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EFFECT OF BREED AND SEX ON RABBIT CARCASS YIELD AND MEAT QUALITY

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ABSTRACT : The objective of this work was to determine the differences on yield and quality of carcasses of different sex (male and female) and breed (New Zealand (NZ), Californian (CA), Chinchilla (CH) and Rex (RX)). Ten rabbits (balanced sexes) of each breed were used. Rabbits were grown under the same conditions, fed the same commercial diet and slaughtered when reached Mexican commercial weight (2.00 kg). Carcass yield, percentage of the main tissues, chemical composition of meat, shear force of cooked *longissimus dorsi* muscle and sensorial characteristics were evaluated. Main effects (breed and sex) and interactions were statistically analyzed. Breeds were similar on dressing percentages. However, meat from NZ carcasses had the higher dripping losses (5.44%); NZ male had heavier skin compared to their female counterparts. Carcass composition was very similar among breeds. Male had a higher percentage ($P<0.05$) of bone compared to female (17.69 and 16.18, respectively). CH female had higher inter-muscular fat than NZ female (3.99 % *vs* 2.08%). Meat composition was also very similar among breeds with the exception of dry matter percentage. CA females had more intra-muscular lipds than CA male. Shear force was similar among breeds and sexes. No differences were found for aroma, flavor and general satisfaction. However, RX meat was the most tender ($P<0.05$) compared to the CA meat (5.38 and 4.85, respectively), when sensorily evaluated. In conclusion, regardless of the production purposes of the breed (meat or fur), carcass yield and meat quality are very similar for rabbits slaughtered at 2.00 kg.

RÉSUMÉ : Effet de la race et du sexe sur le rendement à l'abattage et la qualité de la viande de lapin.
Le but de ce travail a été d'évaluer les différences de rendement à l'abattage et de qualité de la viande selon le sexe (mâle et femelle) et la race (Néo-zélandais (NZ), Californien (CA), Chinchilla (CH) et Rex (RX)). Pour chaque race, 5 mâles et 5 femelles ont été utilisés. Ils ont été élevés dans les mêmes conditions, ont été nourris avec même aliment commercial et abattus lorsqu'ils ont atteints le poids commercial au Mexique : 2,00 kg. Le rendement à l'abattage, le pourcentage des principaux muscles, la composition chimique de la viande, la force de cisaillement du muscle long dorsal cuit, et les caractéristiques sensorielles ont été évalués. Les principaux effets (race et sexe) et leur interaction ont été analysés statistiquement. Le rendement à l'abattage a été similaire pour toutes les races. Cependant, la perte au ressuyage la plus élevée (5,44%) concerne les carcasses des NZ; la peau des NZ mâles est plus lourde que celle des femelle NZ. La composition des carcasses varie peu selon les races. Comparés aux femelles, les mâles ont un pourcentage plus élevé ($P<0,05$) d'os (17,69 *vs* 16,18%). Les femelles CH ont plus de gras inter-musculaire (3,99 % *vs* 2,08%) que les femelles NZ. La composition de la viande a été très proche pour toutes les races sauf pour le pourcentage de matières sèches. Les femelles CA ont plus de lipides intra-musculaire que les mâles de même race. La force de cisaillement a été similaire pour les 4 races et pour les 2 sexes. Aucune différence n'a été perçue pour l'arôme, le parfum ou la note de satisfaction générale. Cependant lors de l'évaluation sensorielle, la viande des RX a été considérée la plus tendre ($P<0,05$) comparée à celle des CA (notes de 5,38 et 4,85 respectivement). En conclusion, si on ne tient pas compte de l'objectif général de production de la race (viande ou fourrure), le rendement le rendement à l'abattage et la qualité de la viande sont tout à fait similaires lorsque les lapins sont abattus au poids commun de 2,00 kg,

INTRODUCTION

Commercial rabbit production in Mexico has a great potential because it produces a highly nutritious meat at low cost. Rabbits have high growth rate, high feed efficiency, an early marketing age and require a small land area; therefore rabbits can be grown by low income producers. The most used meat breeds in Mexico are New Zealand (NZ) and Californian (CA); however, in recent years, production included Chinchilla (CH) and Rex (RX) breeds, mainly for their fur. Few studies had been carried out in Mexico to study carcass quality and yield, and they have been mainly for NZ breed (CORTÉS, 1978; DOMÍNGUEZ, 1982; FRAGOSO, 1993). LEBAS (1989) mentioned that some particular zootechnical qualities could be found between different breeds in the same breeding environment due to the differences in genotypic values. These comparisons allow us to acknowledge the best breed for the type of production one wishes to establish. The purpose of this study is to determine the differences in yield and meat quality of rabbit carcasses (both sexes) from breeds specialized in meat, such as CA and NZ, and fur production, CH and RX..

MATERIALS AND METHODS

In this research, 40 rabbits (balanced sexes) from CA, NZ, CH and RX breeds (10 each) were used. Animals were fed *ad-libitum* with a commercial diet. Rabbit final weight was established between 1.95 and 2.05 kg. CA, NZ and CH rabbits were 70 days old at the time of slaughter, and RX rabbits were 80 days old at the time of slaughter. The animals were slaughtered without previous fasting by dislocating the first cervical vertebrae and cutting the jugular veins and carotid arteries. All animals were slaughtered the same day. Carcasses were refrigerated for 6 hours at 4 °C and the weight of the cold carcass was obtained.

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Table 1 : Effect of breed, sex and interaction on rabbit carcass characteristics.

PRODUCTION		BREEDS					SEX				INTER-ACTION
		MEAT		FUR							
		CA	NZ	CH	RX			F	M		
Parameters	n	*Means*	*Means*	*Means*	*Means*	*EE*	n	*Means*	*Means*	*EE*	P<0.05*
Live weight (g)	40	1999.7	1998.3	1966.9	1939.0	43.7	40	2020.0	1932.0	30.9	ns
Cold carcass wt. (g)	40	1130.5	1154.5	1173.5	1138.0	27.5	40	1168.5	1129.8	19.5	ns
Dressing percent (%)	40	55.24	54.65	57.80	56.76	1.04	40	55.76	56.45	0.74	ns
Drip loss (%)	40	2.57[a]	5.44[b]	3.37[a]	3.22[a]	0.67	40	3.54	3.76	0.47	ns
Skin (%)	40	13.14	13.96	12.96	12.89	0.04	40	13.20	13.45	0.19	BxS*
Scraps (%)	40	30.16	28.40	26.80	28.50	1.24	40	28.95	27.93	0.88	ns
Head (%)	40	10.60[a]	12.46[b]	11.80[a]	11.20[a]	0.44	40	11.6	11.40	0.31	BxS*

[a,b,c] Means with different superscripts in the same row and within main effects are significantly different (P<0.05)

Dressing percentage was obtained from cold carcass weight. Cold carcasses had the head on. After determining yields, the head was cut off and weighed. The following measures were taken to determine carcass yield: live weight (before slaughter), hot carcass weight, skin weight, scraps (heart, kidneys, lungs, liver, stomach, intestines and the distal parts of fore and hind legs), and head weights.

Left side carcasses were used to obtain primal cuts by the technological division (BLASCO *et al.*, 1992) and to carry out the dissection procedures. Muscle, bone, fat, nerves, blood vessels and fascia were dissected to determine carcass composition. Fat was separated into internal (mesenteric and renal), subcutaneous and inter-muscular fat. The percentage from each dissected part was obtained in relation to the half carcass.

Chemical composition of the meat from the carcasses was obtained using *L. dorsi* muscle from the right half carcass. Protein was determined with the KJELDHAL method (AOAC, 1990), dry matter percentage by dry oven (AOAC, 1990), ashes percentage by calcination (550°C in Heraeus oven; AOAC, 1990) and percentage of fat by the Goldfish method (AOAC, 1990).

The dissected left *L dorsi* muscle of each carcass was used to measure shear force using a Warner Bratzler machine (Salter, G-R Elec. Mfg. Co, Manhattan, KS, USA). The muscle was cooked in an electric stove until the geometrical center of the piece was 70°C (recorded using iron-constantan thermocouples of 0.127 mm in diameter). It was allowed to cool down at room temperature for 2 hours. Once the meat was cold, cylinders of 1.27 cm wide with the fibres oriented parallel to their length were obtained using the standard metallic cylinder for WB connected to an electric driller. The shear force and cook losses were registered.

Sensory analyses were run using 85 non-trained (consumer) panelists (MORTEN, 1991). Right legs (without fat or connective tissue) were cooked with the same technique used for the shear force test. After cooking, the leg was cut into 10 g portions (MORTEN, 1991) and two pieces served to each consumer. Panelists were given an affective test to evaluate flavor, tenderness, aroma, and general satisfaction, using a 7-point hedonic scale: 1 (dislike a lot), 4 (nor like, nor dislike) and 7 (liked a lot).

A descriptive analysis of the data was performed. Analysis of variance was used to determine the effects of breed and sex on the parameters measured (SAS, 1991). The model included main effects and the interaction. When significant differences were found for breed, means were submitted to the LSmeans analysis. Sensory data was analyzed using a non-parametric analysis, Kruskal-Wallis, where the only main effect was breed.

RESULTS AND DISCUSSION

The effects of breed, sex and the interactions on the carcass characteristics are presented on Table 1. It can be observed that, as planned, animals reached the same final weight. No significant differences were found among the dressing percentages of the different breeds. COBOS *et al.* (1995) and HULOT *et al.* (1994) reported an average dressing percentage for crosses of NZ and CA rabbits of 58% and for NZ of 60%, for 2 kg and 2.5 kg, respectively, which is three and five points above of those found in this study. On the other hand, PILES and PLA (2000), reported average dressing percentage of 56.4% for crosses of CA, which is similar to those found in this study for the breeds specialized in fur production, RX and CH. Dressing percentage was not affected by sex.

Breed affected drip losses, NZ carcasses being the ones to lose most moisture during the cooling period. HULOT *et al.* (1994) reported drip losses of 2% which is similar to that found for CA, CH and RX and much lower than found for NZ. NZ carcasses' drip losses affected their final dressing percentage, in such a way that they would not be classified as good commercial carcasses. PILES and PLA (2000) reported a head percentage of 8.51 compared to the 11.51% that was found in this study.

Sex did not influence any of the carcass characteristics; however positive interactions were found between sex and breed for the percentages of skin and head. In most species, males have higher potential growth than females, but in rabbits, these differences are not as important due to the fact that they are slaughtered at a very young age, before they reach puberty, when the differences are highly remarkable (BERNARDINI *et al.*, 1995). OUHAYOUN (1984) mentioned that sexual dimorphism is expressed by a higher weight, but is not present before fifteen weeks, that could explained why no differences were found in this study between sexes for carcass yield. BERNARDINI *et al.* (1995) mentioned that the head percentage in male is higher in relation to female (8.05 and 8.0, respectively). Female rabbits from NZ breeds had higher (P<0.05) head percentages than NZ males (13.36 *vs* 10.38%, respectively); however females from CA, CH and RX had similar head percentages to their same breed males. It was also found that males from NZ had heavier (P<0.05) skin compared to their female counterparts (15.32 *vs* 12.02, respectively). On the other hand, CA males had lighter skin than CA females (12.06 *vs* 14.21%, respectively). Head percentage on CH and RX males and females were similar.

The effects of breed, sex and interactions on carcass composition are shown on Table 2. Breed and sex had no influence on the carcass muscle percentage. However, CA and RX carcasses have a tendency to present the higher (P<0.05) muscle percentages (68.82% and 66.39%, respectively) compared to CH and NZ (64.56% and 62.25% respectively); which indicates that the RX and CA carcasses have a higher edible portion.

Results showed that females had a lower (P<0.05) percentage of bone (16.18% and 17.69%, respectively) and a similar percentage (P>0.05) of muscle to males (67.94% and 64.57%, respectively). BERNARDINI *et al.* (1995) reported that females had a better muscle/bone relation in contrast to males (7.3/1 and 7.1/1 respectively).

No significant differences were found among breeds or sexes for total, subcutaneous or internal fat percentages. However, internal fat percentage was similar for all the breeds; although no significant differences were found, NZ animals had the lowest values. BERNARDINI *et al.* (1995) mentioned that the drip losses are influenced by the little amount of perirenal fat; this agrees with the data obtained in this study, where NZ carcasses had the lowest value of internal fat (although not statistically different) and the higher (P<0.05) drip loss (2.6%). Even though internal fat is not the only factor (relation muscle/bone, handling, transport, refrigeration, etc) that influences the drip loss, the two are highly related (BERNARDINI *et al.*, 1995; COPPINGS and EKHATOR, 1990). The interaction between breed and sex for intermuscular fat was found significant. However, the only differences found were between CH females and NZ females (3.96 *vs* 2.08%).

Table 3 presents the effects of breed, sex and interactions on the chemical composition parameters and physical properties of *L. dorsi* muscle from rabbits. Muscle lipid content showed a significant interaction for breed and sex. CA females had more intramuscular lipids than CA males; on the other hand, NZ males had a higher percent of lipids in the meat than NZ females. CH and RX males and females had similar percentages of intramuscular lipids. RX meat had the highest percentage of dry matter compared to CA and CH meat. Dry matter from NZ meat was similar to the other breeds. Sex did not influence dry matter, protein and ash percentages. Comparing to data from COBOS *et al.* (1995) we found that in *L. dorsi* muscle average percent of protein and dry matter were very similar to the data found in their study for total muscles of the carcass (18.59 and 27.5 *vs* 19.10 and 26.40, respectively) However, lipids were much lower (2.2 *vs* 7.8) in the present research, due to the choice of the muscles : *L. dorsi* in our case and total muscles in the work

Table 2 : Effect of breed, sex and interaction on rabbit carcass composition.

PRODUCTION	BREEDS						SEX				INTER-ACTION
		MEAT		FUR							
	n	CA	NZ	CH	RX		n	F	M		
Tissues (%)		*Means*	*Means*	*Means*	*Means*	*EE*		*Means*	*Means*	*EE*	P<0.05*
Muscle	40	68.82^{a}	62.25^{a}	64.56^{a}	66.39^{a}	1.88	40	67.94^{a}	64.57^{a}	1.32	ns
Bone	40	17.04^{a}	17.59^{a}	17.22^{a}	15.9^{a}	0.56	40	16.18^{a}	17.69^{b}	0.40	ns
Fat Total	40	7.31^{a}	5.96^{a}	6.50^{a}	7.21^{a}	0.66	40	6.70^{a}	6.78^{a}	0.47	ns
Subcutaneous	40	1.57^{a}	1.53^{a}	1.39^{a}	1.78^{a}	0.27	40	1.40^{a}	1.60^{a}	0.20	ns
Internal	40	2.07^{a}	1.66^{a}	2.02^{a}	2.53^{a}	0.27	40	2.03^{a}	2.01^{a}	0.19	ns
Intermuscular	40	3.66^{a}	2.77^{a}	3.34^{a}	2.91^{a}	0.35	40	3.27^{a}	3.07^{a}	0.25	BxS*
Other*	40	8.73^{a}	9.23^{a}	8.55^{a}	8.04^{a}	0.51	40	8.33^{a}	8.94^{a}	0.36	ns

^{a,b} Means with different superscripts in the same row and within main effects are significantly different (P<0.05)
*Other= nerves, blood vessels and fascia.

Table 3 : Effect of breed, sex and the interaction on the chemical composition and physical properties of the rabbit *Longisimus dorsi*.

PRODUCTION		BREEDS					SEX				INTER-ACTION
		MEAT		FUR							
	n	CA	NZ	CH	RX		n	F	M		
Parameters		*Means*	*Means*	*Means*	*Means*	*EE*		*Means*	*Mean*	*EE*	P<0.05*
Fat	40	2.15	2.30	2.12	2.28	0.15	40	2.24	2.19	0.10	BxS*
Dry matter	40	24.43^{a}	27.37^{a,b}	25.16^{a}	28.66^{b}	0.90	40	26.31	26.51	0.64	Ns
Protein	24	19.21	19.07	19.21	18.86	0.34	24	19.19	19.15	0.25	Ns
Ashes	24	4.44	4.52	4.43	4.49	0.09	24	4.49	4.44	0.06	Ns
Cooking losses (g)	112	4.50^{a}	4.86^{a}	5.24^{b}	5.23^{b}	0.12	112	5.17^{a}	4.78^{b}	0.09	BxS*
Warner Bratzler (kg/cm^2)	112	2.45	2.81	2.29	2.31	0.23	112	2.33	2.51	0.16	Ns

^{a,b} Means with different superscripts in the same row and within main effects are significantly different (P<0.05)

Table 4 : Effect of breed on sensorial characteristics of rabbit meat.

Production		BREED				
		MEAT		FUR		
Parameter	n	CA	NZ	CH	RX	EE
Aroma	85	5.01	4.75	5.08	4.97	0.11
Flavor	84	4.96	4.72	5.08	4.95	0.38
Tenderness	85	4.82^{a}	5.00^{ab}	5.04^{ab}	5.38^{b}	0.14
General satisfaction	85	4.85	4.85	5.11	5.08	0.12

^{a,b} Means with different superscripts in the same row are significantly different (P<0.05)
* Scale: 1= dislike a lot, 7= like a lot.

of COBOS *et al* (1995). PILES and PLA (2000) analyzed meat composition on the hind leg of CA crosses, obtaining a 4.16% of lipids, 21.13% of protein and 73.91% of moisture, which are basically very similar to the data of CA *L. dorsi* meat found in this study.

A significant interaction was found for cooking loss. RX males had lower cooking losses compared to RX females. No differences were found between sexes for CA, CH and NZ breeds. CA females had lower (P<0.05) cooking loss compared to the CH, NZ and RX females (4.5 *vs* 5.1, 5.03 and 6.05). Also, CH males had the highest (P<0.05) cooking loss compared to the other males (5.4 *vs* 4.5, 4.65 and 4.6, respectively).

Shear force test showed that cooked meat from all the breeds and sexes were similar (Table 3). COPPINGS and EKHATOR (1990) reported higher cutting force (3.28 kg/cm²) in relation to those found in this study. Another research (MACIAS *et al.*, 1998), in which the tenderness between the CH and NZ breeds was studied, the shear force was lower (1.86 kg/cm² and 1.78 kg/cm² respectively) compared to that of this research. MACIAS et al (1998) found no differences (P>0.05) between breeds. Meat tenderness can be influenced by the conservation methods, refrigeration and freezing (MACIAS *et al.*, 1998). When freezing the carcass, the tenderness in rabbit meat increases (COPPINGS and EKHATOR, 1990), this could be one of the reason we found these differences.

Sensory evaluation results are presented on Table 4. No significant differences were found in relation to aroma, flavor and general satisfaction among breeds. RX meat tenderness was the most liked compared to that of CA breed (5.38 *vs* 4.85, respectively). No differences were found for tenderness among CA, CH and NZ breeds.

This study showed that if the same feeding levels and handling techniques are used to the point of having the same final weights, breeds specialized for fur (CH and RX) have similar carcass and meat characteristics to those specialized for meat (CA and NZ).

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