HUMANE SLAUGHTER OF BOVINE

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Abstract

HUMANE SLAUGHTER: THE *Ante-Mortem* HANDLING

Humane slaughter is the technical and scientific proceeding set that guarantees the animal welfare since loading, in the rural property, to the bleeding. The slaughter must be performed without unnecessary suffering. The humane conditions must be presented during preslaughter handling. The animal stunning is considered the most critical operation during slaughter. In the act of slaughter it is essential that a state of unconsciousness or insensibility up to the end of bleeding, ensure total freedom from suffering and efficiency bleeding. This article encloses *ante-mortem* process such as transport and handling, stunning and bleeding methods and its effects on meat quality and animal welfare.

Key words : cattle slaughter, animal welfare, handling, transport, stunning, bleeding.

1 Introduction

Some decades ago, slaughter was considered a low scientific technological operation, and was not seriously studied by universities, research institutes and the industry. Slaughter technology of food animals became scientifically important only when it was observed that events, which happen from farm to slaughter, had a large influence on meat quality (SWATLAND, 2000).

In the developed countries, there is an increasing demand for processes called humane slaughter, aiming at reducing unnecessary suffering of the slaughtered animal (CORTESI, 1994; PICCHI & AJZENTAL, 1993). Humane slaughter can be defined as a set of technical and scientific procedures which guarantee animal welfare from loading at the farm up to bleeding in the slaughter plant.

It is essential that slaughter is performer without unduly suffering and that bleeding is efficient. Humane conditions should prevail not only at the act of slaughter, but also in the moment before slaughter (GRACEY & COLLINS, 1992).

Several criteria define a good slaughter method (SWATLAND, 2000): a) animals cannot be treated cruelly; b) animals cannot be unduly stressed; c) bleeding must be done as quickly and as complete as possible; d) carcass bruising must be minimal; e) slaughter must by hygienic, economic and safe for the operators.

Conventional methods of bovine slaughter involve the stunning operation before bleeding, except for Jewish or Islamic ritual slaughters (CORTESI, 1994).

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It is the moral duty of man to respect all animals and to avoid undue suffering of those destined to slaughter. Each country must establish regulations at slaughter plants with the aim to ensure conditions for the humane protection of different species (CORTESI, 1994, LAURENT, 1997).

Adequate cattle handling at the processing plant is essential for the safety of workers, meat quality and animal welfare. Well-designed plant facilities also minimize the effects of stress and minimize slaughter conditions (GRANDIN 1996, 2000a, 2000b, 2000d, 2000e, 2000f).

The stages of transport, unloading, lairage, movement, stunning and bleeding of the animals are important for the slaughter process, and all undue suffering must be avoided. In this sense, training, habilitation and sensibility of the workers are essential (CORTESI, 1994).

Animal welfare problems are always related to inadequate facilities and equipment, distractions obstructing animal movement, lack of training of the personnel, lack of equipment maintenance, and improper handling (GRANDIN, 1996).

2 Animal transport

Road transport is the most common means of taking animals to slaughter (TARRANT et al., 1988). In Brazil, animals are transported mainly by road, in the so-called "cattle trucks", with trailers measuring 10.60 x 2.40 meters, divided into three sections: front with 2.65 x 2.40 m, intermediate with 5.30 x 2.40 m, and rear with 2.65 x 2.40 m. The average capacity is 5 animals in the front and rear sections, and 10animals in the intermediate section, with a total of 20 animals.

Road transport under unfavorable conditions may cause death or bruising, weight loss and stress (KNOWLES, 1999).

Cattle mortality during transport is extremely low. Younger animals are more susceptible than older animals (KNOWLES, 1995). In South Africa, 0.01% cattle mortality in 1980 and 0% mortality were reported out of 22,000 animals transported in 1990. There are no records of cattle mortality during transport in the UK. Older articles report that railway transport is more problematic than road transport (KNOWLES, 1999).

Fat animals are more susceptible than thin animals. High environmental temperature, long transport distances, decrease of the space used for the animal also contribute to transport problems (THORNTON, 1969).

Water and feed deprivation lead to weight loss. The proportion of weight loss reported in the scientific literature is extremely variable, from 0.75% to 11% of live weight in the first 24 h of water and feed deprivation (WARRISS, 1990; KNOWLES, 1999). Weight loss is directly related to the length of transport, varying from 4.6% for 5 h to 7% for 15 h, and can only be recovered after 5 days (WARRISS et al., 1995). Weight loss is initially caused by gut content loss, and access to water during feed deprivation reduces losses. Carcass weight is also variable, with values lower than 1% to values of 8% after 48 h of feed and water deprivation (WARRISS, 1990). Liver weight tends to decrease faster, and also rumen volume, which content becomes more fluid (WARRISS, 1990).

There are some recommendations for the reduction of live weight and carcass weight loss during transport, as the use of oral electrolytic solutions (SCHAEFER et al., 1997). However, the use of vitamins A, D and E injections do not reduce weight loss (JUBB et al., 1993b).

The main aspect to consider during cattle transport is the space occupied per animal, i.e., load density, which can be classified as high (600Kg/m^2), average (400Kg/m^2) or low (200Kg/m^2) (TARRANT et al., 1988). The Farm *Animal Welfare Council* - FAWC (KNOWLES, 1999), provides a formula to calculate the minimum space to be occupied by an animal, $A = 0.021\ W^{0.67}$, where A is the area in square meters and W is the live weight of the animal in kilos, recommending an average of 360kg/m^2. Randall, mentioned by KNOWLES (1999) recommends another equation: $A = 0.01\ W^{0.78}$, and The *Animal Welfare Advisory Committee* of New Zealand adopts Randall's equation for minimum space, and FAWC equation as maximum space (KNOWLES, 1999).

Theoretically, under the economic standpoint, high load density is desirable, but this procedure has been responsible for increase in bruising and stress, and densities higher than 550Kg/m^2 are not allowed (TARRANT et al., 1988, 1992). In Brazil, the average load density is 390 to 410Kg/m^2.

The increase in stress during transport is caused by unfavorable conditions, such as feed and water deprivation, high humidity, high air velocity, and high load density (SCHARAMA et al., 1996). The physiological responses to stress are translated as hyperthermia, and increase in the respiratory and heart rates. Increase in the plasma levels of cortisol, glucose and free fatty acids are associated to

the stimulation of the pituitary and adrenal gland. An increase in neutrophil counts, and a decrease in lymphocytes, eosinophils, and monocytes can also be found (KNOWLES, 1999; GRANDIN, 2000d, GRIGOR et al., 1999).

These physiologic responses increase in the animals transported in the rear third of the vehicle (TARRANT et al., 1988), are directly related to the movement of animals during transport in bad roads (KENNY & TARRANT 1987), and to high load density (TARRANT et al., 1992). Cortisol also increases in the initial phase of transport, but recovers along time (WARRISS, et al., 1995).

Loading and unloading operations, if carried out properly, do not produce important stress reactions (KENNY & TARRANT 1987). The angle of the vehicle access ramp in relation to the ground cannot be steeper than 20^o, and an angle of $15^o$is desirable (CORTESI, 1994).

The extension of carcass bruising is a form of evaluation of transport quality, which directly affects carcass quality, taking into consideration that bruised parts are trimmed from the carcass with the knife, resulting in economic loss and also indicating animal welfare problems (JARVIS & COCKRAM, 1994). The extension of bruising increases with high load densities, particularly those higher than a $600kg/m^2$ (TARRANT et al., 1992).

The main influence of transport on carcass quality is muscle glycogen depletion due to physical activity or physical stress, promoting an abnormal decrease in *post-mortem* pH, causing D.F.D. (dark, firm, dry) meat. These stressful conditions are caused by long transport times (KNOWLES, 1999). A transport time over 15 h is unacceptable from animal behavior and welfare standpoint (WARRISS, et al., 1995).

A new concept of on-line monitoring of animal transport was presented by GEERS et al. (1998), which aims at checking animal welfare and improving the prevention and the control of animal diseases. The system, called TETRAD - *Transport Animal Disease Prevention*, consists of a telemetry system and data sent by satellite. The animal has an electronic device (a transponder) that provides its identification, body temperature, and its geographical position in the vehicle. The vehicle has a laptop computer that transmits animal data via satellite to a control station, where transport monitoring is carried out.

3 Lairage and water feeding

The period of lairage or water feeding at the slaughter plant is the time needed for the animals to completely recover from the disturbances occurred due to transport from the place of origin to the plant (GIL & DURÃO, 1985).

According to article 110 of RIISPOA (Regulation for Industrial and Health Inspection of Animal Products - BRASIL, 1968), animal must rest, be fasted and receive water in the lairage for 24 hours, but this period can be reduced as a function of shorter transport distances. Argentina also adopts this procedure (ARGENTINA, 1971). The official Portuguese regulations also establish a minimum of 24 h of lairage (GIL & DURÃO, 1985). In Australia, a lairage time of 48 hours is used, being 24 hours with feed, and 24 h with water (SHORTHOSE, 1991). In Canada, lairage time is 48 h with feeding (GRANDIN, 1994). In general, a minimum lairage period of 12-24 h is needed for the recovery of cattle submitted to harsh transport conditions for short distances. Animals submitted to the same conditions for longer periods require several days to recover normal physiological conditions (THORNTON, 1969).

The main objective of lairage is to reduce gut content in order to make eviscerations easier (THORNTON, 1969), and also to replenish muscle glycogen reserves (BARTELS, 1980; SHORTHOSE, 1991; THORNTON, 1969), as stress conditions deplete these reserved before slaughter (BRAY et al., 1989).

During lairage, animals are subjected to *ante-mortem* inspection with the following aims: a) demanding and checking the health and vaccine certificates of the cattle; b) identifying the hygienic and health status to aid, with informative data, the *post-mortem* inspection tasks; c) identifying and isolating sick or suspicious animals before slaughter, as well as late-pregnancy and recently calved cows; d) verifying the hygiene conditions of the pens and annexes (BRASIL, 1968; GIL & DURÃO, 1985; SNIJDERS, 1988; STEINER, 1983).

There are five basic causes for animal welfare problems in slaughter plants (GRANDIN, 1996, 1996b): a) stress caused by inadequate equipments and methods, which result in excitement, stress and bruising; b) disturbances hindering natural animal movement, such as reflex of the water on the floor, shining metals and high frequency noises; c) untrained personnel; d) lack of equipment maintenance, such as maintenance of floors and walkways; and e) bad condition of the animals arriving at the plant,

particularly due to transport. Welfare is also affected by species, breed, and genetic line (GRANDIN, 1996), and by inadequate management, such as regrouping or mixture of groups of animals of different origin, promoting fights (KNOWLES, 1999; ABATE, 1997).

Lairage, the adopted management and the novel situations to which the animal is submitted are causes of psychological stress, whereas extreme temperatures, hunger, thirst, fatigue and injuries are the main causes of physical stress (GRANDIN, 1997).

Studies to determine the stress level to which the animal is submitted during *ante-mortem* operations have variable results, and are difficult to interpret in order to define animal welfare (GRANDIN, 1997, 1998, 2000g). Stress evaluations of stress during the *ante-mortem* period must be carried out at the access ramp to the stunning cabinet, or in the space of spray bath.

4 Spray bath

In Brazil, after lairage, animals usually go through an access ramp to the stunning cabinet, which has sliding doors. The spray bath is carried out in this access ramp. According to the Brazilian Ministry of Agriculture (BRASIL, 1968, 1971), it must contain a tubular system of transversal, horizontal and lateral showers, aiming at the center of the ramp. Water pressure cannot be lower than 3 atmospheres (3,03 Kgf/cm^2), and a hyperchloride solution at 15 ppm of available chloride is recommended. Argentina adopts a similar method (PIBOUL, 1973).

In Brazil, the final narrowing of the access ramp is called "syringe", where there are perforated pipes or sprays, according to article 146 of RIISPOA (BRASIL, 1968). The single or double syringe must have a "V" form transversally, aiming at allowing the passage of a single animal.

The spray bath replaced the dip bath, which, taking into account the large amount of dirt accumulated in the tank and the unfeasibility of changing the water often, was a factor of disease dissemination (MUCCIOLO, 1985).

The aim of bathing the animal before slaughter is to clean the hide in order to ensure a hygienic skinning, to reduce dust, as the hide becomes humid, thereby increasing cleanness in the slaughter room (STEINER, 1983). Spray bath before slaughter does not affect the efficiency of bleeding, nor the level of hemoglobin retained in the muscles (ROÇA & SERRANO, 1995).

According to STEINER (1983), the cleaning of cattle, particularly of the legs, hooves and anal region must be carried out in the pens, walkways or syringes, using pressure hoses or sprays. It is recommended that animals remain for a short period of time at the access ramp to dry the hide, as it is impossible to perform hygienic skinning if the hide is wet. The author recommends that cattle which still have some dirt on the hide at this stage must have only their legs and hooves sprayed after stunning.

At the access ramp to the stunning cabinet, evaluations of the stress caused during the *ante-mortem* period must be carried out. At this point, GRANDIN (2000g) proposes the evaluation of animal sliding and falls, as well as vocalizations. The evaluation of sliding and falls (when the animal touches the floor with its body) must be carried out on at least 50 animals, using the following scale:

- excellent: no sliding or falls;
- acceptable : sliding or falls of less than 3% of the animals;
- not acceptable: 1% de falls;
- severe problem: 5% of falls or more than 15% of sliding.

Calm handling, which promotes animal welfare, makes it almost impossible to cause sliding or falls. All areas where the animals walk must be provided with non-sliding floors (GRANDIN, 2000g).

Vocalizations are indications of pain in cattle. The number of times cattle vocalizes during stressful handling is related to plasma cortisol level. The use of electric prod to move the animals causes a large rate of vocalizations. The evaluation must be carried out with at least 100 animals, also in the access ramp to the stunning cabinet. The evaluation criteria, according to GRANDIN (2000g), are:

- excellent: up to 0.5% of cattle vocalize;
- acceptable: 3% vocalize;
- not accepable: 4 to 10% vocalize;

- severe problem: more than 10% vocalize.

The need to use the electric prod to move animals is also a sign that handling is improper. The electric prod cannot be applied in the sensitive parts, such as eyes, ears, and mucosas, and cannot have more than 50 volts. Reducing the use of electric prod improves animal welfare. The criteria to evaluate the use of electric prod in cattle, according to GRANDIN (2000g), are (in % of cattle moved with the use of the prod):

Table 1 —

	Access ramp to the stunning cabinet	Entrance at the stunning cabinet	Cattle total
excellent	0%	$\leq$ 5%	$\leq$ 5%
acceptable	$\leq$ 5%	$\leq$ 20%	$\leq$ 25%
Severe problem	-	-	$\geq$ 50%

5 Stunning method

Stunning can be considered as the first operation of slaughter *per se*. Determined by the adequate process, stunning consists in putting the animal in an unconscious state which must last until bleeding, avoiding undue suffering and promoting a thorough bleeding (GIL & DURÃO, 1985).

The stunning instruments or methods which can be used are: mallet, cash knocker, firearm-gunshot, pneumatic-powered stunners, pneumatic-powered air injections stunners, cartridge-fired captive bolt stunners, cutting of the medulla, electro-narcosis, and chemical processes. Slaughter can also be made by jugulation (*Kasher* or kosher method), without previous stunning.

The stunning mallet is extensively used in Brazil, particularly in clandestine plants. There are not many studies on the use of mallet in cattle (LEACH, 1985). The use of mallet as a slaughter method caused severe lesion of the bone tissue, with depression of the affected region. It produces a cranial-encephalic contusion, and not concussion, as reported by several researchers. There is also a large incidence of macroscopic and microscopic hemorrhages in the pons and the bulb, which can be considered as an indirect lesion, that is, a hemorrhage at the opposite point of the blow in the brain caused by the counter-blow of the basilar portion of the occipital bone (ROÇA, 1999).

The cash-knocker leads to diffusive brain lesion or injury caused by sudden blow and changes in the intra-cerebral pressure, resulting in a rotational deformation of the brain, with consequent lack of motor coordination, while preserving heart and respiratory activity (BAGER et al., 1990; LEACH, 1985). According to LAMBOOY et al. (1981), the cash-knocker is not acceptable as a stunning method due to its low efficiency, which can be evaluated by heart rate, blood pressure, respiration, presence of reflexes, electro-encephalogram, and electro-corticography (BAGER et al., 1990, 1992; FRICKER & RIEK, 1981; LAMBOOY et al., 1981; LEACH, 1985). The efficiency of stunning by cash-knocker was observed by LAMBOOY et al. (1981) only in 50% of the slaughtered animals, i.e., when stunning caused diffuse brain hemorrhage.

Articles on the use of firearm-gunshot and pneumatic-powered stunners are also scarce. The use of firearms is considered as a high-risk operation in slaughter plants (LEACH, 1985).

The pneumatic-powered air injections stunners manufactured in Brazil have a rod terminal measuring 11 mm diameter, with a convex end and an impact power of 8 to 12 Kg/cm^2. they do not have direct air injection aiming at brain tissue laceration. The air exit at the rod terminal aims only at aiding the return of the bolt. The use of pneumatic-powered air injections stunners produces severe brain laceration, causing rapid unconsciousness in the animal and can be considered as an effective method for cattle slaughter (ROÇA, 1999).

The cartridge-fired captive bolt stunner is highlighted in scientific articles. The bolt crosses the brain at high velocity (100-300m/s) and power (50 Kg/mm^2), producing a temporary hole in the brain. Brain injury is causes by an increase of the internal pressure and by the lacerating effect of the bolt. This

is considered the most effective and humane method for cattle, horses and sheep stunning. (DALY et al., 1988; FRICKER & RIEK, 1981; GRACEY & COLLINS, 1992; LEACH, 1985; WORMUTH & SCHUTT-ABRAHAM, 1986), and it is also used in swine (DEPARTAMENT OF AGRICULTURE, USA, 1999) and poultry (LAMBOOIJ et al., 1999).

The use of captive bolt stunners (pneumatic or cartridge-fired) causes lesions of the central nervous system, spreading it throughout the animal organism. SCHMIDT et al. (1999, 1999a) found brain tissue in the right ventricle of 33% of the animals slaughtered by pneumatic-powered air injections stunners, 12% of animals slaughtered by pneumatic-powered stunners without air injections, and 1% of those slaughtered by cartridge-fired captive bolt stunners.

The cutting of the medulla was used for buffalo slaughter, due to the high resistance of the cranium, which prevents stunning by other mechanical means.

Electro-narcosis and carbon dioxide are used only for swine, and it is unfeasible for cattle (TROEGER, 1991; WOTTON et al., 1992).

Except for electro-narcosis and carbon dioxide stunning, the success of a technique depends on the skill of the operator, who must be specially trained to perform stunning (LEACH, 1985).

The stunning cabinet is a metal facility. The bottom and the side that collects vomit are movable, the former with lateral flapping movement, and the latter with sliding movement, mechanically and simultaneously activated after the animal is slaughtered, thereby ejecting the animal from the vomit area (BRASIL, 1971).

After stunning, the animal slides onto the tubular grid of the vomit area, and it is suspended in the aerial trail by one hind leg, with the aid of a hook and a block. At this moment, regurgitation may occur, and there must be plenty of water available for washing (MUCCIOLO, 1985).

The efficacy of stunning must be observed at the bleeding site. Signs of improper stunning are: vocalizations, presence of eye reflexes, eye movement, front leg contraction. GRANDIN (2000) adopts the following criteria for the assessment of the stunning process in cattle:

- excellent: less than 1 per 1000 animals partially stunned;
- acceptable: less than 1 per 500 animals partially stunned.

The only stunning processes mentioned by the European Convention on animal Protection are: a) mechanical means with the use of brain percussion or penetration instruments; b) electro-narcosis; c) gas anesthesia. The techniques of mallet, nails or knives, bolt mallet, bolt mask, and firearms are banned. The exception is the slaughter according to religious rituals, and emergency slaughter (GIL & DURÃO, 1985). Brain concussion is allowed in Belgium, France and Luxembourg, but it is forbidden in the Netherlands since 1920 (LAMBOOY et al., 1981; LEACH, 1985).

In the State of São Paulo, the Bill of Law 297 was approved by the House of Representatives in 1990 (SÃO PAULO, 1990), and the Bill of Law 3929 was discussed at the National House of Representatives in 1989 (BRASIL, 1989). These bills of law establish the slaughter methods of food animals in Brazil. Only the methods through penetration and concussion stunning, electro-narcosis, and chemical methods with the use of carbon dioxide are allowed, and the use of mallet is forbidden. The Bill of Law 297 was sanctioned by the Governor do São Paulo and published as Law 7705 (SÃO PAULO, 1992) in February, 19th, 1992, regulated by Act 39.972 of February, 17th, 1995 (SÃO PAULO, 1995), whereas the Bill of Law 3929 was vetoed at the Agriculture Commission of the National House of Representatives on October, 29th, 1991.

In 1999, the Agriculture Defense Department of the Ministry of Agriculture (BRASIL, 1999) presented the Norm 17, on July, 16th, on the *Technical regulation of stunning methods for the humane slaughter of food animals*, establishing a term of 90 days for suggestions or critics for this proposal. After the suggestions of the scientific community, there was a meeting to define the Regulation, which was published in January, 2000 (BRASIL, 2000).

6 *Kasher* Ritual

The Jewish religion is the most strict as to food laws, involving raw material selection, slaughter, food preparation and consumption, use of certain tools, and also feeding rules in certain days, such as the *sabbath* or *feasts* (LÜCK, 1994, 1995). In contrast with the religious requirements, these methods have

been criticized as cruel (REVISTA NACIONAL DA CARNE, 1995) and also due to the lack of care as to hygienic and health aspects (LÜCK, 1994).

The *Kasher* or *schechita* slaughter involves animal restraint, head pulling by the mean of a hook, and an incision, without sudden movements, between the cricoids cartilage and the larynx (PICCHI & AJZENTAL, 1993), cutting the skin, muscles, trachea, jugular veins and carotid arteries (REGENSTEIN & REGENSTEIN, 1988), sometimes reaching the cervical vertebrae (SANT EGANA, 1967). According to REGENSTEIN & REGENSTEIN (1988), this procedure aims at allowing maximum blood removal.

The word *kosher* or *Kasher* is used to define food prepared according to Jewish laws (REGENSTEIN & REGENSTEIN, 1979, 1988; BARKMEIER, 1998; CHANIN & HOFMAN, 1998, KOF-K KOSHER SUPERVISION, 1998). The Jewish food laws, called *kashrut*, are followed by members of the Jewish religion (REGENSTEIN & REGENSTEIN, 1979, 1991; LÜCK, 1994, 1995), who are more than 6 million people in the USA. Only in the state of New York, with more than two million Jews, the Department of Agriculture has a special section *New York Agricultural and Market Law*, paragraph 201-a) responsible for the safety and legitimacy of the food marketed as *Kasher* or *kosher*. *Kasher* food represent a market of US$35 billion/year, including more than 38,000 food items certified as *Kasher* produced by 9,600 companies of the food industry (AMERICAN MEAT INSTITUTE, 2000, KOSHER, 1997; STERN, 1990; SOJKA, 1995).

Kasher food is bought not only by Jews, but also by Muslims, Adventists, vegetarians, people with allergy to certain foods and ingredients, and other consumers who perceive *Kasher* food as high quality food. *Kasher* food is: beef, chicken, fish with scales, dairy products, fruits, vegetables, and bakery products. Pork, mixtures of meat and dairy products, shrimp, lobster, and seafood are not considered *Kasher* (BARKMEIER, 1998, IBEN, 1995; KHOLMEINI, 1979; KOSHER, 1997; LÜCK, 1994, 1995). Problems with Trichinella spiralis and Taenia solium were probably responsible for the Jewish ban on pork (THORNTON, 1969). However, REGENSTEIN & REGENSTEIN (1979) assert that the laws regulating the *Kasher* ritual are not "health laws". Food restrictions, such as the designation of animals as pure or impure, the prohibition of mixing meat and dairy products, and the consumption of blood are quoted in the Bible (LEVITICUS, XI:1-19; EXODUS, 22:31, 23:19; DEUTERONIMY, XII:21-25; XIV, 1-21).

Schechita is the slaughter ritual for the preparation of *Kasher* meat. It is performed by a butcher called *schochet*, who is trained for a long time. The proposal of the ritual is to cut the jugular veins and the carotid arteries quickly, promoting fast unconsciousness and insensivity. The cutting instrument used in this operation is called *chalaf*, which is properly sharpened and examined after each use. Each stage of the *schechita* is preceded by a special prayer called *beracha*. When non-domestic animals are slaughtered, their blood must be covered with sand or earth. Animal inspection is made by the *shochet* to check for diseases, injuries, and especially the presence of adherences of malformations, condemning the animal for human consumption (HOROVITZ, 1998; SHISLER, 2000). Lungs are inflated to check for adherences. In Brazil, animals are also inspected by the Federal Inspection Service.

To perform bleeding, the animal is moved to the stunning cabinet used for non-*Kasher* meat production, exposes one hind leg in an opening, the leg is held by a chain with a block, the cabinet is opened, allowing the animal exit, and the chain is suspended by a hoist. The animal is lowered until its back touches the ground, maintaining its hind suspended. A hook, with a "V" shape, is placed in the mandible and the neck is stretched. The *shochet* places one hand on the animal's neck, and with a movement with the *chalaf* , cuts, between the first and the second ring of the trachea, the skin, jugular veins, carotid arteries, esophagus and trachea, and cannot touch the cervical vertebrae with cutting edge of the knife. The incision must be performed without interruption, sudden movements, dilacerations, nor on the larynx. After the incision, the animal is hoisted to finish bleeding and to be skinned (PICCHI, 1996; PICCHI & AJZENTAL, 1993).

The biggest problem with the Jewish ritual of cattle slaughter in Brazil is the restraint system, which is not efficient, and does not takes into consideration that most of the cattle is Zebu, which is more excitable than European cattle. The restraint and crude throat-cutting cause severe stress in the animals slaughtered by the *Kasher* method. Soon after throat cutting and hoisting, animals show front leg flexure and contraction of the muscles of the face, obvious signs of pain (ROÇA, 1999).

The analysis of the cranial-encephalic changes shows that the *Kasher* slaughter does not cause lesions in the tegument and in the brain; there are some hemorrhages at the arachnoids and pia-mater. In the brain, there is congestion and some microscopic lesions of hemorrhages. Brain injury caused by this slaughter method is extremely small, and lower as compared to the methods using mallet or pneumatic stunners (ROCA, 1999).

For humane and safety reasons, slaughter plants performing Jewish slaughter must have modern equipment for vertical restraint. The practice of hoisting live cattle or sheep must be eliminated. Several schemes and restraint equipment are recommended by the *American Society for the Prevention of Cruelty to Animals* (ASPCA) (GRANDIN, 2000b, 2000c). Figure 1 shows the scheme for bovine restraint, and Figure 2 the ASPCA model of restraint cabinet.

The apparatus consists of a narrow cabinet with a front opening for the animal's head. After the animal enter the cabinet, a gate pushed it forward and an abdominal lifter is placed under the chest. The head is restrained by a face lifter, so the rabbi can cut the throat. The movement of the abdominal lifter must be restricted to 70 cm so that the animal is not lifted from the floor. The gate pushing the rear must be equipped with a separate pressure regulator, allowing the operator to regulate the pressure on the animal. The operator must avoid sudden movements of the controls. In general, the animal will remain quiet, and the cabinet closes slowly, and therefore less pressure will be needed to promote perfect restraint (GRANDIN, 2000a; GRANDIN & REGENSTEIN, 1994).

According to ASPCA (GRANDIN, 2000a), the ASPCA cabinet can be easily installed during the weekend, with minor interruptions of slaughter plant activities. The maximum capacity is 100 bovine heads per hour and works efficiently at a rate of 75 animals/hour.

Kasher meat for consumption must have few blood vessels and nerves. The front quarters, head and ribs are the most consumed parts by Jews. There is also a prohibition of sciatic nerve consumption (PICCHI & AJZENTAL, 1993). Meat preparation according to the *Kasher* ritual aims at eliminating as much blood as possible. Water must be immersed in water for 30 minutes, followed by dry salting for one hour, followed by three consecutive immersions in water for a period of one hour each (FOLHA DE SÃO PAULO 1992, 1992a; SHISLER, 2000).

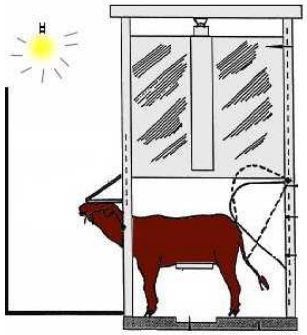

Figure 1 — Scheme of the ASPCA restraint cabinet

7 Bleeding

Bleeding is performed by the saggital opening of the neck by the middle line and cutting the anterior aorta and anterior vena cava in the beginning of the carotid arteries and at the end of the jugular veins. Blood in then collected by the blood drainage groove (BRASIL, 1971). Care must be taken not to cut to deep in the chest direction, as blood may enter the thorax and adhere to the parietal pleura and to the tips of the ribs (THORNTON, 1969).

Two bleeding knives must be used - one for neck incision, and another to cut the vessels. Knives must be immersed in the sterilization box after each animal is bled, as microorganisms of the knife have been already found in the muscles and bone marrow (MUCCIOLO, 1985).

However, blood sometimes is used for edible purposes, and therefore must be collected by special knives (vampire knives) directly connected to the arteries. These knives have a tube connected to handle which takes blood directly to sterilized flasks (PISKE, 1982).

Figure 2 — Model of the ASPCA restraint cabinet

Bovine blood volume is estimated in 6.4-8.2 L/100Kg live weight (BARTELS, 1980; KOLB, 1984). According to BARTELS (1980), the amount of blood obtained by bleeding when the animal is laid down is approximately 3.96 L/100 Kg live weight, whereas with the use of aerial line is 4.42 L/100 Kg live weight. When bleeding is properly done, which is necessary for good conservation, about 60% of the total blood amount is removed, and the remaining blood is retained in the muscles (10%), and viscera (20 - 25%) (PISKE, 1982; HEDRICK et al., 1994; SWATLAND, 2000).

Blood has high pH (7.35 - 7.45) (KOLB, 1984), and due to its high protein content, it quickly undergoes putrefaction (MUCCIOLO, 1985). Therefore, the conservation capacity of improperly bled meat is very limited. In addition, it causes a visual problem for the consumer (BARTELS, 1980; HEDRICK et al., 1994). Thus, bleeding efficiency can be considered as an important requirement of slaughter operations in order to obtain a high quality product (WARRISS, 1977).

However, there is a debate on the relationship among bleeding, hygiene and meat appearance. We know that the blood of healthy animals is almost sterile, and has plasma factors with anti-microbial activity. Thus, the interruption of bleeding by hemostasis was suggested as a means to improve meat sensorial traits, such as tenderness, flavor, juiciness and appearance (B.E. WILLIAMS 1971, US Patent 3573063, apud WARRISS, 1984).

Several factors are responsible for bleeding efficiency, such as the physical state of the animal before slaughter, stunning method, and interval between stunning and bleeding. All diseases which debilitate the circulatory system can affect bleeding. Feverish, acute diseases promote generalized vasodilatation , impairing an efficient bleeding. The same is observed in animals slaughtered in agonic state, when the circulatory system is markedly changed (BARTELS, 1980, PETTY et al., 1994).

The spray bath has been pointed as a procedure capable of improving bleeding through peripheral vasoconstriction (BARBOSA DA SILVA, 1995), but according to ROÇA & SERRANO (1995), this stage of cattle slaughter does not affect the efficiency of bleeding or the level of hemoglobin retained in the muscles.

As to the effects of stunning on bleeding efficiency, scientific studies have dealt mainly with sheep, with the use of electro-narcosis, throat-cutting, captive bolt pistols and mallet.

The results obtained by different authors are conflicting due to the use of different methods to evaluate bleeding efficiency. In sheep, the use of electro-narcosis as compared to crude throat-cutting, evaluated by CHRYSTALL et al. (1981), and electro-narcosis compared to captive bolt pistol or mallet, studied by WARRISS & LEACH (1978), did not show differences in the values of residual hemoglobin in the meat, but PAULICK et al. (1989) found a lower quantity of blood collected after bleeding of sheep submitted to electro-narcosis, as compared to captive bolt pistol stunning.

In cattle, the slaughter method clearly affects the bleeding process, with the highest efficiency in *Kasher* slaughter and the lowest in pneumatic pistol stunning immediately followed by electric stimulation (ROÇA, 1999)

Any stunning method produced an increase in the blood pressure of the arterial, venous and capillary systems, causing a transitional increase in heart rate (THORNTON, 1969), factor which favor bleeding. The volume of blood collected is also higher if bleeding is performed immediately after stunning. VIMINI

et al. (1983, 1983a) asserted that the volume of collected blood in inversely proportional to the interval between stunning and bleeding.

The importance of immediate bleeding is obvious as it is observed that the velocity of the flow from a cut vessel is 5 to 10 times faster than in the intact vessel, and only after much blood is lost that blood pressure falls (THORNTON, 1969).

In Argentina, the maximum interval allowed is two minutes for cattle (ARGENTINA, 1971), and, in the Netherlands. 30 seconds after electro-narcosis in sheep (LEACH, 1985). In Brazil, the Federal Inspection Service recommends a maximum interval of 1 minute (BRASIL, 2000).

A problem related to bleeding is the emergence of muscle hemorrhages characterized by petechiae, stripes or ecchymoses in several areas of the muscles caused by increased blood pressure and capillary ruptures (LEACH, 1985; THORNTON, 1969). Several factors are responsible for these changes, such as the increase in the interval between stunning and bleeding (THORNTON, 1969), the state of anxiety of the animals at the moment of slaughter (GIL & DURÃO, 1985), traumatism, infections, and ingestion of toxic substances (SMULDERS et al., 1989).

The efficiency of bleeding can be defined as the volume of residual blood or blood retained in the muscles after slaughter. Literature on the methods of evaluation of bleeding efficiency is scarce. Perhaps the technical difficulty to evaluate residual blood is the main cause of this (WARRISS, 1977). Considering a marked individual variation in the level of blood hemoglobin, ROÇA (1993) used the ratio between blood hemoglobin and residual hemoglobin in the muscle to establish the efficiency of bleeding, and expressed the results in mL of blood retained in the muscle per 100 g of muscle.

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