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Solvent-extracted cashew nut meal as a dietary protein source for layer chicks

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Abstract

This study aimed to produce a low-fat cashew nut meal (CNM) containing less than 6% fat and assess its effect on layer chick growing performance and health status. The experiment used 225 one-day-old layer ISA Brown chicks with an average live weight of 27.38 ± 1.85 g, divided into 15 batches of 15 animals each. Five diets containing 0, 25, 50, 75, and 100% CNM as a replacement for soybean meal were tested. The test included three replicates of 15 chicks for each diet. The CNM was obtained after oil extraction using an automatic press followed by solvent extraction. The CNM contained 40.6% crude protein and 5.38% fat. Except for the chicks fed on the 100% CNM diet that had the worst growth performance parameters, those on the other diets had an average final live weight of 662.13 g and an average feed conversion ratio of 2.76. The highest average daily gain (15,07g/d) was observed in chicks on the 75% CNM diet. Hematological analyses showed no marked difference between the animal groups. Regarding the blood biochemical profile, the total cholesterol levels were similar in the chicks for all diets. High-density lipoprotein cholesterol levels were 1.4 times higher in the chicks fed on CNM-based diets compared to those fed a soybean meal-based diet. It was concluded that low-fat CNM could replace soybean meal by up to 75% in layer chick feed without negative effects on growth performance and health status.

Keywords: biochemical profile, growth, health, hematological parameters
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Introduction

One of the main problems faced by most stakeholders in the poultry sector is the high cost of raw materials used in animal feed. The value of agricultural by-products in animal nutrition presents a solution to this problem (Batonon-Alavo *et al.*, 2015). Thus, cashew by-product use in poultry feed is of great interest in cashew-producing countries. Cashew (*Anacardium occidentale*) belongs to the Anacardiaceae family. At maturity, it produces a false fruit (cashew apple) and a true fruit (cashew nut) (Lautié *et al.*, 2001). Industrially, the cashew nut is processed for human consumption. During processing, 30–35% of the kernels are rejected because they do not reach the minimum quality required for human consumption (Sharma *et al.*, 2020). These discarded cashews are mainly intended for animal feed. Indeed, cashew nut meal is an excellent source of protein (35%) (Akande *et al.*, 2015). It can replace soybean meal, which is an important source of protein, together with fish meal, in poultry feed. Therefore, cashew nut meal (CNM) use in poultry feed has been the subject of several studies (Odunsi, 2002; Freitas *et al.*, 2006; Vidal *et al.*, 2013; Akande *et al.*, 2015; Cruz *et al.*, 2015; Panaite *et al.*, 2017; Silué *et al.*, 2020). CNM is fat-rich (Heuzé *et al.*, 2017). This high-fat content of CNM imposes a limit on its incorporation in poultry feed of <20% (Akande *et al.*, 2015). A diet too high in fat leads to excessive fattening in poultry and a reduction in growth performance. In layer chicks, the diet should be relatively low in fat (2–5%) to ensure a good career for future layers (Bordeaux & Roinsard, 2015). However, most studies carried out on the subject only use a mechanical method (with presses) to extract oil from cashew nut. This method does not facilitate the production of low-fat CNM and makes it difficult to formulate diets containing less than 5% fat with CNM of more than 20% (Akande et al., 2015; Panaite

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et al., 2017; Silué et al., 2020). In addition, existing studies on the same subject have been carried out on older chickens (Vidal *et al.*, 2013; Akande et al., 2015; Silué et al., 2020).

Therefore, this study aimed to produce a low-fat CNM containing less than 6% fat, and assess the effect of its incorporation into the diet on layer chick growth performance and health status. The study hypothesis was that soybean meal could be fully replaced by CNM without any impairment on layer chick growth'. The effect on growth performance of replacing 0, 25, 50, 75, and 100% soybean meal by CNM was assessed.

Materials and Methods

The study was carried out at the Institut National Polytechnique Félix Houphouët-Boigny (Yamoussoukro, Côte d'Ivoire, 6°49′48.0″ N, 5°17′24.0″ W). The region's climate is characterized by temperatures of 18–35 °C and relative humidity of 75–85%. The experiment used 225 one-day-old layer ISA Brown chicks with 27.38 ± 1.85 g average weight. The chicks were divided into 15 groups of 15 animals and housed for the first four weeks in a closed rearing house comprising 15 boxes of 1 m^2. During this step, the chicks were heated with 100-watt infrared electric lamps. From 4–8 weeks of age, the chicks were reared in a screened house subdivided into 15 boxes measuring 4 m² each. At this stage, the chicks were reared on a wooden tray, letting the waste pass through. During this study, general rules for animal experimentation were followed in accordance with the guide for the Care and Use of Farm Animals in Research and Education (FASS, 2010). In the absence of an ethics committee, the Scientific Council of the Joint Research Unit in Agronomic Sciences and Rural Engineering of the Institut National Polytechnique Félix Houphouët-Boigny gave its approval for this study.

Five diets were tested. In these diets, CNM was incorporated at 0, 25, 50, 75, and 100%, as a soybean meal substitute.The experimental diets are named C0, C25, C50, C75 and C100 in reference to the substitution of soybean for cashew nut meal. The cashew kernel meal used was obtained after oil extraction using an automatic press (Home ATK model 245-885-757, Zhengzhou, China), set at 200 °C, followed by solvent extraction in a hermetically sealed stirring tank. Before feed formulation, the raw material chemical composition, including dry matter, ash, fat, crude cellulose, crude protein, and metabolizable energy (ME) was determined. The ingredient formulation used in the experimental diets and chemical composition of the feeds is reported in Table 1. Each diet was assigned to three batches of 15 chicks each; a batch constituted a replicate. During the first week, 5 g of feed per animal per day was distributed. This quantity was increased each week according to the birds consumption.

Table 1 Ingredients and chemical composition of the experimental diets in which cashew nut meal (CNM) was substituted at 0, 25, 50, 75, and 100% for soybean meal in layer chick feeds for 8 weeks

	Experimental foods				
	C0	**C25**	**C50**	**C75**	**C100**
Ingredients (%)					
Corn grain	64	64	64	64	64
Soybean meal	32	24	16	8	0
Cashew nut meal (CNM)	0	8	16	24	32
Vitamins and mineral mixture*	4	4	4	4	4
Chemical composition (g/kg of raw product except metabolizable energy)					
Dry matter, g/kg	852.0	855.0	858.5	862.0	865.4
Crude ash, g/kg	29.1	27.6	26.0	24.5	22.9
Crude protein (CP, N×6.25), g/kg	199.9	199.3	198.7	198.1	197.5
Fat, g/kg	38.9	40.3	41.6	43.0	44.3
Crude fibre, g/kg	35.0	32.0	29.1	26.1	23.2
Metabolizable Energy (kcal/kg)	2892	2988	3084	3180	3276

*vit A (IU) 300,000; vit D3 (IU) 80,000; vit E (mg) 1750; vit K3; vit B1 (mg) 75; vit B2 (mg) 190; vit B5 (mg) 420; vit B6 (mg) 106; niacin (mg) 1500; vit B12 (mg) 0.5; folic acid (mg) 40; biotin (mg) 7.5; phosphorus (%) 8; calcium (%) 28; sodium (%) 3; anticoccidial (mg) 25; choline (mg) 8000; phytase (FTU) 12500; iron (mg) 1300; copper (mg) 630; zinc (mg) 2500; manganese (mg) 3000; selenium (mg) 7,5; iodine (mg) 28; D-L methionine; L-lysine

Feed quantities distributed to the animals were weighed daily. Feed refusals were weighed every morning. The chicks were weighed weekly. Bird mortality and morbidity checks were performed daily until the experiment ended. The morbidity check consisted of global examination (lively or prostrate), followed by the search for clinical signs characteristic of digestive disorders (diarrhoea, faecal colour). At the end of the experiment, which lasted 8 weeks, blood samples were collected from six chickens per diet for haematological and biochemical profile studies. Blood samples were taken in the wing vein using a syringe.

The ingredients and feed dry matter were determined according to the Official Methods of Analysis (AOAC, 1995). Ash content was determined following the AOAC (1995) method. Fat content was determined using the Folch (1957) method. Crude protein content was determined using the Kjeldahl method (BIPEA, 1976). Total carbohydrates and metabolizable energy were determined using calculations (FAO, 2003). Blood haematological parameters and biochemical profiles were analysed using a Zybio Automaton (Shenzhen, China), and a Forward Semi-automaton (Guangzhou, China)m respectively.

Statistical analyses of collected data were performed using R software (R Development Core Team, 2022). Zootechnical and blood parameters were analysed using a one-way analysis of variance with diet as the source of variation. Multiple comparisons of means were performed using Tukey tests, at a 95% level of significance ($\alpha = 0.05$).

Results and Discussion

The CNM chemical composition is recorded in Table 2. The CNM crude protein and fat content were 40.6% and 5.38%, respectively. These values were different than those obtained by Akande *et al.* (2015) and Silué *et al.* (2020), who obtained crude protein content of 22–36% and fat content of 15–25%. These differences can be explained by the oil extraction methods used in these different studies. Indeed, these authors used an extraction with a mechanical press. In the present study, a mechanical extraction coupled with a solvent extraction was used. This double extraction has the advantage of obtaining a high-protein and low-fat CNM.

Figure 1 shows the growth curve and Table 3 the zootechnical parameters of the chicks from 0 to 8 weeks of age. At the end of the experiment, the chicks fed on C0, C25, C50, and C75 diets obtained the same average weight (662 g). The chicks fed on the C100 diet had a final average weight 130 g lower than the other diets. The chicks fed the C25, C50, and C75 diets had the same average daily gain, feed intake, and feed conversion ratio as the chicks on the control diet (C0). C100 produced the worst results. The results obtained for the C100 diet can be explained by the low isoleucine content of cashew nut meal. Indeed, the cashew nut meal, although high in protein and similar in amino acid composition to soybean meal, is deficient in isoleucine (Wardowski & Ahrens, 1990). Chick growth performances recorded in the present trial were better than those obtained by Tossou *et al.* (2019), who recorded an 8-week weight of 589 g, with an average daily weight gain of 9.34 g. The growth performance results obtained in the current study contrasted those of Tossou *et al*. (2019), who worked on the same topic with layer ISA Brown chicks, due to the fact that our experimental diets were richer in protein than theirs. This result is attributable to the fat extraction method used in our study, which produces a higher protein CNM. However, our results remain low compared to the standards set by SAS (2014), who recommend a weight of 671–702 g at 8 weeks of age for ISA Brown strain chicks. It should be noted that the standards set by SAS (2014) apply to chickens raised in a temperate climate, whereas our chicks were raised in a tropical climate.

Chicks fed on the C100 diet had a lower feed intake than those on other diets. This result can be explained by the fact that the C100 diet was higher in metabolizable energy than the others. Indeed, chickens tend to reduce their intake when the energy level in the feed increases (Morinière, 2015). Furthermore, the feed intake recorded in this study (39–40 g/d) is lower than the standards set by SAS (2014) of 49–51 g/d. This result could be due to the climate, which plays a major role in feed intake because animals reduce their daily intake in warm climates to reduce their body heat production (Tierzucht, 2011). In addition, the animals fed on the C100 diet had a feed conversion ratio 1.2 times higher than the other diets. This result is a consequence of the poor growth performance of the animals fed on the C100 diet. The addition of essential amino acids such as isoleucine to improve the C100 diet should allow an enhancement in growth.

Table 2 Cashew nut meal chemical composition (g/kg)

Chemical composition (g/kg as fed)	Cashew nut meal
Dry matter	968.8
Ether extract	53.8
Crude proteins	406.0
Total carbohydrates	459.9
Crude ash	49.1
Metabolizable energy (kcal/kg)	3470.1

Table 3. Growth performance of chicks (mean ± standard error) on experimental diets in which cashew nut meal (CNM) was substituted at 0, 25, 50, 75, and 100% for soybean meal in layer chick feeds for 8 weeks

	Experimental diets					
	C0	C25	C50	C75	C100	*P*-value
Average daily gain (g/d)	14.07±0.21	13.65±0.07	15.05±1.16	15.07±0.15	10.09±0.41	0,0001
Feed intake (g)	39.37±2.02	40.17±1.77	39.72±0.60	39.53±2.71	34.24±2.21	0,0001
Feed conversion ratio	2.80±0.06	2.94±0.03	2.66±0.21	2.62±0.05	3.40±0.11	0,0009

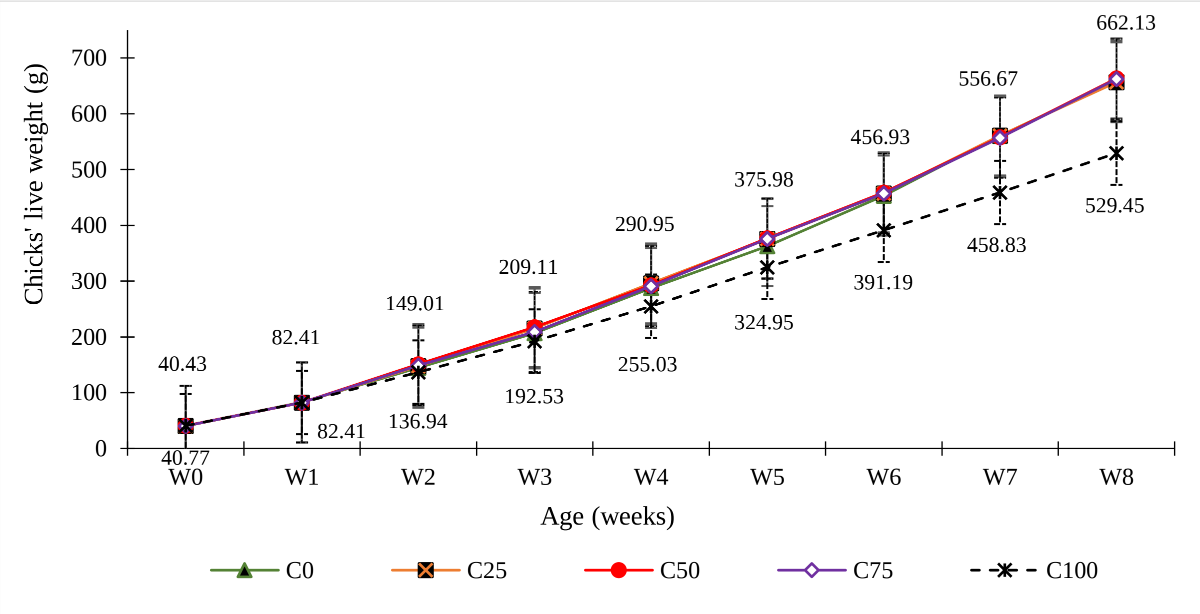

Figure 1 Layer chick growth on experimental diets in which cashew nut meal (CNM) was substituted at 0, 25, 50, 75, and 100% for soybean meal in layer chick feeds for 8 weeks

Throughout the experiment, no mortality or morbidity was observed in the animals. The chicks' haematological parameters at the end of the experiment were not influenced by the diets (P >0.05; Table 4). In addition, the lymphocyte (Lym) average content, red blood cells (RBC), haematocrit (Ht), mean corpuscular volume (MCV), and blood platelets or thrombocytes (PLT) were consistent with the values reported by Bulliot *et al*. (2009). The values for mean white blood cell (WBC) count, mean corpuscular haemoglobin (MCH), and mean corpuscular haemoglobin concentration (MCHC) of the animals fed on these experimental diets were slightly above the standards recommended by Carpenter (2005) and Campbell & Ellis (2007). CNM incorporation in the feed did not alter the haematological parameters of the chicks, since the values obtained were similar to those of the control diet.

Regarding the blood biochemical profile (Table 5), the total cholesterol levels were similar in the chicks for all diets (P >0.05). Triglyceride, uric acid, urea, aspartate aminotransferase, and HDL cholesterol levels were higher in the chicks fed on CNM-based diets compared to chicks fed on soybean meal-based diet (P <0.05). However, creatinine and LDL cholesterol levels were higher in the chicks fed on diets containing soybean meal than in those fed on diets containing CNM. Concerning the biochemical blood profile, the uric acid levels were consistent with the values reported by Larbier & Leclercq (1992). However, the uric acid levels obtained in chicks fed on diets containing cashew meal were substantially higher than in chicks fed on the control diet. Since uric acid is the major final product of nitrogen metabolism in birds, it can be stated that chicks fed on CNM-based diets had more nitrogenous waste elimination than those fed on the control diet. This situation can be explained by the fact that cashew kernel meal is less balanced in isoleucine, an essential amino acid, than soybean meal. Isoleucine addition to cashew meal diets can reduce the nitrogenous waste generated by these diets in chicks.

Table 4. Haematological parameters of chicks (mean ± standard error) on experimental diets in which cashew nut meal (CNM) was substituted at 0, 25, 50, 75, and 100% for soybean meal in layer chick feeds for 8 weeks

	Experimental diets					
	C0	**C25**	**C50**	**C75**	**C100**	**P-value**
WBC (10^3/µL)	47.41±2.00	57.56±2.13	46.71±8.39	51.42±2.55	32.48±11.72	0.052
Lym (%)	78.80±1.45	77.25±2.75	79.85±0.72	80.63±2.47	74.45±1.97	0.136
RBC (10^6/µL)	2.37±0.05	2.60±0.10	2.40±0.34	2.59±0.06	1.68±0.48	0.079
HGB (g/dL)	11.70±0.31	13.10±0.46	11.53±1.64	12.51±0.18	8.26±2.42	0.122
Ht (%)	31.65±0.81	35.65±1.58	31.60±4.50	34.48±0.82	22.66±6.52	0.190
MCV (fL)	133.06±1.26	136.53±1.25	131.20±1.31	132.98±1.07	132.20±2.21	0.095
MCH (pg)	49.25±0.47	50.26±0.69	48.01±0.63	48.26±0.63	47.56±1.48	0.133
MCHC (g/dL)	37.01±0.41	36.90±0.78	36.56±0.21	36.30±0.55	35.95±0.59	0.549
PLT (10^3/µL)	9.66±8.41	18.50±9.13	25.00±7.65	18.33±9.36	30.33±7.58	0.417

**WBC: white blood cells; Lym: lymphocytes; RBC: red blood cells; HGB: haemoglobin; HCT: haematocrit; MCV: mean corpuscular volume; MCH: mean corpuscular haemoglobin; MCHC: mean corpuscular haemoglobin concentration; PLT: blood platelets

However, Sogunle *et al*. (2009), did not find any variation in blood uric acid concentration with a level of 30% cashew kernel incorporation in pullet feed, probably because the diets used in their study were lower in protein than those in the present work. Furthermore, the triglyceride values were within the standards (0.5–2.5 g/L) set by Bulliot *et al.* (2009). However, the triglyceride content obtained in the blood of chicks fed on the CNM-based diets was higher than that of the control diet. Triglycerides are lipid reserves and come from lipid provided by feed but also from hepatic synthesis (Hochleitner, 2013). In the present study, the lipid levels in the CNM-based diets were higher than those in the control diet, suggesting that the excess triglycerides observed in the chicks fed on the cashew meal-based diet were due to the feed. Finally, HDL cholesterol levels were higher in the chicks fed on the cashew meal-based diets compared to the chicks fed on the control. Also called good cholesterol, the role of HDL cholesterol is to capture excess cholesterol in the bloodstream and deliver it to the liver for elimination (Assmann & Gotto, 2004). Cashew meal would therefore be more effective in avoiding the production of cholesterol-rich chicken meat.

Table 5. Blood biochemical profile (mean ± standard error) on experimental diets in which cashew nut meal (CNM) was substituted at 0, 25, 50, 75, and 100% for soybean meal in layer chick feeds for 8 weeks

	Dietary regimes					
	C0	C25	C50	C75	C100	P-value
Blood parameters* **						
Triglycerides (g/L)	2.11±0.020	2.15±0.005	2.14±0.002	2.15±0.003	2.14±0.005	0.045
Creatinine (mg/L)	2.60±0.54	3.15±0.26	1.61±0.13	1.63±0.16	1.50±0.12	0.004
Uric acid (mg/L)	49.33±0.34	51.31±0.15	51.53±0.31	51.18±0.28	51.75±0.11	0.002
Urea (g/L)	0.18±0.02	0.22±0.01	0.21±0.01	0.22±0.01	0.26±0.01	0.0001
AST (UI/L)	148.16±1.48	159.83±1.48	172.33±4.12	186.33±1.67	191.66±3.48	0.0001
Chol total (g/L)	2.13±0.05	2.05±0.04	2.17±0.04	2.13±0.04	2.20±0.05	0.154
Chol HDL (g/L)	0.26±0.01	0.41±0.01	0.31±0.01	0.36±0.01	0.40±0.01	0.0001
Chol LDL (g/L)	1.42±0.07	1.20±0.04	1.40±0.04	1.32±0.04	1.37±0.05	0.015

***AST: aspartate aminotransferase; Chol: cholesterol

Conclusion

This study was performed to evaluate the effects of low-fat CNM on layer chick growing performance and health status and to discuss its possibility for using as a crude protein source. The results showed that low-fat CNM could replace soybean meal up to 75% into chick feed without negative effects on growth performance and health status. Thus, in view of this result, low-fat CNM could be considered a good alternative to soybean meal, which is prohibitively expensive for local animal producers. However, studies should be continued with the aim of obtaining a 100% replacement of soybean meal by cashew nut meal.

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Author contributions

GMMC conducted the work. She explained the results and wrote the manuscript. DS participated in the acquisition of the raw materials and in carrying out the manipulations in the laboratory. TT, KJBA and KK contributed to the improvement of the manuscript by correcting it. YMY contributed to the improvement of the manuscript, validated the laboratory protocols, and supervised the overall work. KK was the scientific leader of this study.

Conflict of interest declaration

The authors declare no potential conflicts of interest

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