BIOCHEMICAL, HAEMATOLOGY, HISTOPATHOLOGY AND CARCASS QUALITY OF *CLARIAS GARIEPINUS* POST -FINGERLING FED FRESH AND DRIED HOUSEFLY MAGGOT

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Abstract

This study examined the biochemical, histopathology, haematology and carcass quality of Clarias gariepinus post-fingerling fed fresh and dried housefly maggot meal for a period of 12 weeks. Three experimental groups of fish were fed with fresh and dried maggot and commercial fish feed as control. Proximate analysis of the maggot meal, carcass quality of fish fed maggot meal, biochemical analysis, haematological parameters and intestine histology of fish fed maggot meal together with control meal were all carried out using standard methods. The results of proximate analysis showed that dry maggot meal contains moisture (8.40%), ash (9.30%), crude fat (11.70%), fat/oil (17.90%), crude protein (28.80%) and carbohydrate (23.90%). The result of carcass quality shows that fish on control feed had the highest value of total length, total weight, dressed weight, liver weight and fillet weight and the result is significantly different from other samples ($p<0.05$). While fish on dry maggot meal had the highest values of condition factor, hepatosomatic index and fillet yield and the result is significantly different from other samples ($p<0.05$). Fish on control feed had the highest values of dressing index. While haematological parameters showed that fish on dried maggot feed meal had the highest values of packed cell volume, haemoglobin, red blood cell, liver glycogen and plasma glucose. However, fish fed with fresh maggot meal gave the highest value of white blood cell. Also, fish fed with control fish meal recorded the highest values of catalase and glutathione s-transferase and the result is significantly different from other samples ($p<0.05$). Intestine histology showed that fish on dry maggot meal performed better than others. Based on the results of the study, maggot meal competed positively in comparison with commercial fish feed. The cost of feed production was greatly reduced using maggot meal in comparison with commercial fish feed. Maggot meal can therefore serve as an alternative for commercial fish feed in aquaculture.

Keywords: *Aquaculture, Maggot Meal, Carcass Quality, Haematology, Histopathology*

I. INTRODUCTION

The need for high-quality, reasonably priced feed has been growing steadily in recent years due to the rapid expansion of the aquaculture industry and other animal businesses. Providing high-quality feed has emerged as the primary goal for all animal farmers, including aquaculturists. Fish feed is crucial to production and yield outcomes even though it accounts for around 60% of production costs [1]. Unconventional feed sources are thought to be one potential substitute that can be utilized in fish feed without sacrificing the nutritional content of the feed, as standard feed sources are typically costly and not always available [2]. Additionally, using less expensive and readily available resources in place of pricey fish meals will lower production costs and increase farmer profits [3]. The availability, pricing, and acceptability of the components by fish and other animals are the main factors to be taken into account when choosing feed ingredients and formulating the feed [4]. While fisheries products like lipids offer polyunsaturated fatty acids like omega-3 fatty acids, which are valued for its high antioxidant effects in human and animal nutrition, fishmeal is thought to be a feasible supply of amino acids and protein [5].

The availability of fish and fish by-products for use as livestock feed needs to increase by about 70% by 2050 in order to meet the increasing demand, with other livestock by-products expected to increase by a factor of two [6]. As a result, it is urgent to investigate alternative sources of fish feed in order to increase fish production. A number of studies have successfully reared and fed various livestock and fish species on insect meals [7]; for instance, Nile Tilapia (*Oreochromis niloticus*) was successfully raised on black soldier fly larvae (BSFL) and house fly maggot (HFMM) [8.9], while African Sharptooth catfish (*Clarias gariepinus*) was reared on HFMM [10]. It is believed that using animal sources of feed that humans do not consume could help to lower feed costs and increase feed availability. In order to meet the nutritional needs for increased production of farmed African catfish, there is an urgent need for high-quality feed for aquaculture systems in the tropics. The nutritional value of house fly maggot produced locally is good, and studies have shown that it may be substituted for traditional feed ingredients such fishmeal in commercial fish feed formulations [11, 12].

As demonstrated by earlier research on fish species like channel catfish (*Ictalurus punctatus*), rainbow trout (*Oncorhynchus mykiss*), turbot (*Scophthalmus maximus*) [13, 14], and white shrimp [15], house fly maggot larvae meal is a great source of protein for a variety of fish species. African catfish is a popular species found in tropical African waterways. It is also a major fish species in commercial aquaculture systems in Nigeria, where it is highly valued for its percentage of filleting and dressing during processing and marketing [16]. The development and growth of aquaculture in African nations, especially Nigeria, has been hampered by the startling rate at which fish feed prices have been rising [17]. The availability of fish meal has been limited, making it unaffordable for struggling subsistence farmers. Further research on essential protein supplements is needed in order to produce fishmeal at a reasonable cost and thus boost catfish production [18]. Consequently, the goal of this study is to assess the biochemical, histopathological, haematological, and carcass quality of post-fingerling Clarias gariepinus that were fed both fresh and dried housefly maggot. Thus, the purpose of this study is to ascertain the histology, blood, and carcass quality of *Clarias gariepinus* that were fed both fresh and dried housefly maggot after they were fingerlings.

II. Material and Methods

Study Area

The study was carried out at Fishery Department, Faculty of Agriculture, Nnamdi Azikiwe University, Awka, Anambra state. The location lies between latitude 6.24^0N & 6.28^0N and longitude 7.00^0E and 7.08^0E on the south eastern part of Nigeria.

Experimental Diets

Maggots were sourced locally within Awka metropolis. They were cleaned and divided into two equal parts. One part was dried using standard method and preserve for fish meal while the part was used fresh, commercial feed was equally purchased from commercial market in Awka. The three meal groups were used to feed the three experimental groups of fish each.

Experimental Fish and Management

A total of sixty (60) fishes were used for the experiment. They were divided into three experimental groups of twenty each. Group 1 were fed with commercial feed, while Group 2 were fed with fresh maggot and Group 3 were fed with dried maggot. All the necessary routine pond management practices were duly observed.

Proximate Analysis of Maggot Meal

Moisture, ash, fiber, protein, fat content in fresh and dried maggots were determined according to the standard laboratory method of AOAC [18]. While, % Carbohydrate = 100 – (% Protein + % Moisture + % Ash + % Fat + % Fibre).

Sample Collection

At the end of the feeding trial nine fish each from the three treatment groups were randomly selected, three from each replicate for blood sample collection and subsequent intestine histology and carcass characterization. The blood samples for haematology were collected and stored in ethylene diamine tetra acetate (EDTA) bottles for haematological indices determination. Other sets of collected blood was transferred into labelled plain bottles for biochemical analysis.

Haematological Analysis

Haemoglobin Estimation

The haemoglobin concentration estimate was determined using the cyanomethaemoglobin method. 20µl of blood sample was taken from the lithium heparinized tube with the aid of a pipette. Mixing was achieved by slow inversion of the tube, for about 20times with 4.0ml of Drabkin's solution. After which the text tube was taken into a calorimeter for reading.The final haemoglobin result was calculated from:

$$Hb = \frac{\text{reading of text x concentration of standard x dilution}}{\text{Reading of standard}} = g/dl$$

Red Blood Cell (Erythrocyte)

Commonly available diluents were used for the red blood cell count (RBCC) i.e. a solution of formal-citrate. The blood sample diluted by washing 20µl of blood into a shellback pipette, and into 4.0ml of modified Drabkins fluid to give a final solution of 1 in 20litres. The diluted sample were then mixed and loaded into the haemocytometer. After the cells sedimentation, the number lying on 5 of the 0.04mm2 area were counted, by charging and placing the Neubergers chamber under a microscope and thereafter counted.

The final value was express as the number of the cell per liter.

$$RBC = \frac{N \times DF \times 10^6}{A \times D} \text{ per liter}$$

Where:

N = the number of cell counted

DF = the dilution factor

A = the area chamber counted

D = the depth of chamber

White Blood Cell (Leucocytes)

The WBC is determined by drawing the blood sample with the aid of pipette about 20µL and put into test tube and mixed with diluents solution at 0.38ml. This prepared diluents will liase (destroy the red cells) the red blood cells and this make the white cells more readily visible. It was spread on blood film and counted until a minimum of 200 cells have been enumerated.

Packed Cell Volume (PCV)

The PCV (haematocrit) was determined with Wintrobe haematocrit, filled to 10mark, to avoid bubbles according to Wintrobes and Westergreens methods with commercially available heparin capillary tubes of 75mm. this was done by centrifuging the haematocrit at 3000 r.p.pm for 30minutes, further readings were taken. The readings were not the same, centrifugation was repeated until two identical consecutive readings were obtained. This was the time required for pack cell on this particular centrifuge, it was removed from centrifuge and the height of the red cell column noted which is to the button of the buffy layer. The tube was divided into 100 divisions; the height of the column of red cells was read off and was expressed as a fraction of the whole blood.

$$PCV = \frac{\text{Column reading}}{\text{100 divisions}}$$

Whole Blood Glucose

Blood glucose levels were determined from whole blood using a hand-held one touch ultraglucose meter (MD-300) and test strips manufactured by TaiDoc. Technologies Corporation and supplied by MD instruments Inc. Whole blood was applied onto the test strips fixed in the hand-held glucose meter. Glucose concentrations were read in mmol.$^{-1}$

Biochemical Analysis

Catalase

Catalase (CAT) (EC 1.11.1.6) activity was measured by following the reduction of H_2O_2 at 30 °C and 240 nm using the extinction coefficient 0.04 mM^{-1}/cm. Immediately before assay, a stock solution was prepared. The quartz assay cuvette contained 50 µl sample solution in a final volume of 250 µl containing 67 mM phosphate buffer pH 7.0 and 20 mM H_2O_2. One unit of CAT represents the amount of enzyme that decomposes 1 µmol of H_2O_2 per minute.

Glutathione *S*-transferase

Glutathione *S*-transferase (GST) (EC 2.5.1.18) activity was measured at 340 nm with 1 mM 1-chloro-2,4-dinitrobenzene (CDNB) and 1 mM GSH in 100 mM potassium phosphate buffer, pH 6.5. The quartz assay cuvette containing 100 mM potassium phosphate buffer pH 6.5. 100 mL GSH and 100 mL CDNB were prepared and the reaction was initiated by the addition of 50 mL sample. Specific activities were determined using an extinction coefficient of 9.6 mM^{-1}/cm.

Plasma Cortisol

Plasma cortisol levels (ng/ml) were assayed for by *E*nzyme-*L*inked *I*mmunosorbent *A*ssay (ELISA) using a Neogen Corporation ELISA kit. An antibody-coated 96-well microplate was used. The standard solutions and the diluted samples were first added to the microplate in duplicates. Diluted enzyme conjugate was then added, and the mixture was shaken and incubated at room temperature for 1 hour to allow competition to take place between the enzyme conjugate and

cortisol in the samples for the limited number of binding sites on the antibody-coated plate. The plate was then washed with a wash buffer to remove all the unbound material. The bound enzyme conjugate was detected by the action of substrate which generated an optimal colour after 30 minutes. Quantitative test results were obtained by measuring and comparing the absorbance reading of wells of the samples against the standards with a microplate reader set at 650 nm using SoftMax Pro Microplate Data Acquisition & Analysis Software. The samples were each diluted ten (10) times before being assayed.

Carcass Quality Determination

Biometric parameters were measured before degutting, descaling, skinning, beheading, and harvesting of fillets using standard methods. These were total length (TL) in centimeters (cm), total weight (TW), dressed weight (DW), liver weight (LW), and fillet weight (FW) in grams (g). Dissection was done using a sharp knife and scissors.

The following parameters were calculated:

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$$\text{Condition Factor} \quad (CF) = \text{fish} \frac{TW}{(TL \times TL \times TL)} \times 100$$

$$\text{Hepatosomatic index (HIS\%)} = 100 \times \frac{LW\ (g)}{TW\ (g)}$$

$$\text{Dressing index (DW\%)} = 100 \times \frac{DW\ (g)}{TW\ (g)}$$

$$\text{Fillet weight (FW\%)} = 100 \times \frac{FW\ (g)}{TW\ (g)}$$

Histopatological Analysis

Histological analyses were carried out on the fish intestines and the liver. Liver samples and 1 cm segments from the mid gut of the intestinal tract were preserved in 10% neutral buffered formalin for 24 hours. Subsequently, liver and intestine tissues were dehydrated using standard histological techniques in graded ethanol series and embedded in paraffin wax for histology. From each sample, 3-5 µm sections were cut and mounted on glass slides before staining with haematoxylin and eosin.

Slides were examined under light trinocular microscopy at 400X (Leica Microsystems model DM750, Leica, Bannockburn, IL, USA). Each slide was photographed with a DVC digital camera (Digital Video Camera Company, Austin, TX) mounted on a BH-2. Twenty measurements for villi height and width (µm) were taken from each intestine slide using Image J (1.46) software. Baeverfjord and Krogadahl (1996)s method was used to count goblet cells in each segment.

Liver degradation was quantified by examining the hepatocyte nuclei, vacuolisation and cytoplasm according to McFaden *et al*. (1997). Each liver specimen was assigned one of 3 grades (1-3), a healthy specimen scoring 1 and a degraded liver scoring 3 (Table 1). The mean score of all samples in that treatment was expressed as the hepatocyte degradation value.

Statistical Analysis

Data collected from the experiment were subjected to analysis of variance (ANOVA) test, Duncan Multiple Range Test (DMRT) was used to compare differences among individual means and the data were analyzed using SPSS version 20. Differences were considered significant at 0.05 level (P>0.05).

III. Results

Table 1 showed the proximate analysis of fresh and dried maggot feed**, the** results indicated that dry maggot meal contains Moisture (8.40%), Ash (9.30%), Crude Fat (11.70%), Fat/Oil (17.90%), Crude protein (28.80%) and Carbohydrate (23.90%). The table 2 showed the growth response of fish fed maggot meal. Fish on control feed had the highest yield on Total length, Total weight, Dressed weight, Liver weight and Fillet weight and the result is significantly different from other samples ($p<0.05$). The values for Total length, Total weight, Dressed weight, Liver weight and Fillet weight ranged from 19.00 ± 0.00 to 15.90c ±0.00, 316.00 ± 0.00 to 285.80 ±0.00, 213.73 ±0.10 to 204.73 ±0.30, 18.70 ±1.00 to 17.00c ± 0.00 and 243.00 ±2.00 to 215.80 ±1.00 respectively.

Table 3 showed the haematological parameters of fish fed maggot meal. The values for Packed cell volume, Haemoglobin, Red Blood Cell, Liver glycogen and Plasma Glucose ranges from 24.50 ±0.10 to 25.8 ±1.10, 7.80 ±0.10 to 8.83 ±1.00, 2.40 ±2.00 to 2.79 ±1.00, 38.43 ±0.50 to 45.65±1.00 and 76.00 ±2.00 to 89.00 ±1.00 respectively. The values for Catalase and Glutathione S-transferase ranged from 275.93 ±1.00 to 454.02 ±0.50 and 176.33b ±1.00 to 236.88 ±0.50 respectively. The value for White Blood Cell ranged from 16.28 ±0.50 to 18.76 ±2.00. Also, Table.4 shows the intestine histology of fish fed maggot meal. Fish on dry maggot feed meal had the highest yield on Villi width and Goblet cell number and the result is significantly different from other samples ($p<0.05$). The values for Villi width and Goblet cell number ranged

from 82 ± 2.00 to 84 ±3.00 and 450 ±1.10 to 485 ±3.10 respectively. Fish on control feed meal had the highest yield on Villi length and the result is significantly different from other samples ($p<0.05$). The value for Villi length ranged from 602 ±1.00 to 614 ±0.10.

Histopathology of Liver

The Figures 1-3 shows the intestine histology of fish fed maggot. Arrows point to hepatocytes (hp), sinusoids (sn), Kupffer cells (kc) and blood vessels (bv). In the present study, histological changes were also observed in the liver of fish fed with dry and fresh maggot. Severe vacuolation of hepatocytes and mild congestion were seen in fish liver fed with fresh diet (Fig. 3). Also unstained portions showing fat vacuoles were observed in hepatocytes of fish fed with dried maggot (Fig. 2). Vacuolation in hepatocytes with pyknotic nuclei were observed in fish fed on fresh maggot (Fig. 3). He fresh maggot feed caused severe cytoplasmic vacuolation (Fig. 3) while dried maggot feed caused hepatocytes degeneration and mild vacuolation (Fig. 2).

Table 1: Proximate Analysis of Fresh and Dried Maggot Feed (Mean ±SD)

Proximate Composition	Fresh Maggot Feed	Dried Maggot Feed
Moisture	25.78 ± 0.12^{b}	8.40 ± 0.77^{a}
Ash	4.83 ± 0.01^{a}	9.30 ± 0.73^{b}
Crude Fiber	23.40 ± 0.1^{b}	11.70 ± 1.00^{a}
Fat/Oil	9.11 ± 0.08^{a}	17.90 ± 1.11^{b}
Crude Protein	19.8 ± 0.10^{a}	28.80 ± 0.50^{b}
Carbohydrate	17.51 ± 0.11^{a}	23.90 ± 2.00^{b}

Means in the same column bearing different superscript differed significantly (P<0.05)

Table 2: Carcass Quality fish fed maggot meal

Organ Weight	Control Feed	Fresh Feed	Dried Feed
Total length (TL) (cm)	$19.00^{a} \pm 0.00$	$15.90^{c} \pm 0.00$	$16.00^{b} \pm 0.00$
Total weight (TW) (g)	$316.00^{a} \pm 0.00$	$285.80^{c} \pm 0.00$	$300.00^{b} \pm 0.00$
Dressed weight (DW) (g)	$213.73^{a} \pm 0.10$	$204.73^{c} \pm 0.30$	$207.70^{b} \pm 0.05$
Liver weight (LW) (g)	$18.70^{a} \pm 1.00$	$17.00^{c} \pm 0.00$	$17.50^{b} \pm 0.50$
Fillet weight (FW) (g)	$243.00^{a} \pm 2.00$	$215.80^{c} \pm 1.00$	$223.00^{b} \pm 2.00$
Condition factor	$4.67^{c} \pm 1.00$	$5.68^{b} \pm 1.00$	$7.32^{a} \pm 1.20$
Hepatosomatic index	$16.89^{b} \pm 1.10$	$16.81^{c} \pm 2.00$	$17.14^{a} \pm 0.70$
Dressing index	$1.48^{a} \pm 2.00$	$1.39^{c} \pm 1.00$	$1.44^{b} \pm 0.50$
Fillet yield	$1.30^{c} \pm 0.00$	$1.32^{b} \pm 2.00$	$1.34^{a} \pm 1.00$

Means in the same column bearing different superscript differed significantly (P<0.05)

Table 3: Hematological and Biochemical Parameters of Fish Fed Maggot Meal

Parameters	Control feed	Fresh feed	Dried feed
Packed cell volume (%)	$25.17^{b} \pm 1.00$	$24.50^{b} \pm 0.10$	$25.8^{a} \pm 1.10$
Haemoglobin (g/100ml)	$8.20^{b} \pm 1.00$	$7.80^{c} \pm 0.10$	$8.83^{a} \pm 1.00$
Red Blood Cell(g/100ml)	$2.77^{b} \pm 3.10$	$2.40^{c} \pm 2.00$	$2.79^{a} \pm 1.00$
White Blood Cell (g/100ml)	$16.28^{c} \pm 0.50$	$18.76^{a} \pm 2.00$	$18.70^{b} \pm 1.00$
Liver glycogen (mg/g)	$38.43^{c} \pm 0.50$	$43.55^{b} \pm 2.00$	$45.65^{a} \pm 1.00$
Catalase (µg/g/1min)	$454.02^{a} \pm 0.50$	$310.88^{b} \pm 2.00$	$275.93^{c} \pm 1.00$
Plasma Glucose (mmol/L)	$69.00^{d} \pm 0.50$	$76.00^{c} \pm 2.00$	$89.00^{a} \pm 1.00$
Plasma Cortisol (×10ng/ml)	$6.28^{c} \pm 0.50$	$8.76^{a} \pm 2.00$	$8.70^{b} \pm 1.00$
Glutathione *S*-transferase(µg/g/1 min)	$236.88^{a} \pm 0.50$	$188.00^{a} \pm 2.00$	$176.33^{b} \pm 1.00$

Means in the same column bearing different superscript differed significantly (P<0.05)

Table 4: Intestine Histology Fish Fed Maggot Meal

Intestine histology	Control feed	Fresh feed	Dried fish
Villi length (µm)	$614^{a} \pm 0.10$	$602^{c} \pm 1.00$	$611^{b} \pm 3.00$
Villi width (µm)	$83^{b} \pm 3.00$	$82^{c} \pm 2.00$	$84^{a} \pm 3.00$
Goblet cell number	$450^{c} \pm 1.10$	$462^{b} \pm 3.10$	$485^{a} \pm 3.10$

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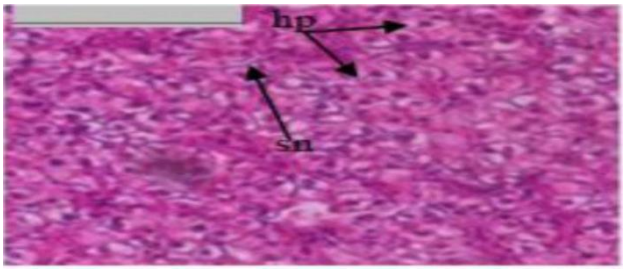


Figure 1: Liver histology in Control feed fish sample. Scale bar = 100 µm. arrows point to hepatocytes (hp), sinusoids (sn), Kupffer cells (kc) and blood vessels (bv).

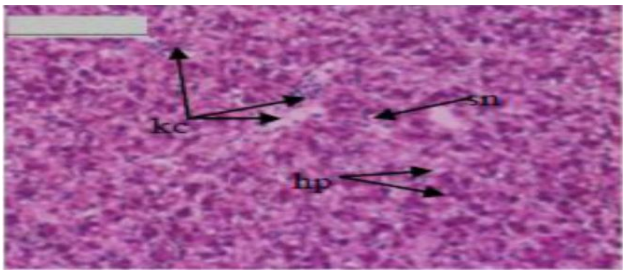
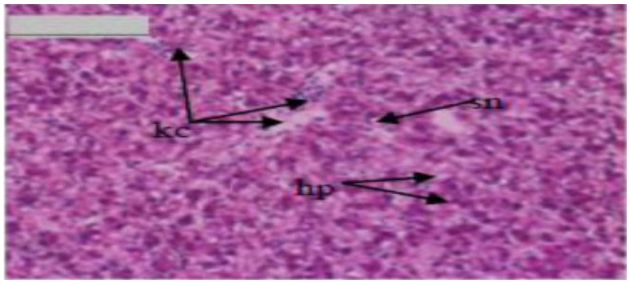


FIG 2. Liver histology in fresh feed fish sample. Scale bar = 100 µm. arrows point to hepatocytes (hp), sinusoids (sn), Kupffer cells (kc) and blood vessels (bv).



PIX 3. Liver histology in fresh feed fish sample. Scale bar = 100 µm. arrows point to hepatocytes (hp), sinusoids (sn), Kupffer cells (kc) and blood vessels (bv).

IV. Discussion

The proximate analysis results for both fresh and dried maggot meal in this investigation are consistent with those of Idowu et al. [19], who also performed proximate analysis on their maggot meals. Fish fed dried maggot meal had the highest yield on condition factor, hepatosomatic index, and fillet yield, according to the results of the carcass quality analysis. There is a significant difference ($p<0.05$) between the results and other samples. Fish fed control feed produced the highest dressing index yield, and the results differed significantly ($P<0.05$) from other samples. In practically every parameter that was examined, fish that were fed fresh maggot meal had the lowest mean value. This could be ascribed to lower feed intake as a result of diminished palatability [20]. Reduced palatability is frequently observed in diets when fishmeal is significantly substituted with other protein sources, particularly if it contains anti-nutritional factors (ANFs), according to Ebenso and Udo [21]. Nevertheless, the kinds and concentrations of ANFs for the different test substances were not determined in this investigation. This investigation supports previous results by Sogbesan et al. [22] regarding Clarias gariepinus feed consumption.

Fish fed dried maggot feed meal had the best yield in terms of packed cell volume, hemoglobin, red blood cell, liver glycogen, and plasma glucose when it came to haematological parameters. This difference in results from other samples was statistically significant ($p<0.05$). Catalase and glutathione S-transferase values were highest in fish given control fish meal, and this result differs significantly ($p<0.05$) from other samples. White blood cell counts were highest in fish fed fresh maggot meal, and the results differed significantly from other samples ($p<0.05$). Fish fed dry maggot meal outperformed the control group in the majority of the haematological parameters measured, according to the results of the tests. This observation has resemblance to that made by Akintayo et al. [23], who noted marginal variations in total protein, hemoglobin, and packed cell volume among maggots given fish meal.in C. gariepinus fed diets based on toasted sunflower seed meal. El-baraasi and Farma[24] found that variations in the makeup of fish diets could account for variations in fish blood parameters. As a component of the immune system, white blood cells (WBCs) supply the body with defense, and a high WBC count in fish is indicative of illness or stress [25]. Akinwande et al. [26] asserted, however, that immunity and an animal's ability to withstand a susceptible illness or disease are the reasons behind a detectable rise in the white blood count of fish or any other animal. This increase could suggest that the fish were highly immune or disease-resistant. Overall, this demonstrated that commercial fish diets can be substituted with dry maggot fish meal.

Fish fed maggot meal had the highest yield on villi width and goblet cell quantity, as revealed by the intestinal histology of the fish. This difference in yield from other samples was statistically significant ($p<0.05$). The fish fed the control feed meal exhibited the highest yield on villi length, with a statistically significant difference ($p<0.05$) from the other samples.

No other nutritional diseases or intestinal alterations were noted in this study. Fish fed dry maggot meal fared better than the control in the majority of the criteria examined, according to the intestinal histology. Jimoh et al [27] results with Nile tilapia (*Oreochromis niloticus*) fed diets containing watermelon (*Citrullus lanatus*) at different replacement levels are comparable to the present results. The reason for the decline in villi height is a less surface area available for absorbing nutrients. Additionally, these fish's enterocytes displayed a rise in the quantity of goblet cells. Since goblet cells create mucus that lines the brush boundary, an increase in their number could be a sign of greater irritation. This mucus acts as a lubricant, shielding the body from mechanical and chemical harm [28]. The rise in goblet cell count could potentially reflect an immunological reaction to antigens like saponin present in the diet [29]. The mucosa, which is made up of the lamina propria (connective tissue) and lamina epitelialis (simple columnar and glandular epithelium), the submucosae, which are made up of two layers (Stratum compactum and Stratum granulosum), the muscular layer, and the serosa make up the histological structure of this portion of the digestive system [30].

There is an initial reaction and inflammation to maggot feed, according to Uran et al. [31]. However, the intestine returns to a normal histological structure after one month of adaptation, and catfish are better able to withstand the presence of anti-nutritive ingredients in food, as stated by Francis et al. [32], who assert that tolerance is species-specific. When 30% of the fishmeal in the catfish experiment was swapped out for maggot meal, there were no detectable pathological alterations in the intestines [33]. When Grisdale-Helland et al. [34] conducted the experiment with Atlantic halibut (Hippoglossus hippoglossus L.), similar outcomes were seen. Fish fed both fresh and dry maggots showed histopathological alterations in their livers in the current investigation. Upon eating diets enhanced with animal protein, Ogunji et al. [35] found necrosis and degradation of hepatocyte cell membranes in gilthead seabream (Sparus aurata L.) and European seabass. In a similar vein, liver tissues of catfish fed 50% mustard protein displayed histopathological anomalies [36]. Hepatocyte vacuolization and disarray were noted by Russell et al. [37] in the liver of fish fed a diet containing 30% SBM. The current study has proven that liver histology is a necessary component of nutrition studies, with the finding that the measurement of the nuclear area of hepatocytes might be a helpful metric in this kind of research (Figure 1-3). Because the liver is involved in the metabolism of items that exit the digestive system, it is thought to be an excellent sign of nutritional disease. If the diet is inadequate, it is easy to identify histological alterations in the liver [38]. Hepatocyte vacuolization, fatty liver degeneration, alterations in metabolic activity, alterations in liver parenchyma, and necrosis are the most often seen alterations in the liver [39]. Consuming protein- or fat-containing meals might cause histological alterations in the liver [40]. Changes in liver metabolism, such as picnosis, kariolysis of the nucleus, or necrosis of the cell, can be seen by examining the size of a nucleus. In lab tests when soybean meal was substituted for fishmeal, a piknosis of the liver nuclei and a reduction in nuclear area was noted. These results indicate that fish fed diet containing exclusively soybean meal are malnourished. In field experiments, we have observed that the average hepatocyte nuclear area in the liver of rainbow trout raised in cages clearly varies with the season [41].

V. Conclusion and Recommendations

Fish on control feed had the highest yield on total length, total weight, dressed weight, liver weight, and fillet weight, while fish on dry maggot meal had the highest yield on condition factor, hepatosomatic index, and fillet yield, according to the results of all the growth response tests conducted on fish fed the meal. The fish with the highest dressing index yield were those fed control feed. In practically every metric that was examined, fish who were fed fresh maggot meal had the lowest mean value. Fish on dry maggot feed meal had the highest values of packed cell volume, hemoglobin, red blood cell, liver glycogen, and plasma glucose, according to the haematological parameters of the fish fed the meal. Catalase and glutathione S-transferase levels were highest in fish fed control fish meal. Fish that were fed fresh maggot meal produced the highest concentration of white blood cells. Fish on dry maggot feed meal had the largest villi width and goblet cell quantity, while fish on control feed meal had the longest villi, according to the intestinal histology of the fish given the meal. The results of the study demonstrated that, when compared to commercial fish feed, maggot fish meal had a positive competitive advantage. Comparing the cost of producing feed with maggot meal vs commercial fish feed revealed significant savings. Commercial fish feed can be substituted with maggot meal. It is advised that the commercial production of maggot for animal feed be given priority and that the anti-nutritional components of maggot meals be investigated in light of the foregoing result.

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