Journal of Food, Nutrition and Agriculture 2020, 3: 26-32
http://dx.doi.org/10.21839/jfna.2020.v3.333

Research Article

Biologically upgraded cocoa pod husk: Effect on growth performance, haemato-biochemical indices and antioxidant status of broiler chickens

Olayemi Aanuoluwapo Olugosi*, Johnson Oluwasola Agbede, Gbenga Emmanuel Onibi, Issac Abayomi Adebayo, Akinlolu Oluwafemi Ayeni

Department of Animal Production and Health, School of Agriculture and Agricultural Technology, The Federal University of Technology, Akure, Nigeria

(Received: 28-05-2020; Revised: 04-08-2020; Accepted: 13-08-2020; Published: 07-09-2020)
*Corresponding author (E-mail: oladom54@yahoo.com)

ABSTRACT

A 49 day feeding trial was conducted to determine the effect of biologically upgraded cocoa pod husk meal (BCPHM) on the growth performance, haemato-biochemical indices and antioxidant status of broiler chickens. Three experimental diets were formulated at both starter and finisher phases in which BCPHM was added as an active feed ingredient at 0, 10, 20% and designated as diets 1, 2 and 3 respectively. One hundred and fifty day old Marshal broiler chicks weighing 39±2.5g/bird were allotted to 3 dietary treatments (10birds/replicate, 50birds/treatment) in a completely randomized design. The Average daily weight gain (ADWG), total weight gain (TWG) and final body weight (FBW) of broiler chicks fed diets containing 10% BCPHM was significantly ($p<0.05$) higher than that of control and diet containing 20% BCPHM at starter phase. At finisher phase, the values of ADWG, TWG and FBW were at par with that of control. Feed Intake was seen to increase as BCPHM increased in the diet at finisher phase. Carcass traits, relative internal organ weight, haemato-biochemical indices of broiler chickens were similar across dietary treatment. Superoxide dimutase (SOD) and Catalase (CAT) of birds fed control diet were significantly ($p<0.05$) higher than those of birds fed BCPHM based diets. Ten percent dietary inclusion of BCPHM appears optimal in broiler diet since beyond this level growth performance declined.

Key words: Cocoa pod husk meal, antioxidant attributes, health monitoring indices

INTRODUCTION

Globally, the consumption of poultry products, especially poultry meat (broiler chicken), has constantly been on an increase over the years, and this development is estimated to continue due to the increasing acceptance and craving for it. (Kim *et al*., 2012). The advance in the poultry industry in developing countries has led to an increase in the demand for feed and feed ingredients which is the major constituent in poultry production (Adegbenro, 2016, Adegbenro *et al*., 2020). It has gradually been established that the supplies for conventional feed ingredients cannot be met, even according to optimistic forecasts (Yenesew *et al*., 2015). This is majorly due to the fact that these conventional ingredients also serve as food for the human population. With rising costs of conventional feed ingredients which are essentially import dependent, animal nutritionists have been clamoring for the use of agro-wastes as alternative feed stuffs, which are cheaper and readily available in large quantities in countries with agro-based economies. It is therefore more imperative ever than before to find local agricultural wastes that are commonly available, unsuitable for human consumption, cheap and can provide commercial diet for livestock without negatively affecting their health and productivity.

Cocoa pod husk (CPH) is an agro-industrial by-product obtained after the removal of the cocoa beans from the fruit in the cocoa industry (Olugosi *et al.,* 2019), the husk constitutes about 75% of the whole cocoa fruit (Bentil *et al.,* 2015). In Western Africa, large quantities of CPH are produced annually and generally go to waste. It is generally considered a potential feedstuff for animal diets. Past research carried out on the potential use of CPH and other by-products of the cocoa industry as feedstuff have proven to be efficient in reducing the cost of feed by using it to replace other expensive feedstuff. The aim of the study therefore, was to find alternative use to biologically upgraded cocoa pod husk meal in broiler chicken production with a view to enhancing animal protein consumption in developing countries were pod is produced in large quantities.

MATERIALS AND METHODS

Ethical approval and experimental site

This study was carried out after all animal experimental protocols were approved by the Research and Ethics Committee of the Department of Animal Production and Health, of the Federal University of Technology, Akure, (FUTA) Nigeria. The feeding trial was conducted from July to August in 2019 at the Teaching and Research Farm of the Department of Animal Production and Health, FUTA, Ondo State, Nigeria. The average daily temperature-humidity index

(THI) of the experimental pen was 31.0˚C±1.56. The THI, an indicator of thermal comfort level for enclosed animals was calculated as described by Jimoh *et al*. (2018) using the following formula: THI = t-[(0.31-0.31×RHt-14.4)], where RH = relative humidity/100 and t = ambient temperature.

Cocoa pod husk collection and fermentation

Freshly discarded Cocoa pod husk was collected and processed to cocoa pod husk meal as earlier described by Olugosi *et al.* (2019). Cocoa pod husk meal (CPHM) was taken through solid state fermentation where, 100g of urea was dissolved in 100l of water used to moisten 100kg sterilized CPHM. One liter of the starter culture, *Rhizopus stolonifer* was used to inoculate the urea treated CPHM and kept in a tray incubating chamber for 14days after which it was sundried for 5days to inactivate the microorganism. The best microbially enhanced CPH meal obtained in reports by Olugosi *et al.* (2019) with respect to enhanced crude protein, reduced crude fibre and anti-nutritional factors typified by theobromine after laboratory analysis was used as active feed ingredients in the diets of broiler chickens.

Experimental birds, experimental diets and design

Three (3) experimental diets were formulated for each phase (starter and finisher) to meet the NRC (1994) minimum requirement. Biologically upgraded Cocoa pod husk (BCPH) meal was incorporated into the diet as test ingredient at varying inclusion level of 0%, 10% and 20% based on 100% diet and designated as diets 1, 2 and 3 respectively. One hundred and fifty (150) day old Marshal broiler chicks were randomly assigned to the three dietary experimental treatments of five replicates and ten (10) chicks per replicate and arranged in Completely Randomized Design. The birds in each replicate were housed in their respective wood shavings littered 200 × 100 cm pen. The experimental house temperature was maintained within 31 ℃ ± 2 for the first 7 days and reduced by 2 ℃ after each consecutive 7 days until the house temperature was 26 ℃ ± 2. Illumination was provided for 23 h/day. The weight of each group (10 chicks) was balanced (±1g). Thereafter, their respective starter experimental diets (Table 1) were fed *ad libitum* for 21 days during which the weekly feed consumption and weight changes were measured and feed conversion ratio calculated. The finisher diets (Table 1) were fed to each respective group from day 22 to day 49 and the same parameters in starter phase were measured.

Chicken growth performance, slaughtering procedure, sample collection and analysis

The performance characteristics of the birds, i.e. the body weight (BW) and the feed intake (FI) were determined on weekly basis. Thereafter, the body weight gain (BWG) and the feed conversion ratio (FCR) were estimated. On day 49, three birds per replicate were randomly selected, tagged, weighed and sacrificed. After stunning, the jugular veins of the birds were cut with clean, sharp stainless knife. The blood was allowed to flow into plain and Ethylenediaminetetraacetic acid (EDTA) bottles. The blood in the plain bottle was centrifuged; thereafter, its serum was separated and frozen at − 20 °C prior to analysis. The total protein, cholesterol, creatinine, urea, aspartate aminotransferase (AST) EC 2.6.1.1.1, Alanine transferase (ALT) EC 2.6.1.1.2, and bilirubin were determined with a Reflectron^R Plus 8C79 (Roche Diagnostic, GobH Mahnheim, Germany) using commercial kits. Also determined were oxidative activities, the serum glutathione peroxidase (GPx) was determined as described by Rotruck *et al.* (1973), while the catalase (CAT) activity was determined as described by Aebi (1974) and Superoxide dimutase (SOD) activity was determined by using the method of Misra and Fridorich (1972) and the procedure adopted by Kolawole (2016). The blood samples collected in EDTA bottle were used for erythrogram (packed cell volume, haemoglobin concentration, red blood cell, white blood cell, Mean corpuscular volume (MCV) and mean corpuscular hemoglobin (MCH) determination using haematology analyzer. The slaughtered weights and dressed weight of the birds were estimated after de-feathering, evisceration and dressing. The relative organ weight of heart, lung, liver, spleen, proventiculus and gizzard of the birds were also evaluated.

Chemical analysis

Proximate analyses of the experimental diets were carried out using the standard procedures. Dry matter was determined using AOAC method (method: 930.15; AOAC, 1995) while, crude protein was determined according to method 942.05 (AOAC 1995). Crude fat was analyzed by the soxhlet method (method: 920.39; AOAC 1995), ash was determined after ashing in a muffle furnace at 600℃ (method 965.17; AOAC 1995) and nitrogen free extract was calculated by difference.

Statistical analysis

All data collected were subjected to a one-way analysis of variance (ANOVA) in completely randomized design (CRD) using SPSS Version 20. Noticeable significant differences were separated by using the Duncan Multiple Range Test of the same statistical package.The statistical model $Y_{ij} = \mu + D_i + E_{ij}$ was used in this experiment, where Y_{ij} is the observed mean, μ is the overall mean, D_i is the effect of the *r*th treatment (*r* = diets 1, 2 and 3) and E_{ij} is the random error due to experimentation.

RESULTS

Growth performance and carcass traits of broiler chickens fed varying levels of biologically upgraded cocoa pod husk meal

The Effect of BCPHM on growth performance of broiler chickens are shown in Table 2. At starter phase (1-21 days). 10% dietary inclusion level of BCPHM significantly (p<0.05) influenced the ADWG, FBW, TWG and FCR of broiler chicken. When compared to control, birds fed 10% BCPHM had higher ADWG (27.03g/bird/day), FBW (609.49g/bird)

Table 1: Ingredients composition, calculated and analyzed nutrient composition of broiler diets at starter and finisher phases

Cocoa pod husk meal inclusion levels						
Feed ingredients	**Starter phase**			**Finisher phase**		
Ingredient (%)	0	10	20	0	10	20
Maize	50.40	40.40	30.40	55.00	45.00	35.00
BCPHM	0.00	10.00	20.00	0.00	10.00	20.00
Wheat offal	3.00	3.00	3.00	5.00	10.00	13.00
GNC	16.00	16.00	16.00	8.00	3.00	0.00
Soyabean meal	17.00	17.00	17.00	21.25	21.25	21.25
Fish meal	5.00	5.00	5.00	3.00	3.00	3.00
Vegetable oil	5.00	5.00	5.00	4.00	4.00	4.00
Di-calcium phosphate	1.00	1.00	1.00	1.50	1.50	1.50
Limestone	1.50	1.50	1.50	1.50	1.50	1.50
Premix	0.30	0.30	0.30	0.30	0.30	0.30
DL – methionine	0.20	0.20	0.20	0.10	0.10	0.10
L – Lysine	0.10	0.10	0.10	0.10	0.10	0.10
Salt	0.30	0.30	0.30	0.30	0.30	0.30
Calculated analysis						
Crude protein (%)	22.43	23.00	23.64	19.57	19.23	19.50
Crude fibre (%)	3.20	4.15	5.10	3.34	5.38	7.35
Calcium (%)	1.12	1.13	1.14	1.10	1.12	1.14
Available P (%)	0.46	0.46	0.47	0.49	0.51	0.52
Methionine (%)	0.57	0.56	0.55	0.43	0.40	0.38
Lysine (%)	1.21	1.19	1.19	1.14	1.08	1.05
ME (kcal/kg)	13.36	13.52	13.78	13.13	13.44	13.83
Analyzed composition (%)						
Crude fibre (%)	6.01	6.50	7.72	3.69	9.15	9.23
Crude protein (%)	23.62	23.37	22.47	22.53	24.17	23.99
Ash (%)	8.47	8.14	9.19	5.36	10.40	10.51
Ether extract (%)	13.43	12.66	13.76	13.71	12.93	11.95
NFE (%)	34.52	38.32	33.87	49.72	43.37	44.43
ME (MJ)	15.55	15.35	16.49	14.67	14.61	14.40

ME: (Metabolizable energy) = (37 × %CP) + (81.8 × %FAT) + (35.5 × %NFE) (Pauzenga, 1985); BCPHM: Biologically upgraded cocoa pod husk meal, GNC: Groundnut cake, NFE: Nitrogen free extract.

and TWG (567.68g /bird). However, ADFI and TFI was not significantly affected by BCPHM inclusion, FCR was best in diets of birds fed 10% BCPHM. At finisher phase (1–49days), 20% dietary inclusion level BCPHM significantly ($p<0.001$) reduced ADWG, FBW, TWG and FCR. Total feed intake was observed to increase as dietary inclusion level of BCPHM increased in the diet. When compared to control, ADWG (40.95 g/bird/day), FBW (2048. 50g/bird) and TWG of birds (2006.70g/bird) fed 10% was at par with control; ADWG (41.97 g/bird/day), FBW (2094.00g/bird), TWG of birds (22056.40g/bird) but values were lower for birds fed 20% BCPHM. FCR values decreased as the level of BCPHM increased in the diets ($p<0.001$).

Table 3 shows the effect of BCPHM on carcass and relative internal organs of broiler chickens at finisher phase. The slaughter weight of broiler chickens fed control (2204.60g/bird) and 10% BCPHM (2125.60g/bird) was significantly ($p<0.001$) higher than those fed 20% BCPHM. (1825.10g/bird). Similarly, the dressed weight (2031.60g/bird; 1982.30g/bird)) and eviscerated weight (1764g/bird; 1741.10g/bird) of broiler chickens fed control and 10% BCPHM were significantly($p<0.001$) higher than those of broiler chickens fed diets containing 20% BCPHM dressed weight (1678.70g/bird) and eviscerated weight (1446.90g/bird). BCPHM also significantly ($p<0.001$) influenced the relative weight of the liver, heart and lungs with birds fed the control and 10% BCPHM based diet having higher values than those fed 20% BCPHM based diet.

Haematological indices

Table 4 shows the effect of BCPHM on haemato-biochemical indices and serum antioxidant activities of broiler chickens. The packed cell volume, haemoglobin concentration, red blood cell and white blood cell count of the broiler chickens were stable ($p>0.05$) across dietary treatment. It was observed that MCVand MCH decreased as the inclusion level of BCPHM increased. In the same vein, the serum biochemical indices in the experimental birds were

Table 2: Effects of Biologically upgraded cocoa pod husk meal (BCPHM) on performance of broiler chicken at starter and finisher phases

Growth parameters	Diet 1	Diet 2 10%BCPHM	Diet 3 20%BCPHM	SEM	P value
Starter phase (1 to 21 days					
IBW (g/bird)	37.52	41.81	36.67	1.06	0.08
FBW (g/bird)	567.93^{ab}	609.49^{a}	529.49^{b}	17.13	0.03
TWG (g/bird)	530.41^{ab}	567.68^{a}	492.81^{b}	18.49	0.04
ADWG (g/bird/day)	25.26^{ab}	27.03^{a}	23.47^{b}	0.88	0.04
TFI (g/bird)	901.09	949.68	925.37	26.28	0.47
ADFI (g/bird/day)	42.91	45.22	44.07	1.25	0.47
FCR	1.76^{b}	1.68^{a}	1.89^{c}	0.03	0.001
Finisher phase (1 to 49 days					
IBW (g/bird)	37.52	41.81	36.67	1.06	0.08
FBW (g/bird)	2094.00^{a}	2048. 50^{a}	1720. 50^{b}	34.5	0.001
TWG (g/bird)	2056.40^{a}	2006.70^{a}	1683.80^{b}	34.26	0.001
ADWG (g/bird/day)	41.97^{a}	40.95^{a}	34.36^{b}	0.70	0.001
TFI (g/bird)	5236.10^{b}	5771.20^{ab}	5982.90^{a}	93.91	0.001
ADFI (g/bird/day)	108.86^{b}	117.78^{ab}	122.10^{a}	1.92	0.003
FCR	2. 54^{a}	2.89^{b}	3. 56^{c}	0.05	0.001

^{ab}Means along the same column with different superscripts are significantly (p<0.05; 0.001) different. IBW= Initial body weight, FBW= Final body weight, TWG= Total weight gain, ADWG= Average daily weight gain, TFI= Total feed intake, ADFI= Average daily feed intake, FCR= Feed conversion ratio, BCPHM: Biologically upgraded cocoa pod husk meal.

Table 3: Relative organ weight of broiler chickens fed diets containing varying levels of BCPHM

Parameters	Diet 1 control	Diet 2 10% BCPHM	Diet 3 20% BCPHM	SEM	P value
Slaughter Wt (g/bird)	2204.60^{a}	2125.60^{a}	1825.10^{b}	55.31	0.001
Dressed Wt (g/bird)	2031.90^{a}	1982.30^{a}	1678.70^{b}	37.06	0.001
Evisc. Wt (g/bird)	1764.30^{a}	1741.10^{a}	1446.90^{b}	38.27	0.001
Gizzard. Wt (g/kgBW	46.38	46.81	44.38	1.55	0.49
Prov. Wt (g/kgBW)	9.38	9.63	9.44	0.31	0.84
Heart (g/kgBW)	9.88^{a}	10.25^{a}	8.56^{b}	0.40	0.02
Spleen Wt (g/kgBW)	2.19	2.25	2.00	0.21	0.71
Liver Wt (g/kgBW)	50.63^{a}	48.94^{a}	43.13^{b}	1.81	0.02
Lung Wt (g/kgBW)	12.25^{a}	12.31^{a}	10.19^{b}	0.63	0.04

^{ab}Means along the same column with different superscripts are significantly (p<0.05; 0.001) different. SEM = Standard error mean, Evisc.Wt= Eviscerated weight, Prov. Wt= Proventiculus weight, BW = bodyweight, Wt = Weight, BCPHM: Biologically upgraded cocoa pod husk meal.

not significantly affected (p>0.05) by the dietary treatment. Superoxide Dimutase (SOD) and Catalase (CAT) of broiler chickens were significantly (p<0.001) influenced by the dietary treatment and were higher in birds fed control diet when compared to those fed BCPHM based diets.

DISCUSSION

Performance characteristics

There was improved bird growth (TBW, TWG, ADWG and TFI) of birds fed 10% BCPHM based diet at both starter and finisher phases. By implication, the processing method (solid state fermentation with *Rhizopus stolonifer*) adopted for CPH in this experiment was effective in reducing its anti-nutritional factors to minimal level which, improved its nutritional value to the level that supports acceptability and normal growth of the broiler chickens. The result from this study showed an improvement in the use of CPH meal as Olubamiwa *et al.* (2002) and Teguia *et al.* (2004) reported a negative effect in feed intake, live weight gain and FCR at higher inclusion of CPH meal but, the result was supported by Nortey *et al.* (2015) who reported a higher live weight of broiler chickens fed on enzyme treated CPH meal based diet.

The stability of the body weight gain in birds fed diets containing 10% BCPHM across the two phases against birds fed the control and diet containing 20% BCPHM suggest that the optimum inclusion level of BCPHM could be 10%.

Carcass characteristics and relative organ weights

The values for the relative organ weights of broiler chickens fed diets containing BCPHM revealed that the administration of biologically upgraded cocoa pod husk at different inclusion exerted a different effect on the carcass characteristics and relative organ weights. The least carcass weight consistently observed in broiler chickens fed diet containing 20% BCPHM resulted from their smaller live weight (Tuleun and Igba

Table 4: The effect of BCPHM on broiler erythrogram, serum biochemical indices and serum antioxidant enzymes

Parameters	Diet 1 Control	Diet 2 10% BCPHM	Diet 3 20% BCPHM	SEM	P value
Haematological indices					
PCV (%)	32.14	33.33	31.67	0.76	0.30
Hb (g/dl)	10.67	11.17	10.60	0.28	0.33
RBC (10^6/mm^3)	2.40	2.62	2.54	0.12	0.19
WBC (10^9/mm^3)	105.88	110.33	110.41	1.88	0.18
MCV (μ^3)	134.43^a	128.67^b	125.50^b	2.19	0.04
MCH (pg)	44.77^a	42.87^b	41.78^b	0.71	0.04
Serum biochemical indices					
TP (g/L)	56.27	51.71	51.68	3.79	0.62
CREA (mmol/L)	23.27	23.63	23.63	2.32	0.99
UREA (mmol/L)	1.44	1.35	1.38	0.05	0.48
CHOL (mmol/L)	3.69	3.78	4.27	0.21	0.20
AST (UI/L)	229.43	223.55	204.97	10.37	0.33
ALT (UI/L)	39.93	37.03	37.08	1.18	0.21
BILI (µmol/L)	4.01	4.28	4.48	0.46	0.70
Serum antioxidant activity					
SOD (%)	6.20^a	4.50^b	1.75^c	0.55	0.001
GPX (µmol/ml/min)	52.74	42.63	56.02	5.88	0.25
CATALASE (mmol/ml/min)	1.17^a	0.89^b	1.04^{ab}	0.08	0.01

PCV: Pack cell volume, Hb: Haemoglobin, RBC: Red blood cell, WBC: White blood cell, MCV:Mean Corpuscular Volume, MCH: Mean Corpuscular Haemoglobin, TP: Total protein, CREA: Creatinine, CHOL: Cholesterol, AST: Aspartate transamine, ALT: Alanine transamine, BILI: Bilirubin, SOD: Superoxide dismutase, GPX: Glutathione peroxidase, BCPHM: Biologically upgraded cocoa pod husk meal.

2007), since the surface area and the weight determine the amount of feathers and visceral organs required, respectively. Reduction in slaughter weight, dressed weight, eviscerated weight and heart at 20% inclusion of BCPHM when compared with 10% BCPHM, as observed in this report could be due to poor utilization of nutrient in BCPHM by the birds for muscle and organ development as BCPHM was increased in the diet. The significant differences observed in the lung weight agreed with the report of Omoikhoje *et al.* (2010)who reported significant differences in the lung of birds fed diets containing CPH meal at varying inclusion levels. They also reported no significant differences in the heart and liver which disagreed with the current findings. Etuk and Udedibie (2006) reported that when anti nutritional factors (ANFs) are reduced by some treatments to non-toxic level, the liver would not be enlarged. The effect of possible reduction in ANFs as a result of the biological upgrading of CPH was evident in this study as birds fed diets containing 20% BCPHM showed marked reduction in liver weight as level of BCPHM was increased. The reduction of these organs could be due to decreased metabolic activities of the liver (Omeje, 1999). The findings support the report that liver is a major detoxification organ and hence increase in its activities may result in enlargement and probably increased weight (Akinmutimi, 2004). The reduction in liver weight and heart weight relative to weights of broiler chickens fed 20% BCPHM when compared to control might also be due to the hepatoprotective properties and anti-inflammatory properties of BCPHM. Previous reports have shown that CPH flour is a source of functional compounds such as phenolics, pectins, and fibre which possess good health benefits (Vriesmann *et. al.,* 2012). Polyphenols offer protection against coronary heart disease, cancer, and neurodegenerative disorders due to their antioxidant and free radical scavenging properties (Wan *et. al.,* 2001).

Haematology and serum biochemical indices

Haematological parameters are important indices of the physiological and pathological status for both animals and humans (Adeneye *et al.,* 2006). Blood being the medium of transportation of substances in the body makes its examination crucial to clinically investigate the presence of several metabolites and other constituents in the body, which also plays a vital role in the physiological, nutritional and pathological status of the animal (Doyle, 2006). Administration of diets containing the biologically upgraded cocoa pod meal did not alter the haematological parameters of the birds to a large extent. However, a significant difference was observed in MCV and MCH which agreed with the findings of Adeyeye *et al.* (2017) who reported that processed cocoa pod husk had significant effect on MCV of rabbit. However, significant variation observed in MCH disagrees with the report of Ankrah *et al.* (2015). These authors reported significant variation in MCH when they studied haematological responses of laying chickens fed with diets containing pito mash treated with cocoa pod-husk ash extract. Mean Corpuscular Haemoglobin has been described as an indicator of the blood carrying ability of the red blood cell. Pack Cell Volume and haemoglobin are directly related to the nutritional balance of the diet fed to the animal. Higher Pack cell volume and haemoglobin in birds fed diets containing 10% BCPHM led to better protein utilization which was evident in better weight gain recorded in birds fed diet containing 10% BCPHM.

The values for the serum biochemical indices of broiler chickens fed BCPHM were within normal range for healthy chickens as was reported by Anon (2000). Alanine aminotransferase (ALT) and Aspartate aminotransferase (AST) levels are the most commonly used to detect liver cell inflammation or destruction. The reduction in ALT and AST levels in birds fed diets containing 20% BCPHM confirms that CPH has hepato-protective properties (Ofosua Adi-Dako *et. al*., 2006). The stability of serum indices in broiler chicken across the dietary treatment indicated the safety of the diets and their support for normal physiological functions of the broiler chickens.

Serum antioxidative status

One of the major causes of retarded growth in livestock is oxidative stress. Anti-oxidant significantly delay or prevent oxidation of lipids, protein, carbohydrates and DNA (Oboh and Rocha, 2007). In this study, birds fed diets containing BCPHM were observed to be prone to stress by the reduction in SOD and CAT concentration and this was evident mostly in the reduced growth performance recorded in birds fed diet containing 20% BCPHM. This negates the reports of Adeyeye *et al,* (2019) who reported higher serum GPx and CAT concentration in broiler chickens fed processed cocoa pod husk meal.

CONCLUSION

Dietary BPCHM inclusion up to 10% supports the performance and stability the of haemato-biochemical indices of broiler chickens. However, antioxidant status of the birds showed that they were stressed at higher inclusion rate when BCPHM was in their diet. There is a need for further studies to ascertain the cause of these changes. To further increase the higher inclusion level of BCPHM in the diet of broiler chicken, the use of multigrain enzyme is proposed, this is receiving our attention currently.

Authors' contributions

Conceptualization of the research work was done by Agbede JO. and Olugosi OA. Data curation carried out by Olugosi OA, Ayeni AO, Agbede JO, Onibi GE and Adebayo IA. All authors managed all the activities of the experiment and interpreted the data collectively and gathered reference materials. Formal analysis was carried out by Olugosi OA and methodology of the experiment carried out by Olugosi OA and Agbede JO. Software designed by Olugosi OA, while validation of the research work was approved by Agbede JO, Onibi GE and Adebayo IA.,. Investigation was carried out by Olugosi, OA and Ayeni AO.Olugosi OA prepared the first draft of the manuscript - original draft while Agbede JO, Onibi GE and Adebayo IA reviewed and edited the manuscript and approved the final manuscript.

Ethics approval

The experimental research complied with the institutional, national and international guidelines and was carried out after all animal experimental protocols were approved by the Research and Ethics Committee of the Department of Animal Production and Health, of the Federal University of Technology, Akure, (FUTA) Nigeria.

Availability of data and materials

The datasets used and analysed during the current study are available from the corresponding author on reasonable request.

REFERENCES

Adegbenro, M., Oyedun, O.I. and Aletor, V.A. (2020). Evaluation of bread waste fortified with moringa leaf meal on performance and health status of broiler chickens. *Journal of Experimental Agriculture International*, 42(2), 152-160.

Adegbenro, M., Agbede, J.O., Onibi, G.E. and Aletor, V.A. (2016). Composite leaf meal: Effects on haematology and biochemical indices of growing pigs. *Archiva Zootechnica,* 19(2), 65-69.

Adeneye, A.A., Ajagbonna, O.P., Adeleke, T.I. and Bello S.O. (2006). Preliminary toxicity and phytochemical studies of the stem bark aqueous extract of *Musanga cecropioides* in rats. *Journal of Ethnopharmacology*, 105(3), 374-379.

Adeyeye, S.A., Agbede, J.O., Aletor, V.A. and Oloruntola, O.D. (2017). Processed Cocoa (Theobroma cacao) Pod Husks in Rabbits Diet: Effect on Haematological and Serum Biochemical Indices. *Asian Journal of Advances in Agricultural Research,* 2(4), 1-9.

Adeyeye, S.O., Ayodele, S., Oloruntola, O.D. and Agbede, J. (2019). Processed cocoa pod husk dietary inclusion: Effects on the performance, carcass, haematogram, biochemical indices, antioxidant enzyme and histology of the liver and kidney in broiler chicken. *Bulletin of the National Research Centre*, 43, 54.

Aebi, H. (1974). Catalase estimation In: Bergmeyer HV (ed.). *Methods of Enzymatic Analysis*. Verlag Chemic, New York. 21, 673-84.

Akinmutimi, A.H. (2004). Effect of cooking periods on the nutrient composition of *Mucuna utilis* seeds. *Nigerian Poultry Science Journal*, 2(3), 45-51.

Ankrah, A., Donkoh, A., Abando- sam, E.A. and Okrah, D. (2015). Haematological Response of layers fed with dietary containing pito Mash treated cocoa pod Husk Ash Extract. *Advanced studies in Biology,* 7(3), 121-129.

Anon. (2000). Guide to the care and use of experimental animals Vol. 1. (Canadian council on animal care, Ottawa, Ontario, Canada). 85-90.

AOAC. (1995). Official methods of Analysis (15th ed). Association of Official Analytical Chemist.

Belewu, M., Adekola, F., Adebayo, G., Ameen, M., Muhammed, N., Olaniyan, A., Adekola, O. and Musa, A. (2010). Physico – Chemical characteristics of Oil and Biodiesel from Nigerian and Indian Jatropha curcas Seeds. *International Journal of Biological and Chemical Science*, 4(2), 524-529.

Bentil, J.A., Dzogbefia, V.P. and Alemawor, F. (2015). Enhancement of the nutritive value of cocoa *(Theobroma cacao)* bean shells for use as feed for animals through a twostage solid state fermentation with *Plerotus ostreatus* and *Aspergillus niger*. *International Journal Applied Microbiology and Biotechnology Research,* 3(2), 20-30.

Doyle D. (2006). William Hewson (1739-74). The father of haematology. *British Journal of Haematology*, 133(4), 375-381.

Etuk, E.B. and Udedibie, A.B.I. (2006). Dressed and internal organ weights of broilers fed toasted pigeon pea seed meal diet. *International Journal of Agriculture and Rural Development.*

Jimoh, A.A., Ayedun, E.S., Oyelade, W.A., Oloruntola, O.D., Daramola, O.T., Ayodele, S.O. and Omoniyi, I.S. (2018). Protective effect of soursop (*Annona muricata* linn.) juice on oxidative stress in heat stressed rabbits. *Journal of Animal Science and Technology,* 60, 28.

Kim, Y.I., Lee, Y.H., Kim, K.H., Oh, Y.K., Moon, Y.H. and Kwak, W.S. (2012). Effects of supplementing microbially-fermented spent mushroom substrates on growth performance and carcass characteristics of Hanwoo steers (a field study). *Asian Australas Journal of Animal Science*, 25, 1575–1581.

Kolawole, A.K. (2016). Effect of Organic Turmeric Supplemented-diet in Rabbits Acutely Exposed to Ultraviolet Radiation: Oxidative Stress in the Blood. *Anatomical Physiology,* 6, 229.

Misra, H.P. and Fridovich, I. (1972). The univalent reduction of oxygen by flavins and quinines. *Journal of Biological Chemistry,* 247, 188-192.

National Research Council. (1994). Nutrient Requirements of Poultry: Ninth Revised Edition. National Academy Press, Washington D.C. pp. 174.

Nortey, T.N., Ewusi, I., Kpogo, L.A., Oddoye, E.O.K and Naazie, A. (2015). Cocoa pod husk with enzyme supplementation is a potential feed ingredient in broiler diets. *Livestock Research for Rural Development,* 27 (5).

Oboh G. and Rocha J.B. (2007). Distribution and antioxidant activity of polyphenols in ripe and unripe tree pepper (*Capsicum pubescens). Journal of Food Biochemistry*, 31, 456-473.

Ofosua, A., Kwabena, O., Samuel, F.M., Mariam, E.L., Boakye-Gyasi, C.S. and Mike, P. (2016). Physicochemical and Antimicrobial Properties of Cocoa Pod Husk Pectin Intended as a Versatile Pharmaceutical Excipient and Nutraceutical. *Journal of Pharmaceutics*, 1, 1-12.

Olubamiwa, O., Soetan, O.A., Olamijulo, O.A., Hamzat, R.A. and Longe, O.G. (2002). Utilization of variously treated cocoa bean shells in layer mash. *Proceedings of the 27th Annual Conference, Nigeria Society of Animal Production (NSAP)* March 17-21, 2002, Federal University of Technology, Akure, Nigeria, pp 267-269.

Olugosi, O.A., Agbede, J.O., Adebayo, I.A., Onibi, G.E. and Ayeni, O.A. (2019). Nutritional enhancement of cocoa pod husk meal through fermentation using Rhizopus stolonifer. *African Journal of Biotechnology*, 18(30), 901-908.

Omeje, S.I., (1999). Issues in Animal Science. 1st Edn., Raykennedy Scientific Pub., Enugu, Nigeria.

Omoikhoje, S.O., Obasoyo, D.O and Okungbowa, S.U. (2010) Response of broiler chickens to dietary levels of roasted fluted pumpkin pod husk waste meal. *Journal of Applied Science,* 4(3), 2113-2124.

Pauzenga, U. (1985). Feeding parent stock. *Zotecnica International*, 22-24.

Rotruck, J.T., Pope, A.L., Ganther, H.E., Hafeman, D.G., Hoekstra, W.G. (1973). Selenium: Biochemical role as a component of glutathione peroxidase. *Science*, 179, 588 – 590.

Teguia, A., Endeley, H.N.L and Beynen, A.C. (2004). Broiler performance upon dietary substitution with treated cocoa bean cake for broiler chicks. *British Poultry Science,* 39, 519-523.

Tuleun, C.D. and Igba, F. (2007). Growth and carcass characteristics of broiler chickens fed water soaked and cooked velvet beans (*Mucuna pruriens*) meal. Proceedings of the 32nd Annual NSAP Conference, March 18-21, 2007, Calabar, Nigeria, 240-243.

Wan, Y., Vinson, J.A., Etherton, T.D., Proch, J., Lazarus, S.A. and Kris-Etherton, P. M. (2001). Effects of cocoa powder and dark chocolate on LDL oxidative susceptibility and prostaglandin concentrations in humans. *American Journal of Clinical Nutrition*, 74(5), 596–602.

Vriesmann, L.C., Teófilo, R.F., Lúcia de Oliveira, C. and Petkowicz, M. (2012). Extraction and characterization of pectin from cacao pod husks (Theobroma cacao L.) with citric acid, LWT. *Food Science and Technology*, 49, 108–116.

Yenesew, A., Agraw, A., Yihenew, G. and Dessalegn, M. (2005). Poultry Production Manual. Bahir Dar University Capacity Building for Scaling up of Evidence Best Practices in Agricultural Production in Ethiopia (ADUCASCADE) working paper 14, 17.