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Research Article

Influence of Genotype on Growth Performance and Physicochemical Quality of Rabbit Meat

Zikhona Rani*, Nolwandle September, Progress Sodella and Rob Gous

Animal and Poultry Science, University of KwaZulu-Natal, South Africa

***Corresponding author:** Zikhona Rani, Animal and Poultry Science, University of KwaZulu-Natal, Private Bag X01, Scottsville 3201, Pietermaritzburg, South Africa

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Abstract

This study evaluated the effect of breed on growth performance, meat quality and carcass characteristics in rabbits. Forty-eight (48) rabbits of six commercial rabbit breeds [Chinchilla giganta (CHIN), New Zealand White (NZW), New Zealand Red (NZR), Californian (CAL), American sable (SAB), and Cinnamon (CIN)] were used in this study. The rabbits were randomly selected at the weaning stage (35 d) and housed separately in mesh wire cages with two rabbits in each cage. The rabbits were fed a commercial pelleted diet twice a day in the morning and later in the evening. Water was provided ad libitum. Data were collected for six weeks post-weaning. Liveweight differences across breeds were unrelated to the initial weights of the breeds, which differed because the rabbits from different breeds were not of the same age at the start of the trial. Feed intake (FI) did not differ between breeds, whilst Feed conversion efficiency (FCE) differed only between the NZW and CIN breeds. Slaughter weight (SW), chilled carcass weight (CCW), reference carcass weight (RCW) and dressing out percentage (DO%) differed across breeds ($P<0.05$). L* (Lightness), a*(redness), b*(yellowness) and water holding capacity (WHC) differed across breeds ($P<0.05$). It was concluded that growth performance and meat quality differ between rabbit breeds.

Keywords: Rabbit Meat; Feed Intake; Meat Lightness; Meat Redness; Meat Yellowness; Weight Gain

Introduction

The lack of animal protein for human consumption is one of the main challenges in developing countries [1] due mainly to the high rate of population growth [2]. This pattern is expected to increase in 2050 as the worldwide demand for meat protein is expected to increase (73 %) with a large portion of the increase expected to be from developing countries [3]. This challenge necessitates the identification of alternative animal protein sources that are inexpensive to produce, to address the high demand in animal protein. Rabbit production can serve as an inexpensive alternative source of animal meat protein in developing countries due to low production cost, short gestation period (30 d), high litter size and early sexual maturity [4]. Additionally, rabbit meat quality is excellent due to its high protein and low fat and cholesterol content [5]. For these reasons, rabbit meat is one of the animal protein sources that can be used to prevent malnutrition in developing countries [6].

The common commercial rabbit breeds used for meat production are New Zealand White (NZW) and Californian (CAL) [7]. However, there are other commercial rabbit breeds such as Chinchilla (CHIN), Cinnamon (CIN) and Rex [8] which can be reared for fur as well as meat. Extrinsic and intrinsic factors such as genetics, environment and feed determine growth performance and meat quality [9]. There are breeds that mature earlier than others, whilst some take longer to mature and reach the target market weight [10]. On the other hand, meat quality differs in rabbit breeds [11]. The most common limitation to the development of rabbit production in tropical countries such as South Africa is heat stress which leads to decreased growth performance [12]. This factor necessitates more studies to investigate the growth performance and meat quality to identify rabbit breeds that are more suitable for meat production to provide quality meat protein in the tropics as well as to cater for food security. The objective of this study was to investigate the effect of genotype on growth performance, carcass characteristics and physico-chemical properties of rabbits.

Materials and Methods

Ethical procedure

Approval for all experimental protocols was granted by the University of KwaZulu-Natal Animal Research Ethics Committee (ref no: AREC/069/018M).

Study Site

This study was conducted at the University of KwaZulu-Natal, Ukulinga Research farm Pietermaritzburg, South Africa (30° 24'S, 29° 24'E, altitude 700-775m; and 735 mean annual rainfall).

Animals, Housing and Feed

Forty-eight rabbits from six commercial strains [Chinchilla Giganta (CHIN), New Zealand White (NZW), New Zealand Red (NZR), Californian (CAL), American Sable (SAB), and Cinnamon (CIN), 8 rabbits per strain] were used for this study. The rabbits were randomly selected at the weaning stage of five weeks of age and housed in wire cages which were placed above ground. Each cage housed two rabbits. The house in which the cages were situated had a concrete floor; wood shavings were placed under the cages as bedding to absorb urine and faeces; and ventilation and temperature were monitored daily. Each cage was fitted with a feeder and nipple drinker. Rabbits were fed commercial pelleted diet twice daily, in the morning (8h00 am) and afternoon (4h30 pm) for six weeks post-weaning, until they reached slaughter weight age of 11 weeks (Table 1). Feed was restricted for the first five days of the trial by removing feed from cages in the morning and afternoon; thereafter feed and water were provided ad libitum.

Table 1: Chemical composition of the commercial feed used in the trial.

Items	Quantity (g/kg)
Moisture	120
Crude protein	160
Fibre	170
Fat	25
Calcium	15
Phosphorus	7

Rabbits were weighed individually each week to determine body weight gain. Feed intake was determined by weighing feed in and out each week, from which feed conversion efficiency was calculated. Live weight gain was calculated as the difference between the body weight at weaning and that at the end of the growing period.

At the end of the six weeks feeding trial, four rabbits from each breed were randomly sampled for further analysis. These rabbits were transported early in the morning before dawn to prevent heat stress and possible mortalities. All rabbits were transported to a slaughterhouse (Rotamaster farm) located 100 km from the research farm. During the 12-hour fasting period the rabbits were provided with fresh clean water. Prior to slaughter they were stunned electrically and immediately hung by the hind legs in the processing line and quickly bled out for 90 seconds by cutting the jugular vein and the carotid artery. After slaughter the hot carcass was weighed, hung upside down and stored in a cold room (4°C) for 24 h. The chilled carcass weight was measured with the temperature of the carcass at 5°C.

Carcass Characteristics

Carcasses were prepared according to the guidelines of the World Rabbit Science Association [13]. Hot carcasses were suspended in a ventilated area for 15-30 minutes and chilled at 3-4°C for 24 hours. Both the hot and chilled carcasses excluded the head, kidney, liver, heart, lungs, thymus and oesophagus, which were removed to obtain the reference carcass (commercial carcass).

Meat Quality Measurement

The ultimate pH was measured at 45 minutes (pHu45) and 24 hours (pHu24) postmortem on the longissimus lumborum muscle and the biceps femoris of the left side at the level of the fourth lumbar vertebra, using calibrated pH meter WTW pH 330i (Weilheim, Germany) with glass core probe (penetrated 1 cm deep). The pH was calibrated using pH7 buffer and re- calibrated after every reading. Colour characteristics L* (lightness), a* (redness), b* (yellowness) were measured on the left longissimus dorsi using a CR300 Minolta chromameter (Minolta Camera, Osaka, Japan). The mean of the replicates was used for analysis. The dissected left Longissimus dorsi muscle of each carcass was used to measure shear force using a Warner Bratzler machine. Shear force was measured on fresh meat, with the samples at 5°C. The samples were cut into 1.5 cm by 1.5 cm pieces.

Water holding capacity was measured on left Longissimus dorsi using the texture analyzer method. A core of 1.5 cm was used to prepare the samples as they should be round, and the sample of intact meat was weighed, sandwiched between layers of gauges and filter paper then placed on the texture analyzer. The samples were then compressed with a 35 kg pressure weight for 5 minutes and weighed again after compression. The mean of three replicates was used for analysis. Water holding capacity was estimated as water content of the sample minus water loss of the sample over water content of the sample all multiplied by 100.

$$WHC(\%) = \frac{water\ loss - water\ content}{water\ content} \times 100$$

Determination of Chemical Composition of Rabbit Meat

Proximate analysis of the diet was analyzed according to AOAC standard. For dry matter content AOAC (945.15) method was used, ash (942.05), crude protein (979.09) and ether extract (920.39). Neutral detergent fibre (NDF) and acid detergent fibre (ADF) were analysed using ANKOM fibre analyser [14].

Statistical Analysis

Data were statistically analysed using GenStat 18.2 software. All measurements were processed with two-way ANOVA. Statistically significant differences were indicated by P < 0.05.

Results and Discussion

Breed Effect on Growth Performance

There were differences in liveweight of rabbit breeds at the start of the trial (P<0.01) (Table 2) due to differences in age. CHIN was the oldest (64 d) and hence heaviest breed, whilst the CIN was the youngest (36 d) and the smallest. Due to the difficulty in obtaining rabbits of the same weaning age it was impossible to ensure that all rabbits were of the same age at the start of the trial. Age and weight both contribute to variability in carcass and meat quality, therefore when comparing breeds they should be at a similar stage of maturity [15] and this should be borne in mind when comparing the results of this trial. The rabbits were sampled for meat quality at approximately the same slaughter weight of 2.5 kg. Mean daily weight gain was unrelated to initial body weight (Table 2), the highest gains being in the NZW and Cin breeds, with the lowest being in NZR. No differences were observed in feed intake between breeds in spite of differences in initial body weight, whilst FCE differed only between the NZW and CIN breeds, the NZW breed being more efficient during the trial.

Table 2: Mean initial weight, daily gain and feed intake, and feed conversion efficiency (FCE, g gain/kg feed in) of Californian (CAL), Chinchilla (CHIN), Cinnamon (CIN), New Zealand Red (NZR), New Zealand White (NZW) and American Sable (SAB) rabbit breeds.

	Breed						
	CAL	**CHIN**	**CIN**	**NZR**	**NZW**	**SAB**	**SEM**
Initial	950^{bc}	1448^{a}	796^{c}	869^{bc}	925^{bc}	1002^{b}	69.3
Gain/d	31.4^{bc}	31.0^{bc}	34.5^{ab}	30.8^{c}	35.9^{a}	31.3^{bc}	1.21
Feed/d	122	123	126	125	118	124	4.64
FCE	281^{ab}	284^{ab}	246^{b}	257^{ab}	292^{a}	266^{ab}	14.5

$^{a, b, c}$ Means with the same superscript do not differ (P>0.05)

Breed Effect on Carcass Characteristics

Figure 1 illustrates differences in carcass characteristics between the breeds in SW, HCW, CCW, RCW and DO% (P<0.05). The DO (%) results in the present study were lower than previously reported to be 55.2, 54.7 and 57.8 for CAL, NZW and CHIN, respectively [15]. Furthermore, the CHIN had the highest mean values for slaughter weight, chilled carcass, reference carcass weight and higher dressing out percentage, these traits are also influenced by age. Similar results have been reported no significant differences in carcass characteristics (SW, HC and CC) between NZW and Phendula breeds [16]. Contrastingly, there have be observations of no influence on carcass characteristics among NZW, CAL, CHIN, and Mexican Rex breeds [15]. Housing system influences carcass and physical characteristics of rabbit meat [17]. Rabbits housed in cages tend to have higher dressing percentage than those in pens and pen housed rabbits have lower slaughter weight than rabbits in cages, this could be due to higher locomotion activity in the pen housing, while there is limited movement in rabbits housed in cages. There are many factors that affect the pH value of the meat, such as lairage time, stress, stunning methods and transportation. The housing system affects the physical characteristics of rabbit meat pHu and colour of the meat. Although there are no significant differences observed for the pHu (P>0.05), numerically the pHu24 (4.21) value for CHIN was lower than that for the carcasses of other breeds (Figure 2). This is in agreement with previous demonstrations that the selection for rabbit growth rate has minimal effect on meat quality, pHu and WHC [8].

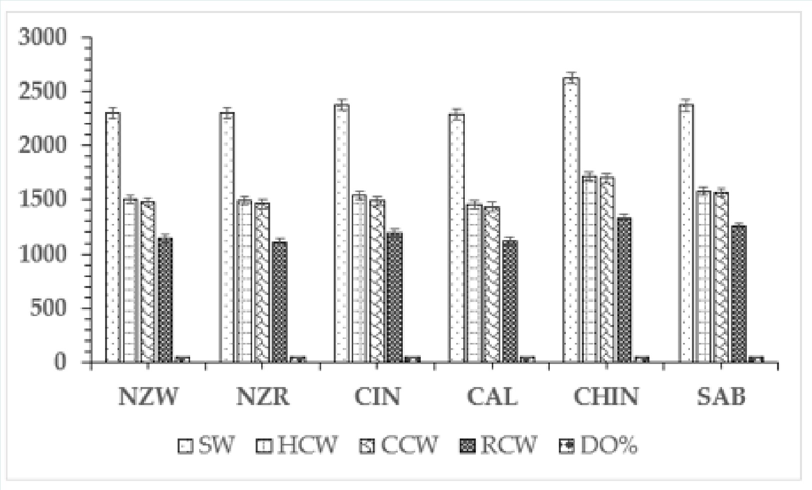

Figure 1: Effect of breed on meat characteristics.

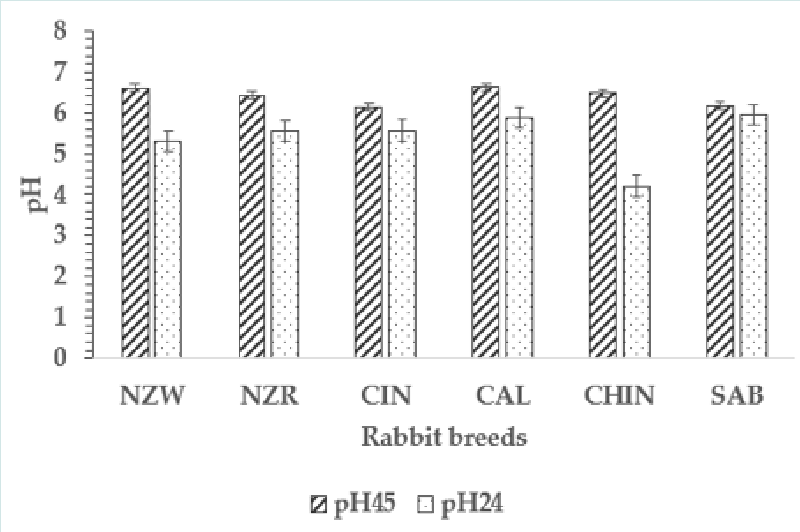

Figure 2: Meat ultimate pH in different rabbit meat breeds.

There were no breed effects on the pH values of the longissimus dorsi between the different breeds at pHu45 and pHu24. Lowest pH values were observed after 24 hours post slaughter. pH also affects the appearance of raw meat and the tenderness of meat. On the other hand, muscle ultimate pH has an important influence on meat quality [18] and is related to the rate of glycogen breakdown and liberation of lactate post-slaughter. Thus, our goal was to achieve an ultimate pH a little lower than 6.0 by 24 h. This was considered to be essential for good product quality [19]. Substantially lower than 6.0 pHu (e.g. 5.0) would make the meat too firm and dry because the myofibrillar network would shrink and water holding capacity (WHC) would decrease. Water holding capacity as a measure of the meat freshness is a vital meat quality attribute, significant differences ($p<0.01$) were observed between breeds for this characteristic (Figure 2). Meat from CHIN had the highest water holding capacity of 66% and that from NZW and CIN had low water holding capacity 59.66% and 59.14% respectively.

Meat colour depends on the level of myoglobin, the degree of oxidation of iron atoms, and on a possible denaturation of globin. Highly significant differences ($p<0.01$) were observed for colour L* (lightness), a* (redness) and b* (yellowness) ($p<0.05$) (Figure 3). This contrasts previous results which reported no significant differences between breeds for L* and a* values [20]. However, structural and biochemical muscle traits may change meat colour due to the influence of genetic type and post-mortem temperature variation in meat [21]. Shear force values reported in the literature vary widely and have been measured with a variety of methods. However, the average WBSF in the current study fell within the lower end of the range of results [22]. Past findings reported that texture parameters did not differ between rabbit genetic lines [23, 24]. However, differences between groups of rabbits were observed in WB shear test parameters assessed on raw meat but not on cooked meat [25].

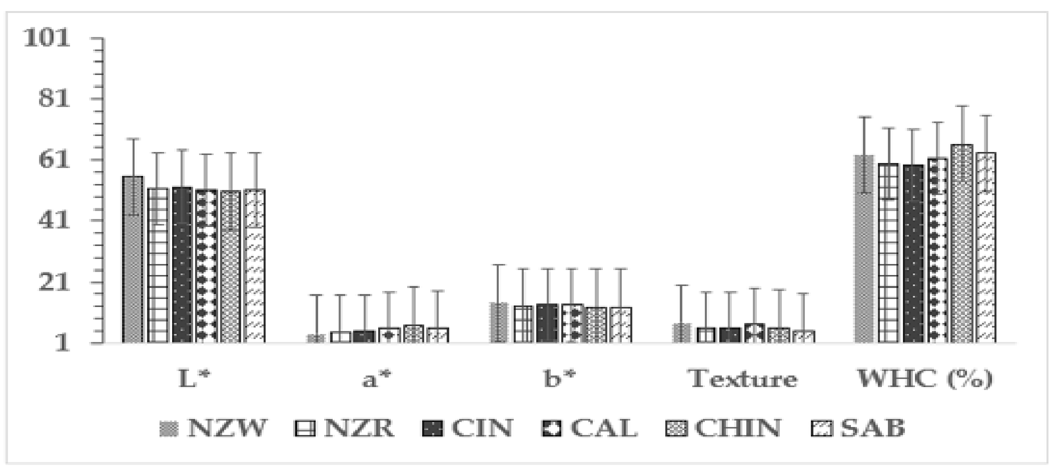

Figure 3: The effect of breeding on physicochemical properties of rabbit meat.

Conclusions

This study demonstrated that liveweight differences across breeds were unrelated to the initial weights of the breeds, which differed because the rabbits from different breeds were not of the same age at the start of the trial. Feed intake did not differ between breeds, whilst FCE differed only between the NZW and CIN breeds. Rabbit breed affected the following meat quality characteristics: SW, CCW, RCW and DO% , L*, a*, b* and WHC. These results are of value when choosing the breed of rabbit to be used in commercial operations.

Author Contributions

Conceptualization, R.G.,Z.R.,and N.S; methodology, R.G.,N.S and Z.R.; software, Z.R and N.S.; validation, Z.R.; formal analysis, R.G., Z.R. and P.S.; investigation, N.S, R.G and ZR.; resources, R.G.; data curation, R.G, Z.R and P.S.; writing—original draft preparation, Z.R. and N.S.; writing-review and editing, Z.R., P.S. and R.G.; visualization, R.G. and Z.R..; supervision, Z.R and R. G.; project administration, R.G. and Z.R..; funding acquisition, R.G. All authors have read and agreed to the published version of the manuscript.

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Data Availability Statement

Data used in this study are available upon request.

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Conflicts of Interest

The authors declare no conflict of interest.

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