Vol. 15(4), pp. 538-545, April, 2020
DOI: 10.5897/AJAR2020.14455
Article Number: B9D237F63455
ISSN: 1991-637X

http://www.academicjournals.org/AJAR

African Journal of Agricultural Research

Full Length Research Paper

The response of pigs to diets containing varying levels of cocoa placenta meal (CPM) supplemented with an exogenous enzyme complex

John Dafaar Damsere[1]*, Michael Boateng[1], Kwame Owusu Amoah[2], Yaw Oppong Frimpong[3] and Daniel Boye Okai[1]

[1]Department of Animal Science, Faculty of Agriculture, College of Agriculture & Natural Resources, Kwame Nkrumah University of Science and Technology (KNUST), Kumasi-Ghana.
[2]Animal Research Institute, Council for Scientific and Industrial Research, Accra, Ghana.
[3]Department of Animal Production and Health, School of Agriculture and Technology, University of Energy and Natural Resources, Sunyani, Ghana.

Received 24 January, 2020; Accepted 23 March, 2020

A nineteen-week experiment was conducted to establish the effects of an enzyme supplementation on growth performance, economics of production, carcass components and blood profile of pigs fed diets containing different levels of cocoa placenta meal (CPM). Twenty-five Large White grower pigs with mean initial live weight of 15.4 kg were randomly allocated to five treatments: T1 (0% CPM), T2 (5% CPM), T3 (10% CPM), T4 (15% CPM) and T5 (20% CPM) in a randomized complete block design (RCBD). Diet T1 had no enzyme but diets T2, T3, T4 and T5 contained 35 g enzyme per 100 kg feed. Each treatment had five pigs and each pig served as a replicate. Feed and water were provided *ad-libitum*. Pigs were slaughtered upon the attainment of a live weight of 70 ± 2.5 kg for carcass studies. Blood samples were collected during slaughtering. Feed cost (€ per kg) was inversely proportional to the inclusion level of the CPM + enzyme. Pigs on the T1 and T2 diets utilized their feed more efficiently ($p < 0.05$) than those on the T3, T4 and T5. However, no differences ($p > 0.05$) were observed in the variations of the feed cost per kg gain values recorded. The CPM + enzyme inclusion resulted in decreased values ($p < 0.05$) for backfat thickness. There were no dietary ($p > 0.05$) effects on the blood profile. Dietary inclusion levels up to 20% CPM + enzyme can be fed to growing-finishing pigs without any detrimental effects on most of the growth performance and carcass criteria.

Key words: Agro-industrial by-product, blood profile, carcass, growth performance.

INTRODUCTION

Much consideration has been drawn to the use of cheaper and less demanded alternatives such as Agro-Industrial by-products and non-conventional feed resources (NCFRs) in the feeding of livestock (Obirikorang et al., 2015) as a result of high cost of conventional feed ingredients. Agro-industrial by-products such as dried brewers spent grains (DBSG), cocoa pod husk (CPH), rice bran, and other NCFRs have been evaluated in

*Corresponding author. E-mail: damseredafaarja@yahoo.com. Tel: +233 242817710.

Ghana as potential feed ingredients for non-ruminant farm animals (Atuahene et al., 2000; Donkoh et al., 2013; Nortey et al., 2015). Moreover, some research done on these products have proved that their use in animals' diets often reduce feed cost (Okai, 1998). Yet, there are other prospective by-products which have not been adequately studied. One of such is the cocoa placenta, a by-product of cocoa bean production.

Cocoa placenta is the slender, fibrous, rope-like tissue which holds the seeds (beans) in position inside the cocoa pod and also supplies nutrients to the cocoa seeds during the developmental stage of the cocoa fruit. The cocoa placenta accounts for about 3% of the cocoa fruit (Atiemo, 2015), which on the average weighs 400 g and therefore a large quantity is produced during the fermentation process of the cocoa beans but are eventually removed and discarded haphazardly during sun drying of the fermented beans. Atiemo (2015) reported that 30,966 metric tons of cocoa placenta is produced annually in Ghana. This can be a nuisance as it invites a lot of houseflies, blocks drain and also pollutes water bodies via run off when scattered around the cocoa drying sites in the communities.

One major challenge apart from the presence of theobromine in cocoa by-products is the high crude fibre content or non-starch polysaccharides (NSP). Choct (2004) indicated that NSP are poorly digested by monogastric animals such as pigs because they do not produce enzymes that are capable of digesting these fibre components. According to Bedford (2000), exogenous enzymes can be used to address the problems of some anti-nutritional factors and high fibre levels that limit feed value, thereby leading to a more economic and efficient utilization of AIBP. This enzyme complex intended to increase the bioavailability of carbohydrates, proteins and fats in the diets of pigs and poultry. It has been suggested that it improves digestibility of feed ingredients and FCR. There is a dearth of information on its usefulness in monogastric diets in Ghana. Therefore, the objective of this study was to determine the growth performance, carcass traits and blood profile of grower-finisher pigs fed diets containing varying levels of CPM (0-20%) supplemented with an enzyme complex.

MATERIALS AND METHODS

Study location and duration of the experiment

The study's location was the Livestock Section of the Department of Animal Science, Kwame Nkrumah University of Science and Technology (KNUST), Kumasi, Ghana. The feeding trial lasted for 19 weeks.

Source and processing of feed ingredients

The wet cocoa placenta (WCP) were gathered from cocoa farmers inKukuom in the Asunafo South District of the Ahafo Region and were sun dried on a raffia palm mat on a platform for 5-8 days, depending on the intensity of the sunshine and the humidity. The dried cocoa placenta (DCP) was ground in a hammer mill to produce Cocoa Placenta Meal (CPM) whilst the other ingredients were obtained from Rakeb Company Limited, Kumasi. Those that required grinding e.g. maize, were handled in the same way as the DCP

Proximate composition of CPM

Proximate analysis of the CPM was carried out using standard procedures outlined by the Association of Official Analytical Chemists (AOAC, 2002). The nutrient compositions of other ingredients were obtained from the NRC (1998).

Experimental animals, diets and design

Twenty-five Large White grower pigs (15 entire males and 10 gilts) with an overall mean initial live weight of 15.4 kg were selected and randomly allotted to five isonitrogenous (17.0% CP) dietary treatments (Table 1) that is, 0% CPM, 5% CPM, 10% CPM, 15% CPM and 20% CPM replacing equal amounts of maize. Adjustments of the wheat bran and soya bean meal levels were made to obtain the crude protein (CP) level desired and all diets contained the same level of fishmeal (5%). The allocations of the pigs were based on sex and live weight in a Randomised Complete Block Design. Each treatment had three boars and two gilts and each pig represented a replicate. A kg of the exogenous enzyme complex contains- Cellulase, 100,000,000 U; Xylanase DS: 5,000,000 U; Beta-glucanase: 70,000 U; Amylase: 300,000 U; Pectinase: 70,000 U; Phytase: 1,450,000 IU; Protease: 3,000,000 U; Lipase: 10,000 U; Arabinase, Alpha galactosidase and Hemicellulase.

Management of pigs

Prior to the commencement of the experiment, all the pigs were tagged and treated with Tectin (Ivermectin) Inj. They were housed in a scrubbed and disinfected welded mesh, individual concrete-floored cages (that is, 160×66×104 cm), constructed within an aluminium-roofed building. Each cage was provided with a 43×12×10 cm concrete water trough. Shallow feeding troughs measuring 46×23×13 cm were used during the first two weeks and they were replaced with deeper and heavier troughs measuring 54×24×27 cm (depth of 11cm at the feeding end) from the third week onwards. Feed and water were provided without restriction throughout the study period.

Parameters measured

Growth performance and economics of production

Weekly feed intake and weight gain were measured and used to calculate the daily feed intake, daily weight gain and feed conversion ratio (FCR). Total feed intake and weight gain were alsocalculated. Cost per kg of each diet was computed by using the open market prices to estimate the cost of all ingredients used in the study. The cost of collecting, transporting and processing of CPM were estimated and added to the cost of the CPM diets. Inaddition, the cost of the inclusion (¢/kg) of enzyme was added to the CPM diets. Feed cost per kg gain for each diet was obtained by multiplying the cost per kg feed by the FCR.

Table 1. Composition (%) of the experimental diets.

Ingredients (%)	0% CPM	5% CPM+	10% CPM+	15% CPM+	20% CPM+
CPM	0	5	10	15	20
Maize	60	55	50	45	40
Soya bean meal	15.5	13.8	12.1	10.5	8.7
Wheat bran	18.5	20.2	21.9	23.5	25.3
Fishmeal	5	5	5	5	5
Dicalcium phosphate	0.25	0.25	0.25	0.25	0.25
Vit-min. premix#	0.25	0.25	0.25	0.25	0.25
Common salt	0.25	0.25	0.25	0.25	0.25
Oyster shells	0.25	0.25	0.25	0.25	0.25
Total	**100**	**100**	**100**	**100**	**100**
Calculated composition (%)					
CP	17.0	17.0	17.1	17.0	17.0
CF	3.68	4.48	5.28	6.07	6.87
DE (MJ/kg)	15.9	15.5	15.1	14.7	14.3
Calcium	0.51	0.52	0.54	0.57	0.56
Phosphorus	0.74	0.73	0.87	0.92	0.98

+ The enzyme was added at the rate of 35 g/100 kg to each of the CPM diets.#Vit-min. premix per 100 kg diet: Vitamin A (8×105U.I); Vitamin D3 (1.5×104U.I); Vitamin E (250 mg); Vitamin K (100 mg); Vitamin B2 (2×102 mg); Vitamin B12 (0.5 mg); Folic acid (50 mg); Nicotinic acid (8x102 mg); Calcium panthotenate (200 mg); Choline (5×103 mg). Trace elements: Mg (5×103 mg); Zn (4×103 mg); Cu (4.5×102 mg); Co (10 mg); I (100 mg); Se (10 mg). Antioxidants: Butylatedhydroxytoluene (1×103 mg). Carrier: Calcium carbonate q.s.p (0.25 kg).

Carcass and internal organs measurement

Four animals (two males and two females) from each dietary treatment were slaughtered for carcass evaluation, upon attaining the targeted weight of 70 ± 2.5 kg after the weekly weighing. Carcass parameters considered on the day of slaughter were; dressed weight, dressing percentage and weights of viscera, respiratory tract, full GIT, empty GIT, empty stomach, liver, spleen, heart, kidneys, trotters and head. After chilling the carcasses at 5°C overnight, the parameters measured were: Chilled dressed weight, carcass length, meanback fat thickness, P_2, loin eye area and weights of leaf fat, fillet, belly, loin, shoulder and thigh. An 8cm-length of the ileum, obtained between the caecum and the small intestine was taken for histological processing and microscopic observations for the villi count, height, width and villi area using the standard procedures outlined by Baker and Silverton (1976).

Haematological and serum biochemical studies

Two samples of blood were taken from each pig using heparinized vacutainer (Venoject, lithium heparin, Terumo Europe, Leuven, Belgium) and sterilized micro tubes.The first sample from each pig was subsequentlyanalysed for haematological parameters whilst the serum obtained from the other sample was used for biochemical studies (Tiezt,1995).

*In vitro*digestion

An *in vitro* trial was conducted on the test ingredient (raw CPM) and the five diets (that is, 0% CPM, 5% CMP+, 10% CPM+, 15% CPM+ and 20% CPM+) to mimic the digestion process in the pig so as to ascertain the effect of the enzyme. Parameters measured were sugar levels and the viscosities of the diets.

Statistical analysis

All data collected were subjected to the analysis of variance procedure of the GenStat Statistical Package Version 11.1 (2009) and differences were deemed significant at $p < 0.05$.

Ethical statement

Protocols used were in this study were approved by the Animal Ethics Committee of Kwame Nkrumah University of Science and Technology, Kumasi.

RESULTS AND DISCUSSION

Nutrient composition of the dried cocoa placenta (CPM)

Proximate composition of CPM (Table 2) showed highervalues for most components than that reported byBoatenget al. (2016) except the NFE and ME values. Boatenget al. (2016) reported NFE and ME values of 63.17% and 3006.91 (kcal/kg) respectively on as-fed basis. Torres-Morenoet al. (2015) attributed variations of proximate values of cocoa beans and African LocustBean Pulp (ALBP) to varietal differences, geographicallocation, type of soils, maturity of fruit at harvest, method used in drying, processing and duration of storage period. The cocoa placenta used by Boatenget al. (2016) was obtained from the Plantations Section of the Department of Crop and Soil Sciences, KNUST, Kumasi, Ghana.

The CP value of the CPM obtained in this study is

Table 2. Proximate composition of the dried cocoa placenta meal (CPM).

Proximate composition (%)	As-fed (%)	Dry matter (%)
Moisture	14.3	-
CP	16.0	18.6
CF	19.0	22.1
EE	3.02	3.52
Ash	9.98	11.6
NFE	37.8	44.1
ME (MJ/kg)$^{\beta}$	9.04	10.5

$^{\beta}$Metabolizable energy was calculated using Pauzenga (1985) equation (that is, ME = 37 × % CP + 81.8 × % EE + 35 × % NFE)

higher than the levels of CP in most of the conventional energy feed ingredients such as maize (8.3%) which is usually used in the diets of pigs in Ghana. It is worth mentioning that, except cocoa bean meal (23.2% CP), the CPM (Table 2) contained more CP than cocoa pod husk (8.4%) and cocoa bean shell (16.7%) in percentage dry matter terms (European Food Safety Authority, 2008). The CF value of 19.0% for the CPM is higher than the CF values of most agro-industrial by-products (AIBPs) reported by Rhule (2015) {that is, cassava peel (13.7 ± 0.23%), cocoa expeller cake (8.57 ± 0.22%), coconut chaff (13.8 ± 1.86%), copra cake (13.9 ± 0.65%), pineapple waste (14.7 ± 2.89%), pito mash (12.4 ± 2.84%) and brewer's spent grains (16.1 ± 1.29%)}. Therefore, the inclusion of the enzyme was to help degrade the high fibre in the CPM diets in order to release the nutrients that were bound in the fibre to the pigs. As a result of the fibrous nature of most AIBP, several research studies using fibre-degrading exogenous enzymes have been undertaken in Ghana (Alemaworet al., 2009;Nortey et al., 2015).

Growth performance of pigs

There were no differences ($p = 0.77$) in the average daily feed intake among the different dietary treatments although the 20% CPM^{+} diet recorded the least value. There was a trend of decreasing daily weight gain ($p = 0.02$) with increasing levels of the CPM. The 0% CPM and 20% CPM^{+} diets recorded the highest and lowest average daily weight gain (ADWG) value respectively. Boateng et al. (2016) obtained a divergent result of the ADWG ($p > 0.05$) when rats were fed diets containing varying levels of CPM plus XZYME^{TM}. The least ADFI and ADWG recorded by pigs on the 20% CPM^{+} diet had an impact on the duration or number of days spent to reach the slaughter weight of 70±2.5kg because pigs on the 20% CPM^{+}diet spent noticeably ($p = 0.04$) more days (116 days) compared to those on the 0% CPM (84 days) (Table 3).

Contrarily, Tengan et al. (2012) observed similar duration ($p > 0.05$) with varying levels of ALBP at the highest inclusion level (20%), where the pigs took 100 days compared with 105 days (no ALBP) to reach the target weight. The FCR values obtained implied that pigs on 0% CPM diet utilized their feed more efficiently ($p = 0.001$) than those on the 10, 15 and the 20% CPM^{+} diets although the FCR was similar to the 5% CPM^{+} diet. This study confirms the statement made by Whittemore et al. (2003), that feed efficiency is directly affected by growth rate and feed intake and in all cases of feeding high CF diets, feed conversion efficiency decreased, with the decreases being more pronounced in young pigs. The feed cost decreased with increasing level of dietary CPM inclusion even with the addition of the enzyme. This implied that, the feed cost (GH₵ per kg) was inversely proportional to the inclusion level of the CPM^{+} diets. However, there were no differences ($p = 0.1$) in the variations of the feed cost per kg gain values recorded among the dietary treatments and the variations did not follow any particular trend.

Carcass characteristics

All the absolute and relative fat parameters studied (that is,backfat thickness, P_2 measurement and leaf fat) recorded substantial differences ($p < 0.05$) between the control diet (0% CPM) and the CPM^{+} diets except the mean back fat thickness which was similar ($p > 0.05$) withthe 5% CPM^{+} diet. The CPM^{+} inclusion in the diets resulted in decreased values of the fat parameters. For example, the P_2 fat measurement was inversely proportional to the levels of CPM^{+} in the diets. It may beinferred that pigs fed the CPM^{+} diets converted their feed more into lean meat rather than fat deposits as a result oftheir high fibre levels but lower energy concentrations (Table 1). Amoah et al. (2017) observed a similar trend when they studied the performance of pigs at different phases of growth on sun-dried brewers spent grain (DBSG)-based diets. Specifically, the diets with high and low metabolizable energy values (that is, 25% DBSG and30% DBSG) recorded lower values for fat parameters (that is, back fat thickness, leaf fat and P_2 measurement). There were dietary influences ($p < 0.05$)

Table 3. Growth performance of the experimental pigs.

Parameter (kg)	0% CPM	5% CPM+	10% CPM+	15% CPM+	20% CPM+	SEM	p- value
Initial weight	15.5	15.3	15.4	15.6	15.4	0.05	1.00
Final weight	70.0	69.3	69.7	69.5	70.2	0.16	0.91
Duration of trial, days	84.0^{c}	92.4^{bc}	107^{ab}	105^{abc}	116^{a}	5.66	0.04
Daily feed intake	1.87	1.72	1.75	1.72	1.64	0.04	0.77
Daily weight gain	0.65^{a}	0.60^{ab}	0.51^{bc}	0.52^{bc}	0.48^{c}	0.03	0.02
Feed conversion ratio	2.87^{bc}	2.84^{c}	3.33^{a}	3.34^{a}	3.41^{a}	0.12	0.001
Feed cost, €	0.26	0.24	0.23	0.22	0.20	0.01	-
Feed cost/kg gain, €	0.74	0.70	0.77	0.75	0.68	0.02	0.10

a, b, c- Means on the same row bearing different superscripts are significantly different ($p < 0.05$).

Table 4. Absolute and relative carcass characteristics of the experimental pigs.

Parameter	0% CPM	5% CPM+	10% CPM+	15% CPM+	20% CPM+	SEM	p- value
Absolute (kg)							
Warm carcass wt.	51.8	51.1	49.0	50.0	48.6	0.61	0.33
Chilled carcass wt.	44.4	43.2	41.6	41.7	40.7	0.66	0.09
Dressing percentage, %	73.9	73.8	70.9	71.8	69.6	0.83	0.15
Loin eye area, cm^2	32.7	31.4	33.5	32.3	34.5	0.53	0.18
Mean backfat thickness, cm	2.58^{a}	2.50^{a}	1.58^{b}	1.62^{b}	1.50^{b}	0.24	0.001
P_2 measurement, cm	1.94^{a}	1.66^{b}	1.16^{b}	0.72^{c}	0.69^{c}	0.25	0.003
Leaf fat	0.64^{a}	0.47^{b}	0.34^{c}	0.33^{c}	0.34^{c}	0.06	0.002
Head	5.10	5.10	4.94	4.94	5.05	0.04	0.96
Trotters	0.96	1.04	1.07	1.07	1.08	0.02	0.46
Thigh	6.95	6.54	6.90	6.90	6.85	0.07	0.60
Loin	5.80	5.66	5.69	5.69	5.84	0.04	1.00
Fillet	0.41	0.41	0.41	0.41	0.40	0.002	1.00
Viscera	12.1^{b}	12.2^{b}	12.3^{b}	12.3^{b}	14.6^{a}	0.48	0.02
Full GIT	8.56^{b}	8.15^{b}	8.50^{b}	8.50^{b}	11.3^{a}	0.58	0.01
Empty GIT	2.94	3.17	2.84	2.84	3.04	0.06	0.40
Empty stomach	0.55^{d}	0.67^{b}	0.60^{c}	0.60^{b}	0.68^{a}	0.02	0.001
Relative (%)							
Leaf fat	0.91^{a}	0.67^{b}	0.49^{c}	0.47^{c}	0.49^{c}	0.08	0.002
Head	7.27	7.37	7.16	7.09	7.23	0.05	0.96
Trotters	1.36	1.50	1.55	1.53	1.55	0.04	0.39
Thigh	9.91	9.45	10.0	9.93	9.80	0.10	0.59
Loin	8.25	8.17	8.23	8.18	8.36	0.03	1.00
Fillet	0.58	0.60	0.60	0.59	0.57	0.006	1.00
Viscera	17.2^{b}	17.6^{b}	17.8^{b}	17.7^{b}	20.8^{a}	0.65	0.01
Full GIT	12.2^{b}	11.8^{b}	12.3^{b}	12.2^{b}	16.1^{a}	0.80	0.01
Empty GIT	4.19	4.57	4.12	4.09	4.36	0.09	0.38
Empty stomach	0.78^{c}	0.96^{a}	0.87^{b}	0.87^{b}	0.97^{a}	0.03	0.001

a, b, c - Means on the same row bearing different superscripts are significantly different ($p<0.05$).

on the absolute and relative weights of viscera, full GIT and empty stomach of the experimental pigs. Pigs on the 20% CPM+ dietary treatment obtained the highest absolute and relative viscera, full GIT and empty stomach weights compared to the rest of the dietary treatments. According to Jørgensenet al. (1996), pigs adapt to diets with increased fibre content by increasing gut volume and weight (Table 4).

Table 5. Villi parameters of the experimental pigs.

Parameter	0% CPM	5% CPM+	10% CPM+	15% CPM+	20% CPM+	SEM	p-value
Villi count, mm^2	1190	1476	1512	1602	1602	75.8	0.27
Villi height, µm	1003	1237	1291	1362	1362	66.3	0.32
Villi width, µm	187	239	221	239	239	10.1	0.76
Villi area, µm^2	586287	948108	940540	1017699	1056279	83717	0.42

Table 6. Haematological and serum biochemical parameters of the experimental pigs.

Parameter	0% CPM	5% CPM+	10% CPM+	15% CPM+	20% CPM+	SEM	p-value
Haematological assay*							
HCT, %	42.9	46.3	43.8	49.4	45.7	1.13	0.67
HGB, g/dL	13.4	13.9	13.7	14.3	13.6	0.15	0.93
RBC, 10^6/ml	6.98	8.01	7.30	7.73	7.68	0.18	0.72
LYM, 10^3 /µl	12.8	12.6	12.9	10.9	11.9	0.37	0.95
MCH, pg	19.2	17.6	18.7	18.6	17.8	0.30	0.25
MCHC, g/dL	31.3	30.4	31.2	39.1	29.8	1.71	0.12
MCV, µm^3	61.4	57.9	60.0	63.9	59.7	1.00	0.25
MON, 10^3 /µl	2.90	0.51	0.43	0.33	0.60	0.49	0.58
NEU, 10^3 /ml	5.72	9.41	11.6	15.5	8.85	1.62	0.22
PLT, 10^3 /ml	234	278	203	247	301	17.1	0.73
WBC, 10^3/ m	19.7	24.3	25.8	27.6	22.4	1.37	0.43
BAS, 10^3 /Ml	0.24	0.23	0.33	0.19	0.13	0.03	0.24
Serum biochemical assay							
Total cholesterol, mmol/L	2.28	2.21	2.34	2.12	2.52	0.07	0.23
Globulin, g/l	31.1	35.2	33.1	35.5	36.2	0.94	0.65
Total BIL, umol /L	2.90	2.90	2.90	2.58	2.86	0.06	0.69
Total protein, g/Dl	64.4	71.9	67.9	70.4	65.3	1.44	0.68
Triglycerides, mmol/L	0.69	0.54	0.83	0.67	0.84	0.06	0.42
Albumin, g/L	33.2	36.8	36.9	34.9	33.4	0.80	0.88

*HCT- Haematocrit, PCV- Packed Cell Volume, HGB- Haemoglobin, RBC- Red Blood Cell, LYM- Lymphocytes, MCH- Mean Cell Haemoglobin, MCHC- Mean Cell Haemoglobin Concentration, MCV- Mean Cell Volume, MON- Monocytes, NEU- Neutrophils, PLT- Platelets, WBC- White Blood Cell and BAS- Basophils.

The 20% CPM+ diet had the highest crude fibre percentage (Table 1) and that could have accounted for the highest weights of the viscera, full GIT and empty stomach. Pigs that were fed a diet containing 30% distillers dried grains with solubles showed increased visceral organ mass relative to the control fed pigs (Agyekumet al., 2012).

Some villi parameters

Montagne et al. (2003) had reported that, an increase in villi to crypt ratio leads to an increase in surface area for greater digestion and absorption of available nutrients to occur. However, the villi count, height, width and surface area measurements showed no dietary effects ($p > 0.05$) among the dietary treatments studied (Table 5). However, there were trends with the villi counts and heights; that is, as the inclusion rates of the CPM+ increased the mean values increased.

Haematological and Serum Biochemical Studies

There were no dietary effects ($p > 0.05$) on all the haematological and serum biochemical parameters (Table 6) considered in the experiment. It is worth stating that, all the mean values obtained across the different dietary treatments fell within the physiological ranges for Large White pigs raised in Ghana as reported by Okai et al. (1995). It can be deduced that the haematological and serum biochemical values obtained attest to the fact that

Table 7. Total sugars and viscosity of raw CPM and the dietary treatments.

Parameter	Raw CPM	0% CPM	5% CPM+	10% CPM+	15% CPM+	20% CPM+	SEM	p-value
Sugar, mg/L	5450[f]	13865[a]	10546[b]	9554[c]	9248[d]	9228[e]	1103	0.001
Viscosity, mm^2/s	1.27[a]	1.09[d]	1.13[cd]	1.13[cd]	1.15[bc]	1.17[b]	0.03	0.001

a, b, c, d e f- Means on a row with different superscripts are significantly different ($p < 0.05$).

CPM plus enzyme-an exogenous enzyme complex, had no adverse effects on the physiology of the experimental pigs.

In vitro digestibility

Dietary effects ($p < 0.05$) were found in the mean values of the total sugar and viscosity measurements (Table 7). The total sugar decreased clearly ($p < 0.05$) as the inclusion level of CPM^+ increased. This trend could probably be attributed to the inability of the supplemented enzyme to satisfactorily degrade the cell structures of the CPM to release sugars (energy) bound in its cells (McDonald et al., 2010). It has been reported that soluble fibre increases digest a viscosity and thereby slowdown the diffusion of the substrate and enzymes in the porcine small intestine, which hampers nutrient digestion and absorption (Wenk, 2001). The highest viscosity values recorded by the 15 and 20% CPM^+ diets (Table 7) could mean that the high crude fibre values recorded (Table 1) may contain some soluble fibre components which led to increase in the viscosity values. It could also mean that there were important ($p < 0.05$) enzymatic degradation on soluble fibres of the CPM^+ diets since the viscosity values seemed to have increased with an increasing in CPM inclusion.

Conclusions

The growth rate and daily weight gain parameters of growing-finishing pigs were substantially lowered when CPM-based diets at 10-20% inclusion levels plus enzyme were fed. However, feed cost per kg body weight gain, haematological parameters and serum profiles were not affected by the inclusion of CPM^+ in the diets. All fat parameters considered were clearly lowered with the CPM-based diets containing 10-20%. In summary, the CPM^+ diets were not only cheaper but also resulted in leaner carcasses though such pigs took considerably longer to reach the market weight.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

REFERENCES

Agyekum AK, Slominski BA, Nyachoti CM (2012) Organ weight, intestinal morphology, and fasting whole-body oxygen consumption in growing pigs fed diets containing distillers dried grains with solubles alone or in combination with a multi-enzyme supplement. Journal of Animal Science 90(9):3032-3040.

Alemawor F, Dzogbefia VP, Oddoye EO and Oldham JH (2009). Enzyme cocktail for enhancing poultry utilisation of cocoa pod husk. Scientific Research and Essay 4:555-559.

Amoah KO, Asiedu P, Wallace PA, Bumbie GZ, Rhule SWA (2017). The performance of pigs at different phases of growth on sun-dried brewers spent grain. Livestock Research for Rural Development 29(5). Available at:http://www. lrrd.org/lrrd29/5/kwam29090.html

AOAC (2002).Official Methods of Analysis," 18th Ed. Association of Official Analytical Chemists, Washinton, D.C. USA.

Atiemo KA (2015). Response of albino rats to diets containing varying levels of cocoa placenta meal (CPM). B.Sc. thesis. Department of Animal Science, Kwame Nkrumah University of Science and Technology 46p.

Atuahene CC, Donkoh A, Ntim I (2000) Blend of oil Palm slurry and rice bran as feed ingredient for broiler chickens. Animal Feed Science and Technology 83:185-193. Available at: https://www.sciencedirect.com/science/article/pii/S037784019900 1376

Baker FJ, Silverton RE (1976) Introduction to Medical Laboratory Technology. 5th eds. Butterworth & Co. Ltd. Boston, U.S.A.

Bedford MR (2000).Exogenous enzymes in monogastric nutrition-their current value and future benefits. Animal Feed Science and Technology 86:1-13.

Boateng M, Okai DB, Opoku-Asenso A, Aye KA, Frimpong YO (2016).Cocoa placenta meal: Nutrient composition and response of albino rats to diets containing graded levels, with or without Xzyme™, an exogenous enzymes-probiotics complex. Proc. 33rd GASA Symp., Univ. Dev. Studies, Tamale pp. 266-272.

Choct M, Selby EAE, Cadogan DJ, Chambell RG (2004).Effect of liquid to feed ratio, sleeping time and enzyme supplementation on performance of weaner pigs. Australian Journal of Agricultural Research 55(2):247-252.

Donkoh A, Attoh-Kotoku V, Korley MM (2013) Nutritional evaluation of dried yam peel: chemical composition and energy value. Ghanaian Journal of Animal Science 7(2):65-71.

European Food Safety Authority (2008).Theobromine as undesirable substances in animal feed: Scientific opinion of the panel on contaminants in the food chain. The EFSA Journal 725:1-66. DOI: 10.2903/j.efsa.2008.725

Genstat Statistical Package (2009).Genstat 12th Edition, Version 7.2 VSN International Limited, UK.

Jørgensen H, Zhao XQ, Eggum BO (1996). The influence of dietary fibre and environmental temperature on the development of the gastrointestinal tract, digestibility, degree of fermentation in the hind-gut and energy metabolism in pigs. British Journal of Nutrition 75:365–378.

McDonald P, Edwards RA, Greenhalgh JFD, Morgan CA, Sinclair LA, Wilkinson RG (2010). Animal Nutrition.7th Edition.Pearson Books714 p.

Montagne L, Pluske JR, Hampson DJ (2003).A review of interactions between dietary fibre and the intestinal mucosa, and their consequences on digestive health in young non-ruminant animals.

Animal Feed Science and Technology 108:95-117.
Nortey TN, Kpogo DV, Kpogo AL, Naazie A, Oddoye EOK (2015). Cocoa pod husk is a potential feed ingredient in laying hen diets. Livestock Research for Rural Development, Volume 27. Available at: http://www.lrrd.org/lrrd27/6/nort27119.htm
NRC (1998). Nutrient Requirements of Swine.10th revised edition. National Academic Press, Washington, D.C. pp. 56-87.
Obirikorang KA, Amisah S, Fialor SC and Skov PV (2015). Local agro-industrial by-products with potential use in Ghanaian aquaculture: a review. Aquaculture International 23:403-425.
Okai D B (1998) Alternative feed resources for pigs in Ghana. DeGraft Graphics and Publications, Kumasi, pp. 1-10.
Okai DB, Osafo ELK, Kwarteng FA, Tackie JK (1995) Haematological and serum biochemical patterns in Large White pigs raised in Ghana. Journal of the University of Science and Technology 15(1):1-4.
Pauzenga U (1985). Feeding parent stock. Zootechnical International 5:15.
Rhule SWA (2015)Research and development advances in the use of agro-industrial by-products: complete replacement of maize in pig diets. Capital Print, Accra. p 52
Tengan KD, Okai DB, Boateng M,Karbo N (2012). Nutritional evaluation of African Locust Bean Pulp (ALBP) –fruit fraction: nutrient profiles and effects of the pulp on the growth performance, blood constituents and carcass characteristics of growing pigs. Ghanaian Journal of Animal Science 6(1):62-68.
TieztNW (1995). Clinical Guide to Laboratory Test, 3rd ed. (NW Tietz; ed.). Philadelphia: WB Saunders 997p.
Torres-Moreno M, Torrescasana E, Salas-Salvadó J, Blanch C (2015) Nutritional composition and fatty acids profile in cocoa beans and chocolates with different geographical origin and processing conditions. Food Chemistry166:125-132.
Wenk C (2001). The role of dietary fibre in the digestive physiology of the pig. Animal Feed Science and Technology 90:21-33.
Whittemore EC, Emanns GC, Kyriazakis I (2003). The relationship between live weight and intake of bulky foods in pigs. Animal Science 76:89-100.