Blood Indices and Carcass Characteristics of Growing Rabbits Fed Pigeon Pea (*Cajanus Cajan*) Meal as Replacement for Groundnut Cake at Graded Levels

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ABSTRACT

Pigeon pea (Cajanus cajan) seeds contain approximately 20–22% crude protein and appreciable amounts of essential amino acids and minerals, suggesting their potential as an alternative protein source in animal feeding systems. Despite this nutritional potential, information on the utilization of Cajanus cajan meal (CCM) as a replacement for conventional protein sources such as groundnut cake in rabbit diets is limited, particularly with respect to its effects on haematological indices, serum biochemical parameters, and carcass characteristics of weaner rabbits. This present study evaluated the blood profile and carcass characteristics of weaner rabbits fed Cajanus cajan meal as replacement for groundnut cake. Forty (40) growing rabbits of mixed breeds, aged 5–6 weeks, were randomly allotted to four dietary treatments (10 rabbits per treatment) in a completely randomized design over a 10-week feeding trial. Four concentrate diets were formulated by directly replacing groundnut cake with CCM at 0, 10, 15, and 20%, respectively. The results showed no significant differences ($p > 0.05$) among treatments in packed cell volume, red blood cell count, haemoglobin concentration, and monocyte count. White blood cell count was significantly higher ($p < 0.05$) in rabbits fed the 15% CCM diet, followed by those fed 0 and 10% CCM diets, while the lowest value was observed in the 20% CCM diet. Lymphocyte count was significantly highest ($p < 0.05$) in rabbits fed the 20% CCM diet, followed by 0, 10, and 15% CCM diets. Rabbits fed CCM-based diets recorded significantly higher ($p < 0.05$) eosinophil counts compared with the control diet. Serum biochemical indices revealed that rabbits fed the 20% CCM diet had the highest ($p < 0.05$) total protein concentration, followed by 0 and 15% CCM diets, while the least value was observed in the 10% CCM diet. Animals fed CCM-based diets also recorded significantly lower ($p < 0.05$) serum cholesterol levels compared with rabbits fed the control diet. However, no significant differences ($p > 0.05$) were observed among treatments with respect to carcass characteristics. This study therefore concluded that Cajanus cajan meal (CCM) could totally replace groundnut cake in rabbit diets without adverse effects on haematological and serum parameters as well as carcass qualities.

Keywords: *Alternative protein, Carcass qualities, Heamatology, Rabbit nutrition, Serum biochemistry*

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INTRODUCTION

Rabbit meat has gained increasing recognition as a high-quality source of animal protein due to its low fat, cholesterol, and sodium contents, making it particularly suitable for individuals with cardiovascular diseases, diabetes, hypertension, and middle-aged populations (FAO, 2021).

This growing awareness has contributed to a steady rise in demand for rabbit meat, especially in developing countries where small livestock production plays a vital role in food security and household income. However, the sustainability and profitability of rabbit production are being constrained by the rising cost of conventional feed ingredients, notably protein sources such as groundnut cake and soybean meal. These ingredients are increasingly expensive due to competition between humans and livestock, climate-related production challenges, and fluctuations in global commodity markets (Ogunwole et al., 2022).

The high cost of conventional feedstuffs has necessitated an intensified search for alternative, non-conventional, and locally available feed resources that are nutritionally adequate, economically viable, and environmentally sustainable. Leguminous grains represent a promising option because of their relatively high protein content and wide adaptability to tropical environments. Among these, pigeon pea (*Cajanus cajan*) is widely cultivated in tropical and subtropical regions, yet remains underutilized in human diets and industrial applications, leading to surplus availability and low market preference (FAO, 2023).

Pigeon pea seeds contain appreciable levels of crude protein (20–29%) and essential nutrients, although their utilization is limited by the presence of anti-nutritional factors and relatively low levels of sulphur-containing amino acids such as methionine (Adeyemi et al., 2021). Several studies have demonstrated the successful inclusion of pigeon pea seed meal in poultry diets, with substantial replacement of conventional energy and protein sources without detrimental effects on growth performance, feed efficiency, and carcass characteristics (Egbeyale et al., 2022).

Despite these encouraging findings, extrapolation of such results to rabbit remains limited due to species-specific differences in digestive physiology, nutrient utilization, and sensitivity to dietary anti-nutritional factors. Rabbits, being hindgut fermenters with a unique caecal microbial ecosystem, may respond differently to legume-based diets compared to poultry or ruminants. Consequently, there is a clear need for species-specific evaluation of pigeon pea seed meal in rabbit nutrition. More importantly, available literature has largely focused on growth performance and carcass traits, with limited emphasis on the physiological and health implications of pigeon pea-based diets in rabbits. Haematological and serum biochemical indices are widely recognized as reliable indicators of nutritional adequacy, immune competence, and metabolic well-being, and they provide early warning signs of dietary stress or subclinical toxicity (2021; Oloruntola et al., 2023). However, comprehensive data on the effects of pigeon pea seed meal inclusion on these blood parameters in rabbits remain scarce and fragmented. Therefore, this study is justified by the need to bridge the existing knowledge gap regarding the use of *Cajanus cajan* seed meal as an alternative protein source in rabbit diets, with particular emphasis on its effects on haematological indices and overall health status. Findings from this study are expected to provide scientifically validated information that will support the formulation of cost-effective rabbit diets, reduce dependence on expensive conventional protein sources, and enhance sustainable rabbit production systems in developing countries

Objective of the study are:

(a) To evaluate the effect of graded replacement of groundnut cake with *Cajanus cajan* meal on haematological indices.
(b) To assess serum biochemical responses of rabbits fed graded levels of CCM based diets.
(c) To determine carcass characteristics of rabbits fed CCM-based diets.

Therefore, this study examined the effect of replacing groundnut cake with graded levels of *Cajanus cajan* meal on the blood profile of weaner rabbits.

MATERIAL AND METHODS

Experimental site

This study was conducted at the Department of Animal Health and Production Technology, The Oke Ogun Polytechnic, Saki Teaching and Research farm, located at longitude 8.6275ºN and latitude 3.4058ºE in Oyo State, Nigeria.

Experimental diets

Pigeon pea (*Cajanus cajan*) was purchased from local market, cleaned and milled then stored for subsequent use. Four concentrate diets were compounded by direct replacement of groundnut cake with *Cajanus cajan* meal (CCM) at 0, 10, 15 and 20% respectively (Table 1).

Table 1: Gross composition of the experimental diets.

Ingredients	0%CCM	10%CCM	15%CCM	20%CCM
Maize	40.0	40.0	40.0	40.0
Wheat offal	25.0	25.0	25.0	25.0
Groundnut cake	20.0	10.0	5.0	0.0
Cajanus cajan	0.0	10.0	15.0	20.0
Palm kernel cake	11.5	11.5	11.5	11.5
Bone meal	2.0	2.0	2.00	2.00
Lysine	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25
Salt	0.50	0.50	0.50	0.50
Vitamin premix	0.50	0.50	0.50	0.50
Total	100	100	100	100
Proximate composition of the experimental diets (%)				
Parameters (%)	**0%CCM**	**10%CCM**	**15%CCM**	**20%CCM**
Dry matter	89.3	86.8	88.9	89.0
Crude protein	18.1	15.6	14.8	14.0
Crude fibre	7.7	7.9	7.5	7.89
Ether extract	3.7	3.4	3.3	2.5
Ash	16.7	15.6	16.8	16.0
Carbohydrate	42.9	44.2	46.6	48.6

Premix provided per kg diet: vitamin A, 12,000 IU; vitamin D3 , 1,000 IU; vitamin E acetate, 50 mg; vitamin K3 , 2 mg; biotin, 0.1 mg; Fe, 100 mg; Cu, 20 mg; Mn, 50 mg; Co, 2 mg; I, 1 mg; Zn, 100 mg; Se, 0.1 mg; Robenidine, 66 mg.

Animals and experimental design

A total of forty mixed-breed weaner rabbits, aged between 5 and 6 weeks and weighing 400–600 g at the start of the experiment, were used in a 10-week study. The rabbits were randomly allocated to four treatments (10 rabbits per treatment) in a completely randomized design where feed and water were served daily. Pigeon pea grains were purchase from local markets, sun dried to a constant weight and milled. Four concentrate diets were compounded by direct replacement of groundnut cake with *Cajanus cajan* meal (CCM) at 0, 10, 15 and 20% respectively. The experimental diets were fed to rabbits at 4% of their body weight. Standard ethical approval and animal welfare compliance of the Nigerian Institute of Animal Science guidelines were duly followed.

Blood Analyses

At the end of the feeding period, the animals were starved of feed for 24 hours before blood samples were collected for haematological analysis. The blood samples were collected from each rabbit from the external ear vein using a sterilized disposable syringe and needle between 6.30 and 7.30 am. Blood samples were collected into labelled Ethylene-deamine tetra-acetic acid (EDTA) treated tubes for haematological analysis and into tubes without anticoagulant for serum biochemical evaluation (Bitto and Gemade, 2001).

Determination of carcass qualities of rabbit

At the end of the experiment, the selected rabbits (3) from each treatment were fasted for 12 hours and slaughtered through stunning and the cervical dislocation of the head for carcass analysis. The skin, head, forelimb, hind limb, loin, thorax, kidney fat, intestine, liver, lungs and heart were removed, weighed then converted to percentage of the body weight.

Chemical Analyses

Samples of experimental diets were taken to laboratory for determination of the proximate composition according to the method of AOAC (2012).

Statistical Analysis

Data obtained were subjected to analysis of variance procedure of General Linear Model and the Duncan's New Multiple Range Test option of SAS (2020) was used to separate the means.

RESULTS

The proximate content of the diets fed to rabbits was shown in Table 1. The crude protein content decreased as the graded levels of CCM increased in the diets. However, the dry matter, crude fibre, ether extract and ash were

Table 2: Haematological indices of rabbits fed Cajanus cajan meal.

Parameters	0%CCM	10%CCM	15%CCM	20%CCM	SEM
Packed Cell Volume (%)	50.5	49.0	50.5	48.0	0.77
Red Blood Cell ($x10^6$)	7.7	6.6	6.4	5.9	0.33
White Blood Cell ($x10^3$)	10.6^{ab}	10.6^{ab}	13.5^{a}	8.6^{b}	0.42
Haemoglobin (g)	16.8	16.4	16.8	15.2	0.56
Lymphocyte (%)	25.5^{ab}	23.5^{ab}	16.5^{b}	33.5^{a}	0.69
Neutrophils (%)	65.0^{ab}	65.0^{ab}	73.5^{a}	57.5^{b}	1.59
Monocyte (%)	6.0	6.5	5.5	5.0	0.31
Eosinophil (%)	3.5^{b}	5.0^{a}	4.5^{ab}	4.0^{ab}	0.25

[a,b] Means with different superscripts are significantly different ($p<0.05$).

Table 3: Serum metabolites of rabbits fed Cajanus cajan meal.

Parameters	0%CCM	10%CCM	15%CCM	20%CCM	SEM
Total protein (g/dl)	6.7^{ab}	4.4^{c}	5.8^{b}	7.5^{a}	0.46
Albumin (g/dl)	4.1^{a}	3.5^{b}	4.1^{a}	3.1^{b}	0.37
Globulin (g/dl)	2.8	2.1	2.8	2.3	0.14
Albumin/Globulin ratio	1.8	1.9	1.8	2.0	0.08
Alkaline phosphatase (u/l)	54.0^{a}	49.5^{b}	47.9^{b}	40.5^{c}	2.02
Alanine transaminase (u/l)	49.5	45.5	47.0	41.5	1.37
Aspartate transaminase (u/l)	108.5^{b}	121.6^{a}	123.8^{a}	125.5^{a}	4.57
Cholesterol (mg/dl)	57.5^{a}	52.5^{a}	45.5^{b}	38.5^{c}	2.72
Creatinine (mg/dl)	1.80	1.42	1.05	1.25	0.10

[a,b] Means with different superscripts are significantly different ($p<0.05$).

Table 4: Carcass characteristics of rabbits fed Cajanus cajan meal.

Parameters	0%CCM	10%CCM	15%CCM	20%CCM	SEM
Slaughter weight (g)	2050.00	2650.00	2250.00	2200	50.15
Hot carcass (g)	420.00	558.50	481.50	460.50	38.01
Dressing (%)	52.00	48.5	51.60	54.90	14.79
Head (%)	6.06	4.99	5.25	5.56	0.23
Thorax (%)	4.57	4.93	4.87	5.19	0.19
Fore limb (%)	3.41	3.07	3.25	3.42	0.15
Hind limb (%)	5.09	5.87	5.92	6.28	0.44
Abdomen (%)	6.68	7.02	7.55	6.99	0.63
Loin (%)	11.12	11.90	12.40	12.15	0.99
Skin (%)	4.29	4.63	4.19	4.58	0.41
Stomach (%)	2.97	3.07	2.13	2.85	0.22
Liver (%)	1.33	1.73	1.35	1.34	0.11
Kidney (%)	0.25^{b}	0.35	0.30	0.25	0.33
Lungs (%)	0.20	0.25	0.25	0.20	0.33
Heart (%)	0.15	0.01	0.15	0.10	0.02

[a,b] Means with different superscripts are significantly different ($p<0.05$).

relative through all the experimental diets. Howbeit, the carbohydrate fraction was highest in 20%CCM (48.6), followed by 15%CCM (46.6), 10%CCM (44.2) and 0%CCM (42.9). There were no significant differences ($p>0.05$) among the mean counts of packed cell volume, red blood cell, haemoglobin and monocyte (Table 2). The 15%CCM (13.50) diet had significantly highest ($p<0.05$) white blood cell count followed by 0%CCM (10.6) and 10%CCM (10.6), least was 20%CCM (8.6) while the lymphocyte count was significantly highest in 20%CCM (33.5), followed by 0%CCM (25.5), 10%CCM (23.5) and 15%CCM (16.8). However, rabbits fed diets containing CCM had significantly higher ($p<0.05$) eosinophil than 0%CCM. There were no significant differences ($p>0.05$) among the means of globulin, albumin to globulin ratio, alanine transaminase and creatinine of weaner rabbits fed the experimental diets (Table 3). Rabbits fed diets containing 20%CCM (7.5) had significantly highest ($p<0.05$) total protein followed by 0%CCM (6.7), 15%CCM (5.8) and least 10%CCM (4.4). The alkaline phosphatase was significantly highest ($p<0.05$) in 0%CCM, followed by 10%CCM (49.5) and 15%CCM (47.9) then 20%CCM (40.5). Furthermore, diets containing graded levels of CCM were significantly higher ($p<0.05$) in aspartate transaminase than 0%CCM. However, animals fed diets containing CCM had significantly lower ($p<0.05$) cholesterol content than 0%CCM diet. There were no significant differences ($p>0.05$) among the carcass characteristics values except for kidney and lungs across the experimental treatments (Table 4).

DISCUSSION

The proximate composition of diets containing graded levels of *Cajanus cajan* meal (CCM) showed notable changes in nutrient distribution as CCM inclusion increased from 0% to 20% (Table 1). These variations have important implications for the formulation and utilization of CCM as a partial replacement for conventional protein sources in rabbit nutrition. The dry matter (DM) content of the experimental diets remained consistently high across treatments (86.8–89.3%), indicating that inclusion of CCM did not adversely affect the moisture stability of the diets. Similar observations were reported by Amaefule et al. (2005), who noted that pigeon pea–based diets maintained acceptable dry matter levels suitable for rabbit feeding. A progressive decline in crude protein (CP) was observed with increasing CCM inclusion, decreasing from 18.1% in the control diet to 14.0% at 20% CCM. This trend is consistent with reports by Akande et al. (2009) and Modupe et al. (2023), who indicated that pigeon pea meal contains moderate protein levels but may dilute dietary crude protein when it replaces more protein-dense ingredients such as groundnut cake or soybean meal. Ravindran and Blair (2018) further emphasized that the protein content of pigeon pea varies widely depending on cultivar and processing method, making diet balancing essential when it is used at higher inclusion levels. The crude fibre (CF) content remained relatively stable (7.5–7.9%) across all diets. This stability is desirable in rabbit feeding since adequate dietary fibre supports normal gastrointestinal function and caecal fermentation. According to Gidenne et al. (2015), moderate fibre levels are essential for maintaining gut motility and preventing digestive disorders in rabbits, suggesting that CCM inclusion did not compromise fibre adequacy in the present study. A gradual reduction in ether extract (EE) was recorded as CCM inclusion increased. This agrees with the findings of Akande et al. (2009), who reported lower fat content in pigeon pea meal compared to oilseed cakes. Reduced dietary fat may lower metabolizable energy concentration, which could affect growth performance if not compensated for by other energy sources, as highlighted by Ravindran (2016). The ash content of the diets showed minimal variation among treatments, indicating that mineral composition was not markedly altered by CCM inclusion. Similar results were reported by Amaefule et al. (2005), who observed that pigeon pea–based diets maintained comparable mineral levels to conventional rabbit diets. An increasing trend in carbohydrate content was observed with increasing CCM inclusion (42.9% to 48.6%). This rise is attributable to the reduction in protein and fat fractions and reflects the carbohydrate-rich nature of pigeon pea seeds. Modupe et al. (2023) reported similar increases in carbohydrate content when pigeon pea meal replaced conventional feed ingredients, suggesting a shift toward higher fermentable carbohydrate availability. Several studies have demonstrated that pigeon pea meal can be successfully incorporated into rabbit diets when properly processed. Amaefule et al. (2005) reported that boiled pigeon pea seed meal could be included up to 20% without adverse effects on growth performance and carcass traits. Likewise, Akande et al. (2009) showed that roasted pigeon pea meal supported normal growth and feed efficiency in rabbits when diets were formulated to be isonitrogenous and isocaloric. These findings emphasize the importance of processing in reducing anti-nutritional factors such as tannins and trypsin inhibitors, which have been documented in raw pigeon pea seeds (Modupe et al., 2023). Overall, the observed reduction in crude protein and ether extract with increasing CCM inclusion highlights the need for nutrient balancing, particularly for growing rabbits with high protein and energy requirements. Supplementation with additional protein sources or essential amino acids may be necessary when CCM is used at higher levels. In agreement with Ravindran and Blair (2018), the present findings suggest that *Cajanus cajan* meal is a viable alternative feed ingredient, provided that diet formulation and processing strategies are carefully considered.

The lack of significant differences ($p > 0.05$) in globulin, albumin–globulin ratio, alanine transaminase (ALT) and creatinine among weaner rabbits fed graded levels of *Cajanus cajan* meal (CCM) suggests that renal and hepatic functions remained within normal physiological ranges across treatments. ALT and creatinine are standard markers of liver and kidney integrity, respectively; stable values imply that inclusion of CCM up to 20% did not induce organ stress or toxicity. This observation agrees with earlier reports that nutritionally balanced, plant-based protein sources do not adversely affect serum ALT or creatinine levels in rabbits (Adeyemi et al., 2020). Rabbits fed the 20% CCM diet recorded the highest total protein concentration ($p < 0.05$) compared with other treatments. Elevated total protein levels may reflect improved protein supply and utilization, particularly at higher inclusion levels of legume feedstuffs rich in essential amino acids. Higher serum total protein has been widely interpreted as an index of nutritional adequacy and metabolic efficiency because it represents both albumin and globulin fractions available for metabolic and immune functions (Kaneko et al., 2008). Comparable increases in serum total protein have been reported in rabbits fed quality plant protein sources without evidence of metabolic dysfunction (Abd El-Latif et al., 2019). The decreasing trend in alkaline phosphatase (ALP) with increasing CCM inclusion—being highest ($p < 0.05$) in the control (0% CCM) and lowest in the 20% CCM group—may indicate differences in tissue turnover, bone metabolism or intestinal activity. ALP reflects multiple physiological processes including bone growth and gut mucosal function rather than being a highly specific hepatic marker (Kaneko

et al., 2008). The lower ALP values observed alongside unchanged ALT and creatinine suggest that CCM-based diets did not elicit pathological alterations in liver or bone tissues. Similar reductions in ALP have been reported in rabbits fed alternative or novel feed ingredients and were interpreted as a non-stress physiological response when diets remained nutritionally adequate (Ewuola et al., 2012). Aspartate transaminase (AST) was significantly higher ($p < 0.05$) in rabbits fed CCM-based diets compared with the control. AST is widely distributed in liver, muscle and other tissues and may increase moderately in response to dietary protein quality or metabolic adaptation, provided values remain within normal physiological limits (Kaneko et al., 2008). Recent rabbit nutrition studies have similarly reported diet-related variations in AST in the absence of overt liver dysfunction (Abd El-Monem et al., 2021). One of the most consistent findings in this study was the reduction in serum cholesterol concentration in rabbits fed CCM-containing diets compared with the control. Legume-based plant proteins and fiber-rich feed ingredients have been widely reported to reduce serum cholesterol in monogastric animals through modulation of lipid absorption, bile acid excretion and cholesterol metabolism (Adeyemi et al., 2020). In rabbits, diets rich in plant protein and dietary fiber frequently result in reduced plasma cholesterol levels which were considered a beneficial metabolic response (Aderemi et al., 2016). The observed hypocholesterolemic effect therefore aligns with previous rabbit feeding trials involving legume meals and plant bioactive compounds.

The carcass evaluation of rabbits fed diets with graded levels of *Cajanus cajan* meal (CCM) showed that partial replacement of groundnut cake with CCM up to 20% did not negatively affect carcass yield or organ development. Slaughter and hot carcass weights generally increased at 10% CCM inclusion before a slight decline at higher levels, indicating that moderate inclusion of CCM can support growth performance similar to conventional protein sources. This finding is consistent with Bishmang, et al. (2024), who reported no significant detrimental effects on carcass traits when rabbits were fed diets containing various plant protein sources. Dressing percentages were highest at 20% CCM (54.9%), suggesting good carcass yield even at higher inclusion levels. Minor variations in the relative weights of carcass components such as the head, thorax, limbs, abdomen, loin, skin, stomach, liver, lungs, and heart remained within normal physiological limits, demonstrating that organ integrity was maintained across treatments. Research by Gulukun et al. (2025) on kidney bean (Phaseolus vulgaris) seed meal supports these findings, showing that processing methods of legume seed meals had little adverse effect on carcass characteristics in rabbits. The absence of pathological changes in organ weights, including the kidneys and lungs, aligns with broader literature on alternative feedstuffs for rabbits. For example, Chisowa et al. (2013) found that rabbits fed pigeon pea (*Cajanus cajan*) and other legume grains as protein sources showed acceptable carcass quality, though specific breed and feed differences influenced performance.

Conclusion

Cajanus cajan meal could safely replace groundnut cake up to 20% in rabbit diets without adverse effects on haematological indices, serum biochemistry, or carcass traits. CCM inclusion maintained normal liver and kidney function, improved total serum protein, and reduced cholesterol levels. Thus, CCM is a nutritionally adequate and cost-effective alternative protein source for sustainable rabbit production. Further studies should assess long-term and reproductive effects of CCM inclusion.

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