Effects of banana peels on growth performance, dry matter digestibility and feed efficiency of growing male rabbits

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Abstract
This study was conducted to evaluate the effects of substituting maize grains with banana peels in male growing rabbits with aged 6 weeks. The efficiency of banana peels was assessed in dry matter intake (DMI), gain in body weight (GBW), feed efficiency (FE), dry matter digestibility (DMD), organic matter digestibility (OMD), crude protein digestibility (CPD), crude fiber digestibility (CFD), ether extract digestibility (EED), nitrogen free extract digestibility (NFED), gain in body weight (GBW) cost, dry matter intake (DMI) cost and profit per rabbit. Twelve male growing rabbits were divided into 4 equal groups i.e., T0, T1, T2 and T3. Maize grains were replaced with banana peels at the rate of 0%, 25%, 50% and 100% in rations T0, T1, T2 and T3 respectively for 56 days. The DMI, DMD, and OMD were significantly improved in banana peels supplemented groups. The CPD, CFD and EED were significantly ($P<0.05$) different among the groups, whereas NFED was not significant ($P<0.05$) changed. Higher profit per rabbit was recorded in groups T1, T2, and T3 compared to control group T0. It is concluded that feeding banana peels showed improvement in DMI, DMD, OMD, CFD and EED except CPD and resulted in more profit per Kg GBW.

Key words: Banana, feed additive maize, growth, rabbits

Introduction
Protein plays a significant role in human health and disease prevention. The animal protein availability for human consumption is less and the price is high, in another word it beyond the reach of public, therefore seriously affecting the health and fitness of human being in developing countries (Bamgboseet al., 2002). It is considered necessary to resolve the crisis of protein by increasing small livestock production. Household rabbits (*Oryctolaguscuniculus*) are herbivorous, fed on grains and green roughages and generally maintained in cages and pens. Rabbits utilize low amount of cereal grains and more roughage in feed and have potential of meat production, short gestation period, fast growth rate and low feed requirements (Cheeke, 1986).
Rabbit meat is characterized by high levels of essential amino-acids, low cholesterol level (Hernandez and Gondret, 2006. Cholesterol present in rabbit meat is about 59mg per 100g of muscle, less than other species *i.e.,* 61mg per 100g in pork, 70mg per 100g in beef while 81mg per 100g in chicken (Hernandez, 2008). One study reported that 100gm of rabbit meat have 25mg cholesterol, which is very close to the cholesterol level of wild animal's meat (Marinov et al., 2009).
Nutritionists are exploring an alternative source of feed to replace supplement of cereals grains in rabbit feed in order to make the rabbit meat production more profitable. Bananas (*Musa sapientum L.*) fruit is the world 2nd largest fruit production after citrus while banana peel represents 40% by weight of the banana fruit (Alkarkhi et al., 2010; Mohapatra et al., 2010). About 18-20% of banana peels are wasted every year (disposed or thrown) causing harms ecologically issue. Banana peels are wealthy resources and consist of starch 3%, crude protein 6-9%, crude fat 3.8-11% & total dietary fiber 43.2-49.7% (Emaga et al., 2008). Substitution of 15% plantain peel in place of maize had no considerable effect on weight gain of weaned rabbit (Omole et al., 2008). Sun dried ripe plantain peels could substitute up to 75% of maize (Ajasin et al., 2006). Combination of dried and ground ripe banana peels and yam peels (3:1) gave

excellent performances in weaned rabbit and was the most valuable when it replaced 50% of the maize (Akinmutimi et al., 2006). The present study was designed to evaluate comparative effects of maize grains and banana peels on growth performance of male growing rabbit in vivo digestibility of nutrients and to calculate comparative economics of the experimental rations.

Materials and methods

Experimental design

The experiment was carried out in Small Ruminant Nutrition laboratory, Department of Animal Nutrition, Faculty of Animal Husbandry and Veterinary Sciences, The University of Agriculture Peshawar-Pakistan. A sum of 24 growing rabbits of 5-6 weeks of age, with average weight of 500g was divided into 4 groups (6 rabbit per group). Rabbits was purchased from a local market and housed in cages measuring 360× 450× 310 mm separately under room temperature 20°Ċ (Laudadio et al., 2009). Rabbits were adopted for 15 days before the start of experimental trail (56 days) to become familiar to feed and dewormed for endo-parasites. Four experimental diets T0, T1, T2 & T3 were formulated with fresh banana peel replacing maize grains at 0, 25, 50 & 100% respectively. The rabbits were allowed to water *ad libitum*.

Digestibility Trial

A week after the start of the experiment, fecal samples were collected daily from each group and dried at 65^{o}C to a constant weight to determine the dry matter. After 7-8th week another sample was collected for in vivo digestibility. The samples of each of the replicates were allowed to cool in glass desiccator to prevent further absorption of moisture. The samples were analyzed for crude protein, crude fiber and ether extract for each experimental group according to the method of AOAC (2007).

Dry Matter and Ash

For evaluation of dry matter (DM) and ash about 2g samples of rations and feces were taken in pre-weighed crucibles in duplicate. The crucibles were placed in oven for 18h at 100°C. Post dried samples were reweighed. The DM% was determined by using the following formula.

$$DM\ (\%) = \frac{C-A \times 100}{B-A}$$

Where A = weight of empty crucible, B = weight of crucible + (pre dried sample), C = weight of crucible + (post dried sample).

The samples were burnt in muffle furnace at 550°C for 6 hours for ash content. After incineration the samples were cooled again in desiccator and re-weighed. Ash was calculated as under:

$$Ash\ (\%) = \frac{D-A \times 100}{C-A}$$

A = empty crucible weight, C = (crucible wt. + post dried sample), D = (crucible wt. + ash)

Organic matter (OM) was calculated after subtracting ash from DM.

Crude Fiber

It is the organic residue that remain when a moisture free sample is digested first with weak acid solution (H_2SO_4) and then with a weak alkaline solution (NaOH). The residues collected after

digestion is ignited and the loss in weight on burning is registered as crude fiber. In a beaker 2g moisture free sample was taken. 200 ml boiling dilute H_2SO_4 was added and digested for 30 minutes on crude fiber extraction apparatus. Then filtered through glass Buchner funnel with an aid of suction air pump and washed with hot water until it became acid free. Again it was transferred to a tall beaker and 200 ml boiling dilute NaoH was added and then were filtered through glass Buchner funnel with an aid of suction air pump. Then washed with 10 ml dilute H_2SO_4 and with hot water until it became acid free. It was changed to a prepared Gooch crucible and washed with 10ml ethanol. Sample was dried in oven at 135°C for 2 hours and cooled in desiccator for 30 minutes and weighed. Samples were incinerated in muffle furnace at 600°C for 30 minutes. Burned residues were cooled in desiccator for 1hour and reweighed. CF% was calculated as under:

$$\% \text{ CF (sample)} = \frac{\text{(crucible wt. + dried residue) - (crucible wt. + ash residue)}}{\text{(Sample wt.)}} \times 100$$

$$\% \text{ EE (DM)} = \frac{\text{CF \% in sample}}{\text{DM \% in sample}} \times 100$$

Crude Protein

Crude protein (CP) calculation, in digestion tube 0.5g air dried ground sample was taken. Also 3g catalyst and 5-7 ml H_2SO_4 was added and put the digestion tubes in digestion assembly at 450°C for one hour. For distillation glass tube was placed in distillator and 5ml NaOH (30%) was added. Boric acid solution (10ml) was taken in conical flask. After 5-7 min ammonia was produced due to condensation. Conical flask was placed under automatic burette for titration.

Calculation = (TR-BR)× AtomicWt. of N × Normality of H_2SO_4× Dilution factor × 100/Sample wt. (g)

TR = Titration reading, BR = Blank reading

Nitrogen Free Extracts

Nitrogen free extracts (NFE) was measured by subtracting the sum of percentages of moisture, CP, EE, CF & Ash from 100. The resultant values were expressed as % Nitrogen free extract.

% NFE = 100 - (% Moisture + % CP + % EE + % CF + % Ash)

Nutrients Digestibility

Nutrients digestibility (ND), digestibility of DM and OM was calculated by the variation between the nutrients consumed and voided in feces by rabbits using the following equation.

$$\text{Digestibility \%} = \frac{\text{A-B}}{\text{A}} \times 100$$

Where

A= Quantity of nutrients ingested by the Animal (g/d) i.e. DM, OM.

B = Quantity of nutrients excreted by the animal in feces (g/d)

Feed Cost

Feed cost was determined by dividing the cost of one bag of feed by 25 kg while cost benefit was determined by calculating and comparing the cost per kg gain of the different treatment groups as prevailing in the local market.

Dry Matter Intake Cost

Dry matter intake cost (DMIC) was the cost of dry matter of feed intake along with transportation and collection charges.

Gain Body Weight Cost

Gain body weight cost (GBWC) was determined by multiplying the rabbit meat weight (kg) with local market rate (Rs. 220 per kg). The net profit was calculated by subtracting DMIC from GBWC.

Statistical Analysis

Statistical analysis was performed with a commercially available software program SPSS version 18, SPSS Inc., Chicago, IL, USA. The data were analyzed using one way analysis of a variance (ANOVA) between treatments. Least Significant Difference (LSD) test was applied when significant differences were found. The value of $P<0.05$ was considered a significant.

Results

Dry Matter Intake, Gain in Body Weight and Feed Efficiency

The effect of different levels of banana peels substitution in ration on daily DMI of male growing rabbits was increased ($P<0.05$) with increasing banana peel proportion in the ration. Maximum DMI was recorded in group T1 followed by T2 & T3, whereas lowest daily DMI was recorded in group T0. The mean daily DMI in groups T0, T1, T2 & T3 were 44.84, 48.31, 47.66 & 45.90g respectively (Table 1). Daily GBW of male growing rabbits was not significantly ($P>0.05$) effected. Highest GBW was observed in group T2 but was not significantly affected from the other groups. Mean daily GBW in groups T0, T1, T2 & T3 were 10.59, 10.65, 10.79 & 10.50g respectively. The overall feed efficiency **(**FE) in experimental animals utilizing banana peels was not significantly ($P>0.05$) effected. The Mean FE recorded in groups T0, T1, T2 & T3 were 4.23, 4.54, 4.42 & 4.37 respectively (Table 1).

Table 1 Effect of different level of banana peels versus maize grains on DMI, GBW and FE of male growing rabbits

	Mean		
Rations/Groups	DMI(g)	GBW(g)	FE
T0	44.836[b]	10.593[a]	4.23[a]
T1	48.306[a]	10.650[a]	4.54[a]
T2	47.656[a]	10.790[a]	4.420[a]
T3	45.903[b]	10.503[a]	4.372[a]

*Means in each column with different superscript are significantly different at $P<0.05$ DMI, dry matter intake; GBW, gain in body weight; FE, feed efficiency

Dry Matter, Organic Matter and Crude Protein Digestibility

Effect of different levels of banana peels replacing maize grains on dry matter digestibility (DMD) was significantly (P<0.05) different and highest DMD was recorded for group T2 compared to group T0. Mean daily DMD in groups T0, T1, T2 & T3 were 44.21, 53.86, 65.30 & 45.52% respectively (Table 2). Highest organic matter digestibility (OMD) was recorded for group T2 when compared to group T0. Mean OMD in groups T0, T1, T2 & T3 were 38.09, 48.60, 59.15 & 43.48% respectively. Effect of various levels of banana peels crude protein digestibility in experimental animals was significantly recorded for group T2 whereas the lowest Crude protein digestibility (CPD) was recorded for group T3. Mean CPD in groups T0, T1, T2 & T3 were 41.03, 35.06, 45.24 & 33.40% respectively (Table 2).

Table 2 Effect of different level of banana peels vs. maize grains on DMD%, OMD% and CPD% of male growing Rabbits

Rations/Groups	Mean		
	DMD	OMD	CPD
T0	44.212^{c}	38.091^{d}	41.025^{b}
T1	53.861^{b}	48.603^{c}	35.063^{c}
T2	65.301^{a}	59.151^{a}	45.243^{a}
T3	45.523^{cb}	43.480^{b}	33.403^{c}

*Means in each column with different superscript are significantly different at P<0.05 DMD, dry matter digestibility; OMD, organic matter digestibility; CPD; crude protein

Ether Extract, Crude Fiber and Nitrogen Free Extract Digestibility

The effect of addition of various levels of banana peels in the diet replacing maize grains on ether extract digestibility (EED) was highly significant and highest EED was recorded for group T2 when compared to group T0. Mean EED recorded was 29.49, 31.93, 42.91 & 38.08%, for groups T0, T1, T2 & T3 respectively (Table 3). Highest crude fiber digestibility (CFD) was recorded for group T2 followed by T1 & T3 respectively, whereas the lowest CFD was recorded for group T0. Mean CFD in groups T0, T1, T2 & T3 were 30.22, 38.88, 49.27 & 37.77% respectively (Table 3). The highest nitrogen free extract digestibility (NFED) was recorded for group T1 when compared to group T0. Mean NFED were 48.09, 54.45, 48.16 & 49.82% in groups T0, T1, T2 & T3 respectively (Table 3).

Table 3 Effect of different level of banana peels versus maize grains on % EED, CFD and NFED of male growing rabbits.

Rations/Groups	Mean		
	EED	CFD	NFED
T0	29.492[c]	30.220[c]	48.098[b]
T1	31.927[c]	38.876[b]	54.453[a]
T2	42.907[a]	49.273[a]	48.163[b]
T3	38.077[b]	37.773[b]	49.823[ab]

***Means in each column with different superscript are significantly different at P<0.05 EED; ether extract digestibility; CFD, crude fiber digestibility; NFED, nitrogen free extract digestibility**

Dry matter intake cost, Gain in body weight cost and Income over feed cost/profit

Significantly decrease in dry matter intake cost (DMIC) was resulted from increasing the level of banana peels in feed. Highest DMIC was recorded for group T0 followed by T1, T2 & T3 respectively. Mean DMIC in groups T0, T1, T2 & T3 were Rs. 84.99, 75.34, 66.32 & 56.72 respectively (Table 4). Highest gain in body weight cost (GBWC) was recorded in group T2 and lowest GBWC was recorded in group T3. Mean GBWC was Rs. 118.67, 119.27, 120.81 & 117.60 in groups T0, T1, T2 & T3 respectively (Table 4). Mean profit in groups T0, T1, T2 & T3 was Rs. 33.70, 43.93, 54.49 & 60.84 respectively. However highest profit was recorded in group T3 and lowest profit was recorded in group T0 (Table 4).

Table 4 Effect of different level of banana peels vs. maize grains on DMIC, GBWC and Profit of male growing rabbits

Rations/Groups	Mean		
	DMIC (Rs.)	GBWC (Rs.)	Profit (Rs.)
T0	84.994[a]	118.667	33.669[d]
T1	75.337[b]	119.267	43.930[c]
T2	66.320[c]	120.813	54.493[b]
T3	56.762[d]	117.603	60.842[a]

*Means with different superscript are significantly different at P<0.05 DMIC, dry matter intake cost; GBWC, gain in body weight cost; Rs, Rupees

Discussion

The present study showed that DMI was significantly increased with increasing banana peel proportion in the rabbits ration. Previous studies also recorded a significant difference in feed intake, because of their taste, fiber and sugars constituent in ripe banana peels which improved their palatability (Omole et al., 2008; Fanimo and Odu 1996; Ketiku, 1973). One study reported that rabbits positioned on 50% based plantain peel diet significantly influenced (P<0.05) in the average feed consumption (Ogunsipe and Agbede 2010; Akinmutimi et al., 2006). Babajide (1998) reported that feed intake reduced slightly as the level of banana peels increased. In the present study the comparative effect of banana peels on feed efficiency was non-significant (P>0.05). Ogunsipe and Agbede (2010) reported that the efficiency of feed utilization was different (P<0.05) among the groups. One previous study also observed that FCR was not different (P>0.05) among the groups

T1, T2, T3 & T4 (Ajasin et al., 2006). According to the observations of Fanimo and Odu (1996), FE was improved at 33% replacement while decreased at 100% replacement. Another study reported that FE feed efficiency was different ($P<0.05$) among the groups that is T1 (0%), T2 (25%), T3 (50%), T4 (75%) & T5 (100%) (Akinmutimi et al., 2006). But our observation showed that the effect of banana peels on GBW of male growing rabbits was not significant changed.

Fanimo and Odu (1996) observed no difference ($P>0.05$) among the rations substituted by 0, 33 & 66%, & 100% replacement for rabbits ration. One study reported that GBW was improved ($P<0.05$) in group T3 by 50% Akinmutimi et al., (2006). Ogunsipe and Agbede (2010) conducted a trail and observed that mean GBW was significant different ($P<0.05$) from that of control ration group. Schiere (1999) reported that GBW was not significant change among all the experimental groups. One study recorded highest GBW in T1 group, whereas the lowest GBW was observed at 100% plantain peel (T5) replacement (Ajasin et al., (2006). Agunbiade et al., (2002) reported that the effect of banana peels substituting maize grains on GBW was not significantly different. Fanimo and Odu (1996) reported that DMD is highly significant at 0% replacement in ration. Ajasin et al., (2006) reported that significantly ($P<0.05$) DMD was observed at 100% replacement. The results of our study showed that addition of different levels of banana peels on DMD of experimental animals was significantly different ($P<0.05$).

In our study the result showed that the effect of substituting with banana peels on CFD was significantly different and highest CFD was recorded in ration T2 followed by T1 and T3, however lowest CFD was recorded in ration T0. It is clear that the effect of various levels of banana peels on CPD was highly improved and highest CPD was recorded in ration T2 (50%) whereas the lowest CPD was recorded in ration T3 (100%). According to the study of Sauer et al., (1980), the presence of crude fiber adversely affected crude protein digestibility. Another study reported that crude protein digestibility in group T0 (0%) was high ($P<0.05$) (Fanimo and Odu 1996)

Ekwe et al., (2011) reported that CFD was higher ($P<0.05$) in ration having 0% and 20% banana peel addition. DMI cost was decreased significantly with increasing the percentage of banana peels in ration. Ajasin et al., (2006) reported that increase in plantain peel in rabbit diet decreases total cost of feed. The lowest cost/weight gain was observed in T4 (75% plantain peel replacement. Akinmutimi et al., (2006) reported that replacement of 100% maize grains results in significantly low cost per kg ration. The effect of different levels of banana peels in rabbit rations on GBWC was not changed significantly. Mean GBWC was (Pakistani currency) Rs. 118.67, 119.27, 120.81 & 117.60 in groups T0, T1, T2 & T3 respectively. Highest GBWC was recorded in group T2, whereas the lowest GBWC was recorded in group T3. Akinmutimi et al., (2006) reported that cost per kg body weight gain was significant different ($P<0.05$). A significant ($P<0.05$) effect of addition of different levels of banana peels in experimental ration was recorded. Mean net return in groups T0, T1, T2 & T3 was 33.70, 43.93, 54.49 & 60.84 rupees respectively. This showed that highest profit was obtained in ration T3 while the lowest profit was recorded in ration T0. The findings are in agreement with the results of Fanimo and Odu (1996) who reported that profit increases significantly ($P<0.05$) with increase in banana peel substitution. Regarding profit recommended diet T3 having 50% banana peel and diet T4 containing 75% banana peels found more profit (Akinmutimi et al., 2006; Ajasin et al., 2006)

Conclusions

It can be concluded from the findings of our study that substituting maize grains with banana peels in male growing rabbits diet showed improvement in DMI, DMD, OMD, and nutrient digestibility except CPD, whereas change in BWG remained similar. Moreover feeding banana peel showed more net return per kg BWG compared to the rabbits fed on maize grains.

Conflict of interest

The authors declare that they have no conflict of interest.

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