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EFFECT OF 3% BIOCHAR AT VARYING LEVELS OF SOAKED FALSE YAM TUBER MEAL ON EGG LAYING PERFORMANCE AND BLOOD PROFILE OF CHICKENS

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ABSTRACT

A twenty-week feeding trial was carried out to determine the effect of 3% biochar (BC) in diets containing varying levels of soaked false yam tuber meal (SFYTM) on the performance of layer chickens. The false yam tubers were peeled and cut into pieces, soaked for 12 days, sun-dried and milled into gritty flour. The BC was obtained from milled wood charcoal. Five experimental diets were tested: 3 diets containing varying levels (4, 6 and 8%) of SFYTM with 3% BC, a diet containing 4% SFYTM (recommended dietary level for layers) without 3% BC and a control diet with no BC and SFYTM. At 49 weeks of age, 250 (Isa Brown) hens of similar live weights were divided into five groups (10 hens/group) and each group replicated 5 times using CRD. A standard commercialized feed was given *ad-libitum* from 49 to 69 weeks of age. Variables measured included mean feed intake, hen day egg production (HDP), egg weight, feed efficiency, feed cost and mortality. An apparent digestibility trial and blood profile analysis were conducted. The apparent DM, CP and NFE of birds on the control diet were higher ($P<0.05$) than those of birds on the other 4 diets. However, CP digestibility of birds fed SFYTM-based diets with BC was higher ($P<0.05$) than that of birds on SFYTM without BC recording mean values of 15.06 and 14.62 respectively. The mean feed intake of all the hens were similar ($P>0.05$). Hens fed SFYTM-based diets with and without BC had similar ($P>0.05$) HDP (74.60 - 77.00) which were higher ($P<0.05$) than that of the control hens (67.70). However, other performance variables were similar ($P>0.05$). For physical egg characteristics, all other parameters were similar ($P>0.05$) in a concession of the albumin weight and the yolk ratio. Blood profile, with exception of alkaline phosphatase were similar ($P>0.05$) for all treatments. Mortality was insignificant ($P>0.05$) with no mortality in hens fed BC. Feeding SFYTM with BC to layers tended ($P>0.05$) to reduce feed cost by 8-14%. It is recommended that 3% BC can be used in layer diets containing up to 8% SFYTM with favourable effect on their performance.

Key Words: Biochar, Chicken, Egg production, False Yam (Icacina oliviformis) tuber, Soaking

INTRODUCTION

Maize is one of the principal cereal crops grown in the sub-Sahara of Africa. Maize is a primary source of energy and can contribute up to 30% protein, 60% energy and 98% starch in animal diets (Loy and Lundy 2019). Corsato *et al.* (2021) reported that, about 85% of the world chicken dietary energy is derived from maize. According to Dahunsi *et al*. (2020), the escalating prices and occasional shortage of maize have contributed immensely to the factors militating against increased commercial poultry production in Ghana. Thus, in addressing problems of high feed cost, there is a need to search for alternative feed resources for use in poultry production (Mengesha, 2012). To achieve cost effectiveness, many researchers have exploited the use of non-conventional feedstuffs such as cassava (Temesgen and Tesfaye (2017). One plant resource of interest as a non-conventional energy feedstuff is false yam (*Icacina oliviformis).* The flour from the tuber is reported to contain 44, 845 and 16 g/kg of crude protein, carbohydrate, and crude fat, respectively (Fay, 1991). Thus, it could serve as an alternative source of dietary energy in poultry rations, if the anti-nutritive factors present in it could be removed.

Processing of false yam tuber such as soaking in water, and soaking with additives (e.g. Saltpeter and common salt) has been recommended to improve its nutritive value for broiler chickens and also reduce the cost of feeding (Dei *et al.*, 2015)

Dei *et al*., 2014a reported that, feeding soaked false yam tuber meal (SFYTM) based diets to laying chickens affected egg production at 5% inclusion level. This is because, the tuber contains anti-nutritional substances including gum-resins, which limit its utilization as food for human and animals (Fay, 1991).

However, Gerlach and Schmidt (2012) reported that BC (charcoal) can act as toxin binder in animal diets. A preliminary study on the use of BC (wood biochar) in the diet of broilers containing false yam seed meal indicates that, wood BC has the potential of aiding utilization of false yam seed meal up to 140g/kg in the broiler chicken diets (Roessler *et al*., 2017. There is limited information on how soaked false yam tuber meal with biochar can influence the egg laying performance of layer chickens.

Therefore, this study was carried out to determine the effect of 3% biochar at varying levels of soaked false yam tuber meal in layer chicken diets on egg laying performance and blood profile of chickens.

MATERIAL AND METHODS

Study site

The experiment was conducted at the Poultry Unit of the Animal Science Department, University for Development Studies, Nyankpala Campus,Tamale. Nyankpala is located in the Guinea Savanna Zone on latitude 09° 25N and longitude 00° 58N at altitude 183m above sea level (SARI, 2004). The temperature fluctuated between 19℃ (minimum) and 42℃ (maximum) with a mean annual temperature of 28.3℃. Rainfall is mono-modal which occurs from April to October with a mean rainfall of 1200 mm and mean annual day-time humidity of 54% (SARI, 2004)

Source and processing of soaked false yam tuber meal (SFYTM)

The false yam (*Icacina oliviformis*) tubers were harvested (dug up by the use of a pick axe and hoe) in the Nyankpala environs. It was then peeled and chopped into small pieces of about 1cm thick and 2 cm long using a knife. The chopped pieces were soaked in ordinary water for twelve days in the ratio; one part of the fresh tuber to two parts of water with the water changed every three days. After soaking, the chopped tubers were sun dried on a concrete floor to a dry matter content of about 90% and then milled into gritty flour and bagged for use. The product was labeled SFYTM. The charcoal used in this study was purchased from the Tamale Central market, crushed using stones, and milled into gritty flour to serve as the biochar for use during the experimentation. It was labeled BC. The composition of soaked tuber sample reported by Dei et al. (2011a) was used for diet formulations. The sample comprised of dry matter basis: 14.27% CP. 0.3.63% EE, 1.10% NDF, 23.14% starch, 70.33% ash and 1.69%.

Experimental birds and design

Two hundred and fifty (250) Isa brown layers obtained from Dormaa in the Bono Region of Ghana were used for this experiment. At 49 weeks of age, birds of similar weights were selected and divided into groups of ten each. Each group of ten birds received one of the five experimental diets for the twenty weeks of the experimental period in a Completely Randomized Design (CRD). Each dietary treatment had five replicates where each replicate consisted of ten birds randomly assigned to each treatment diet (Table 1).

Five (5) experimental diets were formulated as shown in Table 1, 4% SFYTM+3% BC, 6% SFYTM+3% BC and 8% SFYTM+3% BC were the diets containing soaked false yam tuber meal at 4, 6 and 8% inclusion levels respectively with 3% BC added to each of them. Diet with 0% SFYTM and 0% BC served as the control diet (no false yam, no BC). Thus, addition of biochar was to improve utilization of the SFYTM by layer chickens. 3% BC is the level of BC recommended in the diet of broiler chickens (Casey, 2007). The processed false yam tuber meal was used to replace the maize

on percent basis. The diets were formulated to have similar crude protein and caloric values as recommended by NRC (1994) for layer chickens.

Table 1: Composition of experimental diets for layer chickens (49 – 68weeks of age)

Ingredient (%)	**Control diet**	**4% SFYTM+ 0%BC**	**4%SFYTM+3%BC**	**6%SFYTM+3%BC**	**8%SFYTM+3%BC**
Maize	60.00	57.60	57.60	56.40	55.20
SFYTM	0.00	2.40	2.40	3.60	4.80
BC	0.00	0.00	3.00	3.00	3.00
Soybean meal	19.20	19.20	19.20	19.20	19.20
Wheat bran	6.00	6.00	6.00	6.00	6.00
Oyster shell	9.80	9.80	9.80	9.80	9.80
Layer concentrate*	5.00	5.00	5.00	5.00	5.00
Calculated nutrient composition (%)					
Crude protein	16.00	16.00	16.00	16.00	16.00
Calcium	4.10	4.10	4.10	4.10	4.10
Phosphorus	0.48	0.48	0.47	0.47	0.46
ME(MJ/Kg)	11.19	11.16	11.16	11.15	11.13

*Composition of layer concentrate: ME (kcal/kg) 1950; Crude Protein 30%, Crude Fat 4.5%, Crude Fibre 7.5%, Lysine 1.65%, Methionine 2.30, Methionine + Cysteine 2.80%.

Table 2: Analyzed proximate composition of experimental diets (as fed basis)

Parameters (%)	**Control diet**	**4% SFYTM + 0%BC**	**4%SFYTM+3% BC**	**6%SFYTM+3% BC**	**8%SFYTM+3% BC**
DM	93.25	92.75	93.25	92.75	93.25
CP	16.74	14.62	14.85	15.06	14.61
CF	4.15	3.59	3.04	2.52	5.15
EE	2.34	2.32	2.80	2.32	2.80
Ash	9.56	8.81	7.23	11.14	8.86
NFE	54.39	56.69	59.05	55.00	55.53

Data collection on egg laying performance

Feed intake was measured weekly by subtracting the left-over feed at the end of the

week from the amount of feed provided using a digital electronic scale (Jadever, JPS-1050). Eggs were picked and weighed from each replicate every day at 5:00pm using an electronic kitchen scale (SP-10016204). Hen-day egg production was calculated by dividing the number of eggs laid in a day the total number of birds present in replicate and multiplied by 100. The mean egg weight was calculated as the total weight of eggs collected in a day per replicate divided by the number of eggs collected per replicate. Mean eggs mass per hen per day in grams was calculated from the percent hen-day egg production multiplied by average weight of their eggs. Feed-to-egg mass ratio was obtained by dividing the mean feed consumed per hen by the mean egg mass per hen during the same period.

Data collection for the digestibility trial

Known quantities of diets were measured and supplied to the hens on daily basis. The faecal matter was collected in plastic sheet placed beneath the wire-mesh floor of the cages using the Total Collection Method. Faeces were collected daily, from birds in each replicate cage and oven dried (60°C for 48 h). At the end of the trial, collected oven dried samples were pooled into one sample per treatment weighed, ground and stored in air-tight plastic containers for analysis.

Samples of treatment diets and dried faeces were duplicated and analysed for proximate components in accordance with standard methods described by the Association of Official Analytical Chemist AOAC (2000) and the values used to compute apparent nutrient digestibility as indicated below.

Apparent digestibility = (Nutrient consumed – Nutrient excreted in faeces) *100 / Nutrient consumed.

Moisture was calculated by the loss in weight that occurs when a sample is dried to a constant weight in an oven. Ether extract was determined using the soxhlet apparatus equipment. % Ether extract = (Weight of flask + extract – tare weight of flask/Sample Weight) *100.

Crude protein was determined by measuring the nitrogen content of the feed and faecal matter multiplied by a factor of 6.25. Ash was obtained by burning off the organic matter of the feedstuff at 400-600 ^{0}C in muffle furnace for 4 hrs.

Collection of blood sample

Two birds from each replicate were randomly selected for blood sample collection at the end of the study. The selected birds were restrained and 2 ml of blood drawn from their wing veins with a syringe and needle. The collected blood from each bird was emptied into test tubes and labeled. The test tubes containing ethylene diamine tetra acetic acid (EDTA), an anticoagulant which was mixed gently with the blood to prevent blood clot was used for hematological analysis for PCV, RBCs, Hb, MCV, MCH, MCHC and WBCs. The other set of tubes without the EDTA was used for the serum biochemistry analysis.

Economic analysis of experimental diets

The false yam tuber was not bought. However, the cost incurred was due to labour involved in harvesting and processing. Economic variables computed were total feed intake per bird, feed cost per kg diet, total feed cost per bird and feed per dozen eggs.

Data analysis

The parameters for both feeding and digestibility coefficients trial were subjected to analysis of variance (ANOVA) for a Completely Randomized Design (CRD) using GenStat, 3rd version. (Significant differences among treatment means were separated using least significant difference (LSD) and values were considered significant at ($P<0.05$).

RESULTS

Apparent digestibility of experimental diets

Results of the effect of varying levels of SFYTM with 3% BC on apparent nutrient digestibility of the experimental diets by laying chickens are shown in Table 2.

Table 2: Effect of varying levels of SFYTM with 3% BC on apparent nutrient digestibility

Parameters (%)	Control diet	4%SFYTM+0% BC	4%SFYTM + 3% BC	6%SFYTM+ 3% BC	8%SFYTM+ 3% BC	±SED	P-value
DM	80.69[a]	79.11[b]	78.33[c]	78.08[d]	76.17[e]	0.003	<0.001
CP	70.59[a]	63.53[d]	68.45[b]	68.32[b]	66.57[c]	0.756	<0.001
CF	56.60	50.10	56.70	57.30	52.30	4.22	0.380
EE	83.90	87.80	78.30	81.70	84.10	3.24	0.129
Ash	51.37[b]	50.92[b]	46.26[c]	58.78[a]	48.86[bc]	2.222	0.003
NFE	89.10[a]	87.86[b]	88.11[b]	87.28[b]	85.31[c]	0.453	<0.001

SED=Standard error of difference, P-probability, means with the same superscripts in a row are not significantly different (P>0.05). DM-Dry Matter, CP- Crude Protein, CF- Crude Fibre, EE- Ether Extract, NFE- Nitrogen Free Extract.

There were significant differences (P<0.001) in the dry matter digestibility of the experimental diets among the treatments with a decreasing trend (P<0.001) in the DM digestibility of all diets containing SFYTM from the control diet (No SFYTM, No BC). Similarly, all diets containing 3% BC with increasing levels of SFYTM also showed decreasing trend of DM digestibility. Crude protein digestibility was superior (P<0.001) in the control diet over other diets containing SFYTM. (Table 2). Crude fibre digestibility was similar (P>0.05) for all experimental diets. Generally, EE digestibility was high for all experimental diets. However, there was no significant difference (P>0.005) observed for EE digestibility in all diets tested. Ash digestibility for birds fed both control diet was statistically same (P>0.05) and also similar to birds on diets containing 8% SFYTM+3% BC. Diet containing 4% SFYTM+3% BC was significantly (P<0.05) different from birds fed treatments diets containing 6% SFYTM+3% BC but similar to birds on treatment diets containing 8% SFYTM+3% BC. Birds on treatment diets containing 6% SFYTM however differed significantly (P<0.003) from the rest of the treatment diets (Table 2). Digestibility of NFE was significantly (P<0.05) higher for birds on control diet than birds fed diet containing SFYTM with or without BC. However, birds fed diet containing 4 and 6% SFYTM with or without BC had similar NFE digestibility (P>0.005) and higher digestibility values (P<0.001) than birds fed diets containing 8% SFYTM with 3% BC.

Feeding trial

The effects of varying levels of SFYTM with 3% BC on feed intake and egg laying performance of layers are shown in Table 3.

Table 3: Effect of 3%BC at varying levels of SFYTM on performance of layer chicken

Parameters	Control diet	4% SFYTM +0%BC	4% SFYTM+ 3%BC	4% SFYTM+ 0%BC	8% SFYTM+ 3%BC	±SED	P-value
Feed intake (g/b/d)	90.89	91.81	92.31	95.31	89.50	2.859	0.369
Hen-day egg production (%)	67.70[b]	74.60[a]	74.70[a]	77.00[a]	74.80[a]	3.35	0.002
Mean egg weight (g)	56.29	56.74	57.12	57.13	56.49	1.181	0.935
Mean egg mass (g/hen)	38.12	42.41	42.69	43.98	42.30	2.347	0.172
Feed-to-egg mass ratio	2.44	2.18	2.17	2.17	2.12	0.151	0.268
Mortality (%)	0.80	0.40	0.00	0.00	0.00	0.400	0.213

SED=Standard error of difference, P-probability, means with the same superscripts in a row are not significantly different (P>0.05).

Feed intake showed no significant (P=0.369) difference between control diet and the rest of the treatment diets containing SFYTM with or without BC. There was a significant (P<0.002) difference observed in hen-day egg production between birds fed the control diet and those birds fed diet containing SFYTM with or without BC. However, birds fed diets containing SFYTM with or without BC recorded similar (P>0.005) hen day egg production (Table 3).

Egg production performance of experimental hens (49-68 weeks) is shown in Figure 1 below.

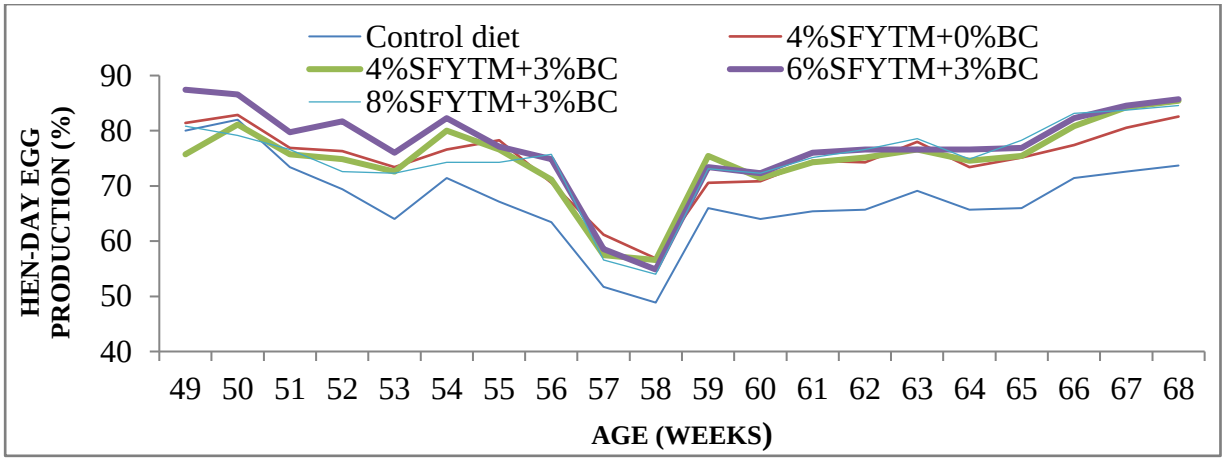


Figure 1: Effect of 3% BC at varying levels of SFYTM on hen-day egg production of laying chickens (49-68 weeks of age)

Egg production during the laying phase as illustrated in figure 1 was higher for birds fed the SFYTM based diets than their counterparts given the control diet throughout the entire 20 weeks of experimentation. Similar hen-day egg production values were recorded for all treatment groups containing the SFYTM. In general, it was observed that egg production of birds on all the five-dietary treatment had a drastic decline at 56 weeks (8th week of study)

of age which lasted for about two weeks before picking up again at 58 weeks (10^{th} week of study) of age and remained fairly constant to the end of the work. The mean egg weight as indicated in Table 3 did not differ significantly (P>0.05) among the treatment groups. There was no significant (P>0.05) difference between birds fed control diet and those birds fed diets containing SFYTM with or without BC. The mean egg mass recorded in this study ranged between 38.12 g (control diet) and 43.98 g (6% SFYTM +3% BC). Feed conversion (feed/egg mass) efficiency presented in Table 3 was not significantly (P>0.05) different among the experimental groups. Values recorded for feed to egg mass ratios had a minimum value of 2.12 for birds fed 8% SFYTM+3% BC and a maximum of 2.44 for birds fed standard diet. Mortality of birds occurred only in groups of bird fed the control diet and 4% SFYM+0% BC. An overall total of six mortality cases were observed in the course of the 20 weeks of study. The control diet recorded a total death toll of four birds and 4% SFYTM+0% BC recording two death cases.

Physical egg quality

Table 4: The Effect of 3%BC at varying levels of SFYTM on physical egg quality characteristics

Parameters	Control diet	4% SFYTM+ 0%BC)	4% SFYTM +3%BC	6% SFYTM+ 3%BC	8% SFYTM+ 3%BC	±SED	P-value
Albumin height (mm)	10.16	10.08	10.16	9.36	10.12	0.289	0.051
Haugh unit	98.92	100.12	99.48	100.20	99.68	1.450	0.902
Albumin weight (g)	37.80^{b}	36.48^{b}	38.80^{a}	39.60^{a}	40.80^{a}	1.362	0.045
Yolk weight (g)	14.12	13.04	13.56	12.80	13.60	0.505	0.119
Shell weight (g)	6.96	6.56	7.04	6.72	7.44	0.323	0.109
Shell thickness (mm)	0.34	0.34	0.34	0.34	0.33	0.014	0.977
Albumin ratio (%)	64.22	64.95	65.22	66.94	65.87	1.065	0.158
Yolk ratio (%)	23.97^{a}	23.33^{a}	22.94^{a}	21.71^{b}	22.14^{b}	0.714	0 .034
Shell ratio (%)	11.81	11.72	11.86	11.37	12.05	0.509	0.747

SED=Standard error of difference, P-probability, means with the same superscripts in a row are not significantly different (P>0.05).

Inference from Table 4 indicate values recorded for albumen height in this research were similar (P>0.05) for birds fed all five dietary treatments. However, birds fed the control diet recorded a mean value (10.16) than those on the 4% SFYTM + 0% BC which recorded (10.08).

There was no significant (P>0.05) difference in terms of protein quality between birds fed all five dietary treatments diets. In terms of numerical differences, those birds fed diets containing SFYTM with or without BC tended to have relatively higher egg protein quality values (99.48- 100.20) than those birds fed the control diet. Birds fed control diet and those on 4% SFYTM+0% BC showed no significant (P>0.05) difference in terms of their mean albumen weight values. It was also observed that, the control diet and 4% SFYTM+0% BC diets were significantly (P=0.045) different from the three remaining treatments diets containing BC. However, mean albumen weight between birds on treatment diets containing BC were statistically same with increasing mean albumen weight values as the inclusion levels of false yam tuber meal increases (Table 4). Table 4 also showed that, values recorded for yolk weight in this research, for all five dietary treatments were similar. Hence, there were no significant (P>0.05) difference in yolk weight between birds fed both the control diet and those fed remaining treatments. There was no significant (P>0.05) difference in shell weight between birds fed all five treatment diets. The mean values recorded ranged from a lower limit value of 6.56-7.44 g. there was no significant (P>0.05) difference in egg shell thickness between birds fed all five dietary treatments.

The albumin ratio which estimates the proportion of albumin to whole egg for birds fed all five treatment diets was similar. Generally, birds on the treatment diets containing SFYTM had higher albumen ratios 64.95- 66.94% than birds on the control diet (64.22%). The yolk ratio estimating proportion of yolk to whole egg was similar (P>0.05) for birds fed the control diet and birds on diets containing 4% SFYTM+0% BC and 4% SFYTM+3% BC. Also, it was observed that, birds on the control diet were significantly (P<0.05) different from birds on 6% SFYTM+3% BC and 8% SFYTM +3% BC. The shell ratio is the proportion of shell to whole egg and this was observed not to vary significantly (P>0.05) between birds fed all five treatment diets in this study (Table 4).

Hematological profile of layer chickens

The effects of SFYTM with 3% BC on hematological parameters of layer chickens as shown in Table 5 indicated no significant (P>0.05) difference in all hematological parameters measured for all five dietary treatments except for the mean platelet volume. Mean platelet volume was similar (P>0.05) for birds fed the control diet and birds fed the 4% SFYTM+0% BC as well as the 8% SFYTM+3% BC diets. Also, birds fed the control diet were different significantly (P< 0.03) from birds on 4% SFYTM+3% BC and 6% SFYTM+3% BC dietary treatments.

Table 5: Effect of at varying levels of SFYTM 3% BC on hematological parameters of laying chicken (49-68 weeks of age)

Parameter	Control Diet	4%SFYM +0%BC	4%SFYTM +3%BC	6%SFYM +3%BC	8%SFYM +3%BC	±SED	P-value
Haematocrit (%)	26.86	28.38	26.24	27.90	25.56	2.484	0.784
Haemoglobin (g/dl)	6.74	7.32	6.70	6.94	6.48	0.653	0.758
MCH (Pg)	31.54	32.60	32.18	31.92	31.62	0.882	0.749
MCHC (g/dl)	25.00	25.80	25.60	24.90	25.30	0.55	0.444
MCV (fL)	126.14	126.36	125.56	128.10	124.92	1.742	0.463
MPV (fL)	9.16^{a}	9.58^{a}	8.34^{b}	8.64^{b}	9.06^{a}	0.374	0.031
RBC ($x10^{6}$ml)	2.13	2.25	2.09	2.18	2.05	0.210	0.895
WBC ($x10^{3}$ml)	9.13	8.44	8.10	8.68	10.55	1.786	0.686

SED=Standard error of difference, P-probability, means with the same superscripts in a row are not significantly different (P>0.05). MCH-Mean cell hemoglobin (Pg), MCHC-Mean cell hemoglobin concentration, MCV-Mean cell volume, MPV-Mean platelet volume, RBC- Red blood cells, WBC-White blood cells

Serum biochemistry profile of layer chickens

Serum biochemical indices from Table 6 showed no significant (P>0.05) difference between all parameters measured under the serum profile of birds fed all five-treatment diets aside the alkaline phosphatase. Birds fed control diet, 4% SFYTM+0% BC and 6% SFYTM+3% BC were statistically same even though birds on the control diet recorded a higher numerical value. Also, it was observed that, birds on the control diet were different significantly (P=0.048) from treatments diets 4% SFYTM+3% BC and 8% SFYTM+3% BC).

Table 6: Effect of 3%BC at varying levels of SFYTM on serum biochemistry parameters of laying chicken (49-68 weeks of age)

Parameters	Control diet	4%SFYM+0% BC	4% SFYTM+3%BC	6% SFYTM+3%BC	8% SFYTM+3%BC	±SED	P-value
Albumin (g/l)	24.90	25.76	23.66	22.62	19.92	3.135	0.408
Globulin (g/l)	35.5	34.2	32.60	29.7	27.0	6.23	0.656
Total proteins (g/l)	60.2	61.5	56.2	52.3	47.5	8.97	0.526
Aspartate transferases (U/l)	146.5	148.5	150.9	136.8	159.2	23.34	0.912
Alanine transferases (U/l)	15.9	10.3	11.0	14.8	12.8	3.48	0.458
Alkaline phosphatase (U/l)	179[a]	107[a]	202[b]	156[a]	233[b]	39.5	0.048

SED=Standard error of difference, P-probability, means with the same superscripts in a row are not significantly different (P>0.05).

ECONOMICS OF FEEDING

From Table 7, feed cost per kg diet decreased slightly (0.62%) with increasing levels of SFYTM in the diets. It was observed that, there was no difference in all treatment diets with respect to the total feed intake. However, birds fed the control diet recorded the highest total feed intake and birds on the 8% SFYTM+3% BC recording the least. Total feed cost and feed cost per egg also showed no significant difference among all five treatments. Feed cost per egg however generally showed lower mean values in diets containing SFYTM with or without BC. There was a reduction of 1.00% comparing the control diet to the rest of the treatment diets containing SFYTM with or without BC.

Table 7: Economic analysis of 3% BC at varying levels of SFYTM on production

Parameter	Control diet	4% SFYTM+ 0%BC	4%SFYTM +3%BC	6%SFYTM+3%BC	8%SFYTM+3%BC	SED	P-value
Feed cost/Kg diet	1.62	1.61	1.61	1.60	1.59	-	-
Total feed intake (Kg/hen)	10.23	9.58	9.23	9.53	8.95	0.690	0.449
Total feed cost(GH₵)/ hen	16.60	15.40	14.84	15.25	14.26	1.117	0.343
Feed cost/egg(GH₵)	0.10	0.09	0.09	0.09	0.09	0.008	0.182

SED=Standard error of difference, P-probability, means with the same superscripts in a row are not significantly different (P>0.05).

DISCUSSION

Apparent nutrient digestibility of feed containing SFYTM with BC

Presence of anti-nutritional factors in feedstuffs has been reported to affect digestibility and utilization of feed by animals (Ramteke *et al*., 20019. False yam has been reported to contain bitter principles (gum resins) which affect digestibility (Fay, 1987). This may be a reason for the decreased apparent digestibility of DM, CP and NFE in the treated diets. It was observed in this study that, as SFYTM inclusion level increased, CP digestibility decreased. It has been reported by Roessler *et al*. (2017 that the residual levels of anti-nutritional factors (gum resin) in the feed may have negatively affected CP utilization and amino acid digestibility. Pekel *et al*. (2015) also reported that anti-nutritional factors react with protein, enzymes, or essential amino acids and form various complexes, thus affecting digestibility and nutrient utilization in poultry.

A similar finding was observed by Wadhwa and Bakshi (2016) who fed some layers with camelina and flaxseed seed meal which also contains terpenes and observed that the DM and CP digestibility were significantly affected. When SFYTM was fed to layer at 5, 7.5 and 10% by Roessler *et al*. (2017 there was also significant reduction in CP digestibility. As reported by Dei *et al*. (2011a) the low levels of CP in SFYTM which was 3.63% will result in decreasing the total CP in the diet as inclusion levels increases.

Addition of BC to the diets containing SFYTM was seen to have improved diet utilization. The BC based diet recorded higher digestibility mean values as compared with the 4% SFYTM+0% BC indicating that BC positively affected CP digestibility. Kutlu *et al*. (2001) reported that biochar is an absorbent for many toxins, gases, fat and fat-soluble substances which is in agreement with what was reported by Salameh and Baha Eddin (2007) that properties of charcoal as an absorbent had an effect on cell membranes, surface tension and eliminating of gases and toxins in the gastro intestinal tract and therefore improved utilization and absorption of nutrients across cell membranes. It is reported that, diet supplementation with charcoal increased digestibility for commercial meat chickens and ducks (Man*et al*., 2021.

Egg production performance

Feed intake

Feeding the birds with diets containing SFYTM with or without BC compared favourably to their counterparts on the control diets with respect to feed intake. The similarities in feed intake as seen in the entire experimental period propose that, the addition of SFYTM with BC enhanced diet palatability comparable to that of the control diet. Treating the false yam tuber by soaking in ordinary water did remove some anti-nutritional factors and thereby increasing its palatability and hence improving the nutritional quality of the tuber. Previous studies by Dei *et al.* (2011a) showed that soaking reduces the bitterness of the tuber thereby improving feed intake. Generally, addition of SFYTM to layer diets up to 100 g/kg did not affect consumption (Mohammed and Dei, 2013) which confirms Razeng *et al*. (2015) indicating birds eat similar quantity of feed with similar nutrient composition. It is also possible that, the treatment with BC contributed to the increase in palatability, as BC is known as a detoxifier and an adsorbent for many toxins, gases, drugs, fat and fat-soluble substances (Kutlu *et al*., 2001). According to Baha Eddin (2007) addition of citrus wood charcoal had considerable improvement in feed intake. It is clear in this study that BC had effect on feed intake because birds on 4% SFYTM+0% BC diet had a lower numerical feed intake value (91.81 g/b/d) whiles 4% SFYTM+3% BC recorded a higher numerical feed intake value (92.31) even though they were not statistically significant.

Hen day production

All diets containing SFYTM with or without BC did better than the control diet. This could be as a result of the nutritional composition of SFYTM and the positive effect of BC on diet utilization. As reported by Dei *et al*. (2014a), incorporation of SFYTM up to 40 g/kg in the diets of layer chickens had favourable effect on egg production. The improvement in egg production can be attributed to the lower concentration of the anti-nutritional factors (terpenes) reported by Vanhaelen *et al.* (1986) and Darmawan *et al*. (2022 which was not adequate at the levels tested to hinder digestibility and utilization of the diets. Also, it is known that adding BC to the diet of animals improves their performance. Man*et al*. (2021 reported that, diets supplemented with charcoal resulted in an increased weight feed conversion ratio in commercial meat chickens and ducks.

The decline in hen day egg production at age 56 weeks was due to a change in layer concentrate (Hendrix) which was different from the initial koudijs brand used at the start of the experiment. Birds will automatically react to any change in diet composition which could lead to low production performance as observed in the cause of this study. Bain *et al*. (2016) recommended that, rapid change in diet and changes in diet composition should be avoided in keeping layer birds. Also, according to Okafor (2014), there are several factors that causes decline in egg production of which changes in diet composition is one of them.

Feed to-egg-mass ratio, expressing the efficiency of diet utilization after digestion into eggs as observed in this study was not significant for all five-treatment diets. However, birds on diets containing SFYTM with or without BC compared favourably to those on the control diets. This was evident in egg production as birds on the SFYTM with or without BC based diet tended to have performed better than their counterparts on the control diets. This is in agreement with Dei *et al.* (2014a) when soaked false yam tuber meal was fed at low dietary levels and Shireen *et al* (2018) who said properties of charcoal as an absorbent improved utilization and absorption of nutrients across cell membranes.

Physical egg characteristics

Among many egg quality characteristics, external factors such as egg and shell weights are important in consumers' acceptability of shelled eggs. The similarities observed in many of the egg internal and external characteristics revealed that, the addition of SFYTM and BC did not have any negative effect on eggs laid. However, albumin weight and yolk ratio differed.

The high albumin weight recorded by diet containing BC is an indication of better feed utilization. It is reported that, diet supplemented with charcoal results in an increased feed efficiency (Kana *et al*., 2011). Also, higher albumin weight by diet containing SFYTM and BC than control diet is in harmony with the report of Aziza *et al*. (2013) who also fed layers with two different types of non-conventional feedstuff (camelina and flaxed seed meal) and recorded a higher albumen weight in the treated diet than the control diet.

Mortality

No mortality was recorded for birds that were on diet with SFYTM with BC but few cases of mortality was recorded for birds fed the control diet as well as the 4% SFYTM+0% BC diet. This reflected in the value recorded for MPV. In this study, higher values of MPV were recorded by birds on the control diet and those on the 4% SFYT+0% BC diet. According to Liu *et al*. (2012), MPV is higher when there is destruction of platelets and this may be seen in inflammatory bowel disease. Several researches have been conducted over the past decade to better understand the benefits of BC as a feed supplement for broilers. Gerlach and Schmidt (2012) found that BC deactivated toxins already in the digestive system, positively activating intestinal flora and vitality. Teleb *et al.* (2004) found that diet supplemented with 0.5% BC made from locally available wood overcame the detrimental effects of feeding broilers 30 ppb aflatoxin by showing reduced mortality rates and improved growth rates when compared to those fed 30 ppb aflatoxin.

Haematological profile and serum biochemistry

Blood biochemical parameters reflect the physiological state of the animal resulting from nutrition, pathogenic factors activity, welfare level or breeding technology (Brito et al, 2020).

Mean platelet volume is the only parameter that differed in this present study and is a parameter calculated to indicate the presence of diseases. The lower mean platelet volume by diet containing BC as compared to the control diet and 4% SFYTM+0% BC is a clear indication that BC could help in preventing diseases in animals. According to Liu *et al*. (2012) MPV is higher when there is destruction of platelets and this may be seen in inflammatory bowel disease. Not only that, several diseases cause high MPV in blood (Noris *et al*., 2016). However, the haematocrit values are within reference value for normal chicken reported by Gylstorff, (1983) and Bounous and Stedman, (2000); which is 24.00-43.00% and 22.00-35.00% respectively. Most values for haemoglobin were a little less than the reference values which are between 7-13% as reported by Bounous and Stedman, (2000). This may be due to the diet, because the control diet and the remaining diets were lower than the reference value. According to Mohammed *et al*. (2015), haematological parameters did not differ when SFYTM was incorporated in the diet of layer chickens. According to Egbunike and Akusu (1983) factors such as genotype, breed of animals, management or environment, age, diseases, medication and nutrition may have influence on the blood parameters of farm animals.

All serum biochemical parameters measured in this study were not significant except for alkaline phosphatase which was significant. The total protein and albumin values reported in this study were similar to what have been reported by Bubel *et al.* (2015) with birds from 54-65 weeks old. These birds were also fed a plant with medicinal properties as false yam and BC. Alkaline phosphatase (ALP) is a hydrolytic enzyme widely observed in animal tissues. The differences in alkaline phosphatase in the study may be due to other factors than the test material only. This is because the values obtained do not follow any pattern. According to Healthline (2007), the levels of this enzyme in the blood depend on factors such as age, gender and blood type. Abnormal levels of alkaline phosphatase in the blood could indicate issues relating to the liver, gall bladder or bones. Kidney tumors, infections as well as malnutrition has also shown abnormal level of alkaline phosphatase in blood (Levitte et al., 2022.

Economic analysis of production

The incorporation of 3% BC at varying levels of SFYTM appeared to have had favourable effect on cost of feeding layer chicken. Adding 3% BC at varying levels in diets containing SFYTM tended (P>0.05) to reduce total feed cost by 8-14%. Similar results of feed cost analysis were reported by Mohammed *et al*. (2015) when biochar was incorporated in diets containing false yam seed meal. Lower total feed cost and total feed intake (6.98 and 5.49 kg/bird respectively) was reported by Dei *et al*. (2014a) at 4% inclusion level of SFYTM as compared to the current study with BC.

CONCLUSION AND RECOMMENDATION

Conclusion

Incorporation of 3% BC in diets containing up to 8% SFYTM significantly improved apparent crude protein digestibility but depressed dry matter digestibility.

Addition of 3% BC in diets containing up to 8% SFYTM significantly improved egg production of layer chickens.

Feeding of BC to layer chickens had no adverse effects on their blood profile with no mortality as recorded in birds on the control diets.

The use of 3% BC in diets containing SFYTM tended to have favourable effects on economics of production with 8-14% reduction in total feed cost.

Recommendation

Based on the results of this study, it is recommended that farmers can use up to 8% SFYTM in layer chicken diet by adding 3% BC. It is also recommended that inclusion levels of SFYTM should be increased above 8% to ascertain the level at which 3% BC can effectively improve the utilization of SFYTM in future studies.

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