Livestock-handling quality assurance

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ABSTRACT: Careful handling of pigs and cattle at slaughter plants helps preserve meat quality. Cattle handled quietly have less bruising and cattle that remain calm during handling are less likely to have dark cutting or tough meat. In pigs, quiet handling and a minimum of electric prod use in the stunning chute reduce PSE approximately 10%. Quiet handling also helps reduce blood splash in pigs and kosher cattle. Meat damage from poor injection technique may be reduced in animals that are handled quietly. Proper injection technique is easier in calm animals. People manage what they measure. Objective scoring should be used to measure the quality of handling. Vocalization scoring can be used to assess handling quality. The percentage of cattle that vocalize (moo or bellow) during handling through chutes is determined. Other measures are the percentage of animals poked with an electric prod and the percentage of cattle that walk quietly into a squeeze chute. Cattle that walk quietly into the squeeze chute are less likely to get shoulder injuries, which cause extensive meat damage. Cattle that are handled quietly with a minimum of electric prod use vocalize less than cattle that are excessively prodded with an electric prod. Squeal scoring can be used in pigs to assess handling quality. Several studies show that vocalization is correlated with physiological measures of stress in both cattle and pigs. Regular auditing and measurement of handling practices will help maintain meat quality and improve animal welfare.

Key Words: Dark Cutting Meat, Handling, Kosher Food, Porcine Stress Syndrome, Slaughter

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Introduction

For this symposium article, I was asked to present data from both scientific research and observations based on 26 yr as a consultant to the feedlot and meat industry. During 1999 and 2000, I observed handling of cattle and pigs in 58 slaughter plants in the United States, Canada, Europe, Australia, New Zealand, and South America. From 1997 to 2000, I observed handling in 28 feedlots in six states. During my career I have visited several hundred feedlots.

Quiet handling of livestock will help preserve meat quality. Cattle that became agitated in squeeze chutes had lower weight gain, tougher meat, and more dark cutters (Voisinet et al., 1997a,b). Dark-cutting beef is darker and drier than normal and has a shorter shelf life, which are severe quality defects. Bruising is also affected by handling. Injections into the muscle can cause extensive meat damage (George et al., 1995a,b, 1996, 1997). It is easier to properly give injections when cattle are standing still in a squeeze chute. Handling pigs quietly at the slaughter plant will help prevent PSE pork. This is a serious quality defect that makes pork pale and gives it poor water-binding capacity. Retailers are willing to pay a premium for pork that is not PSE (Von Rohr et al., 1999). Stressful preslaughter handling causes a deterioration of porkmeat quality (Warriss et al., 1994; Van der Wal, 1997; D'Souza et al., 1998). Blood splashing is small blood spots in the meat. Meat with blood splashing cannot be sold at premium prices. Handling practices affect blood splash in pigs and kosher cattle (Calkins et al., 1980; Grandin, 1994; Grandin and Regenstien, 1994).

This paper reviews the extent of handling-related meat-quality problems, and it will cover the use of auditing methods that will help maintain careful handling of livestock.

Review of Handling-Related Quality Problems

Bruises

Forty-eight percent of U.S. fed steers and heifers have bruised carcasses (Smith et al., 1995; Boleman et al., 1998). Studies in both sheep and cattle indicate that animals sold through auction markets have more bruises than animals sold directly to a slaughter plant (Cockram and Lee, 1991; McNally and Warriss, 1996; Hoffman et al., 1998). Bruising of cull cows is extensive. Damage to cow meat is becoming a greater eco-

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nomic issue because 44% of the beef from cull cows is sold as primals and 100% visual lean subprimals (Smith et al., 1999). Twenty-two percent of cull cows had severe bruising, and 2.2% had severe bruises that destroyed a major portion of the carcass (Smith et al., 1999). A recent Canadian study showed that 15% of the cattle had severe bruising and 78% of carcasses had some bruising (Van Donkergoed et al., 1997). A comparison between the 1994 and 1999 audit of cull cows indicates that economic losses from bruises declined from $3.91 to $2.24 per cow (Smith et al., 1994, 1999). Even though there has been some improvement, the losses are still very extensive. Quiet handling provides the advantage of significantly reducing bruising. Cattle that originated from a feedlot with quiet handling had 8.35% bruised carcasses, and cattle that came from a feedlot where employees handled them roughly had 15.5% bruised carcasses (Grandin, 1981).

Injection-Site Damage

Smith et al. (1999) reported that losses from injection-site lesions have become worse in cull cows. The cost rose from $0.66 in 1994 to $1.46 in 1999. Much of this increase was in dairy cows. My observations in 28 feedyards in six states indicate that most feedyard personnel inject steers and heifers in the neck to avoid damage to the most valuable parts of the carcass. These observations were made from 1997 through 2000. In beef cattle the majority of lesions showing up in the top butt and expensive cuts occurred before the animals came to a feedlot (George et al., 1995a; Boleman et al., 1998).

The plant manager at a major western packer observed that in fed cattle most of the injections were given in the neck or shoulder, but many of the injections penetrated the muscle and were not given subcutaneously. Many squeeze chutes have long-neck extender bars on the headgate to hold the head for administration of growth-promotant implants in the ear. I have observed that these bars make it almost impossible to give an injection properly in the neck. The extender bars cover up the neck. My observations in 28 feedyards indicate that some feedyards use neck-extender bars that interfere with giving subcutaneous injections in the correct location on the neck.

I have also observed during the last 26 yr that the handling of cattle in squeeze chutes has improved, but some rough handling that causes cattle to rear, struggle, and run into things is still occurring. Agitated cattle that have been prodded with electric prods often hit the headgate at a run. I have observed serious injuries that may destroy a large portion of the shoulder meat. During the summer of 2000, I observed at a slaughter plant healed injuries on fed-beef carcasses. These injuries had occurred before the cattle arrived at the feedlot. When I called the feedlot where the cattle had originated, the manager reported that he watched the calves being handled at the ranch of origin. He stated that most of the calves were electrically prodded, and they entered the squeeze chute at a run. This resulted in 5% of the calves becoming lame.

Dark-Cutting Beef

Scanga et al. (1998) reported that the average percentage of dark cutters in nine feedyards varied from 0.64 to 0.05%. Data were compiled from 15,439 pens of feedlot cattle. Schiefelbein (2000) collected data on 55,876 cattle of eight breeds. The average dark-cutter percentage was 0.37%. The average percentage of dark cutters for each breed was as follows: Red Angus, 0.08%; Charolais, 0.26%; Gelbvieh, 0.28%; Hereford, 0.30%; Angus, 0.40%; Salers, 0.62%; Simmental, 0.82%; and Limousin, 0.99%. The breeds with a calmer temperament that walk quietly into a squeeze chute or packing-plant restrainer system had a lower percentage of dark cutters. Both packers and feeders have observed that groups of cattle that become highly agitated and rear, kick, struggle, or run into objects during handling sometimes have up to 20% dark cutters. Two feedlot managers reported that eliminating electric prods during the loading of fed cattle into trucks greatly reduced dark cutters. Many factors contribute to causing dark cutters. Aggressive use of growth-promotant implants and weather extremes also increases dark cutting (Scanga et al., 1998). Other factors are breed of cattle or excitement and agitation during handling (Voisinet et al., 1997b; Schiefelbein, 2000). Stockyard practices can also contribute to the depletion of glycogen that causes dark cutting. Mixing strange cattle from different pens or pastures will increase dark cutting (Grandin, 1978, 1979; McVeigh and Tarrant, 1983; Warris et al., 1984).

Pale, Soft, Exudative Pork and Death Losses

Morgan et al. (1993) reported that 9.1% of all hams and loins processed in the United States had PSE. Genetics is a major factor in causing PSE (Lundstrom et al., 1989; Sather et al., 1991). Death losses in pigs are related to both genetics and handling. Murray and Johnson (1998) reported in a Canadian study that death losses were 9.2% in PSS (porcine stress syndrome) homozygous positive pigs, 0.27% in carriers, and 0.05% in homozygous negative pigs. Pigs that have the PSS gene also have more PSE (Sather et al., 1991). I have observed in three packing plants that both death losses and quality problems are highest in heavy 125-kg pigs that carry the stress gene (Grandin, 2000a). In 1999 and 2000, I visited 20 pork slaughter plants and observed that high temperatures and humidity also increase death losses and PSE. I have observed in three plants in the United States that PSE often increases when the first hot days begin in spring. High temperatures and humidity increase death losses (Warriss et al., 1994). Keeping pigs cool and careful, quiet handling can help reduce both PSE and death

losses. Resting pigs for 2 to 4 h prior to stunning will significantly reduce PSE (Malmfors, 1982; Milligan et al., 1996). Showering pigs cools them off and will also reduce PSE (Smulders et al., 1983). When pigs get excited they get overheated, and an overheated pig is more likely to have poor-quality pork (Gariepy et al., 1989). Careful, quiet handling and reducing electric prod use will help prevent pigs from getting overheated. Brundridge et al. (1998) have found that using an electric prod significantly raised a pig's heart rate. Minimizing electric prod use in the stunning chute will reduce PSE (Channon et al., 2000; Grandin, 2000a). I observed in four plants that reducing electric prod use, squealing, and pile-ups in the chute leading to the stunner resulted in 10% less PSE, and more pork was suitable for high-quality exports in Japan.

Blood Splash in Pork and Ritually Slaughtered Cattle

A complete discussion of the effect of stunning method on blood splash is beyond the scope of this paper. Stunning method does have a significant effect on the extent of blood splash (Gilbert and Devine, 1982). The discussion in this paper will mainly cover handling. At two plants I have observed that lean, heavily muscled pigs are more prone to blood splash and broken backs than pigs with thicker fat. Elimination of electric prods will reduce blood splash (Calkins et al., 1980; Channon et al., 2000). Possible explanations for the detrimental effects of electric prods may be stunning difficulties caused by agitated pigs struggling or rearing during stunning or stretching and twisting of the skin when excited pigs pile up. In sheep, the angle of the side of the conveyor V restrainer affected the incidence of blood splash (Thornton et al., 1979). Grandin (1985/86) found that running pigs through a broken V restrainer with one inoperative side conveyor stretched and pulled the skin and increased blood splash.

Blood splash is a severe problem in kosher (Jewish ritual) slaughter, which is done without stunning. Observations in three plants indicated that it varied from 3 to 30% of the cattle. In four kosher plants, I observed that captive bolt stunning immediately after the throat was cut brought about a threefold reduction in blood splash, compared with kosher slaughter without captive bolt stunning. Unpublished data obtained from plant records indicated that carefully done kosher slaughter of grain-fed cattle without stunning still produced 3 to 4% blood-splashed carcasses. Blood splash and blood spotting were assessed by looking for petechial hemorrhages on the ribeye during grading. These hemorrhages form small blood spots in the meat. When cattle become excited and agitated due to excessive use of electric prods and struggling during restraint, blood splash can rise to 30% of the carcasses. Good operators of a properly designed upright restraint box can greatly reduce blood splash because they minimize pressure exerted on the rear of the cattle with the pusher gate. The design of the box is shown in Grandin (1994) and Grandin and Regenstien (1994). Unpublished data collected at a large glatt kosher plant indicated that the percentage of carcasses with blood splash was 3.5% with a skilled restraint box operator and 10% with a poorly trained operator. The cattle were held in an upright standing position when the throat cut was made. In a regular plant where cattle are stunned with a captive bolt, blood-splash levels are usually less than 0.5% of beef carcasses.

Excessive blood splash in glatt kosher cattle in which captive bolt stunning after the throat is cut is not permitted, has caused some plants to leave the kosher business. There is some anecdotal evidence that the blood-splash problem may be worse in grain-fed cattle. During my career, I have been to 17 kosher calf and beef plants. Five of these plants that slaughter grain-fed beef have lost customers due to blood-splash. For over 10 yr in New Zealand, electrical stunning has been used prior to Muslim halal slaughter of grass-fed cattle. I have visited three of these plants, and the managers reported that blood-splash was minimal. When the Australians attempted to adopt this technology for grain-fed beef, it was a commercial failure. The two plants that tried it removed the electrical stunning equipment and replaced it with captive-bolt stunning because high levels of blood-plash caused too many customer complaints.

Keeping cattle calm during handling, minimizing the time that the animal is restrained, and avoiding excessive pressure applied to the body will reduce blood splashing (Grandin and Regenstein, 1994). For animal-welfare reasons the animal should be restrained in a device that holds it in a comfortable upright position during the throat cut (Grandin, 1994; Grandin and Regenstein, 1994). Some kosher plants have poor animal welfare because conscious, unstunned animals are suspended by a chain wrapped around the rear leg.

Problem of Maintaining Good Handling Practices

In different slaughter plants, I have documented a substantial reduction in bruises, blood splash, or PSE by training employees and improving handling. In one kosher beef plant, a $500 to $1,000 loss per day due to blood splash was prevented by stopping the excessive use of electric prods and by operating the restraining box correctly to prevent excessive pressure from being applied to the animal's body. In three pork plants, a 10% improvement in the acceptance rate for Japanese export occurred when handlers were trained to reduce electric prod use and to move smaller groups of pigs.

Unfortunately, in all four of these plants, handlers gradually slipped back into their old rough habits because the quality of handling was not continually monitored on a regular basis. There was a one-time effort to

improve handling, and then management's attention was shifted to other parts of the plant. They failed to maintain good handling practices even though the financial loss was well documented.

In many other slaughter plants and feedlots, I have observed a gradual deterioration in handling practices after a one-time training session had improved handling. In some cases, the deterioration occurred slowly, and the people did not realize how poor their practices had become because they had nothing to which to compare their performance. I conducted a survey in 1996 for the U.S. Department of Agriculture of handling practices in 21 beef and pork plants. Seven (33%) of the plants were rated a serious problem for abusive use of electric prods (Grandin, 1997a). In one plant, bulls were paralyzed with an electric prod. The survey was an announced USDA visit, and bad practices were observed, because management had come to view these practices as "normal."

Auditing Handling

Managers manage the things that they measure. One of the reasons why handling practices deteriorated after training was because the quality of handling was not measured on a regular basis. Monitoring handling on a regular basis would be similar to monitoring bacterial counts for food safety. It is likely that bacterial counts in meat and on equipment would gradually increase if measuring on a regular basis were discontinued.

Auditing of the critical control points of handling will help maintain handling standards to ensure good animal welfare and to help preserve meat quality. Grandin (1998a) developed an objective scoring system for handling and stunning at slaughter plants. The system is simple so that it can be easily implemented. It was essential to find the important critical control points, but not to have too many things to measure. The variables measured are 1) percentage of animals stunned correctly on the first attempt, 2) percentage of animals insensible on the bleed rail, 3) percentage of cattle that vocalize (moo or bellow) during movement through the chute and restrainer, 4) percentage of animals electrically prodded, and 5) percentage of animals that slip or 6) percentage that fall (Grandin, 1997b). A minimum of 100 animals are scored in large beef and pork plants and 50 animals in small plants with a line speed of less than 100 per hour.

To keep the auditing process simple, each variable is scored on a yes/no basis for each animal (e.g., vocalized, yes or no; electric prodded, yes or no). Attempting to determine the intensity of a vocalization is not practical under commercial conditions.

Vocalization Scoring

The percentage of cattle that vocalize is a sensitive indicator of problems such as excessive electric prod use, slipping in the stunning box, excessive pressure applied by a restraint device, and missed stuns (Grandin, 1997a). Grandin (1998a,b) reported that 98% of vocalizing cattle were associated with an obvious aversive event such as being prodded with an electric prod, missed captive bolt stuns, slipping in the stun box, excessive pressure from a restraint device, or being left alone too long in a chute or stun box. Vocalization scoring can be used to monitor improvements or a deterioration of handling quality. A lone bovine left in a crowded pen or stun box too long will often vocalize. A reduction in the use of electric prods is associated with a significant reduction in the percentage of cattle that vocalize. Grandin (1998b) reported that reducing the percentage of cattle electrically prodded from 90 to 14% reduced the percentage of cattle that vocalized from 32 to 13%. The 13% that still vocalized were responding to excessive pressure applied by a restraint device. In a second plant, the percentage of cattle electrically prodded was reduced from 76 to 20%, and the percentage of cattle that vocalized dropped from 12 to 3% (Grandin, 1998a,b). Further data collected in 21 beef plants indicated that the average percentage of cattle that vocalized was only 3.08%, and the range was 0.66 to 17% (Grandin, 2000b). The plants scored in Grandin (2000b) had lower percentages of cattle that vocalized compared to those in Grandin (1998a) because the employees were demonstrating their best behavior. The plants in Grandin (2000b) were being audited for animal welfare by McDonald's Corporation. Therefore, an electric prod was only used on cattle that refused to move. Ten plants (48%) that had low or no electric prod use had 1% or fewer of the cattle vocalizing (Grandin, 2000a). Four plants (19%) had higher percentages of 7, 8, 12, and 17% vocalizing (Grandin, 2000b). These elevated percentages were due to excessive electric prod use on cattle that constantly balked and backed up. In one plant that had 8% of the cattle vocalizing, the cattle were balking at a dark restrainer conveyer entrance. Another 100 cattle were scored after a light was installed to illuminate the entrance. The percentage of cattle that vocalized dropped to zero because balking was greatly reduced and the use of the electric prod was also reduced.

Vocalization in both cattle and pigs is correlated with physiological measures of stress (Dunn, 1990; Warriss et al., 1994; White et al., 1995). In pigs, the intensity of squealing was related to poorer pork quality (Warriss et al., 1994). Vocalization scoring provides a simple way to identify problems with excessive electric prod use or other problems with equipment or handling. Data from Grandin (1998b, 2000b) indicate that plants with more than 3% of the cattle vocalizing during handling usually have a problem such as excessive electric prod use or a poorly maintained captive bolt stunning. Vocalization scoring is only done when animals are being moved through the chute, stun box, or restrainer. Animals standing undisturbed in the

holding yards are not scored. Vocalization scoring provides an easy way for a plant to audit its own handling practices. Excessive use of electric prods will usually be reflected by a higher percentage of cattle vocalizing (Grandin, 1998b). People auditing vocalization must be observant, because sometimes the aversive event associated with vocalization is not readily apparent. At one beef plant, some cattle vocalized loudly in a conveyor restrainer. The restrainer was in good repair, but a local welding shop had built replacement conveyor slats wrong. They had a variation in height of over 2 cm from one slat to the next. This welding shop mistake created sharper corners that stuck into the cattle.

Watts and Stookey (2000) report that there are genetic differences in the tendency of certain genetic lines of cattle to vocalize. All the beef-slaughter plants that minimized electric prod use had a first-shot stunning score of 95% or better, had nonslip flooring, and had no problems with their restrainers such as sharp edges had a vocalization percentage of 3% or fewer of the cattle (Grandin, 2000b). Three percent is the minimum passing score on the American Meat Institute guidelines (Graindin, 1997b). Watts and Stookey (2000) are concerned that a plant could get an acceptable vocalization data percentage with one group of cattle and fail with another. I have collected vocalization data in over 50 beef plants on more than 4,000 cattle. There were only two groups of 50 and 100 cattle in which more than 5% of the cattle spontaneously vocalized while moving through the chutes when there was no aversive event such as an electric prod used associated with the vocalization. One group was 19 mature cull bulls that were handled together in a single group. The other group were black fed heifers of unknown genetics that had no visible Brahman characteristics. If an auditor encounters a group of cattle that seem to be vocalizing without an aversive event present, it is recommended to score several more groups of 100 cattle from different origins. In the plant with the black heifers, the vocalization percentage dropped to less than 3% when other groups of cattle were scored. It may not be advisable to apply the 3% pass rate to mature bulls handled in groups.

It is likely that cattle that vocalize without an associated obvious aversive event are cattle that are more easily stressed. I have observed both in feedlots and plants that highly vocal cattle also tend to become more agitated and struggle more during handling in squeeze chutes in feedlots. These cattle will need careful handling to reduce stress because cattle that become agitated during handling are more likely to have meat-quality problems or lower weight gains (Voisinet et al., 1997a,b).

I have also observed that some pigs with an excitable temperament are more likely to squeal when slapped on the rear. At four pork plants, I noted that these pigs are more likely to pile up during handling and they are more likely to balk or back up in a race. In two fully integrated pork companies and at an independent pig farm where two known genotypes were housed in the same facilities, I observed that pigs from the genotype containing the PSS stress gene were more likely to squeal when slapped than pigs that were stress gene-free. Shea-Moore (1998) reported that there were behavior differences between high-lean and low-lean pigs. A plant that has a high percentage of overly vocal pigs can still use vocalization scoring to monitor handling quality within that plant. Plants that audit vocalization on a regular basis have found that it is a simple measure that has helped them to maintain quiet, careful handling. Auditors must also be observant to ensure that a condition does not exist that could prevent an animal from vocalizing. If a plant restrains sensible animals by paralyzing them with an electric current, the animals may not be able to vocalize. Immobilization with electricity is highly aversive to animals and detrimental to their welfare (Lambooy, 1985; Grandin et al., 1986a; Pascoe, 1986). The use of electricity to immobilize a sensible animal would make vocalization scoring impossible. It is my opinion that for welfare reasons electrical immobilization of conscious animals should be prohibited.

I also have developed a simple squeal scoring system for pork-slaughter plants (Grandin, 2000a). The percentage of time that the entire stunning area is quiet is calculated by counting the number of stunner cycles when all the pigs are quiet. As each pig is stunned, the auditor checks yes (heard a squeal) or no (room quiet). Large plants that have worked hard to reduce electric prod usage have been able to achieve percentages of 52 and 80% of the time quiet. Prior to working on improving handling the percentage of time that the room was quiet was 0 to 5%. Even though this method has no way of being adjusted for the number of pigs in the room, it still is useful as a simple method to measure improvement. Large plants with over 100 pigs in the stunning area have been able to achieve 52 to 80% of the time quiet.

Audit on a Regular Basis

To maintain a high level of quality in handling, audits must be done on a regular basis. During 1999, there has been a tremendous improvement in stunning and handling compared with data collected in 1996 (Grandin, 2000b). This is due to audits of handling and stunning conducted by McDonald's Corporation. By the end of 1999, 42 beef plants and 19 pork plants were audited. Ninety percent of the beef plants at the end of 1999 were able to stun 95% of the cattle with one shot, compared to only 30% in 1996. Thirty-seven percent (15 plants) stunned 99 to 100% with one shot. In 1996 only one beef plant (10%) was able to do this. The percentage of cattle vocalizing was also reduced in 1999. In the 1996 USDA survey, 10% of the cattle surveyed vocalized during handling (Grandin, 2000a). In the 1999 McDonald's audits, the percentage of cattle

that vocalized in 42 plants dropped to an average of 2.7%.

There are two factors that account for the big improvement: personnel being held accountable for their practices by a major customer and the requirement to do self-audits. Many plants do regular self-audits and send them into the McDonald's system. After all, one manages the things that they measure. Data coming in from the year 2,000, McDonald's and Wendy's audits indicate that plants that conduct regular self-audits have maintained their handling quality. Continuous measurement is essential.

Measuring Handling Quality in Squeeze Chutes

The same type of auditing system can also be used to monitor handling practices in feedlots, farms, and ranches. Three simple measures can be used to audit handling in squeeze chutes: percentage of cattle that vocalize during handling, percentage of cattle electrically prodded, and the percentage that walk into and out of the squeeze chute. Cattle that walk quietly into a squeeze chute are less likely to become injured, and they struggle less. In five feedyards, I have observed that cattle vocalized more during ear-tagging or implanting than during handling and stunning in a slaughter plant. However, the percentage that vocalize during movement though the single-file chute and catching in the squeeze chute can easily be kept at 3% or less. The increased vocalization occurs when people handle the head for ear-tagging or implanting.

I have given cattle-handling demonstrations at about 20 feedlots. An easily achievable electric-prod use percentage is 1% of the cattle prodded. It is important to get the electric prod out of people's hands. A flag on a paddle stick should be the primary driving tool for handlers to carry. The electric prod should remain on the vaccine table and only be picked up and used on an animal that refuses to enter the squeeze chute.

Electronic Auditing

Electronic measurement of handling quality can be done easily. Burrows and Dillon (1997) used a police radar unit that is used to catch speeding cars to monitor the speed at which cattle left a squeeze chute. Animals that ran out of the squeeze chute at a high speed gained weight more slowly. Schwartzkoph-Genswein et al. (1998) instrumented a squeeze chute to measure how hard cattle hit the headgate and how much an animal shook the chute. Their instruments measured fluctuating signals from the electronic scale under the squeeze chute. They also installed strain gauges on the headgate to measure the force of cattle hitting the headgate. It would be easy to correlate headgate-force measurements and shaking measurements with weight gain, dark cutters, injection-site damage, sickness, and implant quality. The advantage of electronic measurement is that it would provide continuous feedback on handling quality.

Individual cattle identification that can be tracked with a computer makes it possible to document losses caused by poor handling. A rancher reported that cattle transported by one driver consistently had 1.5% more weight loss. Unpublished data from a small meat company reported that 80% of consumer complaints about tough beef could be traced to one producer who had difficult cattle to handle. It is likely that rough handling or poor driving may have contributed to these losses. Instrumenting a truck to electronically record the incidence of rapid braking and sudden acceleration could be done easily. Sudden movements of a truck can throw cattle off balance.

Financial Incentives and Handling Quality

When people are held accountable for losses, they will take steps to stop them. When losses can be passed on to the next market segment, there are no financial incentives to reduce them. For example, cattle sold live weight had twice as many bruises as did cattle sold on the rail (Grandin, 1981). Feedlot managers had an incentive to reduce bruises when they had to pay for them. Horned cattle and cattle with their horn tips cut off have significantly more bruises (Shaw et al., 1976; Wynthes et al., 1979). Ranchers have no incentive to dehorn newborn calves if they do not receive a premium price for hornless animals.

Systems of financial incentives must have accurate measurements of losses. Without continuous measurements, an incentive system will not work. In two new vertically integrated companies, I have observed that handling improved when companies became vertically integrated and each segment in the company was held accountable for losses. However, this improvement will only take place if accurate information on losses from bruises, PSE, dark cutters, or injection-site damages is communicated throughout the system. Two established vertically integrated companies have failed to show handling improvements because the packing and producer segments are run as independent businesses and communication between them is poor. Computerized systems for tracking losses and individual electronic or bar-code identification of animals will facilitate monitoring of losses. Changes will not occur until the measuring tools are in place.

During my 26-yr career, I have observed that paying feedlot processing crews strictly on a piecework basis with no measurements of work quality encourages rough, careless handling and sloppy administration of injections. Feedlot processing crews should be given financial rewards for doing their jobs correctly. However, the variables being measured must be chosen carefully. For example, if a crew is paid solely on the quality of growth-promotant implant administration in the ear, they may be tempted to squeeze the cattle excessively in the hydraulic squeeze chute or use de-

vices to hold the head that will interfere with proper injection technique.

Solving Animal-Balking Problems

If animals constantly balk and refuse to move, it will be almost impossible to reduce electric-prod use and to handle the animals quietly. Lighting problems can slow animal movement. Cattle and pigs often balk and refuse to enter a dark place (Van Putten and Elshof, 1978; Grandin, 1996). In one beef slaughter plant, adding a light at the entrance of a dark conveyor restrainer reduced balking and the need for an electric prod. The percentage of cattle that vocalized dropped from 8 to 0% after the light was installed (Grandin, 2000b). For more information on solving lighting problems, refer to Grandin (1996, 1998c). During cattle-handling workshops in 20 feedyards, I have observed that it was almost impossible to reduce electric prod use in three yards. This occurred when the handling facility was located inside a dark building. It was especially a problem on bright, sunny days. In two of these yards, it became possible to eliminate the use of an electric prod in the crowd pen after a large roll-up door was opened to admit light into the building. In slaughter plants, air drafts blowing into the faces of approaching animals may make them balk and back up (Grandin, 1996).

Moving objects such as a loose, dangling chain end, moving people up ahead, and flapping objects should be removed because they attract an animal's attention, and it may balk and refuse to move. Animals notice small visual details that most people ignore. Shiny, sparkling reflections off shiny metal or wet floors can also cause balking. In three plants, moving a ceiling lamp to eliminate a shiny reflection reduced balking. To have really quiet handling, all the little distractions that cause balking must be removed (Grandin, 1996, 1997a,b,c,d, 1998a,b,c).

Working with Squeeze Chutes

Well-designed facilities, curved chutes, and round crowd pens will facilitate the movement of animals. Design information can be found in Grandin (1990, 1997d, 1998d, 2000a). The single-file chute that leads to the squeeze chute and the sides of the squeeze chute should be solid. Angled rubber louvers mounted on the side drop-down bars are recommended on the squeeze chutes. These louvers prevent the cattle from seeing people when they enter the squeeze chute. However, the side drop-down bar with the attached louver can be opened for access to the animal's body.

On most squeeze chutes, I recommend removal of long-neck extender bars from the headgate to provide access to the neck for injections. If cattle are handled quietly before they get up to the squeeze chute they easily can be backed up in the headgate to make their necks easily accessible and hold their head still for ear implants. Some squeeze-chute operators deliberately catch the animal's jaw in the neck-extender bars to make the neck accessible for injections. This will result in 50% or more of the cattle vocalizing, and catching the jaw can also injure the animal. An animal that has been accidentally hit on the head by the headgate remembers the aversive experience and is more likely to refuse to enter a squeeze chute again in the future (Grandin et al., 1994). It is also likely that hitting the animal's jaw may cause pain that may inhibit feed consumption. Cattle that walk quietly into a squeeze chute can be easily caught right behind the jaw with a headgate that does not have neck-extender bars. The head will be held still for implanting, and the neck will be accessible at the first drop-down bar for injections.

Cattle that walk quietly into a squeeze chute are also less likely to get severe shoulder injuries. Some squeeze chutes have a spring-loaded headgate to absorb the shock of an animal hitting it. On a hydraulic chute, the pressure must be set correctly to avoid injuries. Cattle should be able to stand in a squeeze chute without straining, grunting, or vocalizing. The pressure-relief valves should be set so that the squeeze chute will automatically stop squeezing at a reasonable pressure. When cattle are calm, less pressure will be required to hold them.

Behavioral Principles of Handling

Handlers must be trained in the behavioral principles of cattle handling. For more information on behavioral principles of handling, refer to Grandin (1987, 1995, 2000a) and Smith (1998). Handlers of cattle and pigs need to understand the animals' flight zone and point of balance. Some other handling tips are to fill the crowd pen that leads up to the single-file chute half full, move small bunches, and avoid yelling and whistling. Waynert et al. (1999) found that yelling and whistling had a greater effect on the heart rate of cattle than the sound of a gate slamming. Lanier et al. (2000) found that cattle with an excitable temperament were more sensitive to intermittent, high-pitched sounds and rapid movement than cattle with a calmer temperament.

Accustom Animals to Handling

Pigs and cattle move more quietly during handling if they have become accustomed to people walking through their pen or pasture before they arrive at a slaughter plant. This is especially important for animals from certain genetic lines that tend to be more excitable. Feedlot and slaughter-plant managers have reported that excitable cattle that rear, kick, struggle, and run into objects are difficult to handle and they have more dark cutters. At two large slaughter plants and three feedlots, I have observed that excitable genetic lines of cattle such as Salers and Limousins are more likely to become highly agitated if they had been

handled exclusively by people on horseback prior to arrival. They become agitated when they first see a person on foot because they have never been handled by a person on foot on the feedlot or ranch. Burrows and Dillon (1997) suggest that training and getting cattle accustomed to handling are most important for cattle with excitable temperaments. Binstead (1977), Fordyce et al. (1985, 1988), and Fordyce (1987) all report that training young *Bos indicus* heifers produced calm adult cows that were easier to handle. The problem with animals with excitable genetics is that they are more reactive to sudden, novel experiences (Grandin and Deesing, 1998). Ranchers have reported that an animal may be calm at the home ranch and then become highly agitated in an auction ring or at a feedlot.

In two large pork slaughter plants that own pig-growing and finishing facilities, I have observed that certain genetic lines of lean hybrid pigs are easier to drive and less likely to pile up and squeal during handling if a person has walked through their pen every day during finishing. Three large meat companies instruct their growers to walk their pens every day to accustom the pigs to people in the pens. Experiences prior to slaughter will affect ease of handling. Contact with people in these pens will produce less-excitable pigs (Grandin et al., 1986b; Grandin, 1987). Geverink et al. (1998) and Abbot et al. (1997) both reported that moving pigs out of their finishing pens and walking them in the alley produce animals that are easier to drive. To provide good meat quality, an animal that is reasonably easy to drive and move must be presented to the slaughter plant.

Welfare Issues

Increasing public concern about animal welfare is a major reason why major restaurant companies and supermarkets are auditing handling and stunning practices in the United States and abroad. Many of the poor handling practices discussed in this paper must be corrected to improve animal welfare. Hitting cattle hard on the jaw with the neck-extender bars on a squeeze chute headgate or repeated shocking of animals with electric prods are practices that the public would not find acceptable. They also need to be corrected because it is the right thing to do.

Implications

Regular measurement and auditing of animal handling in feedlots and slaughter plants will help maintain the quality of handling. People manage the things that they measure. Some of the variables that should be measured are percentage of animals prodded with an electric prod, percentage that vocalize and the incidence of slipping and falling. Quiet handling of pigs and cattle will help preserve meat quality and improve animal welfare.

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