NEW HANDLING AND TRANSPORTATION STRATEGIES UNDER CANADIAN CONDITIONS

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ABSTRACT
Death losses during transportation in Canada may be low (0.08%), but the total loss amounts to approximately 17,000 pigs per year. The rate of loss is higher during the summer months and differs with farm of origin and with transporters. The effect of the farm of origin can be attributed, among others, to the pre-transport handling of pigs and farm design. Canadian research and industry reports showed that withdrawing feed prior to transport, the elimination of electric prods and driving pigs in small groups through sufficiently wide alleys and ramps reduce the incidence of transport losses (DOA and non-ambulatory pigs) and carcass condemnations, while improving pork quality. Results arising from transportation studies run in Canada over the last few years showed that the design of the pot-belly trailer, characterized by multiple and steep ramps, and 180° turns, increases the use of electrical prodding, influences pig behaviour and welfare parameters (core body temperature, heart rate and blood indicators) and reduces meat quality. These effects are even more evident when this truck is used for the transport of stress-susceptible pigs for short distances, and for long distance transportation (18 h) in winter.

INTRODUCTION
In Canada, up to 17,000 dead-on-arrival (DOA; 0.08%; CFIA, 2006-2010) has been reported each year. A pig death during transit is a major economic loss for producers and transporters. In Quebec, it has been reported at $4 million lost due to death losses (13,000 deads or 0.08 %) and carcass value loss (30 %) resulting from the percentage of pigs becoming non-ambulatory during transport (0.44 %; Martel, 2010).

An epidemiological study run in Ontario reporting 0.17% in-transit mortality rate and 0.27% non-ambulatory pigs on arrival at the plant identified the major source of variation in animal losses as being the farm (25%) followed by the transporter and the packer (16 % each) (Sunstrum et al., 2006; Dewey et al., 2009).

The objective of this paper is to provide an overview of current research findings and outputs of industry initiatives related to the effects of handling techniques, moving strategies, loading facilities and transport conditions on total losses, stress response to preslaughter handling and carcass and meat quality.

HANDLING AT THE FARM
In the afore-mentioned Canadian epidemiological study a wide variation among producers was reported with 10% of the producers losing at least 0.4% of their pigs during transport (Dewey et
al., 2004). The effect of the farm of origin on animal losses and stress response, as well as on carcass and meat quality in pigs, can be partly attributed to differences in the preparation of pigs for transport (i.e. feed withdrawal), barn design and in the handling of pigs as they are moved out of the barn and loaded onto the truck (Correa et al., 2010; Correa, 2011a).

**FEED WITHDRAWAL BEFORE TRANSPORT**

Feed withdrawal is one of the practices for on-farm preparation of pigs before harvest which in Canada is regulated by codes of practice (AAFC, 1993). The potential advantages of feed withdrawal include the higher well-being of animals during transport (Bradshaw et al., 1996; Guàrdia et al., 1996), higher ease of handling (Eikelenboom et al., 1991), reduced carcass contamination due to lower risk of gut contents spillage during carcass evisceration (Saucier et al., 2007), and improved pork quality (Guàrdia et al., 2004, 2005).

Under practical conditions, Correa (2011a) reported that the application of the appropriate fasting interval at the farm reduced by half the proportion of animal losses during transport, while its misapplication produced 77% condemned carcasses due to contamination.

Despite these potential advantages, however, feed withdrawal is sometimes not used or misapplied by producers, resulting in complaints and penalties from the slaughter sector. For instance, a survey conducted at swine farms in Quebec reported that only 15% of pigs had no access to the feeder until the time of transport (Viau and Champagne, 1998). Some reasons for not withholding feed prior to transport were: 1) lack of a shipping room to which pigs sorted by live weight (split-marketing) could be transferred from their home pen in order to withdraw feed and allow them to rest until the arrival of the truck and 2) concern about body weight losses reducing the economic value of the carcass.

Chevillon et al. (2006) reported significant carcass weight loss (360 g/pig) only after 24 h of feed withdrawal. This loss resulted in a 0.33-point difference in dressing yield, which is equivalent to 30 g/h of cold carcass weight loss for a pig weighing 110 kg at slaughter. Kephart and Mills (2005) reported that 24 h of feed withholding permitted a savings of 2 kg of feed/pig. Furthermore, feeding pigs until the time of transport may be very costly because feed consumed by pigs takes 4 to 8 h to be absorbed in the small intestine after ingestion and most nutrients enter the blood 9 h after intake; thus, feed provided to pigs in the last 10 h will not be converted to carcass gain and represents a waste that the processing plant needs to deal with (Warriss, 1985).

Based on current data, Faucitano et al. (2010) considered that a period of 24 h between the last meal and slaughter appears to be an acceptable compromise to obtain optimal carcass yield and pork quality and safety. However, the welfare of fasted pigs still needs to be elucidated as pigs arriving at slaughter with empty stomachs are likely to feel hungry, as suggested by the increased drinking rate (Saucier et al., 2007; Goumon et al., 2012).

**LOADING FACILITIES AND HANDLING**

Loading pigs onto the truck is considered the most critical stage of the transport period as shown by the 110-130 increase in the heart rate and by the increase of stress indicators (lactate) levels in blood compared to the values observed for a pig at rest, with these effects lasting until slaughter and eventually affecting meat quality (Correa et al., 2010; Edwards et al., 2010). The stress associated with loading procedures results from a combination of different factors, such as the
design of the loading facility (either ramp or quay), group splitting in the finishing pen, group size, and handling system.

1. Alley and ramp design

On farms, the alley width is generally limited to the width of two pigs (0.6 to 0.8 m; Lachance et al., 2005). According to Kavanagh et al. (2009), an alley width of 0.9 to 1.2 m is the most conducive to easy handling (less turn-backs and handling interventions) compared to 2.4 m, regardless of the group size. However, these recommendations may not be applicable to the pigs of today as they are heavier and larger than in the past, which may result in increased incidence of bruises and lacerations on the carcass caused by animals hitting the alley and ramp walls while being driven to the truck (Correa, 2011a). In view of the risk of injury and the changes in pig body weight (from 113 to 130 kg) and conformation (3-4 inches wider) that have occurred over the last 5 years, the barn ramp and exit width have been increased by almost 1 m at a number of swine farms in Quebec (Correa, 2011a).

2. Group size

Moving pigs in a group size larger than the farm alley, loading quay or ramp is a common practice at loading. This practice is mistakenly considered effective for speeding up handling; instead, it increases aggression and reduces resting behaviour, even in unmixed pigs (Barton-Gade, 1997). Considering the heart rate increase and the time involved in loading a transport vehicle, moving groups of 2 to 6 pigs at a time, depending on the farm alley and loading quay or ramp design, is recommended to help both producers and transporters save costs and ensure good animal welfare (Grandin, 1999; Lewis and McGlone, 2006). Recently, research trials run at the Prairie Swine Centre in Saskatchewan (Kavanagh et al., 2009) reported that, compared to groups of 12 or 20 pigs, moving a group of 4 or 8 animals is preferable for minimizing stress, based on the number of turn-backs, subjective handling score, squeals and handling interventions, regardless of the alley width (2.4 or 0.9 m).

3. Moving tools

Poor farm facilities combined with the presence of large groups of pigs may cause handling problems at loading leading to indiscriminant use of electrical prodding and slowing down the loading procedure.

In Canada, the electric prod is used by 90 to 95% of truck drivers (Correa, 2011b). Recently, Correa et al. (2010) compared the efficacy of the board combined with either the electric prod or the paddle for driving pigs out of the finishing pen and along the alley and loading ramp. The electric prod helped move pigs quickly, but it was an aversive method with more pigs slipping, falling and overlapping. These behaviours may cause injury and muscle fatigue as evidenced by the higher number of non-ambulatory pigs on arrival at the plant and bruised carcasses resulting in higher ultimate pH due to glycogen exhaustion and blood splashes in the ham at slaughter (Correa et al., 2010).

Aggressive handling from handlers is often related to fatigue caused by the physical effort (higher heart rate) to load pigs onto a truck, especially when facilities are inadequate (e.g. > 24° ramp slope; Goumon et al., 2011). The implementation of animal welfare programs including training of personnel, removal of electric prods and economic incentives proved to reduce the proportion of animal losses from 0.41 to 0.08% and of condemned carcasses from 0.13 to 0.03% (Correa, 2011a).
TRANSPORT CONDITIONS

1. Trailer design

In Canada, truck designs can vary widely, from small single deck trucks to large three-deck punch-hole trailers (often referred to as “pot-belly” trailers). Pot-belly (PB) trailers are quite common in Canada, as they are often dual-purpose (transporting either pigs or cattle) and allow the transport of large loads of pigs (more than 200) on three decks (10 compartments) in one journey and for long distances. However, these vehicles incorporate multiple (up to 5) and steep (up to 40° slope) internal ramps and 180° turns, which result in a lower easiness of handling during loading and unloading, increasing the use of electric prods and extending the load and unload time (Torrey et al., 2008). These observations have been associated with the higher proportion of DOA and fatigued pigs in the PB trailer when compared to other vehicle types equipped with hydraulic decks, such as a double-decked truck or a flat-deck trailer (Cormier and Doonan, 2008; Correa, 2011a). This difference in stress response (based on exsanguination blood variables) between the PB trailer and other vehicle types equipped with hydraulic decks (flat-deck trailer) is even more evident when they are used to haul stress-susceptible (Hal-carriers) genotypes for a short distance (40 km; Vanelli Weschenfelder et al., 2010).

The very few results on the effects of vehicle design on pork quality are inconclusive. Correa et al. (2008) reported no effect on pork quality when comparing a PB trailer with a double-decked truck during 2 h travel time, whereas Vanelli Weschenfelder et al. (2010) found higher pHu (ultimate pH) values in hams of pigs being transported a short distance (45 min) using a PB trailer compared with a flat-deck trailer. However, no effect on meat quality was reported when these two trailer models were used for longer distance transportation (7 h).

It has been evidenced that the animal location (deck and/or compartment position in the truck) during transportation has an impact on its welfare and meat quality (Bench et al., 2008). Within the PB trailer, a higher proportion (32%) of pale, firm and non-exudative (PFN) pork was reported in pigs transported in the upper and lower decks in summer by Correa et al. (2008). Within the deck, pigs located in the upper front and bottom rear compartments showed an increased body temperature after loading (Tamminga et al., 2008) and higher heart rate at unloading (Goumon et al., 2012), while higher pHu and lower drip loss values, indicative of DFD (dark, firm, dry) pork, were reported in the loin and hams of pigs located in the middle front compartment (“bottom-nose”; Correa et al. 2009). More recently, Brown et al. (2012) reported an overall increased risk of PSE (pale, soft, exudative) pork traits in pigs loaded in the top front compartment. These effects are very likely the result of the physical exertion required by pigs to negotiate the ramps to get to these compartments.

2. Microclimate control inside the truck

Environmental temperature during transit is generally considered as one of the greatest contributors to in-transit losses (Clark, 1979; Haley et al., 2008a,b). The highest deaths recorded in the above-mentioned Canadian transport survey were during the month of August (0.40%) when the maximum ambient temperature was 33.6°C (Haley et al., 2008b). However, seasonal effects on total transport losses do not always correspond with increases in environmental temperature. For example Clark (1979), using data from Saskatchewan, reported greater mortality losses in winter.
Given that the thermoneutral zone for pigs is 26-31°C, the air temperature inside the vehicle should not exceed 30°C (Randall, 1993). Temperatures up to approximately 30.2°C have been reported inside the PB trailer, with the lower front compartments being up to 6 and 20°C warmer than the external ambient temperature during Canadian commercial transports in winter and summer, respectively (Brown et al., 2011). Haley et al. (2008b) found that as internal trailer temperature increased, DOA also increased with the 90th percentile of temperature corresponding with an internal temperature of 26.3°C. As the 90th percentile of temperature increased by 1°C, DOA increased by 1.26 (Haley et al., 2008a). Within the PB trailer, higher temperatures have been recorded in the front compartments of the middle and bottom deck (or “belly”), while the upper compartments presented lower temperatures (Brown et al., 2011). The higher and lower temperatures have been explained by the reduced ventilation and poor insulation, respectively (Brown et al., 2011). As suggested by Brown et al. (2011), in the summer the bottom and front compartments of a stationary PB trailer can be cooled by increasing the ventilation rate using fans in combination or not with water sprinkling to increase evaporative cooling. Indeed, effective ventilation and/or water sprinkling in a stationary truck are credited with reducing deaths during transport (Nielsen, 1982; Chevillon, 2000). In the summer of 2011, a joint project was run by the pan-Canadian swine transportation group with the objective to evaluate the efficiency of water sprinkling in a stationary vehicle on the behavioural and physiological response, and carcass and meat quality, in pigs and to identify the most appropriate average temperature to obtain the maximum efficiency. According to the preliminary results, the increase in ambient temperature (from 15 to 25°C) and the application of water sprinkling after loading and before unloading reduced lactate levels in blood at exsanguination, resulting in higher pH at 1 h post-mortem in the loin muscle. However, the better post-mortem muscle acidification rate only resulted in higher water exudation in this muscle at higher ambient temperature, regardless of water sprinkling in the truck. The effects of water sprinkling were different according to the compartment location inside the trailer, with better pork quality in the loin and ham being especially recorded in sprinkled pigs located in the middle front compartment. Water sprinkling also reduced exsanguination lactate levels in pigs transported in the middle front and rear compartments. Overall, it can be concluded that the maximum efficiency of water sprinkling in the stationary truck, in terms of lower transport stress and improved pork quality, can be obtained in the warm season, starting from 20°C (Nannoni, unpublished results).

3. Transport duration and distance

According to the most recent transport survey in Canada, most pigs spent less than 3 h in the truck and 4% spent more than 24 h in transit (Aalhus et al., 1992). However, due to increased regionalization of packing plants over the last 15 years, it is speculated that today a larger percentage of pigs are long-haul transported (Bench et al., 2008).

The relationship between journey length and transport stress does not appear to be linear. Haley et al. (2008b) found that for each 50 km increase in distance DOA can be expected to decrease 0.81 times, and finally reported a decreased risk of in-transit death losses with distances over 134 km. Similarly, it has been observed that pigs hauled very short distances for under 30 min are less easy-to-handle at the plant and may produce poorer pork quality (PSE) than pigs transported for longer distances (Grandin, 1994).

Based on the results of the pan-Canadian swine transportation project (2007-2011), it appears that transport times above 6 h may result in energy depletion and an increased incidence of meat...
quality defects related to the production of DFD pork (Correa et al., 2009). The combined effects of winter transport and longer transport times may have caused increased levels of energy depletion and further increased the incidence of DFD meat. Therefore, a study was run to evaluate the effects of transport duration (6, 12 and 18 h) on animal welfare during transportation and pork quality in summer and winter in Manitoba. The first preliminary results showed that under Canadian climatic conditions, pigs transported for 18 h in winter showed greater evidence of stress, in terms of higher core body temperature and heart rate (Goumon et al., 2012). The effects of season and trip duration on pork quality were modulated by the compartment location in the truck, with the winter longer transport time (18 h) resulting in a higher incidence of DFD pork in pigs located in the rear bottom compartment (Brown et al., 2012).

CONCLUSIONS

The quality of the design of the loading facilities and of the handling system plays a key role in determining the effects of the farm on pig response to pre slaughter stress and on meat quality. To reduce the load time and the workload of loading crews, it is recommended that farms use shipping rooms, move pigs in batches suited to the alley and ramp size and minimize, if not eliminate, the use of electric prods. With regard to moving tools, more research is needed to develop a low-stress handling tool to assist loading crews in loading and moving pigs in challenging areas, such as the transition area between the barn and the loading area and loading ramps.

Research on swine transportation is very recent in Canada as showed by the fewer number of studies being run so far compared to the US and Europe. Considering the incidence of transport losses under Canadian transport conditions, more research on transport factors such as vehicle design, loading density, travel time and their interaction is needed. More specifically, considering the impact of thermal conditions during transport on pig welfare and mortality, transport conditions should be improved by the use of fan-assisted ventilation in combination or not with water sprinkling or misting in summer, or by a combination of insulation and ventilation in winter. The use of truck models featuring hydraulic ramps or decks ramps would reduce the workload of handlers and improve the welfare of pigs.

LITERATURE CITED


