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MEAT QUALITY AND MUSCLE FIBRE TRAITS IN RABBITS OF DIFFERENT GENETIC ORIGIN AND SEX

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Introduction

In some EU countries of Latin origin, such as Italy, France and Spain, the breeding of rabbits for meat production purpose is greatly diffuse. In these countries, the rabbit meat represents the fourth meat consumed, after pig, beef and poultry meats. Intensive rabbit meat production is based on the use of hybrid rabbits, extracted from a few breeds and strongly selected for production traits. The hybrid rabbits are nowadays showing poor resistance to some diseases, which increases the use of chemicals. On the other hand, the actual consumer is now looking for safer meats, obtained with the respect of the animal welfare and with good nutritional and sensory attributes. For these main reasons, the needs for the use of rabbit breeds, purebred or their crosses, showing a good resistance to diseases is emerging, with the aim to reduce or stop the use of chemicals for the benefit of the consumer. However, unselected breeds often show poor growth and carcass yield. Among the adoptable breeds, Vienna Blue and Burgundy Fawn ones seem to be adequate to be introduced for this purpose.

Objectives

The aim of this study was to compare the chemical composition of the hind leg meat, the pHu and L*a*b colour of BF and LL muscles, the fibre type distribution and dimension, and the enzymatic activity of the LL muscle of rabbits of both sexes derived from 2 sire genetic origins, Vienna Blue and Burgundy Fawn, and the commercial hybrid rabbit. The study aimed also to investigate on the relationship between some muscle fibre traits and some indicators of the meat quality in rabbits of different genetic origin (GO). The meat quality analysis and the muscle fibre characteristics of B and F animals was performed in order to find that GO whom can give the best growth and meat performance, without renouncing at the viable attitudes of unselected rabbits.

Methodology

Forty-five rabbits of both sexes, derived from offspring of three GO (B = sire Vienna Blue, F = sire Burgundy Fawn and H = hybrid rabbits), were used. The mother origin of B and F GO was a mongrel. From weaning onward, all the animals were caged by pairs

indoor and fed ad libitum the same pelleted diet until the slaughter weight, fixed at 2.8±0.11kg. Within 10 minutes after death a sample of Longissimus lumborum (LL) muscle was removed from each rabbit, frozen in isopentane cooled by liquid nitrogen and stored at –80°C. The activities of the enzymes citrate synthase (CS, E.S 4.1.3.7) and lactate dehydrogenase (LDH, EC 1.1.1.27), were recorded. These enzyme were respectively characteristics of the oxidative and glycolytic metabolic pathways as described Bass et al. (1969). For histochemical determinations, 6 serial cross-sections were obtained with a cryostat at –20°C. One section was stained with azorubine (reference stain). Four sections were processed for the mATPase activity after acid or alkaline pre-incubation (Guth & Samaha, 1970). The sixth was stained for succino-dehydrogenase (SDH) activity according to Nachlas et al. (1957). Computerised image analysis (Buche, 1990) was used to classify the fibres as βR (red and slow twitch fibre), αR (red and fast twitch fibre) or αW (white and fast twitch fibre) according to Ashmore & Doerr (1971). The analysis combines the myofibrillar ATPase and SDH stain intensities of each cell. For each muscle fibre type the respective percentage and the cross-sectional area (CSA; μm2) were determined. Twenty-four hours post mortem the pH (pHu) and the L*a*b colour values (CIE, 1976) were measured on Biceps femoris (BF) and LL muscles, while the chemical composition (water, lipids and ash) was analyzed on the hind leg meat (AOAC, 1984). Protein content was estimated by difference. ANOVA was performed using the GLM procedure of the SAS (1990) program. The model included the GO (H, B, F), the sex (S) and the GOxS interaction as fixed effects. LS means were calculated for all the effects involved in the model and the t test between means was calculated.

Results & Discussion

Table 1 summarises the effects of the rabbit's GO and sex (S) on the chemical composition of hind leg meat. At the fixed slaughter weight of 2.8±0.11kg, the rabbits of the 3 GO significantly differed in slaughter age (88 *vs* 109 *vs* 122 days for H, B and F GO, respectively; $P<0.001$), indicating that B and F crossbred rabbits are less precocious and have lower growth performance than H rabbits. This difference in age did not produce a similar trend in the chemical composition of the hind leg meat because the meat of H rabbits had intermediate water and lipid content, while the highest water and the lowest lipid contents were found in B rabbits. The selection for increased growth rates in H rabbits has strongly increased their precocity and this could preclude their slaughter at eldest age, if the market conditions or specific production lines require eldest rabbits. The results obtained here show that rabbits from B group could be used for this purpose. The water content of the hind leg meat was found to be higher in males than in females (73.5 *vs* 72.9%; $P<0.05$) while the lipid content showed the opposite trend (4.03 *vs* 3.06%, $P<0.001$). However, the GOxS interaction evidenced that females have higher lipid content only in F ($P<0.001$) and C GO ($P<0.05$). Data reported in literature indicate that the chemical composition of the rabbit meat is not so influenced by the S either in hybrid (Dalle Zotte *et al.*, 1996) or in purebred rabbits (Preziuso *et al*., 1996), when the age at slaughter is under 87 days. At older age the sexual dimorphism become important also in the rabbit, as demonstrated in the present work. The pHu value of the meat was not influenced by the experimental treatments (Table 2). It has been shown that the pHu

of meat did not differ among genetic lines of hybrid rabbits when the animals were slaughtered at the same live weight but within a difference of 15 days of age (Dalle Zotte & Ouhayoun, 1998). Nevertheless, the pHu value significantly decreases with rabbit's age, but this decrease stops at 42 days of age in predominant oxidative muscles, such as the *P. major* (Dalle Zotte & Ouhayoun, 1995), or at 70-77 days of age in predominant glycolytic muscles, such as the LL (Dalle Zotte & Ouhayoun, 1995) and the BF (Dalle Zotte *et al.*, 2005b). This is due to the lessening of the glycolytic activity (Dalle Zotte & Ouhayoun, 1995). The L* value of BF muscles was significantly modified by the GO (50.7 *vs* 52.9 *vs* 54.1 for H, B and F, respectively: $P<0.05$) and was higher in B+F than in H ($P<0.05$), indicating that crossbred rabbits could have paler meat than hybrid ones (Table 2). Since the age also increases from H to B and to F, this rise in L* value could also depend on the rabbits' age. In F animals, the females showed higher L* values than males (55.3 *vs* 53.0; $P<0.05$). In literature it has been reported that L* value of BF muscle do not change with rabbit's age (Dalle Zotte *et al.*, 1996; Dalle Zotte *et al.*, 2005b; Preziuso *et al.*, 1996), but the considered ages were below 87 days. Preziuso *et al.* (1996) comparing the Burgundy Fawn and the New Zealand White sires did not observe difference in L*a*b* values of BF muscle; in the same study, L* value was higher and a* value was lower in females than males ($P<0.05$) supporting the results found in the present work. The percentage of αW fibres in LL muscle differed between B and F animals (78.9 *vs* 84.3%; $P<0.05$) while that of H rabbits was intermediate (83.2%; Table 3). Arnal & Lòpez (2001) did not find difference on fibre type distribution among 7 purebred and 1 synthetic line slaughtered at 77 or 84 days of age, without consideration of the respective weights. The increase with age of the percentage of αW fibres associated with an increase of the relative glycolytic energy metabolism, to the detriment of the percentage of oxidative and slow twitch fibres (βR), has already been reported (Dalle Zotte & Ouhayoun, 1995; Dalle Zotte *et al.*, 1996; Arnal & Lòpez, 2001; Dalle Zotte *et al.*, 2005a, 2005b). Since the variation of metabolic ratio between breeds result in some cases from differences in precocity (Ouhayoun & Dalle Zotte, 1993), in hybrid rabbits the αW fibres are predominant if compared with unselected rabbits. For these reasons, in the present study the elder age of F than H GO could determine an increase in the αW fibres percentage. Males showed higher mean CSA of αR fibres than females (1221 *vs* 952 μm^2; $P<0.05$). The mean CSA of the three fibre types was the highest in B animals. This could indicate higher growth potentialities in B than in F animals. The CS and LDH activities in LL muscle were not affected by rabbits' GO and S.

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Conclusions

The results obtained in this study confirm that B and F crossbreds are less precocious than H rabbits. Furthermore, this study demonstrate that among B and F crossbreds, the B achieves earlier the fixed slaughter weight and produce leaner meat with a lower proportion of white muscle fibers but without change in the meat pHu and colour values. Compared to the H and F animals, the B ones evidenced a tendency towards higher CSA for all the fibre types in LL muscle. Further research need to be done in this area in order to clarify the relationship between the genetic origin and the fibre traits in rabbits slaughtered at advanced age for commercial purpose.

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Table 1. Performances at slaughter and chemical composition of hind leg meat (% of fresh weight)

	GENETIC ORIGIN (GO)			SEX (S)		*P-value*[a]				RMSE[b]
	H	B	F	FEMALE	MALE	GO	S	B+F *vs* H	GOxS	
N. rabbits	12	14	15	17	24					
Slaughter weight, g	2863	2792	2737	2810	2785	ns	ns	*	ns	113
Slaughter age, days	88[a]	109.3[b]	122.1[c]	106.2	106.8	***	ns	***	ns	9.0
Water, %	73.0[ab]	73.7[b]	72.9[a]	72.9	73.5	*	*	ns	ns	0.8
Protein, %	22.2	21.9	22.0	21.9	22.2	ns	ns	ns	ns	0.5
Lipids, %	3.56[ab]	3.16[a]	3.91[b]	4.03	3.06	†	***	ns	*[c]	0.77
Ash, %	1.26	1.25	1.22	1.24	1.25	ns	ns	ns	ns	0.04

[a] ns, not significant: *P*>0.10; †: *P*<0.10; *: *P*<0.05. ***: *P*<0.001. Within a row, means with different superscripts (a, b, c) are significantly different. [b]RMSE is the residual mean square error. [c] B =females 3.16% *vs* males 3.15% (ns); F= females 4.78% *vs* males 3.04% (P<0.001); H=females 4.14% *vs* males 2.98% (P<0.05)

Table 2. pH and L*a*b* colour values for *Biceps femoris* and *Longissimus lumborum* muscles

	GENETIC ORIGIN (GO)			SEX (S)		*P-value*[a]				RMSE[b]
	H	B	F	FEMALE	MALE	GO	S	B+F *vs* H	GOxS	
N. rabbits	12	14	15	17	24					
Biceps femoris										
pHu	5.83	5.80	5.75	5.77	5.81	ns	ns	ns	ns	0.08
L*	50.7[a]	52.9[b]	54.1[b]	52.5	52.7	*	ns	*	**[c]	1.7
a*	4.41	4.02	3.88	4.51	3.71	ns	ns	ns	ns	1.76
b*	2.25	2.76	3.64	3.24	2.53	ns	ns	ns	ns	1.35
Longissimus lumborum										
pHu	5.66	5.64	5.65	5.63	5.67	ns	ns	ns	ns	0.07
L*	58.8	58.7	58.9	59.1	58.5	ns	ns	ns	ns	1.9
a*	2.05	2.65	1.93	2.13	2.29	ns	ns	ns	ns	1.25
b*	-2.09	-0.59	-0.08	-0.73	-1.12	ns	ns	ns	ns	1.44

[a] ns, not significant: *P*>0.10; †: P<0.10; *: *P*<0.05 **: *P*<0.01. Within a row, means with different superscripts (a, b) are significantly different. [b]RMSE is the residual mean square error. [c] B=females 52.4 *vs* males 53.4 (ns); F= females 55.3 *vs* males 53.0 (P<0.05); H=females 49.7 *vs* males 51.8 (ns)

Table 3. Morphometric traits, fibre type distribution and enzymatic activity of the *Longissimus lumborum* muscle

	GENETIC ORIGIN (GO)			SEX (S)		*P-value*[a]				RMSE[b]
	H	B	F	FEMALE	MALE	GO	S	B+F *vs* H	GOxS	
N. rabbits	15	13	13	15	25					
Fibre cross-sectional area (μm^2):										
αR	915	1215	1130	952	1221	ns	*	†	ns	349
αW	1746	1947	1555	1704	1795	ns	ns	ns	ns	538
βR	758	1137	892	884	974	ns	ns	ns	ns	454
Fibre type distribution (%):										
αR	12.9	15.4	13.2	14.1	13.5	ns	ns	ns	ns	4.2
αW	83.2[ab]	78.9[a]	84.3[b]	82.3	82.0	†	ns	ns	ns	5.8
βR	3.9	5.6	2.5	3.6	4.5	ns	ns	ns	ns	4.3
Enzymatic activity (IU)[c]:										
CS	5.72	5.89	6.10	6.02	5.79	ns	ns	ns	ns	1.35
LDH	909	912	837	893	879	ns	ns	ns	ns	131
LDH/CS	164	163	144	155	158	ns	ns	ns	ns	39

[a] ns, not significant: $P>0.10$; †: $P<0.10$; *: $P<0.05$. Within a row, means with different superscripts (a, b) are significantly different; [b]RMSE is the residual mean square error; [c]IU: moles of substrate degraded/min/g fresh meat