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# Environmental conditions for swine during marketing for slaughter a national review



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The images represent the Research Branch's objective: to improve the long-term competitiveness of the Canadian agri-food sector through the development and transfer of new technologies.

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Les dessins illustrent l'objectif de la Direction générale de la recherche : améliorer la compétitivité à long terme du secteur agro-alimentaire canadien grâce à la mise au point et au transfert de nouvelles technologies.

*Conception par le Service aux programmes de recherches*



# Environmental conditions for swine during marketing for slaughter a national review

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porcs de boucherie durant le transport à l'abattoir :  
étude nationale*

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## SUMMARY

Pale, soft, exudative (PSE) pork and dark, firm, dry (DFD) pork are undesirable pork quality types that result from stress during a period of approximately 48 h before pigs are slaughtered. However, across Canada, little is known about how often market conditions occur that can cause stress and that affect pork quality. A national survey of marketing conditions was conducted in 1987. This publication describes the results of that survey. Practices and conditions that can increase animal stress are discussed and recommendations for change are outlined.

## RÉSUMÉ

On sait que les viandes de porc PSE (pâles, molles, exsudatives) et DFD (foncées, fermes, sèches) sont des viandes de qualité inacceptable, qui sont causées par l'exposition des animaux au stress durant une période d'environ 48 heures précédant l'abattage. Par contre, au Canada, on connaît peu la fréquence des conditions du marché qui peuvent produire le stress et cette situation affecte la qualité de la viande de porc. En 1987, on a mené une étude sur ces conditions. Cette publication discute des résultats de l'étude, des pratiques et situations susceptibles d'accroître le stress chez les animaux, ainsi que de recommandations pour tenter de corriger ce problème.



## INTRODUCTION

Pork quality can be influenced at almost any point, from the time pigs are assembled on the farm for shipping to the abattoir until the time carcasses have completed their cooling cycle in the abattoir. The degree of stress and the access to feed and water, as well as stunning and chilling procedures, are known to have major effects on the development of pork quality problems. These problems consist of pale, soft, and exudative meat (PSE) and dark, firm, and dry meat (DFD). Across Canada little is known about marketing conditions that can affect pork quality. Without knowing what is the norm in Canada, recommendations for change are impossible.

In 1987 the Research Branch and the Food Production and Inspection Branch of Agriculture Canada designed and implemented a survey to obtain extensive information on conditions on farm, during transport, and in assembly yards and abattoirs. The Food Production and Inspection Branch collected data over approximately 2 years from marketing boards, pig producers, truckers, and abattoirs. Research Branch scientists at the Lacombe Research Station edited and analysed the data. This publication presents results of that survey.

In general, all provinces and all sectors of the industry participated in the survey. However, because of differences in the way the hog industry is set up from province to province, not all provinces were represented for every part of the survey. Rather than give equal weighting to each of the province's data, the data were weighted based on the number of market hogs reported for each province. In some cases, data are presented as a single response per province.

## BACKGROUND

Over 57 thousand hog producers were registered in Canada in 1987, of whom just over 50% were active producers. The total market hog production in Canada in 1987 was 13.6 million head. Quebec and Ontario were the two largest hog producers in Canada, producing approximately 33% and 31% of the market hogs, respectively. Alberta was the third largest hog producer, producing approximately 13% of the market hogs, followed by Manitoba (11%) and Saskatchewan (5%). British Columbia and the Maritime Provinces made up the rest of the market hogs produced in Canada, having less than 2% of the total each (Fig. 1). On average, provinces exported approximately 2% of their market hogs to

the United States and interprovincial movement of hogs was common: 3-28% of hogs produced crossed provincial borders for slaughter, depending on the province.

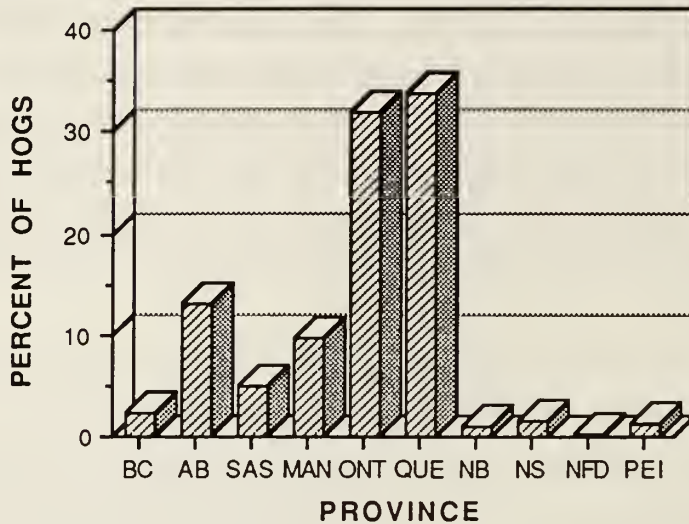


Fig. 1 Canadian provincial hog production

The average carcass weight of slaughter hogs in 1987 was 78.5 kg; Fig. 2 shows the distribution of carcass weights by province. Average grade index for hogs ranged from a low of 102 in Quebec to a high of 105 in British Columbia. The average grade index over all market hogs was 103.

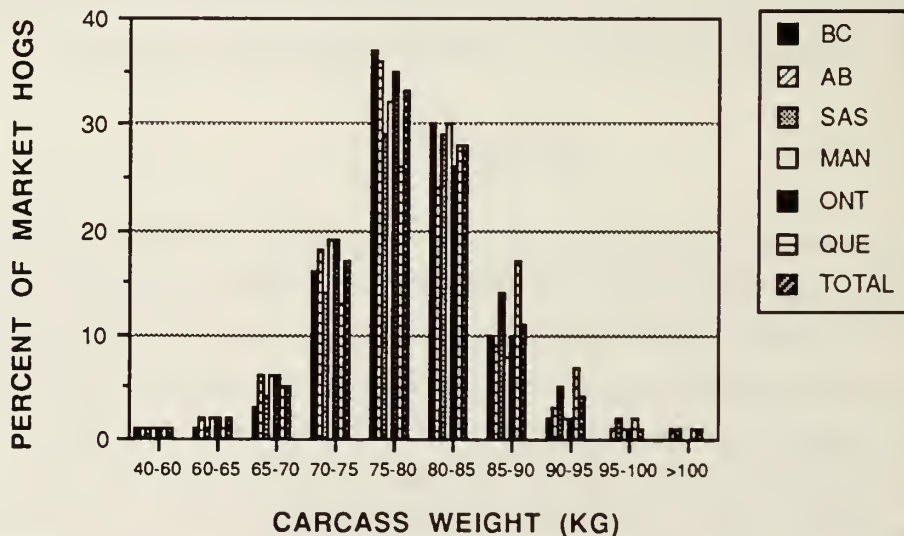


Fig. 2 Distribution of carcass weight at slaughter by province



## CONDITIONS ON FARM

Four hundred and ninety-five producers responded to this section, representing 1.66% of the active producers in Canada. Where appropriate, the data were weighted based on provincial production of hogs to represent Canadian hog production practices. Although not all producers answered all the questions, the response rate was generally greater than 96%.

The average number of market hogs shipped per year per farm in Canada in 1987 was 3744, with a range for individual respondents between 5 and 350 thousand hogs. On a provincial basis, Quebec had the highest average number of market hogs shipped per year per farm (approximately 5500) and Prince Edward Island had the lowest (less than 1000; Fig. 3).

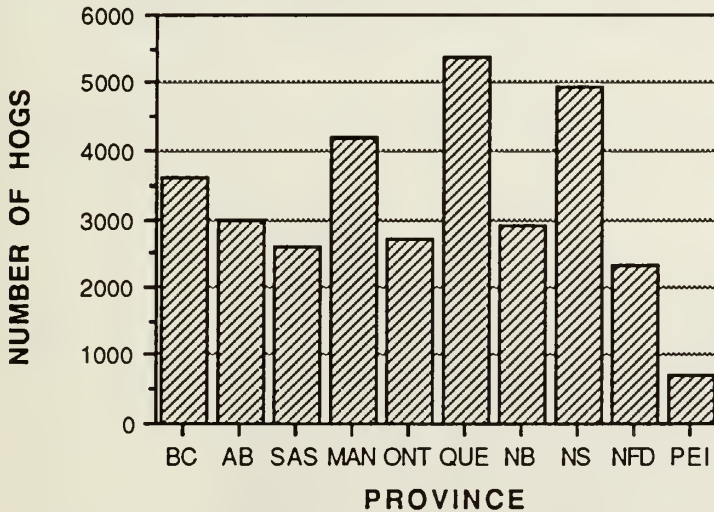


Fig. 3 Average number of market hogs shipped per year per farm

Most Canadian market hogs (93%) were assembled less than 4 h before shipping, with a small proportion of hogs (2.7%) assembled over 24 h before shipping (Fig. 4). Seventy-six percent of the market hogs were mixed to assemble a load, whereas only 13% of the hogs were kept separate by their original feed pen to assemble a load. Producers in Saskatchewan had the lowest percentage of mixing hogs to assemble a load; however, mixing still occurred 55% of the time (Fig. 5). To handle the pigs, Canadian producers used electric prods routinely about 50% of the time. Boards were routinely used about 86% of the time and

whips or slappers were routinely used only 5% of the time (Fig. 6). A significant variation in use of electric prods, whips and slappers, and boards was reported among the provinces (Fig. 7).

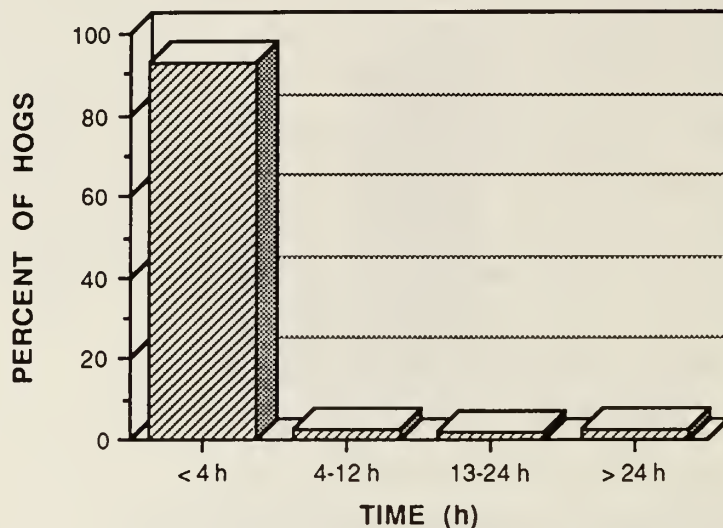


Fig. 4 Length of time loads of hogs are assembled at the farm prior to shipping

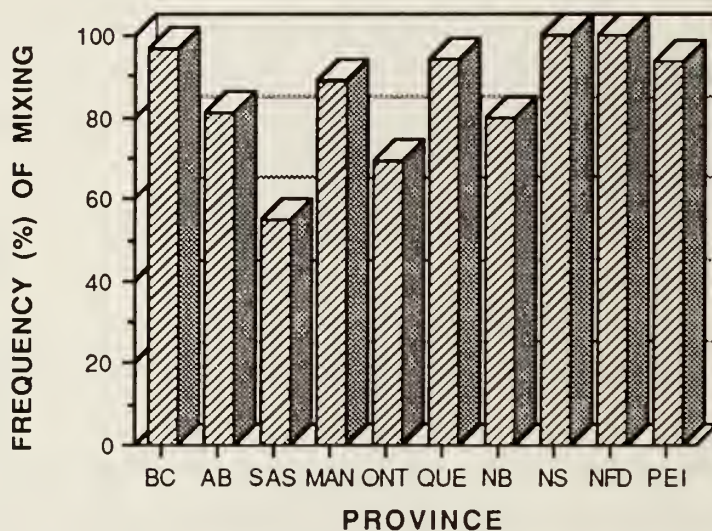


Fig. 5 Frequency of mixing hogs to assemble a load on the farm

Most hogs marketed in Canada had access to water (92%) and a large proportion (62%) had access to feed before shipping (Fig. 8). Again, a significant variation was found among provinces (Fig. 9). The average number of hogs assembled into a group for shipping varied among the provinces (Fig. 10).

Approximately 41% of the hogs were assembled in groups less than 20; 45% in groups of 20-50; 7% in groups of 51-100; and 6% in groups larger than 100. Despite the fact that almost half the producers assembled hogs in groups of less than 20, producers indicated that an average of 46 hogs were shipped by truck at a time. For each producer, the number ranged from a low of two hogs to a high of 250.

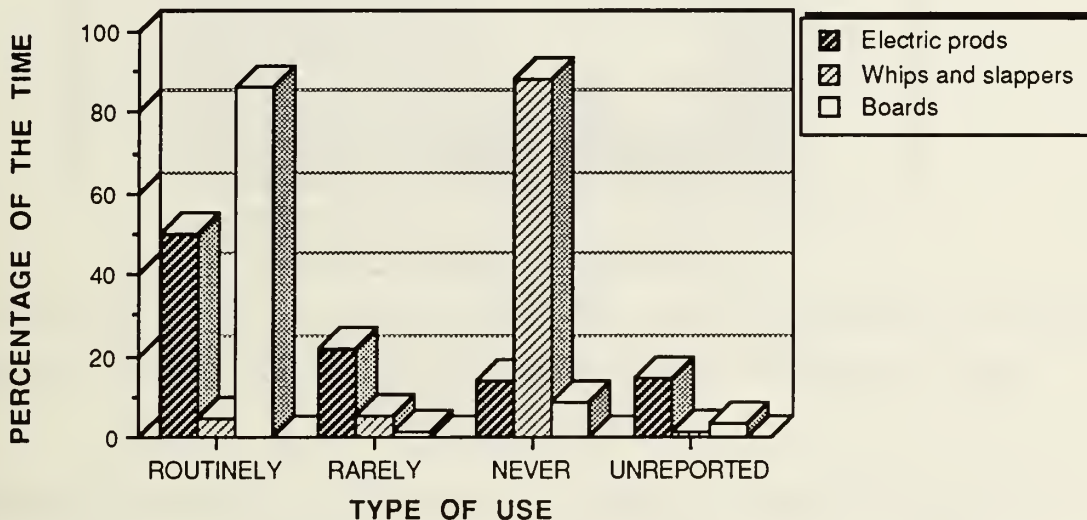


Fig. 6 On-farm usage of electric prods, whips or slappers, and boards

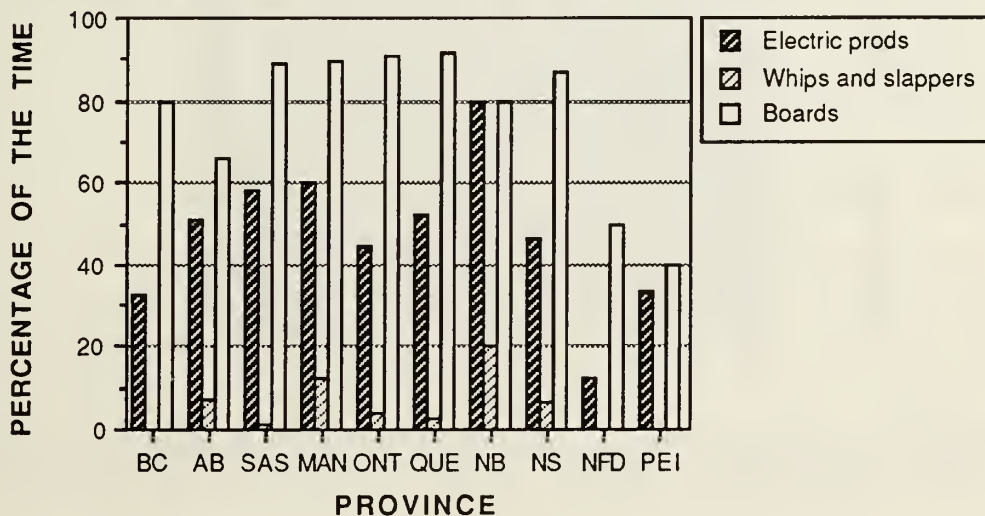


Fig. 7 On-farm routine usage of electric prods, whips or slappers, and boards by province



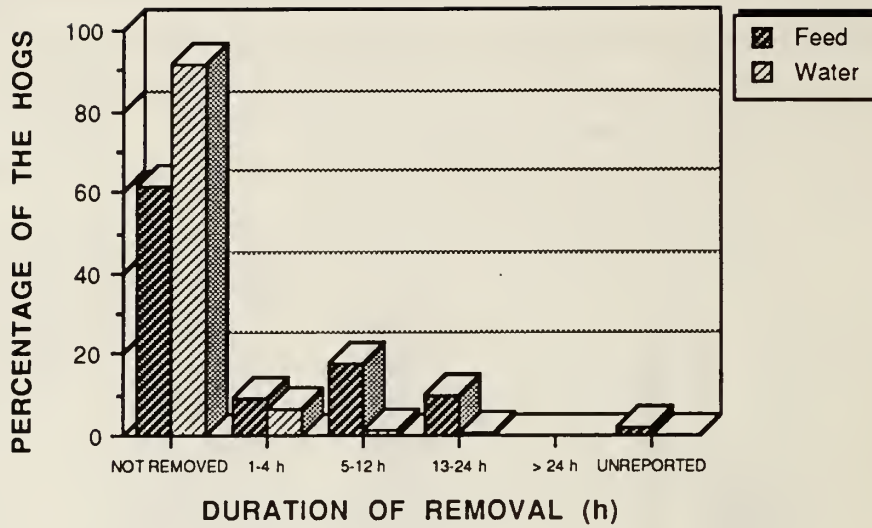


Fig. 8 Duration of on-farm removal of feed and water prior to shipping

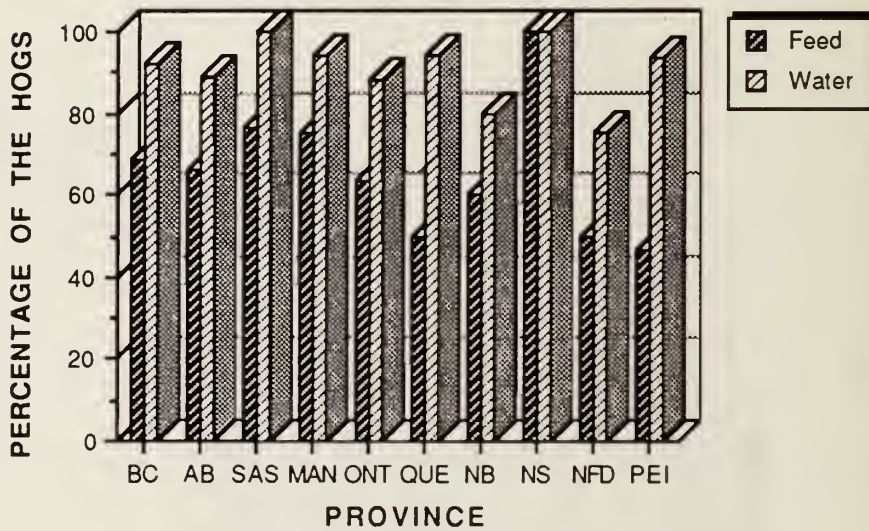


Fig. 9 Percentage of hogs with access to feed and water prior to shipping

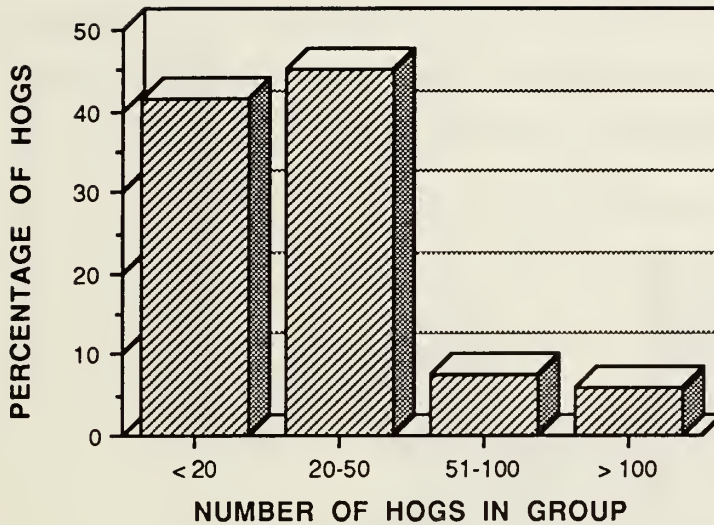


Fig. 10 Average number of hogs assembled into a group for shipping from farms

### TRANSPORTATION

The Maritime Provinces, representing approximately 5% of the pig population, did not respond to this section. British Columbia, Alberta, Manitoba, Saskatchewan, Ontario, and Quebec responded to most of the questions. Manitoba, Saskatchewan, and Ontario provided a unified response for their provinces. For British Columbia, Alberta, and Quebec, individual truckers responded, and for comparative purposes these numbers were converted to a single response for each province. Since these data conversions weakened the conclusions, data reported in this section should be interpreted with caution.

An attempt was made to categorize the number of hogs shipped to market by truckers or by individual farmers, with or without further mixing on the truck or at assembly yards. Alberta, Saskatchewan, Ontario, and Quebec, representing 81% of the hogs marketed in Canada, responded to this question. However, the answers provided by the provinces did not add to the total number of hogs slaughtered per province, therefore, the frequency of each practice could not be estimated. Quebec indicated that they had no assembly yards in use.

Of the 95% of the hogs represented (British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, and Quebec), 44% were transported to market in pot liners, 23% in multi-level trucks, 12% in single-level trucks, and 6% in stake or body trucks (Fig. 11). Average space allotments among the various types

of trucks were similar, ranging from 0.32 to 0.34 m<sup>2</sup> per hog. During hot weather, average space allotments increased slightly to approximately 0.34 m<sup>2</sup> per hog. However, the space allotments reported for pot liners remained constant at 0.32 m<sup>2</sup> per hog, regardless of the ambient temperature.

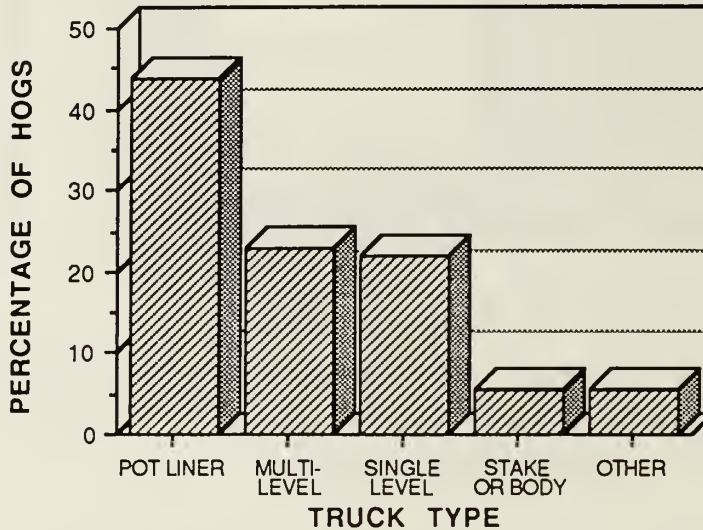


Fig. 11 Truck type used to transport hogs from farm to slaughter plant

Of the 95% of the hogs represented, 54% spent less than 3 h from time of loading at the farm until unloading at the slaughter plant. Less than 4% of the hogs spent more than 24 h between the farm gate and the slaughter plant (Fig. 12). The shortest transit time to market was reported in Alberta (0.17 h) whereas the longest transit time was reported in Ontario (72 h).

### ASSEMBLY YARD

Only Alberta, Saskatchewan, Manitoba, and Ontario responded to this section. Although this only represented 58% of the total market hogs in Canada, some of the provinces, most notably Quebec, did not have assembly yards, and therefore this information probably represented a large proportion of the hogs that may be marketed through assembly yards. The proportion of hogs that actually passed through assembly yards on their way to market in these provinces is unknown.



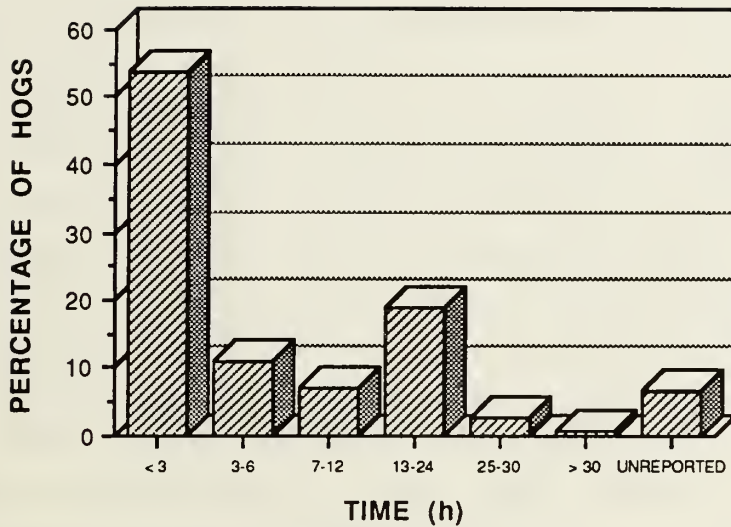


Fig. 12 Average transit time from farm to slaughter plant (BC, AB, SAS, MAN, ONT, QUE)

To aid the movement of pigs, whips and slappers were routinely used at assembly yards 61% of the time. Electric prods were routinely used only 20% of the time, and boards were in routine use about 29% of the time (Fig. 13).

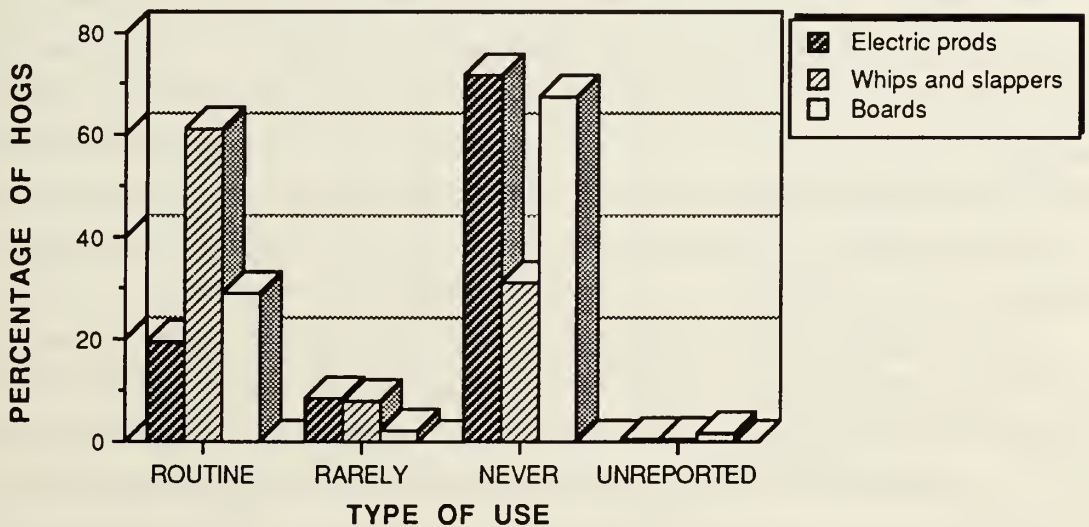


Fig. 13 Total assembly yard usage of electric prods, whips, or slappers and boards

Most assembly yards routinely (100% of the time) or frequently (70% of the time) mixed loads of hogs for shipment to the slaughter plant (73% and 27%,

respectively). Hogs that passed through an assembly yard on route to slaughter spent approximately 4 h at the assembly yard, with a normal range of 2-10 hours. Shortest and longest extremes were 0.5 h and 48 h, respectively. It should be noted that in some cases, assembly yards were located at the slaughter plant.

A range of pen types were used at assembly yards, including long narrow pens and large square ones. The average space allotment in pens at assembly yards was 0.66 m<sup>2</sup> per hog but, depending on the province, this ranged from 0.58 to 0.80 m<sup>2</sup> per hog. Hogs travelled an average distance of 41 m to move from the trucks to the holding pens at assembly yards. This ranged from distances as short as 3 m to distances as long as 160 m, depending on the assembly yard. Most alley ways had closed or solid sides, with a minimum of shadow (85% had no shadow; 15% had some shadow). Although 91% of assembly yards reported that minimum slipping occurred along the alley ways, 7% reported moderate slipping, and 2% reported that hogs went down frequently. Ninety percent of the alley ways were straight and slightly over 8% were curved.

## **TRANSPORTATION FROM ASSEMBLY YARD TO SLAUGHTER PLANT**

Saskatchewan, Manitoba, and Ontario were the only provinces that responded to this section, representing approximately 47% of the total market hogs in Canada. Both Saskatchewan and Ontario indicated that no hogs were shipped to the slaughter plant from assembly yards by individual farmers; therefore hogs leaving the assembly yards destined for slaughter were trucked in commercial trucks. However, the proportion of hogs that actually passed through assembly yards on their way to market in these provinces is unknown.

Saskatchewan and Ontario (36% of the total market hogs) indicated that 88% of the hogs were shipped on pot liners from assembly yards to the slaughter plants. Multi-level trucks (7%) were the next most common method of shipping hogs. Less than 5% of the hogs were transported in single-level, stake, or body trucks (Fig. 14). On average, hogs spent approximately 23 min on the trucks after arrival at the slaughter plant, before unloading. Time before unloading at the slaughter plant ranged from immediate unloading to a wait of 4 h before unloading.

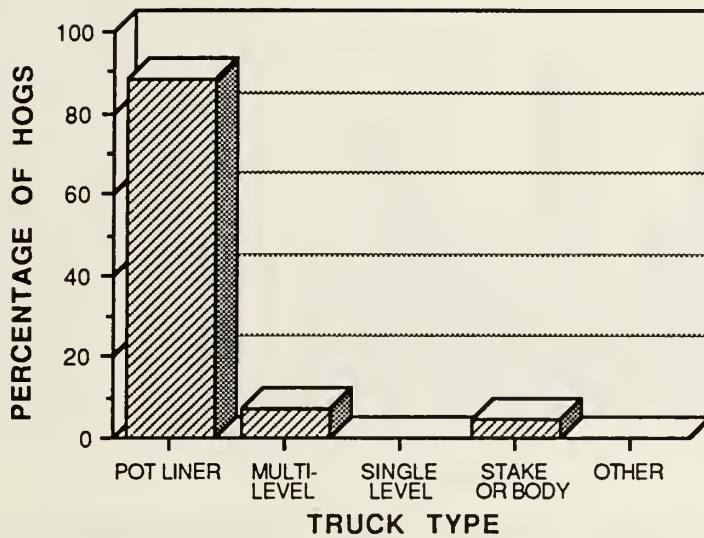


Fig. 14 Truck type used for transport of pigs from assembly yard to slaughter plant (SAS, ONT)

### SLAUGHTER PLANT

With the exception of Newfoundland, representing 1% of the total market hogs in Canada, all provinces responded to this section. In total, 28 slaughter plants responded to the survey. Where possible, this figure was converted to a single response per province and weighted for the proportion of market hogs produced in that province.

After unloading at slaughter plants, approximately equal proportions of hogs were either mixed into larger groups (47.9%) or maintained as a group without mixing (48.6%). Approximately half (49.7%) the total market hogs were housed in large square pens, whereas 41.2% were housed in long narrow pens. Average pen size was 69.7 m<sup>2</sup>, with a range reported for individual plants from a low of 13 m<sup>2</sup> to a high of 400 m<sup>2</sup>. The average space allotment in these pens was reported to be 0.57 m<sup>2</sup> per hog, with a high of 1.26 for Manitoba and a low of 0.38 for Saskatchewan (Fig. 15).

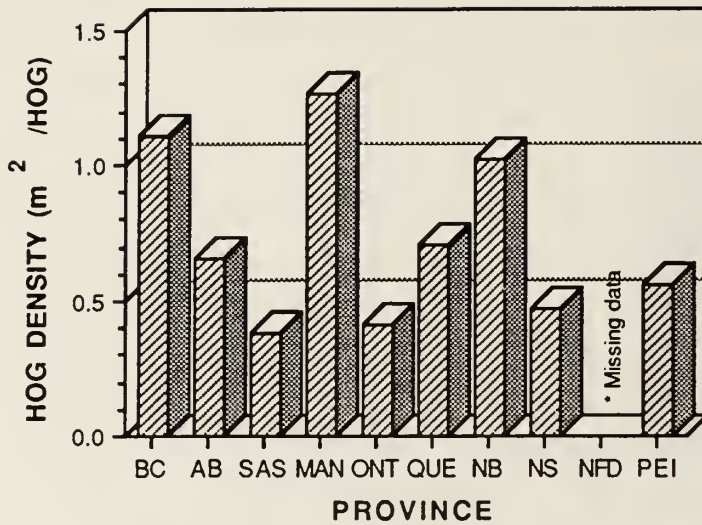


Fig. 15 Average stocking density at slaughter plants

At approximately 69% of plants, hogs rested for at least 3 h from time of unloading to slaughter. However, almost 9% of the hogs were slaughtered within an hour of arrival at the plant, allowing little time to rest (Fig. 16). Although these times were estimated to be the normal practice, most plants indicated that the time may vary according to the number of pigs available for slaughter.

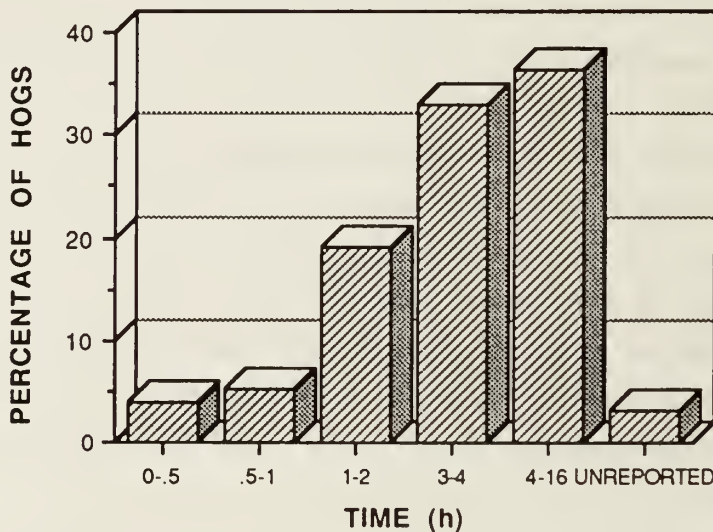


Fig. 16 Time from unloading at abattoir to slaughter



To aid in the movement of hogs, whips and slappers were routinely used at slaughter plants 48% of the time. Electric prods were routinely used only 20% of the time, and boards were in routine use only 3% of the time (Fig. 17). Eighty-nine percent of the total market hogs had access to water before slaughter whereas the balance did not. In approximately 75% of the cases where hogs were not normally provided access to water, water would have been given if the lairage period became excessive (more than 2.5 h). Approximately 68% of the hogs were sprayed with water in the holding pens. Moving hogs from the holding pens to the crowd pen required stock workers to use frequent or continuous intervention 50% of the time, moderate intervention 34% of the time, and minimum intervention 16% of the time.

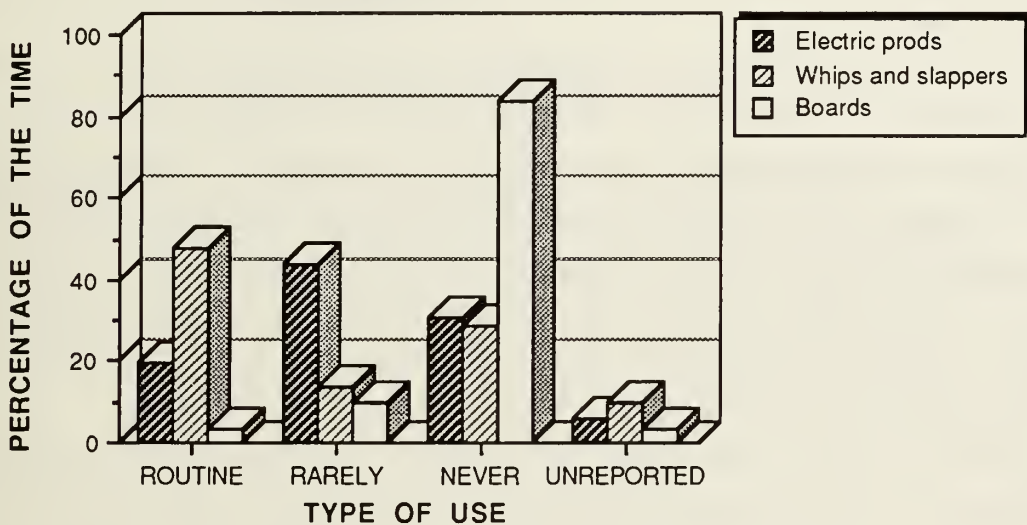


Fig. 17 Total slaughter plant usage of electric prods, whips or slappers and boards

Of the 11 slaughter plants that responded, only three reported any gradient in the main chute to the crowd pen. One plant had a 1 m incline in 240 m, one plant had a 1 m incline in 12 m, and one plant indicated that they had a slight downward elevation (grade not indicated). Most plants (83%) had closed or solid chute sides and approximately 17% had open chute sides. Hogs had to travel an average distance of 28.6 m from the holding pen to the crowd pen, with a range from a low of 1 m to a high of 155 m. Most hogs (70%) did not have to travel along chutes that were in shadow on route to the crowd pen, although 30% of the hogs passed through some shadowed areas. Approximately 67% of the hogs had good

flooring along the chutes, with a minimum of slipping. Moderate slipping along the chutes was reported for approximately 33% of the hogs. Most hogs (91%) travelled along straight chutes, and 9% travelled along curved chutes on their way to the crowd pen.

Of the 48% of the slaughter plants that responded, 64% indicated a slight upward elevation from the crowd pen to the restrainer and stunning area. The grade reported ranged from a 0.5% incline to a 25% incline. The rest of the plants reported no incline from the crowd pen to the restrainer and stunning area. Of the 100% of the plants that responded, most plants (83%) reported that the chute sides to the restrainer were closed or solid, whereas only 17% indicated that they were open. As a proportion of total market hogs, 88% of the hogs were marketed through plants that have closed or solid chute sides between the crowd pen and the restrainer.

The average market hog in Canada had to travel approximately 5.7 m along the restrainer immediately before stunning, with the range from 2 to 28 m. As well, the average market hog remained in the restraining chute for 1.56 min before stunning, with a range reported from 0.1 to 15 min. In most plants (89%) the animal handler in the crowd pen used an electric prod. On average, a handler in the crowd pen electrically prodded 38 out of every 100 market hogs in Canada. As well, 35 out of every 100 market hogs were subject to electric shocks in the restrainer area from either electric prods or the restrainer.

A manual rather than an automatic stunner was used in 69% of plants, representing 62% of the total market hogs. The average market hog was stunned with 538 volts. However, stun voltages were reported to range from 240 to 800 volts, depending on the plant. The average stun time was 3.5 s with a range between 0.5 s and 15 s. Sixty-two percent of the plants (representing 63% of the market hogs) applied the electrodes to the head only, whereas 38% of the plants applied them to both the head and the back. Most plants (55%) cleaned the stunner electrodes every day, whereas 17% of the plants cleaned them once a week. Twenty-eight percent of the plants used some other cleaning routine.

Figure 18 shows the average processing times for various operations in all plants. The range in times reported for these processes were as follows: stunning to sticking 2-72 s; sticking to scalding 1.2-15 min; scalding 3.3-8.0 min; scalding to grading 10-90 min; and grading to cooler 1-15 min. One company from British Columbia graded in the cooler, hence the reported 90 min time from scalding to grading. The average scalding temperature was 60° C, with a range from



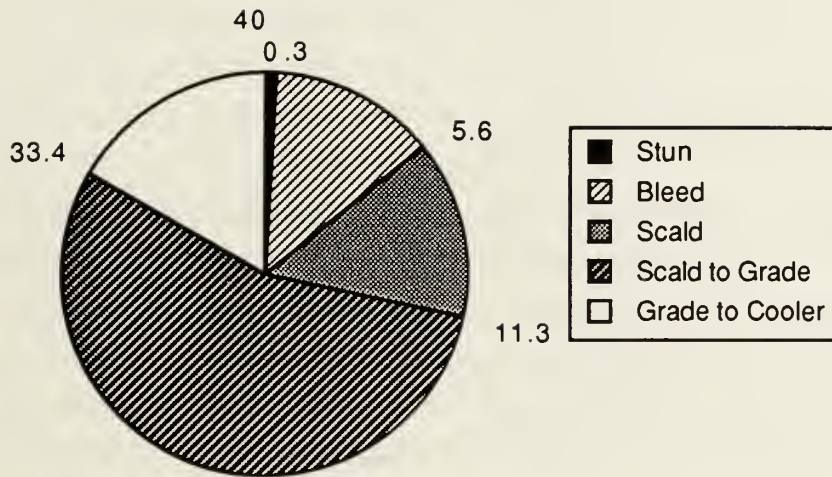


Fig. 18 Kill floor time clock (min)

Of the 93% of the plants that responded, 30% used blast chillers, 11% used spray chillers and 59% used conventional chillers. For plants using spray chilling, the duration of the spray chill was 4.9 h, with an average of 2.3 cycles of water sprayed per hour. The average duration of the spray cycle (seconds water spray was on) was 38 s. Most plants (80%) did not turn on the spray chiller until the cooler was fully loaded. Only two plants reported their blast chiller conditions. Temperatures were similar for both plants (-10 and -13° C). However, the time spent in the blast chiller ranged from 45 to 90 min. Neither plant reported the wind speed of their blast chiller.

### RECOMMENDED PRACTICES FROM THE FARM TO SLAUGHTER

The results of this survey clearly indicate areas where the management of hogs between the farm and slaughter plant can be improved to reduce the incidence of PSE and DFD pork in Canada. Many of the stresses experienced by hogs on route to slaughter plants are relatively mild if confined to isolated incidences. However, most hogs experience many different types of stress, the cumulative effect resulting in problems of pork quality. The hog industry must coordinate its efforts to minimize the stress of marketing at every point along the market chain in order to reduce the incidence of PSE and DFD pork. The sections

that follow summarize the various types of stress that a typical hog may experience on route to the slaughter plant and provide recommendations where appropriate.

## **REMOVING FEED AND WATER**

Although removing feed before shipping is a fairly common practice in Canada (38% of the hogs do not have access to feed), water need not be removed before shipping because additional weight loss occurs as a result of dehydration. Despite this fact, 8% of the hogs marketed in Canada do not have access to water before shipping. These animals may sometimes be slaughtered within an hour because of short transit times and immediate slaughter at the plant. However, in the worst case, these animals may be without water for up to 72 h.

Withdrawing feed before transport reduces the mortality rate during transit and reduces slaughter plant problems associated with handling a full digestive tract. As well, a higher incidence of PSE may occur if feed is not removed before shipping, if the transit distances are short, and if animals are slaughtered soon after arriving at the slaughter plant. Research has shown that the duration of feed restriction can affect liveweight, carcass weight, and meat quality. Feed given within 10 h of slaughter is not converted to carcass gain and is wasted. However, within 24 h of feed withdrawal, liveweight losses of 5% occur, and 20% of this weight loss is occurring in the carcass. With even greater times off feed, liveweight losses continue to increase, with the proportion of this loss coming from the carcass also increasing. However, the withdrawal of feed can result in a reduction of PSE, and therefore a balance must be struck between carcass losses and quality losses. Currently, research suggests that a maximum feed withdrawal of 18 h before slaughter and a minimum feed withdrawal of 4-6 h before transport optimizes both carcass weight and meat quality. Clearly, this time frame is inappropriate when animals are raised further than 18 h from a slaughter plant.

## **MIXING UNFAMILIAR HOGS**

In Canada, only 13% of market hogs are kept separately by their original feed pen while a load is assembled at the farm. Mixing also occurs on trucks, in the

assembly yards, and almost 50% of the time at slaughter plants. Hence, very few hogs escape mixing with unfamiliar animals before slaughter.

Mixing unfamiliar hogs often results in a great deal of fighting, which is regarded as very potent stress and may result in DFD pork. In addition, the scratching and bruising may result in carcass losses. Fighting damage is reduced if mixing takes place at loading, because hogs tend to fight less on a moving truck. A container transport system that allows pigs to be moved to slaughter without mixing would be ideal, but the cost and logistics make the system difficult to incorporate into the present Canadian marketing system. Pen shape may contribute to reduced fighting because long narrow pens allow animals to stand at the perimeter of the pen along the fences. Assembly yards and slaughter plants in Canada currently use both square pens and long, narrow pens.

### **AIDS FOR MOVING HOGS**

As hogs move from farms to assembly yards to slaughter plants, the use of boards to help movement decreases (86% to 29% to 3%, respectively). Whips or slappers were used predominantly by assembly yards (61%) and slaughter plants (48%). Although electric prods are the most stressful aid for moving hogs, they are still routinely used on farms (50% of the time), at assembly yards (20% of the time), and for unloading at slaughter plants (20% of the time). As well, 38% of the hogs are electrically prodded in the crowd pen and 35% of the hogs are subject to electric shocks in the restrainer area from either electric prods or the restrainer. Although electric prods may ease the movement of hogs, electric shocks can start a rapid glycogen breakdown, which can result in PSE or DFD pork, depending on the extent and timing of the breakdown. Alternatives to the electric prod are urgently needed. As well, the Canadian swine industry must try to eliminate the use of whips and slappers for moving hogs because they inflict pain and can cause bruising.

### **TRANSIT, UNLOADING, AND RESTING TIMES**

Most hogs spend less than 3 h from time of loading at the farm until unloading at the slaughter plant. However, approximately 4% of hogs spend more than 24 h in transit. Short transit times do not allow much time between the



stress of loading and unloading. As well, social regrouping as a result of mixing before shipping continues on the truck. If short transit times are combined with short resting times (9% of hogs are slaughtered immediately off the truck) the incidence of PSE pork can be expected to increase. As previously mentioned, long transit times result in higher carcass weight losses. Once the abattoir is reached, the hogs should be unloaded from the truck as soon as possible. Although the average time to unloading is fairly reasonable at 23 min, in extreme cases some loads wait for up to 4 h before unloading. Research has shown that a minimum of 1 h in lairage is necessary to reduce body temperature to normal. A lairage period of 2-4 hours before slaughter is recommended.

## **STOCKING DENSITY**

On average, hogs are provided with 0.66 m<sup>2</sup> of space per hog when housed at assembly yards. At the slaughter plants, average space allotment is 0.57 m<sup>2</sup> per hog. During transit average space allotments ranged between 0.32 and 0.34 m<sup>2</sup> per hog. Overcrowding can lead to heat stress, fatigue, lower meat quality, and higher death rates. As well, densely packed hogs fight more, resulting in increased skin damage. The recommended space allotment (Agriculture Canada Recommended Code of Practice for Care and Handling of Pigs, 1984) for market weight hogs is 0.85 m<sup>2</sup> per hog housed in pens and 0.34-0.41 m<sup>2</sup> per hog during transit, depending on ambient temperature. It appears that hogs are shipped, assembled, and held before slaughter with less than the recommended allowances for space.

## **FACILITY DESIGN**

For the most part, assembly yards reported fairly good facilities with few areas of shadow (15% of the hogs experience some shadow) along the alleys and a minimum of slipping; 9% of the hogs experience some slipping along the alleys. In slaughter plants the lighting and footing reported were not as good, with 30% of the hogs having to pass through some shadow and 33% experiencing some slipping along the alleys.

Most hogs travel an average of 41 m along straight alleys; 90% have straight alleys at assembly yards. In slaughter plants the average distance from the holding pen to the crowd pen was 29 m, with an additional 5.7 m on average along

the restrainer. Most hogs (91%) travel along straight rather than curved alleys in slaughter plants. Few plants have any type of gradient in the main chute from the holding pen to the crowd pen. Of the slaughter plants that responded (48%), 64% indicated an upward elevation from the crowd pen to the restrainer, the incline ranging from 0.5% to 25%.

Slippery walkways, poor lighting, steep ramps, walking distance, and the shape of chutes and alleys can all contribute to increased stress in hogs. It is difficult to make any general recommendations for facility design, except for adopting long, narrow pens that allow easy separation of loads and curved alleys leading to the restrainer that aid moving hogs with a minimal use of electric prods.

## **SLAUGHTERING PROCEDURE**

Type of stunning, time from stunning to sticking, and scalding are the three slaughtering procedures that can have the greatest effect on the development of PSE pork. High-voltage electrical stunning is the method of choice in Canada for stunning hogs, with most plants using stun voltages of 240-800 volts. These voltages are adequate for humane stunning, with average stun times reported to be 3.46 s. The range reported for stun times (0.5-15 s) appears to be barely adequate on the one hand and excessive on the other, given the range reported for stun voltages. The range reported from stunning to sticking was 2-72 s. Seventy-two seconds from stunning to sticking is an excessive amount of time for both humane treatment and for achieving the best meat quality. As a general guideline, hogs should be stuck within 15 s of stunning. The reported ranges in scalding temperature (58-63 °C) and scalding time (3.3-8.0 min) between plants are fairly narrow and unlikely to contribute to a significant variation in the incidence of PSE pork from plant to plant.

## **COOLING RATE**

Carcass cooling systems have been developed to reduce the deep muscle temperature and thereby minimize the growth of spoilage bacteria. Of the Canadian slaughter plants that responded, 30% use blast chillers, 11% use spray chillers, and 59% use conventional chillers. Blast chilling lowers the rate of postmortem pH decline, resulting in improved meat quality in carcasses

susceptible to PSE. Although spray chilling has only a slight benefit to carcass cooling rate, it does result in reduced carcass shrinkage without adversely affecting meat quality.





