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Effects of long distance transportation and CO_2 stunning on critical blood values in pigs

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ABSTRACT

The aim of the study was to evaluate the effect of two stressful stimuli, long transportation and 80% CO_2 stunning on metabolic–physiological variables, hemodynamic and gas exchange in slaughter pigs imported from the U.S. to Mexico City with a journey time of 27 h, with 8 h of lairage at the abattoir. A total of 589 pigs from three genders were monitored. Overall results show that both stimuli caused metabolic and physiological disturbance. Gilts were more efficient in controlling glycemia after a long transport journey (24 h), than castrated males ($P<0.05$), whose glucose was increased above the 30 mg/dL basal level. Females on arrival had 23 mg/dL more lactate compared to basal levels ($P<0.05$). Stunning caused more physiological effects compared to transportation. Regarding the gender factor, females and entire males were more susceptible to transport stress and stunning compared to the castrated pigs, and entire males showed more complications restoring the gas exchange compared to females and barrows.

1. Introduction

Care of the production process in fattening pigs during transportation from the farm to the abattoir, environmental and truck temperatures, at lairage, stunning and slaughter, and postmortem handling are important in order to ensuring animal welfare and optimum meat quality (Averos, Herranz, Sanchez, Comella, & Gosalvez, 2007; Dewey, Haley, Widowski, Poljak, & Friendship, 2009; Mota-Rojas, Guerrero-Legarreta, & Trujillo-Ortega, 2010; Mota-Rojas, Orozco-Gregorio, González-Lozano et al., 2011; Mota-Rojas et al., 2009, 2010). Sutherland, McDonald, and McGlone (2009) reported that the percentage of pigs dying or becoming nonambulatory during transport decreased during journeys lasting more than 4 and 5 h, respectively. The effect of stress on pork quality in Mexico has been reported by Mota-Rojas et al. (2006) and Becerril-Herrera et al., 2010). It is well known that stress is caused by stimuli such as hunger, fear, thirst and weather, among others, which in turn causes physiological and metabolic changes (Grandin, 1997; Mota-Rojas, Orozco-Gregorio, González-Lozano et al., 2011; Mota-Rojas, Orozco-Gregorio, Villanueva-Garcia et al., 2011; Orozco-Gregorio et al., 2010). Maintaining a high standard of animal welfare during transport and slaughter of pigs requires both appropriate equipment and supervision of employees (Kephart, Harper, & Raines, 2010; Mota-Rojas et al., 2010).

Recently, interest has focused on the welfare of animals transported in general, partly because of the longer journeys, especially for trading, nearly 7 million pigs each year are exported within the European Union (Christensen, Barton Gade, & Blaabjerg, 1994). In Mexico there is a prevailing marketing system of beef cattle with varying distances for transportation to a number of slaughterhouses, as in the case of Mexico City and the State of Mexico which receive animals for slaughter from Puebla (12.84%), Jalisco (38.26%), Guanajuato (19.15%), and other states (29.75%). On the other hand, live pigs are imported mostly from the U.S. and are transported for up to 27 h to Central Mexico's abattoirs (Becerril-Herrera, Alonso-Spilsbury et al., 2007a; Becerril-Herrera, Mota-Rojas et al., 2007b).

Pigs are highly susceptible to stress with physiological adaptation mechanisms like augmentation of catecholamine secretion, resulting

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in an increase in cardiac output, oxygen consumption, reduction in body temperature and pH and lactic acid accumulation (Edwards, Grandin, Engle, Porter et al., 2010; Edwards, Grandin, Engle, Ritter et al., 2010; Hambrecht, Eissen, & Verstegen, 2003) and increased gluconeogenesis, thus augmenting the basal metabolic rate (Becerril-Herrera, Alonso-Spilsbury et al., 2009a; Mota-Rojas et al., 2009). As stress increases in the animals it causes a metabolic imbalance that affects the post-mortem glycolytic potential, altering the degree of muscle acidosis and flesh color (Hambrecht et al., 2004; Leheska, Wulf, & Maddock, 2003). Inappropriate methods of slaughter, hygienic conditions, premortem rest period, poorly planned facilities and mistreat of animals by the staff of the slaughterhouse, directly influence normal values of pH, temperature, water retention capacity and meat color (Mota-Rojas et al., 2006, 2005).

The aim of this study was to assess the impact of changes in acid–base metabolism, energy profile, carcass quality and blood gases resulting from the handling of the intact male, female and castrated male American pigs subjected to chronic stress (27 h journey duration) and acute stress (CO_2 stunning chambers).

2. Material and methods

2.1. Location

The study was carried out in a federal inspection plant in Central Mexico.

2.2. Experimental handling

A total of 589 American swine from a cross of Duroc sire with Yorkshire × Landrace dam breeds, were monitored. The day before they left the farm for transportation to the slaughterhouse, random blood samples were taken from 159 pigs approximately 155 days old. Samples were obtained by nose snare restraining the pigs for 5 s, and were used as both baseline and reference sample. The next day the animals were transported for 27 h until final destination in Central Mexico. The experiment was carried out in accordance with the guidelines for the ethical use of animals (Sherwin et al., 2003). All procedures related to the use and care of the animals respected the Mexican regulation NOM-062-ZOO (1999). During loading and unloading, at the farm and at the abattoir pigs were gently handled, no shouting and no electric prods were used.

Animals were fasted for 8 h prior to transport, and transported to the slaughter house with no water or food available during an average time period of 27 h. Three journeys were required in order to randomly transport the three gender groups of study: gilts, barrows and intact males, with 180 pigs per trailer; the stocking density was approximately 0.40 m^2 per pig. The three vehicles left the farm at 5:00 AM, with an arrival time recorded between 7:00 and 10:00 am the next day. At the abattoir pigs were unloaded through a 0.95 m^2 (wide) by 10 m (length) fixed ramp, which slope was 50°.

Average ambient temperature and relative humidity upon arrival were respectively, 19–20 °C and 61%. During the rest period at the abattoir by 8 h, all pigs had access to food and water ad libitum. Pigs were housed with a space allowance of 0.75 m^2/100 kg during lairage time.

2.3. Groups distribution

Animals were randomly distributed, considering the three genders and 3 bleeding times (or sampling occasions): basal, after transport and after stunning, according to Table 1.

2.4. Energetic profile, acid–base balance and blood tests

Blood samples were taken from the jugular vein using a 0.25 mL heparinized syringe. The investigators who sampled the pigs had the skills to collect the blood at the first attempt in less than 5 s. Hematocrit (%), glucose (mg/dL), serum electrolytes [Na^+, K^+ and Ca^{2+} (mmol/L)], blood lactate (mg/dL), partial pressure of carbon dioxide [PCO_2 (mm Hg)] and oxygen [PO_2 (mm Hg)] levels, were obtained by means of an automatic blood gas and electrolyte analyzer (GEM Premier 3000, Instrumentation Laboratory Diagnostics S.A. de C.V. Mexico). Lithium heparin was used to avoid blood clotting. Individual body temperature was also monitored within 1 s, through an ear thermometer (ThermoScan Braun, Germany).

Table 1
Groups distribution, considering the three genders and 3 bleeding times (or sampling occasions): basal, after transport and after stunning.

Group number	Number of animals, gender and group
1	75 females as reference values
2	84 barrows as reference values
3	81 entire males as reference values
4	105 females transported for 27 h
5	80 barrows transported for 27 h
6	138 entire males transported for 27 h
7	88 females stunned by CO_2
8	106 barrows stunned by CO_2
9	78 entire males stunned by CO_2

2.5. Stunning methods

Pigs were moved into de CO_2 stunner in groups of four; handling was low-stress moving the animals with gently slaps on their backs with no shouting or blows, and without using electric prods or goads, in order to get them into the stunning chamber.

Pigs were stunned in a dip lift CO_2 anesthesia chamber set at 80% CO_2 atmosphere during 60 s. Four pigs were put together per gondola, reaching 3 m deep to gas exposure. The stunner facility consisted of a raceway and a dip-lift stunning unit. The raceway from the lairage pens to the stunning unit allows movement but prevents the animal from turning around. The floor of the cradle has holes to facilitate the distribution of the gas inside, so pigs could sniff small concentrations of the gas while they were at the end of the raceway and in the cradle.

2.6. Measuring the energetic profile, acid–base balance and blood gases post-slaughter

Immediately after stunning, pigs were bled for a third sample, which was collected in a capillary tube to assess the effect of stunning considering the acid–base balance and blood gases, through the gas analysis equipment described above.

2.7. Statistical analyses

The results were analyzed through a completely random design, with a 3 by 3 factorial design, according to the following model:

$$Y_{ij} = \mu + \iota_i + \xi_{ij}$$

$$i = 1, 2 \ldots \text{group}$$

$$j = 1, 2, 3 \ldots \text{repetitions}$$

where:

Y_{ij} response variable;
μ general mean;
A_i Effect of factor A at i level. (Basal, post transport, post stunning)
B_j Effect of factor at j level (gender)