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EFFECT OF TRANSPORT DURATION AND GENDER ON RABBIT CARCASS AND MEAT QUALITY*

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ABSTRACT: In order to evaluate the effect of transport duration and gender on carcass and meat quality, 204 rabbits were reared in individual cages from 35 d of age until slaughter at 77 d (average live weight at shipping: 2662±189 g). Before slaughter, four groups of rabbits were formed and transported for 2, 4, 6, or 8 hours from the breeding unit to the slaughterhouse. Increasing the duration of transport increased transport losses (2.44% to 4.59%; $P<0.001$), decreased dressing percentage (59.5% to 58.9%; $P<0.01$) and increased the redness of the *longissimus dorsi* muscle (CIE a* 2.38 to 2.73; $P<0.05$). Commercial carcass grading for colour, conformation and fatness were not affected by transport duration. The effect of gender was appreciable at slaughter: final live weight and transport losses were higher in females than males. Dressing percentage was lower in females (59.1 *vs* 59.8%; $P<0.01$) due to the greater gut content. Carcasses of females showed a higher proportion of *longissimus* muscle ($P<0.01$). The meat of females was darker (CIE L* of *biceps femoris* muscle: 54.9 *vs* 55.9; $P<0.01$) and less coloured (Chroma index of *longissimus lumborum* muscle: 3.52 *vs* 3.87; $P<0.05$) than males.

Key words: Rabbit, transport, gender, carcass quality, meat quality.

INTRODUCTION

Carcass and meat quality in rabbits are only weakly affected by dietary treatments whereas management and ontogenetic factors may play a greater role (Parigi Bini *et al.*, 1992; Ouhayoun, 1998; Xiccato, 1999; Dalle Zotte, 2000). Among these factors, transport and slaughter conditions also have an important effect on animal welfare, which more and more is being considered in rabbit production (Xiccato *et al.*, 1999;

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CAVANI *et al.*, 2000; DAL BOSCO *et al.*, 2002).

In other species, transport has appreciable effects on welfare when stressing conditions like overcrowded cages or long transport duration occur, with possible negative consequences on carcass characteristics and meat quality (WILSON, 1981; LAWRIE, 1991). In rabbits, the absence of appreciable modification of meat characteristics such as those seen with DFD or PSE meat, however, has limited interest in research on effects of transport conditions. Nevertheless, previous studies showed an increase in rabbit meat pH and darkness as a consequence of a long transport (MASOERO *et al.*, 1992; OUHAYOUN and LEBAS, 1994; DAL BOSCO *et al.*, 1997), but a favourable effect on meat tenderness (XICCATO *et al.*, 1994).

Among the management factors, gender separation is not a common practice in rabbit rearing because of the limited sexual dimorphism and the large variations in commercial slaughter weight adopted within and among the various countries (DALLE ZOTTE, 2000). However, carcass traits and meat characteristics may be affected by gender to a different extent, especially in the case of rabbits slaughtered at heavy weight (>2.5 kg).

The aim of the present study was to evaluate the effect of transport duration and gender on carcass traits and meat quality in growing rabbits slaughtered at 77 d of age.

MATERIALS AND METHODS

Animals and experimental arrangement

Two hundred four rabbits of a hybrid line (Grimaud Frères, France) were sexed, kept in individual cages under controlled environmental conditions in an experimental breeding unit and fed a commercial diet (CP: 17.2% DM; ADL: 4.7% DM, DE: 11.8 MJ/kg DM) from 42 d of age until slaughter at 77 d. During the trial, seven rabbits died and 19 were excluded due to respiratory and digestive problems that caused severe reduction of growth (strong reduction of feed intake and loss of weight for more than

one week, and final live weight less than 2 kg).

Rabbits were slaughtered in a commercial slaughterhouse. To evaluate the effect of transport duration on carcass and meat quality, the day before slaughter the rabbits were divided into four homogeneous groups based on live weight and variability, and submitted to 8, 6, 4 or 2 hours of transport. The four groups were loaded on the truck at different times (00:00, 02:00, 04:00 and 06:00 a.m.). The size of the transport cages was 50 cm x 100 cm x 30 cm high and 12 rabbits per cage were loaded at a density of 24 rabbits/m^2. Feeding ended at 00:00 a.m. in all groups, while drinking was allowed until loading. Between one loading and the successive one, the truck travelled near the the breeding unit. After the last group was loaded at 06:00 a.m., the truck travelled to the slaughterhouse in about two hours.

Commercial slaughter, carcass and meat quality recordings

All rabbits were slaughtered between 9:00 and 10:00 a.m., after 1-2 hours of pre-slaughter wait, taking into account the transport group, i.e. one rabbit per each group. Rabbits were stunned by electro-anesthesia and killed by jugulation.

After 3 h chilling at 4°C, carcasses were graded by a specialized evaluator for conformation (scale value from 1, poor, to 5, optimum), fatness (from 1, scarce, to 3, optimum, to 5, excessive) and colour (from 1, pale, to 3, optimum, to 5, red). After grading, the carcasses were moved to the laboratory and stored at 4°C.

Twenty-four hours after slaughter, carcasses were dissected according to the method of BLASCO *et al.* (1993). The pH was measured on *longissimus lumborum* and *biceps femoris* muscles using a pH meter (HI 9025C, Hanna Instruments, Sarmeola di Rubano, Padova, Italy) equipped with a combined Ingold electrode (406 M3). The L*a*b* colour (CIE, 1976) was measured on the same muscles using a colorimeter (Minolta CR100 Chromameter, Minolta Corp., Ramsey, NJ). The chroma (C*) and the hue indexes (H*) were calculated as [$C^* = (a^{*2}+b^{*2})^{0.5}$] and [$H^* = \arctan (b^*/a^*)$]. Cooking losses on the hind leg were measured following the procedures described by XICCATO *et al.* (1994). Shear press force on the cooked hind leg was measured using an Instron machine (Model

1140) equipped with a Warner-Bratzler device (XICCATO *et al.*, 1994).

Statistical analysis

The data were analysed by a two-way ANOVA with transport duration and gender as main factors. Because no significant interaction was observed, the results were reported as means for the main effects. The GLM procedure of SAS (SAS, 1991) was used for all analyses. Orthogonal polynomial contrasts were used to compare means by groups of transport.

RESULTS AND DISCUSSION

Carcass quality

Increasing the duration of transport caused a significant increase of transport losses (linear component of variance, $P<0.001$) (Table 1). During the first four hours of transport, transport losses mostly depended on urine and fecal losses, as demonstrated by the decrease in gut content. For longer transport durations (6 to 8 hours), a progressive dehydration of rabbits could be hypothesized, since dressing percentage decreased while gut content remained stable at around 16% LW from 4 h of transport on.

Dressing percentage increased from 2 h to 4 h of transport and then decreased (quadratic component of variance, $P=0.01$). The same trends for transport losses and dressing percentage were described by other authors (LUZI *et al.*, 1994; XICCATO *et al.*, 1994). Neither carcass traits nor the commercial value of chilled carcasses graded 3 h after slaughter were affected by transport duration. Despite the increasing transport duration, no lesions or damages to carcasses were observed, thanks to suitable stocking cage density and transport conditions.

The effect of gender on slaughter results was more apparent than the effect of transport. Females were heavier ($P=0.02$) but showed higher transport losses ($P=0.02$) than males and gave lower dressing percentages as a consequence of the higher gut contents, as previously described by LAMBERTINI *et al.* (1990) and PARIGI BINI *et al.*

Table 1: Slaughter results and carcass quality.

	Hours of transport				*P*-value	Gender		*P*-value	RSD
	2	4	6	8		Female	Male		
Number of Rabbits	44	45	45	44		85	93		
Live weight before transport (LW), g	2648	2634	2699	2664	0.38	2694	2629	0.02	189
Transport losses, %LW	2.44	2.93	4.39	4.59	<0.001	3.81	3.37	0.02	1.27
Slaughter weight (SW), g	2583	2556	2579	2542	0.41	2590	2540	0.07	181
Skin and distal legs, %LW	16.4	16.2	16.2	16.3	0.76	16.2	16.4	0.10	0.8
Gut content, %LW	16.9	16.1	16.0	15.7	<0.001	16.4	15.9	0.01	1.4
Cold carcass weight, g	1577	1587	1593	1568	0.81	1591	1571	0.28	118
Dressing percentage, %LW	59.5	60.2	59.0	58.9	<0.01	59.1	59.8	<0.01	1.5
Dressing percentage*, %SW	61.0	62.0	61.7	61.7	0.07	61.4	61.9	0.03	1.4
Reference carcass (RC), g	1333	1334	1345	1325	0.88	1345	1324	0.19	103
Dissectible fat, %RC	2.85	2.79	2.82	2.82	0.92	2.90	2.74	0.14	0.69
Hind legs, %RC	32.9	33.0	32.9	33.0	0.74	33.0	32.9	0.38	1.0
Longissimus muscle, %RC	12.5	12.6	12.3	12.8	0.54	12.8	12.3	<0.01	0.9
Muscle/bone of hind leg	5.00	5.04	4.94	4.83	0.15	4.99	4.92	0.44	0.62
Commercial evaluation									
Colour	3.50	3.80	3.69	3.73	0.14	3.67	3.68	0.90	0.58
Conformation	4.93	4.89	4.91	4.80	0.11	4.89	4.87	0.75	0.36
Fatness	2.93	2.90	2.91	3.07	0.39	2.97	2.93	0.69	0.72

RSD: Residual standard deviation. * Quadratic component of variance, $P<0.01$.

(1992). Moreover, females had a higher proportion of *longissimus* muscle ($P<0.01$), while no difference was observed for fat proportion or muscle to bone ratio. At the commercial grading, the carcasses of the two genders were similar and scored as rather coloured (3.67 *vs* an optimal value of 3), but close to optimal conformation (4.88) and fatness (2.95). Weak effects of gender on carcass traits were also described by PARIGI BINI *et al.* (1992) and LAMBERTINI *et al.* (1994).

Meat quality

As for carcass traits, transport duration had few effects on meat characteristics (Table 2). Contrary to expectations, pH and colour traits of the *biceps femoris* muscle were not affected and no difference was recorded for cooking losses and shear press force measured on the hind leg. On the other hand, the *longissimus lumborum* muscle was more red in rabbits submitted to a longer transport (CIE a* from 2.38 to 2.73; $P=0.05$).

Apparently, in our conditions of transport, rabbits did not undergo particularly stressing conditions and rested quietly in the transport cages after loading. Therefore, carcass and meat quality were only mildly affected. When comparing rabbits submitted to transport or not, higher pH, lower CIE L* and higher CIE a* values were recorded in the muscles of transported rabbits (MASOERO *et al.*, 1992; XICCATO *et al.*, 1994). Transport modified sensory properties of meat by reducing both toughness and shear press force (XICCATO *et al.*, 1994). Comparing two transport distances (15 *vs* 400 km), DAL BOSCO *et al.* (1997) found that the meat of rabbits submitted to longer transport had a higher pH and was darker and more red. The higher pH also increased the water holding capacity of the meat and reduced cooking losses while increasing shear press force in rabbits transported for a longer time.

In our trial, gender also affected meat quality. *Biceps femoris* muscle was darker (L*: 54.9 *vs* 55.9; $P<0.01$) and less coloured (lower C*) in females than males. The *longissimus lumborum* muscle of females had also a lower C* ($P<0.04$), mainly due to the less negative value of the yellow index (CIE b*) compared to males. A lower C* in the muscles of female rabbits was also recorded by CAVANI *et al.* (2000). A weak effect

Table 2: Meat quality.

	Hours of transport				*P*-value	Gender		*P*-value	RSD
	2	4	6	8		Female	Male		
Number of Rabbits	44	45	45	44		85	93		
Biceps femoris muscle									
pH	5.80	5.80	5.79	5.77	0.97	5.79	5.79	0.95	0.09
L*	55.6	55.3	55.7	55.0	0.28	54.9	55.9	<0.01	2.0
a*	2.66	2.81	2.70	2.81	0.64	2.64	2.85	0.22	1.10
b*	-0.64	-0.57	-0.68	-0.94	0.19	-0.65	-0.76	0.51	1.17
C*	3.00	3.07	3.01	3.24	0.37	2.93	3.23	0.07	1.07
H*	-0.24	-0.18	-0.27	-0.32	0.19	-0.23	-0.27	0.58	0.40
Longissimus lumborum muscle									
pH	5.65	5.63	5.63	5.64	0.13	5.64	5.64	0.57	0.09
L*	57.8	57.6	57.6	57.4	0.37	57.6	57.6	0.82	2.1
a*	2.38	2.55	2.55	2.73	0.05	2.65	2.50	0.25	0.87
b*	-2.04	-2.08	-2.08	-2.24	0.84	-1.63	-2.41	<0.01	1.82
C*	3.46	3.75	3.75	4.00	0.05	3.52	3.87	0.04	1.11
H*	-0.67	-0.59	-0.53	-0.61	0.43	-0.51	-0.69	0.02	0.48
Hind leg									
Cooking losses, %	24.0	24.0	24.0	24.0	0.99	24.0	24.0	0.87	1.9
Shear press force, kg/cm2	1.03	1.07	1.07	1.07	0.83	1.02	1.09	0.07	0.20

RSD: Residual standard deviation.

of gender was observed on meat shear press force and was lower in females than in males (P=0.07), though the meat from both sexes had a low resistance to shear (1.05 kg/cm^2).

CONCLUSIONS

Transport duration did not substantially modify carcass or meat quality in our study. Increasing the transport duration from 2 to 8 hours caused higher transport losses and affected dressing percentage without modifying carcass traits. The effects of transport duration on meat quality were weak and reached statistical relevance only for the *longissimus lumborum* muscle which became more red when increasing the hours of transport. A more pronounced negative effect could be hypothesized if unsuitable or overcrowded transport cages were used, with more stressful conditions leading to physical damage of carcasses.

Differences between gender at 77 d of age were significant for carcass traits but weak for meat quality. Therefore, the advantage of gender separation in rabbit rearing is limited to the higher dressing percentage of the females.

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