

Beneficial Effects of Cashew Oilcake (*Anacardium occidentale*) on Haematological Parameters in Gallus Broilers

Camille Koffi^{1,*}, Daouda Fofana², Masse Diomandé², Kanga Sita N'Zoué¹,
N'Goran Mathieu Kouamé¹, Mamadou Kamagaté¹

¹Laboratory of Clinical Pharmacology, Department of Fundamental and Bioclinical Sciences, UFR Medical Sciences, Alassane Ouattara University, Bouake, Côte d'Ivoire

²Agrovalorisation Laboratory, Department of Biochemistry and Microbiology, UFR Agroforestry, Jean Lorougnon Guédé University, Côte d'Ivoire

*Corresponding author: koffi.camille@yahoo.fr

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Abstract Local food products are used in poultry feed in Côte d'Ivoire. The aim of the study was to assess the impact of cashew oilcake on haematological parameters in broilers. Using standard broiler feeds, experimental start-up, growth and finishing rations were formulated by substituting soybean meal for cashew meal at 0%, 25%, 50%, 75% and 100%. For 6 weeks, 5 batches (F₀, F₂₅, F₅₀, F₇₅ and F₁₀₀) of 5-day-old Cobb 500 chicks were successively fed 03 experimental feed rations. On the 45th day of feeding, blood samples were taken from the fasting chickens, followed by haematological analyses. The results showed that the white blood cell count of broilers in batch F₅₀ (11.38.103/ μ L) was lower than the normal value (12-30.103/ μ L). In addition, the haematocrit levels of birds in batches F₅₀ (20.72%) and F₂₅ (23.82%) were relatively low compared with the normal value (27-55%), which would indicate a possible microcytic anaemia in these birds. The mean corpuscular volume of the birds fed the cashew meal-based ration was lower, particularly that of batch F₁₀₀ (118.5 mm³) and F₇₅ (122.26 mm³) compared with the control batch (129.54 mm³). The mean corpuscular volume of broilers fed cashew meal rations was within the normal range (90-140 mm³), ruling out anaemia in these birds. Cashew oilcake has nutritional effects comparable to those of soybean oilcake in broilers, and could therefore be a substitute for soybean oilcake in poultry feed in Côte d'Ivoire.

Keywords: cashew oilcake, soybean oilcake, haematological parameters, broilers chicken

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1. Introduction

As a result of population growth in West Africa, livestock production remains insufficient to meet the population's animal protein needs [1]. Poultry farming currently occupies a prominent place in development and poverty reduction strategies in most developing countries [2]. In less than 20 years, Côte d'Ivoire has gone from entirely traditional production to increasingly modern production [3]. In addition, industrial poultry farming is highly dependent on external supplies of chicks and rearing inputs, leading to a rise in the production price of poultry for poultry farmers [4]. This problem suggests the need to look for new sources of feed, particularly easily accessible protein sources that do not compete with human consumption needs [5]. Among these alternative resources, cashew kernel meal from the cashew nut (*Anacardium occidentale*) is well placed. Cashew kernel meal is

available and easily accessible in all cashew nut processing areas, and its nutritional qualities make it a good source of protein and energy [6]. However, the incorporation of a new food source into poultry diets will have to maintain their health, as measured by biological parameters [7].

The study of blood constituents provides valuable information on the general condition of the animal [8,9]. The aim of the present study was to determine the impact of cashew oilcake incorporated into broiler chicken feed on haematological parameters.

2. Materials and Methods

Study area

This study was carried out in a peripheral poultry area in Port-Bouët, south-east of Abidjan, Côte d'Ivoire (Figure 1).

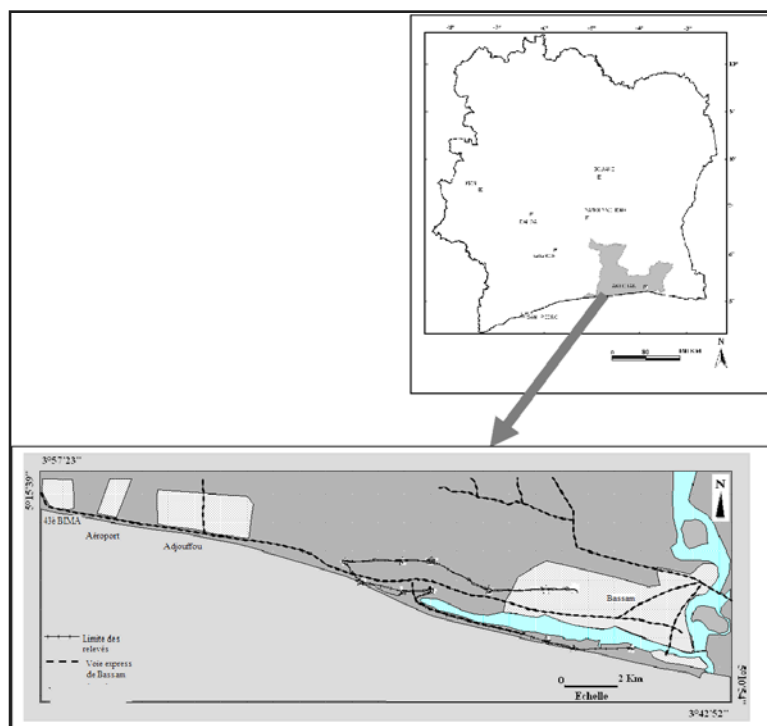


Figure 1. Location of the study area, city of Abidjan [10]

Plant material

The plant material consisted of declassified cashew kernels collected from an industrial cashew nut processing unit, 'Eburnie', and soya cake purchased commercially from the 'KENZ' company in Abidjan (Figure 2).



Figure 2. Plant materials (a- Soya cake, b- Cashew cake)

Animal material

Chicks (Cobb 500) vaccinated against Newcastle disease were purchased from the 'IVOGRAIN' company in Abidjan and transported to the experimental farm located in the commune of Port-Bouët, Abidjan.

Formulation of experimental chicken feed rations

The compositions of the standard broiler starter, grower and finisher rations are presented in Table 1.

Table 1. Standard broiler rations

Ingredients (%)	Food rations		
	Starter	Growth	Finishing
Maize	62	66	69
Soya cake	30	28	26
Fish	5,5	3	3
TNH Chair	1	1	1
Shell	0,6	0,7	0,4
Fysal-MP®	0,3	0,25	0,2
Salt	0,25	0,3	0,3
Toxo-XL®	0,2	0,15	0,1
Bi-calcium phosphate	0,15	0,6	00
Total	100	100	100

TNH Chair = vitamin complex; Fysal-MP = free and buffered organic acid mixtures; Toxo-XL = broad-spectrum mycotoxin sensor.

Based on the above standard rations F_0 , experimental rations F_{25} , F_{50} , F_{75} and F_{100} are formulated by substituting 25, 50, 75 and 100% soybean meal for cashew meal, respectively, as described by Fofana *et al.* [11].

Composition of experimental groups of broilers

After an incubation period, 5 batches of 15 unsexed 5-day-old Cobb 500 chicks were formed. For 6 weeks, these groups of chickens were successively fed starter, grower and finisher rations according to the following experimental scheme:

F_0 : batch of chickens fed standard feed rations

F₂₅: batch of chickens fed experimental diets consisting of 25% substitution of soybean meal for cashew meal

F₅₀: batch of chickens fed experimental rations consisting of 50% substitution of soybean meal for cashew meal

F₇₅: batch of chickens fed experimental feed rations consisting of 75% substitution of soybean meal for cashew meal

F₁₀₀: batch of chickens fed experimental feed rations consisting of 100% substitution of soybean meal for cashew meal.

Determination of mortality and zootechnical parameters

The number of deaths was recorded daily and the mortality rate (%) was calculated. A hierarchical classification analysis (HCA) based on the zootechnical data was used to group the experimental batches according to their evolutionary similarities. The zootechnical parameters were grouped according to their similarities in growth performance using Principal Component Analysis (PCA).

Determination of blood haematological parameters

On 45th day of the study, the chickens were fasted overnight before blood sampling. Using a syringe, the blood of 5 chickens chosen at random from each batch was drawn from their wing veins and packed in EDTA tubes at +4°C for blood cell count (CBC) on a Sysmex XN-550 at the haematology laboratory of the University Hospital of Cocody, Abidjan, Côte d'Ivoire.

Statistical analysis

The various results obtained were recorded in the Microsoft Excel spreadsheet. The means of the data were compared by analysis of variance (ANOVA) using the Turkey test with GraphPad Prism 8.4.3 (686) software. The significance threshold was $p < 0.05$.

3. Results and Discussion

3.1. Results

Effect of cashew oilcake on broiler mortality

Overall, mortality was low in all groups of chickens fed the different diets (Table 2). Most chickens died at the start-up stage, namely 5% (F₀), 3.33% (F₁₀₀ and F₅₀) and 1.67% (F₇₅ and F₂₅).

Table 2. Effect of cashew meal-based rations on mortality rate

Diets	Mortality (n=60)				
	F ₀	F ₁₀₀	F ₇₅	F ₅₀	F ₂₅
Start	3	2	1	2	1
Growth	1	0	0	0	0
Finish	0	0	0	0	0
Total	3	2	1	2	1
Mortality rate (%)	5	3,33	1,67	3,33	1,67

F₀:0% substitution of soya meal; F₁₀₀:100% substitution of soya meal; F₇₅:75% substitution of soya meal; F₅₀:50% substitution of soya meal; F₂₅:25% substitution of soya meal.

Effects of cashew oilcake on zootechnical parameters of broilers

Four experimental groups of broilers were distinguished according to their evolutionary similarities (Figure 3). The G_I group included all broilers fed F₀ and F₂₅ rations. Group G_{II} included chickens fed the F₅₀ ration. Group G_{III} consisted of chickens fed ration F₇₅. Group G_{IV} consisted of chickens fed ration F₁₀₀.

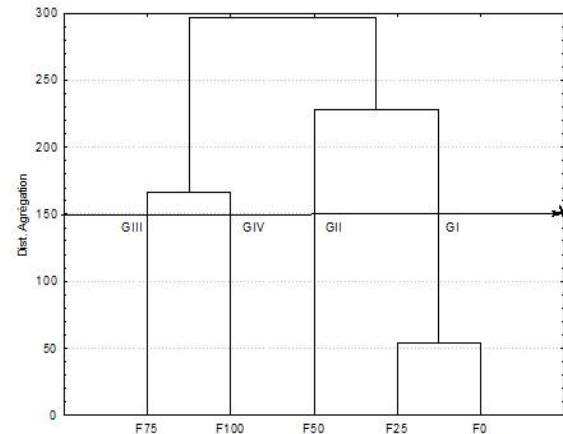


Figure 3. Hierarchical classification of batches of broilers fed cashew cake-based rations

G_I: group of broilers fed rations F₀ and F₂₅; G_{II}: group of broilers fed ration F₅₀. G_{III}: group of broilers fed ration F₇₅; G_{IV}: group of broilers fed ration F₁₀₀.

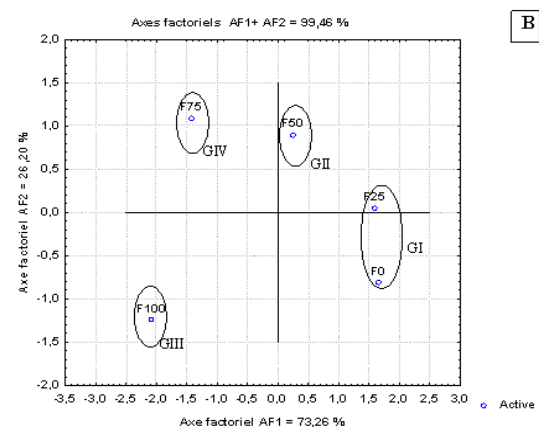
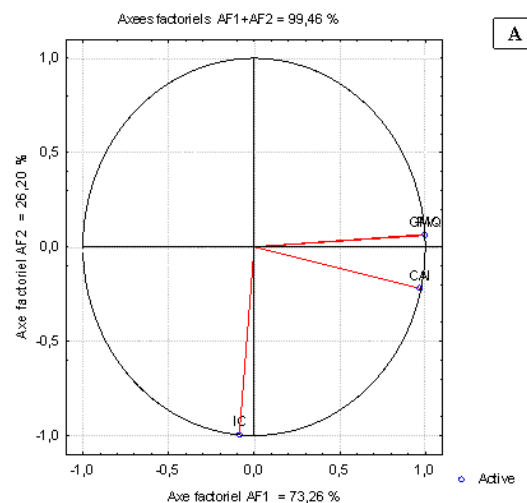


Figure 4. Main components of growth characteristics of broilers fed rations based on cashew oilcake

Two axes for grouping broilers, namely axis AF_1 (73.26%) and axis AF_2 (26.20%), were selected on the basis of the mean values of each zootechnical variable (Figure 4). These 2 grouping axes express 98.13% of the information contained in the data matrix. The correlation circle showed a strong negative correlation of the feed intake index (CI) on the AF_1 factorial axis and a strong positive correlation between average daily gain (ADG) and individual feed intake (IFA) on the AF_2 factorial axis (Figure 4A). The factorial map showed the distribution of the five (5) experimental batches according to growth performance characteristics. Comparative analysis of Figures 4 A and 4 B revealed that the batches in group G_I (F_0 and F_{25}) were characterised by their high individual feed intake (IFA) and average daily gain (ADG), followed by group G_{II} (F_{50}) and group G_{III} (F_{100}), which was characterised by its very high feed conversion ratio (FCR).

(A) Correlation circle of the growth parameters projected on the factorial axes; CI: consumption index; CAI: individual feed intake; GMQ: average daily gain; (B) Factorial map showing the distribution of the five experimental batches formulated according to growth characteristics; F_0 : 0% substitution of soybean meal; F_{100} : 100% substitution of soybean meal; F_{75} : 75% substitution of soybean meal; F_{50} : 50% substitution of soybean meal; F_{25} : 25% substitution of soybean meal; G_I , G_{II} , G_{III} and G_{IV} : groups observed.

Effect on haematological parameters in broilers

Erythrocyte parameters

Table 3. Effect of cashew cake-based rations on erythrocyte parameters in broilers

Erythrocyte parameters	Diets				
	F_0	F_{100}	F_{75}	F_{50}	F_{25}
RBC ($10^6/uL$)	2,66±0,73	3,66±1,4	2,3±0,30	1,63±0,11	1,91±0,38
HB (g/dL)	8,7±2,28	9,46±3,71	7,07±0,7	5,34±0,48	6,4±1,24
HT (%)	34,06±9,25	43,04±16,7	28,12±3,31 _c	20,72±1,39 _d	23,82±4,7 _{de}
VGM (fL)	128,05±2,5 _a	117,72±1,1 _b	122,26±2,3 _e	127,12±0,5 _{4ac}	124,71±0,6 _{8ac}
TCMH (pg)	32,71±0,84 _a	25,87±4,13 _b	30,74±1,28 _a	32,76±0,89 _a	33,51±0,51 _a
CCMH (g/dL)	25,54±0,56	21,98±3,65	25,14±0,59	25,77±0,75	26,87±0,51

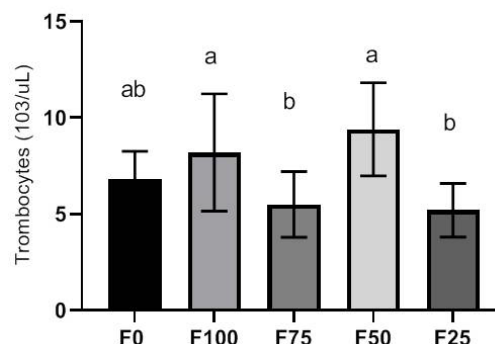
Means followed by different letters (a, b, c) within the same line are significantly different ($p < 0.05$); F_0 : 0% substitution of soybean meal; F_{100} : 100% substitution of soybean meal; F_{75} : 75% substitution of soybean meal; F_{50} : 50% substitution of soybean meal; F_{25} : 25% substitution of soybean meal. HT: Haematocrit; HB: Haemoglobin; TCMH: Mean corpuscular haemoglobin content; CCMH: Mean corpuscular haemoglobin concentration; VGM: Mean corpuscular volume; RBC=Number of Red Blood Cells.

Batch F_{100} (43.04%) recorded the highest haematocrit (HT) level, unlike batches F_{75} , F_{50} and F_{25} , which recorded haematocrit levels of 28.12±3.31%, 20.72±1.39% and 23.82±4.7% respectively, which were significantly ($p < 0.05$) lower than those of the F_0 control (34.06%). The mean corpuscular volume (MCV) of batches F_{100} (118.5 g/dL) and F_{75} (122.26±2.32 g/dL) were significantly different ($p < 0.05$) compared with the F_0 control (129.54 g/dL). The mean corpuscular haemoglobin content (MCHC) and mean corpuscular haemoglobin

concentration (MCHC) of batch F_{100} (25.87±4.13 pg and 21.98±3.65 g/dL respectively) were significantly ($p < 0.05$) lower than the control (32.71±0.84 pg) (Table 3).

Trombocytes

Trombocyte levels in broilers fed cashew meal were similar to those in control chickens (Figure 5).



Bands with different letters (a, b) are significantly different ($p < 0.05$)

Figure 5. Trombocyte count in broilers fed soybean and/or cashew meal-based rations

White blood cell parameters

White blood cell (WBC) levels in chickens fed cashew-based rations in batches F_{50} (11.38.10³/uL) and F_{25} (13.66.10³/uL) were significantly ($p < 0.05$) lower than in the F_0 controls (20.17.10³/uL). With the exception of neutrophil levels in batch F_{100} , leukocytes in broilers fed cashew cake-based rations were statistically low ($p < 0.05$) compared with those in the F_0 control batch (Table 4).

Table 4. Effect of cashew meal-based rations on leukocyte parameters in broilers

Leukocyte parameters	Diets				
	F_0	F_{100}	F_{75}	F_{50}	F_{25}
WBC ($10^3/uL$)	20,17±8,5 _a	19,16±6,84 _a	16,62±4,18 _{abc}	11,38±6,36 _{bc}	13,66±2,19 _{bc}
Neutrophils ($10^3/uL$)	15,35±6,35 _a	17,27±6,25 _a	11,02±2,65 _b	9,54±6,43 _b	9,93±2,03 _b
Lymphocytes ($10^3/uL$)	1,51±0,61	0,94±0,44	3,38±1,34	1,19±0,53	1,86±0,15
Monocytes ($10^3/uL$)	1,24±0,73	0,51±0,24	0,45±0,06	0,23±0,04	0,6±0,19
Eosinophiles ($10^3/uL$)	0,012±01	0,02±0,01	0,01±0,01	0,02±0,02	0,03±0,2
Basophiles ($10^3/uL$)	2,05±1,09	0,42±0,19	1,76±0,52	0,39±0,19	1,09±0,28

Means followed by different letters within the same line (a, b, c) are significantly different ($p < 0.05$); F_0 : 0% substitution of soya meal; F_{100} : 100% substitution of soya meal; F_{75} : 75% substitution of soya meal; F_{50} : 50% substitution of soya meal; F_{25} : 25% substitution of soya meal.

3.2. Discussion

This study analysed the zootechnical parameters and in particular the haematological profile of broilers fed standard and experimental diets. The experimental diets were obtained by substituting soybean meal from the standard diet for cashew meal.

During the 45 days the broilers were fed, mortality rates observed were ≤5%. This low mortality was noted during the start-up phase of rearing. Similar results of 3.03% mortality in broilers were found by others authors [12].

Kere et al. [13] found similar mortality rates of between 1.76 and 3.46% in Burkina-Faso. On the other hand, the work of Abdellaoui [14] in Algeria observed a higher mortality of 8.33%.

In fact, the low mortality in broiler rearing can be explained by good control of rearing conditions, good nutritional qualities of the feed consumed and suitable climatic conditions [15,16]. Betene [17] found that the mortality rate for broilers rose from 8% in the cold season to 12% in the hot season. Mortality was highest in the start-up phase, when chicks are highly susceptible to pathogens and their immune systems are still underdeveloped [18].

The present study showed that the 50% experimental diet substituting soybean meal for cashew meal (F₅₀) significantly reduced the number of white blood cells (WBC) in poultry (11.38.10³/μL) compared with chickens fed standard F₀ diets with a WBC level of 20.17.10³/μL.

Similarly, Msaid [19] showed that heat stress reduced WBC levels to 11.06.10³/μL and 11.42.10³/μL respectively in local chickens and hens, *Gallus gallus domesticus*. However, Kiki [20] found that chilli powder (*Capsicum frutescens*) in the diet did not influence the haematological parameters of broilers, which had WBC values ranging from 22.78 to 25.22.10³/μL; the normal WBC level in broilers being between 12.10³ to 30.10³/μL. The normal WBC levels observed are thought to be due to the absence of bacterial or parasitic infection, an inflammatory syndrome or an allergic drug reaction in the chickens [21].

The haematocrit (HT) levels of birds in batches F₅₀ (20.72%) and F₂₅ (23.82%) were significantly lower than those of control birds F₀ (34.06%) and normal haematocrit values of between 27 and 55%, indicating the presence of microcytic anaemia in birds in batches F₅₀ and F₂₅. In contrast, the haematocrit level of birds in batch F₁₀₀ was normal at 43.04%. Other studies had found normal haematocrit levels of between 26.52 and 28.00% [22] and between 37.42 and 38.30% [20] in broilers.

In general, the mean corpuscular volume (MCV) of birds fed cashew meal-based rations from batches F₁₀₀ (118.5 mm³) and F₇₅ (122.26 mm³) were in line with normal values (90 - 140 mm³) for MCV in broilers. Kiki (2013) found normal values between 127.85 and 130.30 mm³ [20]. Kamagaté [23] also reported normal VGM values of between 129.82 and 131.88 mm³ in broilers undergoing BIOFOR antibiotic treatment. With the exception of batch F₁₀₀, whose mean corpuscular haemoglobin content (MCHC) was 25.87±4.13 pg, the MCHC values of the other batches of chickens fed cashew meal-based diets were comparable to that of the control batch (32.71±0.84 pg). However, the MCHT values of all chickens were within the standard (25-48 pg) for broilers. Most interestingly, the mean corpuscular haemoglobin concentration (MCHC) of chickens fed cashew oilcake was comparable to that of control chickens and in line with normal values (20-34 g/dL) in broilers [24].

The number of thrombocytes in chickens fed cashew kernel meal was significantly different (p<0.05). Values were lower than those of [22], which ranged from 35.74 to 47.26.10⁹/L in Ross 308 broilers, and [25], which ranged from 21.33 to 30.33.10⁹/L in broilers fed alkaline phosphatase supplementation. Since thrombocytes play an

important role in blood coagulation, a low thrombocyte count would increase the risk of bleeding in hens [26].

Finally, the differential leucocyte count showed that, with the exception of neutrophil count, the other leucocyte parameters were comparable to those of the control. Neutrophil values were higher than those of [25], which ranged from 5.20 to 6.85.10³/uL obtained in broilers after 42 days of dietary supplementation with alkaline phosphatase of microbial origin. Neutrophils are important mediators of natural resistance to bacterial infection in poultry [27], and their high levels could suggest bacterial infection [28]. Lymphocyte levels were close to 1.5-2.79.10³/uL, as obtained by Thema et al. [22] in Ross 308 broilers.

Monocyte and eosinophil levels were within the normal range of 0.15-2.10⁹/L and 0-1.10⁹/L respectively [29]. Basophil levels were higher than those found by Escobar et al. [25] of between 0.8 and 0.99.10⁹/L in broilers after 42 days of dietary supplementation with alkaline phosphatase.

Conclusion

This study showed that red and white blood cell levels in broilers were affected to varying degrees depending on the experimental rations consumed. The haematological parameters of the rats varied disparately from one group of chickens to another fed different cashew meal-based rations. Overall, the incorporation of cashew nut meal into poultry rations had beneficial effects on their zootechnical and haematological parameters, comparable to those of soya meal. Cashew nuts would be a genuinely inexpensive local substitute for imported soya and would reduce the production costs of poultry feed in Côte d'Ivoire. In the future, biotechnological studies aimed at adapting the granulometry of cashew oilcake will be necessary to produce better quality feed rations for poultry.

Declarations

Authors' Contributions

Daouda Fofana wrote the research project. He reared the broilers and carried out the biological tests in the laboratory. Camille Koffi supervised the research work and took blood samples from the broilers. He also wrote the article and is its corresponding author. N'Goran Mathieu Kouamé and Kanga Sita N'zoué reviewed the article. Mamadou Kamagaté and Masse Diomandé are the scientific supervisors of the research project.

Ethical Consideration

The present study was approved by the Scientific Committee of the "Medical Sciences Training and Research Unit (UFR SM)" of the "Alassane Ouattara University" and all experimental protocols were carried out in accordance with the NIH Guide for the Care and Use of Laboratory Animals.

Competing Interest

The authors state that there were no competing interests.

Data Availability

All relevant data are within the paper and its supporting information files.

List of Abbreviations

ADG (Average Daily Gain); CAI (Individual Feed Intake); CBC (Blood Cell Count); CCMH (Mean Corpuscular Haemoglobin Concentration); CI (Consumption Index); F₀ (Batch of chickens fed standard feed rations); F₁₀₀ (Batch of chickens fed experimental feed rations consisting of 100% substitution of soybean meal for cashew meal); F₂₅ (Batch of chickens fed experimental diets consisting of 25% substitution of soybean meal for cashew meal); F₅₀ (Batch of chickens fed experimental rations consisting of 50% substitution of soybean meal for cashew meal); F₇₅ (Batch of chickens fed experimental feed rations consisting of 75% substitution of soybean meal for cashew meal); FCR (Feed Conversion Ratio); Fysal-MP (Free and Buffered Organic Acid Mixtures); GB (Number of White Blood Cells); G_I (Group of Broilers Fed Rations F₀ and F₂₅); G_{II} (Group of Broilers Fed Ration F₅₀); G_{III} (Group of Chickens Fed Ration F₇₅); G_{IV} (Group of Chickens Fed Ration F₁₀₀); GMQ (Average Daily Gain); GR (Number of Red Blood Cells); HB (Haemoglobin); HCA (hierarchical classification analysis); HT (Haematocrit); IFA (Individual Feed Intake); MCHC (Mean Corpuscular Haemoglobin Concentration); MCHC (Mean Corpuscular Haemoglobin Content); MCV (Mean Corpuscular Volume); PCA (Principal Component Analysis); TCMH (Mean Corpuscular Haemoglobin Content); TNH Chair (Vitamin Complex); Toxo-XL (Broad-Spectrum Mycotoxin Sensor); UFR (Teaching and Research Unit); VGM (Mean Corpuscular Volume); WBC (White Blood Cell).

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