Manipulating pork quality through production and pre-slaughter handling

Nather Aziz

Maple Leaf Pork, 2010 Winston Park Drive,
Suite 200, Oakville, ON L6H 5R7
Email: azizna@ mapleleaf.ca

Summary
Pre-slaughter handling has a significant effect on meat quality, depending on the severity of the stress and the consequent changes in the metabolic activities in the muscle. Pigs can be stressed at any point, starting from loading at the farm, to slaughter. The level of stress is mostly dependent on the genotype of the pig, with higher levels in PSS and RN gene carrier pigs. Resting time in the barn prior to slaughter can range from at least 2-4 hours to overnight and it is influenced by the genetics of the pig, feed withdraw time and distance of transportation. During resting in the barn, each pig requires about 0.55-0.67 m2/100 kg to move and rest. Mixing pigs with others unfamiliar is not recommended, especially in large groups in crowded pens. Drinking water should be reachable, and water sprays and misting is recommended especially during the hot season to reduce body temperature and respiratory rate. Stressing the pigs between lairage and stunning is critical and meat quality can be damaged.

Genetic Effects on Meat Quality
Meat quality in pigs can be affected by two major genetic differences: Major gene effects and Polygenic effects. Pork quality can be categorized into the quality-related traits of pH, colour, intramuscular fat, tenderness, flavour, water-holding capacity, and oxidative characteristics.

Major gene effects There are three known major commercially important gene effects: sex chromosome, stress (HAL) gene, and Napole (RN-) gene.

Sex effect: The sex-chromosome influence can be demonstrated as differences between barrows and

gilts. The main quality difference of sex-linked traits is that barrow longissimus muscles have more marbling than those from gilts. However, barrows have more back fat and are lower in meat yield percentage than gilts at constant market weights, suggesting a hormonal contribution to the onset of fattening.

Stress gene effect: The stress (HAL) gene was first described as porcine stress syndrome (PSS). These PSS hogs, when stressed physically, are more susceptible to death and typically produce pale, soft and exudative (PSE) meat. When triggered by physical stress, there is a defect in the Ca++ release channel of the sarcoplasmic reticulum of the muscle cell. In normal muscle, contraction is initiated by a release of Ca++ through this channel. However, in PSS hogs, a defect in the gate of the channel protein prevents it from closing, allowing Ca++ to continue to leak. A continued high rate of metabolism associated with this disorder can lead to prolonged acidosis and fatal collapse. Shortly after harvest, muscle from stress-susceptible pigs, will have a significantly reduced pH value and greater light reflectance. Halothane screening has been used as a tool to detect PSS pigs. Using halothane-screening generally does not detect the carriers (Nn) of the PSS gene. However, blood typing can be used to segregate pigs into (NN), carriers (Nn), and stress susceptible (nn) pigs. While stress susceptible (nn) pigs can result in 90-95% incidence of PSE, they produce carcasses that are 3-4% leaner with less back fat and larger loin eyes and hams. Live weight gains are similar to Nn pigs, but stress susceptible pigs are slightly more efficient in converting feed into carcass weight.

Napole effect The origin of the Napole (RN-) gene was in the Hampshire breed. This gene causes a lower ultimate muscle pH and associated PSE pork and greater cooking loss. The low pH values are dependent on high glycolytic potential and extended pH decline postmortem, which is believed to result from single gene with two alleles. In genetic evaluation studies, the Hampshire breed and their crosses, often have a lower ultimate pH, partially due to the occurrence of this RN gene in the population. In addition to a lower ultimate pH, the RN gene is associated with a lighter (paler) colour and reduced water holding capacity.

Polygenic Inheritance Differences among breeds and hybrids offer genetic diversity and opportunities for producers to select from different populations and to optimize heterosis (hybrid vigor) of lowly heritable traits. Within breeds, there is genetic variability and selection pressure that continually change their population. While no sire line excels in all traits, certain lines can be selected to meet desired objectives. When focusing on quality-related traits, the Berkshire breed appears to have a superior combination of desirable loin quality traits; the Duroc breed appears to excel in intramuscular fat (marbling), whereas the Hampshire breed appears to have lower ultimate pH and higher drip losses, yet desirable tenderness evaluations (characteristics of RN- gene). Correlations among production traits such as daily gain, back fat and loin eye area and most quality traits such as colour, muscle pH, and Instron shear force are usually low. Only external fat (10th rib and last rib) and fat within the muscle (marbling) have a moderate relationship. Even though the relationship of fatness and meat palatability is not strong, pork from extremely lean carcasses and/or carcasses with low marbling, tends to be less tender and less juicy than pork from carcasses with more fat over the loin. Therefore, selection considerations should be placed on quality attributes as well as production and meat yield percentage to optimize efficient production of lean, high quality pork.

Feed Effect on Meat Quality

Feeding at levels close to *ad libitum*, increases fat deposition and improves tenderness and other aspects of eating quality in pigs compared to restricted feeding. Two possible explanations have been suggested for this: high level of feed intake promote increased fat deposition including marbling fat; and animals which have deposited muscle rapidly are likely to have high activities of proteolytic enzymes which will tenderize meat more effectively post-mortem. Metabolic modifiers can be used to improve rate of gain, feed efficiency,

dressing percentage, carcass meat yield, meat quality and palatability and extend shelf life. Many dietary ingredients can change eating quality particularly in the pig, but these do not usually affect carcass or meat composition. Numerous studies have shown that vitamin E at high levels, prevent the oxidative breakdown of unsaturated fatty acids and improves meat colour in pork. Pigs fed high levels of vitamin D3 have increased muscle firmness and decreased drip losses whereas growth rate and feed intake are reduced.

Effect of pre-slaughter handling on meat quality

It is important to recognize that any of the stress factors during pre-slaughter handling can result in changes in the metabolites of muscle. These changes, in turn, are responsible for the differences in the ultimate properties of meat. The nature of the changes depends on such factors as the duration or severity of the stress, and the level of the pig's stress resistance.

Feed Withdrawal: Through their daily intake of food, pigs are supplied with sources of energy for their growth and maintenance. Surplus energy is stored in the liver, muscles and fat tissue. During transport and lairage the energy consumption will be dependent on the genotype of the pig and treatment they receive. Some pigs will consume large amounts of energy, especially if they fight; others will have a low consumption. Long fasting periods contribute to muscle glycogen depletion. It has been suggested that prolonged feed withdrawal period could be used deliberately to reduce muscle glycogen levels and hence, by limiting the extent of post-mortem muscle acidification, reduce the incidence of PSE meat. Considerable progressive reductions in the incidence of soft, exudative pork have occurred with longer fasts up to 48 hours in both Nn and nn halothane genotypes. When pigs are fasted or exercised, muscle glycogen is used for energy. If adequate feed and rest are not provided, glycogen deficiency may exist when slaughter occurs. Pigs not been fed on the day of slaughter and held for long periods in the lairage have the most DFD-meat and furthermore the DFD-frequency increases during the first hours of the holding period due to fighting.

Transportation: Pigs reaction to transport can be influenced by their stress-susceptibility. Most of the research has shown clearly that the effect of any pre-slaughter handling will be dependent on the genetic predisposition of the pig concerned. Very stress-susceptible pigs may produce high incidences of PSE meat after the stress associated with only short transport distance. More stress resistance pigs may show little or no reaction over moderate distances under good conditions. However, most pigs show some evidence of fatigue and muscle glycogen depletion after longer transport, particularly under poor conditions leading to an increased incidence of DFD meat. Important elements of the conditions of transport are stocking density and ventilation of the vehicle. Too high stocking densities, poor ventilation in hot weather and poor transporter designs, road conditions and driving technique are likely to reduce pork quality. As well as very high ambient temperatures, very low temperatures may also be stressful to pigs. However, longer transport can allow some recovery from the stress of loading so that the level of PSE is reduced. This effect will be reinforced if muscle glycogen is depleted during transport. The effect of increasing transport and lairage was studied by Malmfors (1982) who found that pigs subjected to both a short transport and a short lairage produced 22% PSE carcasses and 9% DFD. Long transport followed by long lairage reduced PSE to 9% but increased DFD to 11%.

Lairage: During lairage, pigs must be allowed some recovery from the stress of transport and unloading especially in more stress sensitive pigs. Rest for up to about four to six hours, tends to reduce the incidence of PSE meat. Extending lairage time will probably reduce PSE even further but may increase the level of DFD meat. This is especially true if pigs are held overnight without food. Glycogen depletion may nevertheless be insufficient to elevate ultimate meat pH, particularly in some strains of the Hampshire breed and their crosses. These have extremely high muscle glyco-

gen concentration (up to 70% higher in white muscles when compared with other breeds) leading normally to very low ultimate pH values. Even when subjected to long lairage these pigs do not appear to produce meat with high ultimate pH. Some results showed that pigs rested for 24 hours had only 1.9% PSE meat whereas 0-2 hours of resting in pigs with high energy reserves resulted in 13.1 % PSE. It is important that conditions in the lairage provide the animals room to rest with stocking densities of about 0.55-0.67 m2/100 kg pig. Mixing groups of unfamiliar pigs leads to fighting. The physical exertion associated with fighting depletes muscle glycogen stores and lead to DFD meat. It may also increase the incidence of PSE meat if the stress occurs immediately pre-slaughter. Severe short-term stress, particularly before slaughter, does increase the incidence of PSE in pigs with high energy reserves. The use of water sprays or misting systems to cool pigs in hot environmental conditions, affects pig behaviour in lairage pens, especially when this is used intermittently to maximize evaporative cooling. Cooling reduces surface and rectal temperatures and respiratory rate in pigs. Adapting plant design to pig behaviour, both in the lairage and in the area immediately before stunning is required. Proper design will facilitate forward movement of pigs with minimal stress; allowing high slaughter rates to be achieved without use of force.

References

Barton Gade, P. A. (1984). Influence of halothane genotype on meat quality in pigs subjected to various pre-slaughter treatments. Proc. 30th Euro. Meeting of Meat Res. Workers. pp. 8-9.

Dikeman, M. E. (2003). Metabolic modifiers and genetics: Effect on carcass traits and meat quality. Proc. 49th ICoMST. pp. 1-38.

Eikelenboom, G., Bolink, A.H., and Sybesma, W. (1991). Effects of feed withdrawal before delivery on pork quality and carcass yield. Meat Sci. 29:25-30.

Eikelenboom, G and D. Minkema. (1974). Prediction of pale, soft, exudative muscle with a non-lethal test for the halothane-induced porcine malignant hyperthermia syndrome. Tijdschrift voor Diergeneeskunde. 99:421-426.

Enright, K.L., D.K. Anderson, M. Ellis, F.K. McKeith, L.L. Berger, and D.H. Baker. (1998). The effects of feeding high levels of vitamin D3 on pork quality. J. Anim. Sci. 76 (Suppl.):149(Abstr.).

Estrade, M., X. Vignon, and G. Monin. (1993). Effect of RN-gene on ultrastructure and protein fractions in pig muscle. Meat Sci. 35:313-319.

Grandin, T. (1997). Assessment of stress during handling and transport. J. of Anim. Sci. 75:249-257.

Honkavaara, M. (1991). Effect of transport on porcine stress. Proc. 37th ICoMST. pp. 257-260.

Malmfors, G. (1982). Studies on some factors affecting pig meat quality. Proc. 28th Europ. Meeting Meat Res. Workers. pp. 21-23.

Monahan, F.J., J. A. Asghar, J.I. Gray, D.J. Buckley and Morrissey. (1992). Influence of Dietary Vitamin E % x – Tocopherol) on the colour stability of pork chops. Proc. 38th ICoMST. pp. 543

Monin, G., and P. Sellier. (1985). Pork of low technological quality with a normal rate of muscle pH fall in the immediate post-mortem period: the case of the Hampshire breed. Meat Sci. 13: 46-63.

Murray, A.C., Jones, S.D.M., and Sather A.P. (1989) The effect of pre-slaughter feed restriction and genotype for stress susceptibility on pork lean quality and composition. Can. J. Anim. Sci. 69:83-91.

National Pork Producers Council. (1995) Genetic evaluation: Evaluation of terminal line program results. National Pork producers Council, Des Moines, IA.

Nielsen, N.J. (1981). The effect on Environmental factors on meat quality and deaths during transportation and lairage before slaughter. Proceedings of the Symposium "porcine stress and meat quality-causes and possible solutions to the problems", Jeloy, Norway, pp. 287-297.

Warriss, P. D. (1994). Ante-mortem handling of pigs. In "Principles of Pig Science", pp. 425-432, eds D. J. A. Ecole, J. Wiseman and M. A. Varley. (Nottigham University Press: Nittingham, UK).

Warkup, C. C., and Kempster, A. J. (1991). A explanation of the variation in tenderness and juiciness of pig meat. Anim. Prod. 52:599

Weeding, C. M., Guise, H. J. and Penny, R. H. C. (1993). Factors influencing the welfare and carcass and meat quality of pigs; the use of water sprays in lairage. Anim. Prod. 56:393-397.

Wassmuth, R., and Glodek, P. (1992) The influence of the Hampshire factor on meat quality in pigs. Proc. 43rd Ann. Meet. Europ. Assoc. Anim. Prod. Madrid, Spain.

Wood, J.D. (1991). Consequences for meat quality of reducing carcass fatness. In: J.D. Wood and A. V. Fisher (eds). Reducing Fat in Meat Animals. Elsevier Applied Science, London. pp. 344-397.