**Journal of Fisheries**
Volume 6 Issue 1 Pages 553–562 April 2018
Peer Reviewed | Open Access | Online First

eISSN 2311-3111
pISSN 2311-729X

**Original Article**
DOI: 10.17017/jfish.v6i1.2018.245

# Growth performance, haematology and histopathology of African catfish (*Clarias gariepinus*) fed varying levels of *Aloe barbadensis* leaves

**Sherifat Ibidunni Adegbesan • Samuel Olubodun Obasa • Ikililu Abdulraheem**

*Department of Aquaculture and Fisheries Management, Federal University of Agriculture, Abeokuta 121001, Ogun State, Nigeria.*

**Correspondence**
Mrs Sherifat Ibidunni Adegbesan; Department of Aquaculture and Fisheries Management, Federal University of Agriculture, Abeokuta 121001, Ogun State, Nigeria.
ibidunnisherifat@yahoo.co.uk

**Manuscript history**
Received 17 February 2017 | Revised 20 September 2017 | Accepted 24 October 2017 | Published online 1 February 2018

**Citation**
Adegbesan SI, Obasa SO and Abdulraheem I (20xx) Growth performance, haematology and histopathology of African catfish (*Clarias gariepinus*) fed varying levels of *Aloe barbadensis* leaves. Journal of Fisheries 6(1): 553–562. DOI: 10.17017/jfish.v6i1.2018.245

**Abstract**

One hundred and twenty *Clarias gariepinus* fingerlings (2.33 ± 0.07 g) were fed with 40% crude protein diets containing three concentrations of *Aloe barbadensis* leaves-paste: ABL1, 1%; ABL2, 2%; ABL3, 3%, and control, 0% *ad libitum* twice daily for 12 weeks. Mean weight gain and percentage weight gain increased ($P < 0.05$) as concentration of *A. barbadensis* increased. Survival rate decreased as concentration of paste increased. Differences ($P < 0.05$) seen in packed cell volume (PCV), haemoglobin (Hb), and red blood cell (RBC), thus highest in ABL3: PCV (36.67 ± 0.89%), Hb (12.37 ± 0.37 g $dl^{-1}$) and RBC (3.47 ± 0.08×$10^6$ $L^{-1}$) and lowest in control: PCV (22.0 ± 0.58%), Hb (7.37 ± 0.20 g $dl^{-1}$) and RBC (2.07 ± 0.06 ×$10^6$ $L^{-1}$). Liver histology of control fish was normal, while fatty degenerations were seen in the treated fish. The histology of fish kidney was normal in all treatments. The study concluded that 1% *A. barbadensis* leaves-paste could effectively improve growth performance, nutrient utilization and survival of cultured *C. gariepinus*.

**Keywords:** Growth performance; *Aloe barbadensis* leaves-paste; dietary supplement; *Clarias gariepinus*

## 1 | INTRODUCTION

According to Food and Agriculture Organization (FAO) there is a gradual increase in aquaculture production (inland and marine) from about 55.7 million tons in 2009 to 167.2 million tons in 2014 (FAO 2016). Aquaculture as is an emerging industrial sector requires continued research with scientific, technical developments and innovations (Alicia *et al.* 2005; Mohsin *et al.* 2012; Galib *et al.* 2013) in different aspects of production including the search for natural alternative growth promoters to be used as feed supplements. Several studies had been carried out in developing new dietary supplementation strategies in which various health and growth promoting compounds like probiotics, prebiotics, synbiotics and phytobiotics have been used (Denev 2008). To develop alternative practices for growth promotion and disease management in aquaculture, attention has also been focused in identifying novel drugs, especially from plant sources. These drugs may be delivered to the cultivable organisms through feed supplementation. Several herbs have been confirmed as growth promoters in aquatic animals (Rao *et al.* 2006; Immanuel *et al*. 2007). Phytobiotics are plant-derived, natural compounds and medicinal herbs embedded into diets to enhance animal productivity. These include Aloe vera (*Aloe barbadensis)*, garlic (*Allium sativum*)

and ginger (*Zingiber officinale*) widely used as growth promoters in different species of fish (Adedeji *et al*. 2008).

Aloe vera is a tropical or sub-tropical plant with turgid lance-shaped green leaves with jagged edges and sharp points (Qiao *et al.* 2013). It is a perennial plant belonging to the Liliaceae or Aloeaceae family and a succulent cactus-like plant, which grows in hot and dry climates (Choi and Sung 2003). Aloe vera is made up of a colourless liquid product, called gel consisting primarily water and polysaccharides, and a yellow latex representing 20 – 30% by weight of whole leaf with bitter taste, has aloe-emodin, aloin and barbaloin as its active ingredients (Plaskett 1998; Vogler and Ernst 1999). 75 compounds are present in aloe vera leaf, and each with several remedial properties. These include lignin, saponins, anthraquinones, minerals, vitamins, 28 amino acids, enzymes and sugars (monosaccharides and polysaccharides) (Banwankar *et al*. 2014). The polysaccharides include pectin, cellulose, hemi cellulose, glucomannan, accemannan and mannose derivatives (Lee *et al*. 2001).

Aloe vera does not affect food taste or appearance, so it is a safe, natural alternative to synthetic preservatives (Chandrakesan *et al.* 2009). *A. barbadensis*, is a growth promoting plant and also enhances immune responses in fish (Alishahi *et al*. 2010). A study examining aloe vera leaves at two concentrations (5 and 10%) in cockerels' diets reported that 5% aloe vera leaves improved body weights and feed efficiency of birds (Odo *et al*. 2010). Mmereole (2011) also reported that 1% aloe vera leaves in broiler diet enhanced body weight gain in the birds. It is noteworthy that *A. barbadensis* leaves-paste has not been used as a phytobiotics in fish species. Hence, this study aims at determining the growth promoting effect, haematology and histopathology of *Clarias gariepinus* fed different concentrations of *A. barbadensis* leaves-paste.

## 2 | METHODOLOGY

The research work was done at the fish farm (hatchery unit) of the Department of Aquaculture and Fisheries Management, College of Environmental Resources Management, Federal University of Agriculture, Abeokuta, Ogun State, Nigeria from April 2015 to September 2015. The feeding trial was conducted in twelve (12) rectangular plastic tanks each with a capacity of 60 L of fresh water and each tank was two-third filled (40 L).

### 2.1 | Experimental fish

African mud catfish (*C. gariepinus*) fingerlings of mean weight 2.33 g were used as the test fish species in this study. A total of one hundred and twenty (120) fingerlings were purchased at Motherhood Fish Farm, Abeokuta, Ogun State, Nigeria. The fish were randomly (completely randomized design) allotted into four (4) treatments in the plastic tanks at a stocking rate of ten fingerlings per tank in triplicates.

### 2.2 | Experimental diets

A ration of 40% crude protein (CP) containing fishmeal (72% CP), soybean meal (42% CP), groundnut cake (45% CP), using yellow maize (10% CP) as the energy source and fixed ingredients including vitamin premix (1%), lysine (0.5%), methionine (0.5%), di calcium phosphate (0.5%); salt (0.5%) and vegetable oil (4.0%). Afterwards, fresh leaves of aloe vera (*A. barbadensis*) were obtained from a herbarium in Sagamu, Ogun State and authenticated by a botanist. The leaves were thoroughly washed with distilled water and weighed on an electronic scale (Mettler Toledo FB602, Jenway UK), cut into pieces with a knife and blended in electric blender (Binatone, BLG 555, China) with water added at a ratio of 1:1 as described by Muhammad-Jameel et al. (2014) to give *A. barbadensis* leaves-paste. The proximate composition of *A. barbadensis* leaves-paste is shown in Table 1 following procedure described by AOAC (2011).

**TABLE 1:** Chemical composition of aloe vera leaves (Muhammad-Jameel *et al*. 2014).

| *Contents* | *Percentage (%)* |
|---|---|
| Moisture | 96.80 ± 0.45 |
| Crude Protein | 6.90 ± 0.06 |
| Crude Fat | 2.85 ± 0.05 |
| Total ash | 14.65±0.03 |

The aloe vera leaves-paste were added on top of the basal diet and thoroughly mixed to formulate four isonitrogeneous (40% crude protein) *A. barbadensis* leaves-paste supplemented diets. Thus, the experimental diets are made up of three treatment diets containing different concentrations of *A. barbadensis* leaves-paste and the control as follows: Treatment 1 (Control), 0% *A. barbadensis* leaves-paste; Treatment 2 (ABL1), 1% *A. barbadensis* leaves-paste; Treatment 3 (ABL2), 2% *A. barbadensis* leaves-paste; and Treatment 4 (ABL4), 3% *A. barbadensis* leaves-paste.

The compounded feeds were pelletized (2 mm), sun dried, allowed to cool in an open air, packed and stored in an opaque nylon bag separately. The percentages of all the feed ingredients used in formulating the four experimental diets are listed in Table 2. The proximate analyses of the four experimental diets were carried out following AOAC (2011).

### 2.3 | Experimental procedure

The fish were acclimated to the experimental system for a

period of 14 days before the commencement of the feeding trial and were fed two times daily with a commercial diet (40% CP). The fish were weighed in batches; ten per treatments at the beginning of the experiment. Prior to the commencement of the experiment, all fish were starved for 24 hours to eliminate variation in weight due to residue food in the gut and at the same time to increase the appetite of the fish. Fish were fed with the diets at two feeding regimes, in the morning between 08:00 – 09:00 hr and in evening between 17:00 – 18:00 hr, *ad libitum* for (84 days) 12 weeks. The fish were weighed in each tank weekly using a sensitive electronic weighing scale (Mettler Toledo FB602, Jenway UK) to monitor the fish growth and ensure adequate feed consumption. Mortality was monitored daily. The proximate analyses of the fish carcasses were also carried out following AOAC (2011).

**TABLE 2** Different feed ingredients and their percentages in the experimental diets

| *Ingredients* | *Control* | *ABL1* | *ABL2* | *ABL3* |
|---|---|---|---|---|
| Fishmeal | 31.2 | 31.2 | 31.2 | 31.2 |
| Soybean meal | 15.6 | 15.6 | 15.6 | 15.6 |
| Groundnut cake | 15.6 | 15.6 | 15.6 | 15.6 |
| Yellow maize | 30.5 | 30.5 | 28.75 | 27.75 |
| Vitamin premix | 1.0 | 1.0 | 1.0 | 1.0 |
| Lysine | 0.5 | 0.5 | 0.5 | 0.5 |
| Salt | 0.5 | 0.5 | 0.5 | 0.5 |
| Vegetable oil | 4.0 | 4.0 | 4.0 | 4.0 |
| Methionine | 0.5 | 0.5 | 0.5 | 0.5 |
| DCP | 0.5 | 0.5 | 0.5 | 0.5 |
| *A. barbadensis* leaves (%) | 0.0 | 1.0 | 2.0 | 3.0 |
| **Total** | **100** | **100** | **100** | **100** |

*ABL, A. barbadensis leaves paste; DCP, Di calcium phosphate*

### 2.4 | Water quality parameters

During study water temperature (°C) and dissolved oxygen (mg $L^{-1}$) were measured every week using a combined digital YSI dissolved oxygen meter (YSI Model 57, Yellow Spring Ohio, USA); pH was also monitored weekly using pH meter (Mettler Toledo-320, Jenway UK). Status of different water parameters are shown in Figure 1.

### 2.5 | Haematological analysis

The blood samples were taken from the dorsal fin of the fish following Klontz and Smith (1986) and taken to the laboratory of Department of Veterinary Microbiology, College of Veterinary Medicine (COLVET), FUNAAB for haematological analysis. The samples were analysed according to methods adopted in fish haematology (Ivanova 1983; Haghighi 2010). The haematological parameters obtained include packed cell volume (PCV) or Haematocrit (HCT), Haemoglobin (Hb) and red blood cell (RBC). The absolute red blood cell indices (mean cell haemoglobin (MCH), mean cell volume (MCV), and mean cell haemoglobin concentrations (MCHC) were calculated. The white blood cell (WBC) and differential count (neutrophils and lymphocytes) were determined as described by Dacie and Lewis (2001).

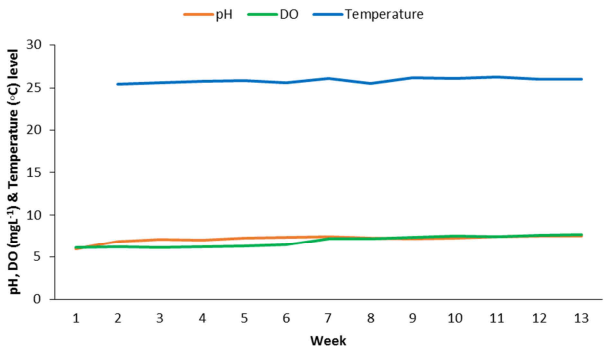


**FIGURE 1** Physicochemical parameters of water during the period of experiment

### 2.6 | Histopathology

The histopathological examinations were carried out on the liver and kidney of the fish at the Department of Veterinary Pathology, COLVET, FUNAAB. The organs were carefully removed from the body of the fish so as to avoid damage and preserved in 10% formalin solution. The fixed tissues were processed routinely for histological analysis as described by Samuelson (2007). The necrotized areas were then photographed and read accordingly to determine the histopathological effects of *A. barbadensis* leaves.

### 2.7 | Data analysis

Growth performance of fish was determined following the methods as illustrated by Agbebi *et al.* (2012) in term of final mean body weight, survival (%), specific growth rate, (SGR, % $day^{-1}$). The following growth parameters were calculated at the end of the study:

$$\text{Percentage weight gain PWG (\%)} = \frac{Final\ mean\ body\ weight}{Initial\ mean\ body\ weight}\ x\ 100$$

$$\text{Specific growth rate, SGR} = \frac{L_n W_2 - L_n W_1}{Time\ (days\ of\ experiment)}\ x\ 100$$

where,
$W_1$ = initial weight gained; $W_2$ = final weight gained; $L_n$ = natural logarithm

$$\text{Survival rate} = \frac{No\ of\ fish\ remaining\ at\ the\ end\ of\ the\ experiment}{No\ of\ fish\ at\ the\ beginning\ of\ the\ experiment}\ x\ 100$$

Feed Conversion Ratio (FCR), Protein Efficiency Ratio (PER) and Net Protein Utilization (NPU) responses were

calculated using the following formulas:

Protein efficiency ratio (PER) = $\frac{Mean\ weight\ gain}{Average\ crude\ protein\ fed}$

where,
Mean weight gain (MWG) = Final weight (g) of fish – Initial weight (g) of fish

Feed Conversion Ratio (FCR) = $\frac{Dry\ Weight\ of\ feed\ fed\ (g)}{Fish\ Weight\ gained}$

ANPU = $\frac{Net\ Protein\ in\ Carcass}{Protein\ fed} x\ 100$

Protein intake = $\frac{Total\ feed\ consumed\ x\ Crude\ protein\ in\ feed}{100}$

All data obtained were subjected to one way analysis of variance (ANOVA). Data were checked for normality before ANOVA and found suitable for the parametric test. Duncan Multiple Range Test (Duncan 1955) was used for comparison among diets means at an α significance level of 0.05. All the tests were carried out using statistical software SAS (Version 15.0).

## 3 | RESULTS

### 3.1 | Proximate composition of experimental diets

The crude protein contents of the diet ranged between 39.98 and 40.01%, crude fibre 3.04 and 3.42%, ether extract 4.70 and 5.42% and nitrogen free extract 35.77 and 38.60 (Table 3).

**TABLE 3** Proximate composition of the experimental diets

| *Components* | *Percentage of dry weight* | | | |
|---|---|---|---|---|
| | *Control* | *ABL1* | *ABL2* | *ABL3* |
| Moisture | 10.50 | 10.98 | 9.86 | 9.56 |
| Crude protein | 40.01 | 40.00 | 40.04 | 39.98 |
| Fibre content | 3.10 | 3.12 | 3.04 | 3.42 |
| Ash | 5.20 | 4.45 | 3.95 | 3.74 |
| Ether extract | 5.42 | 5.20 | 4.98 | 4.70 |
| Nitrogen free extract | 35.77 | 36.25 | 38.13 | 38.60 |

*ABL = Aloe barbadensis leaves*

### 3.2 | Carcass compositions of experimental fish

The initial and final carcass compositions of the fish fed with varying levels of *A. barbadensis* leaves and the control are presented in Table 4. Moisture content (12.40 ± 0.08%) and crude protein content (49.84 ± 0.21%) was highest in ABL1.

### 3.3 | Growth Performance and nutrient utilization

The growth performance and nutrient utilization of *C. gariepinus* fed *A. barbadensis* leaves paste at three varying levels of dietary supplementation are shown in Table 5. Final weight (20.28 ± 0.72 g), weight gain (17.95 ± 0.78 g) and percentage weight gain (772.2 ± 54.94 %) was highest in ABL3 (Table 5).

**TABLE 4** Initial and final carcass compositions of fishes

| *Components* | *Percentage of dry weight (Mean ± SD)* | | | | |
|---|---|---|---|---|---|
| | *Initial* | *Control* | *ABL1* | *ABL2* | *ABL3* |
| Moisture | 11.54 | 11.84 ± 0.23$^{b}$ | 12.40 ± 0.08$^{a}$ | 11.61 ± 0.08$^{b}$ | 12.26 ± 0.02$^{b}$ |
| Crude protein | 43.50 | 47.37 ± 0.55$^{d}$ | 49.84 ± 0.21$^{c}$ | 49.50 ± 0.02$^{c}$ | 49.50 ± 0.39$^{c}$ |
| Fibre | 0.90 | 1.23 ± 0.02$^{c}$ | 1.28 ± 0.10$^{c}$ | 1.27 ± 0.04$^{c}$ | 1.48 ± 0.02$^{b}$ |
| Ash | 0.98 | 4.18 ± 0.31$^{a}$ | 3.41 ± 0.01$^{b}$ | 3.47 ± 0.01$^{b}$ | 3.84 ± 0.11$^{b}$ |
| Ether extract | 8.50 | 12.44 ± 0.08$^{a}$ | 11.93 ± 0.23$^{a}$ | 10.69 ± 0.02$^{b}$ | 12.33 ± 0.08$^{a}$ |
| Nitrogen free extract | 34.58 | 22.95 ± 0.09$^{a}$ | 21.14 ± 0.28$^{b}$ | 23.47 ± 0.04$^{a}$ | 20.81 ± 0.43$^{c}$ |

*Means along the same row with same letter are not significantly different (p > 0.05)*

**TABLE 5** Growth performances and nutrient utilization of *Clarias gariepinus* fed *Aloe barbadensis* leaves-supplemented diets

| *Parameters* | *Values (Mean ± SD)* | | | |
|---|---|---|---|---|
| | *Control* | *ABL1* | *ABL2* | *ABL3* |
| Initial weight (g) | 2.30 ± 0.06$^{a}$ | 2.30 ± 0.06$^{a}$ | 2.33 ± 0.07$^{a}$ | 2.33 ± 0.07$^{a}$ |
| Final weight (g) | 14.22 ± 1.12$^{c}$ | 16.39 ± 0.33$^{cb}$ | 18.79 ± 0.57$^{b}$ | 20.28 ± 0.72$^{a}$ |
| Weight gain (g) | 11.92 ± 1.16$^{c}$ | 14.09 ± 0.34$^{c}$ | 16.46 ± 0.52$^{b}$ | 17.95 ± 0.78$^{a}$ |
| Percentage weight gain (%) | 518.3 ± 10.21$^{c}$ | 613.7 ± 22.28$^{b}$ | 705.6 ± 13.93$^{a}$ | 772.2 ± 54.94$^{a}$ |
| Feed intake (g) | 19.17 ± 2.29$^{c}$ | 22.08 ± 0.51$^{cb}$ | 25.66 ± 1.25$^{b}$ | 27.56 ± 1.01$^{a}$ |
| Feed conversion ratio | 1.40 ± 0.07$^{b}$ | 1.57 ± 0.01$^{a}$ | 1.56 ± 0.05$^{a}$ | 1.54 ± 0.02$^{a}$ |
| Protein intake | 7.67 ± 0.92$^{c}$ | 9.05 ± 0.15$^{b}$ | 10.27 ± 0.50$^{b}$ | 11.02 ± 0.41$^{a}$ |
| Specific growth rate (%/day) | 2.31 ± 0.19$^{b}$ | 2.36 ± 0.02$^{b}$ | 2.48 ± 0.02$^{a}$ | 2.57 ± 0.07$^{a}$ |
| Protein efficiency ratio | 1.80 ± 0.09$^{a}$ | 1.56 ± 0.03$^{b}$ | 1.61 ± 0.05$^{b}$ | 1.63 ± 0.02$^{b}$ |
| ANPU (%) | 50.29 ± 1.38$^{d}$ | 70.08 ± 2.51$^{a}$ | 63.61 ± 4.23$^{b}$ | 57.12 ± 2.19$^{c}$ |
| Survival rate (%) | 86.67 ± 8.82$^{a}$ | 83.33 ± 3.33$^{b}$ | 73.33 ± 3.33$^{c}$ | 76.67 ± 6.67$^{c}$ |

*Means along the same row with same letter are not significantly different (p > 0.05); ANPU = Apparent net protein utilization*

### 3.4 | Haematological indices of experimental fish

PCV was significantly higher in fish fed the diets supplemented groups than the control (Table 6). Other haema-

tological indices of fish fed varying levels of *A. barbadensis* leaves and the control are also shown in Table 6.

### 3.5 | Histopathology of experimental fish

Figure 2 represents fragment of the liver tissue showing regular hepatocyte in cords and plates with normal portal tract and central vein. Vacuolar degenerations were observed in the fish livers from the *A. barbadensis* leaves-paste (Figures 3–5). There was moderate and diffuse vacuolar degeneration of hepatocyte, mild fibrous connective tissues proliferation (necrosis) was also seen (Figure 3); Figure 4 reveals moderate vacuolar degeneration of hepatocytes with fibrous connective tissues proliferation. There was marked and diffuse vacuolar fatty degeneration of the hepatocytes, moderate infiltration of the hepatocyte cytoplasm by lobules of matured adipocytes (Figure 5).

**TABLE 6** Haematological parameters of *Clarias gariepinus* fed *Aloe barbadensis* leaves-supplemented diets

| Parameters | Values (Mean ± SD) | | | |
|---|---|---|---|---|
| | Control | ABL1 | ABL2 | ABL3 |
| PCV (%) | 22.00 ± 0.58$^{d}$ | 29.00 ± 3.18$^{b}$ | 25.67 ± 3.18$^{c}$ | 36.67 ± 0.89$^{a}$ |
| Hb (g dl$^{-1}$) | 7.37 ± 0.20$^{d}$ | 9.67 ± 0.20$^{b}$ | 8.57 ± 1.01$^{c}$ | 12.17 ± 0.32$^{a}$ |
| RBC (×10$^{6}$ L$^{-1}$) | 2.07 ± 0.06$^{d}$ | 2.73 ± 0.06$^{b}$ | 2.42 ± 0.30$^{c}$ | 3.44 ± 0.07$^{a}$ |
| MCH (pg) | 35.60 ± 0.07 | 35.35 ± 0.01 | 35.47 ± 0.19 | 35.32 ± 0.18 |
| MCHC (g dl$^{-1}$) | 33.33 ± 0.00 | 33.27 ± 0.04 | 33.61 ± 0.22 | 33.28 ± 0.08 |
| MCV (fl) | 10.71 ± 0.03 | 10.63 ± 0.02 | 10.56 ± 0.02 | 10.62 ± 0.03 |
| WBC (×10$^{3}$) | 11.20 ± 0.52$^{b}$ | 12.30 ± 0.64$^{a}$ | 11.87 ± 0.32$^{b}$ | 12.67 ± 0.32$^{a}$ |
| Neutrophils (%) | 40.00 ± 1.73$^{a}$ | 34.67 ± 1.45$^{c}$ | 33.00 ± 4.62$^{c}$ | 38.67 ± 1.45$^{b}$ |
| Lymphocytes (%) | 56.67 ± 1.45$^{b}$ | 62.67 ± 0.88$^{b}$ | 64.67 ± 4.91$^{a}$ | 58.00 ± 1.16$^{c}$ |
| Eosinophils (%) | 3.00 ± 0.00$^{a}$ | 2.67 ± 0.33$^{b}$ | 2.67 ± 0.33$^{b}$ | 3.00 ± 0.00$^{a}$ |
| Monocytes (%) | 0.67 ± 0.33 | 0.67±0.33 | 0.00±0.00 | 0.67 ± 0.33 |
| Basophils (%) | 0.00 ± 0.00 | 0.00 ± 0.00 | 0.00 ± 0.00 | 0.00 ± 0.00 |

*Means along the same row with same letter are not significantly different ($p > 0.05$*

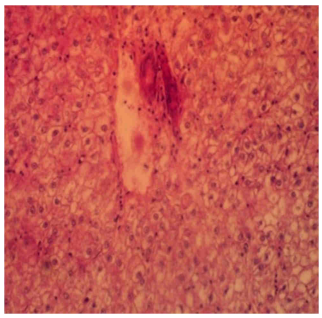

**FIGURE 2** Histological section of liver of fish fed with control diet

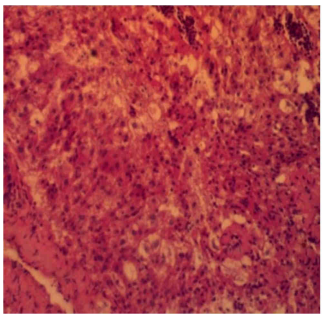

**FIGURE 3** Histological section of liver of fish fed 1% *A. barbadensis* leaves

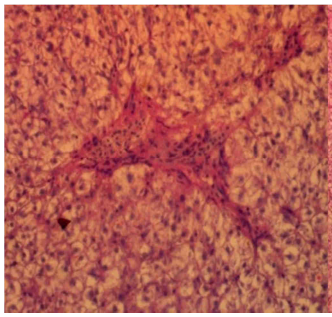

**FIGURE 4** Histological section of liver of fish fed 2% *A. barbadensis* leaves

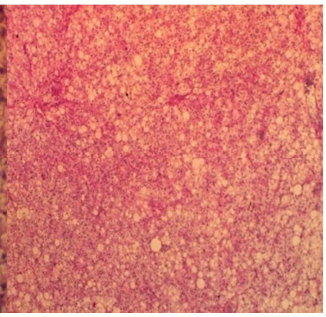

**FIGURE 5** Histological sections of liver of fish fed 3% *A. barbadensis* leaves

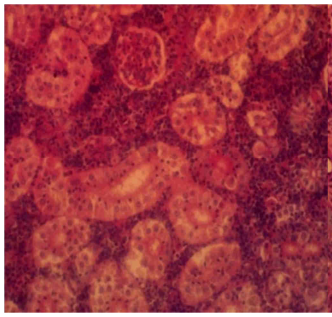

**FIGURE 6** Histological section of kidney of fish fed control diet

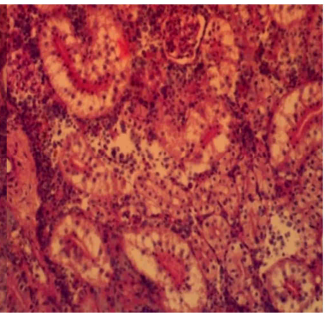

**FIGURE 7** Histological section of kidney of fish fed 1% *A. barbadensis* leaves

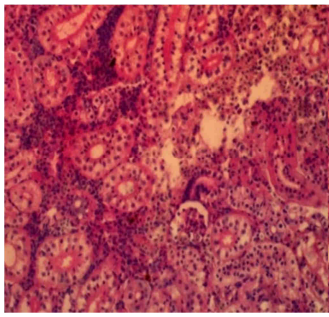

**FIGURE 8** Histological section of kidney of fish fed 2% *A. barbadensis* leaves

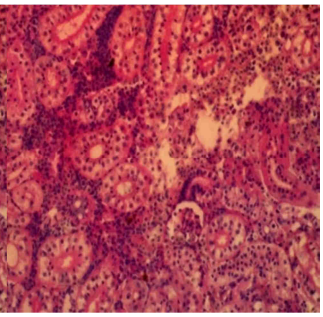

**FIGURE 9** Histological section of kidney of fish fed 3% *A. barbadensis* leaves

The histological sections of the kidney of fish fed varying levels of *A. barbadensis* leaves paste and the control are shown in Figures 6 – 9. Figure 6 reveals kidney tissues with regular epithelial cells and no physical damage done to the tissues. Figure 7 shows fragment of kidney tissue showing moderate diffuse vacuolar degeneration of the epithelia cells of the tubules. Necrosis was revealed in fish fed 2% (ABL2) *A. barbadensis* leaves (Figure 8). Figure 8 reveals that the kidney with moderate diffuse vacuolar degeneration of the epithelia cells of the tubules with mild fatty change. Figure 9 indicates fragment of kidney tissue with mild diffuse vacuolar degeneration of renal tubules.

## 4 | DISCUSSION

There was a general increase in weight gain in the course of the experiment with the highest growth performance observed in fish fed 3% *A. barbadensis* leaves (ABL3). This aligned with the work of Bello *et al.* (2012) who recorded similar increase in weight gain of fish when fed diets supplemented with walnut leaf and onion bulb residues. The increase in the growth rate of *C. gariepinus* in the first few weeks of culture in the study may be due to initial starvation of the fish which made them more metabolically active, which is similar to Obasa and Faturoti (2001) observation in juvenile *Heterotis niloticus*. They recorded an increase in growth of the fish as they were subjected to delay in feed distribution.

The superior performances of fish fed the supplemented diets in PWG, SGR and ANPU over control diet could be due to the presence of growth promoters, stimulants or constituents in *A. barbadensis* leaves (glucomannans, acemannan). This is in accord with the result of Muhammed-Jameel *et al.* (2014) who found that inclusion of aloe vera leaves up to 2% in the diet showed better growth performance of Fayoumi chicks. This was corroborated by Heidahieh *et al.* (2013) who demonstrated that high levels (2%) of aloe vera had a positive effect on growth performance in rainbow trout.

However, the feed intake increased as the concentrations levels of *A. barbadensis* leaves increased. The increased feed intake observed in this experiment in diet supplemented groups could be attributed to change in feed taste and stimulated appetite (Windisch *et al.* 2008). This result is in agreement with Darabighane *et al.* (2012) who reported increased feed intake in the supplemented groups which were treated by 2% aloe vera gel dissolved in water. The increased FCR recorded in fish fed supplemented diets than the control is similar to the report of Bello *et al.* (2012) who revealed that inclusion of 1.5% walnut leaf increased FCR in the supplemented groups than the control. This was also corroborated by Abd-El-Rhman (2009) which showed that the addition of propolis – ethanolic extract and crude propolis increased the FCR, FER and PER in the supplemented groups when compared with the control. No significant differences ($p > 0.05$) in FCR among all dietary ginger powder treatments are available (Zomrawi *et al.* 2011) which conforms to the result obtained in this study. According to De Silva (2001), feed conversion ratio is between 1.2–1.8 for fish fed carefully prepared diets, and the results from the present study falls within this range. The highest PER obtained in the control diet could be attributed to the absence of tannin in the feed. Also, Davies *et al.* (2006) observed that protein efficiency ratio, is a measure of how well the protein sources in a diet could provide the essential amino acid requirement of the fish fed the diet. The better SGR recorded in the supplemented diets is in correlation with the result of Abou–Zeid (2002) who showed that *Allium sativum* supplementation positively affected *O. niloticus* biomass and SGR.

The reduction in survival rate in fish fed the supplemented diets as recorded in this experiment could be a result of some phytochemicals inherent in these feeds. This result disagreed with the findings of Farah *et al.* (2012) who concluded that survival rate of fish was promoted in diets supplemented with *Mellisa officinalis* and aloe vera.

Haematological parameters are routinely used for the evaluation of physiological environment and husbandry stressors in fishes (Ranza-faival *et al.* 2000). The changes in the blood characteristics of *C. gariepinus* caused by stress due to exposure to environmental pollutant, diseases or by pathogens have been studied by many researchers especially in capture fisheries (e.g. Ezeri 2001; Gabriel *et al.* 2001). Haematological components of blood are also valuable in monitoring feed toxicity especially with feed constituents that affect the formation of blood in culture fisheries (Oyawoye and Ogunkunle 1998).

The PCV of 22 to 37% observed in this study is within the range of 20 to 50% reported by Pietse *et al*. (1981). The present study indicates that *C. gariepinus* fed *A. barbadensis* leaves paste showed significant ($p < 0.05$) increase in haematocrit (PCV), haemoglobin, RBC, WBC, except for WBC of 2% inclusion of ABL in comparison to the control. This was in agreement with the work of Haghigi and Rohani (2013) who observed similar increase in the haematological parameters in rainbow trout fed ginger powder. These were also similar to the findings of Farah *et al.* (2012) who reported significant enhancement (higher values) of WBC and PCV in diet supplemented with *M. officinalis* and aloe vera. De Pedro *et al.* (2005) indicated that total and differential leukocyte counts are important indices of non-specific defense activities in fish.

The increased WBC and lymphocytes as the level of inclu-

sion in the blood of fish fed *A. barbadensis* leaves (Table 8) may be attributed to increased production of leucocytes in the hematopoietic tissue of the liver. This agreed with the work of Schaperclaus *et al.* (1991) who also recorded similar increase in WBC and lymphocytes in the blood of *C. carpio* fed aloe vera. The WBC and lymphocytes are the defense cells of the body. Douglas and Jane (2010) demonstrated that the amount of WBC and lymphocytes in the blood has implication in immune responses and the ability of the animal to fight infection. High WBC count is usually associated with microbial infection or circulating system (Oyawoye and Ogunkunle 1998). The range of RBC ($2.07\times10^6$ to $3.47\times10^6$ $mm^3$) recorded in this study is comparable with $2.24\times10^6$ to $2.49\times10^6$ $mm^3$ reported by Sotolu and Faturoti (2009) in a study on growth performance and haematology of *C. gariepinus* fed varying inclusion of *Leucaena laucocephala* leaf meal. Reduction in the RBCs was observed in fish fed ABL2 and could be ascribed to the higher concentration of anti -metabolites especially tannin. This is in agreement with the work of Dienye and Olumuji (2014) who observed similar decrease in RBC in fish fed higher level of *M. oleifera* leaf meal.

There were no significant difference in MCH, MCHC and MCV observed in fish fed varying levels of *A. barbadensis* leaves paste and the control. This is in correlation with Haghigi and Rohani (2013) who observed no significant difference in MCV value in ginger powder fed diet and control.

The histopathology of the liver of fish fed with control diet showed that the liver was normal with mild fatty change. The mild fatty change might be attributed to the high fat content of catfishes. The histological sections of fish fed ABL1 and ABL2 were also normal with necrosis; however, the liver of fish fed ABL3 revealed marked and diffuse vacuolar fatty degeneration of the hepatocytes. This is in agreement with the report of Rapatsa and Moyo (2014) who observed vacuolation in fish livers fed *M. oleifera* diet treatment and the control. Also, histological sections of the liver of fish fed ABL3 indicated fish health was compromised at the highest dose. This is corroborated with the finding of Ashade *et al.* (2014) who revealed that liver of fish fed 30% untreated ginger peel had a severe fatty change. The presence of diffuse vacuolar degeneration of hepatocytes in fish fed varying levels of *A. barbadensis* leaves and may be as a result of excessive work required by the fish's liver to get rid of the plant toxicant from its body during the process of detoxification. This is corroborated by the work of Bamidele *et al.* (2015) who revealed similar effect on the fish liver.

It is noteworthy that vacuolar degeneration is a morphopathological alteration of the gastro-intestinal tract, and it may be associated with toxins and/or infection, which causes significant loss of water and potassium. Steatosis (lipid accumulation in the liver cells) could be present when there is excessive fat to be metabolized, or the lipid function of the liver cells are impaired due to hypoxia, toxic damage or certain infectious diseases (Szende and Suba 1999). Both vacuolar degeneration and fatty degeneration are reversible injuries, and cells can recover their normal functions (homeostasis) when the stress is removed (Szende and Suba 1999). Nonetheless, the recovery of cells will depend on the severity and duration of exposure to stressors.

The absence of visible changes in the histological sections of the kidney of fish with varying dietary doses of *A. barbadensis* leaves could be as a result of tolerability of the dietary supplements to the fish kidneys. This was in agreement with the observation of Bamidele *et al.* (2015) who found similar result on the kidney of *C. gariepinus* fed *M. oleifera* seed meal. This is corroborated by Daudu (2012) who observed no renal damage done in the broiler chickens fed ginger by product meal. Necrosis was observed in fish fed ABL2 which is in line with the report of Agbebi *et al.* (2013) who observed tubular degeneration and necrosis of *C. gariepinus* fed 10 g ginger powder. This portends the fact that lower concentration of *A. barbadensis* leaves as the 1% dietary supplementation in the present study is tolerable by fish metabolic organs such as the liver and kidney.

## 5 | CONCLUSION

The present study showed that dietary supplementation of *A. barbadensis* leaves paste is encouraged to improve the growth performance; nutrient utilization and health of catfish (*C. gariepinus*) fingerlings, due to the growth promoting and immunostimulation properties. However, the inclusion of *A. barbadensis* leaves beyond 2% in the diet of fish will cause histopathological disturbances on the liver, *A. barbadensis* leaves dietary supplementation are regarded to be tolerable to the fish kidney. Hence, for better growth performance, nutrient utilization and fish survival, it is inferred that 1% *A. barbadensis* leaves paste could be used as a supplement in the diet of fish. However, more research should be carried out on the uses of *A. barbadensis* in order to reduce the anti-nutritional factors and better utilize the plant.

## ACKNOWLEDGEMENTS

The authors appreciate the efforts of members of staff in the Hatchery unit of the Fish Farm of the Federal University of Agriculture, Abeokuta in ensuring regular supply of water for the research work. We thank the technologist in the Fish Nutrition laboratory of the Department of Aquaculture and Fisheries Management for his assistance in

the proximate analyses of the experimental diets and fish. The technical support of the staff in the Departments of Veterinary Microbiology & Veterinary Pathology, COLVET in respect of haematological and histopathological analyses is also recognized. Lastly, the authors also thank reviewers for the time and effort that they invested into the review of our manuscript, and for their helpful comments and suggestions.

**REFERENCES**

Abd-El-Rhman AMM (2009) Antagonism of *Aeromonas hydrophila* by propolis and its effect on the performance of Nile tilapia, *Oreochromis niloticus*. Fish & Shellfish Immunology 27(3): 454–459.

Abou-zeid SM (2002) The effect of some medical plant on reproductive and productive performance of Nile tilapia, *Oreochronis niloticus*. PhD Thesis, Faculty of Agriculture, Cairo University, Egypt. 212 pp.

Adedeji OS, Farimi GO, Ameen SA and Olayemi JB (2008) Effects of bitter cola (*Garcinia kola*) as growth promoter in Broiler Chicks from day old to four weeks old. Journal of Animal and Veterinary Advances 5(3): 191–193.

Agbebi OT, Ilesanmi AI and AbdulRaheem I (2013) Additive potentials of *Z. officinale*in the aflatoxin secreted in waste mould feed fed to *Clarias gariepinus* (Burchell, 1822). International Journal of Biological and Chemical Science 7(1): 236–246.

Agbebi OT, Lawal HB and Odebiyi VC (2012) Aflatoxin effect of moulded gel waste mixed with ginger and its histopathological study on *Clarias garepinus.* Global Journal of Science Frontier Research 12(1): 7–15.

Alicia ET, Magariños B and Romalde JL (2005) A review of the main bacterial fish diseases in mariculture system. Aquaculture 246(1–4): 37–61.

Alishahi M, Ranjbar MM, Ghorbanpour M, Peyghan R, Mesbah M and Razi Jalali M (2010) Effects of dietary Aloe vera on some specific and nonspecific immunity in the common carp (*Cyprinus carpio*). International Journal of Veterinary Research 4: 189–195.

AOAC (2011) Association of International Official Analytic Chemists, AOAC International, 18th edition, Arlington, Virginia.

Ashade OO, Adelusi OE and Ligali NA (2014) Histopathological effects of untreated ginger peel (*Zingiber officinale*) fish meal on the intestine tissue profiling of African catfish (*Clarias gariepinus*). International Journal of Fisheries and Aquatic Studies 2: 95–98.

Bamidele NA, Obasa SO, Ikeiwenwe NB, Abdulraheem I, Adeoye AA and Odebiyi OC (2015) Effect of dried moringa (*Moringa oleifera*) seed meal based diet on the growth, haematological, biochemical parameter and histopathology of African catfish, *Clarias gariepinus* fingerlings. International Journal of Fisheries and Aquatic Studies 2: 27–34.

Bawankar R, Singh P and Subramanaian B (2004) Bioactive compounds and medicinal properties of Aloe vera L.: an update. Journal of Plant Sciences 2(3): 102–107.

Bello OS, Emikpe BO and Olaifa FE (2012) The body weight changes and gut morphometry of *Clarias gariepinus* juveniles on feeds supplemented with walnut (*Tetracarpidium conophorum*) leaf and onion (*Allium cepa*) bub residues. International Journal of Morphology 30(1): 253–251.

Chandrakesan PK, Muralidharan VD, Kumar G, Ponnudurai TJ, Harikrishnan KS and Pani VN (2001) Efficacy of an herbal complex against caecal coccidiosis in broiler chickens. Veterinarski Archive 79: 199–203.

Choi S and Chung MH (2003) A review on the relationship between aloe vera components and their biological effects. Seminars in Integrative Medicines 1(1): 53–62.

Dacie JV and Lewis SM (2001) Practical Haematology 9th Edition, Churchill Livingstone, London. 633 pp.

Darabighane B, Abolfazl Z, Ahmad ZS and Akhtar (2008). Using aqeous extract of aloe gel as anticoccidial and immunostimulant agent in broiler production. Sarhad Journal of Agriculture 24: 665–669.

Daudo OM (2012) Effect of ginger by-product meal supplementation with enzyme/palm oil on performance, blood chemistry and histopathology of broiler chickens. PhD Thesis, Ahmadu Bello University, Zaria, Nigeria. 205 pp.

Davies OA, Inko-Tariah MB and Amachree D (2006) Growth response and survival of *heterobronchus longitilus* fingerlings fed at different feeding frequencies. African Journal of Biotechnology 5: 788–787.

De Pedro N, Guijarro AI, López-Patiño MA, Martínez-Álvarez R and Delgado MJ (2005) Daily and seasonal variations in haematological and blood biochemical parameters in the tench, *Tinca tinca* Linnaeus, 1758. Aquaculture Research 36: 1185–1196.

De Silva SS (2001) Performance of *Oreochromis niloticus* fry maintained on mixed feeding schedules of different protein levels. Aquaculture and Fisheries 16: 621–633.

Denev SA (2008) Ecological alternatives of antibiotic growth promoters in the animal's husbandry and Aquaculture. DSc Thesis, Department of Biochemistry, Microbiology, Trakia University, Stara Zagora, Bulgaria. 294 pp.

Dienye HE and Olumuyi OK (2014) Growth performance and haematological responses of African mud catfish *Clarias gariepinus* fed dietary levels of *Moringa oleifera* leaf meal. Net Journal of Agricultural Science 2(2): 79–88.

Douglas JW and Jane KW (2001) In Schalm's Veterinary Haematology. John Willey and Sons, Blackwell Publishing Ltd. 1232 pp.

Duncan DB (1955) Multiple ranges and multiple F-tests. Biometrics 11: 1–42.

Ezeri GNO (2001) Haematological responses of *Clarias gariepinus* to bacterial infection and prophylactic treatment with antibiotics. Journal of Aquatic Science 16: 22–24.

Farah A, Kasiri M, Sudager M, Soleiman IM and Zorrieh Zahra SMJ (2012) Effect of dietary supplementation of *Mellisa officinalis* and Aloe vera on haematological traits, lipid oxidation of carcass and performance in rainbow trout (*Oncorhynchus mykiss*). Online Journal of Animal and Feed Research 2(1): 1–5.

FAO (2016) State of world fisheries and aquaculture, contributing to food security and nutrition for all. Food and Agriculture Organization, Rome.

Gabriel UU, Alagon JK and Allison ME (2001) Effects of dispersed crude oil water dispersion on the haemoglobin and haematocrit of *Clarias gariepinus*. Journal of Aquatic Science Environmental Management 5(2): 9–11.

Galib SM, Mohsin ABM, Chaki N, Fahad MFH, Haque SMM (2013) An overview of the traditional rice-prawn-fish farming in Kalia of Narail District, Bangladesh. Journal of Fisheries 1(1): 1–6. doi: 10.17017/jfish.v1i1.2013.1

Haghighi M (2010) Laboratory methods of fish haematology. Aquaculture Science Publications, Tehran, Iran. pp. 29–71.

Haghighi M and Rohani MS (2013) The effect of powered ginger (*Zingiber officinale)* on the haematological and immunological parameters of rainbow trout *Oncorrrhychus mykiss.* Journal of Medicinal Plant and Herbal Therapy Research 1: 8–12.

Heidarieh M, Mirvaghefi AR, Sepahi A, Shiekhzadeh N and Shahbazfar AA (2013) Effects of dietary aloe vera on growth performance, skin and gastrointestine morphology in rainbow trout, *Oncorhynchus mykiss*. Turkish Journal of Fisheries and Aquatic Sciences 13: 361–373.

Immanuel G, Citarasu T, Sivaram V, Micheal Babu M and Palavesam A (2007) Delivery of HUFA, probionts and biomedicine through bioencapsulated *Artemia* as a means to enhance the growth and survival and reduce the pathogenesity in shrimp *Penaeus monodon* postlarvae. Aquaculture International 15(2): 137–152.

Ivanova NT (1983) Atlas of fish blood cells, LPP, Moscow, Russia. 80 pp.

Klontz GW and Smith LS (1986) Methods of using fish as biological research subjects. In methods of animal experimentation Vol. iii (Grey WI, ed.). Academic Press, New York. pp. 323–383.

Lee JK, Lee MK, Yun YP, Kim Y, Kim JS, Kim YS, Kim K, Han SS and Lee CK (2001) Acemannan purified from aloe vera induces phenotypic and functional maturation of immature dendritic cells. International Immunopharmacology 1(7): 1275–1284.

Mmereole EUC (2011) Evaluation of the dietary inclusion of aloe vera as an alternative to antibiotic growth promoter in broiler production. Pakistan Journal of Nutrition 10: 1–5.

Mohsin ABM, Reza MS and Galib SM (2012) Uses of chemicals in aquaculture ponds in Rajshahi district, Bangladesh. Bangladesh Journal of Progressive Science and Technology X(I): 61–64.

Muhammad-Jameel AK, Sohail, HK, Salma M, Syeda, SG, Jamila S, Farouq H, Mehdi H and Muhammad A (2014) Effect of Dietary supplementation of *Aloe vera* leaves on growth performance and immunity of *Fayoumi* Chicks. Pakistan Journal of Nutrition 13(4): 191–195.

Obasa SO and Faturoti EO (2001) Growth response and serum component and yield of the African bony tongue (*Heterotis niloticus*) fed varying dietary crude protein level. ASSET Series A 1(2): 97–104.

Odo BI, Ekenyem BU and Nwamo AC (2010) Effects of aloe vera as leaf protein concentrate on growth performance of cockerels. International Journal of Poultry Science 9: 426–428.

Oyawoye EO and Ogunkunle M (1998) Physiological and biochemical effects of raw Jack beans on broilers. Proceedings of Annual Conference, Nigeria Society of Animal Production 23: 141–142.

Pietse JJ, Smith GL, van Viiet KJ, Schoobe HJ and Hattingh J (1981) Some blood parameters of the Chinese grass carp, *Ctenopharygodon idella* (Valenciennes). South African Journal of Zoology 16(2): 124–126.

Plaskett LG (1988) The health and medical uses of aloe vera. Life Sciences Press.

Qiao J, Li HH, Zheng Ch J, Feng ZY and Wang W (2013) Dietary supplementation with aloe vera polysaccharide enhances the growth performance and immune function of weaned piglets. Journal of Animal Feed Science 22: 329–334.

Rainza-paiva MJT, Ishikawa CM, Das-Eiras, AA and Felizardo NN (2000) Haematological analysis of Chara *Pseudoplatystoma fasciatum* in captivity Aqua Responsible aquaculture in the new millennium. European Society Special Publication, Nice, France. 28: 590

Rao YV, Das J, Pradhana BK and Chakrabarthi R (2006) Effect of *Achyranthes aspera* on the immunity and survival of

*Labeo rohita* infected with *Aeromonas hydrophila.* Shell Fish Immunology 20: 263–273.

Rapatsa MM and Moyo NAG (2014) Effect of *Moringer oleifera* on the histology, haematology and growth of *Oreochromis mossambicus* in aquadams fertilized with chicken manure in South Africa. African Journal of Aquatic Science 39(3): 295–303.

Samuelson A (2007) Textbook of veterinary histology. Elsevier Health Sciences Publishing Company, London, United Kingdom. 560 pp.

Schaperclaus W (1991) Fish diseases. Oxonian Press Pvt. Ltd., New Delhi. 1398 pp.

Sotolu AO and Faturoti EO (2009) Growth performance and haematology of *Clarias gariepinus* fed varying inclusions of *Leucaena laucocephala* leaf meal. Revista UDO Agricola 9(4): 979–985.

Szende B and Suba Z (1999) Introduction to histopathology. Medicinal Publishing, Budapest. 292 pp.

Vogler BK and Ernst E (1999) Aloe vera: a systematic review of its clinical effectiveness. British Journal of General Practice 48: 832–828.

Windisch W, Schedle K, Plitzner C and Kroismayr A (2008) Use of phytogenic products as feed additives for swine and poultry. Journal of Animal Science 86: 140–148.

Zomrawi WB, Abdel Atti KHA and Mahala AG (2011) Effect of ginger root powder supplementation on broiler chick performance, blood and serum constituents, Online Journal of Animal and Feed Research 1(6): 457–460.

**CONTRIBUTION OF THE AUTHORS**

**SIA** primary data collection, statistical analysis and manuscript (MS) writing; **SOO** primary supervisor of the study; **IA** co-supervisor of the study.