Time derivatives in air temperature and enthalpy as non-invasive welfare indicators during long distance animal transport in Spain and Portugal

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Abstract

Extreme environmental temperatures and high relative humidity can have serious negative effects on animal production at the farm level, but less is known about environmental changes during live transport of domestic animals to slaughter. Although upper temperature limits have been established to transport pigs in Europe, few indices include relative or absolute humidity maxima or mention appropriate enthalpy ranges. In this study temperature and humidity sensors were installed on commercial vehicles on ten long-distance (15 h) livestock transport journeys that carried pigs from Spain to Portugal. Psychometric charts indicated differences in air enthalpy (kg water/kg dry air) between summer and winter trips, but that did not translate into poor carcass pH45 min after slaughter. The changes in temperature (ºC/second) and humidity (%RH/second) were much higher during transport than normal levels on the farm.

Keywords: pig, enthalpy, stress, welfare, indicator, non-invasive

1. Introduction

The welfare of pigs can be compromised by high environmental temperatures, but less is known about how relative humidity and enthalpy influence the level of welfare of pigs during transport. Although upper temperature limits have been established to transport pigs in Europe, few indices include relative or absolute humidity maxima or mention appropriate enthalpy ranges.

The transport of live animals is an important part of the animal production chain and is often the most visible to consumers. Poor handling during transport has a negative effect on society's view of animal production as a whole and also has a negative effect on product quality, beginning with stressed animals and ending with high intermediate (pH45 min) and final pH levels (pH24). Carelessness at this crucial stage in the production chain can destroy the added value of products painstakingly added during previous months on the farm.

Spain is the second largest swine producer in Europe and exports up to a third of its national production. Most exports leave the country as live transport by road to Portugal, Italy and France, but little is known about the environmental conditions of these journeys and their possible effects on stress and product quality. With this goal in mind, we analysed the changes in temperature and humidity during nine journeys by road from Pamplona (Spain) to Lisbon (Portugal) to establish help to establish a non-invasive indicator of pig welfare during transit (see Villarroel et al., 2011), related with plasmatic stress indicators and meat quality indicators.

2. Methods

2.1 Journeys and animals

Nine commercial journeys were carried out from Pamplona (Navarre, Spain) to near Torres Vedras (Lisbon, Portugal) with pigs from the Biurrun S.L. company at different dates in 2010 and 2011 (see Table 1). We used the same vehicle for all journeys, adequate for pig transport (MAN truck and Pessaioli trailer), with three levels and the possibility of using 6 compartments per level (220 cm long, 245 cm wide, 84 cm high), leaving a surface area of 5.39 m^2 per compartment and transporting approximately 240 pigs per journey. The animals were taken to the Sicasal abattoir in the town of Vila Franca do Rosario, 30 min north of Lisbon.

We recorded temperature and humidity values inside as well as outside the vehicles, and on the farm before transport and after transport at the abattoir using data loggers (Onset computers, Hobo H8 loggers). The devices were placed on the second floor (of three floors) in the trailer, protected with a metal shield especially designed to avoid direct contact by the pigs and possible deterioration, while being at animal height. Temperature and humidity values were recorded at intervals of 5 min for very journey. Pigs were Large White Landrace x Duroc, both males and females, with an approximate age of 6 months and an average live weight of 100 kg. Upon arrival at the abattoir, all pigs rested at least 12 h before slaughter, after which meat pH was measured at 45 min post-slaughter.

2.1 Data analysis

The psychrometric graphs obtained were obtained using the data obtained from the sensors and calculated according to the ASBE model tan includes temperature, relative humidity, absolute humidity and enthalpy. The psicrometric data ASAE D271.2, defined in Abril 1979 and revised in 2005 (ASABE 2006 ST. Joseph, MI) were used to calculate the psychrometric properties during transport, both inside and outside the tráiler.

Statistical analysis

All the statistical analyses were carried out using the SAS program (Statistical System Institute Inc. Cary, NC. 2000). The data on temperature and humidity both inside and outside were analysed by the Repeated measures procedure. While the data on pH were compared using the proc mixed procedure. The averages were compared using the least square difference test (LSD) with a level of significance of 5% ($P< 0.05$).

3. Results and Discussion

As observed in Table 1, the temperature inside the vehicles never reached above 35°C, which, according to the European Union Regulation 1/2005 (Chapter 2, Section 3.1, European Commission, 2004), should never be passed when transporting pigs. All the animals arrived safely to the abattoir without mortality or apparent lesions.

Both the interior temperatures (inside the vehicle at animal height) as well as the exterior (outside the livestock vehicles) were significantly higher during journeys 1, 2, 5 and 6, which were carried out in summer. Also in those journeys, the relative humidity was significantly higher. According to Lucas et al. (2000) and Seedorf et al. (1998) high temperatures and lower humidity are more common in summer months, and high relative humidity values are only common when the temperature is not very high. Our data suggest however that even at high temperatures, humidity during transport can be quite high as well, which also affects enthalpy.

Enthalpy can be defined as the total heat content of the air that surrounds an animal, and depends on the temperature and humidity. The average enthalpy in the winter months was 0.012 kg water/ kg dry air (±0.009) and in the summer 0.006 kg water/ kg dry air (±0.002).

The values of enthalpy (Figure 1) ranged from 0.003-0.02 kg water/ kg dry air, which is similar to the results found by Villarroel et al. (2011). According to the psychrometric graphs, the enthalpy did not undergo very wide changes among journeys during transport, but we do observe more of a difference if we group the journeys carried out during the summer and winter. Enthalpy is more uniform among journeys in winter, since the temperatures and lower and more similar among trips.

Table 1. Results of the average temperature and humidity inside and outside livestock vehicles on 9 journeys carrying 240 live pigs from Spain to Portugal.

Trip	Date	Tint (°C)	Text (°C)	HRint (%)	HRext (%)	pH45
1	22/04/2009	20.64^{c}	24.35^{c}	66.96^{b}	52.38^{c}	6.13^{a}
2	19/08/2009	29.21^{b}	29.34^{b}	38.28^{ef}	38.87^{e}	6.03^{a}
3	21/01/2010	13.68^{e}	15.05^{e}	76.95^{a}	72.55^{a}	6.03^{a}
4	29/06/2010	29.72^{b}	32.98^{a}	34.77^{ef}	37.71^{e}	6.15^{a}
5	30/06/2010	34.56^{a}	29.51^{b}	32.72^{f}	55.59^{b}	6.32^{b}
6	31/01/2011	11.64^{f}	6.79^{g}	36.41^{e}	57.58^{b}	6.06^{a}
7	02/02/2011	12.62^{f}	9.70^{f}	52.91^{d}	56.95^{b}	6.10^{a}
8	03/02/2011	14.55^{e}	19.81^{d}	52.68^{d}	44.70^{d}	6.10^{a}

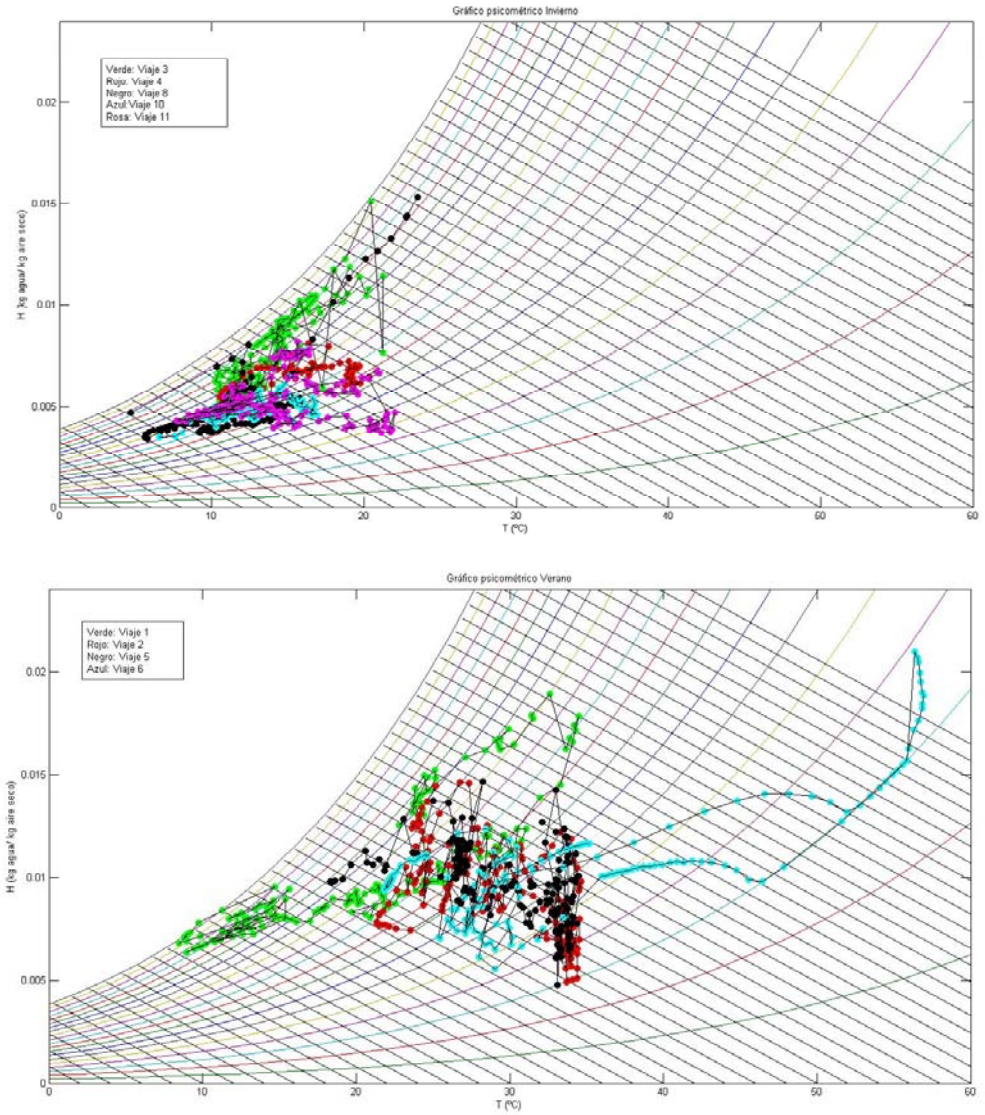
Tint: inside temperature; Text: outside temperature; HRint: inside relative humidity; HRext: outside relative humidity. Different letters mean significant ($P<0.05$) differences among journeys (rows).

Regarding meat pH, pH45 min was only significantly higher after journey 4, in the summer months, but quite similar among other months. A low pH45 (closer to 6.0) is worse and suggests meat that could end up being DFD (dark, firm and dry), where glycogen levels could have been lower in the pigs at slaughter. According to those results, a higher pH45 (trip 4) would suggest better conditions and better welfare.

We can conclude that in the climatic conditions observed in this study, the season of the year, the duration of the journey and the distance do not interfere with the animal welfare. It is necessary to carry out more studies to carry out a more exhaustive look at effect on meat quality. The results suggest that the enthalpy during transport can be a good non-invasive indicator of animal welfare in addition to temperature and relative humidity.

Acknowledgements
We thank Birurrun SL and Ancoporc for their help in carrying out field work, as well as Sicasal in Portugal. The work was financed in part by the project P2009/AGR-1704 (Comunidad de Madrid).

Figure 1. Psychrometric graphs of the journeys carried out in winter and summer.



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