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HAEMATOLOGY AND SERUM BIOCHEMISTRY OF PIGS FED GROWER FEED FORTIFIED WITH COCOA (*THEOBROMA CACAO*) SEED TESTA

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Abstract: The on-farm attempt to cut down feed costs through bulk fortification of standard animal feed with available cheap conventional feed ingredients or wastes had been a normal practice without a known empirical impact on livestock health and wellbeing. Therefore, this study determined the haematological parameters and serum biochemistry of pigs fed cocoa (*Theobroma cacao*) seed testa at varying inclusion levels in the formulated standard grower pig feed; T_1:0% CST, T_2:25% CST, T_3:50% CST, T_4:75% CST and T_5:100% CST. Thirty (30) 8-week-old pigs were randomly assigned to the five treatments of six pigs each and replicated thrice, with two pigs per replicate in a completely randomised design (CRD). The experiment lasted for 10 weeks. At the end of the feeding trial, blood samples were collected randomly from three pigs per treatment through the jugular vein using hypodermic needle and syringe for haematological analysis and serum biochemistry. This study recorded significant differences ($P<0.05$) in most of the haematological parameters, except for white blood cell (WBC), platelet and heterophils; apart from high-density lipoprotein, all serum biochemical indices were also significantly different ($P<0.05$). Haematological parameters and serum indices were within the normal range for the healthy pig, except for lymphocytes. However, based on the results of the haematological indices and the serum biochemical parameters, it could be concluded that cocoa seed testa at the 25% inclusion level in the standard grower pig feed had the optimum support for the wellbeing and healthy performance of pigs.

Key words: blood parameters, serum indices, pig health, pig diets, cocoa seed testa.

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Introduction

Feed constitutes about 75–80% of the production cost of pigs (Tewe, 1997). This is presently evident from the high cost of conventional feedstuffs like soybean meal, groundnut cake and fishmeal (Amaefule et al., 2019). This is consequent upon the fact that both legume and cereal grains that are available are keenly competed for by man for either direct consumption and/or for industrial uses (Emiola et al., 2011). Hence, the high cost of such ingredients results in a level that their ideal usage in feed formulation for livestock becomes almost uneconomical. Keeping costs within reasonable margins demands alternative uses of non-conventional feed ingredients. This resulted in searching for alternative feed stuffs of almost zero competition with human nutritional needs. However, the on-farm attempt to cut down feed costs through bulk fortification of standard animal feed with available cheap conventional feed ingredients or wastes had been a normal practice without a known empirical impact on livestock health and wellbeing.

There are several reports on both energy and protein-based under-utilised feed resources for feed ingredients in pig and poultry nutrition. These reports include tigernut (Ukpabi et al., 2015), palm oil sludge (Esonu et al., 2006), wild variegated cocoyam (Agbabiaka et al., 2006). Additionally, Makinde et al. (2019) reported that cocoa and its by-products show great potential as an alternative feed resource that can replace conventional feed ingredients in animal nutrition. Most agro and industrial by-products are now being used with little or no processing in feeding livestock. Cocoa by-products show great potential as an alternative feed resource that can partially replace conventional feed ingredients used in animal nutrition (Olayinka et al., 2019). Cocoa bean testa/shell is the seed coat covering the cocoa cotyledon, and it constitutes nearly 10% of the bean weight, resulting in problems of disposal for the cocoa processing factories in Nigeria. Moreover, Magistrelli et al. (2016) noted that the pig stands above other monogastrics in the use of cocoa testa in their nutrition; with a positive effect on the balance of the intestinal microbial ecosystem, subsequently reducing intestinal inflammatory diseases. The presence of theobromine, an anti-nutrient, in cocoa bean shells brought a lot of setbacks to cocoa bean testa utilisation in livestock feeding. However, theobromine remediation strategies like physicochemical treatments such as the boiling of cocoa bean testa/shell or hydrotropic extraction have been proposed (Makinde et al., 2019). Oduro-Mensah et al. (2018) also proposed fungi fermentation treatments for cocoa bean testa/shell. Caffeine and theobromine are purine alkaloids widely consumed as stimulants and snacks in coffee and cocoa-based foods and drug ingredients (Emiola et al., 2011).

A recent body of knowledge on these two alkaloids, however, is centered on their potential reproductive toxicities. Evidential in the prominent effects of increasing concentrations of dietary theobromine were anorexia, decreases in body

weight of mature rats, growth retardation in immature rats and atrophy of the thymus glands in rats of both sexes and testicular atrophy in male rats as reported by Emiola et al. (2011). However, the level of the inherent negative impact of the alkaloids in the cocoa bean testa/shell can be established through haematological indices of the animal fed the diet containing cocoa bean testa/shell. The opportunity derived from blood examination during investigations revealed the presence of some metabolites in addition to other constituents in the body of animals as it plays a vibrant role in the physiological, nutritional and pathological status of an organism (Nse Abasi et al., 2014). Findings by Olafedehan et al. (2010) have revealed that important information for the diagnosis and prognosis of diseases is embedded in the blood composition of animals. Haematological studies are useful in the diagnosis of many diseases as well as the investigation of the extent of damage to blood (Emiola et al., 2011). A haematological study is of ecological and physiological interest in helping to understand the relationship of blood characteristics to the environment (feed/feeding inclusive) and so could be useful in the choice of animals that are genetically resistant to a certain form of diseases and environmental conditions as revealed by Isaac et al. (2013). Amusa et al. (2015) have made us understand that haematological components are very important in monitoring feed toxicity, particularly of feed constituents that have direct effects on blood formation. Therefore, the study was designed and structured to determine the effects of graded levels of cocoa (*Theobroma cacao*) seed testa/shell incorporated into pig grower feed on the haematological indices and serum biochemistry of pigs.

Material and Methods

Experimental site

The experiment was conducted at the Piggery Unit of the University Teaching and Research Farm, College of Agriculture, Osun State University, Osogbo, Ejigbo Campus, Ejigbo, Osun State. The site is located on latitude 7º54N and longitude 4º18E at an altitude 426 m above sea level. Ejigbo is strategically located in the middle of the region, 35 km north-east of Iwo, 30 km from Ogbomoso in the north and 24 km from Ede in the south-east. It is about 40 km north-west of Osogbo, the capital of Osun State and about 95 km north-east of Ibadan. The mean annual rainfall in Ejigbo is 52.35mm and there were variations from the mean value from year to year (Ejigbo - Wikipedia, 2020).

Experimental materials

Sun-dried cocoa seed testa was sourced from a reputable Cocoa Processing Industry in Akure, Ondo State, Nigeria. The proximate composition of the cocoa

seed testa was as reported by Rojo-Poveda et al. (2020) in Table 1. The formulated grower pig feed is presented in Table 2.

Table 1. The proximate composition of cocoa seed testa.

Composition	Value (g/100g)
Protein	10.30–27.40
Crude fat/oil	1.50–8.49
Ash	5.96–11.42
Moisture	3.60–13.13
Crude fibre	39.25–66.33
Carbohydrate	7.85–70.25
Energy	122.0 kcal/100g

Source: Rojo-Poveda et al. (2020).

Table 2. The gross composition of the standard grower pig feed.

Ingredients	Composition (%)
Maize	42.23
Rice bran	14.97
Wheat bran	14.97
Fish meal	3.28
Soya bean meal	19.97
Groundnut cake	2.43
Bone meal	1.58
Salt	0.32
Premix	0.25
Total	100
Calculated analysis	
Metabolisable energy (Kcal/kg)	3435
Crude protein (%)	18

Experimental diet

The five experimental diets as shown in Table 3 comprised the 100% formulated standard grower pig feed with 0% cocoa seed testa (T_1), a mixture of the 75% standard grower pig feed and 25% cocoa seed testa (T_2), a mixture of the 50% standard grower pig feed and 50% cocoa seed testa (T_3), a mixture of the 25% standard grower pig feed diet and 75% cocoa seed testa (T_4) and 100% cocoa seed testa with the 0% standard grower pig feed (T_5). The formulated standard grower pig feed and the bulk mixtures of the cocoa seed testa and the grower pig feed were milled at the University Teaching and Research Feed Mill, Ejigbo Campus, College of Agriculture, Osun State University, Osogbo, Ejigbo. The experiment lasted for ten weeks. The five experimental diets (treatments) were assigned to the

pigs (experimental units) in a completely randomised design experiment. The facilities allowed for continuous access to water and feed by the pigs ad-libitum.

Table 3. Experimental diets.

Diets	Composition (%)	
	Standard grower pig feed	Cocoa seed testa
T_1	100	0
T_2	75	25
T_3	50	50
T_4	25	75
T_5	0	100

Experimental design, duration and management

A total of thirty (30) 8-week-old weaner pigs were divided into five groups of six pigs per treatment and housed in an individual pen with intensive and conventional managements. Each pen (containing a group of the animals) was assigned to each of the five dietary treatments in a completely randomised design (CRD) to give five treatments with six replicates each. Feed and water were supplied ad-libitum. Before the arrival, the pen was cleaned and disinfected. Routine management operations as applicable to the study area were carried out in the course of the experiment. The experiment lasted for 10 weeks.

Experimental sample collection and preparation

At the termination of the experiment, feed was withdrawn for about 15 hours prior to blood collection; three pigs were selected randomly from each treatment. Samples of blood were drawn from each pig through the jugular vein using a hypodermic needle and a syringe. Ten mm of blood samples were taken early in the morning aseptically through the jugular vein from each animal.

Each blood sample (4ml) meant for the determination of haematological parameters was kept inside an anticoagulant sample bottle containing ethylenediaminetetracetic acid (EDTA) and was gently shaken to prevent coagulation while the sera (6ml) were collected in non-EDTA bottles and preserved in an ice-pack for further transfer to the laboratory, where they were analysed to determine the haematological indices and serum biochemistry parameters using standard laboratory procedures.

Data analysis

The data obtained were subjected to one-way analysis of variance (ANOVA) using the SAS software (SAS version 9:1, 2008). If significant differences were found, then the means were separated using the Duncan's Multiple Range Test (DMRT) of the same statistical package.

Results and Discussion

Haematological indices of pigs fed cocoa seed testa fortified diets

Results of the haematological parameters as presented in Table 4 revealed that six out of nine haematological variables investigated showed a level of significant difference (P>0.05). They include: packed cell volume (PCV), haemoglobin concentration (HBC), red blood cell (RBC), lymphocytes, monocytes and basophils. There were no significant (P>0.05) differences in white blood cell counts (WBC), blood platelet (thrombocytes) and heterophil values. Treatments T1 (0%) (38.00± 0.58%), T2 (25%) (39.50± 0.87%) and T4 (75%) (37.50± 1.44%) were similar in PCV values with T3 (50%) (26.00± 0.58%) and T5 (100%) (31.50± 0.87%) being significantly (P<0.05) different from one another. However, T3 (50%) and T5 (100%) were significantly different from treatments T1 (0%), T2 (25%) and T4 (75%). PCV recorded the highest value in T2 (25%), closely followed by T4 (75%) and then T1 (0%); similarities were seen in the three treatments.

Table 4. The effect of cocoa seed testa (CST) at various inclusion percentages on haematological indices of weaner pigs.

Parameters	T1 (0%)	T2 (25%)	T3 (50%)	T4 (75%)	T5 (100%)
PCV (%)	38.00±0.58^{a}	39.50±0.87^{a}	26.00±0.58^{c}	37.50±1.44 ^{a}	31.50^{b}±0.87
HBC (g/dl)	11.30±0.40^{bc}	12.65±0.38 ^{a}	8.90±0.23^{d}	11.05±0.32^{c}	12.15^{ab}±0.26
WBC (x10^{3}/µl)	5200.00±202.07	5700.00±317.54	4725.00±245.37	5175.00±129.90	5375.00±534.05
RBC (x10^{6}/mm^{3})	5.15±0.25^{b}	6.38±0.10^{a}	4.07±0.60^{c}	5.18±0.60^{b}	4.87±0.09^{b}
Platelet (x10^{3}/µl)	76500.00±2020.73	78500.00±5484.83	7300.00±1732.05	80750.00±1299.04	81000.00±3752.78
Lymphocytes (%)	59.50±1.44^{bc}	65.00±1.15^{a}	57.50±0.87^{c}	62.50±1.44^{ab}	62.50±0.87^{ab}
Heterophils (%)	31.00±0.58	32.00±1.73	35.00±1.73	34.50±1.44	35.50±1.44
Monocytes (%)	1.50±0.29^{ab}	1.00±0.00^{b}	2.00±0.00^{a}	1.00±0.00^{b}	1.50±0.29^{ab}
Basophils (%)	0.50±0.29^{b}	2.00±0.58^{a}	0.50±0.29^{b}	0.50±0.29^{b}	1.50±0.29^{ab}

^{abc}means in the same row with different superscripts are significantly different (P<0.05). PCV – packed cell volume, HBC – haemoglobin concentration, RBC – red blood cell, WBC – white blood cell.

The significant difference recorded for haemoglobin concentration (HBC) among the treatments followed no definite trend. However, similarities were noticed across the treatments for HBC except for T3 (50%) (8.90±0.23g/dl). Treatment T2 (25%) (12.65±0.38g/dl) with the highest HBC value had a similar value with T5 (100%) (12.15±0.26g/dl) but significantly different (P<0.05) from others. T3 (50%) had the least HBC value (8.90±0.23g/dl) and was significantly

different from all the treatments. T2 (25%) had the highest RBC value (6.38±0.10 $x10^6/mm^3$) and was significantly ($P<0.05$) different from the other treatments. Treatments T1 (0%) (5.15±0.25 $x10^6/mm^3$), T4 (75%) (5.18±0.60 $x10^6/mm^3$) and T5 (100%) (4.87±0.09 $x10^6/mm^3$) which were similar ($P>0.05$) regarding RBC values were significantly ($P<0.05$) different from T3 (50%) (4.07±0.60 $x10^6/mm^3$). Treatment T2 (25%) had the highest lymphocyte value (65.00±1.15%) and was significantly ($P<0.05$) different from treatments T1 (0%) (59.50±1.44%) and T3 (50%) (with the least value, 57.50±0.87%) but similar to treatments T4 (75%) and T5(100%), which were equally similar to treatment T1 (0%), which had a similar value with treatment T3 (50%). T3 (50%) (2.00±0.00%) had the highest monocyte value and significantly ($P<0.05$) different from T2 (25%) (1.00±0.00%) and T4 (75%) (1.00±0.00%). Treatment T2 (25%) (2.00±0.58%) had the highest basophil value, which was significantly ($P<0.05$) different from treatments T1 (0%) (0.50±0.29%), and T3 (50%) (0.50±0.29%).

The effects of the diets on the haematological parameters are good indicators of the physiological and health status of the animals as reported by Etim et al. (2013). The higher the percentage of PCV, RBC and HB, the better the haematological profile of the animal (Akinduro, 2016). T2 (25%) (39.50± 0.87%) had the highest PCV, which made it the most preferred among the treatments, though other treatments met the standard percentage required according to Eze et al. (2010). Serum indices are always a reflection of animal responsiveness to their internal and external environment (Akinduro, 2016). Haematological components are those parameters that are related to the blood and blood-forming organs. Blood acts as a pathological reflector of the status of exposed animals to toxicants and other conditions (Olafedehan et al., 2010).

The significant difference indicated different effects of the treatments (percentage levels of cocoa testa in the standard grower pig feed) on the haematological parameters (Olumide et al., 2017). However, all the haematological indices except lymphocytes had their values within the normal range for healthy pigs (Research Animal Resources [RAR], 2009; Etim et al., 2013). Consequently, the non-significant effects of the treatments on WBC, blood platelet (thrombocytes) and heterophil values reflected their sustained physiological contributions in the wellbeing of the pigs.

The slightly higher values recorded for lymphocyte above the normal range in pigs (40–60%) as reported by Etim et al. (2013) showed that the fed diets i.e., T2 (25%), T4 (75%) and T5 (100%) (65.00±1.15%, 62.50±1.44% and 62.50±0.87%) respectively, showed that the pigs could be susceptible to lympho-proliferative neoplasm, notably occurring in viral and bacterial infections, often seen in infectious mononucleosis (Epstein-Barr virus) and whooping cough (*Bordetella pertussis*) (Mania et al., 2018), as a result of higher values for lymphocyte above the normal range. These results contradict that of John et al. (2020) stating that

lymphocyte counts were not significantly affected by the use of a related by-product (cocoa placenta meal [CPM]) supplemented with exogenous enzyme complex. Packed cell volume is involved in the transport of oxygen and absorbed nutrients, whose increased value results in an increased primary and secondary polycythemia (Isaac et al., 2013). However, no symptoms of polycythemia were found in the pigs since their PCV values fell within the normal range.

The pigs under treatment T2 (25% cocoa seed testa) significantly had the highest value similar to those observed in treatments T1 (0% cocoa seed testa) and T4 (75% cocoa seed testa). Similarly, the haemoglobin concentration (HBC) value of the pigs under T2 (25% cocoa seed testa) had the highest value of 12.65±0.35g/dl within the normal range of HBC for pigs (Research Animal Resources [RAR], 2009; Etim et al., 2013). These tend to show that 25% cocoa seed testa in the standard pig grower feed enhanced the best transport of oxygen, nutrient absorption and carbon dioxide exchange in the animal. Also, the RBC values for all the treatments were within the normal range of 4.5–6.3(x 10^6/mm^3) reported by RAR (2009) for healthy pigs. Hence, indicating that the feed was of high quality in terms of protein content, the level of digestibility and tolerable level of anti-nutrients, the optimum carriage of oxygen to the tissues as well as the level of carbon dioxide returned to the lungs would have been realised (Isaac et al., 2013). White blood cell (WBC) and platelet (thrombocytes) counts were not significantly ($P>0.05$) affected by the treatments. Animals in T1 (0%, control), T2 (25%) and T5 (100%) maintained the normal WBC range, which corroborated a report by Brockus et al. (2005) 5.2–17.9 (x10^3/µl), while T3 (50%) and T4 (75%) fell below the normal range.

However, this result contradicted that of RAR (2009) range of 7–20 (x10^3/µl). Nonetheless, the inclusion of cocoa seed testa above 25% suggests a negative effect on the blood. This is similar to a report made by Ogunsipe et al. (2017), which showed that 20% was the optimum biological level of cocoa shells when used as an energy substitute for maize in a pig diet. Most importantly, animals fed 50% and 75% cocoa seed testa indicated that they would have a less defensive mechanism against any infection as a result of low WBC. However, a high value of WBC has been associated with the toxicity of diets or the poor detoxification process which led to the increased production of WBC to fight foreign substances in the body. However, a low value suggests susceptibility to infection (Nwakolor, 2001). Moreover, this might be the reason for disease condition (central nervous system depression, restlessness, diarrhea recorded in the treatments). Cocoa seed testa has been used in laying birds by Olumide et al. (2017) and found to be useful in the replacement of maize up to 10% in the diet of commercial laying birds without any harmful effects on the egg quality indices, performance and haematology. This tends to create the possibility of specifically replacing either energy or protein-based feed ingredients with cocoa seed testa in pig diets. Protein

and energy have been found to be two major components of feed that are determinants of the performance and productivity of farm animals (Amaefule et al., 2019).

Serum biochemistry of pigs fed diets fortified with cocoa seed testa

The effect of cocoa seed testa on serum biochemistry was evident as all the tested blood indices measured for serum analysis such as alanine transaminase (ALT), aspartate transaminase (AST), cholesterol, alkaline phosphatase, triglyceride, low-density lipoprotein, globulin, total protein and albumin showed significant ($P<0.05$) differences except for high-density lipoprotein. The ALT content increased across the treatments, which means the significant changes could have resulted from the inclusion of cocoa seed testa in the diets of the animals, with T5 (100%) (containing the highest inclusion, being the highest inclusion level (6.71±0.01 U/L), followed by T4 (75%) (5.44±0.34 U/L), T3 (50%) (3.97±0.03 U/L) and T1 (0%) (2.00±0.23 U/L). However, T2 (25%) (1.77±0.74 U/L) had the lowest value. Treatment T2 (25%) (45.47±3.05 U/L) had the highest AST value, which made it significantly ($P<0.05$) different from other treatments. The similarity was noticed between T4 (75%) (29.77±2.77 U/L) and T5 (100%) (32.34±4.33 U/L) in the AST content of the serum, unlike T1 (0%), T2 (25%) and T3 (50%); T3 was similar to treatments T4 (75%) and T5 (100%). T1 (0%) had the least AST value. Cholesterol was significantly ($P<0.05$) different across the treatments. Treatments T2 (25%) and T3 (50%) had the highest and the lowest cholesterol values, respectively. Treatment T4 (75%) was next to the highest, followed by T1 (0%) and T5 (100%). ALP was the highest in treatment T1 (0%), followed by T5 (100%) and T2 (25%). Treatments T3 (50%) and T4 (75%) had similar values. Treatments T2 (25%) (101.82±0.03mg/dl) and T1 (0%) (72.73±1.05mg/dl) had the highest and lowest values of triglyceride, respectively. Similarities were noticed between T3 (50%) and T4 (75%) and between T3 (50%) and T5 (100%). Regarding low-density lipoprotein, the similarity was observed between T1 (0%) and T5 (100%) (with the lowest value, 9.14±1.54 mg/dl), and T3 (50%) recorded the highest value of 30.44±0.79mg/dl.

Equally, there were significant differences ($P<0.05$) among the treatments for globulin. Namely, T4 (75%) (2.85±0.23 mg/dl) had the highest value, which was significantly ($P<0.05$) different from T2 (25%) (1.85±0.17g/dl), and T3 (50%) (2.05±0.29g/dl). T5 (100%) (1.49±0.21g/dl) had the lowest value, but similar to T1 (0%) (2.35±0.02g/dl). Also, treatments T2 (25%) and T3 (50%) were similar in values, with both having shared similarities with treatments T1 (0%) and T5 (100%). Treatment T1 (0%) (6.36±0.21g/dl) significantly ($P<0.05$) had the highest total protein value similar to treatment T4 (75%) (6.29±0.02g/dl) but different from treatments T2 (25%) (5.04±0.24g/dl), T3 (50%)(4.83±0.29g/dl) and T5 (100%) (The lowest value, 4.81±0.27g/dl) that were similar in values. The albumin was

significantly (P<0.05) different among the treatments with treatment T1 (0%) having the highest value (4.01±0.01g/dl, significantly (P<0.05) different from other treatments. Treatments T4 (75%) (3.44±0.01g/dl) and T5 (100%) (3.32±0.06g/dl) had similar values that were significantly (P<0.05) different from treatments T2 (25%) (3.19±0.07g/dl) and T3 (50%) (the lowest value, 2.78±0.00g/dl) that were as well different significantly (P<0.05) in values.

Table 5. The effect of the varying dietary inclusion of cocoa seed testa (CST) at various percentages levels on the serum biochemistry of pigs.

Parameters	T1 (0%)	T2 (25%)	T3 (50%)	T4 (75%)	T5 (100%)
Alanine transaminase ALT (U/L)	2.00±0.23^{c}	1.77±0.74^{c}	3.97±0.03^{b}	5.47±0.85^{ab}	6.71±0.01^{a}
Aspartate transaminase (AST) (U/L)	25.32±0.59^{c}	45.47±3.05^{a}	35.61±0.03^{b}	29.77±2.77^{bc}	32.34±4.33^{bc}
Cholesterol (mg/dl)	105.10±2.55^{c}	135.71±0.20^{a}	61.91±0.79^{e}	111.33±2.61^{b}	73.47±1.57^{d}
Alkaline phosphatise (U/L)	69.90±1.35^{a}	16.72±0.39^{c}	5.19±0.48^{d}	5.44±0.34^{d}	22.66±1.31^{b}
Triglyceride (mg/dl)	72.73±1.05^{d}	101.82±0.03^{a}	88.64±1.31^{bc}	85.00±1.31^{c}	90.91±2.10^{b}
High-density lipoprotein (mg/dl)	31.41±3.55	32.29±0.11	29.75±2.15	27.44±0.07	27.50±2.55
Low-density lipoprotein (mg/dl)	11.15±0.62^{d}	15.04±1.25^{c}	30.44±0.79^{a}	19.20±1.09^{b}	9.14±1.54^{d}
Globulin (g/dl)	2.35±0.02^{ab}	1.85±0.17^{bc}	2.05±0.29^{bc}	2.85±0.23^{a}	1.49±0.21^{c}
Total protein (g/dl)	6.36±0.02^{a}	5.04±0.24^{b}	4.83±0.29^{b}	6.29±0.21^{a}	4.81±0.27^{b}
Albumin (g/dl)	4.01±0.01^{a}	3.19±0.07^{c}	2.78±0.00^{d}	3.44±0.01^{b}	3.32±0.06^{b}

^{abcde}means in the same row with different superscripts are significantly different (P<0.05).

Data obtained for total protein and albumin indicated that the control diet had the highest value. The low values of total protein and albumin under the different treatments containing the cocoa seed testa were also noticed by Olumide et al. (2017), and Olorode et al. (1996) confirmed that the significant reduction in the total protein of birds fed 10% and 15% shea butter cake was an indication of poor protein utilisation. This is most likely associated with the theobromine content in cocoa seed testa, suggesting that theobromine remediation strategies as proposed by Makinde et al. (2019) and Oduro-Mensah et al. (2018) can be employed to boost the quality of cocoa seed testa in realising better utilisation. Aspartate transaminase (AST) for all the treatments was found to be within the normal range reported by RAR (2009). Hence, the animals were free from myocardial infarction and skeletal muscle disorders and they had liver and other organs functioning well. Moreover, the pigs under experimental diets containing levels of cocoa seed testa have improved triglyceride when compared with the control diet. The value recorded for

triglyceride falls within the normal range as reported by RAR (2009) which is equally an added advantage to the test ingredients used and at the same time falls within the normal range reported by RAR (2009).

Conclusion

Based on the analysed data, it could be concluded that the haematological indices and serum biochemistry parameters recorded supported the general health and wellbeing of the pigs fed cocoa seed testa-based diets without compromise. Hence, the 25% inclusion of CST in the standard grower pig feed had the optimum support for the wellbeing and healthy performance of the pigs.

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HEMATOLOGIJA I BIOHEMIJA SERUMA SVINJA HRANJENIH SMEŠOM ZA PORAST OBOGAĆENOM OPNOM SEMENA KAKAOA (*THEOBROMA CACAO*)

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R e z i m e

Pokušaji da se u praktičnim uslovima smanje troškovi ishrane životinja, korišćenjem dostupnih jeftinijih konvencionalnih hraniva ili sporednih proizvoda, pored standardne hrane za životinje, predstavljaju široko zastupljenu praksu bez poznatog empirijskog uticaja na zdravlje i dobrobit životinja. Ovim istraživanjem su utvrđeni hematološki parametri i biohemija seruma prasadi koja su kao komponentu smeše za porast konzumirala opnu semena kakaoa (*Theobroma cacao*) pri različitim nivoima uključivanja: T1:0% CST (engl. *cocoa seed testa*), T2:25% CST, T3:50% CST, T4:75% CST i T5:100% CST. Trideset (30) osmonedeljnih prasadi nasumično je raspoređeno u pet tretmana od po šest prasadi (tri puta po dva praseta) po modelu slučajnog blok sistema. Eksperiment je trajao 10 nedelja. Na kraju hranidbenog ogleda, uzorci krvi su uzimani od po tri slučajno izabrana praseta, po tretmanu, iz jugularne vene, korišćenjem podkožne igle i siringe za hematološku i biohemijsku analizu seruma. Ovom studijom su utvrđene značajne razlike ($P<0,05$) u većini hematoloških parametara, osim leukocita, trombocita i heterofila; pored lipoproteina visoke gustine, svi biohemijski indikatori seruma su takođe bili značajno različiti ($P<0,05$). Hematološki parametri i parametri seruma bili su u normalnom opsegu za zdrave svinje, osim limfocita. Međutim, na osnovu rezultata hematoloških parametara i biohemijskih parametara seruma, može se zaključiti da uključivanje opne semena kakaoa na nivou od 25% u standardnu smešu za porast prasadi ima optimalan efekat na dobrobit i zdravlje svinja.

Ključne reči: parametri krvi, parametri seruma, zdravlje svinja, ishrana svinja, opna semena kakaoa.

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