



Haematological and Serum Biochemical Profiles of *Clarias gariepinus* (Burchell, 1822) Fed Commercial and Farm-made Feeds

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The present study was carried out to determine the haematological and serum biochemical profiles of *Clarias gariepinus* juveniles fed commercial and farm-made feeds and reared in intermediate bulk containers (IBC) tanks. Nine hundred juveniles ($15.15 \pm 3.48\text{g}$; $128.37 \pm 9.67\text{mm}$) were stocked in 09 IBC tanks (1m^3) at a density of 100 fish/tank in triplicate and fed with imported extruded (Le), locally pelleted (Lpe) and locally extruded (Lex) feeds thrice a day to satiation for 16 weeks. At the end of the experiment, blood samples were collected from 10 fish/ dietary treatment to determine haematological and biochemical indices. Results revealed that Red Blood Cells Count, Packed Cell volume and Haemoglobin concentration were highest ($p < 0.05$) in fish fed with "Le" feed while Mean Cell Haemoglobin Concentration, Mean Cell Haemoglobin, Mean Cell Volume, White Blood Cells

Count, Lymphocytes, Monocytes, Granulocytes and Platelets showed no significant difference ($p > 0.05$) among the dietary treatments. As for serum biochemistry, Total Cholesterol and Glucose were highest ($p < 0.05$) in fish fed with “Le” feed while Total Protein, Alanine Transaminase, Aspartate Transaminase and Alkaline Phosphatase were significantly higher ($p < 0.05$) in fish fed “Lpe” and “Lex” feeds. Conclusively, variation of dietary treatments was not detrimental to the health status of *C. gariepinus* reared in plastic IBC tanks.

Keywords: Haemato-biochemistry; serum; fish feed; *Clarias gariepinus*; IBC tanks.

1. INTRODUCTION

World population is growing geometrically expecting to reach 9 billion in 2050 [1]. Projections show that feeding this population would require an increase of the overall food production by 70% [2]. Therefore, there is the need for safe and nutritious production techniques to meet the increasing diet needs of the world's population [3]. Aquaculture is one of the fast growing food production sectors accounting for 16.6% of animal protein consumed worldwide. As such, it is the ideal candidate for meeting the growing food demand in the future [4, 5].

The African catfish (*Clarias gariepinus*, Burchell, 1822) is one of the most cultured freshwater fish species in the tropics [6]. This is mainly due to its positive attributes: resistance to diseases, high fecundity, thriving on cheap feed, hardiness, rapid growth rate and good adaptability to captivity conditions [7]. However, its culture is faced with many problems among which is the provision of nutritionally balanced cost effective feeds. Given that fish feeds have been projected to account for as much as 40-70% of overall expenditure of its culture venture [5, 8].

In recent years, fish nutrition has improved with the development of cheaper and readily available balanced diets that promote optimal growth and health of fish [8]. The advent of these improved feeds coupled with revised management protocols has greatly limited fry mortality; improved fingerlings productivity and has thereby enhanced survival and sufficient supply of fingerlings. These practices have been disseminated to fish farmers and have led to tremendous improvement in fingerlings production and eventually aquaculture production especially in Cameroon [9]. As a result, Cameroon's aquaculture has substantially expanded, today totaling over 9000 tons [9] from 50 tons produced in the year 2000 [10].

Intensive production of *C. gariepinus* has increased in the last few decades in most African

countries [11] including Cameroon and this has led farmers to now raise fish in out of pond holding systems (concrete tanks, fast tanks, tarpaulins, plastics, Water recirculating aquaculture systems etc.) especially in urban and peri-urban areas. This is a clear departure from the traditional earthen pond culture system which made fish production seasonal and unreliable in comparison to a more advanced reliable, intensive, and result-oriented culture system [12,13]. With this level of intensive stocking density, there is therefore the need to monitor the health status of cultured fish to prevent the outbreak of devastating diseases [12].

Haemato-biochemical analyses are one of such studies that reliably monitor the physiological condition and health status of cultured fish [14,15] since morphological and biometric parameters alone do not always give a complete picture [16]. Haematological and biochemical parameters have proven to be valuable tools in determining the health status of fish in response to dietary manipulations [17,18]. In addition, Svobodova et al. [19] stated that haematological investigation can be used to: appraise the suitability of new and unconventional feeds, examine the effect of stress situation, evaluate the condition of the fish and evaluate the non-specific resistance of different fish breeds and strains. Studies on haematological and biochemical responses of *C. gariepinus* to feed have been centred on responses to different: feedstuffs [11], dietary inclusion and substitution levels [20-24] and culture systems including: concrete tanks [25], tarpaulin tanks [26], water recirculating aquaculture systems [12,27], earthen ponds [11, 28] and reservoirs [29,30]. Based on literature, there is paucity of information on haematological and biochemical responses of *C. gariepinus* fed with industrially manufactured and locally formulated feeds and reared in plastic tanks. The aim of this study was thus, to investigate the effects of imported feeds and locally formulated feeds on haematological and biochemical parameters of *C. gariepinus*

blood reared in IBC (Intermediate bulk containers) holding tanks.

2. MATERIALS AND METHODS

2.1 Study Area

This study was carried out at the grow-out production unit of the Fish Farming Demonstration Association (FIFADA) Yaoundé, Cameroon and ran from August 2021 to January 2022. The unit consisted of 09 IBC tanks for grow-out which were exposed to 12h of daylight and 12h of night.

2.2 Experimental Fish

A total of nine hundred fingerlings of mean initial weight (15.15 ± 3.48 g) and length (128.37 ± 9.67 mm) were acclimated in 03 IBC (Intermediate Bulk Container) tanks ($1 \times 1 \times 1 \text{m}^3$) containing 800L domestic water for two weeks before the commencement of the experiment using an imported extruded feed (Le Gouessant).

2.3 Experimental Diets

Locally available feed ingredients: fishmeal, soybean cake, groundnut cake, wheat bran, cassava flour, palm kernel cake, premix, L-lysine (FoodChem®), DL-methionine (FoodChem®) and refined palm oil were purchased to formulate the locally pelleted feed (Lpe) by Pearson square method then enhanced with trial and error method for perfection. The ingredients were processed, mixed and pelleted with a flat die pelletizer (Capsfeed Ltd), sun-dried and stored in airtight containers at room temperature until further use. Locally extruded (Lex) and imported extruded (Le) feeds (Le Gouessant) were respectively purchased from a respectable feed producer (VicFeeds) and a retailer (AgroBio) in Yaoundé, Cameroon. The gross composition of ingredients of the experimental diets is presented on Table 1. Proximate analysis carried out according to standard methods [31] revealed the following: imported feed (42.00% crude protein, 11.00% crude fats and 2.30% crude fibre), locally pelleted feed (32.55% crude protein, 5.15% crude fats and 6.21% crude fibre) and locally extruded (33.57% crude protein, 5.57% crude fats and 3.90% crude fibre).

2.4 Experimental Design

The fish were randomly stocked in 09 IBC tanks at a density of 100 fingerlings per tank in

triplicate and reared for 16 weeks. The juveniles were hand-fed experimental diets thrice daily (between 8:30-9:30am in the morning, between 14:30-15:30pm in the afternoon and between 20:30-21:30pm in the night) to satiation. Domestic water (tap) that was well de-chlorinated (left for 48h) and oxygenated was used. Water level in each tank was maintained at 800L throughout the study period. One third of water from each tank was replaced daily and completely changed every fortnightly throughout the experimental period to maintain a relative uniform water quality and prevent fouling from feed remnants and metabolic waste. Water parameters of importance to aquaculture were measured fortnightly (between 5am to 6am) according to APHA [32] and Boyd [33]. All the parameters were within standard limits for aquaculture as recommended by Boyd [33] except for dissolved oxygen which had low values ($<3 \text{mg/L}$). This could be attributed to the time of sampling [34].

2.5 Haematological Analysis

Ten live specimens of *C. gariepinus* were harvested from each dietary treatment and their weights and lengths measured to the nearest 1g and mm respectively. Mean weight and length obtained for fish fed with "Le" were $693.40 \pm 38.55 \text{g}$ and 426.10 ± 7.79 mm respectively. Those fed with "Lpe" were respectively $261.54 \pm 22.08 \text{g}$ and 302.50 ± 11.28 mm and those fed with "Lex" were respectively $297.27 \pm 25.27 \text{g}$ and 322.30 ± 6.42 mm.

Blood samples were collected via caudal puncture with a hypodermic needle inserted to a plastic syringe and 5ml of blood was extracted: 2.5ml was decanted into plastic tubes (Eppendorf) containing Ethylene Diamine Tetra-Acetic acid (EDTA) as the anticoagulant and the remaining 2.5ml stored in dry tubes for biochemical analysis. The site chosen for puncture was wiped dry with tissue paper to avoid contamination with mucus. The blood samples were rocked gently in the tubes to allow thorough mixing of its contents with the anticoagulant. Thereafter, the samples were taken to the Haematology Laboratory of the "Chantal Biya" International Reference Centre (CIRCB) for haematological analysis. Haematological parameters of interest to this study were: Red blood cells (RBCs) count, Packed cell volume (PCV), haemoglobin (Hb) concentration, Mean cell haemoglobin

concentration (MCHC), Mean corpuscular haemoglobin (MCH), Mean cell volume (MCV), White blood cells (WBCs) count, lymphocyte (LYM), monocytes (MON), granulocytes (GRA) and platelet (PLA).

2.6 Biochemical Analysis

The second portion of the collected blood was dispensed into dry tubes. This was then centrifuged for five minutes at 3000turns/min to obtain serum for colorimetric measurement of total cholesterol (TC), total protein (TP), aspartate aminotransferase (ASAT), alanine aminotransferase (ALAT) and glucose (GLU) with LABKIT kits (CHEMELEX, S.A.) as well as of alkaline phosphatase (ALP) with BIOLABO kits following the manufacturers' instructions.

2.7 Data Analysis

Results were analysed using the statistical software GraphPad Prism® (version 8.1.0) and a one-way analysis of variance (ANOVA). Tukey

(Honestly Significant Difference, HSD) test was used to assess significance of differences at 0.05.

3. RESULTS

3.1 Haematological Profile

Results of the mean haematological parameters of *Clarias gariepinus* fish fed with the three experimental diets are presented in Table 2. Most of the blood parameters of the fish did not differed significantly ($p>0.05$) between different treatments except for red blood cells count (RBC), packed cell volume (PCV), haemoglobin (Hb) concentration and mean corpuscular volume (MCV). Imported and locally pelleted feeds showed significant difference ($p<0.05$) in terms of RBC and Hb. Fish fed with imported and locally extruded feeds showed significant difference ($p<0.05$) in terms of RBC, PCV, Hb and MCV. No significant difference ($p>0.05$) in all the studied blood parameters was observed between fish fed with locally pelleted and locally extruded feeds except for MCV.

Table 1. Gross ingredient composition of experimental diets

Ingredients	Le	Lpe	Lex
Fish meal	+	+	+
Soybean meal	+	+	+
Groundnut cake	-	+	+
Pig blood products	+	-	-
Rapeseed meal	+	-	-
Methionine	-	+	+
Lysine	-	+	+
Hydrolysed poultry feather meal	+	-	-
Maize	-	-	-
Corn gluten	+	-	-
Wheat	+	+	+
Wheat feed flour	+	-	-
Cassava flour	-	+	+
Fish oil	+	-	-
Rapeseed oil	+	-	-
Vegetable oil	-	+	+
Palm kernel cake	-	+	+
Other by-products of fermentation	+	-	-
Premix	-	+	+
Vitamins	+	+	+
Compounds of trace elements	+	-	-
Binders	+	-	-
Monocalcium phosphate	+	+	+
Oyster shell	-	+	+

Le: imported feed; **Lpe:** Locally pelleted feed; **Lex:** Locally extruded feed; **+**: Present; **-:** absent

Table 2. Haematological parameters of *C. gariepinus* fed with different dietary treatments

Parameters	Le	Lpe	Lex
RBCs ($\times 10^6/\text{mm}^3$)	5.67 \pm 0.47 ^a	3.57 \pm 0.31 ^b	3.36 \pm 0.37 ^b
PCV (%)	43.22 \pm 1.46 ^a	37.49 \pm 1.50 ^b	35.34 \pm 1.64 ^b
Hb (g/dl)	14.80 \pm 0.74 ^a	11.29 \pm 0.78 ^b	10.76 \pm 0.67 ^b
MCHC (g/dl)	32.70 \pm 1.14 ^a	30.56 \pm 0.83 ^a	29.91 \pm 1.00 ^a
MCH (pg)	31.77 \pm 0.99 ^a	29.26 \pm 1.01 ^a	29.02 \pm 1.51 ^a
MCV (fl)	88.33 \pm 1.80 ^a	82.40 \pm 2.16 ^a	77.20 \pm 2.30 ^b
WBCs ($\times 10^3/\text{mm}^3$)	7.71 \pm 0.20 ^a	8.05 \pm 0.26 ^a	7.95 \pm 0.26 ^a
LYM (%)	27.47 \pm 2.28 ^a	38.81 \pm 5.6 ^a	32.96 \pm 4.53 ^a
MON (%)	6.04 \pm 0.77 ^a	7.99 \pm 1.43 ^a	7.51 \pm 0.99 ^a
GRA (%)	53.91 \pm 6.06 ^a	41.89 \pm 5.71 ^a	55.13 \pm 6.86 ^a
PLA ($\times 10^3/\text{mm}^3$)	435.00 \pm 11.05 ^a	445.70 \pm 8.10 ^a	449.10 \pm 9.02 ^a

Le: imported feed; **Lpe:** Locally pelleted feed; **Lex:** Locally extruded feed. Values are expressed as mean \pm SEM. Means in each row with different superscript are significantly different at $p < 0.05$.

Table 3. Serum biochemical parameters of *C. gariepinus* fed with different dietary treatments

Parameter	Le	Lpe	Lex
TC (mmol/L)	2.44 \pm 0.10 ^a	2.00 \pm 0.11 ^b	2.03 \pm 0.10 ^b
TP (mg/dL)	342.41 \pm 8.44 ^a	403.64 \pm 14.38 ^b	391.47 \pm 18.94 ^{ab}
ALAT (IU/L)	11.49 \pm 0.59 ^a	14.02 \pm 0.60 ^b	11.45 \pm 0.67 ^a
ASAT (IU/L)	152.98 \pm 8.85 ^a	198.48 \pm 9.53 ^b	241.82 \pm 9.48 ^c
ALP (IU/L)	136.67 \pm 8.29 ^a	261.29 \pm 14.60 ^b	202.76 \pm 11.92 ^c
Glu (mg/dL)	110.71 \pm 4.45 ^a	86.76 \pm 2.54 ^b	107.99 \pm 5.26 ^a

Le: imported feed; **Lpe:** Locally pelleted feed; **Lex:** Locally extruded feed. Values are expressed as mean \pm SEM. Means in each row with different superscript are significantly different at $p < 0.05$.

3.2 Biochemical Profile

Results of the biochemical analysis of fish serum per studied diets are presented in Table 3. All studied biochemical parameters differed significantly ($p < 0.05$) between fish fed with imported and locally pelleted feeds. Only total cholesterol (TC), aspartate amino transferase (ASAT) and alkaline Phosphatase (ALP) differed significantly ($p < 0.05$) between fish fed with imported and locally extruded feeds. Of the studied parameters, only total cholesterol (TC) and total protein (TP) showed no significant difference ($p > 0.05$) between locally pelleted and locally extruded fed fish.

4. DISCUSSION

4.1 Haematological Profile

Red blood cells (RBCs) also called erythrocytes are the most abundant blood cells (98–99%) in fish [35]. The highest RBCs count observed in fish fed with imported feed could be attributed to its highest crude protein content. In fact, Ahmed and Ahmed [8] observed that high dietary protein levels resulted in high RBCs counts indicating a well oxygen transport in the body thereby

improving health status and increasing growth performance. Erythrocyte counts observed in this study were higher than those obtained previously for *Clarias gariepinus* cultured in out of pond productions systems (concrete, tarpaulin and plastic tanks) and fed different commercial (floating) and farm made (sinking) feeds [26, 36]. A similar trend was observed in previous studies with *C. gariepinus* cultured in freshwater earthen ponds [11]. Witeska *et al.* [37] observed that erythrocytes depend greatly on environmental and biological factors such as water quality and type, fish activity, age, sex, nutritional status, reproductive status and can differ among various populations of the same species, corroborating the differences observed between this study and previous ones. However, erythrocyte values obtained from the studied diets were within the normal range for a healthy fish [38,39]. In addition, Rastogi [39] stated that erythrocyte counts greater than $1.00 \times 10^6/\text{mm}^3$ were considered high and indicative of the high oxygen carrying capacity of the blood, which is characteristic of fishes capable of aerial respiration and high activity.

Packed cell volume (PCV) also known as haematocrit is the simplest measure of

erythrocyte content in blood as a percentage of erythrocytes in blood volume [37]. It is a useful tool in fisheries and aquaculture management for checking anaemic condition in aquatic species [26] and effect of stressors on the health of fish [40]. The low PVC of fish fed with locally formulated diets could be attributed to anti-nutritional factors in the feed ingredients during processing since the reduction in the concentration of haematocrit in the blood usually suggests the presence of toxic compounds (e.g. haemagglutinin) which generally affects blood formation and growth. Nonetheless, these values were higher than those observed by Bake *et al.* [26] and Mogaji *et al.* [36] working on the same fish species in similar conditions and also those of Abdel-Hay *et al.* [11] and Fagbenro *et al.* [23], working in different conditions. Though Alwan *et al.* [41] stated that low PCV in fish could be attributed to a reduction in RBC volume caused by osmotic changes, the values obtained were within normal range (20- 38%) for catfishes [28].

Haemoglobin concentration is a good indicator of anaemic conditions in fish according to Blaxhall and Daisley [42] as it reflects organisms' oxygen supply which should be maintained stable as much as possible [43]. The lower haemoglobin levels in fish fed with both locally pelleted and locally extruded feed could be explained by the fact that the feeds' ability to provide sufficient oxygen to the tissues was restricted considerably [44]. However, these values were higher than those obtained by Afia and Gift [26] and Mogaji *et al.* [36] working on the same fish species in similar conditions and also those of other authors [11, 23, 27, 43] working in different conditions.

Haematological indices: Mean corpuscular haemoglobin concentration (MCHC), mean corpuscular haemoglobin (MCH) and mean corpuscular volume (MCV), have a particular importance in the diagnosis of anaemia in most animals [45]. MCHC is a good indicator of red blood cell swelling [46]. That MCHC values did not vary significantly between the studied diets suggest that MCHC was not affected by dietary treatments. This corroborates the work of Afia and Gift [26] who worked with the same species under similar conditions. That MCH values did not also vary significantly between dietary treatments also suggest that MCH was not affected by dietary treatments. However, only imported feed showed values within reference interval (30.21 - 46.74pg) for catfishes [12]. Diyaware *et al.* [47] suggested that higher MCH indicates a good volume of haemoglobin which

indicates effective oxygen transportation in the bloodstream required for optimal wellbeing of the fish. That MCV values were significantly lower in locally extruded feed could be due to lower iron content of the feed which could result in anaemic conditions. In fact, Adesina [20] observed that MCV indicates the status or size of RBCs and reflects normal or abnormal cell division during RBC production. Thus reduced MCV values could be linked to shrinkage of RBCs produced in low iron environment or by destruction of RBCs leading to anaemia as reported by Afia and Gift [26] and Alwan *et al.* [41].

The leukogram (White blood cells count, lymphocytes, monocytes and granulocytes) is an indicator of health in fish [48] and is used to get a picture of the status of an animal's immune system [49]. The insignificant changes in the leukogram of fish fed with the studied diets suggest that any possible stress-related factors (handling during sampling, anti-nutrients) were too low to induce pathological changes in the fish immune status [23].

4.2 Biochemical Profile

Analyses of serum biochemical constituents give useful information for detecting and diagnosing metabolic disturbances and diseases in fishes [50].

That total cholesterol was higher in fish fed with imported feed could be due to the higher proportion of fat in the chemical composition of the test diet [51]. The low total cholesterol observed in local feeds could be due to its high plant composition in comparison with imported feed. In fact, plant ingredients have been reported to possess phytosterols which compete with cholesterol for adsorption in the digestive system resulting in reduced levels of blood cholesterol [52, 53].

Serum total protein concentration provides critical information on the functional status of various organs and/or systems [54]. Proteins maintain colloid osmotic pressure and serve as catalyst in biochemical processes [55]. Increased concentrations of total protein observed in fish fed with locally pelleted and extruded feeds could be explained by structural liver alterations with reduced amino transferase activity, and concurrent reduced de-amination capacity [56]. Nonetheless, these concentrations were by far lower than those obtained by Adesina [20] and Bello *et al.* [22] working on the same species.

Hepatic enzymes (transaminases and alkaline phosphatase) are important enzymes for monitoring the health status of fish [57]. These enzymes are synthesized in the liver and in hepatocellular or cholestatic liver injuries; they are liberated into the serum [55]. Increased levels of transaminases in the blood serum of fish are usually associated with dying or damaged liver cells while a decrease could suggest leakage of enzymes into the serum [58, 59]. The values of Alanine amino transferase (ALAT) in this study were lower than the reference range (38.19-39.40UI/L) reported for *Heterobranchus longifilis* by Okorie-Kanu and Unakalamba [60] but were within the range (3.50-50.20UI/L) for *Synodontis membranacea* as reported by Owolabi [61]. Values of Aspartate amino transferase (ASAT) and Alkaline Phosphatase (ALP) were higher than values obtained by Okorie-Kanu and Unakalamba [60] and Owolabi [61]. This difference observed could be attributed to difference in the fish species (*H. longifilis* and *S. membranacea* respectively), culture media (concrete tank and lake respectively) and feeds (imported extruded and natural feeds respectively).

Serum glucose is regarded as an exceptional indicator of the fish health due to its rapid response to the various kinds of stressors [62]. Artacho *et al.* [63] stated that glucose in serum is a major metabolite of carbohydrate metabolism, thus the higher glucose concentration observed in fish fed with imported and locally extruded feeds could be attributed to their higher glycogen reserves.

5. CONCLUSION

The study revealed that with regards to haematological parameters, red blood cells count, packed cell volume and haemoglobin level differed among the test diets whereas parameters of erythrocytes indices (mean corpuscular haemoglobin concentration, mean corpuscular haemoglobin and mean corpuscular volume) and leucogram (white blood cells, lymphocytes, monocytes and granulocytes) did not differ significantly among dietary treatments. With regards to serum biochemistry, total cholesterol and glucose were higher in fish fed with imported feed while total protein, alanine amino transferase, aspartate amino transferase and alkaline phosphatase were higher in fish fed with locally pelleted and locally extruded feeds. Thus, variation in dietary treatments was not

detrimental to the health status of *C. gariepinus* reared in plastic IBC tanks.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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