Effect of Energy Feeds and Breeds on the Carcass Characteristics and Meat Quality of Rabbits

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Abstract

The study was carried out to investigate the effects of energy feeds and breeds on the carcass characteristics and meat quality of rabbits. Thirty-six weaned male rabbits were used at 30 days of age from three breeds (New Zealand White, Califonia, and Chinchilla) each breed comprised 12 rabbits. The dietary feed composition consisted of three cereal grains: maize, wheat, and sorghum at an inclusion level of 50% each, and water given on an ad libitum basis. There-after, nine rabbits from each dietary treatment, equivalent to three rabbits per experiment unit were slaughtered and the carcass characteristics and meat quality were evaluated. The differences in slaughter weight, carcass weight, and dressing percentage from the rabbit breeds fed energy feeds were found insignificant (P>0.05). However, the meat significantly (P<0.05) differed in terms of chemical composition. The loin muscle had a higher crude protein and lower fat value. Higher protein 24.91% for Chinchilla-fed diets 2, and 24.41% California-fed diet 1 as well as low ether extract 1.07% for Califonia fed-diet 1 followed by 1.11% and 1.12% Califonia fed diets 2 and Chinchilla-fed diets 1 while the neck muscle had higher dry matter and higher ether extract. A 28.51 % of dry matter for New Zealand white-fed diet 2 followed by 26.36% Chinchilla-fed diets 2 and higher ether extract 8.79%, 8.65 %, and 8.04% from those rabbits fed diet 3. Also had a significant effect (P<0.05) on meat tenderness higher in loin muscle was 6.45 N. Results suggest that the inclusion of 50% of each maize and wheat grain in rabbit diets enhanced meat protein and reduction fat values, especially in the loin and thigh muscle than sorghum grain.

Keywords: Carcass, energy feed, meat quality, rabbit breed

Introduction

Energy is a very important diet for rabbit growth, approximately 2,500 Kcal of digestible energy is required in the rabbit diet (FADIAF, 2013), as well as fiber is crucial, the low fiber content in rabbit diets may have negative effects on nutrient digestion and absorption (Gidenne, 2015). In Tanzania, maize, wheat, and sorghum grains are common energy feed available as an energy source for livestock. These grains are primary energy supplement in animal diets and can contribute up to 30, 60, and 98% of the diet's protein, net energy, and starch, respectively (Mlyneková *et al.,* 2018).

Rabbits are herbivores that efficiently convert cereal grains into animal proteins of superior nutritive value for people (Dalle-Zotte *et al.,* 2011). According to these researchers, a rabbit can produce 20 percent of the proteins and an average lipid content of 1.8 g/100 g of meat.

Hernández *et al* (2010) reported that rabbit meat is considered a functional food due to its high nutritional properties. Rabbit meat is a source of low allergenic valuable proteins with high nutritional value (essential amino acids), and it has an excellent lipid profile, i.e., low levels of fat and cholesterol (Tufarelli *et al.,* 2022), due to its high content of unsaturated fatty acids and a good ratio of polyunsaturated fatty acids, (Dos santos *et al.,* 2022). The potential to encourage rabbit meat into the human diet is high, due to its sensory characteristics, low-fat content, high unsaturated fatty acids, valuable proteins, mineral content, and vitamins (Konjević, 2007), while its energetic value is similar to other meat.

However, in Zanzibar Tanzania, there is a lack of information on the effect of energy feeds and breeds on the carcass characteristics and meat quality of the rabbits. Therefore, this study assessed the effect of energy feeds and breeds on the carcass characteristics and meat quality of rabbits to solve public rabbit meat consumption.

Materials and Methods

Experimental location

The study was conducted at the Zanzibar Livestock Research Institute in Unguja Zanzibar, for 3 months. Zanzibar is an island in the Indian Ocean, located on the eastern side of Tanzania about 30km from the east coast of Africa. The Island is located between latitude 04051' South and longitude 39011'East. It receives an average annual rainfall of 1600 – 1900 mm/annual. The rainfall pattern is bimodal with long rains from March to May and short rains from October to December while temperatures vary between 18ºC - 32ºC.

Experimental Design and Dietary Treatments

The randomized complete block design and three dietary treatments were used to evaluate energy feeds and breeds on carcass characteristics and meat quality of rabbits. The dietary treatment was designated as Diet 1, Diet 2, and Diet 3, where each diet was comprised of three experimental units each including four replicates.

Experimental rabbits and their management

Thirty-six weaned male rabbits were used at 30 days of age from three breeds (New Zealand White, California, and Chinchilla) each breed comprised 12 rabbits, hereafter designated in diet 1, diet 2, and diet 3. The rabbits were fed ad libitum the dietary composition of three cereal grains namely maize, wheat , and sorghum at an inclusion level of 50% each, and free access to water was given. The twelve rabbits from each breed were divided into three experiment units each comprised of four rabbits were received one dietary treatment. The allocation of the rabbits of each breed to the three dietary treatments was done such that rabbits from the same mother or uniform age/weight were randomly allocated to the three dietary treatments. Each rabbit was lodged in an individual cage (house) whose area was 90×60×60 cm for 3 months, hence the total number of cages in the dietary treatment was twelve. Furthermore, the experimental rabbits were given ivermectin drugs to control ecto and end-parasite regularly throughout the experimental period, and antibiotics were used to treat experimental rabbits that showed signs of infectious diseases.

Chemical composition of experimental diet

Chemical composition (i.e. Dry matter, Crude protein, Ether extract, Ash, Crude fiber, and Metabolize energy/Kilocalories) for the formulated diets was determined according to procedures described by (AOAC, 1990) using a near-infrared reflectance system (NIRS) at the Tanzania Veterinary Laboratory Agency in Temeke, Dar es Salaam, Tanzania

Carcass yield and Organ components

At four months of age, twenty-seven rabbits were weighed to obtain slaughter weight and slaughtered, nine rabbits from each dietary treatment where three rabbits from each experimental unit were randomly selected from each treatment starved of feed but were given fresh drinking water for 18 hours overnight before slaughter. The slaughtered rabbits were skinned, eviscerated, and weighed again to obtain eviscerated weights, and a longitudinal split of the carcass was done to obtain the right and left halves. All edible organs were separated and weighed. Carcass yield was calculated as dressing percentage by using equation 1 and organ weight as indices of production was measured using a weighing balance. The edible organ components (liver, heart, and spleen) were expressed as a percentage of the organ components by using equation 2.

$$\text{Dressing \%} = \frac{\text{Carcass weight}}{\text{Live weight}}\, x100 \quad \ldots\ldots\ldots(1)$$

$$\text{Organ component (\%)} = \frac{\text{Weight of component}}{\text{Live weight}}\, x100 \cdots\cdots(2)$$

Meat chemical composition

Six samples weighing 125gm from each of the thighs, loin, and neck muscles of the three rabbits from each experiment unit were used to determine chemical composition. The meat samples were finely ground and thoroughly mixed for the determination of chemical composition, and then the proximate analysis was applied to determine protein, ether extract, ash, and dry matter contents.

Meat tenderness and cooking loss

Meat samples from thigh, loin, and neck muscles used for the determination of tenderness were preserved in a deep freezer at -20°C for 2 days and then refrigerated at 40C for one day. They were afterward vacuum packed and transported to the Sokoine University of Agriculture at the Department of Animal, Aquaculture, and Range Sciences - laboratory for analysis. At the laboratory, the meat samples were thawed at 5°C and then cooked in the water bath at 71°C for 1 hour after which they were allowed to cool to 40°C before being refrigerated again for 24 hours. After refrigeration, the samples were weighed and recorded to determine the cooking loss percentage. Thereafter, the meat was sliced into a 1 cm thick cube and then placed in the Warner Blade Sheer Force Machine for determination of tenderness.

Data analysis

The data on carcass characteristics and meat quality were analyzed using a Statistical Analysis System (SAS, 2005). The General Linear Model (GLM) procedure was used to compare treatment means where the means were separated using the least significant difference at a 5% level of significance. The model used in the analysis was: - $Y_{ij} = \mu + t_i + b_j + \varepsilon_{ij}$

Where:

Y_{ij} = Expected observation of the jth treatment

μ = Overall mean

t_i = Treatment effect of the jth treatment

b_j = Replicate effect of the jth replicate

E_{ij} = Random error

Results and Discussions

Analysis of feed ingredients

The chemical composition of experimental feed ingredients is presented in Table 1. The chemical composition of the feed ingredients observed in the present study was within the expected values, although slight variations were observed such as low CP content for wheat grain and high EE and CF in sunflower seed cake and maize bran as reported by (Mutayoba *et al.,* 2011). On the other hand, wheat grain had slightly low starch content compared to maize and sorghum grains, these results do not concur with (Heuzé *et al.,* 2015) reported that the starch content in the wheat grain ranged between 69.1 - 74.9%. The variation in the results might be caused by either the differences of the variety used or genetic factors that can affect the chemical characteristics of cereal grains and other plant products (Peltonen-Sainio *et al.,* 2012).

Table 1: Chemical composition of feed ingredients

	Percentage composition							
Ingredient	**DM**	**CP**	**EE**	**CF**	**Ash**	**STARCH**	**Ca**	**P**
Maize grain	89.1	10.1	1.4	1.2	2.3	70.0	0.13	0.80
Wheat grain	90.5	9.0	1.5	1.4	7.6	68.2	0.96	1.35
Sorghum grain	86.1	13.9	1.2	2.8	4.5	72.1	0.13	0.39
Fish meal	89.1	69.0	4.4	-	9.2	-	3.18	1.92
Sunflower seed cake	92.8	24.0	15.2	22.8	5.8	-	0.30	0.73
Maize bran	88.3	5.2	5.9	12.2	6.4	-	0.14	0.78

Key: DM = Dry matter, CP = Crude protein, EE = Ether extract, CF = Crude fiber, Ca = Calcium, P = Phosphorous

Experimental diets

Table 2 displays the experimental diets, shows that had slightly lower Crude protein and Calcium in Diet 1 compared to other diet treatments. The low Crude protein and Calcium disagreed (FEDIAF, 2013) reported that an average of 14 -18 % protein and 0.5 - 0.9% Calcium were required in rabbit diets as mentioned in the nutritional guidelines for feeding pet rabbits in Europe. Similar to the report of (Gidenne *et al.,* 2020) on rabbit nutrition and feeding strategy, this contrast between the results and present findings might be caused by either the types of feed ingredients used or the storage conditions of feeds (Peltonen-Sainio *et al.,* 2012). The Crude fiber was slightly lower for all experimental diets than the values reported by (Gidenne, 2015). The low fiber content in rabbit diets may have negative effects on nutrient digestion and absorption. The mineral contents (i.e. calcium and phosphorous) and ether extract were within the range values observed by (Mateos *et al.,* 2020). While, the metabolized energy obtained in the study was within the range reported by (Gidenne *et al.,* 2020; Lebas *et al.,* 2000).

Table 2: Chemical composition of experimental diets

	DIETARY TREATMENTS		
Nutrients (% DM)	DT 1	DT 2	DT 3
Dry matter	90.3	89.1	89.2
Crude Protein	13	14.0	13.6
Ether extract	5.9	7.6	7.7
Crude fiber	8.9	9.0	8.8
Ash	9.0	9.0	8.9
Calcium	0.37	0.48	0.80
Phosphorous	0.52	0.54	0.64
ME;Kcal/kg	2600	2630	2580

Key: ME= metabolize energy, Kcal = kilo-calorie, DT 1 = diet with 50% maize grain, DT 2 = diet with 50% wheat grain, DT 3 = diet with 50% sorghum grain

Carcass yields and Organ components

Table 3 displays carcass yield and organ components of the rabbit breeds. Carcass weight, and dressing percentage of the rabbit breeds were statistically analyzed there were insignificant differences. This trend was similarly observed for edible and non-edible components. The present findings conform with the findings of (Birolo *et al.,* 2022) who reported that no negative effect on carcass weight and dressing percentage when assessing the meat quality of two commercial crossbred rabbits fed different types of energy and protein diets. Similarly, the report by (Ghosh *et al.,* 2008) observed no significant effect ($p>0.05$) of the carcass yield and organ components between the Soviet chinchilla and Grey giant when using rabbit diets containing up to 40% of energy feeds to evaluate carcass and meat quality traits of rabbits under the warm-humid condition of West Bengal, India.

Moreover, the study by Adeyemo *et al.,* (2014) reported a significant effect ($p<0.05$) in carcass weight, dressing percentage, edible and non-edible organs, when evaluating the carcass characteristics of growing rabbits fed concentrate to forage ratio. Had higher for rabbit-fed diets containing 50% of concentrates and forage. The variation in the results might be caused by forage containing insoluble fibers (lignin and hemicellulose) that restrict the bio-availability of other components such as non-proteic amino acids, polyphenols, and glycosides are important resources in animal nutrition (Aganga *et al.,* 2003). However, the present study showed that maize, wheat, and sorghum grains could be valuable energy sources for rabbits at an inclusion level of 50% of each in rabbit diets without affecting carcass yields and organ components.

Meat chemical composition

Table 4 presents the results of the chemical composition of the rabbit meats from the neck, loin, and thigh muscles, there were significant differences ($p<0.05$) in dry matter, crude protein, ether extract, and ash values. The neck muscle had a higher dry matter from New Zealand white-fed diet 2 followed by Chinchilla-fed diet 2 and Zealand white-fed diet 3, whereas

Table 3: Effects of energy feeds and breeds on carcass yields and organ components

	TREATMENTS										
	DIET 1			DIET 2			DIET 3				
Parameter	**NZ**	**CA**	**CH**	**NZ**	**CA**	**CH**	**NZ**	**CA**	**CH**	**SEM**	**Pr > F**
Carcass weight (g)	872.50	992.50	902.50	892.50	812.50	970.00	962.50	935.00	845.00	82.92	0.8065
Dressing percentage (%)	51.27	53.75	52.71	52.50	50.55	53.89	52.65	52.85	52.97	1.43	0.7874
Liver (%)	3.52	3.39	3.71	3.41	3.79	3.75	3.18	3.37	2.86	0.46	0.8857
Heart (%)	0.29	0.27	0.29	0.29	0.31	0.27	0.28	0.28	0.33	0.02	0.6858
Kidney (%)	0.88	0.67	0.74	0.76	0.94	0.83	0.83	0.85	0.82	0.12	0.6858
Lung (%)	0.74	0.67	0.88	0.89	0.96	0.83	0.95	0.98	1.34	0.17	0.4229
Gut (%)	18.99	16.68	17.53	15.36	16.89	16.38	17.57	17.05	17.44	1.47	0.8637
Head (%)	9.10	9.34	9.24	9.50	9.82	9.03	9.30	9.07	9.00	0.47	0.9427
Leg (%)	2.65	2.57	2.80	3.11	2.98	2.78	2.63	2.85	3.02	0.22	0.7049
Skin (%)	11.17	10.18	9.71	10.00	11.26	10.28	11.30	10.97	9.52	0.71	0.5266

Key: Diet 1 = diet with 50% maize grain, Diet 2 = diet with 50% wheat grain, Diet 3 = diet with 50% sorghum grain. NZ= New Zealand breed, CA= California breed, and CH= Chinchilla breed

Table 4: Effects of energy feeds and breeds on meat chemical composition

	TREATMENTS										
	DIET 1			DIET 2			DIET 3				
Parameter	**NZ**	**CA**	**CH**	**NZ**	**CA**	**CH**	**NZ**	**CA**	**CH**	**SEM**	**Pr > F**
Neck muscle											
Dry matter (%)	22.48e	21.55e	23.38d	28.51a	23.30d	26.35b	26.14b	24.60c	23.18d	0.20	<.0001
Crude protein (%)	19.50c	22.09a	19.86c	18.93d	19.03c	19.86c	17.90e	20.28b	19.48c	0.42	0.0037
Ether extract (%)	7.79c	7.63c	7.70c	7.90b	7.67c	7.85b	8.79a	8.04b	8.65a	0.02	<.0001
Ash (%)	4.57c	4.45c	4.87b	4.22d	4.55c	4.57c	5.38a	3.31e	5.49a	0.19	0.0009
Loin muscle											
Dry matter (%)	25.68a	24.98c	25.26b	25.43b	25.12b	25.85a	25.30b	23.44d	25.94a	0.31	0.0088
Crude protein (%)	23.89b	24.41a	23.95b	23.63b	23.98b	24.91a	23.40b	21.98c	21.83c	0.23	<.0001
Ether extract (%)	1.21b	1.07d	1.12c	1.24b	1.11c	1.16c	1.35a	1.16c	1.23b	0.02	0.0002
Ash (%)	5.56	6.05	6.42	5.76	5.51	4.53	5.06	4.88	5.23	0.33	0.0582
Thigh muscle											
Dry matter (%)	23.45d	25.22b	23.56d	24.63c	24.46c	26.11a	25.01b	24.14c	22.78e	0.39	0.0054
Crude protein (%)	22.61b	23.63a	23.65a	23.54a	22.07b	23.23a	22.48b	21.63c	21.82c	0.29	0.0033
Ether extract (%)	2.53c	2.45c	2.50c	2.75b	2.68b	2.64c	3.22a	2.89b	2.92b	0.01	<.0001
Ash (%)	4.47c	5.99a	5.62b	6.45a	5.41b	6.03a	6.04a	5.63b	5.50b	0.23	0.0089

[a b c d e] means in the same row with different superscript letters are different ($P < 0.05$).

Key: % = percentage, Diet 1 = diet with 50% maize grain, Diet 2 = diet with 50% wheat grain, Diet 3 = diet with 50% sorghum grain. NZ= New Zealand breed, CA= California breed, and CH= Chinchilla breed higher crude protein from California fed diet 1 and 3, and had higher ether extract for those rabbit breeds fed diet 3. This trend was similarly observed for ash value.

Moreover, loin muscle had a slightly higher dry matter from Chinchilla fed diet 2 followed by the New Zealand white-fed diet 1 while a higher crude protein for the Chinchilla-fed diet 2 and California-fed diet 1 as well as had low ether extract from California-fed diet 1 and 2.

The thigh muscle had a slightly higher dry matter for the Chinchilla-fed diet 2 followed by California-fed diet 1 and New Zealand white-fed diets 3 and had relatively higher crude protein for Chinchilla followed by California-fed diet 1, New Zealand white and Chinchilla fed diet 2, while had low ether extract and ash percentage for those rabbits fed diet 1.

The results disagreed with those reported by (Hernández-Martinez *et al.,* 2018) who observed no negative effect in protein (20.38 - 22.11 %), ether extract (1. 2 - 2. 2%), and ash (0.91-1.01%) in the neck and thigh muscles respectively when evaluating the effects of hydrolyzed sorghum on the meat quality of rabbits. These contrasting results might be associated with genetics and environmental factors (including on-farm and maturity of slaughter). The larger rabbit breed has different carcass characteristics to the medium-sized (Hernandez *et al.,* (2010). However, the present results of protein and ash values in the loin and thigh muscles were within the range reported by (Szendro and Dalle Zotte, 2011). While, the ether extract value of the loin muscle was within the range reported by (Alabiso *et al.,* 2017). However, the higher ether extract and protein values in the neck and loin muscle in three fed diets probably contributed to a neck and loin muscle having higher deposition of fat and protein in the body respectively (Pla *et al.,* 2004; Daszkiewicz *et al.,* 2012). The current study showed that maize and wheat each could include up to 50% in rabbit diets, which enhanced protein and reduction of fat values in rabbit meat.

Meat Tenderness and Cooking Loss

Table 5 displays meat tenderness and cooking loss from the neck, loin, and thigh muscles. Meat tenderness and cooking loss were significantly different ($p<0.05$), on neck, loin, and thigh muscles. Neck muscle had higher tender for Chinchilla-fed diet 2, followed by New Zealand white-fed diet 2 and California-fed diet 1, whereas a higher cooking loss for California-fed diet 3 followed by New Zealand white-fed diet 1 and Chinchilla-fed diet 3.

In terms loin muscle had higher tenderness for Chinchilla-fed diet 2 followed by California-fed diet 1 and a higher cooking loss for New Zealand white-fed 3 and Chinchilla-fed diet 2. Thigh muscle had slightly higher tenderness for the New Zealand white-fed diet 1 and the chinchilla-fed diet 2 and higher cooking loss for the California-fed diet 3 followed by Chinchilla and California-fed diet 2. The present results concurred with the report of (Bianchi *et al.,* 2007) noted a significant effect on meat tenderness of the meat cut when comparison Allo-Kramer and Warner-Brawler devices to assess rabbit meat tenderness. The main factors affecting meat tenderness were attribute to collagen content and its chemical state as well as the myofibrillar, determined by the degree of overlapping of sarcomeres (Sams, 2002). Hernandez-Martinez *et al.,* (2018), reported that there is decreased hardness and increased cooking loss in the rabbit meat when rabbits are feeding sorghum grains because it an increasing nutrient synthesis and assimilation. However, the results reported by (Alagon *et al.,* 2015) noted that no negative effect on meat tenderness and cooking loss of the meat cut when feeding diets containing barley, wheat, and corn distillers dried grains in growing rabbits. This variation of meat tenderness and cooking loss was influenced by the amount of fat and collagen contained in particular cuts (Klont *et al.,* 1998).

Conclusions and Recommendation

It is concluded that the inclusion of 50% of each maize, wheat, and sorghum grains in rabbit diets had no negative effect on carcass characteristics but had a significant effect on meat quality. Therefore, the inclusion of 50% of wheat and maize grain each in rabbit diets increases the protein proportion and reduction of fat values in the rabbit meat, especially in the loin and thigh muscles. The inclusion of 50% sorghum in rabbit diets is a reducing

Table 5: Effects of energy feeds and breeds on meat tenderness and cooking loss

	TREATMENTS										
	DIET 1			DIET 2			DIET 3				
Parameter	**NZ**	**CA**	**CH**	**NZ**	**CA**	**CH**	**NZ**	**CA**	**CH**	**SEM**	**Pr > F**
Neck muscle											
Tenderness (N)	3.47c	3.86b	2.50d	3.87b	2.99d	5.53a	3.08c	3.40c	3.20c	0.35	<.0001
Cooking loss %	30.05a	26.72d	24.37e	23.77e	28.03c	29.86b	28.09c	30.52a	30.19a	0.73	0.0006
Loin muscle											
Tenderness (N)	3.30b	3.39b	2.94d	3.01c	3.13c	6.45a	2.69d	3.01c	3.15c	0.39	<.0001
Cooking loss %	27.00b	24.24d	22.80e	21.82e	25.60c	28.13a	28.49a	26.94b	25.86c	0.69	0.0008
Thigh muscle											
Tenderness (N)	5.19a	3.14c	2.80d	3.05c	2.55e	4.42b	3.41c	2.90d	2.91d	0.32	<.0001
Cooking loss %	21.64e	23.88d	23.43d	24.03c	25.24b	25.95b	24.47c	29.25a	25.14b	0.62	0.0007

[a b c d e] means in the same row with different superscript letters are different ($P < 0.05$).

Key: N= newton, Diet 1 = diet with 50% maize grain, Diet 2 = diet with 50% wheat grain, Diet 3 = diet with 50% sorghum grain. NZ= New Zealand breed, CA=California breed, and CH= Chinchilla breed.

meat tenderness in rabbit meats and increases cooking loss. This study suggested that there are potential advantages of using wheat and maize grains as energy feeds in rabbit diets due to the enhancement of meat protein and its reduction in fat content than sorghum grains.

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