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Cortisol and catecholamine levels in lambs: Effects of slaughter weight and type of stunning

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Abstract

The objectives of this study were (1) to determine the levels of cortisol (C) and catecholamines (adrenaline, A, and noradrenaline, NA) in lambs ($n=45$) at different age/slaughter weight [suckling *vs* light], in farm (T0), after transport (T1), in the slaughterhouse after lairage (T2) and (2) to study the effect of the type of stunning, electrically *vs* gas, on C, A and NA values, in both groups of slaughter weight. Levels of C and A at T0 and T1 were similar in both groups (suckling and light), but NA was higher in suckling lambs as in T0 ($P<0.05$) as in T1 ($P<0.01$). Levels of all hormones were higher in suckling lambs at T2 ($P<0.05$, $P<0.001$ and $P<0.01$, for C, A and NA, respectively). In general, the younger group showed higher values of C, A and NA than the light group after stunning, with significant differences on A and C in the electrically stunned lambs ($P<0.001$, $P<0.05$ respectively) and on A in the gas stunned group ($P<0.01$). Only in the light group, levels of A were higher ($P<0.01$) in the electrically than in the gas stunned group. In conclusion CO_2 could be a good method to stun lambs because stress indexes were similar to levels found in electronarcosis method.

Keywords: Lamb; Carbon dioxide (CO_2); Catecholamines; Cortisol; Stunning; Weight; Pre-slaughter handling; Animal welfare

1. Introduction

Once developed populations have supplied their basic food requirements, consumers' concerns focus on quality of food-stuffs more than quantity (Blokhuis et al., 2003). In addition, the activity of consumer groups, animal protection associations and the important food crisis that have taken place in these past decades have increased our concern for quality products.

Numerous organisations such as the OIE (World Organisation for Animal Health), FAO (Food and Agriculture Organization) have focused on developing a policy in which food protection, sustainable environment and animal welfare have a remarkable importance. In this sense, today's consumer requests more transparency in the information about the breeding and handling of animals, including handling prior to slaughter (Quintili and Grifoni, 2004).

Some authors have also pointed out the existence of a relationship between the pre-slaughter handling of animals and meat quality (Sañudo et al., 1998). Animals are at great risk of fear during the procedures that take them to new situations, such as pre-slaughter handling, which implies an important additional stress (Duncan, 2004).

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The response to the acute stress brings about a cascade of physiological reactions in the organism, activating the nervous sympathetic-adrenomedullary system, which responds to short-term stress through the production of catecholamines (adrenaline and noradrenaline), and the hypothalamic–pituitary–adrenocortical system which involves an increase in plasma cortisol levels, measuring the response to long-term stress (Mellor and Stafford, 2000). Some authors consider cortisol as an ordinary physiological measure of stress (Grandin, 1997) which is very useful during routine husbandry procedures. However, others such as Lay et al. (1992) advise the evaluation of various parameters jointly (C, A and NA), because the plasma cortisol level is subjected to circadian release (Hargreaves and Hutson, 1990). Moreover, due to the availability and low cost of cortisol analytical measures, this indicator seems to have a wider use when evaluating the animal's response to some practices that could endanger its welfare (Mellor et al., 2002). As well, the same authors point out that in order to determine the changes produced a few seconds after receiving the stimulus, as is the case at the moment prior to slaughter, it would be even more useful to evaluate the changes produced within the sympathetic-adrenomedullary system, with the liberation of catecholamines to the bloodstream.

The current European regulation regarding animal protection at the moment of slaughter (EU Council Directive 93/119, 1993) makes stunning previous to slaughter mandatory in order to ensure that animals are unconscious and do not suffer unnecessarily. In sheep, electric stunning is the most common procedure. However, the studies carried out by Pearson et al. (1977) observed an important increase in adrenaline and noradrenaline in electrically stunned lambs, with levels 14 and 20 times higher in each case, as compared to normal levels. In addition, the incidence of convulsions, fractures and muscle haemorrhages in the carcasses is increased when using electrical procedures, which can make stunning unadvisable (Gregory, 2005).

In other species such as swine, Hambrecht et al. (2004) obtained catecholamine levels significantly higher in the gas stunning plants than in the electrical ones while cortisol levels did not vary among abattoirs. In contrast, Forslid (1988) observed that levels of cortisol and catecholamines during gas stunning (CO_2) did not differ from those found post-transport, therefore failing to prove that CO_2 created any emotional stress in addition to that induced by the simple transport.

Other authors (Raj, 1998) studied the effect of CO_2 on poultry, indicating that chickens and turkeys were able to detect the presence of high levels of CO_2 and tended to avoid it. In sheep, there are few studies (Vergara et al., 2005; Rodríguez et al., 2006) regarding the possible advantages of using the gas system with respect to the habitual electro-narcosis procedure, and these studies are related to meat quality.

Therefore the aims of this work were (1) to compare the levels in plasma concentrations of catecholamines and cortisol in lambs of different age/slaughter weight (suckling and light) in different moments before slaughter (in farm, post-transport, in slaughter-house after lairage) and (2) to determine the effect of the different types of stunning (electrical *vs* gas) on the levels of these hormones.

2. Materials and methods

The experimental protocol was approved by the Animal Ethics Committee of the University of Castilla-La Mancha, according to Executive Committee Directive 86/609/CEE of 2 November 1986, which regulates the welfare of animals used in research and for scientific purposes.

2.1. Animals

Forty-five male lambs of the Spanish Manchega breed from the flock at the Experimental Farm of Castilla-La Mancha University (Albacete, Spain) were used in this study. Animals were distributed into two groups of different slaughter weight:

- One group, suckling lambs ($n=25$), was raised exclusively on milk from their dams and slaughtered at 12.8 ± 0.2 kg live weight (30 days old). This group stayed with their mothers until they were loaded and transported to the slaughterhouse.
- A second group, light lambs ($n=20$), was weaned at 30 days after birth (at 12 kg of weight) and then fed a commercial concentrate and cereal straw *ad libitum* until slaughter at 25.1 ± 0.14 kg (70 days old).

Immediately before slaughter, lambs of both groups (suckling and light) were distributed into two groups according to the type of stunning:

- Electrically stunned lambs (suckling $n=15$; light $n=10$): at 110 V, 50 Hz for 5 s (electrodes applied on both sides of the head, behind the ears) (Electronarcosis Panel, MAC-01, Bernard, S.L.).
- Gas stunned lambs (suckling $n=10$; light $n=10$): using CO_2, in groups of five animals in the box, 90% CO_2 for 90 s at the bottom of the well (G. Van Wijnsberghe & Co n.v., Veurne, Belgium) usually used for stunning pigs.