Effects of mid-summer transport duration on pre- and post-slaughter performance and pork quality in Mexico


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Abstract

Seven hundred and fourteen pigs were monitored from transport to slaughter in July in three treatments: 8, 16 and 24 transport hours; lairage time for the three groups was of 8 h. Transport duration significantly \( (P < 0.05) \) affected live-weight gain during the rest period. Weight gain percentages at lairage were 0.05%, 0.78% and 1.15% for treatments 1, 2 and 3, respectively. Transport to slaughter percentage was 2.7%, 4.3% and 6.8% for each of the treatments. Short transport periods significantly increased carcass pH below normal values. Animals transported under acute stress (8 h) showed pale carcasses (high possibilities of transforming into PSE meat). On the contrary, pigs transported for 24 h had more dark red carcasses. Transport from farm to the slaughterhouse should take no more than 16 h in order to improve carcass quality and animals' welfare.

Keywords: Pig; Transport; Slaughter; Lairage; Pork quality; pH

1. Introduction

Transport and handling before slaughter affect both animal weight and meat quality (Gallo, Pérez, Sanhueza, & Gasic, 2000). Poor handling causes economic losses to farmers, transporters and slaughterhouses (Gallo, Espinoza, Sanhueza, & Gasic, 2001). Some stress factors affecting welfare of transported animals include speed variations and vibrations of the truck, contact with strangers, high stocking density and animal commingling, establishment of new hierarchies, and weather conditions such as humidity and high temperatures (Gallo et al., 2001; Grandin, 1994; Grandin, 1997; Martocccia, Brambilla, Macri, Moccia, & Cosentino, 1995; Tadich, Gallo, & Alvarado, 2000). Transport, fasting, slaughter and thirst are also stress factors contributing to live weight loss and poor carcass performance (Schaefer, Jones, & Stanley, 1997; Mota, Becerril, Alonso-Spilsbury, & Ramírez, 2000) causing both physiological and behavioural responses in animals (Geverink, Engel, Lambooij, & Wiegant, 1996; Tadich et al., 2000). Au-Chen et al. (1995) reported weight losses up to 32% when factors mentioned above were not controlled and showed that with adequate transport and handling conditions mortality and detrimental effects on meat quality may be avoided. It is well known that physiological responses of pigs as a consequence of transportation result in physiological stress (McGlone et al., 1993) and/or physical fatigue (Waris, 1998), and can even lead to death. In addition injuries produced during the journey or at lairage affect carcass temperature and pH (Gallo, Lizondo, & Knowles, 2003) leading to alterations in carcass shelf-life (Gallo et al., 2001; Gallo et al., 2003; Gallo et al., 2000; Schaefer et al., 1997). When pH fall is accelerated and is
associated with an excess of body temperature (>40 °C), the result is a pale-, soft- and exudative meat, PSE (Bonelli & Schifferli, 2001).

The objectives of the present study were to evaluate the effects of transport duration on live weight loss of pigs, and to determine the effects of fasting, and lairage period on both live and carcass weights, and on meat quality including pH, colour and temperature.

2. Materials and methods

2.1. Animals

The study was carried out in a municipal slaughterhouse in the State of Mexico in July 2003. A total of 714 fattened pigs (females and barrows) Pietrain × (Yorkshire × Landrace) were monitored. Transportation was done by three similar cattle trailers, with similar capacities and straw bedding, according to the animal care regulations in Mexico (official Mexican regulation NOM-024-ZOO-1995). Pigs were transported without stops and were not fed, nor provided with water.

2.2. Treatments

Animals were transported in three groups: 8, 16 and 24 h, respectively, and were randomly distributed by sex as shown in Table 1.

Pigs from the three groups were loaded using a space allowance of 0.35 m²/100 kg during transportation. Trips were made on different days in July; departure time from the farm for the three groups was 12:00 PM to avoid the confusion of the effect of daylight and the time of transportation, according to the methodology of Gallo et al. (2003). Arrival at the abattoir for Group G₁ was 08.11 h; for Group G₂ at 16:09 h; and for Group 3 G₃, 23.56 h. Distances travelled were 488, 976 and 1464 km for Groups G₁, G₂ and G₃, respectively. Average speed of the trucks in all three groups was 61 km/h.

2.3. Abbatoir

After arrival at the slaughterhouse, the position of the pigs in the trailer was identified, recording whether they were standing, sitting or lying. Hyperventilation occurrence was recorded if respiratory frequency was above 50 breaths per minute.

To obtain weight losses during transport, pigs were weighed in groups before departure from the farm, and also on arrival at the slaughterhouse. Immediately after unloading animals were weighed individually. After 8 h of lairage in the pre-slaughter pens, pigs were individually weighed again using a digital Elec-Weighing scale FTW-150K 150 × 0.05 kg (Excell). Weights were used to calculate weight loss during transport and lairage. A detailed evaluation of live condition was also performed, recording the presence of bruises, erythema and tremor in hindlimbs. Bruises were classified according to the methodology described by Gallo et al. (2000): bruise 1 (b1) affects skin and subcutaneous tissue; bruise 2 (b2) affects subcutaneous and muscular tissues, and bruise 3 (b3) affects subcutaneous, muscular and bone tissues. Erythema was identified as localized (LE1) by well-defined hyperemic borders in loin- and perianal regions, a generalized erythema (GER) was considered when an 80% or greater area of the body surface of the pig showed hyperemia and congestion.

2.4. Rectal temperature at arrival

Rectal temperature was recorded with a digital rectal thermometer immediately after disembarking; each of the transported pigs was marked with an indelible marker on the cervical region in order to identify them before slaughter. Pigs were divided in groups of 80 animals per pre-slaughter pen with 80 m² surface, providing an area of 1 m² per pig.

2.5. Rest period

Lairage time for the three groups was of 8 h; during this period animals were supplied with water ad libitum according to the methodology described by Gallo et al. (2003).

2.6. Fasting

Periods of fasting for the three groups corresponded to the transportation period plus 8 h of lairage period: 16, 24, and 34 h for Groups 1, 2 and 3, respectively. Animals were taken to the slaughter box according to their identification number; the slaughter procedure was followed with the aim of not losing their identification. Pigs were slaughtered following the commercial practice in municipal abattoirs in Mexico (NOM-033-ZOO-1995).

Table 1

<table>
<thead>
<tr>
<th>Groups</th>
<th>G₁</th>
<th>G₂</th>
<th>G₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatments</td>
<td>8 h of transport</td>
<td>16 h of transport</td>
<td>24 h of transport</td>
</tr>
<tr>
<td>Sex</td>
<td>Male</td>
<td>2</td>
<td>Male</td>
</tr>
<tr>
<td>Number of animals per group</td>
<td>97</td>
<td>Male</td>
<td>105</td>
</tr>
<tr>
<td>Total number of animals</td>
<td>240</td>
<td>238</td>
<td>236</td>
</tr>
</tbody>
</table>

2.7. Carcass pH and temperature determination (45 min)

Final pH value for PSE muscles is lower than normal, but rate of pH is faster in muscles that will produce PSE meat than in muscles that will produce normal quality pork and therefore, the pH measurement was performed 45 min after slaughter (pH45) and not at the end of the rigor mortis process (Rubio, 1996; Velasco, 2001).

Carcasses were identified in slaughter sequence for temperature sampling (TC45) and pH45. Both measurements were done on the Longissimus dorsi muscle (central area of the loin) following similar procedures and sampling sites by McPhee and Trout (1995) and Brown, Knowles, Edwards, and Warriss (1999). i.e., on the right side of the carcass, at the level of the tenth and eleventh ribs. For the pH45 measurements a Hanna Instrument (Penetration pH electrode, HI8314, membrane pHimeter, 115 V/60 Hz. Cod. 1.1176) was used. Carcass temperature was taken with a digital thermometer (CITIZEN, model CT561C/F).

In order to observe the effect of transport time on the degree of pork acidity, carcasses were separated in three ranges; pH45 lower than 5.7 (meat with a likelihood of occurrence of pale, soft and exudative, PSE); pH45 from 5.8 to 6.2 (normal pH range), and pH45 higher than 6.3.

2.8. Colour measurement

Subjective colour evaluation was done on the surface of the same muscle’s cut, and similar to Gallo et al. (2000) and Gallo et al. (2001) methodology immediately after pH and temperature measurements were taken. Meat was subjectively classified according to its colouration, using a standard scale according to the NPPC (National Pork Producers Council, 1991). Therefore, five colours were distinguished: pale (1), slightly pink (2), greyish rose (3), light red (4) and dark red (5).

2.9. Meat quality

Criteria used to classify the meat as PSE included: a pale colour (1), a TC45 higher than 40 °C, and a pH45 < 5.5.

2.10. Statistical analysis

In order to analyze skin variables: b1, b2, b3, LE1 and GER, as well as position at arrival (standing, sitting and/or lying), tremor in hindlimbs and hyperventilation, the Chi square test was used. Carcass yield, temperature, colour, pH, and rectal temperature, were analyzed with the Kruskal Wallis test, and significant differences were determined using orthogonal contrasts.

Results obtained for the following traits: live weight at arrival, live-weight during lairage, pre-slaughter live weight gained, and hot carcass weight, were analyzed using a completely randomized design including a factorial 3² arrangement which model was as follows:

\[ Y_{ijk} = \mu + A_i + B_j + (AB)_{ij} + E_{ijk} \]

\[ i = 1, 2, 3 \]

\[ j = 1, 2 \]

where \( Y_{ijk} \) is the response variable (animal weights, carcass performance, etc.), \( \mu \) is the general mean, \( A \) is the effect of factor \( A \) at level \( i \) (transportation duration), \( B \) is the effect of factor \( B \) at level \( j \) (sex), \( (AB)_{ij} \) is the effect of interaction \( AB \) at level \( ij \). \( E_{ijk} \) is the randomized error on the \( K \) repetition, level \( j \) of \( B \) and level \( f \) from \( A \).

In order to determine differences among the treatment means, the Tukey test was used. The significance level considered for all the statistical tests was \( P < 0.05 \). Also, a correlation analysis between slaughter traits was run in order to numerically summarize the degree of relation between any two variables. SAS V 6.12 (1997) was used for the analysis of the treatments’ effect on the different traits.

3. Results

Slaughter performance results are provided in Table 2. Transport duration significantly affected \( (P < 0.01) \) the degree of bruising 1, 2 and 3; as transportation time increased, bruising percentage in animals also increased. On the other hand, the \( \chi^2 \) analysis did not show significant differences between genders in all the treatments.

Significant differences \( (P < 0.01) \) in the presence of erythemas among treatments were found; a higher incidence of both LE1 and GER were noted as transport duration was increased. Sex did not show a significant difference in the 8 h transport treatment; nevertheless, there were significant differences \( (P < 0.01) \) in animals transported during 16 and 24 h, with a greater incidence of erythemas in males.

There were significant differences \( (P < 0.01) \) among treatments for tremor in hindlimbs, the incidence increasing with transport duration. Although no significant statistical differences were observed between genders in animals transported for 8 h; males transported for 16 and 24 h, showed a higher incidence of tremor in hindlimbs compared with females transported over the same period \( (P < 0.01) \).

Significant differences \( (P < 0.01) \) in hyperventilation incidence were observed; it is outstanding that for those animals transported for 16 h, the presence of hyperventilation was higher, specially in males. Nevertheless, hyperventilation incidence did not show significant differences between genders for 8 and 24 h transport period.

Transport duration significantly \( (P < 0.01) \) affected the animals’ position on arrival at the abattoir; moreover, there were significant differences \( (P < 0.01) \) according to the sex. When transport time was shorter, a higher number of pigs arrived in a standing position; more females arrived in a standing position in the group shipped for 8 h. On the other hand, males were more fatigued and arrived in a lying position when the journey took 16 or 24 h.
The mean and standard error of the mean for traits monitored during slaughter are shown in Table 3.

Rectal temperature of pigs at arrival was influenced by the transport duration (Table 3). No significant differences were found between males and females, except for Group 3, where females had a higher temperature than males (treatments 5 and 6).

Live weight at arrival was not affected by the transport duration, whereas there was a gender difference in males weight.

Weight of the hot carcass was negatively affected by transport duration. This was also evident in the carcass yield (%) when transportation time was shorter, G1 obtained the best yields (Table 3).

Regarding the TC45 (data not shown), significant differences ($P < 0.01$) between genders were observed, males showed higher temperatures although carcass temperatures exceeded 40 °C in only four pigs.

pH results are provided in Table 4; $\chi^2$ test showed significant differences ($P < 0.01$) in the treatments on transportation time and sex, there was a higher number of pigs at pH of 5.8–6.2 and this was more evident in females ($P < 0.01$).

Table 5 shows transport duration effects on the carcass colour. $\chi^2$ test indicated significant differences ($P < 0.01$) in the treatments on transportation time and sex, there was a higher number of pigs at pH of 5.8–6.2 and this was more evident in females ($P < 0.01$).
Correlations between slaughter traits are shown in Table 6. The most significant observed correlations correspond to live weight at arrival; this was positively correlated with live weight at slaughter \((r = 0.96)\) and weight of the hot carcass \((r = 0.70)\). Weight of hot carcass was also positively correlated with carcass yield \((r = 0.58)\). Whereas pH at 45 min was negatively correlated with carcass’ temperature at 45 min \((r = 0.73)\), and positively with colour \((r = 0.74)\); there was a negative correlation \((r = -0.61)\) between these latter variables.

Table 4
Number and carcass percentage which presented low, normal and high pH at 45 min post-mortem

<table>
<thead>
<tr>
<th>Treatments</th>
<th>pH &lt; 5.7 low (PSE)</th>
<th>pH 5.8–6.2 normal</th>
<th>pH &gt; 6.3 high</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Observation (%)</td>
<td>Observation (%)</td>
<td>Observation (%)</td>
</tr>
<tr>
<td>Treatment 1 (F 8)</td>
<td>9 (9.27)</td>
<td>73 (75.25)</td>
<td>15 (15.46)</td>
</tr>
<tr>
<td>Treatment 2 (M 8)</td>
<td>31 (21.67)</td>
<td>81 (56.64)</td>
<td>31 (21.67)</td>
</tr>
<tr>
<td>Treatment 3 (F 16)</td>
<td>8 (7.61)</td>
<td>65 (61.90)</td>
<td>32 (30.47)</td>
</tr>
<tr>
<td>Treatment 4 (M 16)</td>
<td>20 (15.03)</td>
<td>49 (36.84)</td>
<td>64 (48.12)</td>
</tr>
<tr>
<td>Treatment 5 (F 24)</td>
<td>4 (3.53)</td>
<td>76 (67.25)</td>
<td>33 (29.20)</td>
</tr>
<tr>
<td>Treatment 6 (M 24)</td>
<td>10 (8.13)</td>
<td>46 (37.39)</td>
<td>67 (54.47)</td>
</tr>
</tbody>
</table>

Contrasts Probability \(\chi^2\)

- Females vs. males 0.001
- Pigs 8 h vs. pigs 16 h 0.001
- Pigs 8 h vs. pigs 24 h 0.001
- Pigs 16 h vs. pigs 24 h NS

PSE, pale, soft and exudative; F, females, M, barrows.

Table 5
Number and percentage of the colour trait in carcasses

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Meat colour</th>
<th>Pale</th>
<th>Slightly pink</th>
<th>Greyish pink</th>
<th>Light red</th>
<th>Dark red</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Observation (%)</td>
<td>Observation (%)</td>
<td>Observation (%)</td>
<td>Observation (%)</td>
<td>Observation (%)</td>
</tr>
<tr>
<td>Treatment 1 (F 8)</td>
<td>7 (7.21)</td>
<td>2 (2.06)</td>
<td>86 (88.65)</td>
<td>1 (1.03)</td>
<td>1 (1.03)</td>
<td></td>
</tr>
<tr>
<td>Treatment 2 (M 8)</td>
<td>25 (17.48)</td>
<td>6 (4.19)</td>
<td>109 (76.22)</td>
<td>1 (0.69)</td>
<td>2 (1.39)</td>
<td></td>
</tr>
<tr>
<td>Treatment 3 (F 16)</td>
<td>4 (3.80)</td>
<td>2 (1.90)</td>
<td>92 (87.61)</td>
<td>1 (0.95)</td>
<td>6 (5.71)</td>
<td></td>
</tr>
<tr>
<td>Treatment 4 (M 16)</td>
<td>11 (8.27)</td>
<td>4 (3.00)</td>
<td>101 (75.93)</td>
<td>1 (0.75)</td>
<td>16 (12.03)</td>
<td></td>
</tr>
<tr>
<td>Treatment 5 (F 24)</td>
<td>2 (1.76)</td>
<td>4 (3.53)</td>
<td>98 (86.72)</td>
<td>1 (0.88)</td>
<td>8 (7.07)</td>
<td></td>
</tr>
<tr>
<td>Treatment 6 (M 24)</td>
<td>7 (5.69)</td>
<td>4 (3.25)</td>
<td>76 (61.78)</td>
<td>2 (1.62)</td>
<td>34 (27.64)</td>
<td></td>
</tr>
</tbody>
</table>

Contrasts Probability \(\chi^2\)

- Females vs. males 0.001
- Pigs 8 h vs. pigs 16 h 0.001
- Pigs 8 h vs. pigs 24 h 0.001
- Pigs 16 h vs. pigs 24 h 0.001

F, females; M, barrows.

Correlations between slaughter traits are shown in Table 6. The most significant observed correlations correspond to live weight at arrival; this was positively correlated with live weight at slaughter \((r = 0.96)\) and weight of the hot carcass \((r = 0.70)\). Weight of hot carcass was also positively correlated with carcass yield \((r = 0.58)\). Whereas pH at 45 min was negatively correlated with carcass’ temperature at 45 min \((r = 0.73)\), and positively with colour \((r = 0.74)\); there was a negative correlation \((r = -0.61)\) between these latter variables.

Table 6
Correlation coefficients \((r)\) within/between different slaughter traits in pigs

<table>
<thead>
<tr>
<th></th>
<th>RTA</th>
<th>LWA</th>
<th>LWS</th>
<th>GWR</th>
<th>HCW</th>
<th>CP</th>
<th>pH45</th>
<th>TC45</th>
<th>Colour</th>
</tr>
</thead>
<tbody>
<tr>
<td>RTA</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LWA</td>
<td>-0.05359</td>
<td>1.0000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LWS</td>
<td>-0.09550</td>
<td>0.96012*</td>
<td>1.0000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GWR</td>
<td>-0.14183</td>
<td>-0.22065</td>
<td>0.06085</td>
<td>1.0000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HCW</td>
<td>0.07897</td>
<td>0.70566*</td>
<td>0.64736*</td>
<td>-0.26091</td>
<td>1.0000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CP</td>
<td>0.20185</td>
<td>-0.12242</td>
<td>-0.23955</td>
<td>-0.39864</td>
<td>0.58484*</td>
<td>1.0000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH45</td>
<td>-0.07301</td>
<td>0.02015</td>
<td>0.07007</td>
<td>0.17251</td>
<td>-0.07955</td>
<td>-0.17595</td>
<td>1.0000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TC45</td>
<td>-0.01887</td>
<td>0.05332</td>
<td>0.02538</td>
<td>-0.10896</td>
<td>0.05969</td>
<td>0.04975</td>
<td>-0.73862*</td>
<td>1.0000</td>
<td></td>
</tr>
<tr>
<td>Colour</td>
<td>-0.08488</td>
<td>0.06299</td>
<td>0.11558</td>
<td>0.17382</td>
<td>-0.06659</td>
<td>-0.20756</td>
<td>0.74899*</td>
<td>-0.61415*</td>
<td>1.0000</td>
</tr>
</tbody>
</table>

P \(< 0.05\).

RTA, rectal temperature at arrival; LWA, live weight at arrival; LWS, live weight at slaughter; GWR, gained weight after lairage; HCW, heated carcass weight; CP, carcass yield (%); pH45, pH at 45 min post-mortem; TC45, carcass temperature at 45 min post-mortem.
4. Discussion

4.1. Transport

Transport time affected the incidence of skin lesions. It is worth highlighting that the incidence of bruises blemishes in males; this can be appreciated in Table 2. Males showed a higher incidence of skin bruises, regardless of the transport duration. Geverink et al. (1996) and Warriss et al. (1998) concluded that a cause of skin damage is the result of pre-slaughter fights among pigs, and these take place to a higher degree among males than among females. It is a common practice to mix different groups of pigs from different farmers during transport and moreover, during the resting period. Pigs in general, do not fight while being transported; they mainly establish social dominance in the pre-slaughter pens (Geverink et al., 1996). McGlone et al. (1993) indicated that after 4 h of transportation shy- and subordinate pigs suffer more stress than dominants. The presence of skin lesions may therefore be an indicator of animal welfare before being sent to the abattoir.

Another important factor influencing trauma during transportation is the high load density. This causes stress, higher number of contusions and fallen animals when compared with medium or lower densities (Tarrant, Kenny, Harrington, & Murphy, 1992). During transportation, balance loss and falling of animals can happen; this situation can be associated with the truck structure and the load density (Tarrant, Kenny, & Harrington, 1988; Tarrant et al., 1992; cited by Gallo et al., 2001), or with the way in which driver handles the vehicle when coming to a stop. The presence of trauma can also be related to the loss of weight by condemning the traumatized tissue (Gallo et al., 2000). Results of this study agree with those reported previously by Gallo et al. (2001); the longer the journey, the more contusions animals will show, this situation causes greater economic losses due to the serious commercial problem that skin lesions provoke.

Warriss, Brown, Bevis, and Kestin (1990) have proven that males produce carcasses with greater damage due to fights, than females. They postulated that the physical efforts associated with fighting may be responsible for the high lactate levels in plasma. According to Grandin (1994), factors such as transportation during the summer (>30 min), overcrowding and mixing of pigs from different places, produce an increase in the incidence of PSE meat, and therefore, recommends that animals weighing around 100 kg should have at least 0.35 m² space during transport; these densities are similar to those used in the present study: 0.36 m²/100 kg, 0.35 m²/100 kg, and 0.35 m²/100 kg for Groups G₁, G₂, and G₃, respectively, and agree also with the Mexican regulation NOM-024-ZOO-1995.

Grandin (1994) and Knowles (1999) have both stated that after a long journey by highway, animals tend to lie down for the last hours of their transportation, regardless of the load density. In our study short transport time (8 h) showed a higher number of animals standing at arrival, and significant differences between genders, more females arrived on their feet compared with males. The longer the trip took, the greater the number of animals arriving in a lying position increased; this was more evident in males, showing statistical differences compared with the females transported during the same period.

Higher rates of animals showing hyperventilation were observed in the group transported for 16 h (42%). This could have been influenced by the arrival timing; Group 2 arrived at 16.00 h and animals had undergone a 5 h period under extremely hot conditions.

Percentages of weight loss during transport were 2.67%, 4.28% and 6.84% for Groups 1, 2 and 3, respectively. These data are higher than described in previous studies by Brown et al. (1999) whose research with pigs transported for 8, 16 and 24 h showed live weight losses of 2.2%, 2.0% and 4.3%, respectively. Pigs transported for 24 h lost 2.6% of their hot carcass weight. Brown et al. (1999) found that weight loss during transport is mainly due to the elimination of feces and urine, although another form of losing weight could be by transpiration and hydration loss which causes a significant decrease. Bak and Wajda (1997) reported that pigs transported for distances of 50 and 100 km without access to water, showed a decrease in carcass yield, a higher weight loss in the pre-slaughter pens, and lower drip loss (PSE). Casas (1990) showed that pigs transported for 24 h lost 2.05–3.91%, when journeys took from 24 to 36 h losses ranged from 3.48% to 5.40%, and when travelling from 36 to 72 h, losses were from 3.88% to 6.37% of live weight. Barranco (1988) recorded a 5% live weight loss when pigs were transported in a truck for 500 km.

4.2. Rest and slaughter

Transport duration significantly \( (P < 0.05) \) affected live weight gain during the resting period; live weight gain percentages due to rehydration were: 0.05%, 0.78% and 1.15% for Groups 1, 2 and 3, respectively. Males from all treatments showed the highest pre-slaughter live weights and percentages due to rehydration were: 0.05%, 0.78% and 1.15% for Groups 1, 2 and 3 regarding carcass yield (%) between sexes; nevertheless, this was different for Group 1 \( (P < 0.05) \). This difference can be explained by studies from Eikelenboom, Bolink, and Sybesma (1991) who found statistical significance.
(P < 0.05) on the effect of sex on the live weight of pigs fasted for 16 and 24 h. Results indicate that females showed lower hydration loss compared with males; this can also be explained if one considers that the higher the adipose tissue, the higher the quantity of water is retained in the body (Rubio, 1996). Coma and Piquer (1999), speculate that the effect mentioned above can be due to the possible difference in the glucogen use during fasting in the composition of muscular fibres or by the pre-slaughter transport behaviour.

Animals which drank greater amounts of water during lairage were those which were transported for the longer periods. These also showed lowest carcass yields since the imbibed water was lost as gut contents during evisceration. It has been observed that handling and transport cause dehydration (Brown et al., 1999; Schaefer et al., 1997; Tadich et al., 2000), this is clearly a log result of factors such as water abstinenence, loss of liquid in urine, excessive animal sweating and an increase of the respiratory frequency. Schaefer et al. (1997) also determined that lack of both food and water reduce animals live weight. Gallo et al. (2003) concluded that carcass weights in cattle also, tend to be lower after long journeys and long periods in the pre-slaughter pens. Furthermore, (Coma & Piquer, 1999) mention that the incidence of DFD meats increases when fasting and transport are prolonged. During transport a dramatic decrease in final carcass weight can be obtained (Prändl, Fischer, Schmidhofer, & Sinell, 1994). Transport, load and unload alterations cause live weight losses, and these lead to a reduction in the final product utilization.

4.3. pH, temperature and carcass colour

Transport in relatively short periods significantly increased the incidence of lower pH45 (16.6% of the pigs transported for 8 h). When an animal is subjected to acute stress, a quick glycolysis takes place, and therefore, the meat pH gets acidified more rapidly than normal, increasing the PSE meat likelihood. On the other hand, when comparing pH45 values between genders, highly significant differences were found, somehow indicating a higher resistance of females to stress.

Warriss et al. (1990) did not find differences between sexes for any pH45 measurement, nor for drip loss, nevertheless, the colour of meat in the females in the present study was significantly (P < 0.05) more pale than in the males. Variation between TC45 influences individual pH values due to the fact that at higher temperatures, anaerobic glycolysis processes are accelerated, and when the back-fat quantity is higher, heat dissipation will be slower. High muscular temperature (>40 °C) in combination with a low pH causes denaturation of muscle protein (Mota et al., 2003). Brown et al. (1999) determined that in 8, 16 and 24 h journeys with or without a 6 h recovery period, there were no effects on pig carcass temperature. On the other hand, Schäfer, Rosenvold, Purslow, Andersen, and Henc- kel (2002) found that metabolic processes and environment-
less, results of this study confirm that the quality of the carcass is affected by a prolonged stress when hogs are transported for 24 h, and therefore, a reduction in such a long journey from the farm to the slaughter house is recommended in Mexico in order to improve the carcass quality and the animal welfare in transit. Law makers must understand that long transport shipments of livestock and poultry imply hardship to the animal and detriment of the quality and quantity of their meat. Therefore, abattoirs must be installed close to the animal production sites. Changes in intensive animal systems must be done. Initiatives on Animal Welfare in Mexico are on their way, a bill for a General Law on Animal Welfare was introduced in 2004, this law may warrant the optimum welfare of farm animals; it is designed to deal with the maintenance, care and housing; transport and mobilization, as well as husbandry, euthanasia and slaughter. It is expected that once is approved by the Senate, it may help to make people and producers more sensitive and conscious of the animal welfare issue.

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