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Performance and Jejunal Morphometry of Broiler Chickens Fed Processed Unripe Plantain (*Musa Paradisiaca* Cv. 'Cadava') Peel Flour Diets Supplemented With Multi-Enzyme

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A B S T R A C T

Performance of broiler finishers fed Sun-dried Unripe Plantain Peel Flour (SUPPF) and Boiled Unripe Plantain Peel Flour (BUPPF) diets supplemented with multi enzyme wa investigat ed for 4-week. A total of 196 two-week old Cobb-500 broilers randomly divided into 7 dietary treatments; 0%, 10%SUPPF, 10%SUPPF+Natuzy me®, 10%SUPPF+Polyzyme®, 10%BUPPF, 10% BUPPF+Natuzyme® and 10%BUPPF+Polyzyme ® with four replicates in a completely design within a 3x2 factorial arrangement. Data collecte d on Final Body Weight (FBW), Average Daily Gain (ADG) and jejunum morphometry were analysed by One Way and factorial ANOVA at 5% level of significance. Results showed that Natuzyme® supplementation to 10%SUPPF diet increased FBW, ADG and enhanced jejunal cells of the chickens. Conclusively, 10%SUPPF diet supplemented with Natuzyme® improved FBW, ADG and jejunal morphology of broilers

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INTRODUCTION

Poultry production has become less profitable due to the high cost of conventional feed ingredients which are often in competition with human consumption as well the poultry industry. Feed cost accounts for between 65 - 70% of the total cost of production (Silas et al., 2014). High prices of conventional feedstuffs such as maize necessitate the search for alternatives in poultry diets. A cheap alternative is Plantain Peel (PP) which is rich in energy. Plantain peel contains approximately 3136kcal/kg metabolizable energy, 11% crude protein, 66% carbohydrates, 9% crude fibre, 3% crude fat and 4% ash (Arogbodo et al., 2024).

Plantain peels are waste products generated from plantain processing industries, households, roadside fryers, restaurants, hotels, eateries and if improperly disposed can lead to environmental pollution (Agubosi et al., 2019). The inclusion of plantain peel in Poultry diets will promote recycling of agricultural by-products, reduce environmental pollution and support sustainable agriculture. Animal nutrition studies have shown that plantain peel meal can be included in feeds for snail (Omole et al., 2008), broilers (Lawal et al., 2012), fish (Agbabiaka et al., 2013), rat (Idoko and Oladiji, 2014), and rabbit (Robert et al., 2020).

However, the inclusion of plantain peel in diets for monogastric animals is limited because of its fibrousness (Akande and Agbetuyi, 2019) and anti‑nutritional substances such as tannin (Blandon et al.., 2015), saponin, phytate and oxalate present in it. Anti-nutritional substances interact with proteins, enzymes, and essential amino acids to form complexes that reduce nutrient digestibility and utilization in poultry (Pekel et al., 2015). Moreover, tannins have been associated with alterations in intestinal nutrient absorption as well as reductions in the villi width and length of the duodenum and jejunum (Johnston et al., 2005).

Akande and Agbetuyi (2019) reported that good processing methods are needed for treating the anti- nutritional factors present in plantain peels in order to enhance its optimal utilization in poultry diets. The addition of multi-enzymes to processed unripe plantain peel diets will help to break down complex nutrients (fibre and starch), improve nutrient digestibility and enhance feed efficiency. Supplementation of exogenous enzymes to fibrous feed ingredients has been reported to improve performance, enhance production efficiency and increase the effectiveness of nutrient utilization (Aguihe et. al., 2015). Therefore, the aim of this study is to determine the performance and jejunal morphometry of broiler chickens fed processed unripe plantain (Musa paradisiaca cv. 'Cadava') peel flour diets supplemented with multi-enzyme.

LITERATURE RIVIEW

Most of the toxic and anti-nutritional substances in plants could be reduced through various processing methods such as soaking, boiling, germination, fermentation, autoclaving and genetic manipulation (Soetan, 2008). Savage and Mårtensson (2010) observed 47% reduction in oxalate content of taro leaves boiled in water for 40minutes. Blandon et al. (2015) reported that in order to reduce the tannin content in dried banana peel, the dried peels were subjected to three different processing methods which includes: autoclaving, oven heating and soaking in boiling water. It was discovered that 1.2g/100g of tannin content in dried banana peel was reduced to 1.04, 0.59 and 0.46g/100g by autoclaving, oven heating and soaking in boiling water, respectively. Hence it is postulated that plantain peel should be treated prior to inclusion in poultry diet.

Poultry naturally produce a wide range of digestive enzymes; however, digestion relying solely on endogenous enzymes can still result in up to 25% of feed remaining undigested due to the presence of anti-nutritional factors (Bedford and Partridge 2010). Previous studies have shown that responses to exogenous enzyme supplementation in poultry performance are inconsistent and influenced by several factors which include: the age of the birds, quality or type of diet used (Sateri et al., 2017) and enzyme product used. Multi-enzyme is expected to be more effective than single-strain enzymes, as different enzymes target different compounds thereby enhancing the release and availability of more nutrients from the diet (Madigan-Stretton et al., 2021).

METHODOLOGY

Experimental Site

The experiment was conducted at the Broiler Unit of the Teaching and Research Farm of Ladoke Akintola University of Technology (LAUTECH), Ogbomoso, Oyo State, Nigeria. All experimental procedures and management practices were approved by the Ethics Committee of the Department of Animal Nutrition and Biotechnology, LAUTECH, Ogbomoso. Oyo State, Nigeria.

Source and Preparation of Test Ingredients

Unripe plantain peels were sourced from plantain chips processing enterprises in Ogbomoso, Oyo State. The preparations of the peels were done as explained in sections I and II below:

1. **Sun-dried Unripe Plantain (*Musa paradisiaca* cv. 'Cadava') Peel Flour**: Unripe plantain peels were sun-dried to a constant weight (when it became crispy). The dried peels were milled using hammer mill fitted with a 0.5mm sieve to reduce the particle size and these were referred to as Sun-dried Unripe Plantain Peel Flour (SUPPF).
2. **Boiled Unripe Plantain (*Musa paradisiaca* cv. 'Cadava') Peel Flour**: The peels were processed according to the method of Togun *et al*. (2026). Unripe plantain peels were boiled at 100˚C for 40 minutes in a cooking pot and then sun-dried to a constant weight (when it became crispy). The dried peels were milled using hammer mill fitted with a 0.5mm sieve to reduce the particle size and these were referred to as Boiled Unripe Plantain Peel Flour (BUPPF).

Experimental Animals and Management

One hundred and ninety-six-day old broiler chicks (DOCs) of Cobb-500 strain were obtained from a reputable commercial hatchery. The animals were housed in a deep litter system of housing. The pens were thoroughly washed and disinfected before the birds arrived. Broiler chicks were fed broiler starter feed in accordance to NRC (1994) requirement prior to starting the experiment for 2 weeks. After two weeks, the birds were randomly assigned to 7 treatments with 4 replicates per treatment with their weight put into consideration. Each treatment contained 28 birds per treatment with 7 bird per replicate. Feed and water were provided *ad libitum* to the birds until the time of termination of the Experiment. Routine management practices and vaccination programme were implemented as scheduled. The experiment lasted for 4 weeks at six weeks of age.

Experimental Diets and Design

Seven experimental diets (broiler finisher) were formulated for the study (Table 2). A corn soybean meal-based diet served as the control. Maize was partially replaced with sun-dried unripe plantain peel and boiled unripe plantain peel flour on weight to weight basis. The inclusion level of 10% was used for unripe plantain peel flour in the experimental diets. Diet in T1 containing10% sun-dried unripe plantain peel flour was not supplemented with any enzyme. Diets in T2 and T3 containing 10% sun-dried unripe plantain peel flour were supplemented with multi-enzyme Natuzyme® and Polyzyme® respectively. Diet in T4 containing 10% boiled unripe plantain peel flour was also not supplemented with any enzyme. Diets in T5 and T6 containing 10% boiled unripe plantain peel flour each was supplemented with multi-enzyme Natuzyme® and Polyzyme® respectively. Polyzyme® and Natuzyme® were supplemented to the experimental diets at 0.5gram/kg feed and 0.35gram/kg feed respectively. A 3x2 factorial arrangement within a completely randomized design was used for the experiment.

Table 1. Gross Composition of the Experimental Diets for the Broiler Finishers

Ingredients (%)	Control	T1 Basal 1 10%SUPPF	T2 10%SUPPF +Natuzyme	T3 10%SUPPF +Polyzyme	T4 Basal 2 10% BUPPF	T5 10%BUPPF+Natuzyme	T6 10%BUPPF +Polyzyme
Maize	53.00	43.00	43.00	43.00	43.00	43.00	43.00
Maize offal	10.00	10.00	10.00	10.00	10.00	10.00	10.00
SUPPF	-	10.00	10.00	10.00	-	-	-
BUPPF	-	-	-	-	10.00	10.00	10.00
Soybean meal	28.90	28.90	28.90	28.90	28.90	28.90	28.90
FM (72%CP)	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Methionine	0.20	0.20	0.20	0.20	0.20	0.20	0.20

Salt	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Vit-Premix**	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Bonemeal	2.60	2.60	2.60	2.60	2.60	2.60	2.60
Limestone	0.70	0.70	0.70	0.70	0.70	0.70	0.70
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
DA (%) *							
Crude Protein*	21.25	22.90	20.30	22.50	20.50	22.95	23.60
Ether Extract*	7.40	6.70	7.10	7.20	6.80	6.70	6.50
Crude Fibre*	5.10	5.20	5.60	5.40	5.20	5.40	5.10
M.E(kcal/kg)	3048.83	2976.85	2994.70	2995.45	3002.65	2881.08	2990.10
Phosphorus	0.66	0.68	0.68	0.68	0.68	0.68	0.68
Calcium	1.46	1.84	1.84	1.84	1.84	1.84	1.84
Lysine	1.15	1.12	1.12	1.12	1.12	1.12	1.12
Methionine	0.55	0.55	0.54	0.54	0.54	0.54	0.54

Note:+= 35gram Natuzyme® per 100kilogram feed and 50gram Polyzyme® per 100kgfeed were supplemented
FM=Fish meal, DA=Determined Analysis , *=Parameers of determined nutrients
ME=Metabolizable energy, determined using Pauzenga (1985) equation;
SUPPF = Sun-dried Unripe Plantain Peel Flour,
BUPPF= Boiled Unripe Plantain Peel Flour,

Data Collection

Growth Performance: Birds feed intake and weight gain were monitored throughout the feeding trial period. The initial feed supplied and feed leftover were used to calculate the feed intake. Average daily intake ADI was estimated by dividing the total feed intake by the number of birds and number of days in each replicate. The weight gain of the birds was calculated as a difference in the initial body weight and final body weight. Average Daily Gain (ADG) was calculated by dividing the total weight gain by the product of the number of birds and the number of days in each replicate. Feed Conversion Ratio (FCR) was calculated by dividing the total feed intake per bird by the total weight gain per bird.

***Organs Length of Experimental Birds*:** On the 56th day of age, 8 birds were selected per treatment at random and starved for about 12 hours to empty the crop and reduce the digesta in the gastro intestinal tract, but they were allowed to have access to clean drinking water. The selected birds were bled, eviscerated and dressed similar to the turkey carcass dissection procedure described by Hann and Spindler (2002). The internal organs of broiler chickens that were removed and measured include: organs such as duodenum, jejunum, ileum, caecum and large intestine.

Morphometric Measurements: After the measurement of the internal organs. Five centimeters (5cm) portion of jejunum were harvested from four chickens per treatment for morphometric assessment. The 5cm jejunal cut were preserved in "Bouins fluid" (Gridley, 1960) for twenty – four hours, exsiccated in different ascension graded of alcohol concentration (70, 80, 90, 95 and 100%), xylene was used to clear, infiltrates in paraffin, embedded in paraffin and finally the paraffin blocks were cut at 5µm thick using sliding microtone as accounted by Nasrin *et al.*(2012). After the cuttings, the portions were floated on slide using an egg albumen and dried on slide warmer. The sections were later stained with standard haemotoxylin and eosin method (Gridley, 1960) for the overall histological assessment. Micrographs were taken with microscope. Morphometric measurements were carried out on villi obtained from each sample. The indices assessed included villi height (VH) measured from the tip of the villi to the crypt; Crypt Depth (CD) measured from the base of the villi to the submucosa; Villi Width (VW) calculated as the average width at the one-third and two-thirds points of the villi and Muscular Thickness (MT) measured from the submucosa to the outer intestinal layer (Geyra *et al*., 2001). Villi height crypt depth ratio was estimated by dividing the villi height by the crypt depth.

Chemical Analysis

***Proximate Composition*:** The proximate composition of the experimental diets were determined according to the method of AOAC (2012).

Metabolizable Energy Determination: The metabolizable energy content of the experimental diets were determined using Pauzenga (1985) equation via proximate composition of the diet.

Statistical Analysis: All data collected were subjected to one-way and 3 × 2 factorial ANOVA using SAS (2004) software. Means were separated using Duncan's multiple range test within the same software package and significance was declared at 5% probability ($P < 0.05$).

RESULT

The growth performance of broiler finishers fed sun-dried and boiled unripe plantain peel flour diets supplemented with multi-enzyme at finisher phase is shown in Table 2. Broilers fed control diet had significantly (P=0.001) highest final body weight (1942.75g/b) which was comparable to those fed 10%SUPPF diet (1886.91g/bird) supplemented with Natuzyme®. Meanwhile broilers fed 10%BUPPF diet (1692.86g/b) supplemented with Natuzyme® had lowest final body weight. The same trend ensued in the ADG of the finishers. There were significant (P=0.005) increases in the ADI of broiler finishers fed 10%SUPPF with Natuzyme® supplementation which was not different from those fed 10%BUPPF diet and 10% BUPPF diet supplemented with Polyzyme®. The best feed conversion ratio was recorded in broilers fed control diet closely followed by those fed 10% SUPPF diet. Broilers fed 10%BUPPF diet and those fed 10% BUPPF supplemented with Polyzyme® diet had the worst. The processing method of plantain peel significantly (P<0.05) influenced the determined parameters [FW (P=0.001), ADG (P=0.001) and FCR (P=0.028)]. The interactions effect of enzyme type and processing method of plantain peel flour significantly influenced ADI (p=0.0004) and FCR (P=0.028). Finishers fed 10% SUPPF had

better FCR than those fed 10% BUPPF. The FCR of finishers fed 10% BUPPF was significantly improved by Natuzyme® supplementation.

Table 2. Growth Performance of 14th Day Old Broiler Finishers Fed Sun-Dried Unripe and Boiled Unripe Plantain Peel Flour Diet Supplemented With Multi-Enzyme From 15th To 42nd Day Of Age (G/Bird)

Parameters	Control	T1 Basal 1 (10% SUPPF)	T2 (10% SUPPF) + NATUZ	T3 (10% SUPPF) + POLYZ	T4 Basal 2 (10% BUPPF)	T5 (10% BUPPF) + NATUZ	T6 (10% BUPPF) + POLYZ	P-Value	SEM	Enzy Type	PMPPF	Interaction
Initial BW	255.00	256.79	253.57	257.14	255.72	256.43	258.57	0.664	1.94	0.337	0.719	0.40
FBW	1942.75^{a}	1832.14^{bc}	1886.91^{ab}	1817.86^{bc}	1742.86^{cd}	1692.86^{d}	1764.29^{cd}	0.001	34.6	0.975	0.001	0.072
ADG	60.28^{a}	56.23^{bc}	5828^{ab}	55.74^{bc}	53.11^{cd}	51.30^{d}	53.95^{cd}	0.001	1.24	0.978	0.001	0.062
ADI	125.62^{bc}	126.53^{bc}	140.85^{a}	128.19^{bc}	136.85^{ab}	117.79^{c}	137.88^{ab}	0.005	3.91	0.446	0.776	0.0004
FCR	2.10^{c}	2.25^{bc}	2.42^{ab}	2.31^{abc}	2.57^{a}	2.30^{abc}	2.56^{a}	0.017	0.09	0.553	0.028	0.028

abcd : Means within the same row bearing different superscripts are significantly different (P<0.050).

Note: SUPPF=Unripe Plantain Peel Flour, BUPPF=Boiled Unripe Plantain Peel Flour,
ADG=Average Daily Gain, ADI= Average Daily Intake,
Initial BW=Initial Body Weight, FBW=Final Body Weight
NATUZ=Natuzyme®, POLYZ= Polyzyme® Enzy type= Enzyme Type
FCR= Feed Conversion Ratio PMPPF= Processing Method of Plantain Peel Flour,

The organ length of broiler finishers fed sun-dried and boiled unripe plantain peel flour diets supplemented with multi-enzyme is shown in Table 3. There were significant differences in the length of the duodenum, left caecum, jejunum, ileum and large intestine. Multi-enzyme supplementation (Natuzyme®. and Polyzyme®.) to 10% BUPPF diet statistically (P<0.0003) increased the length of left caecum of the finisher broilers. Chickens fed 10%SUPPF diets had longer (P<0.05) jejunum (P=0.035) and Ileum than those fed 10% BUPPF diets. Main effect of enzyme type had significant effect on the length of measured organs such as duodenum (P<0.0001), jejunum (P=0.012) and ileum (P=0.025) of the broilers chickens.

The morphometry of the jejunum of broiler finishers fed sun-dried and boiled unripe plantain peel flour diets supplemented with multi-enzyme is presented in Table 4. Broilers fed 10% SUPPF diet supplemented with Natuzyme®. and those fed 10% BUPPF diet had significantly (P<0.0001) highest villi width (210µm) and muscle thickness (365.70µm) respectively. However lowest villi width (128.9µm) and muscle thickness (184.21µm) were recorded in finishers fed 10% BUPPF diet and those fed 10% SUPPF diet respectively. Broilers

fed 10% SUPPF diets with (142.87µm) or without (139.87 µm) Natuzyme®. supplementation had significantly (P=0.010) higher crypt widths than those fed other dietary treatments. Although there were no significant differences in villi height and villi height-to-crypt depth ratio, finisher broilers fed 10% BUPPF and those fed 10%SUPPF diets each supplemented with Polyzyme® had numerically highest villi height (1436.6 µm) and villi height to crypt depth ratio (2.7µm) The main effect of enzyme type significantly (P<0.0001) influence the villi width of the jejunum of finisher broilers with the multi-enzyme group had wider villi width than un-supplemented group. The processing method of plantain peel flour had significant (P<0.0001) effect on the villi width and muscle thickness of the broiler finishers. Feeding SUPPF diets caused wider villi than those fed BUPPF diets. Furthermore, the jejunum muscle of broiler finishers fed BUPPF diet were thicker than those fed SUPPF groups. The interaction effect had significant effect on the cryptal width (P=0.004) and muscle thickness (P<0.0001) of the broilers.

Table 3. Organ Length of Broiler Finishers Fed Unripe and Boiled Unripe Plantain Peel Flour Diets Supplemented With Multi-Enzyme (Cm/Kg)

Parameters	Control	T1 Basal 1 (10%UPPF)	T2 (10% UPPF) + NAT	T3 (10% UPPF) + POLY	T4 Basal 2 (10% BUPPF)	T5 (10% BUPPF) + NAT	T6 (10% BUPPF) + POLY	P-Value	SEM	Enzyme Type	PMPPF	Interaction
Duodenum	27.30^{ab}	32.35^{a}	23.81^{b}	28.74^{ab}	27.96^{ab}	17.47^{c}	13.52^{c}	<0.0001	1.82	<0.0001	<0.0001	0.016
RC	12.94	14.85	13.94	13.47	15.12	13.73	14.72	0.557	0.89	0.429	0.561	0.721
LC	12.01^{b}	13.46^{b}	13.28^{b}	13.49^{b}	13.85^{b}	25.79^{a}	28.62^{a}	<0.0001	1.59	0.0002	<0.0001	0.0002
Jejunum	68.39^{b}	81.71^{a}	63.38^{b}	68.37^{b}	68.82^{b}	67.47^{b}	68.04^{b}	0.006	3.06	0.012	0.254	0.033
Iieum	66.82^{b}	79.65^{a}	60.52^{b}	71.44^{aab}	71.85^{ab}	69.37^{ab}	67.93^{b}	0.026	3.57	0.025	0.793	0.089
Largeintestine	7.31^{bc}	8.75^{ab}	6.66^{c}	7.40^{bc}	7.76^{abc}	9.13^{a}	7.78^{abc}	0.036	0.54	0.498	0.177	0.012

^{a,b,c} : Means within the same row bearing different superscripts are significantly different (P<0.050).

Note: UPPF=Unripe Plantain Peel Flour, BUPPF=Boiled Unripe Plantain Peel F lour,
RC= Right Caecum, LC= Left Caecum,
NAT=Natuzyme®, PMPPF= Processing Method of Plantain Peel Flour,
POLYZ= Polyzyme®

Table 4. Jejunum Morphometry (µm) of Broiler Finishers Fed Sun-Dried Unripe and Boiled Unripe Plantain Peel Flour Diets Supplemented With Multi-Enzyme

Parameters	Control	T1 Basal 1 (10 % SUPPF)	T2 (10 % SUPPF +NAT)	T3 (10 % SUPPF + POLY)	T4 Basal 2 (10 % BUPPF)	T5 (10 % BUPPF + NAT)	T6 (10% BUPPF +POLY)	P-Value	SEM	Enzyme Type	PMPPF	Interaction
Villi height	1295.6	1374.3	1411.2	1400.7	1329.6	1390.8	1436.6	0.896	80.59	0.681	0.881	0.871
Villi width	132.63^{cd}	153.82^{c}	210^{a}	182.36^{b}	128.91^{d}	149.12^{cd}	140.50^{cd}	<0.0001	7.31	<0.001	<0.001	0.067
Crypt depth	561.04	521.09	573.39	517.86	596.81	525.23	664.51	0.174	42.06	0.613	0.114	0.094
Crypt width	128.34^{ab}	139.87^{a}	142.87^{a}	116.33^{b}	110.04^{b}	118.11^{b}	129.24^{ab}	0.010	6.79	0.48	0.140	0.004
MT	279.89^{cd}	184.21^{d}	335.85^{ab}	215.78^{cd}	365.70^{a}	230.61^{cd}	378.82^{a}	<0.001	21.76	0.57	<0.001	<0.0001
VH:CD	2.31	2.64	2.46	2.70	2.23	2.65	2.16	0.161	1.92	0.8930	0.089	0.161

^{a,b,c,d} ; Means within the same row bearing different superscripts are significantly different (P<0.050).

Note: SUPPF= Sun-dried Uunripe Plantain Peel Flour, BUPPF=Boiled Unripe Plantain Peel Flour,
MT=Muscle Thickness, VH:CD =Villi Height toCrypt Depth ratio
NAT=Natuzyme® PMPPF= Processing Method of Plantain Peel Flour,
POLY= Polyzyme®,

DISCUSSION

The slight increase in FBW and ADG of broilers fed 10% SUPPF diet (1886.91g/b) supplemented with Natuzyme® in the present study may be due to the processing method of plantain peel flour as the same multi-enzyme product supplementation to 10% BUPPF diet led to lowest FBW and ADG. The beneficial effects of exogenous enzymes have been demonstrated in several tropical feedstuffs when included in broiler diets. Alefzadeh et al. (2016) reported improved weight gain in broiler chickens fed diets containing dried orange (Citrus sinensis) peel powder supplemented with Natuzyme P50®. Furthermore, Sunmola et al. (2019) observed that supplementing broiler diet containing 25% sweet orange peel meal with Polyzyme® improved the birds' final weight and ADG of the chickens. The higher ADI of broilers fed 10%SUPPF diet may be attributed to the quality of the feed in terms of palatability, acceptability and nutrient utilization as well as the effect of the multi-enzyme. The chickens seemed to find the taste palatability of the diet. The high vitamin C content in PPF is considered to improve the palatability of the diet. Novianti and Yuniastuti (2018) reported that plantain peel flour contained vitamin C, B, calcium and it can increase the nutritional value of food produced. It has been reported that including 250 g/kg vitamin C in laying hen diets increased feed consumption by

0.75% (Torki et al., 2014). The better FCR observed in broilers fed SUPPF diet relative to those fed multi-enzyme supplemented SUPPF diets showed that the chickens utilized the PPF to efficiently produce body mass tissue. The improved FCR of finisher broilers fed SUPPF diet when compared to BUPPF diet may be due to loss of nutrients during boiling. Togun et al. (2025) reported that BUPPF contains 7.38±002% crude protein which was lower than 12.09% crude protein of sun dried unripe plantain peel reported by Arogbodo et al. (2024). It therefore indicates that there is no need to supplement exogenous multi-enzymes to SUPPF diet. The slight improvement in FCR of broilers fed BUPPF diet supplemented with Natuzyme® illustrated the efficiency of exogenous multi-enzyme supplementation. Similar observation was noticed by Lawal et al. (2012). The authors reported that there was improvement in feed conversion ratio of birds placed on Aspegillus niger degraded plantain peel. Lawal et al. (2012) attributed the better feed conversion ratio to the effect of fungal enzymatic degradation conferred on target substrate in plantain peels. However, Blandon et al. (2015) observed that broilers fed 30 and 40% banana peels with or without multi-enzyme had worst feed conversion ratio as compared to control groups.
The longer lengths of jejunum and ileum observed in broiler finishers fed 10% SUPPF in this study could be due to high fibre in the diet. The observed increases in organ length in the present study was consistent with the findings of other authors. Henry et al. (1996) reported that high fibre contents increased length and weight of intestine of broilers. Also, Borin et al. (2006) reported that there were increase in the intestinal length of birds fed high fibre diets based on cassava leaf meal.

The improved villi width observed in broilers fed 10%SUPPF diets supplemented with Natuzymes® may be due to the ability of the multi-enzyme to breakdown the non-starch polysaccharides present in 10%SUPPF diets. Sharifi et al. (2013) observed that addition of Natuzyme® to corn–soybean diets of broiler chickens significantly increased the villi height and improved nutrient digestibility. It has been reported that Increases in villus width (Johnson and Jee, 1986), villus surface area (Awad et al., 2009), and cell mitosis (Yamauchi et al., 2006) enhance the absorptive surface area of the intestine, thereby improving nutrient absorption capacity and overall nutrient digestibility (Onderci et al., 2006). Conversely, short and narrow villi are linked with reduced body weight (Batal and Parsons, 2002). Natuzymes® supplementation to 10%SUPPF diet may have lowered the deleterious effect of anti-nutritional factors present in sun-dried unripe plantain peel flour meal diet such as reduction on the impact of damages on the intestinal lining, thereby improved the FBW and ADG of broiler finishers. It has been reported that anti-nutritional factors reduce the activity of digestive enzymes and may damage the mucosa of the gastrointestinal tract, thereby decreasing nutrient absorption (Doss et al., 2011). The thicker muscle layer in the jejunum of broilers fed 10%BUPPF diets relative to those fed 10%SUPPF diets showed jujenal hypertrophy as a result of boiling the peels. Boiling of unripe plantain peel might have reduced the deleterious effect of tannin on the jujenal morphology (which when left untreated could have severe damage on the jujenal mucosa in those offered sun-dried UPPF). According to

Blandon et al. (2015), soaking dried banana peel in boiling water reduced its tannin content from 1.2 g/100 g to 0.46 g/100 g. It has been reported that a thicker muscularis layer and taller villi along the small intestine are associated with maturation of the intestinal mucosa (Cheled-Shoval et al., 2011). Anti-nutritional factors such as tannins have been associated with alterations in intestinal nutrient absorption (Johnston et al., 2005). In addition, the intestinal mucosal layer comprising the epithelium, lamina propria, and muscularis mucosa serves as the primary barrier against pathogenic bacteria in the lumen and plays a key role in preventing bacterial adherence (Chee et al., 2010).

CONCLUSIONS

1. Broiler finishers fed 10%SUPPF diet had higher final body weight and average daily gain which were slightly improved by Natuzyme supplementation.
2. Feeding 10% sun-dried unripe plantain peel flour diet to broiler finishers increased the length of the jejunum and ileum of the chickens. Morphometric measurement of the jejunum of broiler finishers revealed deleterious effect of feeding sundried unripe plantain (Musa paradisiaca cv. 'Cadava') peel flour.
3. Boiling of the peel did not ameliorate the negative consequence. However, supplementation of 0.35g Natuzyme®/kg or 0.50g Polyzyme®/kg to 10% sun-dried unripe plantain peel flour diet improved morphology of jejunal cells.

RECOMMENDATIONS

It is hereby recommended that 10% sun-dried unripe plantain peel flour supplemented with 35g/100kg diet Natuzyme® should be used to partially replace maize in the diet of broiler finishers for improved growth performance and jejunal morphometry

FURTHER STUDY

Investigations on other processing methods and exogenous enzyme type supplementation is hereby suggested for unripe plantain (Musa paradisiaca cv. 'Cadava') peel flour in the diets of poultry chickens.

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