 43 – 46% which is in line with those obtained from previous studies on Common carpio (*Cyprinus carpio*) strains of Hungary [20] and common carp fed with BSFLM and Meal worm (MW) [21] which reported fillet yield in the range of 42 – 45% and 40 – 43% respectively. The variability in fillet yield could be attributed to differences in the species, fish age, sex, environmental condition and to some extent techniques of filleting [22]. A higher fillet percentage from the fish is desirable since it leads to a higher yield of edible portions.

PPCQF is also referred to as carcass quality. A close relationship seemed to appear between the values for condition factor (K) and the carcass quality (PPCQF). The carcass quality value for treatments C, D1, and D2 increased as their K values increased. However, D3 with the highest K-value (1.187) had the lower carcass quality factor (0.013) compared to the rest of the treatments; this value, however, did not show significant difference from that of the control C (0.012±*0.001*). This agrees with the report of Odiko and Idogun (2016) [18] that a higher K value does not necessarily translate to higher carcass quality. However, the carcass quality was also noticed to have increased with increasing rate of BSFLM inclusion up to 75%.

## V. Conclusion

The results of the proximate composition and carcass quality showed that increase in the BSFLM inclusion up to 75% gave a positive increase in the quality of carcass produced. Therefore, BSFLM can be used to replace fishmeal up to 75% in the diet of *Clarias gariepinus* to improve the quality of the carcass.

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