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THE EFFECTS OF COCKROACH *(Periplenata americana)* MEAL ON THE HAEMATOLOGICAL PARAMETERS OF AFRICAN CATFISH (*Clarias gariepinus* BURCHELL 1822) FINGERLINGS

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ABSTRACT

The effects of cockroach (*Periplenata americana)* meal on the haematological parameters of *Clarias gariepinus* fingerlings (1.13±0.3g) was investigated in a feeding trial for 56 days. Three iso-nitrogenous experimental diets were formulated at 45% crude protein comprising diet 1(control diet), diet 2 (10% fish meal) and diet 3 (10% cockroach meal) in a complete randomized design. The results obtained indicated significant differences ($p<0.05$) among the red blood cell (RBC), white blood cell (WBC), mean cell volume (MCV), hemoglobin content (Hb) platelet count (PLC), packed cell volume (PCV), mean cell hemoglobin (MCH), mean cell hemoglobin concentration (MCHC) and lymphocytes measured. *Clarias gariepinus* fingerlings fed cockroach meal-based diets had significantly ($p<0.05$) higher PCV, MCH, RBC, WBC and lymphocytes than those fed fish meal-based diet including the control diet. It can be concluded that, cockroach meal can be included in the diet of *Clarias gariepinus* without significant adverse effects on its health status.

Keywords: Haematology, African catfish, cockroach, fishmeal, insect

INTRODUCTION

Recent high demand and consequent high prices for fish meal, together with increasing production pressure on aquaculture has probed research into the development of insect's proteins for aquaculture and livestock which will eventually supplement fish meal (Henry *et al*., 2015). The use of insects in livestock, fish and crustaceans feed has been reviewed by Makkar *et al*. (2014) and Riddick (2014) in the diet of juvenile fish and crustaceans. Henry *et al*. (2015) reported that insects like variegated grasshopper (*Zonocerus variegatus*), painted grasshopper (*Poekilocerus pictus*), migratory locust (*Locusta migratoria*), termites (*Macrotermes spp*.), yellow mealworm (*Tenebrio molitor*), asiatic rhinoceros beetle (*Oryctes rhinoceros*), super worm (*Zophobas morio*), domesticated silkworm (*Bombyx mori*), common house mosquito (*Culex pipiens*), soldier fly (*Hermetia illucens*) and common housefly (*Musca domestica*) have been used in fish diets. Insects are also reported to be part of natural diet of both freshwater and marine fish (Howe *et al*., 2014; Whitley and Bollens, 2014). Van-Huis (2013) also reported that, insects are rich in amino acids, lipids, vitamins and minerals and have been considered as potential alternatives to fish meal and fish oil (Henry *et al*., 2015). Insects have been reported to contain between 50 and 82% (dry matter, (Rumpold and Schluter, 2013) depending on the insect species or on the method of processing the insect (Fasakin *et al*., 2003; Banjo *et al*., 2006) while the protein content of a good quality fish meal can reach up to 73% and that of soybean meal contains up to 50% of proteins (Barroso *et al*., 2014). Rust *et al*. (1991) reported that cockroaches if cultured and reared under favourable condition can be used as supply of protein in fish feeds.

Cockroaches have survived on the earth for more than 300 million years (Zurek and Schal, 2004). They are considered one of the most successful groups of animals because of their adaptability in various environmental conditions with approximately 3500 species worldwide

(Kopanic, 1994). Of these species, thirty are found with human habitations (Kinfu and Erko, 2008). *Periplaneta americana,* Linnaeus, 1758, and *Blattella germanica,* Linnaeus, 1767, are the most common species (Al-Mayali and Al-Yaqoobi, 2010; Tilahun *et al.,* 2012). The majority of these species live in tropical and subtropical areas where they are not recognized as pests (Vazirianzadeh, *et al*.,2009). Cockroaches are omnivorous scavengers living in parts of houses and other buildings including toilets, kitchen, stagnant water, sewages (Siachua *et al*., 2008). They consume any organic food sources such as sweets, meats, starches, hair, books, fresh vegetable leaves and decaying matter (Ruth, 2017). Cockroaches serve as a source of food for bird, domestic chicken and small reptiles.

Cockroaches are vectors of pathogens like bacteria (*Klebsiella pneumonia, Enterobacter cloacae, Enterobacter aerogenes, Salmonella* spp., *Shigella sonnei, Vibrio cholerae, Citrobacter freundii* (Ibo *et al*., 2014) viruses *(Poliomyelitis)* (Mourier, 2014), protozoa (oocysts of *Isospora belli, Cryptosporidium parvum, Cyclospora cayetanensis,* cysts of *Entamoeba histolytica, Balantidium coli,* and *Giardia lamblia*) (Uckay *et al.,* 2009; Fotedar , 1989; Graczyk *et al*., 2005; Salehzadeh *et al*., 2007), fungi (*Candida* sp., *Rhizopus* sp., *Aspergillus* sp., *Mucor* sp.) (Tatfeng *et al*., 2005), and eggs of some pathogenic intestinal worms (*Ascaris lumbricoides, Trichuris trichiura,* Hookworm, *Enterobius vermicularis, Hymenolepis nana, Toxocara canis, and Strongyloides stercoralis* larvae) (Nagham *et al*., 2011 Bala and Sule, 2012; Etim *et al*., 2013) with potential zoonotic effects on man (Siachua *et al*., 2008; Uckay *et al*., 2009). American cockroach has been associated with major sources of indoor acute asthma morbidity (Chad and Schal, 2007) since they are mechanical vectors of bacteria (Sirvan *et al*., 2016).

Diploptera punctata a species of cockroach has been reported to produce a high nutrient secretion "cockroach milk" referred to as 'superfood' (Williford *et al.,* 2004). Kendall (2016) also reported that, this cockroach milk is full of protein-dense crystals that is high in essential amino acids, sugars and healthy fat. He stated further that, the protein is carrying more than three times the caloric content than that of buffalo milk. It also contains the 9 essential amino acids (Niaz *et al*.,2018) however, there are ethical questions on its mass production as it requires the killing of lactating females (Sanchari *et al*., 2016). Despite the disgusting nature of the insect, some countries like Thailand, Bangkok, and China are rearing it for human consumption (Nelson, 2018).

Blood parameters are considered patho-physiological indicators of the whole body and thus, are imperative in diagnosing the structural and functional status of fish exposed to toxicants (Adhikari and Sarkar, 2004; Maheswaran *et al*., 2008). Blood analysis is a valuable means of evaluating the physiological condition of cultured fish with respect to determining the effect of diets and other stress factors of fish health (Bello-Olusoji *et al.,* 2006 and Bhatti *et al*., 2009). Animashahun *et al.* (2006) suggested that the comparison of haematological profile with nutrient intake may provide a base line for either increasing or reducing of certain nutrients for different population groups. There is dearth of information on the inclusion of cockroach in the diet of fish and its effect on its haematological parameters. Therefore, this research, investigated into the effects of cockroach meal on the hematological parameters of *Clarias gariepnus* fingerlings.

MATERIALS AND METHODS

Description of study area

The study was conducted in the Laboratory of the Department of Water Resources Aquaculture and Fisheries Technology, Federal University of Technology Minna, Niger State (9.31 '58.8^{o} N; 6.27 '07.7^{o}E).

Acquisition of experimental fish

One hundred and fifty *Clarias gariepinus* fingerlings of mean weight 1.13±0.3g were procured from A.A Fish Farm Kpakungu, Minna Niger State and transported in a 50 litres jerry-can to the Laboratory of the Water Resources, Aquaculture and Fisheries Technology, Federal University of Technology, Minna. The fishes were acclimatized in a 1000 litter's plastic tank for one week and were fed with a commercial feed on a maintenance ration once daily prior to the commencement of the experiment. After acclimation period, fingerlings were weighed with

a sensitive weighing balance model (SF-400 (Capacity 3000g x1g/106g x 0.1g) for the weight of individual fish. Twenty fishes were stocked randomly in triplicate of complete randomized design (CRD) in the rearing plastic of 20 litres capacity of dimension 30 cm x 20 cm.

Aggregation and collection of cockroaches

Adult cockroaches were used in this experiment. They were aggregated in a dedicated room where rotten vegetables and left-over foods were kept as attractant. The temperature of the room was 28^{o}C with relative humidity of 60% with sufficient darkness. Attracted cockroaches were harvested for 2 months by placing a hot charcoal pot in the room to raise the temperature to between 35^{o}C and 40^{o}C which the insect to sought for escape from the room. An escape route was provided and they were killed with a bunch of broom. Harvested cockroaches were then sundried and ground whole for later use. However, the use of insecticides was discouraged to avoid contamination.

Acquisition of feed ingredients

Feedstuffs used for the experiment included soyabean, maize and palm oil which were procured from the Kure Ultra-modern market, Minna, Niger State while the groundnut cake and vitamin-mineral premix were obtained from Makolo fish feeds store in Minna. Adult cockroaches were collected as described above.

Proximate analysis of the feed ingredients

This was carried out in the Department of water Resources Aquaculture and Fisheries Technology laboratory of the Federal University of Technology Minna, Niger State. The feedstuffs were analyzed for moisture, crude lipid, crude protein, ash and crude fibre contents using the method AOAC (2005) Table 1.

Feed formulation

Three iso-nitrogenous experimental diets were compounded at 45% crude protein designated as Diet 1 (control) diet 2 (10% fish meal) and diet 3 (10% cockroach meal) alongside other ingredients (Table 2).

Table 1: Proximate analyses of feedstuffs

Ingredients	Crude Protein%	Lipid%	Ash%	Moisture%	Fibre%
Fish meal	69.23	10.18	10.28	6.08	0.80
Soybean	46.15	24.83	5.35	5.74	1.74
Groundnut cake	48.81	20.03	14.89	6.42	1.85
Cockroach meal	68.25	7.12	6.42	7.12	9.70
Maize meal	10.20	9.57	1.29	10.10	2.00

Table 2: Formulated diets and their proximate composition

Feed stuff	Diet 1 (Control)	Diet 2 (10% fish meal)	Diet 3 (10% Cockroach meal)
Fish meal	0.00	100.00	0.00
Groundnut cake	416.50	284.90	294.50
Soybean	416.50	284.90	294.50
Cockroach meal	0.00	0.00	100.00
Maize meal	67.000	230.30	211.10
Palm oil	50.00	50.00	50.00
Vitamin mineral premix	50.00	50.00	50.00
Total (g/kg)	1000.00	1000.00	1000.00
Proximate composition (%)			
Crude protein	45.05	45.09	45.09
Crude lipid	9.08	13.85	8.88
Crude fibre	1.80	0.80	4.50
Ash	14.88	14.89	12.04
Moisture	7.81	7.18	8.20
NFE	21.38	18.19	21.34

Experimental design and feeding

Nine rearing plastic tanks of 20 litres capacity of dimension 30cm x 20cm were used for the experiment. Twenty (20) *C. gariepinus* fingerlings were stocked at random in the rearing bowls in triplicate while both fish and diets were allotted in a complete randomized design (CRD). The *Clarias garipenus* fingerlings were fed thrice daily (9.00, 13.00 and 16.00) at 3% body weight and adjusted two weeks into the experiment to 5% to reflect the fish nutrient requirement and was maintained throughout trial period of 56 days.

Blood sampling

The blood sampling of the fishes was done at the commencement and at the end of the experiment. The initial blood sample was collected upon arrival of the fish at the laboratory from the hatchery farm while the final blood sample was obtained at the end of the experiment. For the initial blood sample, seven fishes were selected from the pool from which 8 ml of blood sample was obtained from their posterior caudal veins using 2 ml disposable syringes and needles according to Schmitt *et al.* (1999) and mixed with ethylene diamine tetra-acetic acid (EDTA, an anti-coagulant) for analysis. At the end of the experiment, seven samples of live fish were randomly selected from each treatment and 8 ml of blood sample was collected from them as described above.

The blood samples were taken to the haematological laboratory of the Minna General Hospital for analysis using standard methods as described by Schalm *et al*. (1975).

Haematological parameters

Packed cell volume (Haematocrit)

Pre-heparinised capillary tubes were filled up to 2 ml (75%) with blood samples from experimental fish by suction pressure and one end of each tube was immediately sealed with plasticine. The tubes were arranged on a tray and centrifuged for 5 minutes in a micro-haematocrit centrifuge (SP 6–500 UV spectrophotometer) at 12,000 r.p.m. Packed cell volume (PCV) was read by means of a haematocrit reader (UV–VIS Spectrophotometer 108). The results were expressed in percentages (Kelly, 1979).

According to Duke (1975), PCV was obtained as:

$$PCV=\frac{100(blood\ volume - plasma\ volume}{blood\ volume}$$

Blood volume was calculated as follows:

$$\text{Blood volume} = \frac{\text{Plasma volume x } 100}{100 - \text{PCV}}$$

Haemoglobin concentration (Hb)

Determination of Hb concentration involved the cyanomethaemoglobin methods described by Schalm *et al.* (1975) and Kelly (1979). Each 0.02 ml of sufficiently mixed blood was added to 4 ml of Drabkin's solution (which is a mixture of 250 mg potassium ferricyanide, 200 mg potassium cyanide and 50 mg potassium dihydrogen phosphate). The resultant mixture (Drabkin's solution) was allowed to settle for 10 minutes at room temperature to allow all the haemoglobin to react with the reagent to form cyanomethaemoglobin (that is, for proper colour development). The absorbance of the resultant solution was read at 540 nm inside a Unicam spectrophotometer (Spectrumlab 23a Model) against a blank.

Red blood cell (RBC) and white blood cell (WBC) counts

Counting of the blood cells was carried out by means of Neubauer haemocytometer as described by Kelly (1979). The number of red blood cells was determined by diluting (at ratio 1:200) each blood sample collected with Dacies fluid (a mixture of 99 ml of 3% aqueous solution of sodium citrate and 1 ml of 40% formaldehyde) which maintained the normal shape of the red blood cells. The number of white blood cells was determined by diluting (at 1:200, i.e. at the same ratio as for red blood cells) the blood sample with 3% aqueous solution of acetic acid and then gentian violet was added. 1 ml of the mixture was dropped on a microscope slide and labeled according to the dietary treatments. A binocular light microscope (Olympus Japan-312545) was used for counting red and white blood cells from x106d/litre and x103d/litre respectively.

Mean corpuscular volume (MCV)

This refers to the mean volume of red blood cells in a blood sample and was determined

according to the formula proposed by Dacie and Lewis (2001) as follows:

$$MCV(\mu g/ml) = \frac{Volume\ of\ red\ blood\ cells\ in\ ml\ per\ 100\ ml\ of\ blood\ x\ 100}{Number\ of\ red\ blood\ cells\ per\ 100\ ml\ blood}$$

Mean corpuscular haemoglobin concentration (MCHC)

This was calculated from the relationship between haemoglobin concentration and number of red blood cells per 100 ml blood (Dacie and Lewis, 2001).

$$MCHC\ (g/100ml) = \frac{Haemaglobin\ concentration\ x\ 100}{Number\ of\ red\ blood\ cells\ per\ 100\ ml\ blood}$$

Determination of lymphocytes, neutrophils and monocytes were done using Neubauer-type haemocytometer with Turk's solution as the diluting fluid as described by Rusia and Sood (1992).

Statistical Analysis

Statistical package minitab release 14 was used to analyse the data generated. ANOVA was used to establish significant differences in the means and Turkey was used to separate the means.

RESULTS

Table 3 shows the results of haemotological parameters of *Clarias gariepinus* fed cockroach meal with significant differences ($p<0.05$). The hemoglobin content (Hb) shows a range of 3.53 g/100ml to 2.23 g/100ml. The initial value was significantly high (3.53 g/100ml) while the fish meal-based diet (FMBD) was lower ($p<0.05$) (2.23 g/100ml) than the cockroach meal-based diet (CMBD) (2.77 g/100ml). The Packed cell volume (PCV) also ranged from 9.99% to 5.67%. The CMBD had a significantly high ($p<0.05$) PCV value (8.675%) than the FMBD (5.67%) moreover, both were significantly lower ($p<0.05$) than the initial value (9.99%). The mean cell volume (MCV) ranged from 135.30 nm^3 to 59.67 nm^3. The CMBD gave a significantly low $p<0.05$) value of 59.67 nm^3 than the FMBD (75.00 nm^3) while both are significantly lower $p<0.05$) than the initial value (135.30 nm^3). The mean heamoglobin count (MCH) ranged from 39.67 µg/cell to 32.33 µg/cell with CMBD exhibited a significantly higher value ($p < 0.05$) (39.67 µg/cell) than the initial (32.33 µg/cell). The mean corpuscular haemoglobin concentration (MCHC) values ranged from 48.00 g/dl to 31.33 g/dl. The initial value (48.00 g/dl) was significantly high ($p<0.05$) while the CMBD had the lowest value (31.33 g/dl). The red blood cell (RBC) ranged from $2.8310^6/mm^3$ to $1.2310^6/mm^3$. The CMBD gave a significantly high value ($2.8310^6/mm^3$) while the initial was significantly low ($1.2310^6/mm^{3)}$. The platelet count (PLC) ranged from 480.33 to 120.67. The PLC was significantly ($p<0.05$) high for the initial value (480.33) and low for CMBD (120.67). The white blood cell (WBC) ranged from 15.60 to 12.33 and was significantly high for CMBD (15.60 $x10^6/mm^3$) and lowest for the initial value (12.33 $x10^6/mm^3$). The lymphocytes ranged from 19.67% to 8.93%. The CMBD gave a significantly high value (19.67%) while the initial value (8.93%) was significantly lower ($p < 0.05$) than other treatments. The neutrophils ranged from 76.67% to 21.33%. The CMBD exhibited a significantly high value (76.67%) while the initial had the lowest neutrophil value (21.33%). Monocytes and eosinophil ranged from 18.00% to 6.67% respectively while the control diet gave a significantly high value ($p<0.05$) (18.00%) than the initial (6.67%). The basophil ranged from 12.33% to 6.67% with CMBD having a significantly high value (($p<0.05$) (12.33%) while the initial gave a low value ($p<0.05$) (6.67%).

Table 3: Hematological parameters for *Clarias gariepinus* fingerlings fed cockroach meal diets for 56 days.

Hematological Parameters	Initial	Diet 1 Control Diet	Diet 2 Fish Meal (10%)	Diet 3 Cockroach Meal (10%)	SD±
Hb (g/100ml)	3.53 ± 0.03^{a}	2.43 ± 0.06^{c}	2.23 ± 0.58^{d}	2.77 ± 0.06^{b}	0.05
PCV (%)	9.99 ± 0.01^{a}	6.67 ± 0.58^{c}	5.67 ± 0.58^{c}	8.67 ± 0.58^{b}	0.05
MCV (nm^3)	135.30 ± 0.61^{a}	64.33 ± 0.58^{c}	75.00 ± 1.00^{b}	59.67 ± 0.58^{d}	0.71
MCH (µg/cell)	32.33 ± 0.58^{c}	36.33 ± 0.58^{b}	37.00 ± 1.00^{b}	39.67 ± 0.58^{a}	0.71
MCHC (g/dl)	48.00 ± 1.00^{a}	34.33 ± 0.58^{b}	36.00 ± 1.00^{b}	31.33 ± 0.58^{c}	0.82
RBC($\times 10^6/mm^3$)	1.23 ± 0.06^{c}	2.70 ± 0.10^{a}	1.63 ± 0.06^{b}	2.83 ± 0.06^{a}	0.71
PLC	480.33 ± 0.58^{a}	248.33 ± 0.58^{c}	120.67 ± 0.58^{d}	334.67 ± 0.58^{b}	0.29
WBC($\times 10^6/mm^3$)	12.33 ± 0.06^{c}	12.83 ± 0.06^{b}	13.13 ± 0.06^{b}	15.60 ± 0.01^{a}	0.05
Lymphocytes (%)	8.93 ± 0.06^{c}	9.67 ± 0.58^{c}	14.67 ± 0.58^{b}	19.67 ± 0.58^{a}	0.50
Neutrophils (%)	4.33 ± 0.58^{c}	72.33 ± 0.58^{a}	76.67 ± 0.58^{a}	67.67 ± 0.58^{b}	0.58
Monocytes (%)	6.67 ± 0.58^{c}	18.00 ± 1.00^{a}	8.33 ± 0.58^{c}	11.67 ± 0.58^{b}	0.71
Eosinophil (%)	6.67 ± 0.58^{c}	18.00 ± 1.00^{a}	7.67 ± 0.58^{c}	12.33 ± 0.58^{b}	0.71
Basophils (%)	6.67 ± 0.58^{c}	17.67 ± 0.58^{a}	8.33 ± 0.58^{c}	12.33 ± 0.58^{b}	0.58

Mean values having same letter in the same row are not significantly different ($p < 0.05$)

DISCUSSION

Haemological parameters indicate the state of health of fish especially if some degree of variation is observed when exposed to intoxicants, pollutants and pathogens (Kori-Siakpere, 2000; Gabriel *et al*., 2011 and nutritional effects (Rehulka, 2000) in agreement with the findings of this research where significant variation were observed in the haemotological parameters. The haematological parameters measured increased for fishes fed with cockroach meal based diet (CMBD) than those of fish meal-based diet (FMBD) and the control in some parameters like MCH, RBC and WBC. This is in agreement with the report of Fagbenro *et al*., 2010 who reported increase in haematological parameters of *Clarias gariepinus* fed toasted sunflower seed meal and Yue and Zhuo (2008) in hybrid tilapia juvenile fed cotton seed meal. Soyinka and Boafo (2015) also reported increased heamatological parameters in *Clarias gariepinus* Juveniles fed Quail Egg shells. Thus, the high haemoglobin count (Hb) recorded for fishes fed CMBD is indicative of the good health status of the fish in its ability to carry enough oxygen for metabolic activities (Isaac *et al.*, 2013; Ugwuene, 2011 and Isaac *et al*, 2013). The MCV value was low for CMBD but significantly high ($p<0.05$) for FMBD. This may be attributed to the presence of some toxins in the diet which can lead to anaemia in the fish (Oyawoye and Ogunkunle, 2004) however, the presence of toxicant may not pose any significant threat to the health of the fish especially, the CMBD whose haemotological indices were close to the control. Ayotunde *et al.* (2011) and Audu *et al*., 2014 reported that *C. garirpinus* exposed to century leaf had its packed cell volume, red blood cell counts, haemoglobin, and mean corpuscular haemoglobin concentration significantly depleted whilst, white blood cell count was significant increased with increase in the concentration of *A. americana* leaf dust. This decrease in the haematological profiles was attributed to the presence of anti-nutrients in the leaf. Ukagwu *et al*., (2012) also reported lower Hb, red blood cell count (RBCC), packed cell volume (PCV) and higher concentrations of mean corpuscular volume (MCV), mean corpuscular haemoglobin concentration (MCHC), mean corpuscular haemoglobin (MCH) and white blood cell (WBC) indicating that test fish suffered haemolytic anaemia and leucocytocis with similar reports observed by Ololade and Oginni (2010) and Singh *et al*. (2010). Low PCV value recorded by fish fed FMBD in this study is an indication of anaemia or oligohaemia in *C. gariepinus* (George *et al*., 2017; Akinrotimi *et al*., 2012; Akinrotimi *et al.*, 2011; Gabriel *et al*., 2011) and low active fishes (Satheeshkumer, *et al*, 2011). The significant reduction in PCV, Hb, RBC, could be indication of severe anaemia caused by destruction of erythrocytes (Adeyemo, 2005; Omoniyi *et al*., 2002; Khangarot and Tripathi ,1991) or haemo-dilution (Adeyemo, 2005) which is contrary to the finding of this study for fishes fed with CMBD.

The WBC and its indices; lymphocyte, neutrophils and eosinophils and basophils were

increased in the fish fed with CMBD than the control. This can be attributed to development of sufficient immunity against any infection arising from the diet (Soetan *et al*., 2013) and its ability to adapt to the test diet (Iwuji and Herbert, 2012; Isaac *et al.*, 2013). According to Douglas and Jane (2010), the quantity of RBC has implication in immune responses and the ability of the animal to fight infection. Lymphocytes and WBC are the defensive cells of the body Yaji and Auta (2007). The species with higher value of WBC and lymphocytes will be able to resist infection more than the other species in agreement with this study where the WBC value in fishes fed with CMBD was higher ($15.60\pm0.01mm^3$) compared with FMBD ($13.13\pm0.06mm^3$) and the control ($12.83\pm0.06mm^3$) respectively. The lymphocyte for CMBD was $19.67\pm0.58\%$, while the FMBD and control were$14.67\pm0.58\%$ and $9.67\pm0.58\%$ respectively. The fish containing higher value of circulating lymphocytes will be able to defend itself from invading pathogens and therefore has more resistance to diseases (Akinrotimi *et al*., 2011)

Cockroach meal-based diet had high value of the platelet count (334.67 ± 0.58) than fish meal-based diet (120.67 ± 0.58) which implies that, fishes fed CMBD have more ability to maintain hemostasis (Adedeji and Adegbile, 2011). Therefore, from the result obtained from this study, feeding cockroach meal to *C. gariepinus* fingerlings has no negative effects on its health status. However, higher inclusion levels of the test ingredient need to be investigated to ascertain the optimum inclusion level as replacement of fish meal in the diet of *C. gariepinus.*

CONCLUSION

The hematological indices evaluated indicated that *Clarias gariepinus* fingerlings fed with cockroach meal had better health status or physiological condition than those fed with fish meal or the control diet. Further research can be conducted on mass culturing of cockroach and optimum inclusion of cockroach meal in the diet of *C. gariepinus*

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