WORLD RABBIT SCIENCE 1997, 5 (3), 115-119.

EFFECT OF TRANSPORTATION AND STUNNING METHOD ON SOME CHARACTERISTICS OF RABBIT CARCASSES AND MEAT

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ABSTRACT: The influence of distance of transportation and stunning method on rabbit carcass and meat quality was verified using 100 hybrid Provisal rabbits, who came from two intensive farms, 400 and 15 km from the commercial slaughtering house. Rabbits from each farm were divided into five groups and subjected to electric stunning by alternating current with relative combinations of voltage (45 *vs* 80 volts) and amperage (2.5 *vs* 8 amperes), or by cervical dislocation (control). The distance of transportation affected the carcass quality, mainly just after slaughtering: *longissimus lumborum* (l.l.) and *biceps femoris* (b.f.) muscles had higher initial pH values (6.85 *vs* 6.41, l.l; 7.04 vs 6.63, b.f.), and an unpleasant red (a*= 24.2 *vs* 20.1, l.l.; 19.3 *vs* 18.3, b.f.) and dark colour (L*= 44.3 *vs* 61.4, l.l; 41.1 *vs* 60.4, b.f.). After 24 h the differences in pH and lightness were reduced while those of redness became more evident (17.6 *vs* 9.2, l.l.; 15.1 *vs* 5.9, b.f.). In longer transported animals the l.l. muscle had a higher moisture content (76.6 *vs* 74.7%) and drip loss (2.3 *vs* 1.7%), but cooking loss was lower (28.9 *vs* 32.0%), because water holding capacity was higher (65.4 *vs* 62.9%). The shear force was higher (4.0 *vs* 3.5 kg/cm^2). The effect of stunning method was not relevant, low voltage, independent of amperage, showed a significant effect only on initial pH (6.73 and 6.80 *vs* 6.54 and 6.6, l.l.; 6.97 and 6.96 *vs* 6.78 and 6.77, b.f.).

RESUME : Effet du transport et de l'électro-anesthésie sur quelques caractéristiques de la carcasse et la qualité de la viande des lapins.

On a étudié l'influence sur les carcasses et la qualité de la viande, du temps de transport de 100 lapins hybride Provisal entre deux élevages intensifs et l'abattoir, distant l'un de 400km et l'autre de 15km. Les lapins provenant des deux fermes ont été divisés en 5 groupes et soit soumis à l'électro-anesthésie avec une combinaison du voltage (45 vs 80volts) et de l'ampèrage (2,5 vs 8 ampères) ou à la dislocation cervicale (lot témoin). Le temps de transport affecte la qualité de la carcasse, principalement juste après l'abattage : les valeurs du pH initial des muscles longissimus lumborum (l.l.) *et* biceps femoris (b.f.) *sont plus élevées (6,85 vs 6,41 et 7,04 vs 6,63 respectivement) et ont une couleur rouge déplaisante (a*=24,2 vs 20,1 pour l.l. et 19,3 vs 18,3 pour b.f.) ou noire (L*=44,3 vs 61,4 pour l.l. et 41,1 vs 60,4 pour b.f.). Après 24h les différences de pH et luminosité diminuent tandis que l'intensité du rouge s'accroît (17,6 vs 9,2 pur l.l. et 15,1 vs 5,9 pour b.f.). Chez les animaux ayant subis le plus long transport, le muscle l.l. a une teneur en eau supérieure (76,6 vs 74,7%) et une perte au ressuage plus importante (2,3 vs 1,7%), mais la perte à la cuisson est inférieure (28,9 vs 32,0%) à cause de la plus grande capacité de rétention d'eau (65,4 vs 62,9%). La force nécessaire au cisaillement est supérieure (4,0 vs 3,5kg/cm²). L'effet de l'électro-anesthésie n'est pas significatif, un voltage bas, indépendamment de l'ampèrage, montre un effet significatif seulement sur le pH initial (6,73 et 6,80 vs 6,54 et 6,6 pour l.l. ; 6,97 et 6,96 vs 6,78 et 6,77 pour b.f.).*

INTRODUCTION

The welfare of commercial animals is protected by a law which states that slaughtering and bleeding have to be preceded by electric stunning or another suitable method, causing a painless death. This legal provision perplexes slaughterers who ascribe to this treatment an unpleasant red colour of the carcass, which negatively affects marketing, mainly if the product is sold as cut portions.

It is known that the colour of meat is substantially due to myoglobin. The appearance of the meat surface to the consumer depends, however, not only on the quantity of pigment present but also on the type of the myoglobin molecule, on its chemical state and the chemical and physical conditions of other components in the meat. In fresh meat the most common chemical form is oxymyoglobin which gives the bright red colour desired by purchasers (LAWRIE, 1985).

Many factors influence discoloration and one of the most important is the ultimate pH which, in turn, is determined by a variety of factors. Among them, transportation plays a fundamental role, considering that commercial processing plants are often far from rabbit farms and the animals undergo considerable stress before reaching them.

The aim of this study was to check the effect of transportation and stunning method on some characteristics of rabbit carcasses and meat.

MATERALS AND METHODS

Animals and rabbitries

One hundred hybrid male and female Provisal rabbits, 12 weeks old and with a live weight of 2,800 ± 310 g, were slaughtered in a commercial plant, according to usual methods of specialised slaughter houses. Animals came from two intensive farms belonging to the same co-operative which used a standard method of production. Two animals were housed in a wire cage of 0.32 m^2 (in flat deck) and fed *ad libitum* the same commercial diet. Management and hygienic-sanitary treatments were similar. Environment was controlled (temperature 18.5 ± 3.1°C and photoperiod 16 hours light/day).

Transportation

The rabbitries were located 400 km (long - L) and 15 km (short - S) from the slaughtering house and the animals arrived at the slaughtering house at the same time (9 a.m.) after an 8 and 1 hour trip, respectively. The longer transported rabbits were not submitted to fasting, while feeding of the others ended

Table 1 : Effect of transport (L = long distance, S = short d.) and stunning on pH and colour of carcass at the level of *longissimus lumborum* muscle (*lsmeans*).

Treatment		pH*i*	pH*u*	pH fall	1 hour (L*)	1 hour (a*)	1 hour (b*)	24 hours (L*)	24 hours (a*)	24 hours (b*)
Transport:										
L		6.85B	6.35b	0.50	44.3A	24.2B	9.6B	57.8	17.6B	2.0a
S		6.41A	5.99a	0.42	61.4B	20.1A	3.1A	58.9	9.2A	3.8b
Stunning :										
Low V	Low A	6.73b	6.19	0.53	50.8	24.1	7.2	58.2	13.7	3.2
	High A	6.80b	6.32	0.48	52.4	23.3	6.9	57.4	15.4	4.2
High V	Low A	6.54a	6.06	0.48	51.8	23.5	6.8	59.0	12.5	2.0
	High A	6.60a	6.19	0.42	53.4	22.7	7.3	58.2	14.1	2.9
Cervical Dislocation		6.49a	6.09	0.40	53.8	23.0	7.8	57.7	13.0	2.5
SED		0.31	0.13	0.12	2.0	1.7	1.5	2.4	2.4	2.0

n: 100; A, B: P<0.01; a, b: P<0.05

approximately 8 hours before loading. The transport density for all groups was 80 kg/m^2.

Stunning methods

Rabbits from each farm were divided into five groups and stunned by alternating current or by cervical dislocation as follows:

- 80 V, 8 A for 2 sec;
- 80 V, 2.5 A for 2 sec;
- 45 V, 8 A for 4 sec;
- 45 V, 2.5 A for 4 sec;
- Cervical dislocation (control).

The application time (2 and 4 sec) was necessary for the complete collapse of the animals.

Parameters analysed

Carcass and meat quality was determined by examining the following traits: pH, colour, drip loss, water holding capacity, cooking loss, shear force, moisture content.

The pH was measured (two replicates) at the level of the *longissimus lomborum* (l.l.) and *biceps femoris* (b.f.) muscles about 1 hour after slaughtering (pH*i*), on carcasses subjected to fast chilling (temperature 3 °C, hygrometry 70%, air speed 0.3 m/sec) at the commercial plant and again after 24 hours (pH*u*) on carcasses refrigerated at + 4 °C in the laboratory. A Knick digital pH-meter (Broadley Corporation, California, USA) with a composite lanceolate electrode (accuracy 0.01) was used.

On the same muscles and at the same times the colour was evaluated (4 replicates) according to the CIELAB SYSTEM (1976) using a compact tristimulus colour analyzer (MINOLTA CHROMA METERS CR-200, Japan). Absolute measurements of L* (lightness), a* (redness) and b* (yellowness) were taken. Immediately afterwards, the l.l. muscle was dissected and its moisture content (A.O.A.C., 1995) and the above-mentioned physical parameters were evaluated.

The drip loss was calculated as the difference between weights of hot and commercial carcasses, according to BLASCO *et. al.* (1993).

The cooking loss was determined by cooking 20 g (square parallelepiped 6 x 2 x 2 cm) of l.l. in an electric oven pre-heated to 200 ± 10 °C for 15 min (CYRIL *et al.*, 1996).

The water holding capacity was measured by centrifugation according to NAKAMURA and KATOH (1985).

The shear force (kg/cm^2) was measured on cores (1.25 cm x 2 cm), obtained from the mid-portions of the cooked l.l., by cutting perpendicularly to the fiber direction, using a model 1011 INSTRON, equipped with a WARNER-BLATZLER MEAT SHEAR Apparatus, with a 55N Weigh Beam (Instron International Ltd, U.K.).

Statistical analysis - Statistical analysis was performed by on the GLM PROCEDURE (SAS, 1990) using a linear model, evaluating the fixed effects of stunning method and transportation distance. Interactions were evaluated and then omitted because they were not significant.

RESULTS AND DISCUSSION

pH

The distance of transportation significantly affected muscle acidification; initial and ultimate pH of both

Table 2: Effect of transport and stunning on pH and colour of carcass at the level of *biceps femoris* muscle (*lsmeans*).

Treatment		pH*i*	pH*u*	pH fall	1 hour (L*)	1 hour (a*)	1 hour (b*)	24 hours (L*)	24 hours (a*)	24 hours (b*)
Transport:										
L		7.04B	6.60B	0.44	41.1A	19.3	5.9B	55.5a	15.1B	1.1
S		6.63A	6.20A	0.43	60.4B	18.3	1.2A	57.6b	5.9A	0.7
Stunning:										
Low V	Low A	6.97b	6.46	0.51	50.1	19.3	3.2	56.2	10.7	0.3
	High A	6.96b	6.47	0.49	49.1	19.2	3.8	55.8	10.8	0.4
High V	Low A	6.78a	6.37	0.41	50.8	19.0	3.2	56.4	11.4	1.1
	High A	6.77a	6.38	0.39	49.8	18.9	3.8	56.1	11.5	1.2
Cervical Dislocation		6.71a	6.32	0.39	50.5	18.3	4.2	57.2	10.1	0.4
SED		0.20	0.24	0.07	2.1	0.8	1.6	2.9	1.8	2.4

n: 100; A, B: P<0.01, a, b: P<0.05.

muscles were higher on animals subjected to long transportation (Tables 1, 2). This trend, due to a greater glycolysis with transfer of the lactic acid produced to the liver (OUHAYOUN *et al.*, 1988), was particularly visible in the l.l. muscle, being less oxidative than b.f..

Decrease in pH was less with respect to values usually reported in the literature probably because of the low chilling temperature that inhibited the activity of certain glycolytic enzymes (OUHAYOUN *et al.*, 1990b) and stopped the process before glycogen exhaustion. It is probable that, in the absence of limiting factors, short transported animals could produce a greater reduction in pH.

Other researchers (MASOERO *et al.*, 1992; OUHAYOUN and LEBAS, 1994; DALLE ZOTTE *et al.*, 1995) pointed out a similar negative effect of transportation on the ultimate pH.

Stunning method significantly affected the early acidification process. The highest pH values were obtained using low voltage independent of amperage.

No differences on ultimate pH were observed in accordance with other authors (RAJ *et al.*, 1990; HILLEBRAND, 1993). PAPINAHO and FLETCHER (1995) showed that electric stunning resulted in a significantly higher muscle pH at 12 min post-mortem but differences disappeared by approximately 6 h post-mortem suggesting that stunning effects are immediate.

Animals submitted to low voltage, independent of amperage, took more time to prolapse and struggled longer, thus the more active blood circulation favoured the deviation of the lactic acid to the liver causing a higher initial pH of the muscles. Moreover the oxygen availability and aerobic metabolism of myofibrils could have played a significant role. LEE *et al.* (1976) in poultry, showed that electric stunning accelerates immediate aerobic oxidation of glycogen, lowering its availability for *post-mortem* glycolysis.

On the contrary the high voltage and vertebral dislocation both showed lower initial pH values because the blood circulation was suddenly reduced or stopped completely.

Regardless of the treatments, all the pH values in this trial were high with respect to those obtained in laboratory conditions, either as a consequence of fast carcass chilling or of pre-slaughtered stress (loading and unloading, density, manipulation). A similar effect of fast chilling on ultimate pH was also observed by OUHAYOUN *et al.* (1990a) but to a lesser degree and not on all the muscles.

Colour

The colour parameters were significantly influenced by the long transportation, mainly one hour after slaughtering (Tables 1, 2).

The lightness (L*) values were lower, while those of redness (a*) and yellowness (b*) were higher in both the l.l. and b.f. muscles of the longer transported animals.

It is known that with high pH, the cytochrome enzymes survive longer and need oxygen. Moreover, because the muscle proteins are considerably above their iso-electric point, they will hold in a lot of water, and the fibres, being tightly packed together, create a barrier to oxygen diffusion. Consequently the layer of bright red oxymyoglobin becomes thin and the purplish red colour of myoglobin predominates to such an extent that the meat appears dark, also because its surface scatters light to a smaller extent (LAWRIE, 1985).

At 24 hours post-mortem the differences in lightness disappeared in the l.l. muscle and were reduced in the b.f. muscle. A similar trend was observed for the (b*) co-ordinate; the (a*) values diminished much more in muscles of the shorter transported animals, thus differences became more

Table 3 : Effect of transport and stunning on water loss and shear force (*lsmeans*).

Treatment		Carcass	*longissimus lumborum*			
		Drip loss (%)	Cooking loss (%)	Water holding capacity (%)	Shear force kg/cm^2	Moisture (%)
Transport:						
L		2.34b	28.93A	65.40b	3.98b	76.64B
S		1.69a	31.98B	62.92a	3.51a	74.68A
Stunning:						
Low V	**Low A**	2.21	29.76	64.62	3.55	76.01
	High A	1.98	29.24	64.89	3.69	75.48
High V	**Low A**	2.12	31.18	63.02	3.74	75.61
	High A	1.87	30.66	63.48	3.90	75.11
Cervical Dislocation		2.13	30.65	66.70	3.76	76.07
SED		0.80	3.32	2.40	1.83	1.68

n:100; A, B: P<0.01, a, b: P<0.05.

consistent. It could be supposed that the ultimate pH in the longer transported animals was still high enough to interfere with myoglobin oxidation.

Also the values of redness were higher than those reported in the literature, as a probable consequence of the high pH.

The effect of stunning method on colour parameters was not relevant.

Water loss and shear force

The distance of the rabbitry from the slaughter house affected these characteristics (Table 3). In the longer transported animals the l.l. muscle had a higher moisture content and drip loss. The water holding capacity was higher, while the cooking loss was lower. The results, justified by the higher pH values, agree with those of other authors (DALLE ZOTTE *et al.*, 1995).

The shear force was greater in animals subjected to long transportation, in disagreement with data of other researchers (MASOERO *et al*, 1992). We presume that in our experiment the high pH values and the cold shortening of myofibrils caused by fast chilling were responsible for the lower tenderness.

Water loss and shear force were not affected by stunning system.

The absence of significance concerning the stunning method agrees with the conclusion of VAN DER WAL *et al.* (1983) who affirmed that the numerous factors which affect meat quality, make it extremely difficult to determine the effect of the stunning technique.

Also HEAT *et al.* (1983) found that birds stunned with 120 volts yielded carcasses indistinguishable from birds stunned with < 90 volts, routinely applied in the plant.

It is concluded that the long distance from the rabbitry, the use of electric stunning at low voltage, independent of amperage, and fast chilling could cause the production of carcasses that leave the slaughtering houses with a pH (near to 6.5) that is detrimental for their preservation and with an unpleasant colour for consumers. It is certain that other stress factors, besides the ones analysed, contributed to worsening the qualitative traits of carcass and meat.

A technical (feeding plan, additives, transport condition and distance) and slaughtering protocols (resting period before slaughter, electric stunning, chilling rate) for rabbits should be better defined.

Acknowledgements: We wish to acknowledge G. Giannattasio and CLAM Coop (Ancona, Italy) for their collaboration in slaughter trials.

(The work was carried out equally by the authors)

Received : May 7th, 1997.
Accepted : 9th September, 1997.

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