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Concentration of nitrogen-corrected apparent metabolizable energy, nutrient and dietary fiber digestibilities of Banana meal in Broilers

Durain, A. M.[1*], Sulabo, R. C.[2], Adiova, C. B.[2] and Merca, F. E.[2]

[1]Department of Animal Science, College of Agriculture, Central Mindanao University, Musuan Maramag, Bukidnon, 8714 Philippines; [2]Institute of Animal Science, College of Agriculture, University of the Philippines, Los Baños, Laguna, 4031 Philippines.

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Abstract Apparent metabolizable energy (AME), corrected to zero nitrogen retention (AMEn) is frequently used energy system to estimate energy concentration of an ingredient and diet in poultry. Meanwhile, apparent total tract digestibility (ATTD) is commonly used to estimate nutrient digestibility values of particular ingredient in poultry like broiler. The nitrogen-corrected apparent metabolizable energy, nutrient and dietary fiber digestibilities of banana meal in broilers was determined in this study. Results revealed that peeled banana meal was significantly higher ($P<0.05$) in terms of AME and AMEn in broiler than unpeeled banana meal with 3,369 and 3058 kcal/kg DM, respectively. But these energy values were less than the yellow dent corn with 3, 606 kcal/kg, DM. On the other hand, % ATTD of DM, GE and crude fiber of diets with banana meal were significantly higher ($P<0.01$) than corn-soy diet. Specifically, % ATTD of GE of diets with peeled banana meal was significantly higher ($P<0.01$) than diets with unpeeled banana meal. In conclusion, banana peeled meal can be used as an alternative feed energy source in broiler.

Keywords: AMEn, ATTD, Banana meal, Broilers, Crude fiber

Introduction

Livestock and poultry industry aimed to increase production and improve efficiencies to supply ever increasing demand for animal proteins. However, industry continues to experience increasing feed cost over the years, partly caused by increasing prices of yellow corn used as enery source for humans and animals (Donkoh *et al.,* 2012). Thus, there is high interest in looking for alternative energy source that can replace at least part of the conventional ingredient like yellow corn with a least possible cost.

One of the potential alternatives is the utilization of waste from industries of agricultural commodities. Banana co-products such as pseudostem, leaves,

[*]**Corresponding Author:** Durain, A. M.; **Email:** pinedaangelap567@gmail.com

inflorescence, fruit stalk, rhizome, peels (Padam *et al.,* 2012) and banana fruits set as off-grade quality could be one of the potential raw materials for feed production for most of banana producing countries like Philippines.

Banana fruit known to provide greater amounts of energy through its starch (Ibrahim *et al.,* 2000). Unripe banana pulps contain 70-80% starch on DM basis, that is comparable to endosperm of corn grain and sweet potato (Zhang *et al.,* 2004).

It was reported that GE, DE and ME values of banana meal is 18 to 27% lower than corn depending on the age of harvesting (Noblet *et al.,* 2002). In terms of cultivar, DE values of dessert banana meal were the same in young pigs (3,179 kcal/kg, DM) and in growing pigs (3,203 kcal/kg, DM) (Renaudeau *et al.,* 2014) but these values were lower than in plantain meal with 3,609 kcal/kg, DM. However, energy and digestibility values of most banana co-products were based only on predicted average values (Heuze *et al.,* 2016).

This study was to determine the nitrogen- corrected metabolizable energy value, nutrient and dieitary fiber digestibilities of banana meal when fed to broilers.

Materials and methods

Animal and experimental design and treatments

In this study, a total of 24-day-old (Cobb 500) broilers were employed in this experiment. These birds were randomly assigned to three dietary treatments following completely randomized design replicated eight times. Each bird was placed in metabolic cage that allowed total collection of excreta. Treatment 1: corn-soy diet (basal); Treatment 2: basal +30% unpeeled banana meal; and Treatment 3: basal + 30% peeled banana meal.

Feeding and excreta collection

Birds were group-brooded and fed a common chick booster diet for 12 days ad libitum with water available at all times. On d 13 birds were weighed individually, transferred and housed in individual metabolic cage and dietary treatments were fed 65 g to 98 g up to the 19th day as adaptation period. On d 20, birds were weighed again, fasting for 4 hours aand provided with 130 g of feed divided into two meals to lessen feed waste. Total collection of excreta was done every morning for 3 consecutive days. On the last day, birds were fasted for 17 h and weighed after fasting. Daily excreta collections were pooled within cage, weighed and stored at -20C for subsequent analyses.

Chemical analysis

At the conclusion of experiment, 3 days pooled excreta samples were lyophilized, wrapped in aluminum foil and dried at 65C in forced-air oven to constant weight and ground to pass 0.50 mm screen prior to analysis. All samples of excreta, diet and ingredients were analyzed duplicates for proximate analysis determination (AOAC, 2007) and bomb calorimeter for GE (Model 6400, Parr Instruments, Moline II).

Energy calculations

The apparent metabolizable energy (AME) of basal diet was determined using direct procedure whereas the AME in banana co-products was determined using the difference procedure.

The AME of the diet is calculated using the following equation:

$$\boldsymbol{AME} = \frac{(Feed\ intake\ \times GEfeed) - (Excreta\ output\ \times GEexcreta)}{Feed\ intake}$$

The AME is corrected to zero N retention using the factor of 8.22 kcal/g of N (Hill and Anderson, 1958). The AME_n values were calculated using the following equations:

$$\boldsymbol{AMEn} = AME - \left[\frac{N\ gain\ \times 8.22}{DM\ intake}\right]$$

Where: **N gain**= $\left[\frac{BW\ gain\ \times 0.20}{6.25}\right]$

Digestibility calculations

The apparent total tract digestibility (**ATTD, %**) of DM, GE and crude fiber were calculated using the following equation:

$$\boldsymbol{ATTD}\ (\%) = \frac{\left[\boldsymbol{Nutrient_i - Nutrient_f}\right]}{\boldsymbol{Nutrient_i}}\ \boldsymbol{x\ 100}$$

where ATTD is the apparent total tract digestibility, $Nutrient_i$ is the total nutrient intake (g) from d 20 to d 22; and $Nutrient_f$ is the total fecal output (g) of the nutrient originating from the diet fed from d 20 to d 22 (Almeida and Stein, 2010).

Statistical analysis

Data were analyzed using the MIXED procedure of SAS (SAS Inst. Inc, Cary, NC) with replicate as the experimental unit, diet as the fixed effect and replicate as the random effect. Least square means were calculated for each independent variable and α-level of 0.05 and 0.01, respectively for determining significance among means.

Results

Chemical composition of 'Saba' banana variety

On DM basis, GE of the peel was 4,270 kcal/kg greater than the pulp with 3, 989 kcal/kg. The GE and the CP of the whole banana fruit was slightly lower (4,022 kcal/kg and 3.72%, respectively) than published values (4,110 kcal/kg and 4:00-5.30%, respectively) as shown in Table 1. On the other hand, the CP of the peel was slightly greater than the pulp and whole fruit with (6.27%, 3.02% and 3.72%, respectively). Also, it was observed that the crude fiber and ash were greater in the peel (5.58% and 12.41%, respectively) compared with the pulp (0.75% and 2.82%, respectively) and whole fruit (1.76% and 5.19%, respectively). As expected, pulp has NFE of 91.35%, whole fruit has 86.85% and peel was 68.66%.

In terms of dietary fiber composition, pulp was greatest amount of NDF and hemicellulose (60.74% and 39.54%, respectively) followed by peel (56.42% and 30.59%, respectively) and whole fruit had the least (33.78% and 25.94%, respectively). However, ADF, ADL and cellulose of banana peel were highest (25.83%; 7.84% and 12.61%, respectively) than the whole fruit, (7.84%; 2.79% and 5.05%, respectively) and pulp (21.20%; 19.90% and 1.30%, respectively).

Thea daily energy balance of broilers fed with basal diet and banana meal diets showed that DM intake, GE intake, excreta and GE output did not significantly differ among broilers fed with banana meal and corn-soy diets. (Table 2). However, ATTD of GE of banana meal diets was significantly different ($P<0.001$) from corn-soy diets. Diet with peeled banana meal (PBM) had greater ATTD of GE than unpeeled banana meal (UBM). As a result, diets with PBM had the highest AMEn ($P<0.001$) followed by the diets with UBM and corn-soy diets having the least AMEn.

Table 1. Chemical composition of whole fruit, peel, and pulp of *'Saba'* banana variety (DM, basis)

ITEM	WHOLE	PEEL	PULP
GE, kcal/kg	4,022	4,270	3,989
CP%	3.72	6.27	3.02
Crude fat, %	2.48	7.08	2.06
Crude fiber, %	1.76	5.58	0.75
Ash, %	5.19	12.41	2.82
NFE, %	86.85	68.66	91.35
NDF, %	33.78	56.42	60.74
ADF, %	7.84	25.83	21.20
ADL, %	2.79	13.22	19.90
Hemicellulose, %[1]	25.94	30.59	39.54
Cellulose, %[2]	5.05	12.61	1.30

[1]Hemicellulose = NDF – ADF.
[2]Cellulose = ADF – ADL.

Table 2. Daily energy balance (DM, basis) of broilers fed with basal diets and diets with 30% unpeeled and peeled banana meal

ITEM	Basal	Unpeeled banana	Peeled banana	SEM	*P*-value
DM intake, g	95.24	100.91	105.39	3.36	0.13
GE intake, kcal	395.13	412.67	431.64	13.74	0.21
Excreta output, g	33.40	30.95	30.85	1.16	0.24
GE output, kcal	123.24	120.29	118.34	4.60	0.80
ATTD of GE, %	68.73^{c}	70.84^{b}	72.64^{a}	0.57	<0.001
AME of diet, kcal/kg	2,852^{b}	2,897^{ab}	2,975^{a}	23.47	<0.05
AMEn of diet, kcal/kg	2,641^{c}	2,766^{b}	2,859^{a}	21.09	<0.001

Note: Values with different superscripts in same row differ significantly *(P*<0.05).

On both as fed and DM basis, PBM had significantly higher (*P*<0.004) AME and AMEn compared to UBM (Table 3). The AMEn of UBM (3, 058 kcal/kg DM) was less than the energy value determined by Fetuga and Oluyemi (1976) (3,130 kcal/kg). To the best of our knowledge, there is no previous study that determined the AMEn of UBM and PBM when fed to broilers. Moreover, the AMEn of UBM and PBM were 3, 058 and 3,369 kcal/kg, DM, respectively which are both slightly less than the yellow corn with 3, 606 kcal/kg, DM.

Table 3. Concentration of apparent metabolizable energy (AME) and nitrogen-corrected AME (AMEn) of unpeeled and peeled banana meal fed to broilers

ITEM	Unpeeled banana meal	Peeled banana meal	SEM	*P*-value
As fed basis				
AME, kcal/kg	3,289[b]	3,549[a]	71	0.004
AMEn, kcal/kg	2,982[b]	3,290[a]	69	0.003
DM basis				
AME, kcal/kg DM	3,373[b]	3,634[a]	73	0.004
AMEn, kcal/kg DM	3,058[b]	3,369[a]	71	0.003

Note: Values with different superscripts in same row differ significantly *(P*<0.05).

The diets containing either UBM or PBM had greater (*P*<0.001) ATTD of DM and crude fiber compared with corn-soy diets (Table 4). However, there were no significant differences in ATTD of DM and crude fiber between banana meal diets when fed to broilers.

Table 4. Apparent total tract digestibility (ATTD, %) of DM and crude fiber in diets containing unpeeled and peeled banana meal fed to broilers

ITEM	Basal	Unpeeled banana	Peeled banana	SEM	*P*-value
DM	64.81[b]	69.31[a]	70.76[a]	0.67	<0.001
Crude fiber	21.05[b]	55.58[a]	49.30[a]	2.23	<0.001

Note: Values with different superscripts in same row differ significantly *(P*<0.05).

Discussion

Most of the chemical composition of banana meals used in the experiments were within the close range of previously published values except for crude fat, crude fiber and ash content (Bezerra *et al.,* 2013; Heuze *et al.,* 2016) which are greater than the previous values. Also, the gross energy of UBM and PBM (4,043 and 3,974 kcal/kg, DM) were less than the yellow dent corn (4,275 kcal/kg, DM) (NRC, 2012). These differences in chemical composition values might be attributed to the inherent variability of banana varieties used. Between banana co-products, concentrations of GE, crude fat, crude fiber and ash were greater in unpeeled banana meal (UBM) compared to peeled banana meal (PBM). The greater composition of UBM might be due to the presence of banana peels that adds to the energy and nutrient values of the unpeeled banana meal.

The higher ATTD of GE of broilers fed with banana meal diets than corn-soy diets may explained by the observed differences in ATTD of crude fiber, higher GE intake, less GE and crude fiber output. Between banana meal diets, higher ATTD of GE and AMEn of broilers fed with PBM diets might be attributed to greater digestibility of starch and additional energy coming from the fermentation in the large intestine. Studies with banana flour confirmed that substantial amount of starch fraction escape digestion (Faisant *et al.,* 1993) due to its resistance to enzymatic digestion in small intestine but it undergoes complete or partial fermentation in the colon and generate short-chain fatty acids (Topping and Clinton, 2001) which could potentially gives additional energy to the broiler chickens.

The type of animal, age, inherent chemical composition of ingredient and among others were factors that can affect nutrient digestibility. In the study, the higher ATTD of crude fiber in banana meal diets than corn-soy diets were attributed to the type of fiber sources present in banana co-products. On DM basis, banana co-products contain moderate levels of insoluble fibers that may increase chyme retention time in upper GIT, stimulating gizzard development and endogenous enzyme production, thereby improving the digestibility of starch, lipids and other dietary components (Mateos *et al.,* 2012). In this case, broilers fed with banana meal diets were able to ferment and digest fibers present in the diet resulting to no differences in DM and crude fiber digestibility between banana co-products.

Moreover, the AMEn of the PBM and UBM were slightly lower than (3, 369 kcal/kg, DM and 3,058 kcal/kg, DM) with yellow dent corn (3, 606 kcal/kg, DM) (Heuze *et al.,* 2016). This lower energy value of banana meal possible due to intrinsic resistance and encapsulation of banana starch granules causing low digestibility of its starch in small intestine. Banana flour has irregular shaped starch granules with smooth and dense surfaces that partially accounts to its digestion resistance (Zhang *et al.,* 2004). The presence of thick layer of larger blocklets of banana starch granule hampers enzyme action and reduce rate of hydrolysis (Gallant *et al.,* 1992). Also, residual cell walls of banana may entrap starch granules, thereby protecting them from enzymatic action (Tester ans Karkalas, 2002).

Between banana co-products, PBM had greater AMEn than the UBM. The lesser AMEn of UBM was related to the higher dietary fiber levels present in banana peel and increase peel to pulp ratio, resulting to decreased starch content of the meal. The relative percentage weight of banana peel is equivalent to 40% of total fresh weight of banana (Castillo-Israel *et al.,* 2015). In this experiment, peels of Saba variety contain 56.42% NDF; 25.83% ADF and 13.22% ADL (DM basis). Previous studies (Mateos *et al.,* 2012 and Walugembe, 2013) showed significant reduction in energy utilization when broilers fed with ingredient high in NDF and hemicellulose. Inclusion of banana peels in the diet should be taken into consideration when formulating diet for broilers. Therefore, banana co-products such as peeled banana meal may be used as an alternative feed energy source for broilers. These results need further studies for validity. Also, it is need to determine the digestibilties of starch and other fiber sources of banana co-products when fed to broilers.

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