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Original Article

Influence of breed and inclusion levels of pineapple peel on body weight and morphometric traits of domestic rabbit bucks

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Abstract
Thirty-two rabbits of three breeds - Chinchilla (*CH),* Dutch *(DH), and* New Zealand White (*NZ),* 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 % pineapple peel)* in a completely randomized design in a 3 × 4 factorial *to examine the influence on body weight and morphometric traits.* The body weight (BW), body length (BL), chest girth (CG), ear length (EL), fore leg (FL), head length (HDL), hind leg (HL), height at wither (HW), and tail length (TL) were measured. The data obtained were subjected to the analysis of variance (ANOVA). The mean body weight showed that CH and NZ breeds had similar weights, which were significantly (P<0.05) higher than that of the DH breed. There were no significant (P>0.05) differences among the zoometric traits measured except for body length, head length, and tail length. The inclusion levels of pineapple peel had no significant (P>0.05) effect across all the dietary treatments for all the traits except for tail length and ear length with higher dimensions at 15 and 5%, respectively. There were significant (p<0.05) differences in interaction between breed and inclusion levels on body weight and all the morphometric traits except for CG, EL, FL, and HL. Therefore, CH breed is recommended for body weight and up to 15 % PP can be included in the diet of rabbit bucks without any effect on their BW, BL, CG, FL, HDL and HW.

INTRODUCTION

Rabbits (*Oryctolagus cuniculus*) are classified as pseudo-ruminants due to their ability to eat forages and digest fibre efficiently (Ibrahim, 2019); and utilize up to 30% crude fibers (Hassan *et al.,* 2012; Yakubu *et al.,* 2013). The prolific nature of rabbits coupled with their short gestation period and generation interval make them the animal of choice for multiplication and a short way of increasing animal protein supply (Uchewa *et al.,* 2014).

There are numerous breeds of rabbits all over the world varying in types of coat colours and sizes (Adamu *et al.,* 2021). Breeds such as New Zealand, Dutch, and Chinchilla remain the most commonly

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farmed breeds which have particular characteristics that distinguish them from one another (Rabbitfarm, 2020).

Growth in animals is a function of time, nutrition, breed, husbandry system, and health management practices among other, variables, and animals of different ages have different live weights which provide a reliable and informative measure of selection (Thiruvenkander, 2005). Body weight of live animals is the most reliable measure of growth performance (Onasanya *et al.,* 2017).

Pineapple (*Ananas comosus*) is an important plant in the family Bromedioideae (Bartholomew *et al.,* 2003) and it is one of the most important tropical fruits in the world (Esiobu *et al.,* 2014). The total fruit is made up of 75 to 85% juice and 15 to 25% fruit pulp or meal and there is a large quantity of by-products from the pineapple industry that can be used in pseudo-ruminant feed (Elias *et al.,* 2017). The unexpected increase in the cost of conventional feed ingredients (such as maize) used in compounding livestock feeds has necessitated intensive research into the agricultural and agro-industrial by-products like pineapple peel, which are regarded as non-conventional feed sources (Hamzat and Babatunde, 2001).

Linear body measurements of animals have been used to describe body conformation, evaluate breed performance, predict live weight gain and examine relationships among morphometric traits, and reproductive performance to study the interactions between heredity and the environment in several animals, including rabbits (Adewumi *et al.,* 2006; Onasanya *et al.,* 2017).

Therefore, due to the dearth of information on effect of pineapple peel on body weight and morphometric traits of rabbit bucks as well as lack of information on the effect of interaction between rabbit breeds and pineapple peel, this research was conducted to examine the influence of rabbit breeds, inclusion levels of pineapple peel and interaction between breed and inclusion levels on body weight and morphometric traits of domestic rabbit bucks.

MATERIALS AND METHODS

Experimental site

The experiment was conducted at the Rabbit 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 on latitudes 9° 34' 59.99"N and longitude 8° 16' 60.00" E (Ovimaps, 2022).

Source of test material and processing

The pineapple peel (PP) was sourced within Kafanchan and its environs from pineapple sellers. The debris contained in the peel was removed and the peel sun-dried at an average temperature of about 30°C on a concrete floor with constant turning and was crushed into powder form and incorporated at 0, 5 , 10 , and 15 %. Other feed ingredients were obtained from the Dignity Feed Mill, in Kaduna.

Chemical analysis

The proximate composition of the pineapple peel was determined at the Biochemistry Laboratory, Department of Animal Science, Ahmadu Bello University, Zaria, Nigeria. Proximate composition was determined according to the methods of AOAC (1990) and crude protein (CP) was estimated as Kjeldahl N x 6.25.

Ethics approval
According to local regulations, such approval is not required provided the Head of the Department and Research Committee give consent.

Experimental diets
The diet was formulated as presented in Table 1. The experimental diets consisted of the following: Treatment 1 (0 % PP), Treatment 2 (5 % PP), Treatment 3 (10 % PP), Treatment 4 (15 % PP).

Experimental animals, management, and design
A total of 32 rabbit bucks of purebred New Zealand White (NZ), Dutch (DH), and Chinchilla (CH) breeds between the ages of 6- and 7-week old were used for the research, which lasted for 8 weeks. Before the commencement of the experiment, Ivermectin injection (broad-spectrum anti-parasitic drug was administered to the rabbits to treat against endo- and ecto-parasites, and embazin was also administered during the experiment.

The animals' body weights were taken before the commencement of the experiment with an initial average body weight of 762.24 ± 52.66 g. Each rabbit was housed individually per pen and each pen was provided with a feeder and a drinker. Routine management operations such as regular cleaning of pens, feeders, and drinkers were carried out throughout the 56-day research period. The rabbits were randomly assigned to four dietary treatments in a completely randomized design in a 3 x 4 arrangement.

Measurement of body weight and morphometric traits
A sensitive scale (Samurai weighing scale) was used in weighing the animals while a tape rule (tailor's tape) was used in recording body linear measurements on weekly basis. Both body weight and body linear measurements were recorded weekly early in the morning before feeding. The body weight (BW) and the following morphometric traits were measured; body length (BL), chest girth (CG), ear length (EL), fore leg (FL), head length (HDL), hind leg (HL), height at wither (HW), tail length (TL).
The morphometric traits were taken by the standard zoometrical procedures (Teguia *et al.,* 2008) and methods described by Obasi *et al*. (2019) as given below:
Body length (BL): Distance from the points of shoulder to points of hip or first thoracic vertebrae to base of the tail or hip bone (cm).
Chest girth (CG): This refers to the body circumference and was measured just behind the forelegs using a measuring tape (cm).
Fore leg (FL): This is the distance from the shoulder region where the foreleg starts from to the tip or feet of the foreleg (cm)
Ear length (EL): Measured from the ear base to the zygomatic arch of the ear (cm)
Head length (HDL): Head length is the distance from the Glabella landmark (smooth part of the forehead) between the brow ridges to the Opisthocranion (posteriormost point). Also, head length is the distance from the most prominent part of the forehead to the widest part of the back of the head (cm)
Hind leg (HL): Hind leg (hind limb) is a posterior limb of an animal. This is the distance from the base of the hind leg to the tip or feet of the hind leg (cm)
Height at withers (HW): Vertical distance from the ground to the point of withers measured vertically from the ridge between

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 shoulder bones to the forefeet. This was taken using a graduated measuring ruler in centimeters

Tail length (TL): measurement was taken from the base of the tail to the end of the tail.

The model

The fixed effect model employed was:

$Y_{ijk} = \mu + A_i + B_j + (A \times B)_{ij} + e_{ijk}$

Where;

Y_{ijk} =The observation (trait of interest)

μ = Population mean

A_i = Effect of i^{th} breed (i^{th} = CH, DH, NZ)

B_j = Effect of j^{th} inclusion levels (j^{th} = 0, 5, 10, 15)

$(A \times B)_{ij}$ = *Effect of i^{th} breed and j^{th} inclusion interaction*

e_{ijk} =Random error or residual error associated with each record (All error terms were assumed to be random, normally

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

Table 3: Mineral and vitamin compositions of pineapple peel

Parameters	Composition
Calcium (mg/Kg)	2720
Magnesium (mg/Kg)	986.75
Phosphorus (mg/Kg)	3502.53
Vitamin A (%)	2.31
Vitamin C (%)	12.70

distributed and independent with expectation equal to zero).

Statistical Analysis

The data obtained were subjected to the analysis of variance (ANOVA) procedure as contained in the statistical package of Statistix (2009) version 8.0. Means with significant difference were compared using the Duncan Multiple Range Test (Duncan, 1955).

RESULTS AND DISCUSSION

Table 4 shows the effect of breed on the average body weight and zoometric (morphometric) traits of rabbit bucks fed graded levels of pineapple peel. The results obtained for mean body weight showed that Chinchilla and New Zealand White had similar weights, which were significantly (P<0.05) higher than that of the Dutch breed. There were no significant (P>0.05) differences among the zoometric traits measured except for body length, head length, and tail length, where New Zealand White had the highest dimensions, followed by Chinchilla, and Dutch the least.

The current study is in agreement with the report of Sam *et al.* (2020), who observed significant and higher values for tail length in New Zealand White (9.72±0.24cm) and Chinchilla (9.98±0.13cm) amongst other breeds of rabbit raised in the tropics. The no significant difference between CH and NZ for live weight in this current study agreed with the report of Kabir *et al.* (2016), that no significant (P>0.05) difference was observed between the mean live weight of Chinchilla (1696±47 g), New Zealand White (1674±40 g) and California White (1638±41 g) pure breeds. The results for BL in the current study disagreed with the report of Adamu *et al.* (2021), that there was no significant (P>0.05) difference between the body length of Dutch (31.41 cm) and New Zealand White (30.58 cm) breeds of rabbit. The value for ear length (10.45±0.10cm) in Chinchilla obtained in this study was higher than 9.79±0.22cm reported by Onasanya *et al.* (2017), which disagreed with the current findings. The differences obtained could be due to variations in environmental factors and the age differences of the rabbits.

The average body weight and morphometric (zoometric) traits of rabbit

Table 4: Effect of breed on the average body weight and morphometric (zoometric) traits of rabbit bucks

	Breed		
Trait	**CH**	**DH**	**NZ**
BW(g)	1158.80±21.41^{a}	1048.30±23.39^{b}	1130.10±20.41^{a}
BL (cm)	30.54±0.27^{ab}	29.76±0.29^{b}	30.67±0.26^{a}
CG(cm)	19.41±0.22	19.91±0.21	19.58±0.19
EL(cm)	10.45±0.10	10.26±0.09	10.62±0.09
FL(cm)	18.04±0.25	18.19±0.23	17.99±0.22
HDL(cm)	12.08±0.09^{ab}	11.83±0.11^{b}	12.23±0.09^{a}
HL(cm)	25.45±0.26	25.92±0.25	25.84±0.23
HW(cm)	16.83±0.18	17.03±0.17	16.98±0.16
TL(cm)	9.75±0.14^{b}	10.06±0.13^{ab}	10.12±0.12^{a}

ab- Means with different superscripts within the same row are significantly different (P<0.05), CH-Chinchilla, DH-Dutch, NZ-New Zealand White, BW-body weight, BL-body length, CG-chest girth, EL-ear length, FL-fore leg, HDL=head length, HL-hind leg, HW-height at wither, TL-tail length.

Table 5: Average body weight and morphometric (zoometric) traits of rabbit bucks fed graded levels of pineapple peel

Trait	Inclusion levels			
	1 (PP 0%)	2 (PP 5%)	3 (PP 10%)	4 (PP 15%)
BW(g)	1140.40±25.59	1097.90±26.81	1101.90±23.94	1109.50±23.94
BL (cm)	30.45±0.32	30.07±0.33	30.25±0.29	30.52±0.29
CG(cm)	19.84±0.25	19.62±0.26	19.42±0.23	19.66±0.23
EL(cm)	10.22±0.11^{c}	10.53±0.11^{ab}	10.29±0.10^{bc}	10.74±0.10^{a}
FL(cm)	18.00±0.27	17.99±0.28	18.34±0.26	17.96±0.26
HDL(cm)	11.97±0.12	12.15±0.12	11.89±0.11	12.15±0.11
HL(cm)	26.01±0.29	25.79±0.31	25.58±0.28	25.57±0.28
HW(cm)	16.69±0.20	16.72±0.21	17.24±0.19	17.13±0.19
TL(cm)	9.84±0.15^{b}	10.32±0.16^{a}	10.10±0.14^{ab}	9.80±0.14^{b}

^{abc}- Means with different superscripts within the same row are significantly different (P<0.05), BW-body weight, BL-body length, CG-chest girth, EL-ear length, FL-fore leg, HDL=head length, HL-hind leg, HW-height at wither, TL-tail length.

bucks fed graded levels of pineapple peel are presented in Table 5. The results showed that the average body weight of rabbit bucks was not affected (P>0.05) by inclusion levels of pineapple peel. The results also indicated that there was no significant (P>0.05) difference in all the morphometric traits measured except for ear length and tail length, where 15 and 5% inclusion levels were found to be significantly (P<0.05) higher for ear length and tail length traits, respectively. The study disagreed with the findings of Adeyemi *et al.* (2011), who observed significant (P<0.05) differences in the average body weights of rabbits across all inclusion levels (0 , 12.5 , and 25 %) of pineapple peel and the authors reported that 0 and 12.5 % had a similar body weight. The differences between this current study with that of Adeyemi *et al.* (2011) could be due to inclusion levels, differences in the age of the rabbits, and other environmental factors. The no significant (P>0.05) difference obtained in this study for body weight was not in agreement with the report of Aboh *et al.* (2013) as the authors reported significant (P<0.05) differences in rabbits fed 0 , 20, 30 and 40 % with 20 % inclusion level of PP having higher final weight but similar with 0 and 30 % PP inclusion levels. Therefore, the no significant difference observed for body weight means that any of the inclusion levels of pineapple peel can be used to substitute maize in rabbit feed without any detrimental effect on body weight of rabbit bucks in the study area. Meanwhile, the higher EL at 15 % PP inclusion level and TL at 5 % PP inclusion level could be that the values for calcium, magnesium, and phosphorus recorded from the sun-dried PP in the present study could indicate they are useful mineral sources for the rabbit.This current study is in agreement with the report of Ibrahim (2019), who recorded non-significant (P>0.05) difference in mean average body weight of rabbits fed different forages as supplement.

Table 6 shows the interaction between breed and inclusion levels of PP on body weight and morphometric traits of rabbit bucks. There were significant (P<0.05) differences between breed and inclusion levels of PP on body weight in all the morphometric traits except for CG, El, FL, and HL. The highest body weight was between CH×0 interaction (1202.00±67.70

Table 6: The interaction between breed and inclusion levels on body weight and morphometric traits of rabbit bucks

Breed	I.L.	BW(g)	BL(cm)	CG(cm)	EL(cm)	FL(cm)	HDL(cm)	HL(cm)	HW(cm)	TL(cm)
	0									
CH		1202.00±67.70^{a}	30.81±0.85^{a}	20.34±0.65	10.03±0.29	17.79±0.72	12.13±0.31^{ab}	26.85±0.78	16.86±0.53^{ab}	9.90±0.39^{bc}
DH		1045.50±39.09^{bc}	29.61±0.49^{ab}	19.05±0.37	10.09±0.17	17.56±0.42	11.80±0.18^{b}	25.01±0.45	16.44±0.31^{ab}	9.29±0.23^{c}
NZ		1173.80±39.09^{a}	30.93±0.49^{a}	20.12±0.37	10.53±0.17	18.66±0.42	11.99±0.18^{b}	26.18±0.45	16.77±0.31^{ab}	10.33±0.23^{b}
	5									
CH		1193.40±39.09^{a}	30.76±0.49^{a}	19.93±0.37	10.21±0.17	17.68±0.42	11.99±0.18^{b}	25.70±0.45	17.04±0.31^{ab}	10.09±0.23^{b}
DH		918.50±57.74^{c}	28.62±0.72^{b}	18.68±0.55	10.26±0.25	17.71±0.62	11.48±0.27^{b}	25.07±0.67	15.83±0.46^{b}	9.09±0.34^{cd}
NZ		1181.70±47.87^{a}	30.83±0.59^{a}	20.24±0.46	11.13±0.20	18.58±0.51	12.99±0.22^{a}	26.60±0.55	17.30±0.38^{ab}	11.76±0.28^{a}
	10									
CH		1168.60±47.87^{a}	29.75±0.48^{ab}	19.12±0.38	10.25±0.17	18.57±0.42	11.71±0.22^{b}	25.50±0.45	17.77±0.31^{a}	9.85±0.23^{bc}
DH		1044.70±39.09^{bc}	30.06±0.59^{ab}	20.01±0.46	10.01±0.20	18.98±0.51	11.97±0.18^{b}	25.72±0.55	16.80±0.31^{ab}	10.15±0.28^{b}
NZ		1092.30±39.09^{ab}	30.94±0.49^{a}	19.13±0.37	10.61±0.17	17.47±0.42	12.02±0.18^{b}	25.51±0.45	17.16±0.31^{ab}	10.30±0.23^{b}
	15									
CH		1195.10±39.09^{a}	30.84±0.49^{a}	20.25±0.37	10.57±0.17	18.72±0.42	12.33±0.22^{ab}	25.63±0.45	17.42±0.31^{ab}	10.45±0.28^{b}
DH		1060.70±47.87^{abc}	30.74±0.59^{a}	19.91±0.46	11.43±0.20	17.90±0.51	12.22±0.18^{ab}	25.98±0.55	17.29±0.38^{ab}	10.39±0.23^{b}
NZ		1072.80±25.09^{ab}	29.99±0.48^{ab}	18.83±0.37	10.21±0.17	17.26±0.42	11.91±0.18^{b}	25.08±0.45	16.68±0.31^{ab}	8.56±0.23^{d}

^{abcd}- Means with different superscripts within the same column are significantly different (P<0.05), I.L.- Inclusion levels, CH-Chinchilla, DH-Dutch, NZ-New Zealand White, BW-body weight, BL-body length, CG-chest girth, EL-ear length, FL-fore leg, HDL=head length, HL-hind leg, HW-height at wither, TL-tail length

g) but similar with NZ×0 (1173.80±39.09 g), CH×5 (1193.40±39.09 g), NZ×5 (1181.70±47.87 g), CH×10 (1168.60±47.87 g), CH×15 (1195.10±39.09 g), and the least was found in DH×5 (918.50±57.74 g). The results for BL were similar to that of body weight. The highest results for HDL and TL were found in NZ × 5 (12.99±0.22 cm) and NZ ×5 (11.76±0.28 cm), respectively. The results for interactions were similar to the report of Adeyemi *et al*. (2011) who observed significant interactions in growth performance of growing rabbit bucks fed 12.5 % PP and 25 % PP) of fermented and unfermented PP with those fed 0 % PP having a similar body weight.

The differences in the interactions for the current study may not be attributed to the inclusion levels of PP as breeds effects still reflected on the interaction because all inclusion levels with CH had higher body weight and were similar to NZ. This simply implied that any combination for CH and NZ will do better for body weight than DH.

CONCLUSION AND RECOMMENDATIONS

It can be concluded that breed has an influence on the body weight and some morphometric traits (BL, HDL and TL) of rabbit bucks with CH breed having the highest body weight (1158.80±21.41 g) with NZ having significant and higher values for body length (30.67±0.26 cm), head length (12.23±0.09 cm), and tail length (10.12±0.12 cm). Also, the inclusion levels of pineapple peel had no influence on body weight and all the morphometric traits, except on tail length and ear length.The breed and PP inclusion level interactions had effects on body weight and some morphometric traits with CH in any

combination having better performance though similar with NZ at all inclusion levels, except for head length and tail length where NZ in a combination performed better.It could, therefore, be recommended that any of the inclusion levels of pineapple peel in rabbit feed would have no deleterious effect on BW, BL, CG, FL, HDL and HW. Meanwhile, for better body weight and morphometric traits, any of the inclusion levels of PP with CH and NZ breeds should be selected for improvement in a breeding program over DH.

Conflict of interest: The authors declared that they have no conflict of interest.

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