International Journal of Applied and Scientific Research (IJASR)
Vol. 3, No. 10, 2025: 937-946

Lipid and Fatty Acid Composition of Grower Pigs Fed Enzyme Supplemented Cassava Peel Maize Cob Mixture

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A R T I C L E I N F O

Keywords: Cassava, Peels, Maize, Cob, Lipid, Nutrition, Pigs, Fatty Acid

Received : 2 August
Revised : 17 September
Accepted: 17 October

A B S T R A C T

This study was undertaken to determine lipid and fatty acid composition of grower pigs fed enzyme supplemented Cassava Peel – Maize Cob Mixture (CP-CM). Forty, 5 months' male pigs (mixed breed) were assigned randomly to four treatments (n = 10 piglets/ treatment). Each treatment consists of 5 replicate with 2 piglets each in a completely randomized design. Enzyme supplemented dried cassava peel and maize cob meal (CP-CM) at ratio 1:1 was incorporated into the experimental diet to replace maize as follows: treatment 1 (T1) is the control diet (0 % CP-CM with enzymes), T2: (10 % CP-CM with enzymes), T3: (20 % CP-CM with enzymes), T4: (30 % CP-CM with enzymes). The trial lasted for sixty days, feed and water was supplied at all times. Result on the phytochemical composition of CP-CM shows that it contained flavonoids as the most prominent compound (208.2 mg/100g) while cyanide had the lowest concentration of 10.45 mg/100g. Other compounds obtained are: flavonoids (123.4 mg/100g), alkaloids (109.8 mg/100g), tannins (109.8 mg/100g) and phenolic compound (87.12 mg/100g). Increasing the levels of CP-CM improved ($p<0.05$) high density lipoprotein, monosaturated fatty acid and polysaturated fatty acid and decreased the concentrations of serum cholesterol, low density lipoprotein and saturated fatty acid ($p<0.05$). The higher concentrations of polyunsaturated fatty acid increase the nutritional composition of meat and protect against cardiovascular diseases. It was concluded that pigs can be fed CP-CM up to 30 percent without causing any harmful effect on the general performance of pigs

DOI: https://doi.org/10.59890/ijasr.v3i10.116
ISSN-E: 3025-7670
https://journal.multitechpublisher.com/index.php/ijasr/

INTRODUCTION

Livestock feed is costly in developing nations like Nigeria due to the scarcity of cereal grains and the high cost of other high-energy concentrate feed (Wadhwa and Bakshi, 2013). Madubuike et al. (2002) state that the high market price of maize is responsible for a significant portion of the feed costs, which make up 70–80% of the overall cost of raising pigs. One of the main feed grains and a staple in the diets of cattle, maize is utilized as an energy source. When estimating the nutritional worth of other grains, especially their energy content, maize is usually compared to them (Ecocrop, 2010). Maize is a common cereal grain in Nigeria that is utilized extensively for both human consumption and animal feed. However, given its increased demand for various processing industries, maize's availability in Nigeria is in doubt both now and in the future. This circumstance justifies assessing additional locally accessible non-traditional feed sources and incorporating the most promising ones into swine diets. Recently, cassava peel and maize cob have been recognized as unconventional feed sources with significant promise (Daniel, 2024).

One of the easily accessible agro-industrial by-products in nations where cassava is grown and turned into human nourishment is cassava peel. By weight, the peels make up roughly 10% to 15% of the tuber. Its crude protein content ranges from 5.00 to 5.98 percent (Ldowu et al., 2006). Cassava products' dustiness, difficulties in milling, reduction in feed intake, and significant amount of hydrocyanic acid (HCN), an anti-nutritional component, limit their usage in chicken diets (Essec and Nout, I989; and Salami, 1999). However, Oladunjoye et al. (2008) documented a number of processing techniques, such as parboiling, soaking in water, and sun drying (fermentation), to improve the feeding value of cassava products. According to Omoikhoje et al. (2008), monogastrics frequently consume cassava peel meal as a less expensive alternative to maize. Sun-dried maize cobs include 3008.4 kcal/kg of metabolizable energy, 8.61% crude protein, 10.11% crude fiber, 0.93 percent ether extract, 8.21% total ash, and 62.18% nitrogen free extract, according to Daniel et al. (2024). According to reports, maize cobs provide reasonable levels of feed minerals that can keep pigs performing at their best without negatively affecting their health.

LITERATURE REVIEW

Previous studies by Lamidi et al. (2008) have shown that Pineapple crush waste can be fed up to 20% in the diet of broiler chickens without affecting their performance. Similarly, Kanengoni et al. (2015) reported that maize cob can be fed to weaner pigs up to 20 % without causing any deleterious effect on their health status. However, there is scanty information on the effect of enzyme supplemented cassava peel – maize cob mixture on the lipid and fatty acid composition of growing pigs. This research will help to promote livestock sustainability and productivity especially in developing countries.

METHODOLOGY

Experimental Institution

This study was undertaken at the Livestock Unit, University of Abuja in Gwagwalada, Abuja located between latitudes 8o571 and 8o551N and longitudes 7o051 and 7o 061E

Animal management and the processing of cassava peel and maize cob mixture

We purchased fresh cassava peels and corn cobs from a number of outdoor marketplaces in Gwagwalada, Nigeria. Samples were collected, transported to the University of Abuja's Biological Science Department, where they were properly identified by a certified taxonomist and given the voucher number ASD/2025ABJ. Before being transported to the lab for phytochemical analysis, it was first sun-dried individually for 14 days, then hammered into meals and combined in a 1:1 ratio. As shown in Table 1, the phyto-compound analysis was conducted using the methodology recently reported by Daniel et al. (2023).

Forty five-month-old mixed-breed growers were acquired from an Abuja breeding farm and moved to the University of Abuja's pig section in Nigeria. Two weeks before to the start of the trial, the pigs' pens, feeders, and drinkers were thoroughly cleaned before they arrived. Pigs were put on a two-week adaption period, given a preventive medication, and fed a basal diet designed to satisfy their nutritional needs as stated by the NRC (2012). Following the acclimation phase, the animals were divided into four treatments (n = 10 piglets/treatment) at random after being stratified according to body weight. Five replicates of each treatment, each containing two piglets, are used in a fully randomized design.

The pigs were kept in 3.5 m2 semi-open concrete floor pens with drinkers and feeders to provide them with free access to fresh water. The investigation was conducted over 60 days using a completely randomized experimental design. The control diet for Treatment 1 (T1) was 0% CP-CM with enzymes; T2 was 10% CP-CM with enzymes; T3 was 20% CP-CM with enzymes; and T4 was 30% CP-CM with enzymes, as shown in Table 2. Each replicate's daily feed intake was calculated by deducting the feed that was offered from the feed that was declined. Feed offered and denied was weighed at the end of the experiment and recorded every day. Using the techniques described by the Association of Analytical Chemists (2012), proximate analyses of the experimental diet and test component were performed.

Analysis of Lipid Profile in the Serum

At the end of the study blood samples were taken from four randomly selected pigs per treatment for serum lipid analysis. 5 ml of blood was collected into plain sample bottles without anticoagulant before it was sent to the laboratory for further analysis. Parameters examined include; total cholesterol, total glycerides, low density lipoprotein and high density lipoprotein. Samples were analyzed using Doop Auto Serum-Analyzer (model 2344C, Punjab, India).

Fatty Acid Evaluation of Meat Samples

At the end of the experiment meat samples were collected from the thigh muscle of four randomly selected pigs. Animals were feed starved 12 hours before slaughtering, meat samples were collected into sample bottles and placed in an ice before transferring samples to the laboratory for analysis. Fatty acid composition of meat samples was carried out according to methods recently published by Anjum et al. (2013). Briefly, meat sample was injected into gas chromatograph Triple Tripod® (Model GCH-006H, Japan) in splitless mode and subjected to a temperature of 300 °C. Purge flow to spilt vent was 20 mL/minutes at 1.05 minutes with a total flow of 15.000 mL/min. The fatty acid methylated esters were ascertained by comparing their retention times with those of their standards. Fatty acid relative percent was quantified as a percentage of the total analyzed fatty acid in the sample. Adjustment in the kit was done according to recommendations of the manufacturers to obtain precision in results.

Statistical Analysis

Data collected on lipid fatty acid composition were analyzed by using the general linear model (GLM) using procedures of SAS (2004), by employing one-way analysis of variance (ANOVA). Significant differences between treatment's means were separated by Duncan's multiple range test (Duncan, 1955)

The following statistical model was used: $Y_{ij} = \mu + T_i + e_{ij}$ Where: Y_{ij}= the observation of ij; μ = overall mean; T_i = effects of treatments, (i = 1, 2, 3 and 4) and e_{ij} = experimental random error.

RESULT AND DISCUSSION

Result on the phytochemical composition of CP-CM shows that it contained flavonoids as the most prominent compound (208.2 mg/100g) while cyanide had the lowest concentration of 10.45 mg/100g. Other compounds obtained are: flavonoids (123.4 mg/100g), alkaloids (109.8 mg/100g), tannins (109.8 mg/100g) and phenolic compound (87.12 mg/100g). Result obtained suggests that CP-CM has several phyto-constituents with medicinal properties such as, anti-inflammatory, antioxidant, immuno-stimulatory, blood-protective, immuno-modulatory, cytotoxic, antifungal, antiviral, anti-helminthic, antitumor amongst others (Singh et al., 2021; Singh et al., 2022). The high concentration of flavonoids in CP-CM indicates that it has cardio-protective properties (John, 2024a,b) and can protect liver cells from oxidative stress as well as detoxification at the cellular level (John, 2024c,d). Phenolic compounds have been suggested to possess antioxidant properties, thus it can scavenge the activities of free radicals in the cells (John, 2024d; Musa et al., 2020). All the phytochemicals reported in this study restore vitality and strengthens the blood vessels (Adewale et al., 2021). However, the result obtained is in consonance with the report of Daniel (2025).

Ingredient and chemical composition of the experimental diets in Table 2 shows that crude protein values ranged from 17.80 % - 18.30 %, crude fibre (4.00 – 4.71 %), ether extract (2.87 – 3.00 %) and energy (2550.1 – 2601.8 Kcal/kg). Results obtained was within NRC (2012) requirement for growing pigs.

Lipid composition of grower pigs fed CP-CM is presented in Table 3. Total cholesterol values (116.5 – 178.4 mg/dL) was within 110 – 205.1 mg/dL cited by

Etim et al. (2013). Low density and high density lipoprotein were within 92.62 – 106.3 mg/dL and 50.82 – 71.33 mg/dL referenced by Etim et al. (2013); Fasuyi and Ibitayo (2010). The result obtained suggests that CP-CM lowers LDL and supports the heart by improving lipid metabolism (Alagbe, 2024; Hernandez and Alagbe, 2025a). Total cholesterol values decrease as the level of CP-CM increased across the diet indicating that it possesses both nutritional and medicinal properties. According to Daniel et al. (2023) low serum cholesterol can also play a positive role in improving the shelf life of meat samples. Low LDL values in CP-CM group is advantageous in this study because it restores consumers' confidence on the quality of meat as well as reduce the risk of cardio-vascular diseases (Fasuyi and Ibitayo, 2001; Ojediran et al, 2024a). LDL, HDL and total cholesterol values were significantly ($p<0.05$) affected by the treatment.

Fatty acid composition (thigh muscle) of grower pigs fed CP-CM is presented in Table 4. Saturated fatty acid concentration varied from 62.10 – 69.00 %, monosaturated fatty acid (25.00 – 32.04 %) and polysaturated fatty acid (7.00 – 7.16 %). Result obtained were significantly ($p<0.05$) influenced by the treatment. Reduction in saturated fatty acid concentrations simply prevents the dangers of coronary diseases. However, high unsaturated fatty acid in meat samples have been reported to improve the shelf life of meat (Singh et al., 2022). The result obtained in this study is in consonance with the reports of Madalla et al. (2016). Alagbe et a. (2016) also reported that dietary supplementation of Anogeissusleio carpus stem bark had positive influence on the fatty acid composition of broilers meat.

CONCLUSIONS AND RECOMMENDATIONS

In conclusion, CP-CM is rich in phytochemicals with nutritional and medicinal properties. They are well tolerated by the pigs and feeding up to 30 % significantly improves the concentrations of unsaturated fatty acid, high density lipoprotein and significantly reduced total cholesterol, low density lipoprotein and saturated fatty acid in meat samples.

Table 1. Phytochemical Analysis of CP-CM

Components	Concentration (mg/100g)
Saponins	208.2
Flavonoids	123.4
Tannins	51.82
Alkaloids	109.8
Phenols	87.12
Cyanide	10.45

Table 2. Gross Composition of Basal Diets (Expressed in Percentage DM)

Feedstuffs	T1 (0 %)	T2 (10 %)	T3 (20 %)	T4 (30 %)
Corn	55.00	49.50	44.00	38.50
Wheat offal	6.97	6.97	6.97	6.97
Soya beans (45 % CP)	24.00	24.00	24.00	24.00
Groundnut cake (40 % CP)	7.00	7.00	7.00	7.00
CP-CM	0.00	5.50	11.00	16.50
Bone meal	3.00	3.00	3.00	3.00
Limestone	1.50	1.50	1.50	1.50
DL-Methionine	0.20	0.20	0.20	0.20
L-Lysine	0.25	0.25	0.25	0.25
*Premix (Vit&Min)	0.25	0.25	0.25	0.25
Enzymes	0.03	0.03	0.03	0.03
Sodium Chloride	1.80	1.80	1.80	1.80
Total	100.0	100.0	100.	100.0
Determined analysis (% DM)				
Crude protein	18.31	18.02	17.70	17.83
Crude fibre	4.01	4.39	4.51	4.75
Ether extract	3.02	2.93	2.91	2.88
Calcium	0.46	0.46	0.46	0.46
Phosphorus	0.32	0.32	0.32	0.32
Energy (Kcal/kg)	2604.8	2559.7	2557.0	2552.5

Vitamin A, 13,000 I.U., vitamin E, 5 mg, vitamin D3, 3000 I.U., vitamin K, 3 mg, vitamin B2, 5.5 mg, niacin, 25 mg, vitamin B12, 16 mg, choline chloride, 120 mg, Mn, 5.2 mg, Zn, 25 mg, Cu, 2.6 mg, folic acid, 2 mg, Fe, 5 mg, pantothenic acid, 10 mg, biotin, 30.5 mg, and antioxidant, 56 mg are provided as premix per kg diet.

Table 3. Lipid Composition of Grower Pigs Fed CP-CM

Parameters (mg/dL)	T1	T2	T3	T4	**SEM**
Total cholesterol	178.4a	126.2b	118.8b	116.5b	**9.88**
Low density lipoprotein (LDL)	106.3a	94.11b	93.05b	92.62b	**5.71**
High density lipoprotein (HDL)	50.82c	67.19b	70.98a	71.33a	**2.08**

[a,b,c]: Means within a row with different superscripts are significantly different ($p<0.05$); Treatment 1 (T1) control diet (0 % CP-CM with enzymes), T2 (10 % CP-CM with enzymes), T3 (20 % CP-CM with enzymes), T4 (30 % CP-CM with enzymes)

Table 4. Fatty Acid Composition (Thigh Muscle) of Grower Pigs Fed CP-CM

Parameters	T1	T2	T3	T4	SEM
C4:0	3.15^{a}	2.15^{b}	2.11^{b}	2.10^{b}	0.09
C6:0	2.09^{a}	1.51^{b}	1.48^{b}	1.42^{b}	0.12
C8:0	2.03^{a}	1.09^{b}	1.11^{b}	1.10^{b}	0.88
C9:0	5.81^{a}	3.82^{b}	3.71^{b}	3.09^{b}	0.61
C10:0	6.55^{a}	4.17^{b}	4.09^{b}	4.03^{b}	0.75
C12:0	3.81^{a}	2.61^{b}	2.55^{b}	2.50^{b}	0.16
C13:0	1.90^{a}	1.55^{b}	1.45^{b}	1.40^{b}	0.38
C14:0	11.50^{a}	9.94^{b}	9.55^{b}	9.49^{c}	0.12
C15:0	8.62	8.53	8.61	8.77	0.75
C16:0	12.90^{a}	11.46^{b}	10.67^{b}	9.46^{c}	0.15
C17:0	0.60^{c}	0.69^{b}	0.71^{a}	0.72^{a}	0.05
C18:0	1.66^{b}	2.45^{a}	2.51^{a}	2.56^{a}	0.57
C18:1n-9	11.57^{b}	13.06^{a}	13.87^{a}	13.92^{a}	0.08
C18:2	0.79^{b}	1.21^{a}	1.25^{a}	1.34^{a}	0.02
C18:2n-6	1.75^{b}	2.05^{a}	2.11^{a}	2.18^{a}	0.01
C18:3n-6	2.88^{b}	3.25^{a}	3.46^{a}	3.61^{a}	0.15
C18:3n-4	4.77^{b}	5.93^{a}	6.06^{a}	6.11^{a}	0.30
C18:3n-3	3.00^{b}	3.94^{a}	4.05^{a}	4.12^{a}	0.74
C20:0	2.06^{b}	2.85^{a}	2.97^{a}	3.01^{a}	0.16
C22:0	4.02^{b}	5.56^{a}	5.95^{a}	6.08^{a}	0.15
SFA	69.00^{a}	61.00^{b}	62.00^{b}	62.10^{b}	1.67
UFA	31.00^{c}	39.00^{a}	38.00^{a}	37.90^{a}	2.09
MUFA	25.00^{b}	30.05^{a}	32.11^{a}	32.04^{a}	0.13
PUFA	7.00^{b}	9.00^{a}	7.18^{a}	7.16^{a}	0.90

^{a,b,c}: Means within a row with different superscripts are significantly different ($p<0.05$); Treatment 1 (T1) control diet (0 % CP-CM with enzymes), T2 (10 % CP-CM with enzymes), T3 (20 % CP-CM with enzymes), T4 (30 % CP-CM with enzymes)

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