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AN EVALUATION OF WATER HYACINTH [*Eichhornia crassipes* (Martius) Solms-Laubach] MEAL AS A FEEDSTUFF FOR PULLET CHICKS AS DETERMINED BY CARCASS AND HAEMATOLOGICAL CHARACTERISTICS

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ABSTRACT
A total of 300 day-old pullet chicks of Isa Brown strain were fed diets containing 0, 5, 10 and 15 % dietary inclusion levels of water hyacinth meal (WHM) to form Diets 1, 2, 3 and 4 respectively. Each diet was fed to 75 birds, consisting of 3 replicates of 25 birds per replicate, for 8 weeks. At the end of the 8th week of the experiment, two birds per replicate were randomly selected for blood collection. Blood samples were collected from the jugular veins of the birds into test tubes treated with and without EDTA anti-coagulant to obtain whole blood and serum, which were used for the determination of haematological and biochemical parameters respectively. Also, at the end of the 8th week, two birds per replicate were fasted for 12 hours, weighed and slaughtered by manual exsanguination. They were then dressed and their carcass characteristics determined. There were no significant ($p>0.05$) differences in live weight, slaughter weight, defeathered weight, eviscerated weight, dressed weight, meat in carcass, bone in carcass and meat to bone ratio among the control and the WHM diets. Also, there were no significant ($p>0.05$) differences in the weight of the head, forelimb, hind limb, drumstick, neck, breast, back, heart, liver, crop, gizzard and lung but significant ($p<0.05$) differences existed in the weight of the thigh, kidney, intestine and spleen among the dietary treatments. There were no significant ($p>0.05$) differences in haemoglobin concentration (Hb), packed cell volume (PCV), white blood cell concentration (WBC), red blood cell concentration (RBC), mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH) and mean corpuscular haemoglobin concentration (MCHC) among the dietary treatments. Of all the biochemical parameters determined only globulin (Glo) and total protein (TP) showed significant ($p<0.05$) differences across the dietary treatments. Hence, it can be concluded that WHM can be included up to 15 % in the diets of pullet chicks (replacing 75 % wheat offal) without any detrimental effects on their carcass characteristics and haematological profile.

KEY WORDS: Water hyacinth meal, pullet chicks, carcass characteristics, haematological and biochemical profile.

INTRODUCTION

The per capita per year consumption of meat in Sub-Sahara Africa is estimated at 13.4 kg, and projected to be 33.8 kg in 2030 (FAO, 2003). The production of animal protein is insufficient to meet the demands of the ever-increasing human population in this region. The contribution of poultry could be significant in bridging the animal protein supply-demand gap; this is because poultry is the quickest source of meat and its production involves the least hazardous and arduous process in relation to other livestock enterprises (Obioha, 1992). Poultry birds reproduce much quicker to produce meat and eggs and returns high profits on investment. Unfortunately, there is a tremendous decrease in poultry production as a result of high cost of protein and energy feedstuffs. The costs of conventional feedstuffs, which are the major sources of energy and protein in poultry diets, have continued to increase due to their short supply (Defang *et al*., 2008). Hence, in developing countries, feed cost is about 65 to 75 % (Nworgu *et al*., 1999) or 70 to 75 % (Opara, 1999) of the total cost of production compared to about 50 to 60 % in developed countries (Tacke and Flenscher, 1995). There is therefore the need to continue to source for alternative sources of energy and protein that are not likely to face competition and demand as the conventional feedstuffs. Such feedstuffs should not be food for man and should also have limited or no industrial use (Ocheja *et al*., 2012). Water hyacinth [*Eichhornia crassipes* (Martius) Solms-Laubach)] is regarded as the most troublesome aquatic weed in the world (Holm *et al*., 1991). Several international conferences, workshops and symposia have been held all over the world, using different fora, on its eradication and effective mechanical, chemical, biological and integrated control. As a weed species, it multiplies rapidly and forms dense mats (Gopal and Goel, 1993) which interfere with waterways, decimates aquatic wildlife and creates ideal conditions for diseases and its vectors (Kushwaha, 2012). Its excessive growth affects the utilization of water resources by causing the following damages: fouling drinking water with its exudates or decomposition products; obstructing navigation; interfering with the production of rice and other agricultural crops; killing fish by depletion of oxygen in the water; and by serving as a habitat for a variety of harmful animals such as snakes and crocodiles (Das and Kalamdhad, 2011). Despite these disadvantages however,

water hyacinth has potential uses. It functions as a food source for aquatic bio-phages; used for water currents controls; purifies turbid water through sedimentation and sorption; and reduces pollutants through absorption of minerals (Baruah, 1984). It has also been found to be a valuable resource for animal fodder, water purification, fibreboard, biogas, fertilizer and paper production (Lindsey and Hirt, 1999). In Nigeria, the weed is found in over 20 out of the 36 states of the Federation and in the Federal Capital Territory (Bolorunduro, 2002). In China, water hyacinth grows in 17 provinces and has become a bio-disaster. It is estimated that each year, more than 100 million RMB Yuan (equivalent of 12 million US dollars) is spent on control of water hyacinth throughout China, yet the weed remains vigorous and continues to spread (Jianqing *et al*., 2000). The greatest challenge in the water hyacinth saga is converting the obnoxious weed species into a valuable feed resource for poultry. So, the aim of this research work is to evaluate the Water Hyacinth [*Eichhornia crassipes* (Martius) Solms-Laubach] meal as a feedstuff for pullet chicks using their carcass and haematological characteristics when fed different levels of the meal as a replacement for wheat offal.

The research study was carried out at the Poultry Unit of the Animal Production Teaching and Research Farm, Federal University of Technology, Minna, Nigeria. Minna is the State Capital of Niger State and is located in the South Guinea Savanna Vegetation Zone, between Latitude 9^0 $37^{'}$ North and Longitude 6^0 $33^{'}$ East. Its mean annual rainfall is 1300 mm, taken from an exceptionally long record of 50 years. Temperature rarely falls below 22^oC; the peaks are 40^oC (February – March) and 35^oC (November – December). The rainy season starts in April and lasts between 190 and 200 days (2009-2013 Postgraduate School Prospectus, Federal University of Technology, Minna).

Experimental Diets

Whole plants of water hyacinth were collected from the River Niger in Lokoja, Kogi State, and processed as a feedstuff for pullet chicks using the procedure as described by Malik *et al*. (2013). The water hyacinth meal (WHM) obtained were then incorporated into the experimental diets at 0, 5, 10 and 15 % inclusion levels to form Diets 1, 2, 3 and 4; replacing 0, 25, 50 and 75 % wheat offal respectively (Table 3). Proximate compositions of WHM and wheat offal are shown in Table 1, while the minerals and the anti-nutritional factors composition of WHM are shown in Table 2.

MATERIALS & METHODS

TABLE 1: Proximate composition and metabolizable energy content of water hyacinth meal (WHM) and wheat offal (WO)

Parameter	WHM[1]	WO*
Dry matter	93.28	90.70**
Crude protein	13.88	16.20
Ether extract	4.89	4.40
Crude fibre	21.43	11..30***
Ash	24.16	5.70
Nitrogen free extract (NFE)	28.92	61.80
Neutral detergent fibre (NDF)	63.54	60.00
Acid detergent fibre (ADF)	37.46	9.60
Acid detergent lignin (ADL)	12.86	2.00
Cellulose	24.60	7.60
Hemi-cellulose	26.08	50.40
Metabolizable energy (Kcal/kg)	1901	1845**

[1]Result obtained is the average of both the dry season and rainy season determinations.
*As reported by Ososanya *et al.* (2013)
**As reported by Ayssiwede *et al.* (2010)
***As reported by Malau-Aduli *et al.* (2003)

TABLE 2: Mineral and anti-nutritional factors composition of water hyacinth meal

Mineral composition		Anti-nutritional factors (mg/100g)		Recommended Critical Limit (mg/100g)*
Potassium (%)	1.02	Saponin	0.26	7.02
Calcium (%)	3.03	Tannin	1.44	31.20
Magnesium (%)	2.01	Oxalate	2.24	0.54
Zinc (ppm)	0.14	Phytate	0.27	23.40
Copper (ppm)	0.46			
Iron (ppm)	5.87			
Manganese (ppm)	0.76			
Lead (ppm)	0.10			

*Kumar *et al*. (2010)
ppm = Parts per million

TABLE 3: Composition of the pullet chicks' diets (%)

	Water hyacinth meal inclusion levels (%)			
Ingredients (%)	0	5	10	15
Maize	47.20	47.20	47.20	47.20
Ground nut cake	20.00	20.00	20.00	20.00
Fish meal	3.00	3.00	3.00	3.00
Blood meal	2.00	2.00	2.00	2.00
Wheat offal	20.00	15.00	10.00	5.00
Water hyacinth meal (WHM)	0.00	5.00	10.00	15.00
Palm oil	2.00	2.00	2.00	2.00
Bone meal	3.25	3.25	3.25	3.25
Limestone	1.00	1.00	1.00	1.00
Lysine	0.50	0.50	0.50	0.50
Methionine	0.50	0.50	0.50	0.50
Common salt	0.30	0.30	0.30	0.30
*Premix	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00
Calculated values				
Crude protein (%)	20.11	19.94	19.77	19.60
Metabolizable energy (kCal/kg)	2806	2813	2819	2826
Crude fibre (%)	4.10	4.64	5.18	5.72
Calcium (%)	1.55	1.54	1.55	1.55
Phosphorus (%)	1.17	1.15	1.16	1.17
Lysine (%)	1.45	1.42	1.45	1.45
Methionine (%)	0.83	0.82	0.83	0.83

*Each 2.5 kg of the premix contains 10,000,000 IU of vitamin A; 2,000,000 IU of vitamin D3; 23,000 mg of vitamin E; 2,000 mg of vitamin K3; 1,800 mg of vitamin B1; 5,500 mg o vitamin B2; 27,500 mg of niacin (B3); 7,500 mg of pantothenic acid (B5); 3,000 mg of vitamin B6; 15 mg of vitamin B12; 750 mg of folic acid; 60 mg of biotin H2; 300,000 mg of choline chloride; 200 mg of cobalt; 3,000 mg of copper; 1,000 mg of iodine; 20,000 mg of iron; 40,000 mg of manganese; 200 mg of selenium; 30,000 mg of zinc and 1,250 mg of antioxidant.

Experimental Design

300 day-old Isa Brown pullet chicks collected from the Minna Depot of Avian Specialities, Ibadan, Oyo State, were used for this Study. About a week before the arrival of the birds, the pens were thoroughly washed, disinfected and then sealed off from the rest of the poultry house to avoid contamination. Few hours to their arrival, all equipment were put in place (feeders, drinkers, bulbs, heat source, etc) and heated to a suitable temperature (about 35°C). On arrival, the birds were weighed and allocated randomly to the four dietary treatment groups consisting of 75 birds per treatment and three replicates per diet; with each replicate made up of 25 birds. The birds were offered clean drinking water and the experimental diets *ad libitum* throughout the period of the experiment. The experiment lasted for 8 weeks during which time they were managed intensively using the standard code of procedure as recommended for pullet chicks by the Nigerian Institute of Animal Science (NIAS). Routine management operations such as daily removal of left-over (uneaten) feed, washing of drinkers, and cleaning of the environment were carried out. The birds were also given standard medication and vaccination against the common poultry diseases as recommended for this region by the Nigerian Veterinary Medical Association (NVMA).

Parameters determined

(i) **Haematological profile**

At the end of the 8th week of the experiment, 2 birds per replicate (making a total of 6 birds per treatment) were randomly selected for blood collection. Blood samples were collected from the jugular veins of the birds using sterile disposable needles (21-guage) and syringes after the birds were fasted overnight for 12 hours. 5 ml of blood was collected from each bird and divided between two test tubes: one containing EDTA (ethylene diamine tetraacetic acid) as anti-coagulant for the determination of haematological parameters; and the other allowed to coagulate and serum collected for quantitative *in vitro* determination of biochemical parameters, liver function and electrolytes determination. Determination of red blood cells count (RBC), leucocyte counts (WBC), haematocrit (PCV) and haemoglobin concentration (Hb) were carried out using the methods described by Hemening (1992). From the values obtained, mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH) and mean corpuscular haemoglobin concentration (MCHC) were calculated using the formulae of Jaime and Howlett (2008), as given below:

MCV = (PCV x 10) ÷ RBC (expressed in femtolitres or fl)
MCH = (Hb x 10) ÷ RBC (expressed in pictograms or pg)
MCHC = (Hb x 100) ÷ PCV (expressed in grammes per deciliters or g/dl)

Conjugated bilirubin and total bilirubin were determined using the method of Jendrassik and Grof (1938); while albumin was determined using Bromocresol green method (Doumas *et al*., 1971). Total protein was determined using Biuret method (Tietz, 1995). Sodium ion (Na^{+}) and potassium ion (K^{+}) were determined using flame photometric method (Fawcett and Scott, 1960). Both bicarbonate ion (HCO_3^{-}) and chloride ion (Cl^{-}) were determined using titration method (Chaney and Marbach, 1962). Alkaline phosphatase (ALP), serum glutamate oxaloacetate transaminase (SGOT) and serum glutamate pyruvate transaminase (SGPT) were determined using the methods of Reitman and Frankel (1957). Serum urea,

cholesterol and triglycerides were determined using standard methods as stated by Reinhold (1953).

(ii) Carcass characteristics

At the end of the 8th week of the experiment, two birds were selected from each replicate pen and starved overnight for 12 hours; however, during this time, they were given free access to clean drinking water. They were then weighed, slaughtered by severing the carotid artery and jugular veins (manual exsanguination) and then dressed. Slaughter weights, defeathered weights, eviscerated weights, dressed weights, relative weights of cut-up parts and organ weights were determined using the procedures of Lamidi *et al*. (2008). The head was removed at the atlanto-occipital articulation while the hindleg was removed from the carcass at the acetabulum so that the pelvic muscles and bones were left attached to the leg. Also, the proximal part of the hindleg (referred to as the thigh) was separated from the distal part (referred to as the drumstick) at the tibio-femoral joint (Shahin and Abdelazeem, 2005). The meat to bone ratio of the dressed carcass were also determined using the procedure as described by the same authors.

Chemical analysis

The proximate composition of the water hyacinth meal (WHM) and the four experimental diets were determined using the procedures of AOAC (1990). Mineral composition of WHM was determined using the procedures of Yan *et al*. (2005), while its fibre composition was determined using the procedure of Van Soest and Wine (1968). For the determination of the anti-nutritional factors in WHM, the method of Lukas and Markakes (1975) was used for phytic acid; the method of Maga (1982) was used for the determination of tannin while oxalate and saponin were determined using the standard procedures of AOAC (1984).

Statistical analysis

Data collected were statistically analyzed using the SAS (2000) Package based on the Completely Randomized Design Model. Where means were significant ($p< 0.05$), they were separated using the Duncan's Multiple Range Test (Duncan, 1955).

RESULTS

The carcass characteristics of pullet chicks fed graded levels of WHM diets are shown in Table 4.

TABLE 4: Carcass characteristics of pullet chicks fed graded levels of water hyacinth meal diets

	Water hyacinth meal inclusion levels (%)				
Parameters	0	5	10	15	SEM
Live weight (g)	566.67	550.00	563.33	483.33	20.74ns
Slaughter weight (%)	96.78	98.78	97.83	95.98	0.59ns
Defeathered weight (%)	85.37	87.04	87.12	82.95	0.97ns
Eviscerated weight (%)	66.46	67.57	69.83	67.92	0.88ns
Dressed weight (%)	57.13	60.47	62.24	59.17	1.02ns
Meat in carcass (g)	179.12	204.58	210.66	176.46	7.53ns
Bone in carcass (g)	81.04	89.35	92.57	82.40	3.24ns
Meat to bone ratio	2.35	2.31	2.29	2.17	0.08ns

Means in the same row with no superscripts were not significantly ($p>0.05$) different

SEM = Standard error of the means, ns = not significantly different (at $\alpha = 0.05$)

TABLE 5: Weight of cut-up parts (expressed as % of live weight) of pullet chicks fed graded levels of water hyacinth meal diets

	Water hyacinth meal inclusion levels (%)				
Parameters (%)	0	5	10	15	SEM
Head	3.79	3.98	4.06	4.10	0.10ns
Forelimb	11.55	10.78	12.10	11.71	0.28ns
Hindlimb	4.61	4.56	4.95	4.87	0.22ns
Thigh	8.27^{ab}	8.81^{a}	8.60^{ab}	7.57^{b}	0.19*
Drumstick	8.25	8.54	8.94	8.85	0.16ns
Neck	5.60	5.92	6.24	5.93	0.12ns
Breast	9.34	11.28	10.46	9.43	0.38ns
Back	11.53	11.16	10.74	10.66	0.26ns
Heart	0.46	0.43	0.48	0.55	0.02ns
Liver	1.68	2.39	2.11	1.94	0.15ns
Kidney	0.29^{b}	0.52^{a}	0.47^{ab}	0.67^{a}	0.05*
Crop	0.60	0.71	0.74	0.60	0.04ns
Gizzard	3.84	3.26	3.52	3.96	0.16ns
Intestines	6.17^{a}	6.01^{ab}	4.58^{b}	5.41^{ab}	0.28*
Lung	0.46	0.45	0.50	0.45	0.03ns
Spleen	0.13^{b}	0.23^{a}	0.16^{ab}	0.17^{ab}	0.01*

$^{a\ b}$Means in the same row with different superscripts were significantly ($p<0.05$) different

SEM = Standard error of the means, ns = not significantly different (at $\alpha = 0.05$)

TABLE 6: Haematological profile of pullet chicks fed graded levels of water hyacinth meal diets

	Water hyacinth meal inclusion levels (%)				
Parameters	0	5	10	15	SEM
Haemoglobin (g/dl)	8.57	8.83	8.57	9.07	0.18ns
Packed cell volume (%)	28.00	25.00	25.67	27.67	1.00ns
White blood cell (x 10^9/l)	17.47	17.37	17.53	17.33	0.82ns
Red blood cell (x 10^{12}/l)	2.63	2.63	2.60	2.77	0.04ns
MCV (fl)	106.22	95.06	98.91	99.38	3.16ns
MCH (pg)	32.53	33.57	33.02	32.94	0.80ns
MCHC (g/dl)	30.71	35.55	33.37	33.44	0.95ns

Means in the same row with no superscripts were not significantly (p>0.05) different
ns = not significantly different, SEM = Standard error of the means
fl = femtolitres, pg = picogrammes, MCV = Mean corpuscular volume, MCH = Mean corpuscular haemoglobin
MCHC = Mean corpuscular haemoglobin concentration

TABLE 7: Biochemical profile of pullet chicks fed graded levels of water hyacinth meal diets

	Water hyacinth meal inclusion levels (%)				
Parameters	0	5	10	15	SEM
Glucose (mg/dl)	192.43	207.73	220.83	211.53	5.47ns
Urea (mg/dl)	2.60	2.30	3.07	2.93	0.13ns
Cholesterol (mmol/l)	132.67	132.67	115.67	106.00	6.14ns
Triglyceride (mg/dl)	73.33	70.00	83.33	66.67	3.96ns
Bilirubin total (mmol/l)	7.97	7.93	7.13	9.77	0.67ns
Bilirubin conjugate (mmol/l)	15.60	15.73	13.80	20.23	1.54ns
Sodium (mmol/l)	142.67	143.33	145.33	143.33	1.45ns
Chloride (mmol/l)	111.67	110.67	111.00	110.67	0.25ns
Potassium (mmol/l)	4.93	5.77	5.27	5.57	0.14ns
Bicarbonate (mmol/l)	21.00	21.67	22.00	22.33	0.39ns
ALP (IU/l)	61.30	54.07	67.00	66.43	5.57ns
SGOT (IU/l)	99.00	102.00	107.33	103.67	3.22ns
SGPT (IU/l)	19.33	27.33	26.33	23.67	2.29ns
Albumin (g/dl)	2.20	2.20	2.17	2.20	0.01ns
Globulin (g/dl)	2.43^{ab}	1.37^{b}	2.90^{a}	2.67^{a}	0.23*
Total protein (g/dl)	4.63^{ab}	3.57^{b}	5.07^{a}	4.87^{a}	0.22*

$^{a\ b}$Means in the same row with different superscripts were significantly (p<0.05) different
SEM = Standard error of the means, ALP = Alkaline phosphatase
SGOT = Serum glutamate oxaloacetate transaminase, SGPT = Serum glutamate pyruvate transaminase

There were no significant (p>0.05) differences in live weight, slaughter weight, defeathered weight, eviscerated weight and dressed weight among the control and the WHM diets. Also, there were no significant (p>0.05) differences in meat in carcass, bone in carcass and meat to bone ratio among the various dietary treatments. Weights of cut-up parts (expressed as % of live weight) are shown in Table 5. There were no significant (p>0.05) differences in the weight of the head, forelimb, hindlimb, drumstick, neck, breast, back, heart, liver, crop, gizzard and lung but significant (p<0.05) differences existed in the weight of the thigh, kidney, intestine and spleen among the dietary treatments; though it did not follow any particular pattern. The haematological profile of pullet chicks fed graded levels of WHM diets is shown in Table 6 while their biochemical profile is shown in Table 7. There were no significant (p>0.05) differences in haemoglobin concentration (Hb), packed cell volume (PCV), white blood cell concentration (WBC), red blood cell concentration (RBC), mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH) and mean corpuscular haemoglobin concentration (MCHC) among the various dietary treatments. Of all the biochemical parameters determined, only globulin (Glo) and total protein (TP) showed significant (p<0.05) differences among the dietary treatments, with higher values obtained for Diet 3 and 4 (10 and 15 % dietary inclusion level of WHM respectively) than for Diet 2 (5 % dietary inclusion level of WHM).

DISCUSSION

When the proximate composition of WHM is compared to that of wheat offal (Table 1), it can be seen that averagely, WHM has a higher CF content (21 % versus 11 %), lower CP content (14 % versus 16 %), higher ash content (24 % versus 6 %) and comparable ether extract (5 % versus 4 %) and metabolizable energy content (1901 kcal/kg versus 1845 kcal/kg). Based on this, it can be deduced that WHM may be used as a viable substitute to replace wheat offal (WO) in pullet chicks' diets. However, the presence of certain anti-nutritional factors may be a problem. But the anti-nutritional composition of WHM (Table 2) shows that it does not contain appreciable quantities of common anti-nutritional factors, except for the presence of oxalate which is slightly above the recommended critical limit by Kumar *et al*. (2010). According to Rahman *et al*. (2010), Ingestion of forage containing a large quantity of soluble oxalate can result in Ca deficiency in animals due to formation of calcium oxalate in the intestines and the blood. However, WHM contains considerable amount of Ca (3.03 %, comparable to 32 g/kg DM obtained by Tham and Udeh, 2013), which may compensate for losses caused by oxalate.

There were no significant ($p>0.05$) differences in all the carcass characteristics determined, as well as the weight of cut-up-parts (expressed as % of live weight) for the dietary treatments except for weight of the thigh, kidney, intestine and spleen. This result differs from what was obtained by Abeke *et al*. (2007) when he determined the effect of *Lablab purpureus* beans cooked for different time periods on the performance, organ weight and haematological parameters of Shika Brown pullet chicks. It was observed that the raw *Lablab* diet resulted in enlarged liver, heart and the pancreas due to the effect of anti-nutritional factors. These organs were enlarged in their attempt to detoxify the anti-nutitional factors present in the raw seeds; a fact corroborated by Amaefule and Obioha (2001) that pancreas tends to enlarge as its activities increases in the production of proteolytic enzymes. Since no such organ weight increases were obtained for WHM, it points to the fact that it contains no significant amount of such anti-nutritional factors. The values obtained for all the haematological and biochemical parameters determined falls within the reference standards recommended for chicken by Jain (1993) and Banerjee (1998). For the haematological profile, there were no significant ($p>0.05$) differences in haemoglobin concentration (Hb), packed cell volume (PCV), white blood cell concentration (WBC), red blood cell concentration (RBC), mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH) and mean corpuscular haemoglobin concentration (MCHC) among the various dietary treatments. This result is similar to the result obtained by Ocheja *et al*. (2012) who determined the performance and haematological parameters of six weeks' old pullet chicks fed varying levels of Bambarranut (*Voandzeia subterranean)* waste. The authors found that there were no significant ($p>0.05$) differences in blood cellular components, WBC, RBC, PCV, Hb, basophil and eosinophil; except for the neutrophil that was significantly ($p<0.05$) different among the dietary treatments. According to the authors, Bambarranut has a crude protein content of 20.34 % and a crude fibre content of 16.83 % (with low levels of anti-nutritional factors), which is comparable to WHM in composition. In another research study by Iyayi *et al*. (2005), performance, carcass characteristics, haematological and hispathological studies of broilers fed graded levels of Mucuna (*Mucuna utilis*) were determined. PCV levels, Hb concentration and RBC counts decreased with increasing levels of Mucuna in the diets (as a replacement for soya bean meal) due to destruction of the red blood cells by the anti-nutrients. According to the authors, cyanide inhibits the detachment of haem from haemoglobin leading to impairment of erythropoiesis. In this research study, it is most likely that because of the absence of these anti-nutrients in WHM, there was no such step-wise reduction in Hb, RBC and WBC values with increasing levels of WHM in the diets.

There were no significant ($p>0.05$) differences in serum glucose, urea, cholesterol, triglycerides, bilirubin total, bilirubin conjugate, sodium, chloride, potassium, bicarbonate, alkaline phosphatase (ALP), serum glutamate oxaloacetate transaminase (SGOT) and serum glutamate pyruvate transaminase (SGPT) among the dietary treatments; only globulin (Glo) and total protein (TP) showed significant ($p<0.05$) differences. This result compares with the result obtained by Egbewande *et al*. (2011) when they fed African mistletoe (*Tapinanthus bagwensis*) leaf meal to day-old Anak broilers for six weeks. The serum metabolites showed no significant ($p>0.05$) difference among the treatment means except in globulin. The result is also similar to what was obtained by Olorede and Longe (1999) when they fed varying levels of sheabutter (*Butyrospernum paradoxum)* cake to Bovan Nera pullet chicks for six weeks. They found that of the serum metabolites determined, albumin, globulin, total protein (TP), urea, creatinine, cholesterol, SGOT and SGPT were not significant ($p>0.05$) among the dietary treatments. However, there was a reduction in total protein, albumin and cholesterol at higher inclusion levels of sheabutter cake, indicating the inferior nutritional quality of the cake. In this study, however, there was no such reduction in the values of albumin, globulin and total protein at higher dietary inclusion levels of WHM. In fact, the values were not significantly ($p>0.05$) different from that of the Control Diet (Diet 1). This may be an indication of the adequacy of the WHM diets for pullet chicks at 10 and 15 % dietary inclusion levels.

CONCLUSION

Water hyacinth is the world's most troublesome aquatic weed species with millions of Dollars spent every year on its eradication and control. It does not contain anti-nutritional factors in significant quantities that can inhibit the performance of pullet chicks; hence, it can be included up to 15 % in the diets of pullet chicks (as a replacement for 75 % wheat offal) without any detrimental effects on their carcass characteristics as well as on their haematological and biochemical profile. Therefore, when properly harnessed, this feed resource could play a pivotal role in reducing feed cost for poultry in the developing economies of the world.

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