VETERINARSKI ARHIV 76 (1), 19-36, 2006

Alternative cattle slaughtering technologies and/or measures reducing the dissemination of central nervous system tissue during head handling, harvesting of cheek meat and tongue and carcass splitting - a review

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RAMANTANIS, S. B.: Alternative cattle slaughtering technologies and/or measures reducing the dissemination of central nervous system tissue during head handling, harvesting of cheek meat and tongue and carcass splitting - a review. Vet. arhiv 76, 19-36, 2006.

ABSTRACT

There is an abundance of critical hygiene points in connection with the handling of the head and the harvesting of head tissues. If a wide range of precautions is not taken, then the danger of cross-contamination of carcasses, abattoir workers, the environment, equipment, and even wastewater is unavoidable. The most critical process stage, in terms of edible meat contamination with specified risk material (SRM), is the current common practice of the longitudinal splitting of the carcass. The carcass splitting saw poses a particular risk in terms of cross-contamination of carcasses, equipment, surfaces and operatives. Tissues of central nervous system (CNS) carry almost all of the infectivity in cattle subclinically and clinically affected by the bovine spongiform encephalopathy (BSE) agent. Should animals suffering from subclinical BSE enter the usual commercial slaughter procedure, it is likely that the BSE prion, amongst others, will be disseminated onto the processed carcasses. If such carcasses are consumed by humans this may lead to the development of variant Creutzfeldt-Jakob disease (vCJD). Protocols ensuring the safe handling of head and harvesting of head tissues, alternative methods of spinal column/cord removal for reducing the contamination of carcass and/or the environment and measures for the protection of operatives in the abattoir are discussed.

Key words: bovine spongiform encephalopathy (BSE), variant Creutzfeldt-Jakob disease (vCJD), dissemination of central nervous system (CNS) tissue

Introduction and background

Within weeks of identification of the first case of the Bovine Spongiform Encephalopathy (BSE), concerns emerged that this disease could be transmitted to humans in contact with

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ISSN 0372-5480
Printed in Croatia

or consuming beef and beef products (BROWN et al., 2001). Concern was heightened by the discovery that some exotic zoo ungulates, as well as domestic and captive wild cats, were becoming infected (SIGURDSON and MILLER, 2003). The emergence of variant Creutzfeldt-Jakob disease (vCJD) in the UK during the mid-1990s as a new human disease has been convincingly shown to be associated with the infection of humans by the same agent that causes BSE in cattle (TAYLOR, 2003). The first possible transmission of vCJD by blood transfusion (LLEWELYN et al., 2004) and an estimate that 237 individuals per million in the UK might be incubating vCJD (HILTON et al., 2004) have recently attracted considerable attention.

Furthermore, the preclinical deposition of PrP^{Sc} in muscles of hamsters orally exposed to scrapie (THOMZIG et al., 2004), the detection of substantial amounts of PrP^{Sc} in muscle tissue of mice and hamsters experimentally infected with scrapie (BOSQUE et al., 2002; THOMZIG et al., 2003), and of patients with sporadic Creutzfeldt-Jakob disease (sCJD) (GLATZEL et al., 2003) and the detection of low PrP^{Sc} accumulation in myocytes from sheep incubating natural scrapie several months before clinical disease onset (ANDREOLETTI et al., 2004) have revived concerns about potential risks for public health emanating from possibly unrecognized reservoirs for PrP^{Sc} and infectivity in muscles of animals and humans incubating transmissible spongiform encephalopathies (TSEs). Further, variant forms of BSE cases, i.e. with atypical histopathological and/or biochemical phenotype, have been recently reported in Japan (YAMAKAWA et al., 2003), France (BIACABE et al., 2004) and Italy (CASALONE et al., 2004). Strikingly, the molecular signature of the latter disorder was similar to that encountered in a distinct subtype of sCJD and raised the question as to whether there is a link between atypical BSE cases and sCJD, as there is between typical BSE and vCJD. Although routine tests have revealed the unknown strains of BSE prions, it is difficult to judge the frequency of these cases in cattle population due to the low numbers of cases analysed so far. These findings have reinforced the likelihood that we are looking at more than one BSE-strain and raised the spectre of the potential risks for public health emerging from possibly undetected cases. In addition, atypical cases of scrapie were detected recently in Norway (BENESTAND et al., 2003), Germany and France (BUSCHMANN et al., 2004). Surprisingly, three BSE rapid tests failed to detect a significant number of the latter cases.

In cattle, the Central Nervous System (CNS) predominantly harbours the BSE prion and efforts are made to exclude BSE-positive animals and/or specified risk material (SRM) from entering the human and animal food chains. In the member states of the EU25 all healthy slaughtered bovine animals aged over 30 months are compulsorily tested (over 24 months compulsory testing in France, Germany, Italy, Slovenia and Spain; below 24 months voluntary testing in Germany). Nevertheless, BSE cases with clinical symptoms in those of less than 30 months were found in Germany and in the UK. In addition, the reported atypical cases in Japan were aged only 21 and 23 months old, respectively (YAMAKAWA et al., 2003). Had the latter cases been presented for slaughter in the most of the EU25 member states they would not have been tested according to the present age limits used in sampling of healthy bovine animals.

Despite the rigorous application of current SRM control policies traditional slaughter technology, especially captive bolt stunning, head handling and carcass splitting continue to present significant opportunities for CNS material, including BSE prion present in the CNS of any subclinically infected cattle, to contaminate meat entering the human food chain, abattoir equipment, surfaces and operatives, even waste water, and should therefore be replaced by safer techniques (ABAS, 2001; ANIL et al., 1999, 2002; HELPS et al., 2002; KNIGHT, 2004; PRENDERGAST et al., 2003, 2004; RAMANTANIS 2002a, 2002b, 2003, 2004; SCHUETT-ABRAHAM, 2002; SCHWÄEGELE et al., 2002; TROEGER 2001, 2002; TROEGER et al., 2002). If the meat from such carcasses is consumed by humans, this may lead to the development of vCJD (HELPS et al. 2002) or to sCJD, should the link between atypical BSE cases and sCJD be proven. It is clearly unsatisfactory that CNS material, which is widely recognized as posing a definite degree of risk to humans (operatives and consumers), contaminates carcass and abattoir environments. Furthermore, such widespread dissemination of SRM material reduces the overall effectiveness of the measures taken by the European Commission (EC) to ensure that SRM tissues stay out of the human food chain, and that appropriate slaughter procedures are used to prevent the contamination of meat.

We have already proposed the replacement of the penetrative stunning method with cardiac arrest stunning in regions where BSE is present in order that the risk of dissemination of brain particles into the blood, carcass and abattoir environment be avoided (RAMANTANIS, 2002b, 2003, 2004; RAMANTANIS et al., 2005). In the present review the possible risks during head handling and harvesting of cheek meat and tongue, and carcass splitting, are identified and possible remedies are proposed.

Early stages of processing, head handling, and harvesting of cheek meat and tongue

PRENDERGAST et al. (2004, 2003) have shown that after stunning, and prior to decapitation, brain material leaking through the hole made by the captive bolt gun (CB) contaminates the surrounding area of hide, with opportunities for contaminating much of the bleeding area and equipment. The quantity of brain tissue released from the hole may be significantly increased if an animal is shot more than once, which, according to GRANDIN (1997, 1998), may occur in as many as 10 per cent of the animals. During subsequent skinning of the head this contamination inevitably reaches the meat and may subsequently be spread over the entire surface of the head. In this regard PRENDERGAST et al. (2003) recovered higher CNS contamination from the CB apertures after dehiding than from other sites along the slaughter line. These observations demonstrated that the continuing leakage of CNS material might spread to carcass surfaces. Furthermore, the vigorous physical shaking of the animal's head and occasional contact with the floor adjoining the dehiding machine during hide removal increased the risks associated with such a leakage. It was noted also that this impact of the head with the floor was in many cases sufficient to dislodge visible fragments of CNS tissue through the CB aperture and to generate aerosols of CNS material. Consequently, the release of CNS material during the early stages of processing is likely to lead to significant direct and indirect widespread contamination of carcass meat, equipment and operatives.

A further critical process stage is the treatment of the head. Statutory meat inspection stipulates that the head of the animal must also be examined. Prior to this, it is separated with a knife from the ramp and cleaned with a showerhead. When the head is removed the spinal cord is severed with a knife, and the same knife is also used for other cuts on the carcass (TROEGER, 2001). The BSE agent is not completely inactivated by autoclaving at 138 ^{o}C for 1 h, and partially survives exposure to hot air at 200 °C (TAYLOR, 2002). "Hot water sterilization" (82 °C) of the utensils does not inactivate the prions; it only denatures the protein (SCHUETT-ABRAHAM, 2002). The danger therefore exists of both cross-contamination due to spinal cord tissue that may adhere to the knife, and direct contamination of the exposed areas of meat at the neck due to release of cerebrospinal fluid and spinal cord tissue particles. Furthermore, in addition to the possibility of contamination of the exposed areas of meat with brain material released through the frontal hole of the skull caused by bolt stunning, there is a high likelihood of the meat being contaminated with BSE agent containing material released through the foramen magnum. Since the shot hole and the foramen magnum are not on the same plane, but rather at right angles to one another on the head, there is no way of positioning the head so as to prevent spillage or leakage of fluid containing CNS tissue fragments. The situation is aggravated because the shot hole equalizes the pressure making it easier for the fluid to escape; if there is only one aperture (as is the case when no penetrative stunning method is used) a certain quantity will first be released, with further release prevented due to the increase in under-pressure. In support of concerns about the wider dissemination of SRM during head processing PRENDERGAST et al. (2003, 2004) detected CNS proteins on the hands and aprons of the operatives who decapitated the carcasses and the operatives who transferred the head to the SRM bin.

After skinning, the external and internal head washing with hand-held hoses takes place in cleaning booths, located adjacent to the slaughter line, i.e. near the skinned carcasses and only partly screened. When working on tables, contamination of surfaces with released CNS particles and/or fluids containing brain tissue residues is unavoidable. When the head is shifted a contamination hazard exists as a result of the release of fluid/CNS material from the CB aperture and the foramen magnum. Brain particles may flow into the nasal cavity through the bolt shot hole. During the external washing there is the danger of the dissemination of CNS material from the CB aperture to the surface of the head. More importantly, there is the danger of cross-contamination of neighbouring carcass surfaces by aerosolised contaminated water (TROEGER, 2001).

Evidence supporting the dissemination of SRM material was presented by PRENDERGAST et al. (2003) who detected CNS proteins in the head wash water, suggesting that this process and the contaminated water it produces could splash, drip or contribute to the aerosolisation of contaminated CNS material. It is also noted that this procedure could contaminate abattoir workers, the environment and equipment in the immediate vicinity of these activities. When high-pressure cleaners are used walls and ceilings are contaminated. Cleansing head liquid containing blood, brain and spinal cord particles is not collected separately and removed, but flows over the floor, contributing to the contamination spread by the operatives (SCHUETT-ABRAHAM, 2002). More importantly, since the disease-related form of the prion protein is relatively resistant to degradation, and infectivity decays rather slowly in the environment (GALE et al., 1998), the possibility of CNS, SRM and/or prions being washed into, and persisting, in the abattoir and wider drainage system is a cause for concern (PRENDERGAST et al., 2003). The cleaned head is subsequently suspended on the organ conveyor belt and transported through the slaughtering hall to the meat inspection area. Dripping fluid spills onto the floor and can contaminate the abattoir area (TROEGER, 2001).

The transport of large numbers of bovine heads in a cage or in several layers suspended from a hook to the cutting plant increases the risk of cross-contamination of the surface of the head meat with CNS and/or fluid with brain particles released through the frontal hole of the skull caused by bolt stunning, and the foramen magnum, due to shaking during transport. Furthermore, the upper heads contaminate the lower ones and, since a collection basin is not usually placed under the heads, the CNS drip contaminates surfaces and the environment.

The above mentioned risks can be minimized if the head (after partial skinning for hygienic removal of the tongue and official meat inspection) is disposed of in one piece as risk material at the place where the head is removed (TROEGER, 2001). Since contamination of the head surface with CNS tissue cannot be avoided, the German Federal Institute for Consumer Health Protection and Veterinary Medicine (BgVV) suggests that the whole head be disposed of in one piece, with the tongue being certified safe for human consumption provided it is removed hygienically. In this case the external and internal washing of the head can be avoided, preventing further contamination of the sewage sludge (SCHUETT-ABRAHAM, 2002).

In November 2002, the Scientific Steering Committee (SSC) of the EC decided that the definition of bovine skull (entire head less cheek meat and tongue) and the related non-categorization of bovine tongue as SRM may no longer be appropriate in relation to certain slaughter procedures. The removal of the tongue is allowed only if contamination by CNS material or by tonsillar tissue is excluded. The tongue could be at risk from cross-contamination with CNS material as a result of leakage from the foramen magnum (and notably from the stun hole if the penetrative stunning method is used) or cross-contamination with tonsillar tissue as a result of any method of removal of the tongue that did not ensure careful separation of the tongue from all tonsillar tissues.

As far as the harvesting of head meat is concerned, the movement of large numbers of heads, which are often in contact with each other, from the abattoir to the cutting plant, increases the risk of cross-contamination. The risk is increased when any penetrative stunning method is used, but is still not zero if a non-penetrative stunning method is applied because CNS material can still leak from the foramen magnum. It is noted also that the safe harvesting of head tissues would require strict and complex procedures which may not always be realistic under field conditions and which would require major efforts in terms of supervision and control. Furthermore, the Committee accepts that the SSC statement in January 2002 concerning the exclusion from SRM of bovine tongue and cheek meat may not necessarily be any longer appropriate, considering the long list of critical points in the process of slaughtering the animal, the removal, storage and transport of the head and harvesting the cheek meat. The Committee considers that: a) the tongue of animals certified safe for human consumption does not pose a risk if contamination with CNS and tonsillar material is avoided for animals of any age. This may imply that the harvested section of the tongue is shortened ("short tongue"), to avoid removal with the tongue of that part of the root of the tongue containing lingual tonsil and b) the cheek meat of animals certified safe for human consumption does not pose a risk if a wide range of precautions to avoid cross contamination is taken.

After evaluation of the discussed possible risks the Commission adopted Regulation (EC) 1139/2003 regarding the harvesting of the tongue and head meat. Tongues of bovine animals of all ages intended for human or animal consumption are harvested at the slaughterhouse by a transverse cut rostral to the lingual process of the basihyoid bone. A system for harvesting head meat of bovine animals above 12 months at the abattoir is introduced, which includes at least the following provisions: a) harvesting takes place in a dedicated area, physically separated from the other parts of the slaughterline; b) where the heads are removed from the conveyor or hooks before harvesting the head meat, the frontal shot hole and foramen magnum is sealed with an impermeable and durable stopper. Where the brainstem is sampled for laboratory testing for BSE, the foramen magnum is sealed immediately after that sampling; c) head meat shall not be harvested from heads where the eyes are damaged or lost immediately prior to, or after, slaughter or which are otherwise damaged in a way which might result in contamination of the head with central nervous tissue; d) head meat shall not be harvested from heads which have not been properly sealed in accordance with the second indent; e) specific working instructions shall be put in place to prevent contamination of the head meat during the harvesting, in particular in cases when the seal is lost or the eyes damaged during the activity; f) a sampling plan for detection CNS tissue shall be put in place to verify that the measures to reduce contamination are properly implemented.

These provisions are not applied to the harvesting of the tongue or cheek meat in the slaughterhouse if performed without removing the bovine head from the conveyor or hooks. The transport to and the harvesting of head meat in the cutting plants should ensure the prevention of possible contamination of head meat (suspension of properly sealed heads on a rack during the storage period and transport; no damaged or lost eyes; sampling plan for detection CNS tissue; visual control of the heads for signs of contamination with CNS tissue or damage; proper sealing before the commencement of the harvesting of the head meat).

Nevertheless, additional measures should be implemented to further reduce the contamination of cheek meat and tongue, although the contamination of meat cannot be completely ruled out (RAMANTANIS, 2004): a) stunning should not be performed using the penetrative method; an alternative method, e.g. irreversible electrical stunning, should be considered. This probably comprises the most important measure, since a second opening in the cranial cavity not only creates an additional aperture to the foramen magnum through which CNS material can escape but it also equalises pressure in the cranial cavity, facilitating the leakage of CNS material; b) the mechanical dehiding of the hanging carcass from tail to head is recommended. In this case the head hide is removed before the opening of the foramen magnum, reducing the handling of the head after decapitation; c) separate and clean knives for each animal should be used for severing the neck musculature and spinal cord. The severing of the vertebral canal should be performed as the final stage in head removal, after severing the soft parts. Thorough mechanical cleaning of the utensils should be performed before "hot water sterilisation". Separate sterilization units should be installed for knives coming into contact with SRM. If SRM knives are stored together with non-SRM knives the latter might become contaminated via SRM-contaminated water; d) BSE sampling should be carried out immediately after removal of the head before sealing the foramen magnum. The perforated cranium, i.e. bolthole and foramen magnum, should be sealed immediately to reduce contamination. Nevertheless, due to inter-animal anatomical variations of the foramen magnum and because of incorrectly performed stunning, i.e. the not so small and circular aperture of the bolthole, it might be difficult to position an impermeable and durable stopper; e) any contaminated meat areas should be removed by using a disposable knife (in the event that a sufficient number of clean and sterilized knives is not provided) after sealing the foramen magnum; f) the head should be directly moved to a fully sealed head-cleaning chamber and suspended (nose upwards). Transport and further processing in the slaughterhouse should be performed with the head suspended from the snout or corner of the lower jaw. Any processing of the head on tables could contaminate the surface with released CNS (working only on suspended head); g) only internal cleaning [with low pressure, although vacuum cleaning to remove the mucous and debris of the nasal and oral cavities should also be considered (RAMANTANIS, 2004)] of the head should be performed. All unnecessary treatment and contact with the head should be avoided; h) meat inspection should also be performed inside this chamber by always using a clean knife; first incisions to the external masseters are performed, followed by removal of the tonsils. Separate knives should be used when cutting the tongue and removing the tonsillar ring; i) when the heads are stored and/or transported they should neither be suspended over one another nor be in contact with each other; ideally, heads should not be transported at all; j) only the masseters from cattle less than 30 months old should be harvested; k) when cheek meat is harvested the processing of heads should be done in batches by age classes (<12 months; 12 to 24 months and >24 months).

Should the above-mentioned measures fail to prevent contamination of cheek meat with CNS tissue in cattle aged over 12 months, then in the interests of preventive consumer protection the entire head without tongue, but with the brain, eyes, trigeminal ganglia and tonsils, should be classified as SRM and disposed of accordingly.

Carcass splitting and washing

The most critical process stage in terms of edible meat contamination with SRM is the current common practice of the longitudinal splitting of the carcass (TROEGER, 2001). During dressing, beef carcasses are split down the vertebral column using an automatic circular saw or a hand-guided belt- and/or a band-type saw and the spinal cord is removed from each half of the carcass. During the splitting of the carcass the vertebral column is opened. Since the spinal cord is often cut along most of its length the possibility exists that CNS material could be spread over the carcass and surrounding environment (SCHUETT-ABRAHAM, 2002). With the hand-guided belt-type saw in particular, a mixture of sawing residues and rinsing water ("sawing sludge") collects over a period of time in the housing of the saw, which contaminates the blade and which in turn splashes the operatives' apron. This source of CNS material has the potential to contaminate the uninfected carcasses of animals slaughtered later (PRENDERGAST et al., 2004; TROEGER, 2001). Since the infectious agent of BSE is extremely resistant to inactivation by standard inactivation procedures (TAYLOR, 2002) and since it is not practical to decontaminate equipment between successive animals on a moving slaughter line (BUNCIC et al., 2002) and furthermore as the dissemination of CNS material onto the carcass, subsequent carcasses and the environment cannot be avoided during the present practice, the whole process demonstrates another likely route of the BSE prion spreading from infected cattle.

HELPS et al. (2002) confirmed the presence of CNS material on the carcass, in the drip trays positioned below the carcass and on the hand-held screens positioned to either side of and beneath the saw after the splitting of the carcass with a band saw. As expected, the results indicated that the majority of cases of CNS contamination occurred on the internal surfaces of the carcass, along the cut vertebral surface, with lesser contamination in the body cavity. Steam cleaning of the carcass had no effect in reducing contamination of the internal surface of the carcass and appeared to increase the contamination of the external surface. The apparent increase in contamination of the external surface after steam washing was attributed to the transfer of CNS material from the internal surface by the cleaning process. Since the longitudinal splitting of the carcass can disseminate spinal cord material over the carcass, the operator and the environment during the splitting process, the authors proposed the use an oval saw for the removal of the vertebral column encasing the intact spinal cord.

In another study PRENDERGAST et al. (2003) detected the spread of CNS tissue from the spinal cord to other sites on the carcass, noting that such contamination persisted after the gross removal of SRM. Contamination was higher in areas proximal to the "sawing line" at carcass splitting compared to the more distal areas of the carcass. Their study confirmed that the carcass-splitting saw poses a particular risk in terms of cross-contamination of carcasses, equipment, surfaces and operatives. Carcass washing does not remove disseminated spinal cord protein from carcasses, but might also disseminate contaminated material into previously uncontaminated areas. Furthermore, CNS proteins were detected on the hands of operatives transferring the carcasses to the chill room after washing. Thus, previously uncontaminated carcasses could become contaminated with CNS tissue from the operatives' hands.

In a separate study, concerning the dissemination of CNS tissue during slaughtering in three Irish abattoirs, only in one abattoir did the carcass saw and operative's aprons became contaminated (PRENDERGAST et al., 2004). It was concluded that the differences between the abattoirs could have been due to differences in the time in which the saws had been used; the longer the period, the more likely that "sawing sludge" would have accumulated and contaminated the saw.

Since the current common practice of the longitudinal splitting of the carcass allows CNS tissue to contaminate not only the equipment used but also adjacent meat parts, both the BgVV and the German Federal Agency for Meat Research (BAFF) suggest that the splitting of carcasses should be avoided until reliable methods are available to completely remove either the vertebral column encasing the intact spinal cord, or the spinal cord. The paramedian splitting of the carcass in small slaughterhouses (non-band slaughtering, individual slaughtering) is proposed following hand removal of the m. Longissimus dorsi, adjacent muscles and the tenderloin.

Alternative methods of spinal cord and/or vertebral column removal

Since the spinal cord is known to harbour the BSE infective agent and has been banned from the human food chain, it seems unwise to allow it to be often cut along its length during the dressing process. There are various options for avoiding or reducing the risk of contamination of the carcass and/or the environment:

A. Spinal cord removal prior to splitting

There are devices available for extracting the spinal cord from the whole (unsplit) carcass. After decapitation of the carcass a PVC hose is inserted into the vertebral canal and moved cautiously caudally. The entire spinal cord is extracted under vacuum, collected in a closed container and then disposed of as SRM. After carcass splitting any spinal cord rests are usually removed manually with a suction apparatus. However, the latter apparatus, already contaminated with the spinal cord rests, is also frequently used for the removal of adipose tissue rests and/or fluid collections in muscle incisions. Should separate suction apparatus not be used, then cross-contamination cannot be avoided (FORSTER et al., 2002). The dura mater spinalis, classified by the SSC as medium infectivity tissue, with the attached nerve roots remains behind in the vertebral canal. However, nowadays milling tools are available which not only remove the spinal cord but also grid dura mater spinalis, and the mixture is absorbed under vacuum (SHUETT-ABRAHAM, 2002). After the splitting of the carcass the dura mater spinalis is removed, i.e. with a cutter. A part of the dorsal root ganglia could possibly be removed along with the dura mater spinalis (FORSTER et al., 2002).

If the spinal cord is properly and completely extracted, this method ensures a substantial reduction in the risk posed by the common longitudinal splitting of the carcass (TROEGER, 2001). Nevertheless, BgVV reported that in about every third animal visually examined, spinal cord rests were detected. Much of the success of the method is dependent on the operative's skills and on the bending of the vertebral canal, especially at the loin region. Should the PVC hose be inserted violently into the canal, the dura mater spinalis could be perforated and the "collection" takes place outside the vertebral canal, resulting in an incomplete removal of the spinal cord (FORSTER et al., 2002). The treatment of cattle should be performed in batches. After each batch the operative changes the disposable gloves used and a thorough cleaning of the equipment used should be performed (SCHUETT-ABRAHAM, 2002).

In evaluating the method, SCHWÄGELE et al. (2002) detected CNS tissue on the carcass, on the band saw used for the splitting of the carcass and on the aprons of the operatives who performed the vacuum extraction of the spinal cord. Contamination with CNS tissue was attributed to the frequently observed incomplete removal of the spinal cord. The results showed that the applied method of sucking up the spinal cord, followed by sawing along the vertebral column, did not prevent the spread of contamination on the carcass surface and on subsequent carcasses due to sawing residues. The authors concluded that alternative methods should be elaborated and tested accordingly in respect of slaughter technology.

B. Sawing out the entire vertebral column

In principle, the entire vertebral column can be removed encasing the intact spinal cord using a double (two parallel saw belts), a band-loop and/or an oval saw. TROEGER (2001) reported that initial testing of a double belt saw with a saw belt gap of 50 mm was unsuccessful because the saw cut into the spinal ganglia lying sideways in the intervertebral apertures. Since the spinal ganglia are also considered as SRM, a suitable method must be used to avoid cutting into these nerve roots. However, after removing the entire vertebral column the carcass loses its stability, and during freezing excessive muscle contraction of the "sides" is recorded. Furthermore, quality problems of the prime joints, i.e. strip-loin due to poor cohesion of the muscles involved and meat toughening due to contraction have been observed. An alternative to the problems cited is vertebral column removal after the cooling of the carcass. After loosening the filet, the band-loop-saw is applied from the backside of the carcass (as is the case with the traditional splitting saw) and the entire vertebral column, with or without the entire animal's head and including the spinal ganglia, is removed from tail to head. Both the double saw and the band-loop-saw projects have been temporarily suspended (LEFFRINGHAUSEN, 2004, personal communication; FINKE, 2004, personal communication).

An oval saw is an alternative solution (Figures 1, 2 and 3). A smaller saw for sheep carcasses has also been developed. The cattle system is now fully functional. The system, from post-evisceration to finished carcass, operates at three line stations: the first for carcass

Fig. 1. Oval saw (FREUND MASCHINENFABRIK GmbH, 2004)

preparation [medial ('internal') knife work: releasing of kidneys and channel fat, removing gristle on backbone, releasing filets; lateral ('external') knife work: releasing right-hand side of the muscle running down the spinal column, cutting horizontally through the neck tendons; band saw: sawing of aitch bone, sawing down right-hand side of the sacrum],

Fig. 2. After removal of the vertebral column (inside view) (FREUND MASCHINENFABRIK GmbH, 2004)

Fig. 3. The removed vertebral column (FREUND MASCHINENFABRIK GmbH, 2004)

the second station for actual column removal (carcass positioning: spreading of hind legs, raising carcass, attaching and actuating carcass support; column removal with oval saw: pre-cutting, removing column), and the final line for carcass finishing [knife work: neck trimming as required, carcass splitting (completion); washing: removing all bone dust with low pressure cold water] (KNIGHT, 2004).

The carcass-holding assembly has to support the neck lowermost and has a device to open the carcass in the region of the brisket to allow adequate access to the vertebral column. It was found desirable for the operator to avoid gross limb movements or changes in posture to be moved with the oval saw upwards on an ascending platform while the carcass remains stationary. The time required for stations one and three is approximately 30 seconds, whereas the main operation of saw utilization at station two is achieved in approximately 60 seconds. The oval saw can be fitted with a range of cutter blade sizes, the operator selecting the size most suitable for the size of carcass (KNIGHT, 2004).

HELPS et al. (2002) reported that the use of an experimental oval saw resulted in significantly less CNS contamination on the hand-held screens positioned on either side and beneath the saw and on the operator's aprons compared with a normal band saw that split down the vertebral column. There was no difference in the levels of contamination found in the drip trays that collected saw wash water below the carcass. Furthermore, the use of the oval saw reduced contamination on all internal and external areas of the examined carcass. Overall, the study detected significantly less contamination on carcasses whose vertebral column had been removed by the experimental oval saw prior to splitting.

C. Other methods not resulting in the opening of the vertebral canal

TROEGER et al. (2002) evaluated three additional methods to median longitudinal splitting: the whole (not split) vertebral column was removed from the carcass ('V-formation method'), the carcass was split paramedially (the vertebral column remained intact at the one 'side'; 'lateral method') or cutting was carried out without longitudinal splitting ('saddle method'). In all three methods the vertebral canal was not opened. The results showed that there was no risk of CNS contamination of the operatives involved for all the cutting techniques evaluated. Further, microbiological and substantial meat quality was not negatively influenced by the evaluated techniques.

D. Boning of the carcass without splitting

TROEGER (2001) suggested that it would be unnecessary to saw through the vertebral canal if the entire carcass was boned hot or cold, before it was boned in primal cuts. The following work stages must be performed in sequence: cut off the shoulders; saw ribs (from the inside), cut forequarter flanks; saw ribs, cut breast from neck; remove filet; remove force rib; remove strip-loin (from top to bottom); remove hip (from top to bottom); saw ilium; remove the entire vertebral column (including blades of the ilium). It is recommended to pre-cut compact areas of muscle such as the neck area on both sides of the vertebrae in order to prevent the meat becoming sticky due to otherwise delayed cooling.

In some countries, such as Norway and New Zealand, this is a common practice, where beef sides are boned into primal cuts while they are hot (TAYLOR, 1995). Hot or cold boning has the additional advantage that the head can be left in place while the sides are boned and the vertebral column can be removed intact after boning. Hot boning is also beneficial in terms of reduction in loss of carcass weight and requirements for storage space (PRENDERGAST et al., 2004). However, if the latter process were to be introduced in EU25, radical changes in classification system (SEUROP), in slaughter and boning operations would be required. In addition, the cost of veterinary inspection will be higher (JOHANNSEN, 2002).

Measures for the protection of operatives in the abattoir

During a day's production in an abattoir where 400 to 500 cattle are slaughtered the amount of syntaxin 1B being leaked from the bovine heads due to stunning was calculated from 932 to 1165 ng (PRENDERGAST et al., 2003). This material, along with brain and spinal cord tissue being released during the handling and boning of head and carcass splitting, will be dispersed in the blood during exsanguination, onto the floors and walls, equipment, work surfaces and meat surfaces and onto the personnel in the abattoir. Over the course of the day the contamination will accumulate, especially on personnel, with some having higher levels of exposure than others. If the operatives in abattoirs are to be safeguarded, the regular presence of CNS tissue needs to be considered in relation to the abattoir's hazard analysis and critical control point plans (PRENDERGAST et al., 2004).

As part of the risk assessment one should consider the potential routes of exposure. There is no evidence that the BSE agent infects animals by the airborne route (although this cannot be ruled out entirely) but it has been shown to infect animals by oral route. Nonetheless, minimizing exposure to aerosols and dusts is prudent and in keeping with the principles of good occupational hygiene. The other most likely routes of entry are by dusty material contaminating wounds and open lesions on the skin, splashing mucous membranes (eyes, nose and mouth) or by accidental ingestion. According to the decision of the German Committee on Biological Substances at work the basic precaution which should be taken by personnel working at stunning, head removal, head handling, harvesting head tissues, evisceration, spinal cord removal, carcass splitting, abattoir disinfection and other sites and/or procedures at the abattoir, where they could be in contact with SRM, is waterproof protective clothing, including gloves and face-shield (ABAS, 2001).

Conclusions

The safe handling of heads and the harvesting of head tissues would require strict and complex procedures which may not always be realistic under field conditions, and which would require major efforts in terms of supervision and control. Should the wide range of precautions fail to avoid contamination of meat, operatives and abattoir equipment and the environment, then the entire head, after the hygienic removal of the tongue, should be disposed of in one piece as SRM. It is unwise to allow the opening of the vertebral column during the longitudinal splitting of the carcass. The current common practice poses a particular risk in terms of cross-contamination of carcasses, equipment, surfaces and operatives. The removal of the entire vertebral column encasing the intact spinal cord results in significantly less CNS contamination of carcasses, abattoir operatives and the environment. To a lesser extent, the spinal cord removal and the boning of the carcass without splitting it could also be considered. Protection of operatives in the abattoir should be given serious consideration.

(Footnotes)

This paper is part of two presentations at the 3rd Hellenic Symposium on Food Hygiene and Food Technology, 18-19 March, 2004, Athens, Greece, entitled: "Slaughter technology and Bovine Spongiform Encephalopathy (BSE) risks: Part I. The potential dissemination of CNS tissue in the carcass and abattoir environment during the contemporary slaughter process; Part II. Methods and means reducing and/or avoiding the risk of dispersal of CNS tissue during slaughter." Further details and new information on the topic have since been added.

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Received: 27 July 2004
Accepted: 10 January 2006

RAMANTANIS, S. B.: Alternativne tehnologije klanja goveda i/ili mjere za smanjenje diseminacije tkiva središnjeg živčanog sustava. Vet. arhiv 76, 19-36, 2006.

SAŽETAK

Postoji mnogo kontrolnih kritičnih točaka u postupku otvaranja glave i uzimanja moždanog tkiva. Ako nisu poduzete mjere opreza u širokom rasponu, javlja se opasnost od infekcije klaoničkih djelatnika, unakrižne kontaminacije trupova, kontaminacije okoliša, pribora pa čak i otpadnih voda. Najkritičnija faza u tom procesu je kontaminacija mesa specifičnim rizičnim materijalom, što se najčešće događa pri longitudinalnom rasijecanje trupova. Rasijecanje trupova piljenjem predstavlja naročiti rizik u smislu međusobne kontaminacije trupova, pribora, površina i radnika. Tkivo središnjeg živčanog sustava nositelj je infektivnosti u oboljelih goveda i supklinički inficiranih goveda uzročnikom goveđe spongiformne encefalopatije (GSE). Ako supklinički inficirane životinje uđu u uobičajeni postupak klanja, postoji mogućnost da se trupovi zaklanih životinja kontaminiraju uzročnikom GSE-a. U ljudi koji bi konzumirali takvo meso može se razviti varijanta Creutzfeldt-Jakobove bolesti (vCJB). Opisani su postupci koji omogućuju sigurnu klaoničku obradu glave i uzimanje moždanog tkiva. Posebice se raspravlja o alternativnim postupcima uklanjanja leđne moždine koji osiguravaju sigurnu klaoničku obradu i zaštitu klaoničkih djelatnika.

Ključne riječi: goveđa spongiformna encefalopatija, varijanta Creutzfeldt-Jakobove bolesti, diseminacija tkiva središnjeg živčanog sustava