British Journal of Applied Science & Technology
4(13): 1952-1965, 2014

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Do Diets Affect Haematological Parameters of Poultry?

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Authors' contributions

This work was carried out in collaboration between all authors. Author NNE designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript and managed literature searches. Authors UA, ROO and EEAO managed the analyses of the study literature searches and typesetting of the manuscript. All authors read and approved the final manuscript.

Review Article

Received 2nd January 2014
Accepted 19th February 2014
Published 13th March 2014

ABSTRACT

The effects of different diets on haematological parameters of different species of poultry have been examined in this review. In Nigeria, different poultry species contribute to the animal protein supply of the populace in terms of eggs laid and meat produced. Feeding poultry for optimum growth production requires that the birds consume appropriate balanced diets for the health and productivity, it is important that they be fed diets that meet their nutritional requirements. Dietary components affect the blood profile of healthy birds. The blood transports or conveys nutrients and materials to different parts of the body. Therefore, whatever affects the blood, either nutrition or drugs will certainly affect the entire body adversely or moderately in terms of health, growth, maintenance and reproduction. Thus, a readily available and fast means of assessing, clinical and nutritional health status of animals on feeding trials may be the use of blood analysis, because ingestion of dietary components have measurable effects on blood composition.

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Keywords: Diets; nutrients; haematology; haematopoiesis; poultry.

1. INTRODUCTION

Poultry is a general term for birds of several species such as chicken or domestic fowls, ducks, geese, guinea fowls, pigeons, ostriches and other game birds [1]. In Nigeria, different poultry species contribute significantly to the animal protein supply of the populace in terms of eggs laid [2] and meat produced. The general objective of poultry nutrition is to maximize the production performance of birds [3]. Increase in egg and meat production can be achieved through proper nutrition [4]. Feed is an important aspect of poultry production [5]. Inclusion of feed ingredients at normal or required level will enhance egg and meat production [4]. Diets are formulated to provide specific level of nutrients that are needed for optimum performance. For poultry, diets of high energy content promote fast growth [6,3]. Protein being an essential component of the diet needed for survival of animals and humans due to its basic function in nutrition to supply adequate amount of needed amino acids must be properly addressed [7]. Dietary components affect the blood profile of healthy birds [8].

It is often very difficult to assess the current health status of animals without detailed examination of blood [9]. Examination of blood provides the opportunity to clinically investigate the presence of several metabolities and other constituents in the body and it plays a vital role in the physiological, nutritional and pathological status of the animal [10]; [11]. It also helps to distinguish normal state from state of stress which can be nutritional [10]. The haematological examination is among the methods which may contribute to the detection of some changes in health and physiological status, which not be apparent during physical examination but which affects the fitness of the animal [12]. According to [13] haematological analysis involves the determination of different blood parameters such as Packed Cell Volume (PCV), Red Blood Cell Count (RBC), White Blood Cell Count (WBC), among others. Haematological parameters are good indicators of the physiological status of animals [14,15] and it changes are of value in assessing the response of animals to various physiological situations [15] and disease conditions [16]. Haematological parameters have been evaluated in many different species of animals, including poultry, by many researchers. These parameters are known to change with many factors, one of which is nutrition [9].

The review examined the effects of diets on haematological parameters of poultry.

2. POULTRY DIETS AND NUTRITION

2.1 General Nutrient Requirement

Feeding poultry for optimum growth production requires that the birds consume appropriate, balance diets. According to [17] for the health and productivity, it is important that they be fed diets that meet their nutritional requirements [18] posited that if poultry are expected to remain healthy and productive, they must consume adequate amount of all the necessary nutrients. Nutrient recommendations are different for each species and the purpose of the birds (meat versus eggs) as well as the stage of growth and production [19]. As reported by [18] the quantity of each required nutrient varies depending on many variables like species of bird, age, productive state, environmental conditions and disease status. Fortunately, many nutritional deficiency problems can be identified by the unique symptom each exhibits. All poultry and game birds feeds are referred to as “complete” feeds [18]. They contain all the protein, energy, vitamins, minerals and other nutrients necessary for proper bird growth, egg production and health. Complete feeds can be purchased that are formulated to meet all the nutritional requirements (energy, protein and amino acids, fats, vitamins, macro and micro-minerals etc.) of a particular class of poultry. If mixing feed, these nutrient requirements must be taken into account [17]. Cross feeding, such as feeding laying hens diet that is intended for broiler chickens is not advised. Therefore, raising mixed flocks should be done with caution [19]. According to [17] it is important to feed the right feed to the flock. The nutrient requirements will differ depending on the species, level of productivity and the age of the birds being fed [17]; the dietary requirements vary among different poultry species. No single ingredient will meet the nutrient requirements of flock so a mixture is required. The percent of a nutrient in the diet is dependent on the level of energy in the diet. Diets that are higher in energy will need higher concentration of different nutrients (referred to as nutrient dense diets) because the birds will eat less of a high energy diet and they need to be able to obtain the total amount of each nutrients required daily. Diets that are low in energy will lower concentrations of the different diets because the birds will eat more of the diet and thus get the total amount of the nutrients they need each day [17]. Young quail kept for meat production or sport hunting are fed differently from birds saved for egg production or breeding. Meat type quail have larger bodies and gain weight quicker than birds grown for other purposes. Diets must contain nutrient levels that meet the dietary needs of the birds being produced [18].

2.2 Components of Poultry Diets

The National [20] documented that the poultry diets are composed primarily of a mixture of several feedstuffs such as cereal/grains, soybean, animal by-product meal, fats and vitamins and minerals premixes [17] reported that poultry diets are composed of a variety of different feed ingredients mixed in the proportions needed to provide the birds need for energy, proteins, minerals and vitamins [20] also posited that these feedstuffs, together with water, provide the energy and nutrients that are essential for the bird's growth, reproduction and health, namely proteins and amino acids, carbohydrates, fats, minerals and vitamins. [19] stated that it is not recommended to feed only grains to poultry, because it will not provide a complete or balanced diet. The energy necessary for maintaining the bird's general metabolism and for producing meat and eggs is provided by the energy-yielding dietary components primarily carbohydrates and fats but also protein. High quality fish meal is recognized by animal nutritionists as an excellent source of protein, energy, minerals and vitamins. Worldwide, millions of tons of fish meal are produced annually. The majority of the fish meal produced is included in commercial diets for poultry [21]. Meat meal is an animal feedstuff produced by recycling animal by products. These products include meat trimmings, inedible parts and organs, fetuses, and certain condemned carcasses. They are cooked (rendered) to produce a nutritional and economic ingredient. Blood, hair, hoofs, horns, manure, trimmings are not permitted to be added to the meat meal. When bones are added to meat meal, it becomes meat and bone meal. High quality meat and bone meal is usually guaranteed to contain a minimum of 50% crude protein (CP). Meat and bone meal normally contains a minimum of 4% total phosphorus. Calcium typically does not exceed 2.2 times the level of total phosphorus [21]. According to the [20], poultry diets also can include certain constituents not classified as nutrients, such as Xantophylls (that pigment and impart desired colour to poultry products), the "unidentified growth factors" claimed to be in some natural ingredients and anti-microbial agents (benefits of which may include improvement of growth and efficiency of feed utilization) [19] reported that feed supplements are also formulated for specific species and contain a protein source, often soybean meal and vitamins and minerals. Extra calcium may be required, especially, for egg-laying birds and can be purchased in the form of oyster shells or limestone. Supplements may or may not contain medications and/or enzymes. Medications are sometimes added to poultry diets to promote growth and prevent disease. Caution must be exercised when using any medication, as medication effective for one species may cause mortality in another species. For example, a medication used to treat poultry may kill dogs and horses, and medication effective for broilers may be harmful to turkeys and waterfowl [19]. According to [22] exogenous enzymes have been used extensively in the diets of poultry to improve productive performance.

3. NUTRITION AND HAEMATOLOGY

Haematology refers to the study of the numbers and morphology of the cellular elements of the blood – the red cells (erythrocytes), white cells (leukocytes), and platelets (thrombocytes) and the use of these results in the diagnosis and monitoring of disease [23]. The blood transports or conveys nutrients and materials to different parts of the body. Therefore, whatever affects the blood, either drugs, pathogenic organism or nutrition will certainly affect the entire body adversely or moderately in terms of health, growth, maintenance and reproduction [24]. A readily available and fast means of assessing clinical and nutritional health status of animals on feeding trials may be the use of blood analysis, because ingestion of dietary components have measurable effects on blood composition [25,26] and may be considered as appropriate measure of long term nutritional status [27]. According to Togun and [28] haematological studies have been found useful for disease prognosis and for the therapeutic and feed stress monitoring [29] observed that nutrition had significant effect on haematological values like PCV, Hb and RBC [30] reported that when the haematological values fall within the normal range reported for the animal, it is an indication that diets not show any adverse effect on haematological parameters during the experimental period but when the values fall below the normal range, it is an indication of anaemia. Low values for haematological parameters as reported by [31] could be due to the harmful effects of high dietary contents. Physiological and nutritional status of animals could cause differences in values observed for PCV and MCV. Immune status is a function of leucocytes, neutrophils and lymphocytes. Lymphocytes are known to play key roles in immune defense system of both man and animals [32]. When WBC (leucocytes), neutrophils and lymphocytes fall within the normal range, it indicates the feeding patterns do not affect the immune system, most immunological abnormalities observed in malnutrition are usually corrected after nutritional rehabilitation [32]. According to [15] increase in neutophils; lymphocyte ratio is a good indicator of stress [33] which could be nutritional stress. Blood cells arise in the bone marrow from stem cells able to undergo processes of proliferation and differentiation in the haematopoietic microenvironment [34,35]. Adequate haematopoisis is dependent on an intact and functional bone marrow microenvironment, which is an environment fully competent to provide the appropriate signals through the production of soluble factors and cell-cell contact interactions regulating by several mechanisms, directly or indirectly, the self-renewable, proliferation, survival, migration and differentiation of haematopoietic cells [35].Feeding birds with protein deficient diets decreases the production of blood cells, leading to bone marrow hypoplasia and inducing structural alterations interfering with both innate and adaptive immunity [36,37,38,39]. Furthermore, [40] reported that protein malnutrition (PM), as a result of feeding birds with protein deficient diets, results in pathological changes that are associated with leucopenia, bone marrow (BM) hypoplasia and alterations in BM microenvironment leading to haematopoietic failure, however, the mechanisms are poorly understood. The BM mesenchymal stem cells (MSCs) are cells intimately related to the formation of the BM microenvironment, and their differentiation in the adipocytes is important because adipocytes are cells that have the capability to negatively modulate haematopoiesis [40]. In a study subjected experimental animals to protein-energy malnutrition with a low protein diet containing 2% protein, wheras control animals were fed a diet containing 12% protein. The malnourished animals had anaemia and leucopenia as well as spleen and bone marrow hypoplasia and reduction in the expression of CD45 and CD117 positive cells from BM. The alterations found in the malnourished animals led to the conclusion that malnutrition committed MSC differentiation leading to cytokines production contributing to an impaired haematopoietic microenvironment and inducing the bone marrow failure commonly observed in protein malnutrition states. According to [41] maintenance of antioxidant diet was associated with improved recovery of the bone marrow after sublethal or potentially lethal irradiation. Oral supplementation with antioxidants combinations containing L-selenomethionine (SeM), vitamin C, vitamin E succinate, alpha-lipoic acid and NAC appears to be an effective approach for radioprotection of haematopoietic cells and improvement of animal survival, and modulation of apoptosis is implicated as a mechanism for radioprotection of haematopoietic system by antioxidants. Koury et al. [42] posited that folate and vitamin B (Cobalamin) are essential nutrients in diets. Deficiency of either leads to megaloblastic anaemia. In megaloblastic anaemia, the deficiency appears to predispose to other types of malignancy. Decreased incidences of premalignant and malignant matopoietic precursor cells of erythrocytes, granulocytes and platelets are destroyed by programmed cell death, changes in uterine, cervical, bronchial and colonic epithelia were found in susceptible animals who had received oral (apoptosis). This apoptosis can result directly from decreased intracellular folate in folate deficiency or indirectly folate supplementations as compared with similar animals who were not supplemented.

3.1 Avian Haematology

Avian haematology demonstrates a high intra and inter specific variability under physiologic conditions which is caused by the richness in species and the high diversity of metabolic activity due to gender, age, reproductive status and season. A blood panel represents the actual status of circulating cells in the peripheral blood stream. Many influencing factors cause conspicuous variations which results in haematological analysis being a very sensitive diagnostic tool with low specificity [43]. Analysis of normal haematological parameters of poultry is essential for the diagnosis of various pathological and metabolic disorders [44]. It can be used as a diagnostic tool in order to assess the impact of environmental, nutritional and/or pathological stresses [44]. Haematological parameters provide valuable information in the immune status of animals [45]. Such information, apart from being useful for diagnostic and management purposes, could equally be incorporated into breeding programs for the genetic improvement of poultry [44]. It is desirable to know the normal physiological values, under different conditions for proper management, feeding, breeding, prevention and treatment of diseases [44].

Blood can be collected from a variety of sites in avian patients. The choice of a blood collection site is influenced by the species of bird, preference of the collector, physical condition of patient and the volume of blood needed. For best results, venous blood should be collected for haematologic studies. Blood collected from capillaries (e.g. blood from clipped nails) often results in abnormal cell distributions and contains cellular artifacts such as macrophages and material not normally found in peripheral blood. Blood to be used for haematology should be collected into a collection tube containing EDTA (ethylenediaminetetraacetic acid) as anticoagulant. Other anticoagulants, such as heparin, interfere with cell staining and create excessive cell clumping, resulting in erroneous cell counts and evaluations [46]. Valuation of the avian hemogram involves counting the various blood cells per microliter of blood as well as cytologic evaluation of the cells. The techniques involved in the evaluation of the avian hemogram are easily performed by in-house veterinary laboratory personnel. Because avian blood does not store well (e.g. during transport), hematologic results obtained soon after collection are preferred over those performed several hours after [46]. Blood volume in birds depends on the species and varies from 5ml/100g in the ring-necked pleasant to 16.3 to 20.3ml/100g in the racing pigeon. In general, birds are better able to tolerate severe blood loss than mammals, which is due to greater capacity for extracellular fluid mobilization. However, there is a marked variation among avian species in response to blood loss, which may be a reflection of differences in blood volume or extracellular fluid depots [46]. According to Forbes [47] the average blood volume of most birds is approximately 10% of body weight. Ten percent of this volume of 1% of birds body weight may be removed for testing. In comparison to mammals, avian blood cells show unique morphological characteristics e.g. erythrocyte and thrombocyte contain nucleus [43]. According to [47] avian red cells are nucleated which is why manual white cell counts are typically not possible. White cells are similar to mammalian lines, except that the mammalian neutrophils are replaced with heterophils and mammalian platelets are replaced with thrombocytes. Important differentials for leukocytosis with profound heterophilia and monocytosis include chlamydophilosis, aspergilosis and tuberculosis. [48] reported that the interpretation of avian blood cells provide many challenges. According to [47] interpretations that can be made are listed below:

Table 1. CBC findings

CBC Results	Interpretation
Leukocytosis	Infection, inflammation, necrosis, neoplasia, heavy metal toxicosis and stress (particularly in macaws, there should be no toxic changes in white cells)
Severe heterophilia	Chlamydophilosis, aspergillosis, tuberculosis (often with toxic changes in white cells)
Moderate heterophilia	Infection, cellular necrosis
Lymphocytosis	Viral infection, certain stages of chlamydophilosis
Monocytosis	Chronic infection with extensive necrosis and phagocyte activity (typically aspergillus, chlamydo philosis and tuberculosis)
Eosinophilia	Of inconsistent and unproven significance
Basophilia	Uncommon result most often associated with respiratory infections, resulting tissue damage, parasitism and some stages of chlamydophilosis
Leucopenia	Overwhelming bacterial or severe viral infection (particularly circovirus). Leukopenia may also be associated with reduced production of cells or increased use, which is demonstrated by the presence of immature or toxic white cells.

Adapted from: [47]

The normal PCV of birds ranges between 35 and 55%. A PCV less than 35% is indicative of anaemia and a PCV greather than 55% is suggestive of dehydration or polycythemia. An increase in red cell polychromasia is indicative of red blood cell regeneration. In normal birds, the number of polychromatic erythrocytes (or reticulocytes) found in the peripheral blood ranges between one and five percent of erythrocytes [46].

An anaemic bird with a 5% or less degree of polychromasia (or reticulocytosis) is responding poorly to the anaemia or there has not been enough time for the bird to demonstrate a significant response. Hypochromasia can be associated with certain nutritional deficiencies in birds, especially iron deficiency. There is a wide variation in the normal leukograms among birds of the same species. In general, total leukocyte count greater than 10,000/µl are considered suggestive of leukocytosis in tame, adult psittacine birds. A normal thrombocyte count ranging between 20,000 and 30,000/µl of blood or 10 to 15/1000 erythrocyte can be used as a general reference for most birds [46].

3.2 Chicken Haematology

[49] Reported the following range of values for haematological parameters of chicken.

Haematologic Type	Units – International Standard (SI)	Normal Ranges
PCV	%	35.9 – 41.0
Hb	g/dl	11.60 – 13.68
RBC	$X10^{-6}$/ml	4.21 – 4.84
WBC	$X10^{-3}$/ml	4.07 – 4.32
MCV	Fl	81.60 – 89.10
MCH	Pg	27.20 – 28.90
MCHC	%	32.41 – 33.37

Adapted from: [49]

4. EFFECTS OF DIFFERENT DIETS ON HAEMATOLOGY OF DIFFERENT SPECIES OF POULTRY

A feeding trial was carried out by [50] to evaluate the blood parameters of broiler chickens fed *Moringa oleifera* leaf meal (MOLM). MOLM was incorporated into experimental diets at varying replacement levels of 0, 5, 10 and 15% for soybean meal. The RBC, Hb, MCV, MCH and MCHC counts all showed significant differences. PCV and Hb levels decreased as MOLM inclusion increased [50] reported that MOLM could be included especially when the meat quality is targeted [51] conducted a study on the effects of aqueous extract of tamarind pulp on blood parameters of broiler chickens under a semi-arid environment. The birds were divided into four treatment groups and received 0g/l tamarind pulp, 20g/l, 30g/l and 40g/l tamarind pulp in drinking water, feed and water were supplied ad libitum and result showed a significant increase in RBC and WBC. No significant effect of TP was seen on Hb, PCV and MCHC [51] reported that up to 40g/l of tamarind pulp extract can be offered to broiler chicken without any adverse effect on blood constituents. In a study conducted by [52] on physiological response of broiler starter chicken to oral supplementation with Telfaria occidentalis leaf extract (TOLE). The birds were allotted into five treatment groups of oral supplementation. PCV, Hb, RBC and WBC counts were significantly affected by the TOLE supplementation [52] stated that the erythropoietic effect of TOLE on blood samples of broiler starter chickens is a good pointer that it can be used to replace synthetic vitamins in broiler production at starter stage. [53] carried out a trial on the effect of replacing bone ash with eggshell meal at 0, 25, 50, 75 and 100% on blood parameters of broiler chicken. It was observed that the haematological parameters were not affected by the diet except for corpuscular haemoglobin which was best in birds fed 100% eggshell. Similarly, values obtained for MCV were improved in birds fed 100% eggshell. According to [53], it is therefore, recommended that since there was no deleterious and adverse effect of including eggshell meal in the diets on the blood parameters, farmers can use eggshell meal as a major source of dietary calcium in broilers diets [54] conducted a study on the effects of the processing methods of Faidherbia Albida “Gao” on the haematology of broiler chicken fed at 15% inclusion level of the Fapm as partial replacement for groundnut cake meal. The birds were divided into four experimental groups and fed with 0% Fapm diet (control), 15% raw Fapm, 15% soaked Fapm and 15% boiled Fapm respectively. There were no significant differences in the haematological parameters. However, low values of PCV, RBC count, Hb, MCHC and MCH indicative of anaemic state were recorded in broilers on the experimental diets [54] suggested that treatment of Fapm has improvement on haematology of broiler fed 15% inclusion level with boiling showing a better improvement.

Another study was carried out by [55] on influence of dietary intake of melathion on the haematology of chickens. Melathion is routinely employed for protecting grains from insects. In the communication, the feeding of 0.08 (800p.p.m) and 0.16 (1600p.p.m) percent melathion sprayed feed was fed to chickens. The WBC count was slightly increased with both the treatments. The exact mechanism for the increase in WBC is not understood. There was however, no significant change in RBC count, PCV and erythrocyte sedimentation rate [56] conducted a research on haematologic parameters of the Nigerian local grower chickens fed varying dietary level of palm kernel cake (PKC). The birds were randomly allotted to five experimental diets. Five isonitrogenous (17%CP) grower diets containing 2,813 – 3079Kcal/ME/kg diet with varying levels of 10, 15, 20 and 25% PKC inclusion were used to replace maize and soybean in diets 2, 3, 4 and 5 respectively were formulated. Diet without PKC (%PKC) was the control. PCV, Hb, RBC, Platelets, heterophils and eosinophils were similar among birds across diets whereas variations in white blood cell, lymphocytes and monocytes were significant. The values of haematological parameters obtained were within the normal range of values documented for healthy chicken. Inclusion of dietary PKC upto 25% in the diet of the Nigerian local growing chicken elicited no adverse effect on the haematology [56]. In another study carried out by [57] on blood viscosity of finisher cockerel fed dietary inclusions of fermented cassava tuber wastes. Seven experimental diets were fed to the birds, diet with 0% microbially fermented cassava tuber wastes (MFCTWs), 20% microbially fermented cassava peel (MFCP), 40% MFCP, 60% MFCP, 20% Microbially Fermented Cassava Starch Residue (MFCSR), 40% MFCSR and 60% MFCSR. The results showed that the whole blood viscosities were statistically similar while plasma viscosities were influenced significantly in all the treatments. The whole blood and plasma viscosities, however, showed a gradual decline in value as the level of inclusion of the two types of fermented cassava tuber waste (FCTWs) increased in the diets [57] stated that cassava tuber wastes may decrease both plasma and whole blood viscosity and significantly so if plasma viscosity is taken into consideration [57] further reported that the lower viscosity of birds fed CTW at a higher inclusion is suggestive of a positive influence of the CTW at a higher inclusion is suggestive of a positive influence of the CTW diets on the mechanical and geometric properties of the red blood cells. Similarly, [58] carried out a trial on the haematology of finisher cockerel fed graded level of microbially enhanced cassava tuber diets. The birds were fed with seven different cassava tuber waste based (CTW) diets containing 0% CTW (control diet), 20% microbially fermented cassava peel (MFCP), 40% MFCP, 60% MFCP, 20% microbially fermented cassava starch peel (MFCSR), 40% MFCSR and 60% MFCSR. The cassava tuber wastes were inoculated with Lactobacilli (L. delbruecki and L. coryneformis) and one fungus (*Aspergillus fumigatus*) for their protein enrichment and fibre degradation. The results showed that the MCV was highest in birds fed 40% MFCP and 40% MFCSR diets with significant differences among diets, levels of inclusion and interactions between diets versus levels of inclusion. Birds fed MFCP had higher MCH than those fed MFCSR diets. The MFCR diets were, however, better in PCV, RBC and Hb. [58] reported that the use of CTW in cockerel rations would not compromise the haematological status of cockerel birds.

A feeding trial was also carried out by [59] on haematological indices of laying hens fed optimal and sub-optimal rations supplemented with waterleaf (*Talinum triangulare*) tops. The birds in the six treatment groups were fed 117, 121 and 125g of feed/day without Waterleaf Tops Supplement (WLTS) and 117, 121 and 125g of feed/day with 30g of WLTS at 3 days interval respectively. The results depicted that hens fed 117, 121 and 125g of feed/day without WLTS had lower percentages of haemoglobin compared to those on WLTS based diet. The quantity of feed served to the hens significantly and progressively increased with Hb, PCV, WBC and RBC. The WLTS supplementation significantly improved the Hb, PCV, RBC and WBC of hens [59] posited that laying hens need to be fed 121 and 125g of feed/day with 30g of WLTS at 3 days interval for better blood formation. In a trial conducted by [60] on effects of dietary levels of cooked lablab purpureus beans on haematological parameters of broiler finisher. The beans were processed by boiling in water for 30minutes at 100ºC. Seven isonitrogenous diets containing 20.9% crude protein were formulated to contain lablab seed meal at 0.00, 5.0, 10.0, 15.0, 20.0, 25.0 and 30.0 percent levels respectively. Diet 1 had no lablab and served as the control. The PCV and Hb status of the blood indicated significant decrease as the level of seed meal increased. [60] stated that lablab can be included upto 10% level in broiler diets. In a study conducted by [61] on haematological indices of broiler finisher fed potash boiled bambara groundnut (*Voandzein subterranean* (L) Thour) meal as replacement for soybean meal. Potash boiled bambara groundnut meal partly replaced soybean meal at 0%, 25%, 50%. 75% and 100% graded levels. The results of the haematological parameters indicated significant differences only in the PCV and Hb. According to [61] the results of the study showed that soybean meal can be replaced with potash boiled bambara groundnut meal upto 100% level without any deleterious effects on blood constituents of the broiler birds.

Moreover, [62] carried out a research on haematology of guinea fowl fed cassava peel based diets. The trial comprised three treatments with 0%, 10% and 20% cassava peel inclusion. Haematological parameters investigated include PCV, Hb, RBC, WBC and MCHC. The values for PCV, Hb, RBC and MCHC were significant in the treatments. [62] concluded that the results showed that guinea fowl tolerated 10% dietary inclusion of processed cassava peel based on the haematological indices [63] conducted a trial on the replacement value of dietary palm kernel meal for maize on the haematology of local broiler turkey. Six treatment diets in which palm kernel meal replaced maize at 0, 20, 40, 60, 80 and 100 percent were formulated. There were no definite trend in the haematological values for the birds with increase in the level of replacement of maize with PKM. However, in most of the haematological indices, turkeys fed diets 3 and 4 (40 and 60 percent replacement) performed as well as that of diet 0% replacement [63] recommended that PKM can replace maize at 60 percent in the diets of turkey without adverse effects on haematology of the animals [64] conducted a trial on the effect of iron, copper deficient skimmed-milk diets on haematology of Japanese quail. The feeding of iron, copper deficient diet resulted in rapid and severe reductions in PCV, Hb and MCHC. Addition of iron and copper to the skim-milk partially alleviated its adverse effect on haematology. [65] conducted a study on the haematology of Japanese quail fed dietary tri-n-butylin oxide during reproduction and observed the absence of serious effect in blood parameters in both adult and developing chicks. In a trial carried out by [66] on the effects of dietary vitamin E on haematological indices of Japanese quails. The birds were fed on starter and layer diets containing, 0, 1, 5 or 10 times the NRC recommended supplements on vitamin E. It was observed that as the level of vitamin E increased the percentage of erythrocytes hemolysed. [67] carried out an experiment on the effect of dietary protein levels and symbiotic on blood characteristics of Japanese quails (Coturnix coturnix Japonica). The treatment consisted of combination of 3 levels of crude protein, sufficient protein diet (24%, high CP) and low protein diet (22.08%;

low CP). The results together with that of symbiotic showed that there were no significant differences in the haematological indices among birds.

5. CONCLUSION

Diets are formulated to provide specific levels of nutrients that are needed for optimum performance. Blood analysis has been suggested as a readily available and fast means of assessing nutritional health status of animals on feeding trials because ingestion of dietary components have measurable effects on blood composition. Several studies conducted by various researchers have indicated in one way or the other that different diets have different effects on haematological parameters of different species of birds. Thus, considerations should be given to the types of diets and the effects each has on blood parameters, as well as the physiology of birds before feeding them to the animals.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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