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Research Article ***Open Access***

Effect of breed and graded levels of sun-dried pineapple (*Ananas cosmosus*) peel on carcass characteristics of growing rabbit (*Oryctolagus cuniculus*) bucks

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SUMMARY

The study was conducted to determine the effect of breed and graded levels of sun-dried pineapple peel (PP) on the carcass characteristics of growing rabbit bucks. Thirty-two growing rabbits (New Zealand White, Chinchilla and Dutch) aged between 6 and 7 weeks, with an initial average weight of 762,25±52,66 g; were randomly assigned to four dietary treatments (0%, 5%, 10% and 15% PP) in a completely randomized 3 x 4 design involving three breeds and four dietary treatments, with eight rabbits of each breed in each treatment. The experimental diets and clean drinking water were supplied *ad libitum* during the experiment, which lasted 56 days. At the end of the feeding trial, three rabbits from each of the treatments were used for analysis of carcass characteristics. The carcasses were cut into parts, which were weighed. These were the head, loin, thoracic cage, skin, forelimb, shank, hind limb, testis, organs (heart, liver, kidney, caecum, lungs, stomach, and intestine), and abdominal fat. The data were subjected to statistical analysis in SAS software version 9.0. There were no significant (P > 0,05) differences in the weight of any of the organs or retail cuts except for the thoracic cage and shank, with significantly (P < 0,05) higher values in the Chinchilla breed. The results pertaining to the influence of graded levels showed no significant (P > 0,05) difference in any of the parameters except for the caecum, intestine and hind limb, with the highest weights at 10%, 0% and 5% PP, respectively. However, there were no differences and no deleterious effects across all treatments on all major carcass traits of growing

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rabbit bucks. In conclusion, the chinchilla breed is recommended due to the higher thoracic cage and shank weights, and 10% inclusion of pineapple because it resulted in higher caecum weight.

KEY WORDS: breed, graded levels, carcass characteristics, pineapple peel, rabbit bucks

INTRODUCTION

Rabbits feed on vegetables, kitchen waste (such as yam peels, potato peels, potato runners, and offal) and other feeds. In contrast to other monogastric animals, their digestive system is capable of digesting fibre, and they are sometimes known as pseudo-ruminants. Among the various rabbit breeds, Chinchilla has been reported to perform better than the New Zealand White and Dutch breeds (Mallam et al., 2018). Składanowska-Baryza et al. (2020) found that genotype groups of rabbits differed in meat performance, but the differences in meat quality were minor. The increasing popularity of rabbit meat in Nigeria is a response to the exorbitant prices of conventional sources of meat, such as cattle, goats, sheep, pigs and chickens.

Pineapple waste, which occurs as pineapple peels and cores, makes up about 40-50% of the fresh fruits and contains sucrose, fructose, glucose and other nutrients (Krueger et al., 1992). A major constraint to profitable rabbit production for poor farmers is the limited feed availability throughout the year. There is serious competition between humans and animals for available conventional feedstuffs. Although rabbits can survive on all forage diets, optimum performance can only be ensured in a mixed feeding regime including forage and formulated feeds (Arijeniwa et al., 2000). Due to food scarcity and increased competition for available conventional feeds, nutritionists, scientists and agriculturists must investigate the use of cheap and readily available unconventional feedstuffs that could potentially replace more expensive sources of protein (groundnut cake and soybean meal) and energy (maize).

Makinde et al. (2011) found that a mixture of pineapple skin (peel) and sorghum waste can be used as animal feed. Nurhayati (2013) reported that supplementing broiler diets with yoghurt and pineapple waste (pineapple peel) improved broiler performance.

A huge quantity of pineapple peel is wasted, which adds to the problem of environmental pollution. Reports on the use of pineapple peel as a dietary source of energy in rabbit nutrition are scarce. Conversion of this material into a feedstuff suitable for rabbits would not only mitigate the problem of environmental pollution but also provide a new source of animal feed that could be utilized in animal production. In order to satisfy the demand for meat on a global scale, animal species are being genetically improved to enhance the efficiency of meat production (Amiri Roudbar et al., 2017; Masoudzadeh et al., 2020). One of the most important aims of breeders is to increase skeletal muscle growth in animals (Nassiry et al., 2005; Zamani et al., 2015; Arabpour et al., 2021). Enhancement of muscle development and growth is crucial to meeting consumer demands regarding meat quality (Mohammadi et al., 2009; Mohammadabadi et al., 2021).

This study was therefore conducted to determine the effect of breed and graded levels of sun-dried pineapple peel on the carcass characteristics of growing rabbit bucks.

MATERIALS AND METHODS

Experimental site

The experiment was conducted at the Rabbitry Unit of the Teaching and Research Farm, Kaduna State University, Kafanchan Campus, Kaduna State, Nigeria. Kafanchan is located in the southern part of Kaduna State (9° 34' 59.99" N and longitude 8° 16' 60.00" E) (Ovimaps, 2022).

Source of test material and processing

The pineapple peels (PP) were sourced from pineapple sellers within Kafanchan and its environs. After removing debris from the peel, it was sun-dried at an average temperature of about 30°C on a concrete floor with constant turning and then crushed into powder and included in the diet at 0%, 5%, 10% and 15%. The remaining feed ingredients were obtained from Dignity feed mill, Kaduna.

Chemical analysis

The proximate composition of the pineapple peel was determined at the Biochemistry Laboratory, Department of Animal Science, Ahmadu Bello University, Zaria, and the mineral and vitamin content was determined at the Soil Science Department, Ahmadu Bello University, Zaria. Proximate composition was determined according to the methods of AOAC (1990), and crude protein (CP) was estimated as Kjeldahl N x 6,25.

Experimental diets

Ethics approval

According to local regulations such approval is not required provided the department head gives consent.

The diets were formulated as shown in Table 1. Four experimental diets were used: treatment 1 (0% PP), treatment 2 (5% PP), treatment 3 (10% PP), and treatment 4 (15% PP). The protein and energy contents of diets 1, 2, 3 and 4 are 16,00 and 2501,15; 15,53 and 2328,80; 15,08 and 2156,45; and 15,00 and 2084,00 respectively.

Table 1

Gross composition of the experimental diets

Ingredients (%)	Inclusion levels of pineapple peel (%)			
	1 (PP 0%)	2 (PP 5%)	3 (PP 10%)	4 (PP 15%)
Maize	15,00	10,00	5,00	0,00
Pineapple peel	0,00	5,00	10,00	15,00
Maize offal	49,60	49,60	49,60	49,60
Brewers dried grain	8,70	8,70	8,70	8,70
Groundnut cake	6,00	6,00	6,00	6,00
Soybean cake	9,00	9,00	9,00	9,00
Rice husk	9,00	9,00	9,00	9,00
Limestone	1,00	1,00	1,00	1,00
Bone meal	1,00	1,00	1,00	1,00
Common salt	0,25	0,25	0,25	0,25
Vitamin/mineral premix	0,25	0,25	0,25	0,25
Lysine	0,10	0,10	0,10	0,10
Methionine	0,10	0,10	0,10	0,10
Total	100,00	100,00	100,00	100,00
Calculated analysis				
Crude Protein	16,00	15,53	15,08	15,00
Energy (Kcal/kg)	2501,15	2328,80	2156,45	2084,00
Crude fibre	11,20	11,09	11,00	11,00
Calcium	0,72	0,72	0,72	0,72
Available Phosphorus	0,29	0,29	0,28	0,28
Lysine	0,77	0,76	0,75	0,74
Methionine	0,58	0,56	0,54	0,52

Kcal = kilocalories, kg = kilogram

The proximate composition of pineapple peel is presented in Table 2. The values for dry matter, crude protein, crude fibre, fat, ash and nitrogen free extract were 90,92%; 10,04%; 11,61%; 2,09%; 4,04% and 72,22%.

Table 2

Proximate composition of pineapple peel

Nutrients	Composition (%)
Dry matter	90,92
Crude protein	10,04
Crude fibre	11,61
Fat	2,09
Ash	4,04
Nitrogen free extract	72,22

The mineral and vitamin composition of the pineapple peel is shown in Table 3. The values for calcium, magnesium, phosphorus, vitamin A and vitamin C were 2720; 986,75; 3502,53; 2,31; 12,70 respectively.

Table 3

Mineral and vitamin composition of pineapple peel

Parameters	Composition
Calcium (mg/Kg)	2720,00
Magnesium (mg/Kg)	986,75
Phosphorus (mg/Kg)	3502,53
Vitamin A (%)	2,31
Vitamin C (%)	12,70

Experimental animals, management and design

A total of 32 purebred male rabbits (bucks) of the New Zealand White (NZ), Dutch (DH) and Chinchilla (CH) breeds were used for the research. The experiment began when the rabbits were 6-7 weeks old and lasted for 8 weeks. Thus the animals were 14-15 weeks old when they were slaughtered for carcass evaluation. Before the experiment, an injection of Ivermectin (a broad-spectrum anti-parasitic) was administered to the rabbits to treat endo- and ectoparasites. Embazin was also administered during the experiment.

1. Dutch 2. New Zealand White 3. Chinchilla

Fig. 1. Breeds of rabbit bucks used in the study

The animals were weighed before the start of the experiment. Their initial average body weight was 762,24±52,66 g. Each rabbit was housed individually in a well-ventilated pen. Each pen was provided with a feeder and a drinker. Routine management such as regular cleaning of pens, feeders and drinkers was carried out throughout the research period, which lasted for 8 weeks (56 days).

The rabbits were randomly assigned to four dietary treatments in a completely randomized 3 x 4 design involving three breeds and four diets, with eight rabbit bucks of each breed in each dietary treatment.

The model

The following fixed effect model was used:

$$Y_{ijk} = \mu + A_i + Q_j + e_{ijk},$$

where:

Y_{ijk} – observation

μ – population mean

A_i – effect of i^{th} breed (I = 1, 2, 3)

Q_j – effect of j^{th} inclusion level (j = 1, 2, 3, 4)

e_{ijk} – random error or residual error associated with each record (all error terms were assumed to be random, normally distributed and independent, with expectation equal to zero)

Carcass characteristics

At the end of feeding trial, three rabbits each of the NZ, DH and CH breeds from each treatment were randomly selected, tagged and fasted overnight for 12 h to empty the gut before slaughter. However, clean drinking water was provided. The slaughter procedure consisted of stunning, cervical dislocation, and severing the jugular vein with a sharp knife, followed by bleeding, flaying/processing, evisceration and cutting (Nwagu et al., 2009). Each rabbit was slaughtered, skinned and weighed. The live (preslaughter) weights were taken before slaughter, and the carcass weights (dressed weights) were taken (in grams). The rabbits were cut into prime cuts (head, shank, forelimb, hind limb, thoracic cage, and loin), skin/fur, and organs (heart, kidney, liver, caecum, lungs, stomach, intestine, and testis). The abdominal fat and blood were also collected and weighed. The lungs were weighed with the trachea, while the small and large intestines were weighed together. All the carcass parts were weighed using a sensitive scale, and the dressing percentage was calculated using the following formula:

$$Dressing\ percentage = \frac{Carcass\ weight}{Live\ weight} \times 100\%$$

Statistical analysis

The data were subjected to analysis of variance (ANOVA) using the general linear model procedure in statistical analysis software (SAS, 2008). The means were separated using Duncan's multiple range test (Duncan, 1955).

RESULTS

Table 4 presents the effect of breed on the carcass characteristics of growing rabbit bucks. The results showed no significant (P > 0,05) differences across breeds in the carcass traits except for the thoracic cage and shank weights. The 160,75±19,12 g for thoracic cage weight in Chinchilla (CH) was significantly (P < 0,05) higher than in DH and NZ (158,00±2,74 g and 142,25±11,29 g, respectively). The shank weight (33,25±1,38 g) obtained for CH was significantly (P < 0,05) higher than for DH and NZ (26,00±1,47 g and 23,50±0,86 g, respectively). The live weight, carcass weight and dressing percentage across the three breeds ranged from 1237,75±80,35 g to 1284,75±21,40 g; 929,00±61,93 g to 965,25±20,34 g; and 74,29±1,49% to 75,13±0,80%, respectively.

Table 4

Effect of breed on carcass characteristics of growing rabbit bucks

	Breed		
Carcass traits	CH	DH	NZ
Live weight (g)	1284,75±21,40	1275,25±108,79	1237,75±80,35
Carcass weight (g)	965,25±20,34	947,25±83,34	929,00±61,93
Dressing percentage (%)	75,13±0,80	74,29±1,49	75,03±0,55
Heart (g)	4,00±0,41	3,75±0,25	4,00±0,41
Liver (g)	47,25±7,44	42,25±2,17	37,75±3,90
Kidney (g)	9,25±1,03	8,75±0,75	8,00±0,91
Caecum (g)	84,00±7,35	79,25±9,57	82,50±6,85
Lungs (g)	10,50±1,04	8,50±1,17	8,00±0,71
Stomach (g)	85,75±6,73	79,75±6,64	80,50±3,07
Intestine (g)	97,25±9,66	96,75±7,49	85,25±9,97
Abdominal fat (g)	22,25±8,65	16,00±3,49	19,75±4,77
Fore limb (g)	91,00±9,70	90,50±2,22	89,25±7,77
Thoracic cage (g)	160,75±19,12^{a}	158,00±2,74^{a}	142,25±11,29^{b}
Loin (g)	200,75±26,05	199,25±8,09	198,54±13,89
Skin/fur (g)	119,75±3,42	111,54±11,21	112,00±11,99
Head (g)	120,25±4,33	115,75±7,82	118,50±3,93
Shank (g)	33,25±1,38^{a}	26,00±1,47^{b}	23,50±0,86^{b}
Hind limb (g)	159,00±4,97	156,75±13,69	156,50±16,39
Testis (g)	7,25±1,50	6,50±1,19	6,75±0,48
Blood (g)	30,00±10,68	28,75±3,77	26,75±3,57

CH = Chinchilla, DH = Dutch, NZ = New Zealand White, g = gram

Table 5 shows the effect of graded levels of sun-dried pineapple peel on the carcass characteristics of growing rabbit bucks**.** There were no significant (P > 0,05) differences across treatments except for the caecum, intestine and hind limb. The live weight, carcass weight and dressing percentage ranged from 1184,00±104,88 g to 1354,67±10,37 g; 882,33±7677 g to 993,67±16,27 g; and 74,54±0,23 g to 76,15±0,76 g, respectively. There were significant (P < 0,05) differences across the graded levels for the caecum, intestine and hind limb. The caecum and intestine weight were found to be higher at 10% and 0% PP, respectively. The hind limb weight was similar at 0% (168,67±470 g) and 5% (173,33±10,39 g), but these values were significantly (P < 0,05) higher than at 15% (141,67±12,41 g) and 10% inclusion (146,00±17,35 g).

Table 5

Effect of graded levels of sun-dried pineapple peel on the carcass characteristics of growing rabbit bucks

Carcass traits	Graded levels of pineapple peel			
	1 (PP 0%)	2 (PP 5%)	3 (PP 10%)	4 (PP 15%)
Live weight (g)	1354,67±10,37	1278,00±15,69	1247,00±139,37	1184,00±104,88
Carcass weight (g)	993,67±16,27	961,33±23,97	951,33±113,15	882,33±76,77
Dressing percentage (%)	73,38±1,71	75,20±1,02	76,15±0,76	74,54±0,23
Heart (g)	4,00±0,00	4,33±0,33	4,00±0,58	3,33±0,33
Liver (g)	48,00±5,86	42,00±3,21	43,33±8,95	36,33±4,63
Kidney (g)	9,33±0,33	9,33±1,76	8,00±0,58	8,00±1,00
Caecum (g)	76,00±9,00^{ab}	77,67±6,98^{ab}	100,33±2,96^{a}	73,67±4,91^{b}
Lungs (g)	8,67±0,67	10,00±13,11	8,67±1,20	9,00±0,58
Stomach (g)	82,33±3,38	74,67±2,19	84,00±7,94	87,00±9,53
Intestine (g)	106,67±9,20^{a}	79,67±8,29^{b}	93,33±13,87^{ab}	92,67±5,55^{ab}
Abdominal fat (g)	27,33±10,65	16,00±3,79	21,33±5,93	12,67±2,84
Fore limb (g)	98,33±2,40	96,67±7,26	83,00±8,08	83,00±9,50
Thoracic cage (g)	166,33±12,14	1 62,67±3,38	151,00±21,17	134,67±14,90
Loin (g)	213,00±3,06	203,00±10,26	200,00±32,19	182,00±21,78
Skin/fur (g)	126,00±3,06	1 20,33±4,33	106,33±14,31	105,00±14,01
Head (g)	118,00±0,58	121,67±4,97	115,00±3,79	118,00±12,12
Shank (g)	28,00±2,31	30,00±3,21	26,33±4,37	26,00±2,00
Hind limb (g)	168,67±4,70^{a}	173,33±10,39^{a}	146,00±17,35^{b}	141,67±12,41^{b}
Testis (g)	7,67±0,88	6,00±0,58	8,00±1,15	5,67±0,33
Blood (g)	33,33±2,33	24,00±2,00	31,00±7,02	25,67±5,17

DISCUSSION

The crude protein content of 10,04% obtained in the present study is higher than the 9,13% reported by Lamidi et al. (2008) for pineapple crush waste. Adeyemi et al. (2010) reported a value of 5,11% CP, which was lower than the value obtained in the present study. The value obtained in our research was higher than the 4,13% CP reported by Fapohunda et al. (2008). Aboh et al. (2013) attributed the variation in reports of the chemical composition of pineapple peel to inadequate descriptions of the test material

and fertilizer application. The dry matter and nitrogen free extract contents of 90,92% and 2,22%, respectively, were higher than the values reported by Aboh et al. (2013). The crude fibre content of 11,61% in the present study is lower than the value (23,83%) reported by Lamidi et al. (2008). The fat content (2.09%) obtained in our study is lower than the value reported by Lamidi et al. (2008).
The analyses indicate that pineapple peel is a good source of dietary fibre but is low in crude protein. It is also very low in fat and thus could serve as an energy diluent in a low-fat diet (Lamidi et al., 2008).

In research conducted by Ambuselvi and Muthumani (2014), pineapple waste was observed to be acidic, with relatively high content of ascorbic acid (vitamin C). The acidity of pineapple and citrus by-products is typical of ripe fruits and results from the presence of organic acids, mainly malic, citric, ascorbic and tartaric. Ogah and Ukpo (2017) reported 7,42 mg/100 g of ascorbic acid for pineapple, which was higher than the 2,50 to 3,50 mg/100g reported by Ambuselvi and Muthumani (2014). The variation in mineral and vitamin composition could be due to environmental differences, the soil where the pineapple was grown, or handling of the pineapple peel, among other factors.

The lack of significant differences across breeds for the carcass characteristics was in agreement with Kabir et al. (2016), who reported no significant ($P < 0,05$) differences for live weight, dressing percentage, heart, liver, lungs, full gut, empty gut, head, thigh, skin, length of small intestine, or length of large intestine in Chinchilla, New Zealand White and Californian rabbits slaughtered at 63 days. The highest live weight obtained in this study was lower than the live weight (2129±156 g) reported by Ghosh and Mandal (2008). The differences could be due to breed, the source of the animals, age at slaughter, management, and the feed used. Live weight and dressed weight for CH in this study were lower than the live weight (1,93±0,064 kg) and dressed weight (997±69,9 g) reported by Nwagu et al. (2009), but the dressing percentage in our study for CH was higher than the 52,3±0,75% reported by the same authors. The results of the current study were similar to the findings of Kulkarni et al. (1995). The live weight for Dutch and New Zealand White rabbits in our study were lower than those (1,97±0,059 kg and 2,11±0,085 kg) reported by Nwagu et al. (2009) for Dutch and New Zealand White x Californian, respectively. The lack of significant ($P > 0,05$) differences among breeds observed in this study for the loin is in agreement with the findings of Lukefahr et al. (1982), who reported no significant differences among breeds for loin width or giblets percentage.

The lack of significant difference observed across PP inclusion levels for live weight, carcass weight, dressing percentage, and heart, liver, kidney, lungs, stomach, intestine, abdominal fat, forelimb, loin, skin/fur, head, shank, hind limb, testis and blood weight is in agreement with the findings of Lamidi et al. (2008), who reported no significant difference in broiler chickens fed varying levels of pineapple peels. The lack of significant ($P > 0,05$) difference in the dressing percentage indicated that the PP level had no effect on the dressing percentage, as reported by Adeyemi et al. (2010). The dressing percentage in the present study ranged from 73,38% to 76,15%, which was higher than the 68,00-70-34% and 69,49-73,98% reported by Adeyemi et al. (2010) and Lamidi et al. (2008), respectively. Meanwhile, the unusual trends and higher significant differences obtained for the caecum at 10% PP indicates increased numbers of bacteria residing in the caecum of rabbits fed 10% PP. These bacteria ferment, or digest the material that passes into the caecum and use it to produce their own cells, proteins, and vitamins, leading to higher caecum weight. The higher intestine and hind limb weight could be attributed to the moderate level of 10% pineapple peel in the experimental diets. The values recorded for abdominal fat showed no significant (P > 0,05) differences. The results suggest that higher inclusion of dietary pineapple peel did not significantly (P > 0,05) increase abdominal fat, but decreased it. The results for the caecum were similar to those reported by Adeyemi et al. (2010), who found that the inclusion level of pineapple had significant effects on the caecum. There was no evidence to suggest that the inclusion of the test material (pineapple peel) in the diet had any significant negative (P < 0,05) influence on the organ weights, as reported by Adeyemi et al. (2010). The lack of differences in some of the carcass characteristics is in accordance with the report of Sobayo et al. (2008), who found that pineapple peel in the diet of rabbits had no significant effects on the weight of the empty gut, lungs, spleen, kidney and heart. The differences observed in the hind limb weights may not have been due to the treatment effects but to individual differences or human error during cutting, as observed by Yashim et al. (2017).

CONCLUSION

The Chinchilla breed is recommended for its higher thoracic cage and shank weight and higher live weight, carcass weight and dressing percentage than in the Dutch and New Zealand white breeds, and could be used for genetic improvement.

The results of the study revealed that the test ingredient (pineapple peel), which has hitherto constituted an environmental nuisance, could be used as energy and dietary fibre sources, as rabbit bucks could tolerate up to 15% PP in their diets without any deleterious effect on major carcass traits. However, for optimum bacteria activity in the caecum, 10% PP is recommended, as higher caecum weight was obtained at 10% inclusion.

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