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THE EFFECT OF AGE ON THE CARCASS COMPOSITION, PORTION YIELD AND PROXIMATE COMPOSITION OF TWO RABBIT GENETIC TYPES IN SOUTH AFRICA

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Abstract: This study investigated the carcass component yields and meat proximate composition of 2 rabbit genetic types (Californian and hybrid New Zealand Red×Californian), with 5 rabbits per genetic type being slaughtered every 2 wk throughout the study period (9-17 wk) to evaluate the effect of age on these traits. Slaughter weight, reference yield, portion yield (hind leg, foreleg and fore part, as percentage of slaughter weight), meat yield, skin weight and the fat content of the meat (percentage of wet weight) increased significantly with age, while the full gastrointestinal tract, liver, head and feet decreased significantly. This is likely a reflection of the early-maturing nature of bone and viscera and later maturing nature of muscle and fat. These results indicate that delaying slaughter to 13 wk tends to improve yields for valuable carcass components. The Californian had a significantly higher total meat yield at 11 and 17 wk and higher portion meat yields at 9 (hind leg), 11 (hind leg and fore part) and 13 (foreleg) weeks than the hybrid. This was likely due to the later maturation of the hybrid and the influence of the New Zealand Red on carcass quality. It therefore appears that the Californian may be more favourable for meat production, from a carcass and meat quality perspective.

Key Words: rabbit, carcass, meat, Californian, New Zealand.

INTRODUCTION

With the continued concern for food security, particularly in developing countries, many role-players are looking at alternative species for meat production, with one of the options being the so-called 'mini-livestock'. Mini-livestock include species such as guinea pigs or cavies (*Cavia porcellus*), cane rats (*Thryonomys* spp.) and rabbits (*Oryctolagus cuniculus*), and have considerable potential for small scale production in Africa (Nuwanyakpa *et al.,* 1997; Hardouin *et al.,* 2003; Hoffman and Cawthorn, 2013). Rabbits, as possibly the most extensively researched mini-livestock species in terms of meat production, have been particularly focussed on (Lukefahr and Cheeke, 1991; Baruwa, 2014; Blaga and Burny, 2014).

Rabbits have the advantage of being farmed intensively while also being able to utilise high-fibre feeds better than poultry and convert feed to meat more efficiently than cattle or sheep (Lebas and Matheron, 1982; Lukefahr and Cheeke, 1991; Serem *et al.,* 2013). They are also renowned for their prolificacy and high growth rates, allowing intense selection pressure, early slaughter and rapid return on capital outlay (Serem *et al.,* 2013; Baruwa, 2014). Previous studies have also found that South Africans are relatively open to the consumption of rabbit meat, with the black population in particular considering it a healthy option (Hoffman *et al.,* 2004; Hoffman *et al.,* 2005). This suggests that rabbit farming could have potential in South Africa.

However, the conditions under which rabbits are farmed in South Africa are often somewhat different from those in Europe, with this including factors such as the higher ambient temperature and the nature of the feed used. In addition, the genetic isolation of South African rabbits that has resulted from approximately 32-year ban on their importation may have resulted in changes in the production potential of certain breeds. It is therefore necessary to

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assess the production potential of locally-available rabbit breeds in order to identify which would be most appropriate for use in development of the rabbit farming sector (Lukefahr and Cheeke, 1991).

The Californian rabbit played an integral role in the development of many of the hybrid lines popular in intensive modern systems used in developed countries (Lebas *et al.,* 1997), as well as often serving as a sire line in two-way crossing systems. One crossing system that is used by some farmers in South Africa produces first generation hybrids of the New Zealand Red (also known as the Dutch Red in South Africa) and Californian.

The aim of this study was to compare the carcass and meat yields of 2 genetic types available for meat production in South Africa, namely the purebred Californian and the New Zealand Red×Californian hybrid.

MATERIALS AND METHODS

Rearing and housing

Fifty Californian and hybrid (first generation New Zealand Red×Californian) rabbits, consisting of 13 female Californian, 12 male Californian, 12 female hybrid and 13 male hybrid, were used. These were purchased at 8 wk of age from a nearby farm and transported to Welgevallen experimental farm near Stellenbosch in the Western Cape of South Africa (33°56'45.9"S 18°52'02.2"E). The 25 rabbits of each breed were randomly allocated to individual cages equipped with metal feeders and automatic nipple water supply systems. The house was equipped with a fan for cooling, with an average ambient temperature during the trial period of 26–37°C recorded. The rabbits were fed a commercial diet formulated for calves that is commonly used by rabbit farmers in South Africa due to the lack of a readily available commercial rabbit feed. The diet contained 160 g protein, 150 g crude fibre, 120 g moisture, 25 g fat, 8 g calcium and 3.5 g phosphorus per kilogram and was supplied *ad libitum*.

Slaughter and carcass traits

Five randomly selected rabbits per breed were slaughtered at 9, 11, 13, 15 and 17 wk of age. The rabbits were fasted for 24 h and weighed prior to slaughter (slaughter weight). Slaughtering followed national regulations and carcasses were prepared as described by Blasco and Ouhayoun (1996). The weights of the full gastrointestinal tract, skin, head, feet, liver and kidneys were recorded, with the thymus, trachea, oesophagus, lungs and heart being recorded as a single weight (lung-heart). The reference carcass weight (carcass excluding head, all viscera and perirenal fat) was recorded after chilling the carcasses at 2-4°C for 24 h and was used in the calculation of the reference yield. The reference yield can be defined as the weight of the reference carcass as a percentage of the live weight at slaughter. The carcasses were divided using cut points 2, 4 and 5 as described by Blasco and Ouhayoun (1996): cut point 2 bisected the body between the last thoracic and first lumbar vertebra, with the thoracic wall being cut along the prolongation of the 12th rib; cut point 4 separated the forelegs, including the insertion and the thoracic muscles, from the body; and cut point 5 separated the hind legs, including the *os coxae* muscle and the posterior parts of the *psoas major* and *iliacus* muscles. The hind legs, forelegs and fore part (excluding forelegs and their muscle insertion points in the chest) were weighed and then deboned, with the meat and bone yields of each portion also being weighed. All weights were converted to percentages of the slaughter weight and the meat yield was calculated as the sum of the hind leg, foreleg and fore part meat yields.

Proximate analysis

The meat removed from each portion, including the subcutaneous fat, was cut into small pieces and finely minced to ensure a homogenous sample. The minced meat was vacuum-packed and stored at -20°C until used for proximate chemical analysis.

The moisture content was determined according to method 934.01 of the Association of Official Analytical Chemists' (AOAC, 2002) methodology, being weighed before and after drying at 100°C for 24 h. The dried samples were subsequently incinerated at 500°C for a minimum of 6 h, as specified by AOAC (2002) method 942.05, for determination of the ash content. The lipid content was determined by extracting with a chloroform:methanol (2:1)

mixture according to the method of Lee *et al.* (1996) and the protein content was determined according to the Dumas combustion method using a Leco FP-528 (AOAC, 2002; method 992.15).

All values are reported as percentages of the wet weight of the sample.

Statistical analysis

The experiment was performed in a completely randomised design, with 5 replications per breed per age and each rabbit carcass as an experimental unit. Levene's test was used to test for homoscedasticity and the Shapiro-Wilk test for normality. The General Linear Model (GLM) procedure was used to perform the one-way analysis of variance (ANOVA), testing for significant differences between genetic types for each age and between ages within each breed. Bonferroni's test was used to determine which individual ages differed from one another. Statistical tests were performed using SAS® version 9.3 statistical software and statistically significant differences were established at the 5% confidence level to compare treatment means.

RESULTS AND DISCUSSION

Effect of age

While the comparison of the growth curves obtained in this study with previous publications is difficult due to variation in the genetic types and rearing methods used, a general appraisal seems to indicate that growth rates were somewhat slower than previously reported (Pla *et al.,* 1996; Gómez *et al.,* 1998; Ozimba and Lukefahr, 1991; Maj *et al.,* 2009). This could have been due to genetic differences, the poor nutritional balance of the feed used or the relatively high ambient temperatures experienced during the growth phase. Reference yields also appeared to be lower than reported in literature for the rabbits slaughtered at 8 and 9 wk of age (Pla *et al.,* 1996; Gómez *et al.,* 1998), but were higher than those reported by Dalle Zotte *et al.* (2015) at 12 wk of age. However, once again the value of direct comparisons is questionable. The plateau in reference yield observed at 13 wk (Table 1, Figure 1) supports the South African commercial practice of slaughtering at this age and likely reflects differences in the relative growth rates of the different tissues and organs (Szendrő *et al.,* 1998; Dalle Zotte, 2002).

The increase in the reference yield was reflected in the significant decrease in the proportions of gastrointestinal tract, liver, head and feet with age (Table 1, Figure 1), with similar results being reported by Rao *et al.* (1978) and Szendrő *et al.* (1998). This is likely due to their early-maturing nature, as indicated by Huxley's coefficients of growth (k), which are below 1 for these tissues (Pascual *et al.,* 2008). There were no significant changes in the percentages of the kidneys and lung-heart group, possibly due to them having already reached their plateau in growth, as they are both early-maturing tissues (Pascual *et al.,* 2008). The percentages of these organs were both low (Table 1), as found by Dalle Zotte *et al.* (2015). The contribution of the skin increased significantly with age (Figure 1), which could reflects its somewhat later maturation relative to the body as a whole (Szendrő *et al.,* 1998; Pascual *et al.,* 2008; Dalle Zotte, 2015).

The high-value hind leg portion made the greatest contribution of the three portions weighed, as previously reported (Pla *et al.,* 1996; Szendrő *et al.,* 1998). While there was a significant effect of age on this portion, this did not reflect much of an overall trend in the proportion of hind leg, suggesting that growth had already plateaued for this part of the carcass, particularly from 13 wk onwards (Table 1). A similar lack of change was found for the forelegs, which is to be expected as isometric growth has been reported previously for this cut (Pascual *et al.,* 2008). The significant increase in the proportion of the forelegs from 15 to 17 wk in the Californian was unexpected and may have been due to sampling error or the relatively small sample size used.

The fore part portion showed a significant increase from 9 to 13 wk in the hybrid and from 9 to 11 wk in the Californian. While a later growth pattern is expected for this portion than the forelegs ($k_{fore\ part}$=1.13; $k_{forelegs}$=0.99; Pascual *et al.,* 2008), it is somewhat surprising that it continued to show a considerable amount of growth in the absence of corresponding growth in the hind legs, as these 2 portions have been reported to have similar values for Huxley's allometric coefficient (Pascual *et al.,* 2008). However, Butterfield's coefficient is somewhat lower for the fore part than the hind leg, suggesting later maturation for the former (Pascual *et al.,* 2008).

Table 1: Effects of age and breed on the proportion (percentage of slaughter weight) of carcass components in rabbits (mean±standard error).

		Age (weeks)					
	Breed	9	11	13	15	17	*P*-value
Slaughter weight (g)	Calif.	1161^{a}±31	1605^{b}±43	2018^{c}±31	2514^{d}±21	3061^{e}±107	<0.01
	Hybrid	1060^{a}±31	1578^{b}±11	2110^{c}±25	2571^{d}±28	3133^{e}±131	<0.01
	P-value	0.05	0.55	0.05	0.14	0.68	
hind leg portion	Calif.	17.21_{a}±0.65	18.62_{ab}±0.16	19.32_{a}±0.30	19.25_{a}±0.21	19.10_{a}±0.38	<0.01
	Hybrid	15.68_{c}±0.41	17.49_{b}±0.53	19.28_{c}±0.39	19.47_{c}±0.21	18.62_{bc}±0.19	<0.01
	P-value	0.08	0.07	0.94	0.49	0.29	
hind leg bone	Calif.	4.10_{b}±0.13	4.10_{b}±0.13	4.47_{b}±0.13	4.29^{b}_{b}±0.06	3.29_{a}±0.14	<0.01
	Hybrid	4.32_{b}±0.16	4.44_{b}±0.18	4.63_{b}±0.16	4.45^{a}_{b}±0.03	3.11_{a}±0.16	<0.01
	P-value	0.32	0.17	0.45	0.05	0.43	
foreleg portion	Calif.	7.04_{a}±0.41	7.34_{a}±0.25	8.40^{a}_{a}±0.31	8.31_{a}±0.08	10.11_{b}±0.48	<0.01
	Hybrid	6.57_{a}±0.38	7.14_{ab}±0.11	7.57^{b}_{ab}±0.18	8.13_{bc}±0.33	9.00_{c}±0.34	<0.01
	P-value	0.43	0.49	0.05	0.61	0.10	
foreleg bone	Calif.	1.60_{b}±0.09	1.52_{ab}±0.05	1.77_{b}±0.03	1.68^{b}_{b}±0.03	1.31_{a}±0.08	<0.01
	Hybrid	1.82_{bc}±0.08	1.57_{ab}±0.03	1.69_{abc}±0.05	1.84^{a}_{c}±0.04	1.51_{a}±0.08	<0.01
	P-value	0.11	0.41	0.20	0.01	0.12	
fore part portion	Calif.	4.20_{a}±0.36	10.23_{b}±0.47	11.40_{b}±0.83	11.00_{b}±0.28	11.01_{b}±0.20	<0.01
	Hybrid	5.10_{a}±0.23	9.04_{b}±0.26	11.61_{c}±0.39	10.47_{bc}±0.65	10.04_{bc}±0.46	<0.01
	P-value	0.07	0.06	0.83	0.48	0.09	
fore part bone	Calif.	1.40_{a}±0.09	1.59_{ab}±0.13	1.74_{ab}±0.12	1.84_{b}±0.06	1.61_{ab}±0.05	0.04
	Hybrid	1.52±0.08	1.83±0.05	1.72±0.08	1.76±0.05	1.53±0.13	0.06
	p-value	0.38	0.12	0.91	0.31	0.57	
full gastrointestinal tract	Calif.	24.04_{c}±1.52	18.85_{b}±1.14	16.43_{ab}±0.35	15.03_{ab}±0.62	14.56_{a}±0.44	<0.01
	Hybrid	26.90_{c}±2.14	20.86_{b}±0.98	16.68_{ab}±0.90	16.41_{ab}±1.20	14.72_{a}±0.57	<0.01
	P-value	0.31	0.22	0.80	0.34	0.83	
lung-heart	Calif.	1.50±0.07	1.28±0.03	1.24±0.14	1.11±0.08	1.25^{a}±0.04	0.05
	Hybrid	1.21±0.11	1.32±0.10	1.19±0.10	1.10±0.10	1.07^{b}±0.03	0.38
	P-value	0.05	0.68	0.79	0.95	0.01	
liver	Calif.	3.42_{b}±0.45	3.01_{ab}±0.18	2.45^{b}_{ab}±0.08	2.39_{a}±0.11	2.38_{a}±0.06	0.01
	Hybrid	3.21_{cb}±0.11	3.39_{c}±0.12	2.74^{a}_{ab}±0.07	2.67_{ab}±0.17	2.47_{a}±0.19	<0.01
	P-value	0.66	0.12	0.03	0.20	0.66	
kidney	Calif.	0.94±0.09	1.10±0.10	0.84±0.04	0.83±0.04	0.93±0.09	0.11
	hybrid	0.78±0.01	0.83±0.08	0.91±0.05	0.86±0.06	0.78±0.04	0.36
	p-value	0.10	0.07	0.27	0.61	0.14	
head	Calif.	6.14^{b}_{c}±0.11	5.85_{bc}±0.17	5.70_{abc}±0.13	5.02_{ab}±0.30	4.87_{a}±0.20	<0.01
	Hybrid	7.27^{a}_{c}±0.26	5.99_{b}±0.04	5.52_{ab}±0.30	5.64_{ab}±0.16	4.96_{a}±0.20	<0.01
	P-value	<0.01	0.46	0.58	0.10	0.77	
feet	Calif.	3.32_{c}±0.11	3.17_{bc}±0.19	2.66_{ab}±0.07	2.40_{a}±0.11	2.14^{b}_{a}±0.13	<0.01
	Hybrid	3.50_{c}±0.09	3.38_{bc}±0.20	2.46_{ab}±0.06	2.84_{a}±0.17	2.70^{a}_{a}±0.16	<0.01
	P-value	0.23	0.46	0.06	0.07	0.03	

[a-e]Means with different superscript within the same row differ significantly ($P<0.05$, Bonferroni test).
SE: Standard error; Calif.: Californian.

The meat content of the portions, as well as the total meat yield, increased with age (Figure 2), while the bone content decreased in the hind and forelegs (Table 1). Similar results were reported by Szendrő *et al.* (1998), who found an increase in the proportion of meat on the hind leg, and Rao *et al.* (1978) who found that the meat to bone ratio increased with slaughter age. This change in the proportions of meat and bone was expected, as bone is an early maturing tissue (Pascual *et al.,* 2008).

The increase in the meat yield found in this study could also be partly attributed to an increase in the fat content of the carcass, as both intramuscular and subcutaneous fat were included in the deboned meat. The growth of the lipid portion of the carcass is reflected in the significant increase in the extracted fat determined during proximate analysis (Table 2) and is in agreement with the late maturing nature of fat (Pla *et al.,* 1996; Szendrő *et al.,* 1998; Pascual *et al.,* 2008). The fat content of the meat was considerably higher than reported in literature (Rao *et al.,* 1978; Szendrő *et al.,* 1998), but this may be due to the subcutaneous fat being included in the deboned meat or differences in the cuts used, as the hind leg and belly tend to contain more fat than the loin (Szendrő *et al.,* 1998). The high fat content could also be due to the relatively low protein content of the feed used in this study (Szendrő *et al.,* 1998).

The increase in the fat content of the meat was mirrored by a decline in the moisture and protein content, with the highest protein values being found at 9 to 11 wk

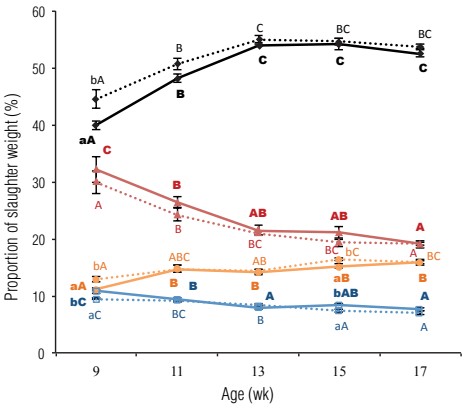

Figure 1: The effect of age and breed on the proportion (percentage of slaughter weight) of different carcass components in rabbits. Means with different lowercase letters (a, b) differ significantly between genetic types and means with different uppercase letters (A, B, C) differ significantly between slaughter ages ($P \leq 0.05$, Bonferroni test). Error bars indicate the standard error. HB – New Zealand Red×California hybrid (significance letters in bold - **A, B, C, a, b**); CB – Californian rabbit (significance letters - A, B, C, a, b). HB reference carcass; HB viscera; HB skin; HB head+feet; CB reference carcass; CB viscera; CB skin; CB head+feet.

Table 2: Effects of age and breed on the proximate composition (percentage of wet weight) of rabbit meat (mean±standard error).

		Age (wk)					
	Breed	9	11	13	15	17	*P*-value
% Moisture	Calif.	$74.14_{c}\pm0.25$	$68.57_{b}\pm1.29$	$68.10_{b}\pm0.65$	$65.69^{b}_{b}\pm1.08$	$55.83^{b}_{a}\pm1.18$	<0.01
	Hybrid	$85.76_{c}\pm0.73$	$71.22_{bc}\pm0.86$	$68.77_{b}\pm0.43$	$68.90^{a}_{b}\pm0.86$	$62.37^{a}_{a}\pm2.02$	<0.01
	P-value	0.07	0.13	0.41	0.05	0.02	
% Protein	Calif.	$19.67_{bc}\pm0.55$	$20.60_{c}\pm1.09$	$15.75^{b}_{a}\pm0.52$	$17.51_{ab}\pm0.49$	$16.73_{ab}\pm0.59$	<0.01
	Hybrid	$20.68_{b}\pm0.39$	$20.38_{b}\pm0.55$	$18.54^{a}_{ab}\pm0.08$	$16.79_{a}\pm0.87$	$17.79_{a}\pm0.19$	<0.01
	P-value	0.18	0.86	<0.01	0.49	0.12	
% Fat	Calif.	$5.56^{a}_{a}\pm0.39$	$9.01^{a}_{b}\pm0.40$	$14.43^{a}_{c}\pm0.83$	$14.95_{c}\pm0.8$	$24.98^{a}_{d}\pm0.90$	<0.01
	Hybrid	$3.12^{b}_{a}\pm0.87$	$7.18^{b}_{ab}\pm0.49$	$11.07^{b}_{bc}\pm0.37$	$12.65_{c}\pm1.01$	$17.89^{b}_{d}\pm2.18$	<0.01
	P-value	0.03	0.02	0.01	0.11	0.02	
% Ash	Calif.	$1.29_{ab}\pm0.06$	$1.16_{ab}\pm0.04$	$1.59_{b}\pm0.22$	$1.09_{a}\pm0.03$	$1.09^{b}_{a}\pm0.03$	0.02
	Hybrid	1.23 ± 0.05	1.18 ± 0.02	1.34 ± 0.03	1.20 ± 0.05	$1.32^{a}\pm0.06$	0.06
	P-value	0.42	0.58	0.30	0.09	0.01	

[ab] Means with different superscript letters in the same column (within traits) differ significantly ($P \leq 0.05$, Bonferroni test).

[a-d] Means with different subscript letters within the same row differ significantly ($P \leq 0.05$, Bonferroni test).

SE: Standard error; Calif.: Californian.

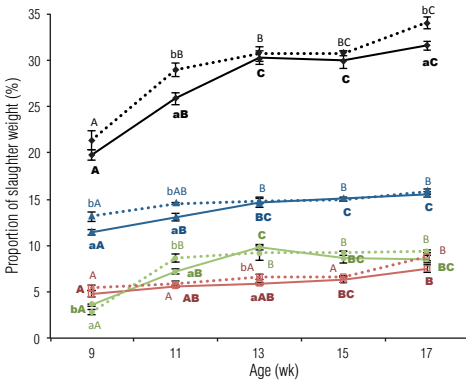

Figure 2: The effect of age and breed on the total meat yield (percentage of slaughter weight) as well as the proportions of meat in each cut (hind leg, fore leg and fore part). Means with different lowercase letters (a, b) differ significantly between genetic types and means with different uppercase letters (A, B, C) differ significantly between slaughter ages ($P \leq 0.05$, Bonferroni test). Error bars indicate the standard error. HB – New Zealand Red x California hybrid (significance letters in bold - **A, B, C, a, b**); CB – Californian rabbit (significance letters - A, B, C, a, b). HB total meat yield; HB hind leg meat; HB fore part meat; HB fore leg meat; CB total meat yield; CB hind leg meat; B fore part meat; CB fore leg meat.

of age (Table 2). This is in contrast with the results of Rao *et al.* (1978), who found no significant change in the protein content with age. The protein content was low relative to values in literature (18.6-23.2%), but as with the fat content, this may be due to differences in the cuts considered (Rao *et al.,* 1978; Szendrő *et al.,* 1998). The decline in the moisture content was likely just a consequence of the increase in the fat content with age (Rao *et al.,* 1978).

The ash content of the meat fell within the norms reported in literature (Szendrő *et al.,* 1998), with a tendency to decrease with age being seen in the Californian, but with no significant change or obvious trend found in the hybrid. Similar results were reported by Szendrő *et al.* (1998).

Effect of breed

As can be seen in Table 1 and Figure 1, the differences between the genetic types in slaughter weight and reference yield were minor. The Californian had a higher slaughter weight and reference yield than the hybrid at 9 wk of age (Table 1). However, the hybrid was heavier at the commercial slaughter age of 13 wk. This may have been due to the effects of heterosis; however, as heterotic effects on growth are usually minor, it more likely reflects differences in the rate of maturation and mature weight of the 2 genetic types (Tůmová *et al.,* 2014; Bura *et al.,* 2015).

The proportions of skin at 9 and 15 wk and lung-heart at 17 wk were higher for the Californian, while the hybrid had greater proportions of liver at 13 wk, head at 9 wk and feet at 17 wk (Table 1, Figure 1). The differences in the proportions of head and feet support the conclusion that the higher mature weight of the New Zealand Red resulted in the hybrid being less mature at the same chronological age as the Californian (Dalle Zotte, 2002; Steenekamp, 2014). Moreover, the New Zealand White has previously been found to have poorer carcass conformation than the Californian, and this may be true of the New Zealand Red as well (Medellin and Lukefahr, 2001). However, further research on the pure New Zealand Red is necessary to confirm this.

The only significant difference between the genetic types in the contributions of each portion was the higher percentage of the foreleg in the Californian at 13 wk (Table 1). Greater differences were found in the percentages of meat and bone in each portion, with the Californian having higher proportions of meat in the hind leg at 9 and 11 wk, in the foreleg at 13 wk and in the fore part at 11 wk (Figure 2). The hybrid also had higher proportions of bone in the hind and forelegs at 15 wk (Table 1). The total meat yield was significantly higher in the Californian at 11 and 17 wk and tended to be higher throughout the growth period (Figure 2). This relatively high meat yield is typical of the Californian breed, which is well known for producing carcasses with a high meat to bone ratio (Ozimba and Lukefahr, 1991; Serem *et al.,* 2013). The hybrid did have significantly more meat in the fore part at 9 wk (Figure 2), which was not expected; however, this difference was reversed by 11 wk and may have been due to sampling error.

The higher proportion of meat in the Californian may also be partly due to the greater proportion of fat in this breed, as reflected by the higher total lipid found during proximate analysis (Table 2). This is typical of a more physiologically mature animal and supports the conclusion that the hybrid was less mature at the same age (Dalle Zotte, 2002).

Differences between the genetic types in the other proximate components were limited, with the higher fat content being reflected in a lower percentage of moisture at 15 and 17 wk and protein at 13 wk in the Californian. The percentage of ash was only significantly higher in the hybrid at 17 wk of age (Table 2).

CONCLUSIONS

An increase in slaughter age was characterised by a decrease in the proportion of organs and an improvement in muscular development, resulting in higher reference yields and meat yields. The plateau in reference yield at 13 wk supports slaughtering at this age.

The Californian tended to have slightly higher reference yields and meat yields than the hybrid, suggesting that it is more favourable for meat production in terms of carcass quality. However, further research into the efficiency of production and reproduction of these genetic types is required to conclusively determine which is more suitable for development in South Africa.

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