American Journal of Food Science and Technology, 2023, Vol. 11, No. 4, 150-155
Available online at http://pubs.sciepub.com/ajfst/11/4/4
Published by Science and Education Publishing
DOI:10.12691/ajfst-11-4-4

Effect of Cashew Kernel Meal on Blood Biochemical Parameters and Biometry of Organs Regulating Nutritional Metabolism in Laying Hens

Silué Fatogoma Etienne[1,*], Ouattara Adidjatou[2], Yéboué Kouamé Hermann[2], Ouattara Karamoko[1], Kati-Coulibay Séraphin[2]

[1]Training and Research Unit of Agriculture, Fisheries and Agro-Industry, University of San Pedro, San Pedro, Côte d'Ivoire
[2]Biology and Health Laboratory, Training and Research Unit of Biosciences, University Felix Houphouët-Boigny, Abidjan, Côte d'Ivoire
*Corresponding author: ngsilue@yahoo.fr

Received September 04, 2023; Revised October 05, 2023; Accepted October 13, 2023

Abstract Cashew kernels are rich in protein, carbohydrates, polyunsaturated fatty acids (PUFA) and monounsaturated fatty acids (MUFA). In Côte d'Ivoire, cashew nut kernel debris is abundant, but are not highly valued. This study aims to assess the impact of cashew kernel meal in diets on serum biochemical parameters and the pathophysiological state of organs regulating nutritional metabolism in hens. To carry out the experiment, 96 hens, aged 20 weeks, of LOHMANN-Brown strain, with an average weight of 1600 ± 36.7 g, were used over a 10-week period. Laying hens were fed four diets: Rt, R10, R15 and R20, with 0%, 10%, 15% and 20% cashew kernel meal respectively. The results indicate that the consumption of the diets caused a significant reduction in the mean value of glucose, total cholesterol and uric acid in the hens' blood, due to the presence in quantity of the PUFAs and MUFAs contained in cashew kernels. In this study, the absence of weight variation in kidneys, livers, hearts and gizzards shows that cashew kernel meal had no deleterious effects on the body's immune responses. On the other hand, spleen mass was reduced in hens fed the R10, R15 and R20 diets, showing that they were immune to splenomegaly. In view of the results obtained, the incorporation of cashew kernel meal, in the diets of laying hens could be an interesting alternative to the use of conventional soybean meal and corn.

Keywords: *cashew kernel meal, laying hen, regulatory organs, organ biometry*

Cite This Article: Silué Fatogoma Etienne, Ouattara Adidjatou, Yéboué Kouamé Hermann, Ouattara Karamoko, and Kati-Coulibay Séraphin, "Effect of Cashew Kernel Meal on Blood Biochemical Parameters and Biometry of Organs Regulating Nutritional Metabolism in Laying Hens." American Journal of Food Science and Technology, vol. 11, no. 4 (2023): 150-155. doi: 10.12691/ajfst-11-4-4.

1. Introduction

In recent years, the poultry industry has emerged as a relevant approach to meeting the growing demand for animal protein [1]. Eggs are the animal protein source with the best nutritional value, as well as being the cheapest, easiest to use and possessing a large number of techno-functional properties that are put to good use in cooking [2]. While the success of a poultry farm depends on a number of factors (breed, environment, etc.), nutrition is the key factor in the expression of poultry's genetic potential.

Feed provides the energy, protein and nutrients essential for growth, reproduction and health [3,4]. They are essential for maintaining the animal's basic metabolism and for meat and egg production [5]. However, feed accounts for 60-70% of direct production costs in poultry farming [6]. As a result, African countries are suffering from the escalating costs of compound feeds, raw materials and, above all, protein feed inputs used by farmers in general and poultry farmers in particular [7]. Increasing quantities of cereals and soybeans are being imported from producer countries, resulting in substantial outflows of foreign currency [8].

To alleviate this problem, research and development efforts should focus on assessing locally available non-conventional or alternative feed resources, particularly for poultry [9]. In Côte d'Ivoire, cashew kernels are available and can be used for this purpose. Like all oleaginous fruits, cashew kernels are rich in protein, carbohydrates and polyunsaturated fatty acids (PUFAs) [10]. With these properties, does the use of cashew kernel meal have an impact on the regulatory organs of nutritional metabolism in hens?

The present study is a contribution to the search for solutions to poultry nutrition problems. The general objective is to enhance the value of cashew kernel meal in poultry nutrition, and more specifically in laying hens. The specific objectives are to observe the pathophysiological state of the organs regulating the nutritional metabolism of hens fed diets containing cashew kernel meal.

2. Material and Methods

2.1. Diet Preparation

The ingredients used in the experimental feeds consisted of several agricultural raw materials: yellow corn, imported soybean meal, cottonseed meal, wheat bran and low-grade rice flour. Downgraded cashew kernels were used to produce the meal. Apart from these agricultural raw materials, some of the inputs used were shellfish, fish meal, lysine, methionine, premix and salt from commercial sources.

Four iso-protein and isoenergy diets named Rt, R10, R15 and R20 were prepared [11]. These provided 0%, 10%, 15% and 20% cashew kernel meal respectively. (Table 1).

2.2. Animal Material and Raising Hens

Ninety-six (96) 20-week-old LOHMANN-Brown pullets with an average weight of 1600 ± 36.7 g were used in this study. They were raised at the experimental farm of the Bingerville School of Livestock and Meat Trades (ESEMVB).

The hens were grouped in batches of four in a compartmentalized hen house (1.0 m x 1.35 m), on a litter-covered floor. They were selected and randomly assigned to an experimental design based on four diets designated Rt, R10, R15 and R20. Each experimental diet was repeated on six (6) groups of hens. The experimentation lasted ten (10) weeks, divided into two phases: an initial adaptation period of two (2) weeks and the actual experimentation lasting eight (8) weeks [12].

Table 1. Chemical composition of different diets

Experimental diets				
Ingredients (Kg)	Rt	R10	R15	R20
Corn	0.6455	0.5100	0.4434	0.3655
Wheat bran	0.0000	0.0300	0.0600	0.0700
Rice flour	0.0000	0.0500	0.0700	0.1100
Soybean meal 44	0.2060	0.1296	0.0605	0.0503
Cashew kernel cake	0.0000	0.1000	0.1500	0.2000
Cotton cake	0.004	0.0279	0.0500	0.0500
Fish meal	0.0400	0.0400	0.0537	0.0417
Oyster shell	0.0880	0.0880	0.0880	0.0880
TNH Eggs 1.25 %	0.0125	0.0125	0.0125	0.0125
Salt (NaCl)	0.0020	0.0020	0.0020	0.0020
Sepiolite	0.0020	0.0100	0.0100	0.0100
TOTAL (Kg)	1	1	1	1
Calculated values				
Metabolizable energy (kcal / kg)	2 756	2 756	2 756	2 756
Crude Protein (%)	17.28	17.25	17.28	17.28
Fat (%)	3.05	5.05	6.13	7.13
Crude cellulose (%)	2.79	3.95	4.53	5.30
Calcium (%)	3.35	3.37	3.46	3.41
Phosphorus (%)	0.17	0.22	0.29	0.29

Rations Rt, R10, R15 and R20 : incorporation rates of 0%, 10%, 15% and 20% of cashew kernel cake respectively

2.3. Blood Sampling

At the end of the experiment, the hens' blood was collected for analysis of biochemical parameters. The wing vein was the most convenient site for blood sampling. The hen was held on its back and a 20-gauge needle, one inch long, was inserted into the wing vein. As soon as the first drops of blood appear in the needle tip, the syringe is uncapped and the amount of blood required for analysis is collected.

Between 8 a.m. and 10 a.m., approximately 5 ml of blood was collected from the animals in EDTA tubes for CBC analysis, and in dry tubes for lipid metabolism analysis. The tubes were stored in a cooler and transported immediately by car to the laboratory for analysis. Blood collected in dry tubes was first centrifuged at 3,000 rpm for 10 min, in a refrigerated centrifuge (Alresa Orto, Spain) at 4°C [13]; the serum collected and deposited in hemolysis tubes was then stored in a freezer (0°C), pending the determination of biochemical parameters.

2.4. Determination of Blood Biochimic Parameters

Serum metabolite assays were performed on serum samples, using a "HITACHI 902 - Roche, Japan" autoanalyzer. Biological constants were determined in a reagent compartment and a sample, control and calibrator compartment. The autoanalyzer uses standard techniques for the determination of blood parameters.

2.5. Biometric Study of Hen Organs in Diets

At the end of the experiment, twelve hens subjected to a 16-hour fast, at a rate of three hens per diet, were sacrificed by decapitation after anesthesia with ethyl urethane [14,15]. A longitudinal laparotomy was performed on the hens to isolate the heart, liver, kidneys, spleen and gizzard. These organs, once weighed, were preserved in boxes containing formalin diluted to the 10th. Only the organs regulating nutrition (livers, kidneys and hearts) were sent to the Laboratory for histological study.

Relative organ weights were expressed as a percentage of the animal's live weight obtained during the last weighing (1). The study involved the liver, kidneys and heart, to which the spleen and gizzard were added. Relative organ weights were determined using the following formula:

$$\textit{Relative organ weight} = \frac{\textit{weight of the organ}}{\textit{final live animal weight}} \times 100 \quad (1)$$

2.6. Statistical Analysis

The results obtained in this study were analyzed using Statistica Version 7.1 software. The mean values per diet from the study criteria were subjected to an analysis of variance (ANOVA), followed by a comparison of means according to the Newman-Keuls test at the 5% significance level. Numerical calculations and graph construction were performed with Excel software.

3. Results

3.1. Mean Values of Serum Metabolites

The mean values of serum metabolites in hens on the different diets are shown in Table 2. Blood glucose levels observed in hens fed the different experimental cashew kernel meal diets R10, R15 and R20 were 2.01 ± 0.01 g/l, 2.15 ± 0.01 g/l and 2.05 ± 0.05 g/l respectively. A significant decrease ($p \leq 0.05$) was observed compared with the blood glucose level of the Rt control diet (2.37 ± 0.10 g/l). The R20 diet induced a significant ($p \leq 0.05$) decrease in total cholesterol levels (0.73 ± 0.07 g/l) compared to the Rt control diet (1.04 ± 0.02 g/l) in hens.

Table 2. Average serum metabolite values for hens on different diets

Parameters	Diets			
	Rt	R10	R15	R20
Glucose (g/l)	2,37 ± 0,10[a]	2,01 ± 0,01[b]	2,15 ± 0,01[b]	2,05 ± 0,05[b]
Triglycerides (g/l)	6,82 ± 1,70[a]	5,34 ± 0,04[a]	5,57 ± 0,01[a]	3,59 ± 0,23[a]
Total Protein (g/l)	52,86 ± 9,32[a]	52,73 ± 2,97[a]	55,03 ± 0,01[a]	54,23 ± 0,01[a]
Total cholesterol (g/l)	1,04 ± 0,02[a]	1,00 ± 0,01[a]	1,06 ± 0,01[a]	0,73 ± 0,07[b]
HDL-cholesterol (g/l)	0,29 ± 0,01[a]	0,25 ± 0,03[a]	0,28 ± 0,01[a]	0, 21 ± 0,01[a]
LDL-cholesterol (g/l)	0,79 ± 0,15[a]	0,79 ± 0,02[a]	0,72 ± 0,20[a]	0,71 ± 0,05[a]
Urea (g/l)	0,056 ± 0,01[a]	0,04 ± 0,01[a]	0,04 ± 0,01[a]	0,05 ± 0,01[a]
Creatinine (mg/l)	3,16 ± 0,12[a]	3,50 ± 0,17[a]	3,06 ± 0,12[a]	3,40 ± 0,10[a]
Uric acids (mg/l)	62,80 ± 0,11[a]	56,25 ± 1,47[b]	42,70 ± 0,57[c]	37,56 ± 0,52[d]
Total bilirubin (mg/l)	2,10 ± 0,57[b]	3,13 ± 0,03[a]	3,20 ± 0,11[a]	3,43 ± 0,06[a]
Conjugated bilirubins (mg/l)	0,16 ± 0,06[a]	0,30 ± 0,11[a]	0,20 ± 0,05[a]	0,36 ± 0,03[a]

[a,b]There is no significant difference ($p > 0.05$) between two means ± standard deviation on the same line. Rt: Control diet; R10: Diet with 10% cashew nut kernel meal, R15: Diet with 15% cashew nut kernel meal, R20: Diet with 20% cashew nut kernel meal

No significant differences ($p > 0.05$) were observed between the values for hens on the different diets (Rt, R10, R15 and R20) for triglycides, total protein, HDL-cholesterol, LDL-cholesterol, urea, creatine and conjugated bilirubin.

The atherogenicity index was 3.72 ± 0.50 for hens on the Rt diet, 2.19 ± 0.09 on the R10 diet, 3.54 ± 0.70 on the R15 diet and 2.05 ± 0.20 on the R20 diet (Figure 1). No significant differences were observed between diet values.

3.2. Average Serum Electrolyte Values

The average serum electrolyte values of hens on the different diets are shown in Table 3. Plasma phosphorus values were 214.200 ± 57.59 mg/l for the Rt control regimen; 197.96 ± 41.58 mg/l for R10; 134.76 ± 59.35 mg/l for R15 and 188.86 ± 3.15mg/l for R20. Plasma calcium values were 72.56 ± 9.59 mg/l for the Rt control regimen; 68.10 ± 6.98 mg/l for R10; 50.33 ± 2.62 mg/l for R15 and 66.26 ± 4.13 mg/l for R20.

The Calcium/Phosphorus ratio of the Rt control diet was 2.93 ± 0.08. For diets R10, R15 and R20, the Calcium/Phosphorus ratios obtained were 2.96 ± 0.49, 2.75 ± 0.83 and 2.87 ± 0.17 respectively. Consumption of cashew kernel meal at different levels did not cause any significant variation ($p > 0.05$) in hen plasma phosphorus and calcium concentrations.

The mean blood magnesium value obtained was 27.43 ± 2.82 mg/l for hens on the Rt control diet, 26.00 ± 0.57 mg/l for R10, 23.70 ± 1.47 mg/l for R15 and 23.53 ± 0.98 mg/l for R20. The R10, R15 and R20 diets produced no significant variation ($p > 0.05$) in magnesium content compared with the magnesium obtained in hens on the control batch.

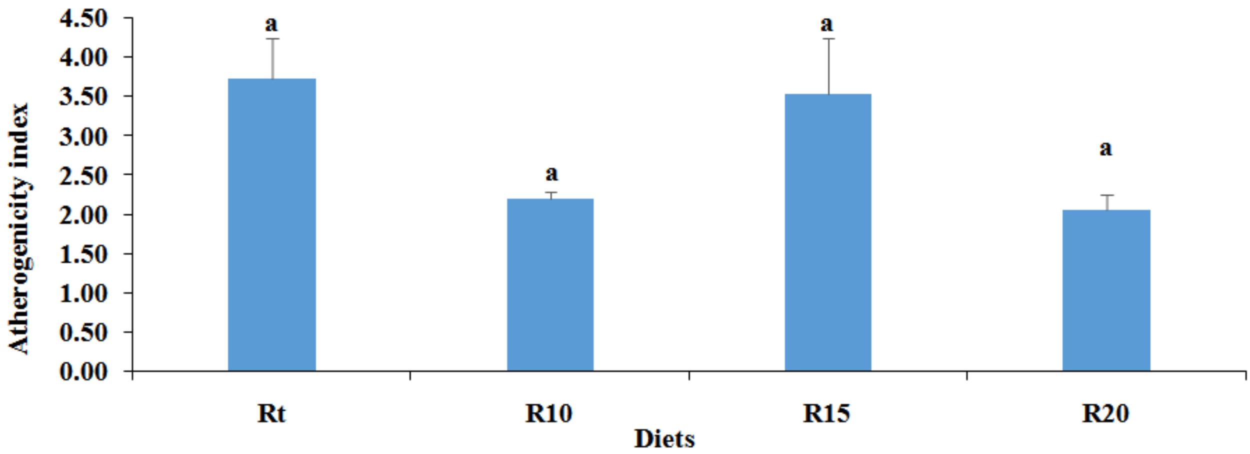
The Fe^{2+} concentration of the Rt control diet was 0.70 ± 0.05 mg/l. Regimes R10, R15 and R20 obtained Fe^{2+} values of 0.48 ± 0.04 mg/l, 0.43 ± 0.03 mg/l and 0.54 ± 0.03 mg/l respectively. Statistical analysis shows that the Fe^{2+} value of the Rt control diet is higher ($p \leq 0.05$) than those obtained with the R10, R15 and R20 diets.

Mean plasma sodium values were 159.56 ± 1.07 mg/l for the Rt control regimen, 156.33 ± 4.67 mg/l for R10, 151.33 ± 3.47 mg/l for R15 and 145.73 ± 12.32 mg/l for R20. Plasma potassium values were 4.72 ± 0.70 mg/l for the Rt control diet, 4.28 ± 0.26 mg/l for R10, 4.23 ± 0.29 mg/l for R15 and 4.93 ± 0.08 mg/l for R20. Consumption of cashew kernel meal at different levels did not cause a significant difference ($p > 0.05$) in plasma sodium and potassium concentrations.

3.3. Mean Values of Hematological Parameters

Table 4 shows the mean values of hematological parameters for hens fed the different diets. Hens fed diets containing 10%, 15% and 20% cashew kernel meal obtained mean hematological values ranging from 242.12 ± 11.94.103/µl to 352.85 ± 1.59.103/µl for white blood cells, from 2.07 ± 0.00. 103/µl to 2.61 ± 0.16.103/µl for red blood cells, from 6.83 ± 0.12 g/dl to 8.76 ± 0.26 g/dl for hemoglobin, from 27.00 ± 0.0% to 35.46 ± 0.12% for hematocrit and from 214.77 ± 7.41.103/µl to 332.66 ± 0.88.103/µl for lymphocytes. These hematological parameters (white blood cells, red blood cells, hemoglobin, hematocrit, lymphocytes) for hens on the R20 diet were significantly higher ($p \leq 0.05$) than those observed in hens on the Rt control diet.

Other hematological parameters, such as GMV, MHT, MCHC, Platelets, Monocytes and Granulocytes, ranged respectively from 126.53 ± 0.59 fl to 133.00 ± 3.90 fl, from 31.03 ± 0.45 pg to 33.70 ± 0.86 pg, from 24.40 ± 0.55 g/dl to 25.36 ± 0.35 g/dl, from 1.33 ± 0.33. 103/µl to 2.00 ± 0.57.103/µl, from 0.49 ± 0.38.103/µl to 0.98 ± 0.31.103/µl and from 18.02 ± 6.95.103/µl to 26.33 ± 4.72.103/µl. Hematological parameters VGM, TCMH, CCMH, Plaquette and Monocytes of diets R10, R15 and R20 showed no significant difference ($p > 0.05$) compared with the control diet.



[a] There is no significant difference ($p > 0.05$) between two values designated by the same letter. Rt: Control diet; R10: Diet with 10% cashew nut kernel meal, R15: Diet with 15% cashew nut kernel meal, R20: Diet with 20% cashew nut kernel meal

Figure 1. Atherogenicity index of hens on different diets

Table 3. Average serum electrolyte values of hens on different diets

Parameters	Diets			
	Rt	R10	R15	R20
Phosphorus [P^{5+} (mg/l)]	72,56 ± 9,59 [a]	68,10 ± 6,98 [a]	50,33 ± 2,62 [a]	66,26 ± 4,13 [a]
Calcium [Ca^{2+} (mg/l)]	214,200 ± 57,59 [a]	197,96 ± 41,58 [a]	134,76 ± 59,35 [a]	188,86 ± 3,15 [a]
Magnesium [Mg^{2+} (mg/l)]	27,43 ± 2,82 [a]	26,00 ± 0,57 [a]	23,70 ± 1,47 [a]	23,53 ± 0,98 [a]
Iron [Fe^{2+} (mg/l)]	0,70 ± 0,05 [a]	0,48 ± 0,04 [b]	0,43 ± 0,03 [b]	0,54 ± 0,03 b
Sodium [Na^{+} (mg/l)]	159,56 ± 1,07 [a]	156,33 ± 4,67 [a]	151,33 ± 3,47 [a]	145,73 ± 12,32 [a]
Potassium [K^{+} (mg/l)]	4,72 ± 0,70 [a]	4,28 ± 0,26 [a]	4,23 ± 0,29 [a]	4,93 ± 0,08 [a]
Ca^{2+}/P^{5+}	2,93 ±0,08 [a]	2,96 ±0,49 [a]	2,75 ±0,83 [a]	2,87 ±0,17 [a]

[a,b]There is no significant difference ($p > 0.05$) between two means ± standard deviation on the same line. Rt: Control diet; R10: Diet with 10% cashew nut kernel meal, R15: Diet with 15% cashew nut kernel meal, R20: Diet with 20% cashew nut kernel meal

Table 4. Average hematological values for hens on different diets

Parameters	Diets			
	Rt	R10	R15	R20
White blood cells (10^3/µl)	242,12 ± 11,94 [a]	264,12 ± 2,09 [a]	251,51 ± 7,74 [a]	352,85 ± 1,59 [b]
Red blood cells (10^3/µl)	2,18 ± 0,04 [a]	2,28 ± 0,01 [a]	2,07 ± 0,01 [a]	2,61 ± 0,16 [b]
Hemoglobin (g/dl)	7,36 ± 0,35 [a]	7,06 ± 0,12 [a]	6,83 ± 0,12 [a]	8,76 ± 0,26 [b]
Hematocrit (%)	29,13 ± 1,31 [a]	28,93 ± 0,18 [a]	27,00 ± 0,05 [a]	35,46 ± 0,12 [b]
GVM (fl)	133,00 ± 3,90 [a]	126,53 ± 0,59 [a]	130,03 ± 0,54 [a]	127,10 ± 0,70 [a]
MHT (pg)	33,70 ± 0,86 [a]	31,03 ± 0,45 [a]	32,90 ± 0,66 [a]	31,50 ± 1,01 [a]
MCHC (g/dl)	25,36 ± 0,35 [a]	24,40 ± 0,55 [a]	25,30 ± 0,45 [a]	24,73 ± 0,66 [a]
Platelets (10^3/µl)	2,00 ± 0,57 [a]	1,66 ± 0,66 [a]	1,66 ± 0,33 [a]	1,33 ± 0,33 [a]
Lymphocytes (10^3/µl)	214,77 ± 7,41 [a]	240,33 ± 7,44 [a]	233,33 ± 12,54 [a]	332,66 ± 0,88 [b]
Monocytes (10^3/µl)	0,70 ± 0,06 [a]	0,70 ± 0,26 [a]	0,98 ± 0,31 [a]	0,49 ± 0,38 [a]
Granulocytes (10^3/µl)	26,33 ± 4,72 [a]	23,10 ± 5,60 [a]	18,02 ± 6,95 [a]	20,14 ± 0,24 [a]

[a,b]There is no significant difference ($p > 0.05$) between two means ± standard deviation on the same line. Rt: Control diet; R10: Diet with 10% cashew nut kernel meal, R15: Diet with 15% cashew nut kernel meal, R20: Diet with 20% cashew nut kernel meal

3.4. Biometry of Organs

The relative organ weights of hens on the different diets are shown in Table 5. Overall, these results do not show any major significant differences, with the exception of the relative weight of the spleen, which is significantly different ($p \leq 0,05$).

The relative kidney weights of hens fed the different diets ranged from 0.47 ± 0.02% on the Rt diet to 0.67 ± 0.04% on the R20 diet. Hens fed the R10 diet had a relative kidney weight of 0.45 ± 0.10%. Relative kidney weights for animals fed the R15 diet were 0.52 ± 0.08%.

Relative liver weight was 1.80 ± 0.13% for hens fed the Rt control diet. Relative liver weights of 1.77 ± 0.08%, 1.96 ± 0.147% and 1.57 ± 0.25% were recorded for hens fed the R10, R15 and R20 diets respectively.

Hens fed the Rt control diet achieved a relative heart weight of 0.38 ± 0.02%. Relative heart weights obtained with hens fed the R10, R15 and R20 experimental diets were 0.37 ± 0.03 0.02%; 0.38 ± 0.02% and 0.36 ± 0.03% respectively.

Relative spleen weight was 0.11 ± 0.01% for the Rt control diet. For diets R10, R15 and R20, the relative spleen weights recorded on the hens were 0.08 ± 0.01; 0.08% ± 0.01 and 0.06 ± 0.01% respectively.

Hens fed the Rt control diet obtained relative gizzard weights of 1.72 ± 0.06%. Relative gizzard weights obtained with hens fed the R10, R15 and R20 experimental diets were 1.78 ± 0.08%; 1.84 ± 0.11% and 1.91 ± 0.16% respectively.

Table 5. Relative organs weights of hens fed different diets

Organs	Diets			
	Rt	R10	R15	R20
Kidneys	0,47 ± 0,02 [a]	0,45 ± 0,10 [a]	0,52 ± 0,08 [a]	0,67 ± 0,04 [a]
Livers	1,80 ± 0,13 [a]	1,77 ± 0,08 [a]	1,96 ± 0,17 [a]	1,57 ± 0,25 [a]
Hearts	0,38 ± 0,02 [a]	0,37 ± 0,03 [a]	0,38 ± 0,02 [a]	0,36 ± 0,03 [a]
Rates	0,11 ± 0,01[a]	0,08 ± 0,01 [b]	0,08 ± 0,01 [b]	0,06 ± 0,01 [b]
Gizzards	1,72 ± 0,06 [a]	1,78 ± 0,08 [a]	1,84 ± 0,11 [a]	1,91 ± 0,16 [a]

[a,b] There is no significant difference (p > 0.05) between two means ± standard deviation on the same line. Rt: Control diet; R10: Diet with 10% cashew nut kernel meal, R15: Diet with 15% cashew nut kernel meal, R20: Diet with 20% cashew nut kernel meal

4. Discussion

Analysis of the results of cashew kernel meal consumption by hens reveals that the effects have very little to do with average metabolite values. In fact, consumption of the diets led to a significant decrease in mean values for glucose, total cholesterol and uric acid. Conversely, it caused a significant increase in total bilirubin.

Glucose levels ranged from 2.01 to 2.37 g/l. According to the authors [16], In poultry, usual blood glucose values are around 2.27-3g/l. Cholesterol levels in this study ranged from 0.73 to 1.06 g/l. These values are around 0.52 and 1.52 g/l in chickens, indicating a normal level of cholesterol in the blood of hens fed cashew nut meal-based diets. The reduction in blood sugar and cholesterol levels in the R10, R15 and R20 diets was due to the presence of monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA) in cashew kernels. The various changes brought about by MUFA and PUFA were at the root of the different reductions in cholesterol levels observed in several studies [17,18]. In these studies, the authors succeeded in reducing serum cholesterol levels in laying hens fed diets supplemented with PUFAs. This result is confirmed by the work of Nicklas [19], who demonstrated that the majority (60%) of the lipids contained in cashew kernels are in the form of monounsaturated fatty acids (oleic acid and α-linoleic acid), a type of fatty acid with beneficial effects on cardiovascular health. Replacing saturated fatty acids in the diet with monounsaturated fatty acids lowers total cholesterol, without reducing HDL ("good") cholesterol.

Dietary fat saturation plays a major role in modulating plasma cholesterol concentrations and determining the risk of coronary heart disease (CHD) [20]. This result is confirmed by the atherogenicity index, which is unaffected by cashew kernel meal. Atherosclerosis is a disease of the arteries, the cause of most serious cardiovascular accidents. An increase in body mass index does not always lead to an increase in the atherogenicity index, as measured by biochemical parameters [21].

A very significant drop in plasma uric acid concentrations was found between the batches of hens studied, depending on the rate of cashew kernel meal incorporation. This could be due to a decrease in protein quality in cashew kernel meal diets. Authors have demonstrated a direct relationship between dietary protein levels and plasma uric acid concentrations [22]. The high protein content typical of the starter food resulted in higher plasma uric acid concentrations. The assessment of uric acid concentrations, in plasma or serum, is widely used in poultry for the detection of kidney disease. Age and diet appear to be the two main factors influencing blood uric acid levels in poultry. Very different plasma uric acid levels in two strains of broiler chickens have been described and indicated that hyperuricemic subjects were highly predisposed to articular gout [23]. Uric acid is the main product of nitrogen catabolism, essentially synthesized by the liver.

Uricemia recorded in hens fed different diets ranged from 40 to 56 mg/l. The values accepted are around 30 to 100 mg in poultry [24]. Uricemia is therefore normal. Creatinine levels recorded in all batches of hens ranged from 3.06 to 3.50 mg/l. This value is below the usual standard, which is between 9 and 18 mg/l in broilers [25]. It also indicates that creatinine production is relatively constant and very little affected by dietary or tissue protein catabolism. The stability of uric acid, uremia and creatinine concentrations suggests that hens are not at risk of impaired renal function [15].

Bilirubin is the breakdown product of red blood cells. Its concentration level increased in hens fed the R20 diet. Bilirubin levels in hens remain low, but increases in this parameter have been observed in cases of severe liver disease. An increase in total bilirubin would indicate liver disease [26].

In birds, infectious diseases lead to inflammation and a significant reduction in plasma iron, which accumulates in the liver. Hypoferemia may be conducive to bacterial growth inhibition, so dietary correction of low plasma iron levels is questionable [27]. The ratio of serum calcium to serum phosphorus was greater than 2. This ratio of serum calcium to serum phosphorus reflects good metabolism of these two minerals by hormones (parathormone and calcitonin) [28].

The weight evolution of certain organs involved in digestion and nutrient absorption is an indirect way of exploring so-called regulatory organs in nutrition studies [29]. The atrophy or hypertrophy of an organ, if not physiological, may be indicative of pathology. In this case, it is indicative of a disturbance in nutritional metabolism within the organ. In this study, the absence of weight variation in kidneys, livers, hearts and gizzards shows that cashew kernel meal had no deleterious effects on the body's immune responses. On the other hand, spleen mass decreased in hens fed the R10, R15 and R20 diets. This reduction in spleen mass shows that these hens are immune to splenomegaly. The spleen plays a fundamental role in immunoglobulin production [30].

5. Conclusion

The present study was prompted by the search for a solution to the problem of adding value to agricultural products by improving protein levels in animal nutrition and the nutritional quality of poultry products. The general objective of this work was to add value to cashew nut kernels in the nutrition of laying hens. Once the nutritional values of these kernels have been highlighted, they could be valorized and used as animal feed, particularly for poultry. In addition, their effects on blood biochemical parameters and the biometry of organs regulating nutritional metabolism were studied.

All these results enable us to understand the effects of cashew kernel meal consumption levels on the well-being of laying hens. Analysis of mean hematological values shows that cashew kernel meal lowers blood sugar and total cholesterol levels. Biometric measurements of the spleen, gizzard, heart, kidneys and liver showed that diets containing cashew kernel meal did not cause any disturbance.

The results indicate that the consumption of cashew kernel meal had very little impact on hematological and biometric parameters. In view of the results obtained, the incorporation of cashew kernel meal, in the diets of laying hens, could be an interesting alternative to the use of conventional soybean meal.

ACKNOWLEDGEMENTS

We would like to thank Dr Achi Louise Atsé, Director of the Ecole de Specialisation en Elevage et Métiers de la Viande (ESEMV) de Bingerville, who provided us with a henhouse for the experiment.

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