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INFLUENCE OF ENVIRONMENTAL ENRICHMENT AND OUTDOOR ACCESS ON PERFORMANCE, CARCASS AND BLOOD PROFILE OF NOILER BIRDS

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ABSTRACT

A total of 250-day-old Noiler chicks was procured from Chi hatchery, Ibadan. The birds were brooded in an indoor floor pen. At the end of the brooding period, four treatment group were made, consisting of fifty-five (55) birds per treatment. Each treatment was replicated into 5 with 11 birds per replicate, in a completely randomized design (CRD). Treatment one: deep litter (DL), trepatment two: Deep litter and environmental enrichment (DL+EE), treatment three: Deep litter and outdoor access (DL+OD) and treatment four: deep litter, outdoor access and environmental enrichment (DL+OD+EE). Data collected were analysed using analysis of variance (ANOVA) of statistical analysis system (SAS) and treatment means were separated using Duncan Multiple Range Test. The growth performance result revealed that birds raised in DL+OD+EE group had significantly (P<0.05) outstanding growth performance. Carcass characteristics profile showed that birds in DL+OD+EE followed by DL+OD had significantly (p<0.05) better carcass and visceral profile. The haematological profile showed that birds in DL+OD+EE group had significantly (P<0.05) higher haemoglobin concentration while DL group have significantly (P<0.05) higher monocytes and lymphocytes. With the exception (P<0.05) of albumin and aminotransferase all other serum biochemical profile were not significant (P>0.05) differences. It could be concluded that: Birds raised on DL+OD+EE had the best growth performance and carcass characteristics. Enrichment and outdoor access enhances haemoglobin concentration, reduces monocytes and lymphocytes thereby regulating the serum biochemical profile of Noiler birds.

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INTRODUCTION

Poultry welfare problems has however, been identified as one of the major barriers to enable maximum performance and productivity, hence these will eventually have deleterious effect in the final product and reduce the profit earning by the poultry farmers (Jibia *et al.,* 2023). Animal welfare concerns the state of an animal relative to the environment in which it lives. In recent times, animal welfare as a term, has arisen in society to express ethical concerns about the quality of life experienced by animals, particularly animals that are used in production agriculture. The term is therefore not one that necessarily expresses a scientific concept, nevertheless, because scientific methods are used to identify, interpret and implement societal concerns about animal quality of life issues, animal welfare has become established as a scientific field (Duncan, 2004).

Thus, animal welfare has now become measurable characteristics of an animal at a particular time or during a period (Grandin, 2015). Still animal welfare remains a complex and emotional topic which is difficult to define and assess. For example, the housing, handling, loading, transporting and unloading of animals can have very substantial effects on their welfare and meat quality, which may be given different interpretations by different stakeholders.

The scientific assessment of animal welfare involves measurements that capture different viewpoints on what constitute a good quality of life for animals. Development of scientific disciplines relevant to animal welfare has a long history and has been summed to include animal husbandry, animal science, veterinary medicine and behavioural science, which contribute to the understanding of welfare problems of animals (Grandin, 2015). Environmental enrichment and outdoor access by poultry have been a subject of study by researchers. Environmental enrichment describes the provision of physical and social opportunities to promote chickens behaviour that is important, valuable and specific to them. It encourages and allows chickens to do things that matter to them, resulting in positive experiences based on their individual interests, which underpins good animal welfare. Jacobs et al. (2023) reported that providing environmental enrichments that increases environmental complexity can benefit poultry welfare. Outdoor access to provide access to a covered veranda or an outdoor area where a wider range of elements, such as natural weather conditions (including sunlight), vegetation, different flooring materials, and insects, in addition to more space may stimulate active spacies-specific behaviour. It has proven to be of immense benefit on the welfare and productivity of poultry. This study will therefore explore the effect of environmental enrichment and outdoor access on performance and welfare of dual purpose chickens.

MATERIALS AND METHODS

Experimental Site

The experiment was conducted at Poultry Unit of Professor Lawal Abdul Saulawa Livestock Teaching and Research Farm, Department of Animal Science, Federal University Dutsin-Ma, Katsina State, Nigeria. Dutsin-Ma LGA lies on latitude 12°26'N and longitude 07°29'E while the farm site lies between latitude 12°27'18' North and 7°29'29' East and 605 meters above sea level with an average rainfall of 700mm within the Sudan Savannah zone Rainfall is between May and September with a peak in August. The mean annual temperature ranges from 29°C – 31°C. The highest air temperature normally occurs in April/May and the lowest in December through February (Gaddafi *et al.,* 2019).

Experimental design and treatments

The experimental birds were laid in a completely randomized design (CRD). The following treatment:
Treatment one – Deep litter without outdoor access (DL)
Treatment two – Deep litter and environmental enrichment (DL+EE)
Treatment three – Deep litter and outdoor access (DL+OD)
Treatment four – Deep litter, outdoor access and environmental enrichment (DP+OD+EE)

Experimental birds and their Management

A total of 250-day-old Noiler chicks was procured from reputable hatchery, Ibadan. The birds were brooded in an indoor floor pen. At the end of the brooding period, fifty-five (55) birds were assigned to each of the treatments above. Each treatment was having 5 replicates of 11 birds each. The deep litter (DL) group were reared indoors on concrete floors without access to outdoors while the other groups were in indoor pens that was open onto separate yards, which were surrounded by net fencing. The outdoor portion was 2 x 20m^2. The birds were fed on commercial diets throughout the study.

Data collection

Growth Performance

Feed intake

A given quantity of feed was measured and fed to the experimental birds on a weekly basis. Weekly feed intake was measured. Daily feed intake and total feed intake were determined. Daily feed intake was calculated by subtracting the leftover of the feed from the daily feed intake

Live weight gain

The experimental birds were weighed before allotting them treatments to get the initial weight.. They were then be weighed weekly early in the morning before being offered feed and water using a weighing balance throughout the experimental period. Total weight gain and daily weight was calculated.

Body weight gain = final body weight – initial body weight.

Average daily weight gain = total weight gain / no of days of experiment

Feed conversion ratio

Feed conversion ratio (FCR) was derived mathematically as the ratio of feed consumed to weight gain as shown in the following equation:

$$\text{Feed conversion ratio} = \frac{\text{Feed intake (g)}}{\text{Body weight gain (g)}}$$

Carcass Characteristics

At end of this study five (5) birds from each treatment were randomly selected and slaughtered by cervical dislocation through the severing of Jugular vein (Halal method), the carcass was singed, eviscerated and cut into various parts. Each body parts were weighed using digital weighing scale and recorded accordingly.

Haematological and Serum Biochemical Parameters Determination

Blood was collected at the point of lay (19 weeks post trail) by using sterile syringe and needle using jugular venepuncture of five Noiler Pullets per treatment after overnight fasting and was put into well labelled blood collection bottles, which contained ethylene diamine tetraacetic acid (EDTA). The blood samples was put in an ice pack and transported to the haematology laboratory for determination of haematological parameters which includes are packed cell volume (PCV) haemoglobin content, white blood cells, red blood cells, neutrophils, lymphocytes, eosinophil, monocytes and basophils were determined by the procedure outlined by Decie and Lewis (2001) while the mean corpuscular haemoglobin concentration (MCHC), mean corpuscular haemoglobin (MCH) and mean corpuscular Volume (MCV) will computed using appropriate formulae (Olaniyi *et al.,* 2012).

MCV, MCH and MCHC will be calculated as follows:

$$\text{Mean corpuscular volume (MCV)} = \frac{Packed\ cell\ volume}{Red\ blood\ cell} x10$$

$$\text{Mean corpuscular haemoglobin (MCH)} = \frac{Haemoglobin}{Red\ blood\ cell} x\ 10$$

$$\text{Mean corpuscular haemoglobin concentration (MCHC)} = \frac{Haemoglobin}{Packed\ cell\ volume} x100$$

Serum biochemical determination

Blood and serum samples was collected at the point of lay of Noiler pullets (19 weeks) by using sterile syringe and needle using jugular venepuncture of five overnight fasted Noiler Pullet from each treatment. 5 ml of blood was collected into labelled sterile sample bottles without anticoagulant and was used for the serum biochemical analysis. The sample was centrifuged at 3000 rpm for 15 minutes. Separated serums were stored frozen at -20ºC in sample bottles without anticoagulant until the time of analysis. The serum biochemical indices to be determined were serum albumin, globulin, total protein, alkaline phosphate (ALP), alanine aminotransferase (ALT), aspartate aminotransferase (AST).

RESULT AND DISCUSSION

Influence of Environmental Enrichment and Outdoor Access on Growth Performance Dual Purpose Chickens

Table 1 present growth performance of dual-purpose chickens raised on deep litter, environmental enrichment and outdoor access. The result showed no significant (P>0.05) differences of initial weight this signifies body weight balance and homogenous allocation of birds into different treatment groups. The result revealed that there were significant (P<0.05) differences in the final weight where birds in deep litter + outdoor + environmental enrichment group (DL+OD+EE) had significantly higher final weight (2.476kg) followed by deep litter (DL) with 2.300kg, deep litter + outdoor (DL+OD) with 2.300kg while deep litter + environmental enrichment (DL+EE) had the lowest final weight of 2.117kg in this study. The increases in final weight in birds raised on DL+OD+EE could be linked to the increase in welfare and outdoor accessibility compared to deep litter group. This could be supported by findings of Jones *et al.* (2020) who states that environmental enrichment, such as providing perches, litter materials and foraging opportunities, enhance the growth performance of poultry.

Environmental enrichment and outdoor accessibility in this study greatly and significantly (P<0.05) influences the weight gain of dual-purpose birds in this study. DL+OD+EE had the highest weight gain of 1.663kg followed by birds in DL+OD (1.493kg), DL (1.483kg) while lower weight gain (1.310kg) were recorded in birds raised on DL+EE. This collaborates with the findings of Jones *et al.* (2020) that broilers reared in enriched environments with access to perches and pecking objects showed a 5 - 10% improvement in weight gain compared to those in barren environment.

The result follows a similar trend (P<0.05) on average daily weight gain (ADWG) in which DL+OD+EE had the highest ADWG values of 21.56g/day followed by 20.30, 20.13 and 17.58g/day for DL, DL+OD and DL+EE respectively.

The result revealed that there were no significant (P>0.05) differences of total feed intake in this study. however, DL group have demonstrated higher numerical values in feed intake which could be likely attributed to enclosure nature of the group since they spend time mostly in feed and water intake while other groups have accessibility to either outdoor or enrichment thus will prevent birds to concentrate and consumed more feed. Feed conversion ratio is an important attribute in measuring animal performance and revealed significant (P<0.05) differences in this study. Birds raised on DL+OD+EE had the best FCR values of 2.699 followed by birds in DL+OD while birds in DL+EE had poor FCR with highest value in this study (3.435). this study validates the findings of Ribers *et al.* (2017) who found that broilers with access to enrichment devices (e.g hanging, toys, pecking objects) had a 3 -5% improvement in FCR compared to control group.

Table 1: Influence of environmental enrichment and outdoor access on growth performance dual purpose chickens

Parameters	DL	DL+EE	DL+OD	DL+OD+EE	SEM	LOS
IW (kg/bird)	0.817	0.820	0.807	0.813	0.043	NS
FW (kg/bird)	2.300^{b}	2.117^{c}	2.300^{b}	2.476^{a}	0.052	*
WG (kg)	1.483^{a}	1.310^{b}	1.493^{a}	1.663^{a}	0.037	*
ADWG (g)	20.30^{a}	17.58^{b}	20.13^{ab}	21.56^{a}	0.487	*
TFI (kg/bird)	4.625	4.500	4.490	4.490	0.059	NS
FCR	3.118^{ab}	3.435^{a}	3.007^{ab}	2.699^{b}	0.123	*

DL = Deep litter, DL+ EE = Deep litter and environmental enrichment, DL+OD = Deep litter and outdoor, DL+OD+EE = Deep litter, outdoor and environmental enrichment, IW = Initial weight, FW = Final weight, WG = Weight gain, ADWG = Average daily weight gain, TFI = Total feed intake, FCR = Feed conversion ratio, SEM = Standard error mean, LOS = Level of significance

Influence of Environmental Enrichment and Outdoor Access on Carcass Characteristics of Dual-Purpose Chickens

The carcass characteristics response of dual-purpose chickens raised using environmental enrichment and outdoor access were presented in table 2 below. The result showed no significant (P>0.05) differences in the live body weight irrespective of environmental enrichment or outdoor accessibility compared to control group. Dressing weight is an important attribute of carcass quality characteristics that revealed the actual carcass weight after bleeding loss and feather removal. Carcass weight showed no significant (P>0.05) differences however, slight numerical variation exist between treatment groups were T4 (Deeplitter + outdoor + environmental enrichment) had slightly highest (2.333kg) carcass weight followed by DL and DL+OD with similar carcass weight of 2.217kg each while lower carcass weight was recorded in DL+EE (Deeplitter + environmental enrichment group) with 2.000kg.

Back weight showed significant (P<0.05) differences were birds raised in DL+OD+EE had the highest back weight (486.7g) followed by DL (463.3g), DL+EE (380.70g) and DL+OD (307.3g) with a lowest back weight. Chest weight is an important carcass attributes and considered as a prime cut in poultry. Considerable and significant (P<0.05) differences were recorded in this study in which 593.0g was highest chest weight obtained in DL+OD+EE, while 441.0g, 437.1g and 381.7g are the chest weight for DL+OD, DL and DL+EE respectively. The result further revealed significant (P<0.05) differences in thigh weight.

Significantly (P<0.05) higher thigh weights were recorded in DL+OD+EE (320.3g) followed by DL+OD (247.0g), DL (226.3g) and DL+EE (211.0g). The higher thigh weight observed in this study could be linked with the availability foraging materials (insects, grasses and inorganic substances from soil) during outdoor access that provides additional protein, vitamins and minerals which will eventually promote development and growth of muscular tissue. Zhan *et al.* (2006) reported that higher levels of amino acids and vitamins optimizes thigh and breast meat yield. Therefore, the slaughter yield chest, thigh and back observed in DL+OD+EE group could be attributed to a possible best synergistic interactive effect of experimental diet and foraging materials obtained by birds during outdoor access. This support the findings of Jibia *et al* (2022); Obinne and Mnereola (2010) that slaughter yield could be influenced by nutrition especially dietary protein and energy that may be obtained from foraging. Similarly, this study further supports the findings of Jibia *et al.* (2022) that the increases in dressing weight could be linked to the increase in welfare and foraging accessibility of birds which enables birds to picks variety of materials from soil, insect, grasses and other edible materials in one way might contain proportion of vitamins and minerals that play vital role in nutrient utilization and ultimately growth performance.

There were no significant (P<0.05) differences in drumstick, wing, neck and head weight of dual-purpose chicken in this study. however, leg weight of birds raised in deep litter + outdoor + environmental enrichment (DL+OD+EE) was statistically (P<0.05) higher with 81.67g followed by DL+OD (69.00g) while DL and DL+EE had similar numerical values of leg weight (59.33g) in the current study.

Table 2: Influence of Environmental Enrichment and Outdoor Access on Carcass Characteristics of Dual-Purpose Chickens

Parameters	DL	DL+EE	DL+OD	DL+OD+EE	SEM	LOS
Live Weight (Kg)	2.300	2.100	2.300	2.467	0.179	NS
Carcass Weight (Kg)	2.217	2.000	2.217	2.333	0.180	NS
Back (g)	463.300[a]	380.700[ab]	307.300[b]	486.700[a]	61.400	*
Chest (g)	437.100[b]	381.700[c]	441.000[b]	593.000[a]	37.100	*
Thigh (g)	226.300[bc]	211.000[c]	247.000[b]	320.300[a]	12.630	*
Drumstick (g)	212.000	190.300	219.300	242.300	22.210	NS
Wing (g)	171.700	158.300	172.700	195.000	14.920	NS
Neck (g)	116.000	102.700	107.300	142.300	24.050	NS
Head (g)	51.000	47.670	54.330	55.330	3.140	NS
Leg (g)	59.330[a]	59.330[a]	69.000[a]	81.6700[a]	2.309	*

DL = Deep litter, DL+ EE = Deep litter and environmental enrichment, DL+OD = Deep litter and outdoor, DL+OD+EE = Deep litter, outdoor and environmental enrichment, SEM = Standard error mean, LOS = Level of significance

Influence of Environmental Enrichment and Outdoor Access on Visceral organ weight of Dual-Purpose Chickens

The result on the influence of environmental enrichment and outdoor access on visceral organ weight of dual-purpose chicken were presented in

Table 3. There was no significant (P>0.05) differences in liver tissue weight were recorded in this study. The liver weight values in this study collaborates that of Manal *et al.* (2004) who reported that there were no hyperthrophy in the birds raised in a similar study.

The result shows that there were significant (P<0.05) differences in heart, lungs, intestine, crop and proventriculus weight. Intestine is the major organ for nutrient digestion and absorption by squeezing the feed particles through peristalsis movement and rhythmity and digesta will be observed through the intestinal villi. The result revealed significant (P<0.05) differences in intestinal weight.

Gizzard is an important digestive organ that play a mechanical role of feed breaking down to a smaller particle size with the aid of stones, grits and muscular tissue. No significant (P>0.05) differences were recorded in gizzard weight. Bile and gallbladder were not significantly (P>0.05) difference in this study.

Table 3: Influence of Environmental Enrichment and Outdoor Access on Visceral organ weight of Dual-Purpose Chickens

Parameters	DL	DL+EE	DL+OD	DL+OD+EE	SEM	LOS
Liver (g)	44.33	40.00	50.33	51.67	4.93	NS
Heart (g)	7.333[b]	9.333[a]	9.333[a]	9.333[a]	0.745	*
Lung (g)	8.333[ab]	7.333[b]	8.000[ab]	9.333[a]	0.589	*
Intestine (g)	105.3[ab]	96.0[b]	121.7[a]	116.0[ab]	10.12	*
Crop (g)	10.67[b]	17.67[a]	17.67[a]	17.33[a]	0.471	*
Gizzard (g)	58.33	60.33	66.33	64.00	3.87	NS
Proventricolus (g)	11.67[bc]	9.00[c]	15.67[a]	13.67[ab]	1.291	*
Bile (g)	3.000	2.333	2.333	3.067	0.337	NS
Gallbladder (g)	2.067	1.733	2.833	2.100	0.497	NS

DL = Deep litter, DL+ EE = Deep litter and environmental enrichment, DL+OD = Deep litter and outdoor, DL+OD+EE = Deep litter, outdoor and environmental enrichment, SEM = Standard error mean, LOS = Level of significance

Influence of environmental enrichment and outdoor access on haematological profile of dual-purpose chickens

Analysis of haematological profile of the experimental animals is very important; since it is related to health status and are of diagnostic importance in clinical evaluation of the state of health. It also serves as indicator of physiological, pathological and nutritional status of an animal (Okoruwa and Ihimioya, 2014).

The haematological profile of dual-purpose chickens subjected to environmental enrichment and outdoor access is presented in table 4. Despite numerical variations across the treatment groups, the result showed that there were no significant (P>0.05) differences in red blood cell (RBC), packed cell volume (PCV), Mean corpuscular volume (MCV), Mean corpuscular

RBC level and haemoglobin are used to determine and classify anaemia (Jain, 1986). High PCV values indicate either an increase in the number of circulating RBC or reduction in circulating plasma volume (Kopp and Hetesa, 2000) it also provides additional information nutritional status of animal (Adejumo, 2004). The result revealed that there were significant (P<0.05) differences in haemoglobin (Hb) where DL+OD+EE had the highest Hb values (12.36g/dl) followed by DL+OD (12.26g/dl) while birds reared in deep litter had the lowest Hb value (11.35g/dl). Hb has the physiological function of transporting oxygen to tissue of the animal for oxidation of ingested food so as to release energy for the other body functions as well as transport carbon dioxide out of the body of animals (Soetan *et al.,* 2013). The significantly (P<0.05) higher Hb observed in a group that have outdoor accessibility may be as a result good oxygen inhalation from the surrounding environment. This implies that increased Hb level with outdoor accessibility in this study would enhance perfusion rate in the animal tissue and adequate removal of carbon dioxide with improve animal health and production. Studies have reported that broilers with outdoor access had higher hemoglobin levels compared to those kept indoors, suggesting enhanced oxygen carrying capacity (Urtecho-Novelo *et al.,* 2021).

The major function of white blood cells (WBCs) and other differential counts is to defend the body by phagocytosis against invasion by foreign organisms and to produce, transport and distribute antibodies in immune response (Etim *et al.,* 2014). Animals with high WBC and leucocytes counts are capable of generating high volume of antibodies during phagocytosis and have high degree of resistance to disease (Soeten, *et al.,* 2013) and enhance adaptability to local environment (Kabir *et al.,* 2011; Isaac *et al.,* 2013). The result showed that there were no significant (P>0.05) differences in WBC. Despite non-significant (P>0.05) differences birds raised in

DL demonstrated high level of WBC which may be attributed to the management system (intensive-deep litter) which makes the birds face challenges from microbial load in the litter compared to other groups that have minimal contamination level with litter materials due to perches or outdoor accessibility.

The differential count has a specific role in the immune response to different pathological conditions. It helps to evaluate body`s immune response to infections, inflammations, allergies, bone marrow disorders and monitoring treatment response (AACC, 2023). The result showed that there were significant (P<0.05) differences in monocytes and lymphocytes. Birds in DL had significantly (P<0.05) higher monocytes and lymphocytes 3.843% and 58.09% respectively, while DL+OD+EE have demonstrated low monocytes and lymphocytes values of 2.067% and 52.63% respectively.

The result showed that there were no significant (P>0.05) differences in heterophils, eosinophils and basophil in this study.

Table 4: Influence of environmental enrichment and outdoor access on haematological profile of dual-purpose chickens

Parameters	DL	DL+EE	DL+OD	DL+OD+EE	SEM	LOS
RBC ($x10^2$/l)	2.267	2.197	2.254	2.467	0.115	NS
PCV (%)	31.11	32.43	31.89	34.02	1.394	NS
Hb (g/dl)	11.35^{b}	12.09^{ab}	12.26^{a}	12.36^{a}	0.367	*
MCV (fl)	133.8	132.9	133.6	145.5	7.81	NS
MCHC (g/dl)	49.64	48.28	51.53	52.47	4.80	NS
MCH (pg)	66.03	65.96	64.87	66.07	2.016	NS
WBC ($x10^9$/l)	65.49	61.65	62.17	61.91	6.08	NS
Monocytes	3.843	2.233^{b}	3.093^{ab}	2.067^{b}	0.624	*
Lymphocytes (%)	58.09^{a}	53.93^{ab}	57.51^{ab}	52.63^{b}	2.104	*
Heterophils (%)	35.67	40.92	37.69	42.47	3.11	NS
Eosinophils (%)	1.887	1.527	1.293	1.170	0.778	NS
Basophils (%)	0.300	0.400	0.600	0.667	0.542	NS

DL = Deep litter, DL+ EE = Deep litter and environmental enrichment, DL+OD = Deep litter and outdoor, DL+OD+EE = Deep litter, outdoor and environmental enrichment, SEM = Standard error mean, LOS = Level of significance, RBC = Red blood cell, PCV = Packed cell volume, Hb = Haemoglobin, MCV = Mean cell volume,
MCHC = Mean corpuscular haemoglobin concentration, MCH = Mean corpuscular haemoglobin WBC = White blood cell

Influence of Environmental Enrichment and Outdoor Access on Serum Biochemistry of Dual-Purpose Chickens

The serum biochemical profile of Noiler birds raised on different environmental enrichment and outdoor access were presented in table 5 below. The result revealed that were no significant (P>0.05) differences in total protein. The total protein obtained in this study are slightly higher than total protein ranges of Noiler birds reported by Egna *et al.* (2014) who reported that Noiler birds had TP ranges 3.5 – 5.5 g/dl. Total protein reflect nutritional status and liver function of the birds while low total protein (hypoproteinemia) may indicate malnutrition and liver dysfunction.

Albumin is a major protein synthesized in the liver. It play a critical role in maintaining osmotic pressure and transporting hormones, fatty acids and drugs. The result in this study indicates that there were significant (P<0.05) differences in albumin. DL+OD+EE had the higher plasma albumin (3.497g/dl) followed DL+OD (3.190g/dl) while low albumin values were recorded in DL (2.817g/dl). Globulin are involved in immune response and are produced by liver and immune cells. The globulin result in this study showed non-significant (P>0.05) differences.

Alkaline phosphatase in this study are fall within the alkaline phosphatase of Noiler birds reported by Oke *et al.* (2016) and Adeyemo and Longe (2008) who reported that Noiler bird had alp ranges from 50 – 200u/l. alkaline phosphatase is associated with bone metabolism and liver functions. Elevated levels may indicates bone growth or liver damage. Therefore the alp values in this study are within the acceptable levels of healthy birds.

Alanine aminotransferase and aspartate aminotransferase are liver function enzymes. Alt and AST elevated levels may indicate hepatocellular damage. The result showed that DL+OD group had significantly (p<0.05) higher AST. The AST values obtained in this study are similar to the AST values reported by Adeyemo and Longe (2008) and Egna *et al*. (2014) of Noiler birds (50 – 150u/l).

The result revealed that housing enrichment and outdoor access in this study had no significant (p>0.05) effect on plasma electrolytes (sodium, potassium, chloride). Electrolytes are essential for maintaining fluid balance and nerve functions.

CONCLUSION

It could be concluded that: Birds raised on DL+OD+EE had the best growth performance and carcass characteristics. Enrichment and outdoor access enhances haemoglobin concentration, reduces monocytes and lymphocytes thereby regulation of serum biochemical profile of Noiler birds.

RECOMMENDATION

It could be recommended that farmers should improve poultry housing with enrichment and outdoor accessibility for best performance and normal blood profile.

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