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FEEDING VALUE OF PROCESSED POULTRY LITTER AS A REPLACEMENT FOR SOYBEAN MEAL ON GROWTH PERFORMANCE AND BLOOD INDICES OF GROWING RABBITS

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ABSTRACT

The influence of feeding processed poultry litter (PPL) containing diets to rabbits for 56 days on their growth efficiency and blood profile was studied. Four diets: control (CON-0%), low level (LL-7%), medium level (ML-14%) and high level (HL-21%) were formulated to contain PPL at 0%, 7%, 14% and 21%, respectively. A total of 24 New Zealand rabbits weighing 412.5g on average were randomly assigned the four diets, each with six animals in a completely randomized design. Feed intake, body weight gain and feed conversion ratio were measured weekly. Blood was drawn from each animal on the last day of the trial to evaluate hematological and serum biochemical parameters. Platelet were higher at CON-0% and LL-7% and WBC was best at CON-0%. Serum globulin was significantly (P<0.05) higher at CON-0%. Albumin was significantly (P<0.05) higher at CON-0% and LL-7%. Total protein and creatinine showed significantly (P<0.05) lower values at HL-21%. Urea values were significantly (P<0.05) influenced with HL-21% having the highest value. All the blood parameters were within the normal range for clinically healthy rabbits. CON-0% produced the overall best performance. Still, PPL-containing diets were not detrimental to rabbit production, hence could be recommended for rabbit production for a shorter-term feeding regime.

Key words: poultry litter, growth performance, hematology, serum biochemistry, rabbits

INTRODUCTION

Rabbits serve as a source of investment and animal protein for an ever-increasing population and rabbit production serves a significant socio-economic purpose (Jiwuba *et al*., 2020a). Rabbits are raised chiefly for their high-quality meat and biomedical research. Rabbit production has been on the increase in recent years. This could be partly due to its fast growth rate, delicious meat with low cholesterol and sodium contents, high prolificacy and its ability to survive on varieties of feedstuffs. Onyekwere *et al*. (2018) attributed the

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increase in rabbit production to the high price of regular meat like beef, goat meat and chicken and its short reproductive/multiplication interval of rabbits. In an earlier study, Jiwuba (2018) noted that rabbits utilize fiber better than the other monogastric animals (pig and poultry) due to their enlarged cecum, which enables a unique type of digestion known as ceacotrophy or coprophagy (bacteria digestion). This may also enhance their reproduction/production rates. Rabbit production continues to be plagued by issues such as inadequate feeding due to scarcity and high prices of conventional feedstuffs, restricting rabbits' ability to supply much-needed animal protein to the population. This may be due to the shortage and high cost of feeds and feed ingredients. The scarcity and high cost of conventional protein and energy sources such as maize, soybeans, and groundnuts can be due to competition for these scarce resources between man, industries and livestock.

Consequently, researchers are focused on finding potential sources of feed that have little to no human demand. To formulate livestock diets, the alternative feed ingredient must be inexpensive and readily available locally, since this will lower the cost of compounding and make it more affordable to farmers. In rabbit production, a plentiful supply of poultry litter can boost output while lowering the cost of finished feeds. Processed poultry litter is one of the possible materials. It appears to be very useful in solving the animal feed issue, especially among ruminants and pseudo-ruminants, since it is readily available and does not form part of the human diet.

The biochemical compositions of poultry litter and the growth efficiency of animals fed poultry litter have been researched. Pig (Akinfala and Komolafe, 2011), rabbits (Onimisi and Omage, 2006; Owen *et al*., 2009), fish (Omitoyin, 2007), sheep (Bello and Tsado, 2013) and goat (Ajayi *et al*., 2016) fed with poultry litter showed varying results on feed intake, nutrient utilization and growth rate. According to Rude and Rankins (1999), broiler litters are low in energy and yield daily gains of 0.9 to 1.0 kg/d when combined with a grain source on a 1:l as-fed basis and fed to young cattle (Rankins *et al*., 1993). However, using poultry litter or other animal waste as a feed portion has raised some concerns, such as the possibility of bovine spongiform encephalopathy (BSE) in beef cattle. Consequently, poultry litter was temporarily banned in the United States in December 2003 as a feedstuff by the Food and Drug Administration (FDA) (Daniel and Olson, 2020). The ban was, however, lifted in October, 2005 after series of investigations.

In addition, the dangers of cross-infestation with disease agents like *Salmonella typhimurium*, *Escherichia coli*, or *Clostridium botulinum* have challenged poultry litter as a feed component in the livestock feeding system. Due to the fast decomposition of poultry litter immediately after excretion, giving off ammonia, breeding medium for pathogenic microorganisms and medium for disease transmission, flies and other objectionable insects and odor generation associated with poultry litter can lead to serious health hazards and environmental nuisances. It is crucial to subject poultry litter to some treatments to enhance its storage, handling and curtail the risk of disease transmission and environmental contamination. In earlier studies, Haapapuro *et al*. (1997) and Ghaly and MacDonald (2002) noted that heat processing of poultry litter reliably kills bacterial pathogens. Nigeria being a hot tropical Africa, where an average of eight hours of steady sunlight is ensured during the dry season, sun-drying was employed to process the poultry litter. Sun-drying was employed to possibly kill the pathogenic bacteria and reduce the moisture, to reduce the rate of deterioration from chemical and biological activity and the environmental contamination associated with raw litter. Drying also removes manure stickiness and hence allows for easier handling

(Bernhart and Fasina, 2009). Few studies have been conducted recently on the influence of poultry litter as a component of rabbit feed on growth and blood parameters. The study's objective was to determine the influence of processed poultry litter on the rabbits' performance, hematology, and blood chemistry.

MATERIALS AND METHODS

The study took place at the Federal College of Agriculture's Rabbit unit in Ishiagu, Ebonyi State, Nigeria. The College is about three kilometers (3 kilometers) from the center of Ishiagu. The College is located at 5.56 °N and 7.31 °E, with an average annual rainfall of 1653 mm, a temperature of 28.5 °C, and relative humidity of around 80%.

The pure poultry litters were obtained from the battery cage system, Federal College of Agriculture, Ishaigu layers unit. The litter from Issa brown (layers) fed vital feed egg formula ration *ad libitum* was collected at 28th month. The litters were sundried for 10 days at 29.0^0C average daily temperature to reduce moisture and possible activities of harmful microorganisms. They were then ground using a 2mm hammer mill, bagged and used to formulate the experimental diets. Twenty-four New Zealand weaner rabbits weighing an average of 412.5 g were randomly assigned to four experimental diets, each with six animals. The experimental animals were managed in compliance with the Federal College of Agriculture, Ishiagu (FCAI) Animal Ethics Committee's approval and guidelines. Every rabbit was housed in a standard 120 by 150 cm hutch that was elevated 120 cm above the ground. The four treatment groups were given the four diets in a completely randomized design (CRD). Four (4) different experimental diets were formulated and categorized as Control (CON-0%), Low level (LL-7%), 100 Medium level (ML-14%) and high level (HL-21%) to contain poultry litter (PL) at 0, 7, 14 and 101 21%, respectively (Table 1). For 56 days, each rabbit was fed a particular diet. Fresh, clean water was made available regularly. Each animal was immunized against a disease that was common at the time. Prior to the experiment, they were dewormed with kepromec (Ivermectin) at a rate of 0.1 ml per rabbit subcutaneously and given an acaricide bath with Roys' Amitraz 20 at a rate of 1 ml per 2 liter water. Using a weighing scale with a capacity of 30 kg and a sensitivity of 0.001 kg, daily feed intake and weekly weight gain were reported. The difference between the feed supplied and what was left in the feeding trough the next day was used to calculate each rabbit's feed intake. The difference between the rabbits' initial and final weights was used to calculate their live body weight gain, which was calculated on a weekly basis. The feed conversion ratio was determined using the formula:

$$Feed\ Conversion\ Ratio = \frac{Daily\ feed\ intake,\ \ g/day}{Daily\ weight\ gain,\ \ g/day}$$

On the last day of the trial, each animal had a blood sample (5 ml) drawn from the marginal ear vein. The samples (a total of 24, n=24) were divided into two groups and analyzed hematologically and biochemically. For the hematological study, 2.5 ml of each sample was obtained in a labeled sterile universal bottle containing 1.0 mg/ml ethyldiamine tetraacetic acid (EDTA). The remaining 2.5 mL of serum was stored in an anticoagulant-free container and used for biochemical tests. Beckman Coulter Ac-T10 Laboratory hematology Blood Analyzer and Bayer DCA 2000+ HbA1c analyzer were used to determining serum biochemistry and hematological parameters, respectively.

Table 1. Composition of the experimental diets.

Ingredients	Dietary Levels			
	CON -0%	LL -7%	ML -14%	HL -21%
Maize	49.00	49.00	49.00	49.00
Soya bean	24.00	17.00	10.00	3.00
Poultry litter	0.00	7.00	14.00	21.00
Palm Kernel Cake	11.00	11.00	11.00	11.00
Wheat offal	10.00	10.00	10.00	10.00
Blood meal	2.00	2.00	2.00	2.00
Bone meal	1.50	1.50	1.50	1.50
Limestone	1.50	1.50	1.50	1.50
Common salt	0.25	0.25	0.25	0.25
Premix	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25
Total	100	100	100	100

The AOAC (2000) was used to determine the proximate compositions of both feeds and experimental material (poultry litters). By subtracting the amount of other proximate elements, crude protein, crude fat, ash, and crude fiber on a dry weight basis from 100, the nitrogen-free extract was obtained. Calculation of metabolizable energy, AAFCO (1997) was employed using the formula:

$$ME = ((3.5\ x\ protein) + (8.5\ x\ fat) + (3.5\ x\ nitrogen - free\ extract))10$$

To decide if the variable means were significantly different, one-way analysis of variance (ANOVA) was used. With the Duncan Multiple Range Test (DMRT), significantly different means were differentiated. Statistical package for the social sciences (SPSS) was used to perform the research.

RESULTS AND DISCUSSION

The chemical composition of experimental diets and poultry litter is presented in Table 2. The DM of the experimental diets failed to follow a regular trend. The DM ranged between 88.96 (LL -7%) and 89.24% (ML -14%) and this compared favorably with the range of 87.13–89.34% and 90.91–91.15% reported by Ogunsipe (2014) for rabbits fed poultry litter with or without enzyme supplementation and Ojebiyi and Saliu (2014) for rabbits fed bovine rumen content/blood meal mixtures in their diets respectively. The CP decreased progressively with incremental levels of PL with the highest value of 20.39% recorded for CON-0% and a corresponding lowest value of 18.27% recorded for HL-21%. The CP values obtained in this study are well above the 16% dietary crude protein requirement for growing rabbits by NRC (1977) but fall within 18%-22% crude protein level recommended for meat rabbits by Omole (1982). The CF, EE, ash and metabolizable energy failed to maintain a

Table 2. Chemical composition of experimental diets and poultry litter.

Nutrient (%)	Dietary Levels				SEM	PL	*P*-value
	CON-0%	LL-7%	ML-14%	HL-21%			
Dry matter	89.04	88.96	89.24	89.21	0.93	81.65	0.106
Crude protein	20.39	19.39	18.38	18.27	2.12	20.30	0.967
Crude fibre	15.94	16.82	17.00	16.32	2.38	21.18	0.543
Ether extract	4.02	3.65	3.44	2.01	6.45	3.33	0.311
Ash	6.31	6.69	7.33	5.81	5.92	21.19	0.243
NFE	40.38	42.41	43.09	46.80	1.56	15.65	0.589
ME, kcal/kg	2468.65	2493.25	2443.85	2448.30	11.07	1541.30	0.964

PL –poultry litter; SEM – standard error mean; NFE – Nitrogen free extract; ME - Metabolizable energy

particular pattern across the treatments. However, the CF falls above 14% CF recommended by Lebas (1980) but compared well with recommended 14–18% reported by de Blas and Mateos (2010) for growing rabbits. Jiwuba (2018) reported the importance of adequate dietary fiber in promoting growth and intestinal motility in rabbits. The recorded energy range of 2443.85–2493.25 kcal/kg in this study was compared to the recommended energy ranges for young rabbits of 2400–2800 and 2500.00 kcal/kg by Aduku and Olukosi (1990) and NRC (1977), respectively. Rabbits' feed consumption varies according to the amount of energy in their diet. However, the ash values of 5.81–7.33% did not follow a consistent trend. Since ash represents the mineral content of the diet, this may be an indicator that the rabbits' mineral requirements were met (Jiwuba, 2018). The results of the proximate analysis of the processed poultry litter (PPL) were compared favorably with the findings of Onimisi and Omage (2006), Akinfala and Komolafe (2011), Bello and Tsado (2013) and Ogunsipe (2014) for poultry litter.

Table 3 shows the growth performance of rabbits fed poultry litter diets. There was no significant (P>0.05) difference for all the growth and feed intake characteristics, thus indicating that poultry litter in the diets of the growing rabbits did not hamper their feed intake and growth.

Table 4 shows the hematological indices of rabbits fed poultry litter diets. The packed cell volume (PCV) decreases marginally with increasing levels of PL but is unaffected by treatment (P>0.05). The PCV values of 41.90–45.22% obtained in this present study fell within the normal physiological range of 36–48, 34–50 and 31–50% for apparently healthy rabbit reported by Aiello and Mays (1998), Hrapkiewicz and Medina (2007), and Hem *et al*. (2001) respectively. The hemoglobin (Hb) decreased slightly with increasing levels of PL. It was not significantly (P>0.05) influenced by the treatment diets. The Hb values of 10.85 - 11.52 243 g/L reported in this study for both were HL-21% and CON -0% respectively fell within the range of 9.4–17 g/dl by Fudge (1999) for apparently healthy rabbits. The red blood cells (RBC) failed to follow a particular trend and were not (P>0.05) influenced by the treatment diets. The RBC range of 5.66–6.10 x10^{12}/L obtained in this study fell within the range of 4.0–7.2 and 4.5–8.5 x10^{12}/L reported by Hillyer and Quesenberry (1997) and

Table 3. Growth performance indices of growing rabbits fed diets containing poultry litter.

Parameters	Dietary Levels				SEM	*P*-value
	CON-0% (0%)	LL -7% (7%)	ML-14% (14%)	HL-21% (21%)		
Initial weight,g	541.50	543.00	540.30	543.25	0.14	0.235
Final weight, g	1730.32	1680.65	1620.75	1670.43	1.02	0.490
Total weight gain, g	1188.82	1137.65	1080.45	1127.18	0.68	0.576
ADWG, g/day	21.23	20.32	19.29	20.13	0.05	0.331
Total feed intake, g	5627.55	5662.70	5680.80	5707.96	1.26	0.452
ADFI, g/day	100.49	101.12	101.44	101.93	0.33	0.187
FCR	4.73	4.98	5.26	5.06	0.02	0.345

ADWG – average daily gain; ADFI – average daily feed intake; FCR - Feed conversion ratio

Table 4: Hematological indices of growing rabbits fed diets containing poultry litter.

Parameters	Dietary levels				SEM	*P*-value
	CON-0% (0%)	LL-7% (7%)	ML-14% (14%)	HL-21% (21%)		
PCV, %	45.22	44.95	44.30	41.90	0.63	0.553
Hb, g/L	11.52	11.41	11.05	10.85	0.10	0.959
RBC, $x10^{12}$/L	6.05	6.10	5.74	5.66	0.07	0.778
MCHC, %	28.92	28.12	28.95	28.30	0.89	0.889
MCH, pg	19.05	19.05	19.10	18.85	0.04	0.181
MCV, fl	75.10	75.50	76.20	75.25	0.16	0.302
Platelets, x10/L	431.50^{a}	427.00^{a}	309.00^{b}	301.50^{b}	0.16	0.000
WBC, $x10^{9}$	8.70^{a}	6.70^{b}	4.15^{c}	5.10^{bc}	0.65	0.024

$^{a-c}$means on the same row with different subscript are significantly different ($P < 0.05$).
PCV - packed cell volume; Hb - Hemoglobin; RBC - Red blood cells; MCHC – mean cell hemoglobin concentration; MCH - mean cell hemoglobin; MCV - mean cell volume; WBC – white blood cells

Bellier *et al*. (2005) respectively for clinically healthy rabbits. The mean cell hemoglobin concentration (MCHC) failed to follow a particular trend and was not significantly influenced by the treatment diets (P>0.05). The MCHC (28.12–28.95%) reported in this study fell within the normal range of 27–37% reported by RAR (2009) for growing rabbits, thus suggesting the absence of anemia among the animals. The mean cell hemoglobin (MCH) failed to follow a particular trend and was not significantly influenced by the treatment diets (P>0.05). However, the possibility of the rabbits on HL-21% having anemia if the feeding is prolonged cannot be ruled out. The mean cell volume (MCV) failed to follow a particular trend and was not (P>0.05) influenced by the treatment diets. The MCV values in this experiment agree with the normal range reported by Burke (1994) for rabbits. The platelet values obtained in this study continued to decrease as PL levels increased, and the treatment

diets had a significant (P<0.05) effect on platelet values. The platelet range values observed for the rabbits in this study (301.50–431.50 x10^9/L) were within the usual range of 250–661 x10/L stated by Thrall *et al*. (2004) for apparently healthy rabbits. However, the values obtained in this study compared favorably with 355.00–478.50 x10^9/L reported by Jiwuba *et al*. (2020b). The WBC recorded in this study ranged between 4.15–8.70 x10^9/L, for ML-14% and CON-0%, respectively, and was significantly (P<0.05) affected by the treatment diets. However, the values were within the range of 4.0–13.0 x10^9/L, reported by Hem *et al*. (2001) for healthy growing rabbits. The lower values reported in this study thus indicated the possibilities of poor immune among the LL-7%, ML-14% and HL-21%.

Table 5 shows the serum biochemical indices of young rabbits fed poultry litter diets. In the control diet (CON-0%), total protein levels were significantly (P<0.05) higher in comparison with the treatment groups (LL-7%, ML -14% and HL-21%). The total protein levels in this study (54.54–69.19 g/L) were within the normal ranges of 50–75 g/L and 53–75 g/L for apparently healthy rabbits, as stated by RAR (2009) and Suckow and Douglas (1997). The globulin had a progressive decrease (P<0.05) across the treatments, with CON -0% showing the highest value and HL-21% the lowest. The values of 23.81–32.21 g/L reported in this study were within the normal physiological range of 15–33 and 19–35 g/L reported by both BRV (2008) and Carpenter (2005) for clinically healthy rabbits. The albumin was significantly (P<0.05) higher in CON -0% and LL -7% compared to ML-14% and HL-21%. The albumin levels in this study (30.73–36.98 g/L) were within the normal ranges of 24–46 and 27–50 g/L for apparently healthy rabbits, as stated by Hillyer and Quesenberry (1997) and Suckow and Douglas (1997), respectively, indicating that the experimental rabbits' livers were working properly. Serum creatinine values were significantly (P<0.05) influenced, and decreased linearly with incremental levels of poultry litter in the rabbits' diets, with CON -0% having the highest value and a corresponding lowest value for HL-21%. The range of values (53.92–189.82 mmol/L) obtained in this study fell within the normal physiological range of 44–230 mmol/L for apparently growing rabbits reported by (BRV, 2008). Urea concentration values were significantly (P<0.05) influenced, and increased linearly with incremental levels of poultry litter in the rabbits' diets, with having the highest value and a corresponding lowest value for CON-0%. Urea concentrations of 5.16–9.87 mmol/L obtained in this study fell within 4.6–10.7 mmol/L reported by BRV (2008) for apparently healthy growing rabbits. The lower (P<0.05) blood urea reported at HL-21% indicates that the diet's protein quality was not compromised; as a result, a high blood urea level is associated with reduced protein value (Eggum, 1970) or excessive tissue catabolism accompanied with protein deficit. The cholesterol, aspartate aminotransferase (AST), and aminotransferase (ALT) levels did not vary significantly (P>0.05) between the treatments.

It was concluded that poultry litters could be used up to 21% in rabbit diets without affecting feed consumption, body weight gain, or feed conversion ratio. The sun-drying of poultry litter employed in this study supported hematological and serum biochemical indices of growing rabbits since all the blood parameters measured were within the normal physiological range for apparently healthy rabbits. Therefore, it was recommended that poultry litters should be included in the rabbit diets up to 21% in the diets of growing rabbits.

Table 5. Serum biochemical indices of growing rabbits fed diets containing poultry litter.

Parameters	Dietary levels				SEM	*P*-value
	CON-0% (0%)	LL -7% (7%)	ML -14% (14%)	HL-21% (21%)		
Total protein, g/L	69.19[a]	63.12[ab]	58.36[b]	54.54[c]	1.25	0.000
Globulin, g/L	32.21[a]	27.04[b]	24.82[c]	23.81[c]	0.66	0.076
Albumin, g/L	36.98[a]	36.08[a]	31.32[b]	30.73[b]	0.18	0.000
Creatinine, µmol/L	189.82[a]	136.32[ab]	111.11[b]	53.92[c]	0.31	0.043
Urea, mg/dl	5.16[c]	7.14[b]	8.17[a]	9.87[a]	0.91	0.000
Cholesterol, mg/dl	78.37	80.46	76.39	89.80	1.94	0.719
AST, UL	45.99	44.49	46.84	45.05	1.73	0.117
ALT, UL	35.76	35.01	36.12	35.90	1.15	0.806

[a-c]means on the same row with different subscript are significantly different ($P<0.05$).
AST – aspartate aminotransferase; ALT – alanin aminotransferase

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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