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Research Article
Growth, Feed Digestion and Carcass Characteristics of Rabbits Fed With Banana Peel (*Acuminata balbisiana*) Supplementation

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Abstract

Objective: This study was conducted to prove that the economic value of banana peels can be increased by using banana peels as a local rabbit feed ingredient. **Materials and Methods:** This study used a completely randomized block design with 4 treatments and 8 blocks (replications). Each experimental unit used 4 rabbits. The rations (R) consisted of a ration without banana peels (R0), 3% banana peel (R1), 6% banana peel (R2) and 9% banana peel (R3). **Results:** The results showed that energy consumption, total feed consumption, dry matter digestibility and energy digestibility were significantly different ($p<0.05$) between diet groups. The carcass weights of the local rabbits fed R3 and R2 were significantly higher ($p<0.05$) than that of rabbits fed R1 and R0. **Conclusion:** It can be concluded that the use of a banana peels level of 9% results in higher feed consumption, feed digestibility, growth and carcass weight of local rabbits than those observed with the use of 6%, 3% and no banana peels.

Key words: Animal protein, banana peels, carcass meat, digestibility, energy content, protein, rabbit farming, rabbit meat

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

The development of rabbit farming is a strategic breakthrough in the field of animal husbandry to accelerate the achievement of animal protein self-sufficiency. Simonova *et al.*[1] stated that rabbit meat has an advantage in quality over beef, pork and chicken due to its high meat protein content (21.37-21.80 g 100 g^{-1}) and low-fat content (1.37-3.53 g 100 g^{-1}). Nuriyasa *et al.*[2] stated that community demand for meat is increasing rapidly and providing potential opportunities for the development of rabbits. Rabbit farming is very suitable to be developed in rural areas with a small business scale to meet the needs of the animal protein in addition to increase community income. According to Nuriyasa *et al.*[3], rabbits are small livestock and are classified as non ruminant herbivores. Nuriyasa *et al.*[4] stated that rabbit livestock business is simple. It is easy to implement and is expected to meet some of the animal protein needs of the community. Rabbit livestock is one of the livestock commodities that can produce high-quality meat. The structure of the meat is finer than that of other meats and the color and shape resemble chicken meat, with a carcass percentage ranging from 46.23-50.07.

The key to the success of raising rabbits is to be able to provide feed that meets nutrient requirements inexpensively because feed costs can reach 80% of the total production cost. Feed ingredients should have maximum nutritional components at relatively low prices and be abundant. They can also be obtained from agricultural waste products. Banana peels (*Musa* cv) are an agro-industrial waste. They can be potentially used as a rabbit feed ingredient[5]. Feed is an important factor in livestock business and balanced nutrition in the feed is required. Utilize of banana peels in feed may be able to further maximize the use of feed for increasing livestock production. Nuriyasa *et al.*[4] stated that feed has a balanced nutritional content. Feed can be formed into pellets. Livestock is not given the opportunity to pick and choose fed. Nuriyasa *et al.*[6] suggested that farming waste has the potential to be used as rabbit feed.

The objective of this study was to increase the economic value of banana peels and produce low-cost rabbit feed. Research suggests that banana peels have been utilized in the feed of other non ruminants, such as native chickens.

MATERIALS AND METHODS

Animal, treatments and experimental design: The study used a completely randomized block design with 4 treatments and 8 blocks (replications). Each experimental unit used 4 rabbits. The number of rabbits used was 128.

Ration: Ration treatments (R) consisted of a ration without using banana peels (R0), using 3% banana peel (R1), 6% banana peel (R2) and 9% banana peel (R3). The feed was composed of yellow corn, coconut cake, fish meal, tapioca flour, soy flour, rice bran, elephant grass, banana peel and mineral mix. Based on the results of the proximate analysis of feed, the nutrient content of the feed is presented in Table 1.

Variable measurement: Feed consumption was obtained by reducing the amount of feed based on the residual feed (g day^{-1}); energy consumption was determined by multiplying ration consumption by the feed energy content according to the proximate analysis results (kcal day^{-1}); protein consumption was acquired by multiplying ration consumption by the content of feed protein according to the proximate analysis results; dry matter digestibility was calculated based on the total collection method[7] The feces were stored for 7 days, dried in the sun to air dry and then heated at a temperature of 60°C for 24 h. Dry matter digestibility was calculated with the following formula:

$$\text{Dry matter digestibility (DMD)} = \frac{A - B}{A} \times 100\%$$

where, DMD is the digestion of dry matter (%), A is the consumption of dry ingredients in the ration (g) and B is the amount of dry matter excreta (g).

Table 1: Proximate analysis and nutrient content of the feed

	Treatments			
Nutrient	R0	R1	R2	R3
Metabolizable energy (kcal kg^{-1})	2610.01	2616.03	2625.73	2637.78
Crude protein (%)	16.18	16.13	16.10	16.02
Calcium (%)	0.66	0.59	0.63	0.57
Phosphorous (%)	0.47	0.42	0.43	0.39
Fat (%)	6.33	6.48	6.44	7.68
Crude fiber (%)	6.70	6.69	6.06	5.27

R0: Rabbit feed that did not contain banana peels, R1: Rabbit feed that contained 3% banana peels, R2: Rabbit feed that contained 6% banana peel and R3: Rabbit feed that contained 9% banana peel

Digestible energy was calculated based on the total collection method[7]. Energy consumption was obtained by multiplying the ration dry matter by the ration energy content. Energy feces was obtained by multiplying the feces dry weight by the fecal energy content. Digestive energy was calculated using the following formula:

$$DE/GE = \frac{A - B}{A} \times 100$$

where, DE/GE is digestible energy, A is energy consumption (kcal day^{-1}) and B is the energy content in the stool (kcal day^{-1}).

Protein digestibility was calculated based on the total collection method[7]. Protein consumption was obtained by multiplying the dry ingredients of the ration by the protein content of the ration. Fecal protein was obtained by multiplying the dry weight by the fecal protein content. Digestible crude protein was calculated using the following formula:

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

Where, DCP is protein digestibility (%), A is protein consumption (g day^{-1}) and B is the protein content in feces (g day^{-1}).

Weighing of the rabbits was performed every week to obtain weight gain per week. The initial weight weighing was carried out at the beginning of the study to gain initial weight. Weighing was carried out at the end of the study to obtain the final weight. To determine weight gain during the study, the initial weight was subtracted from the final weight. Before being weighed, the rabbits were fasted for 12 h. The feed conversion ratio (FCR) was calculated by comparing the amount of rations consumed with the weight gain during the study.

Carcass data were obtained by slaughtering rabbits at 84 days according to the age of slaughtered rabbits outlined by Owen and Owen[8] Slaughtering of the rabbits was carried out following the same procedure as for chickens by cutting the jugular vein in the neck to bleed[9]. The rabbits were then hung by one of the hind legs by making a cut between the bones and tendons in the back leg elbow joint. The head was released by the atlas joint (*Cervical vertebrae*), the hind legs by the elbow joint (*Metatarsus*) and forelegs by the elbow joint (*Metacarpus*). The tail was released at the base (*Caudal vertebrae*). The skin was released by making an incision at the back of the thigh toward the base of the tail and the thigh that was free and was then pulled toward the neck until it was released. The innards were removed from the abdominal cavity by making a median incision in the abdominal wall. Empty weight was obtained by removing the innards but leaving the lungs with the carcass. The carcass percentage was calculated as the total weight of the fresh carcass and the abdominal and lung fat divided by body weight before being cut by 100[10]. The physical composition of the carcass was obtained by separating the meat, fat and bones. The ratio of meat to bone was obtained by dividing the weight of meat by the bone weight.

Statistical analysis: The data obtained were analyzed by analysis of variance. Differences were considered significant if it was less than 5% ($p<0.05$). Then, one-way analysis was continued with Duncan's multiple range test[11].

RESULTS

The use of banana peels at the levels of 6 (R2) and 9% (R3) led to higher consumption of rations ($p<0.05$) compared to that of rabbits fed a diet with 3% banana peels (R1) and without the use of banana peels (R0), as shown in Table 2. Rabbits fed with R3 feed consumed 183.40 kcal day^{-1} of energy. Rabbits fed with ration R2 consumed 2.16% less energy than those fed R3 feed ($p>0.05$) and groups R1 and R0 consumed 6.42 and 7.00% less energy than that consumed by rabbits fed R3 ($p<0.05$). Protein consumption in rabbits fed rations R0, R1, R2 and R3 did not show significant differences. Rabbits treated with rations using 9% (R3) and 6% (R2) banana peels caused higher levels of dietary consumption than R1 and R0. The results of the phytochemical analysis of banana peels showed that they contain flavonoids. The content of flavonoids in banana peels can function as antioxidants[12]. Bidura *et al.*[13] stated that *Sauropus androgynus* leaves rich in natural antioxidants caused an increase in egg production and a decrease in yolk cholesterol levels in egg laying hens. According to Monagas *et al.*[14], antioxidants that are able to pass into blood vessels throughout the body are selectively permeable and prevent harmful substances from entering the body. This caused rabbits fed rations R3 and R2 to exhibit higher antioxidant levels than those fed R1 and R0. The rations R3 and R2 causes the final body weight and weight gain to be higher than those of the R1 and R0 groups. The higher consumption of rations in groups R3 and R2 caused the consumption of nutrients, especially energy and protein, to be higher. This result is supported by the results reported by Nuriyasa *et al.*[6] who stated that energy and protein consumption are the main components of body tissue

Table 2: The effect of the use of banana peels on consumption, digestion and ration on the growth of local male rabbits

	Treatment[1]				
Variables	R0	R1	R2	R3	SEM[3]
Consumption of rations (g day^{-1})	65.35^{b2}	65.61^{b}	68.34^{a}	69.53^{a}	3.76
Energy consumption (kcal day^{-1})	170.56^{b}	171.63^{b}	179.44^{a}	183.40^{a}	5.16
Protein consumption (g day^{-1})	10.57^{a}	10.58^{a}	11.01^{a}	11.14^{a}	1.17
Initial body weight (g)	405.34^{a}	402.66^{a}	400.12^{a}	400.98^{a}	10.48
Final body weight (g)	1956.08^{b}	1962.11^{b}	2068.44^{a}	2098.12^{a}	15.21
Weight gain (g day^{-1})	18.46^{b}	18.56^{b}	19.86^{a}	20.20^{a}	2.03
Feed conversion	3.54^{a}	3.54^{a}	3.44^{a}	3.44^{a}	0.96
Cut weight (g)	1945.52^{b}	1953.08^{b}	2001.29^{a}	2017.59^{a}	58.11
Carcass weight (g)	936.76^{b}	952.41^{b}	982.63^{a}	996.49^{a}	24.38
Carcass meat weight (g 100 g^{-1} carcass)	61.04^{a}	61.89^{a}	62.21^{a}	62.78^{a}	1.03
Carcass fat weight (g 100 g^{-1} carcass weight)	2.42^{a}	2.85^{a}	3.18^{a}	3.98^{a}	0.48
Carcass bone weight (g 100 g^{-1} carcass weight)	36.54^{a}	35.26^{a}	34.61^{a}	33.24^{a}	1.14
Ratio of meat to bone	1.67^{a}	1.76^{a}	1.80^{a}	1.88^{a}	0.43
Meat protein (%)	20.14^{a}	20.16^{a}	20.22^{a}	20.58^{a}	1.28
Digestion of dry Ingredients (%)	65.28^{b}	65.54^{b}	66.89^{b}	68.01^{a}	2.11
Protein digestion (%)	78.68^{a}	79.03^{a}	79.59^{a}	80.07^{a}	1.07
Digestible energy (%)	73.37^{b}	73.64^{b}	73.88^{b}	75.98^{a}	2.95

R0: Rabbit feed that did not contain banana peels, R1: Rabbit feed that contained 3% banana peels, R2: Rabbit feed that contained 6% banana peel and R3: Rabbit feed that contained 9% banana peel, Means with different superscripts are significantly different (p<0.05), SEM: Standard error of the treatment means

production. Xiangmei[15] stated that energy and protein ration balance is very important for achieving optimal productivity. According to Khalil[12], phenol compounds in banana peels can kill bacterial pathogens (*bactericidal*). Higher energy and protein consumption and the presence of substances that are antibacterial cause increased rabbit growth. The results of the study found that feed conversion ratio ranged from 3.44-3.54. This feed conversion value was still in the normal range, according to the data of De Blass and Wiseman[16], who reported that the range of the feed conversion ratio of rabbit is from 3.0-4.0. The feed conversion ratios in rabbits fed R3 and R4 were slightly lower than in rabbits fed R1 and R0, indicating that the efficiency of the rations used in R3 and R2 was slightly higher than those used in the R1 and R0 groups. Thus, the growth of rabbits fed with rations R3 and R2 was higher than that of rabbits fed R1 and R0. There was no significant difference (p>0.05) in rabbit body weight at the beginning of the study. The final body weight of rabbits fed R3 was 2098.12 g, while the final weight of rabbits fed R2 was 1.41% lower than that of rabbits fed R3 (p>0.05) and the final weight of rabbits fed R1 and R0 were 6.48 and 6.77% lower than those of rabbits fed R3, respectively (p<0.05). These results are not different from the results of Sumadi *et al*.[17], who obtained final weights ranging from 1808-2016 g.

There were no significant differences in the feed conversion variables. The conversion rates for groups R0, R1, R2 and R3 were 3.54, 3.54, 3.44 and 3.44, respectively. The results showed that the average weight of local male rabbit carcasses at 84 days of age ranged from 936.76-996.49 g. This result was higher than that obtained by Prasad *et al*.[7], who found that chinchilla rabbits at 12 weeks of age had a carcass weight of 868.69 g. The difference in results is due to differences in the age of the rabbits and the ration given to the rabbits. The carcass weights of rabbits that received the R3 and R4 diets were higher compared to those of rabbits fed R1 and R0. This is because rabbits fed R3 and R4 had higher cut weights than those fed R1 and R0. McNitt *et al*.[18] stated that carcass weight is closely related to cutting weight. The higher the weight of the rabbit cut, the higher the carcass weight. The results showed that the percentage of local rabbit carcasses was 48.83%. Zerrouki *et al*.[19] stated that the percentage of carcasses is due to differences in strain of the rabit. The use of banana peels at different levels had no significant effect on the percentage of carcasses. Higher carcass weights on R3 and R4 also result in higher non-carcass weights.

There was no significant difference (p>0.05) in the cut weight variable between rabbits fed R3 (2017.59 g) and R2 (2001.29 g). The cutting weights of rabbits that received the R1 and R0 diets (3.20 and 3.57% respectively) were lower, (p<0.05) compared to those of rabbits fed R3. The highest carcass weight occurred in rabbits that received the R3 diet (996.49 g), while that of rabbits fed the R2 diet was lower (1.39%) (p>0.05) and those fed R1 and R0 were lower (4.42% and 5.99% respectively) (p<0.05) than that of rabbits fed R3. There was no significant difference (p>0.05) in the carcass percentage variable between diets. The carcass percentage of rabbits fed R0, R1, R2 and R3 was 48.15, 48.76, 49.02 and 49.39%, respectively. The physical composition of carcasses, which included meat weight (g/100 g carcass), fat weight (g 100 g^{-1} carcass) and bone weight (g 100 g^{-1} carcass) did not show any significant difference (p>0.05) between treatments (Table 2). The group fed R3 produced the highest ratio of meat to bone, which was 1.88. Ratio of meat to bone of the groups fed R2, R1 and R0 (4.26, 6.38 and 11.17%) were lower than that of rabbits fed R3 but the differences were not statistically significant (p>0,05). The study found that the average meat protein from local rabbits was 20.28%. Meat protein of rabbits fed with the R0, R1, R2 and R3 diets was 20.14, 20.16, 20.22 and 20.58%, respectively. The study found that the average weight of carcass meat from local male rabbits aged 84 days was 61.98 g 100 g^{-1} carcass weight. The results of this study were not much different from those of Xiangmei[15], who obtained a carcass meat weight of 69.10 g 100 g^{-1} carcass weight in rabbits at the age of 74 days and 68.50 g 100 g^{-1} at age of 106 days. Rabbits fed rations R0, R1, R2 and R3 produced carcass meat weight per 100 g carcass weight values that were not significantly different. This is because the ration was composed of the same levels of energy and protein. Protein consumption in each group was not significantly different, so the meat produced was also not significantly different. The results showed that the average weight of fat of local male rabbits aged 84 days was 3.11 g 100 g^{-1} carcass weight. The results of this study were still in the normal range because they are not much different from the results of the study of De Blass and Wiseman[16], who reported that the fat of rabbit carcasses at the age of 106 days was 3.60 g 100 g^{-1} carcass weight. Higher energy consumption in rabbits fed R3 and R4 did not affect the carcass fat content. The study found that the average percentage of carcass meat was 61.98%, the bone percentage was 34.91% and the meat-to-bone ratio of the local rabbit carcass was 1.78.

This result is supported by those reported by Sumadi *et al.*[17], who stated that livestock consume rations with the aim of meeting their energy needs and that the excess energy consumed will be stored in the form of fat. The average local male rabbit carcass bone weight was 34.91 g 100 g^{-1} carcass weight. The bone weight did not differ between treatments because bone is an early-developing organ that becomes a priority in growth. McNitt *et al.*[18] reported that at the beginning of growth, minerals consumed by rabbits prioritize forming bones. Zerrouki *et al.*[19] stated that bone growth depends on differences in mineral content in the ration. The ratio of meat to bone indicates the quality of the carcass produced. The use of banana peels in the R0, R1, R2 and R3 feeds showed no significant difference. This was because the meat and bones produced were also not significantly different. The results showed that the average rabbit meat protein was 20.23%. This result was not much different from the recommendation of Simonova *et al.*[1], which reported a meat protein value of 20.8%.

Rabbits fed R3 produced the highest digestibility of dry matter at 68.01%, while that of rabbits fed R2, R1 and R0 was 1.65, 3.63 and 4.01% lower (p<0.05) than that of rabbits fed R3. The digestion of dry matter ration of rabbits fed R3 was the lowest compared to that of rabbits fed R2, R1 and R0 (Table 2). The digestion of dry matter ration is influenced by the crude fiber content of the ration[20]. The crude fiber content of the R3 ration was the lowest (5.27%) compared to that of R2 (6.06%), R1 (6.69%) and R0 (6.70%). The highest dry matter digestibility was observed for R3. The use of banana peels with different levels in the treatment ration had no significant effect on protein digestibility and digestible energy. This condition is also related to feed conversion ratio and was not significantly different (Table 2). Higher protein and energy consumption is accompanied by higher protein and fecal energy contents.

CONCLUSION

The use of banana peels in rabbit feed at a level of 9% resulted in higher consumption of rations, digestibility, growth and carcass weight than observed in rabbits fed diets containing 6%, 3% and no banana peels.

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