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Effect of electrical and mechanical stunning on bleeding, instrumental properties and sensory meat quality in rabbits

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ABSTRACT

Different voltage and frequency (T-1 = 49 V, 250 Hz; T-2 = 130 V, 172 Hz; T-3 = 22 V, 833 Hz) combinations of electrical stunning and cervical dislocation (T-4) were studied in 101 commercial rabbits in an industrial abattoir. Electrical stunning accelerated the early muscular acidification, providing lower pH-45 and pH-2 h values on *Longissimus dorsi* and *Biceps femoris* and higher pH-24 h on *Biceps femoris* than cervical dislocation ($P < 0.02$). Furthermore, meat from rabbits stunned with electrical methods showed more redness (a^* with mean values 1.17–1.30 vs. 0.66, $P < 0.02$), although this cannot be associated to low exsanguination levels because electrical methods tend to produce even higher bleeding percentage than mechanical stunning ($P = 0.063$). Haematin content in muscle, water-holding capacity and cooking losses were similar in all treatments. Shear force did not change because of the stunning methods, but the members of experienced panel found the meat coming from electrical stunning T-1 (with intermediate voltages and frequencies) tougher and less juicy than the meat obtained with other electrical applications or with cervical dislocation ($P < 0.05$).

1. Introduction

The implementation of the European legislation on Animal Protection at the moment of slaughter has led the EU rabbit sector to replace pre-slaughter mechanical stunning methods (such as the commonly used cervical dislocation), with procedures that guarantee in commercial facilities a sufficient degree of unconsciousness and lack of sensitivity to avoid or minimize the reactions of fear, anxiety, pain and stress until the death of the animal. In most cases, both in the EU and in other countries, electrical methods have been chosen for rabbits, with very few abattoirs using gas, others using pneumatically powered stunning guns (OMAFRA, 2011) and some experiments with captive bolt apparatus (Schütt-Abraham, Knauer-Kraetzl, & Wormuth, 1992) which have had little practical repercussion.

The introduction of electrical stunners, with good results from the point of view of the welfare of the animal (Anil, Raj, & McKinstry, 1996, 1998, 2000; María, López, Lafuente, & Mocé, 2001) and improving the work in the abattoir in terms of comfort and risk, gave rise to initial suspicions from the part of specialized workers, who reported that the carcasses obtained after electric stunning showed more pinkness than those obtained by traditional procedures, which were very pale. This made the sector regard post-electrical stunning bleeding as deficient and, also, question the conservation time of the carcasses and the quality of the meat. These ideas were not new, since previous references on electrical stunning used on pigs discouraged its use on fattened pigs due to the damage caused to the carcasses and the reduction of the period of conservation of the meat because of its high blood-holding level (Ducksbury & Anthony, 1929). There are also some old results on pre-slaughter electro-narcosis used in rabbits, as it was studied by Croft (1952), although the methodology was limited and not enough to provoke insensibility periods which were acceptable for the species. Today the electrical possibilities to stun rabbits in commercial practice are varied and they use indiscriminate combinations of high and low voltages, together with high and low frequencies and, in turn, with different intensities and application times. This situation, as well as the negative opinion previously mentioned, led us to develop a work protocol designed to provide information about some electrical combination which would successfully induce an adequate degree of insensibility during the required time and also which would not affect the parameters of the carcass or the quality of the meat. Results on the degree and pattern of desensitization and recovery of rabbits in the conditions of this study were previously published (López, Lafuente and María, 1998; María et al., 2001). Few studies have been carried out on pre-slaughter stunning in rabbits since then (López et al., 2008; Rota Nodari, Lavazza, & Candotti, 2009; Xiong, Zhu, Zhao, Shi, & Tang, 2006) or the results are hardly applicable in commercial practice (Apata, Eniolorunda, Amao, & Okubanjo, 2012). The present study shows the results on rabbit meat quality obtained by applying three electrical combinations of pre-slaughter stunning with a commercial abattoir machine, and compares them with that achieved with the use of cervical dislocation, an unauthorized practice in EU slaughterhouses, which is nevertheless

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widely applied in smaller processing in many countries (McNitt & Swanson, 2005).

2. Materials and methods

2.1. Animals, experimental design and slaughter traits

Terminal rabbits from a three way crossbreeding scheme, from the same commercial farm and similar conditions on the farm and during transport to the slaughterhouse were used. The transport was carried out in a truck. Animals were housed in 8 floors of cages towers (12 rabbits/cage), with a duration of 3.5–4 h of transport and resting for about 2 h pre-slaughter. The choice of each rabbit was at random, but they were within the commercial range of 1.8–2.0 kg. Sex was not considered due to its little effect on meat quality in rabbits (Carrilho, Campo, Olleta, Beltrán, & López, 2009; Cavani et al., 2000; Trocino, Xiccato, Queaque, & Sartori, 2003), nor age (62–65 days), but position on the tower cage was considered (Liste et al., 2009), selecting rabbits from all cages in the tower for each treatment. The experiment was conducted following the Spanish and European animal welfare regulations for animal husbandry, transport and slaughter.

A total of 101 rabbits were used. Rabbits were divided into 4 groups and stunned using one of the following methods: T-1, voltage and power frequency usually used at this slaughterhouse (49 V and 250 Hz) ($n = 24$); T-2, high voltage (130 V) and low frequency (172 Hz) ($n = 24$); T-3, low voltage (22 V) and high frequency (833 Hz) ($n = 27$); T-4, traditional cervical dislocation (CD) ($n = 26$). Rabbits received the electric shock in the frontal sinus (*Fossa temporalis*) through a V-shape jagged electrode, which provided a good grip. The slaughterer was the worker usually responsible for the operation in the abattoir. The contact time of the electrodes was always under 2 s. The combination of extreme electric values (high voltage + high frequency, low voltage + low frequency) was ignored because its effects on the degree of insensibility and the pattern of recovery in rabbits were similar to some of the electric combinations mentioned (López et al., 1998; María et al., 2001) and, also, because these combinations are not often used in commercial slaughterhouses.

Every rabbit was weighed before stunning and slaughtered 10 s after stunning by exsanguination from the main blood vessels on both sides of the neck, oesophagus and trachea. Ninety seconds after slaughter, the rabbit was weighed again: the difference in weight accounted for the blood loss. For the calculations, we used the absolute values of blood weight as well as the percentage in relation to the weight of the live animal.

Immediately after the completion of dressing, which happened 10–13 min after stunning and 2–3 min after evisceration, the carcasses were aired for 6 min (normal time in this slaughterhouse) and then placed in standard storing crates and protected by polyethylene sheets; they were later kept in cold storage rooms at a temperature of 0–4 °C. The pH of the *Longissimus dorsi* (LD) and *Biceps femoris* (BF) from the left side was determined in the storage room firstly 45 min after and then 2 h after the dressing process (CRISON, pHmeter model 507; Crison Instruments, Alella, Barcelona, Spain). The measurements were taken with a penetration electrode in the LD at the level of the 5th–6th lumbar vertebra and in the middle of the BF muscle, the sites recommended by the World Rabbit Scientific Association (Blasco, Ouhayoun, & Masoero, 1992).

2.2. Instrumental and sensory determinations

After 24 h of cooling, the carcasses were evaluated in the laboratory of the University of Zaragoza, where the pH-24 (pHu; according to Hulot & Ouhayoun, 1999) was obtained and then the muscles of the dorsal-proximal region of the hind limbs (*Biceps femoris*, *Semitendinosus*, *Semimembranosus*, *Abductor cruris*, *Gluteus* and *Tensor fasciae latae*) (HL muscles) were dissected, wrapped in aluminium foil and kept at a temperature of 4 °C for a later chemical colour analysis and to determine the water-holding capacity (WHC). The *Longissimus dorsi* muscle from both sides was also dissected dividing it into two portions, cranial and caudal. The cranial ones were used to determine the colour on the area of the cut, as detailed below. They were later vacuum-packaged in a polyethylene bag and used to study the cooking losses (CL) and the muscle texture. The caudal sides were vacuum-packaged in a polyethylene bag and reserved for the sensory analysis.

A Minolta CM 2002 (Minolta Inc., Osaka, Japan) spectrophotometer was used for measuring physical colour in the LD muscle within the CIELAB system (CIE, 1976) with a D65 illuminant and a 10º observer, with an aperture size of 2.54 cm, following the methodology of reference given by Honikel (1998) for meat products. A chemical analysis of the total haem pigments from a minced sample of the HL muscles was carried out to determine the parts per million of haematin per gram of muscle using the method described by Hornsey (1956), with spectrophotometer readings (HITACHI U-1100; Hitachi Ltd., Chiyoda, Tokio, Japan) of optical density at wavelengths 640λ and 512λ (Alberti et al., 2005). All measurements were carried out in duplicate.

Water holding capacity was measured using the modified Grau and Hamm (1953) technique as described by Carrilho et al. (2009), to determine the percentage of expelled juice in a 5 g minced sample of the HL muscles under a weight of 2250 g for 5 min. Water holding capacity was calculated as the difference between the initial and final weights of the samples over the initial weight (percentage of expelled juice). Two samples were used from each rabbit. Both cranial portions of the LD were kept in polyethylene bags and water-bathed (FLANGE, GFL Series D3006; GFL Gesellschaft für Labortechnik mbH, Burgwedel, Germany) at 75–80 °C for 20–25 min to assess the loss of weight after cooking. Cooking loss was expressed as a percentage and was calculated as the difference between the initial and final weights over initial weight of both portions (CL %). Texture was later analysed on these samples after cutting them as prisms (2 cm length × 1 cm^2 base) using a scalpel and with the muscle fibres parallel to longitudinal axis. On these samples we studied the maximum shear force required to break the sample perpendicularly to the muscle fibres. A 4301 series INSTRON (Instron Corp. Barcelona, Spain) machine equipped with a Warner–Bratzler (WB) device was used.

The sensory analysis was carried out 72 h after sacrifice. A trained 11-member taste panel (ISO 8586) evaluated the samples in red-lit cabins. Four sessions with 12 samples in each session were required to obtain the data. In every session, a comparative multi-sample test with three samples each time in a balanced incomplete-block design was used to detect differences in sensory features among the four treatments. The order of presentation was changed between panellists and sessions to avoid first order and carry-over effects (Macfie, Bratchell, Greenhoff, & Vallis, 1989). Both caudal parts of *Longissimus dorsi* were used. They were cooked unseasoned on a SAMMIC P8D-2 (Sammic, Azkoitia, Gipuzkoa, Spain) double plate grill at 200 °C, inside aluminium paper, until the internal temperature reached 65 °C (probe JENWAY 2000; Jenway, Staffordshire, United Kingdom). Each sample was cut in 11 pieces, which were served at random to the taste panel on a hot dish. Bottled water and bread were given to the panel at the beginning of the session and in between dishes. All the panellists tasted pieces from all treatments, and giving a total of 132 assessments per treatment. The parameters were tenderness, juiciness, flavour intensity and overall appraisal in a non-structured scale of 100 points (where 0 stood for very tough, no juiciness, no flavour intensity and low overall appraisal, and 100 stood for maximum tenderness, very juicy, high flavour intensity and high overall appraisal).

2.3. Statistical analysis

Data were processed using the analysis of variance option of the GLM procedure of the SPSS Statistics (19.0) with the stunning treatment as a fixed effect. For the sensory test, session was also included in the