Page 183 to 191

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Effects of Substituting Maize Grains with 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.

Keywords: *Rabbits; Banana; Maize; Growth; Feed; Additive*

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Introduction

Nutrition plays a significant role in human health and disease prevention. The animal protein availability for human consumption has not been able to overcome the gap present between the demand and supply. This small amount of animal protein availability for human consumption in developing countries is due to high prices of meat which has gone beyond the reach of the public and thus affecting the health and fitness of the human being (Bamgbose., *et al*. 2002).

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It is considered necessary to resolve the crisis of low animal protein availability by increasing the growth rate of small livestock production with low cost. In developing countries livestock production plays a vital role in food, social and financial aspects (Oso., *et al*. 2010). Household rabbits (*Oryctolaguscuniculus*) are herbivorous fed on grains and green roughages and generally maintained in cages and pens. Rabbits can utilize low amount of cereal grains and more roughage in diets.

They also have the potential of meat production due to small body size, short gestation period, eminent reproduction, fast growth rate and low feed requirements (Cheeke, 1986). Therefore, rabbit production is one of the targeted sectors to overcome the problem of low protein consumption in developing countries.

Meat of rabbit is rich in protein and characterized by high levels of essential amino-acids. In rabbit meat, uric acid is absent but small amount of purines are present (Hernandez and Gondret, 2006). Rabbit meat have lower cholesterol level as compare to red meat because rabbit meat have less fat content depending on the carcass segment (0.6 to 14.4%) with an average value of 6.8% (Hernandez and Gondret, 2006). Cholesterol present in rabbit meat is about 59 mg/100g of muscle, less than those present in meat from other species i.e., 61 mg in pork, 70 mg in beef and 81 mg/100g in chicken (Hernandez, 2008).

In another study Marinov., *et al.* (2009) reported that 100 gm rabbit meat has 25 mg cholesterol, which is very close to wild animal's meat. The level of energy in rabbit meat is low (160-170 kcal/100g) compared to that of beef (195-380 kcal/100g) and pork (260-330 kcal/100g). However, the high content of essential amino acids in rabbit meat emphasizes its nutritional properties.Rabbit feed mostly comprises of dietary fibers because they are herbivorous and well adopted to plant materials. Nutritionists are exploring alternative and cheap sources of feed to replace or supplement cereals grains in rabbit feed to make the rabbit meat production more profitable. Bananas (*Musa sapientum* L.) are now grown in one hundred and thirty countries which are more than any other fruit. Banana is an appetizing fruit containing 25% carbohydrates. Being an essential staple foodstuff, it provides a precious supply of profits for domestic trade.

Banana contribution is about 16% of the world's total fruit production i.e. the second largest fruit produced after citrus (Mohapatra., *et al.* 2010). Banana peel represents 40% of the total weight of the banana fruit (Alkarkhi., *et al*. 2010). About 18-20% of banana peels were wasted every year which was disposed or thrown causing harms ecologically. Banana peels are wealthy resources of starch 3%, crude protein 6-9%, crude fat 3.8-11% and total dietary fiber 43.2-49.7% (Emaga., *et al*. 2008). Substitution of 15% plantain peel in place of maize had no considerable variation in the 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).Keeping in view the above mentioned beneficial aspects of utilizing banana peels for replacing cereal grains in the diet of rabbits, the present study was designed to evaluate comparative effects of maize grains and banana peels on growth performance of male growing rabbits, to investigate *in vivo* digestibility of nutrients and to calculate comparative economics of experimental rations.

Materials and Methods

Experimental design

The experiment was carried out in Peshawar-Pakistan. A sum of twelve growing rabbits of 5-6 weeks of age, with average weight of 500g was divided into 4 groups. 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.

Experimental diet

Four experimental diets T0, T1, T2, and T3 were formulated with fresh banana peel replacing maize grains at 0, 25, 50 and 100% respectively (table 1). Eachgroup comprising of 3 rabbits was randomly allotted with a single experimental diet. The rabbits were allowed water *ad libitum*.

Ingredients	%DM	%CP	%CF	%EE	%NFE	%Ash
Banana Peel	19.52	8.75	7.19	11.6	78.25	2.0
Maize Grains	90.32	9.21	3.22	3.3	73.52	1.8

Table 1: *Chemical composition of feed ingredients.*

DM, dry matter; CP, crude protein; CF, crude fiber; EE, ether extract; NFE, nitrogen free extract

Digestibility trial

A week after the start of the experiment, fecal samples were collected daily from each group and dried at 65°C to a constant weight to determine the dry matter. After 7-8th week another sample was collected from each of the four treatments for in vivo digestibility. The samples of each of the replicates were allowed to cool in glass desiccator to prevent further absorption of moisture from the atmosphere. Ten days samples were collected, ground and then analyzed for crude protein, crude fiber and ether extract for each experimental unit 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.

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

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 6hours to estimate its ash content. After incineration the samples were cooled again in desiccator and re-weighed. Ash was calculated as under:

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

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. Two hundred ml boiling dilute H2SO4 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 tall beaker and 200 ml boiling dilute NaoH was added and then were filtered through glass Buchnerfunnel with an aid of suction air pump. Then it was washed with 10 ml dilute H_2SO_4 and then with hot water until it became acid free. It was changed to a prepared Gooch crucible, and then washed with 10ml ethanol. Then sample was dried in an oven at 135°C for 2 hours and then was 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 1 hour 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 (CP)

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 1hr. For distillation glass tube was placed in distillator and 5 ml NaOH (30%) was added. Boric acid solution (10 ml) 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 (NFE)

It was measured by subtracting the sum of percentages of moisture, CP, EE, CF and Ash from 100. The resultant values were expressed as % Nitrogen free extract.

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.

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

Where

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

B = Quantity of nutrients excreted by the animal in feaces (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 (DMIC)

It was the cost of dry matter of feed intake along with transportation and collection charges.

Gain body weight cost (GBWC)

It was determined by multiplying the rabbit meat weight (Kg) with local market rate (Rs.220/Kg). The net profit was calculated by subtracting DMIC from GBWC.

Statistical analysis

Data were analyzed by ANOVA using the GLM procedure of the SAS statistical package (2011) according to the following statistical model describes the complete randomized design;

$Yij = \mu + \alpha i + Eij$.....I

I = 1, 2, 3, 4. j= 1, 2, 3, 4.

Results

Dry matter intake (DMI), Gain in body weight (GBW) and Feed efficiency (FE)

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 and T3, whereas lowest daily DMI was recorded in group T0. The mean daily DMI in groups T0, T1, T2 and T3 was 44.84, 48.31, 47.66 and 45.90g respectively (Table 2). Daily GBW of male growing rabbits was not significantly ($P > 0.05$) effected as shown in Table 2.

Highest GBW was observed in group T2 but was not significantly affected from the other groups. Mean daily GBW in groups T0, T1, T2 and T3 were 10.59, 10.65, 10.79 and 10.50g respectively. The overall FE in experimental animals utilizing banana peels was not significantly ($P > 0.05$) effected. The Mean FE recordedin groups T0, T1, T2 and T3 were 4.23, 4.54, 4.42 and 4.37 respectively (Table 2).

Rations/Groups	Mean		
	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]

Table 2: *Effect of different level of banana peels vs. maize grains on DMI, GBW, and FE of male growing rabbits.*

*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 digestibility (DMD), Organic matter digestibility (OMD) and Crude protein digestibility (CPD)

Effect of different levels of banana peels replacing maize grains on dry matter digestibility was significantly ($P < 0.05$) different and highest DMD was recorded for group T2 whereas the lowest DMD was recorded for group T0. Mean daily DMD in groups T0, T1, T2 and T3 were 44.21, 53.86, 65.30 and 45.52% respectively (Table 3). Effect of various levels of banana peels rabbits was significantly different at $P < 0.05$ and highest OMD was recorded for group T2 whereas the lowest OMD was recorded for group T0. Mean OMD in groups T0, T1, T2 and T3 was 38.09, 48.60, 59.15 and 43.48% respectively (Table 3). Effect of various levels of banana peels crude protein digestibility in experimental animals was significantlyrecorded for group T2 whereas the lowest CPD was recorded for group T3(Table 3). Mean CPD in groups T0, T1, T2 and T3 were 41.03, 35.06, 45.24 and 33.40% respectively.

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	45.523c^{b}	43.480^{b}	33.403^{c}

Table 3: *Effect of different level of banana peels vs. maize grains on % DMD, % OMD and % CPD of male growing Rabbits.*

*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 digestibility (EED)

The effect of addition of various levels of banana peels in the diet replacing maize grains on EED was highly significant and highest EED was recorded for group T2 while the lowest EED was recorded for group T0.Mean EED recorded was 29.49, 31.93, 42.91 and 38.08% in groups T0, T1, T2 and T3 respectively.

Crude fiber digestibility (CFD) and Nitrogen free extract digestibility (NFED)

Effect of different proportions of banana peels substituting maize grains in rabbits ration on crude CFD was significantly (P < 0.05) different (Table 4). Highest CFD was recorded for group T2 followed by T1 and T3 respectively whereas the lowest CFD was recorded for group T0. Mean CFD in groups T0, T1, T2 and T3 were 30.22, 38.88, 49.27 and 37.77% respectively. The effect of different levels of banana peels was significant at P < 0.05 and highest NFED was recorded for group T1 while the lowest NFED was recorded for group T0. Mean NFED were 48.09, 54.45, 48.16 and 49.82% in groups T0, T1, T2 and T3 respectively (Table 4).

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}	49.823a^{b}

Table 4: *Effect of different level of banana peels vs. maize grains on % EED, CFD and NFED of male growing rabbits.*

*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 (DMIC), Gain in body weight cost (GBWC) and Income over feed cost/profit

Significantly decreased DMI Cresulted from increasing the level of banana peels in the diet. Highest DMIC was recorded for group T0 followed by T1, T2 and T3 respectively. Mean DMIC in groups T0, T1, T2 and T3 were Rs. 84.99, 75.34, 66.32 and 56.72 respectively (Table 5). Highest GBWC was recorded in group T2 whereas the lowest GBWC was recorded in group T3. Mean GBWC was Rs. 118.67, 119.27, 120.81 and 117.60 in groups T0, T1, T2 and T3 respectively (Table 5). Mean profit in groups T0, T1, T2 and T3 was Rs. 33.70, 43.93, 54.49 and 60.84 respectively. However highest profit was recorded in group T3 while the lowest profit was recorded in group T0 (Table 5).

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]

Table 5: *Effect of different level of banana peels vs. maize grains on DMIC, GBWC and Profit of male growing rabbits*

*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 rabbits ration. According to Omole., *et al*. (2008) significant differences in feed intake could be recognized due to taste and fiber components present in ration. The results of the present study are in line with the agreement of Ketiku (1973), who reported that the presence of simple sugars in ripe banana peels improves their palatability. Fanimo and Odu (1996) reported that DMI was affected by addition of banana peels. According to the observations of Akinmutimi., *et al*. (2006) significant differenceswere present in feed intake and 50% replacement was recommended for feed intake.

The observations of Ogunsipe and Agbede (2010) reported that rabbits positioned on 50% based plantain peel diet influenced (P < 0.05) the average feed consumption. Babajide (1998) reported that feed intake reduced slightly as the level of banana peelsincreased. In the present study the comparative effect of banana peels on FE was non-significant (P > 0.05). Ogunsipe and Agbede (2010) reported that the efficiency of feed utilization was different (P < 0.05) from the control diet. Ajasin., *et al*. (2006) observed that FCR was not different (P > 0.05) among the groups T1, T2, T3 and T4.

According to the observations of Fanimo and Odu (1996), FE was improved at 33% replacement while decreased at 100% replacement. Akinmutimi., *et al*. (2006) reported that feed efficiency was different (P < 0.05) among the groups T1 (0%), T2 (25%), T3 (50%), T4 (75%) and T5 (100%). Data obtained from the present study showed that the effect of banana peels on GBW of male growing rabbits was not significant changed. Fanimo and Odu (1996) observed that no difference (P > 0.05) was present among the rations substituted by 0, 33 and 66%, while 100% replacement for rabbits ration was slightly significant. Akinmutimi., *et al*. (2006) reported that GBW was improved (P < 0.05) in group T3 (50%).

Ogunsipe and Agbede (2010) conducted a trail and observed that mean GBW was different (P < 0.05) from that of control ration. Schiere (1999) reported that GBW is not significant change among all the experimental groups. Ajasin., *et al*. (2006) investigated that significant differences were observed in weekly weight gain of the rabbits feeding control diet (0%). The highest GBW was recorded in T1 whereas the lowest was observed at 100% plantain peel (T5) replacement. Agunbiade., *et al*. (2002) reported that the effect of banana peels substituting maize grains on GBW was not significantly different.

The results of our study showed that addition of different levels of banana peelson DMDof experimental animals was significantly different (P < 0.05). Fanimo and Odu (1996) reported that DMD is highly significant at 0% replacement in ration.Ajasin., et al. (2006) reported that significantly low (P < 0.05) DMD was observed at 100% replacement. 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. Fanimo and Odu (1996) reported that crude protein digestibility in group T0 (0%) was high (P < 0.05).

This study showed that the effect of substituting with banana peels onCFD was significantly different, and highest CFD was recorded in ration T2 followed by T1 and T3,however lowest CFD was recorded in ration T0. 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 and 117.60 in groups T0, T1, T2 and 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 different ($P < 0.05$).

Highly 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 and T3 was 33.70, 43.93, 54.49 and 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 ofFanimo 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 (Akinmutimi., *et al.* (2006). Ajasin., *et al*. (2006) found more profit in diet T4 containing 75% banana peels.

Conclusions

It can be concluded from the findings of the 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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