EFFECT OF PRE-SLAUGHTER FAST AND TRANSPORTATION OF PIGS ON WEIGHT LOSS AND MEAT QUALITY

H. Mayes, L. Hahn, J. Nienaber, G.C. Jesse, M. Anderson, A. Becker, H. Heymann, R. Bryan and H.B. Hedrick, University of Missouri-Columbia; Agricultural Research Service, USDA, Columbia; and Meat Animal Research Center, USDA, Clay Center, Nebraska.

INTRODUCTION

Pre-slaughter handling and transportation of slaughter pigs can have a major effect on weight losses of the live animal and on meat quality. The time period required to move pigs from the farm to slaughter may range from a few hours to one or two days. During this period animals may experience fasting, be mixed with strange animals, which often results in fighting, and various other stresses associated with transportation and handling.

The objectives of the present study were to determine the effects fasting, transportation and mixing of strange pigs had upon live animal and carcass weight losses and meat quality.

EXPERIMENTAL METHODS

Fifty-four crossbred barrows (4-way, white breeds), reared and slaughtered at the Roman L. Hruska U.S. Meat Animal Research Center, Clay Center, Nebraska, were used in the study. There were nine pre-slaughter treatments of six pigs per treatment group. Treatments consisted of a control group; pigs fasted 24 and 48 hours; pigs transported 700 km and fasted 24 and 48 hours; pigs from different rearing pens mixed and fasted for 24 and 48 hours; and pigs from different rearing pens mixed, transported 700 km and fasted for 24 and 48 hours.

The pigs were transported in a livestock trailer towed by a truck. The trailer was divided into pens that allowed 0.36 sq m of floor space per animal, which is more than the area (0.32 sq in) recommended by the Livestock Conservation Institute. The transit time was approximately 9.5 hours and the temperature ranged within the thermo neutral zone (15-24°C).

The pigs were conventionally slaughtered by electrical stunning and exsanguination. Individual live weights were taken prior to initiation of the pre-slaughter treatments and immediately prior to slaughter. Various body components were weighed during slaughter. Likewise, hot carcass, chilled carcass and liver weights were obtained. Liver samples were analyzed for glycogen using modification of the Hawk et al. (1954) procedure for glycogen extraction in combination with the anthrone method of analysis by Loewus (1952). Quantitative and qualitative carcass characteristics that were evaluated included carcass measurements, carcass grade (USDA 1984), pH of the longissimus and gluteus medius muscles, subjective (NPPC 1983) and objective color measurements (Hunter Color Difference Meter) of the longissimus muscle, ham quality (University of Wisconsin 1963), and water holding capacity of the longissimus muscle (Grau and Hamm 1953). Loin chops were oven-broiled and evaluated by a 10 member trained sensory panel for tenderness, juiciness and overall desirability. Tenderness of cooked chops was also measured with an Instron equipped with a Warner-Bratzler shear device.

The data were treated by analysis of variance using initial live weight as a covariate. The mean differences were ascertained using the Fisher Least Squares Differences Procedure as outlined by Snedecor and Cochran (1967).

RESULTS AND DISCUSSION

The effects of pre-slaughter fasting, transportation and mixing of strange animals on live weight, live weight loss, carcass weight, liver weight and liver glycogen are presented in Table 1. The mean initial live weight of pigs prior to treatment was similar for all treatment groups. Slaughter weights, however, were lower ($P < 0.05$) and live weight losses were greater ($P < 0.05$) for all groups of pigs that were fasted, transported and/or mixed compared to the control group. Pigs that were fasted for 48 hours had lower ($P < 0.05$) live weights and greater live weight losses ($P < 0.05$) than pigs fasted for 24 hours. Most of the live weight loss was attributed to fasting and only minimal weight loss was due to transportation and/or mixing of animals. Hot carcass weights of treated groups were lower ($P < 0.05$) than the control group. Carcass weight losses of 0.5 and 1.0 kg were observed for pigs fasted 24 and 48 hours respectively. In a previous study, Mayes et al. (1988) reported greater carcass weight losses of 0.8 and 1.8 kg for pigs fasted 24 and 48 hours, and 1.8 and 3.0 kg for pigs fasted and transported 24 and 48 hours. The previous study was conducted during the summer when temperature was higher than in the present study, resulting in greater weight loss due to body moisture loss.

Table 1. Live weight, hot carcass weight, liver weight and liver glycogen of pigs as affected by pre-slaughter fasting, transportation and mixing of animals.

Treatment[a]	Live weight (kg) Initial	Live weight (kg) Slaughter	Live wt loss (kg)	Carcass (kg)	Liver (g)	Liver Glycogen (mg/g)
Control	109.1^{b}	108.9^{b}	0.2	80.2^{bc}	1.635^{b}	7.4^{b}
24F	111.3^{b}	105.2^{c}	6.1	79.2^{bc}	1.449^{cd}	0.1^{d}
24F-T	110.6^{b}	105.3^{c}	5.3	79.4^{bc}	1.571^{bc}	4.7^{c}
24F-M	107.8^{b}	105.2^{c}	2.6	79.6^{bc}	1.436^{c}	0.3^{d}
24F-T-M	109.1^{b}	105.1^{c}	4.0	80.7^{b}	1.370^{de}	0.8^{d}
48F	109.0^{b}	103.7^{d}	5.3	79.9^{bc}	1.280^{cde}	0.0^{d}
48F-T	111.2^{b}	102.4^{e}	8.8	78.6^{c}	1.338^{de}	0.5^{d}
48F-M	109.5^{b}	102.9^{d}	6.6	79.6^{bc}	1.341^{de}	0.2^{d}
48F-T-M	109.6^{b}	102.9^{d}	6.7	78.8^{c}	1.299^{e}	0.4^{d}

[a]F = fast; T = transported; M = mixing of animals.

[b,c,d,e]Means in the same column bearing a different superscript differ ($P<0.05$).

Table 2. Muscle characteristics of pigs as affected by pre-slaughter fasting, transportation and mixing of animals.

	Longissimus muscle						
Treatment[a]	pH	Firmness score	Water holding capacity	Color score	Hunter color "L"	Hunter color "a"	Ham quality score
Control	5.46^{b}	1.5^{cd}	2.3^{c}	2.8^{c}	48.5^{b}	7.9^{e}	2.5^{d}
24F	5.45^{b}	1.5^{cd}	2.8^{b}	3.0^{cd}	47.8^{b}	8.3^{de}	2.8^{cd}
24F-T	5.53^{b}	2.8^{b}	2.3^{c}	3.5^{de}	45.5^{b}	8.5^{de}	3.8^{b}
24F-M	5.49^{b}	2.7^{b}	2.0^{cd}	3.8^{e}	42.6^{b}	11.1^{b}	3.9^{b}
24F-T-M	5.64^{b}	2.5^{b}	2.3^{cd}	3.5^{de}	46.2^{b}	8.0^{e}	3.9^{b}
48F	5.49^{b}	2.3^{bc}	2.2^{cd}	3.3^{de}	43.1^{b}	11.0^{b}	3.8^{b}
48F-T	5.52^{b}	1.8^{cd}	2.0^{d}	3.1^{cd}	47.1^{b}	9.3^{bc}	3.6^{b}
48F-M	5.53^{b}	2.2^{bc}	2.2^{cd}	3.3^{cde}	44.4^{b}	10.4^{bc}	3.8^{b}
48F-T-M	5.50^{b}	1.8^{cd}	2.2^{cd}	3.2^{cd}	44.8^{b}	11.4^{b}	3.4^{bc}

[a]F = fast; T = transported; M = mixing of animals.

[b,c,d,e]Means in the same column bearing a different superscript differ (P<0.05).

When dressing percentages were calculated on the basis of live weights taken immediately prior to slaughter, the control group had lower dressing percentage (P<0.05) than all groups that were fasted and transported. Pigs that were fasted for 24 hours had lower dressing percentages than those fasted for 48 hours. The increases in dressing percentages related to pre-slaughter treatments are attributed mainly to decreased amount of contents in the gastrointestinal tract.

Fasting and transportation and mixing of animals resulted in reduction in liver weight (P<0.05). This agrees with Cuthbertson and Pomeroy (1970), who reported liver weights were heaviest for pigs not fasted. Likewise, liver glycogen levels were reduced by these pre-slaughter treatments. These findings are in agreement with Warriss and Brown (1983), who reported liver losses in excess of 50% within the first 9 hours of fasting. All pre-slaughter treatments, except mixing of animals, had a significant effect on reduction of liver glycogen, indicating that mixing of animals in this study resulted in minimal stress.

Fasting and transportation had no effect (P<0.05) on carcass backfat measurements, longissimus muscle area, marbling scores or carcass grade, which is in agreement with findings reported by Davidson et al. (1968).

The 24 hour postmortem pH values of the longissimus muscle did not differ among the various treatment groups (Table 2). The subjective muscle firmness scores, however, differed among treatment groups due to treatment, length of fasting and interactions among length of fasting, transportation and mixing of animals. In general, similar differences in water holding capacity of the longissimus muscle were observed among groups and pre-slaughter treatments, as were observed for subjective muscle firmness scores. These observations indicate that the longissimus muscle from animals stressed for a longer period of time was firmer and had greater water holding capacity than muscle from animals that were not stressed or stressed for a shorter period of time. The greater water holding capacity due to stress is in agreement with the findings by Davidson et al. (1968).

Subjective color scores indicate that the longissimus muscle from the control pigs was lighter in color than that of the treated pigs. Although no significant difference (P<0.05) was noted in the Hunter Color Difference Meter "L" values among treatment groups, "L" value of the control pigs was higher, indicating the muscle of these pigs was lighter in color than that of the treated pigs. The difference in color of the longissimus muscle of the control pigs compared to the treated pigs is more clearly shown by the lower Hunter Color Difference Meter "a" value of the control pigs. A lower "a" value indicates less redness.

Subjective ham quality scores were lower (P<0.05) for the control group than for all other treated groups, except the 24 hour fasted group. These lower ham quality scores due to stress agree with work conducted by Jones et al. (1985), who reported the two major muscles of the ham became a darker and deeper red due to fasting. The pH values of the gluteus medius muscle of the hams from the pigs that were fasted, transported and mixed were higher (P<0.05) compared to the control pigs, except for the group of pigs that was fasted 24 hours, transported and mixed.

No differences (P<0.05) were observed in sensory panel scores, shear values or cooking losses of loin chops attributable to pre-slaughter treatments. Tenderness, juiciness and overall desirability scores of all cooked loin chops were within the acceptable range. The Instron shear values were also within the range of being quite acceptable in tenderness for all treatment groups.

CONCLUSIONS

Pre-slaughter fasting and transportation of pigs resulted in significant live weight, carcass weight, liver weight and glycogen losses. These losses were greater during the first 24 hour period compared to the second 24 hour period. Mixing animals had minimal effect on weight losses. Firmness, color and water-holding capacity of muscles were improved by pre-slaughter fasting and transportation.

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ROAD TRANSPORT FACTORS THAT MAY INFLUENCE STRESS IN CATTLE

G.A. Eldridge, Department of Agriculture and Rural Affairs, Animal Research Institute, Werribee, Victoria, Australia, 3030

SUMMARY

Two experiments were designed to assess the influence of temperament and mixing unfamiliar cattle before transport on their heart rate during transport. Data from both experiments was combined to assess the response of heart rate to distance of travel and road type. Although temperament had no significant effect on heart rate, unfamiliar cattle that were mixed 18 h prior to transport had a significantly higher heart rate during transport than cattle mixed for only 2 h (68.2 v 64.4 bpm respectively; P.05). Heart rate did not vary significantly with the distance travelled within each journey (240 km) but did vary significantly (P.05) with type of road that ranged from smooth highway through rough country roads to main suburban roads with traffic lights (69.4, 75.2 and 76.1 bpm respectively). It was concluded that pre-transport management and road type may significantly influence stress during road transport.

INTRODUCTION

Approximately 80 percent of cattle for slaughter are transported by road to saleyards or directly to abattoirs. The stressors to which animals are exposed during road transport can effect the carcass quality, level of bruising and in some cases lead to more serious injury or death (Hails 1978). However, little is known of how these stressors influence the behaviour and physiology of the animal during road transport.

The monitoring of stress related blood parameters such as adreno-corticosteroids during transport is impractical, but as heart rate is very sensitive to environmental stressors, the physical demands of transport and handling can be monitored by radio telemetry without invasive procedures (Stermer **et al.** 1982). In this study heart rate was monitored to determine the influence of some components of road transport and of animal factors on the response of heart rate of cattle during journeys of 240 km.

EXPERIMENTAL METHOD

Three herds of cattle (24, 24 and 16 animals for herds A, B and C respectively) of similar liveweight (approx. 300 kg), purchased from different properties and maintained as separate herds, were used in two experiments to study the effect of temperament and the mixing of unfamiliar animals prior to transport on the heart rate of cattle during transport. The data from both experiments were combined to study the effect of distance of travel and road type on heart rate. During each experiment the cattle were transported in a similar manner over 3 circuits of a predetermined route of 80 km which was composed of 6 types of road (Table 1). The space allowance used in both experiments was that recommended by Grandin (1981) for cattle weighing between 300 and 350 kg liveweight ($0.91m^2$/animal). The 2 experiments were carried out approximately 2 months apart.

In the first experiment, 2 groups of 8 animals from each herd (A, B and C) were assessed as having either "nervous" or "quiet" temperament when restrained in a crush and were transported in separate pens over the journey as described above (1 journey/ herd). The remaining 8 animals from herds A and B were transported in separate pens over the same journey so that all animals within the herd had similar experience to transport.

In the second experiment, 24 animals from herds A and B and 16 from herd C were allocated to 2 treatment groups for mixing either 18 or 2 hours prior to transport. Four animals from each treatment group from 2 different herds were yarded 18 hours prior to transport and were mixed for the appropriate periods. Each treatment group (8 animals) was transported in separate pens in each of the 4 journeys (replicates) as described above.

In both experiments, 4 animals from each pen on the transport vehicle were fitted with radio telemetry equipment to monitor heart rate in the manner described by Eldridge **et al.** (1988).

RESULTS

The mean heart rate of cattle during transport was 78.31.4 (SE) beats per minute (bpm) in experiment 1 and 66.30.9 bpm in Experiment 2.

In Experiment 1, temperament had no significant effect on heart rate of cattle during transport ("quiet" 77.8 bpm; "nervous" 78.8 bpm). In Experiment 2, mixing animals 18 hours prior to transport resulted a significantly higher ($P < .05$) heart rate during travel than cattle mixed 2 hours (68.2 v 64.4 bpm; lsd = 2.9). In both experiments, there was no significant effect of journey (replicate) on heart rate.

Analysis of the combined data showed that heart rate did not vary significantly between the circuits within the journey (72.8, 70.6 and 72.2 bpm respectively for circuits 1,2 and 3). There were significant differences ($P < .05$; lsd = 1.9 bpm) in the heart rate of cattle over the 6 road types (69.4, 69.9, 72.3, 75.2, 76.1 and 74.4 bpm respectively for hway, mnroads, scroads, rcroads, mnsroads and subroads).

Table 1. Road type and distance travelled on each road type on each circuit of the prescribed route.

Road type	Description	Distance
Hway	Smooth dual highway, non-stop travel.	18
Mnroads	Smooth main connecting roads.	30
Scroads	Secondary country roads.	11
Rcroads	Rough country roads,broken and corrugated.	12
Mnsroads	Main suburban roads, traffic lights,stop-start driving.	5
Subroads	Suburban roads, slow stop-start driving.	4

DISCUSSION

Previous observations (Eldridge **et al.** 1986) have shown that the heart rates of similar cattle are approximately 70, 62 and 52 bpm during grazing, standing and lying at rest in the paddock. In these studies, heart rate during transport was not appreciably above that of the grazing animal, thus suggesting that, in general, transport does not seem to be a major stressor to cattle. However, heart rates consistently 20% above those of animals standing quietly in the paddock, if maintained for periods of a day or longer could be associated with a significant reduction in energy reserves.

It appears that temperament as assessed by our technique is not a factor that influences the response of cattle to transport. This agrees with Wythes and Shorthose (1984) who found that there was no evidence in the literature to indicate that temperament influences stress during transport of slaughter cattle, although popular belief is generally to the contrary.

The higher heart rates resulting from mixing unfamiliar animals for 18 h before transport compared to a much shorter period of mixing were not expected as the longer period of yarding was to allow animals to adjust to their new social environment before transport. Dodt **et al.** (1979) found that cattle yarded for 24 h were more bruised than cattle yarded just before transport and concluded that the increased bruising resulted from the longer period for social interaction prior to transport and that little social activity occurred in transit or at the abattoir. Our results also show there is little interaction between animals during transport and that social interaction during a prolonged period of yarding prior to transport may result in animals becoming fatigued and less able to cope with transport.

The mean heart rate of cattle did not vary significantly with distance over 240 km travelled in 5.5 hours. Results of another experiment by Eldridge **et al.** (1988) also indicated that a distance of 425 km has little influence on heart rate, thus suggesting that distance per se up to approximately 550 km is not a critical factor in the road transport of cattle. However, cattle appear to be responsive to differences in road type and appear to find the uneven motion associated with rough country roads and stop-start driving on main suburban roads more demanding than smooth travel. This suggests that differences in road type could account for part of the large variation in the results of experiments on road transport of cattle reviewed by Wythes and Shorthose (1984).

CONCLUSION

It is concluded from the results of these studies that distance travelled up to 500 km and temperament do not appear to influence the stress response of cattle to transport. However, mixing unfamiliar animals in yards for extended periods before transport and the type of roads over which cattle are transported are factors that can significantly influence stress in cattle.

ACKNOWLEDGEMENTS

The author acknowledges the assistance of Mr. D.J. Cahill and Mr. R. Ballandis, the valuable advice of Mr. C.G. Winfield and the financial support of the Australian Meat and Livestock Research and Development Corporation.

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