Epidémiol. santé anim., 1997, 31-32

RISK ASSESSMENT ON THE ROLE OF MEAT-AND-BONE MEAL IN THE OCCURRENCE OF BOVINE SPONGIFORM ENCEPHALOPATHY IN SWITZERLAND

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Suite à la confirmation du premier cas suisse d'encéphalopathie spongiforme bovine (ESB) en Novembre 1990, l'affouragement de protéines animales a été interdit pour les ruminants. Auparavant, environ 10,000 tonnes de farine de viande et d'os (FVO) avaient été mélangées chaque année dans des fourrages concentrés pour bovin, ce qui représentait un tiers de la quantité totale disponible. Comme l'indiquent les données épidémiologiques, l'interdiction d'affourager des FVO a été une mesure efficace pour limiter la diffusion de l'ESB. Néanmoins, à cause de l'inévitable abattage de bovins précliniquement atteints par l'ESB, une inactivation partielle de l'agent causal de la maladie lors de la valorisation des déchets carnés, et une contamination croisée avec de la FVO lors de la fabrication des aliments, une contamination des fourrages concentrés pour bovin avec du matériel infectieux de l'ESB est restée possible. Afin d'évaluer quantitativement ce risque, un modèle stochastique a été développé. Cette étude a montré qu'au maximum 0.7% des charges de FVO produites en 1994 en Suisse contenaient une infectivité d'ESB résiduelle, mais que le niveau moyen de contamination par tonne de fourrage concentré pour bovin découlant de ces charges de FVO aurait atteint le seuil critique connu de 14 DL_{50} orale pour seulement 0.02% des répétitions réalisées.

INTRODUCTION

It is commonly accepted that the occurrence of bovine spongiform encephalopathy (BSE) is primarily due to the ingestion of concentrate feeds containing meat-and-bone meal (MBM) contaminated by the agent of the disease. In Switzerland, the feeding to ruminants of animal-derived protein, such as MBM and greaves, was forbidden on 1 December 1990. Nonetheless, BSE has been confirmed in 21 animals born after this date (BAB cases; as of 4 April 1997).

The objective of the present study was to assess the role of MBM in the occurrence of BSE in Switzerland. In particular, it aimed at assessing whether concentrate feeds for cattle produced in Switzerland after the implementation of control measures in 1990 could still have contained MBM produced from offal infected with the BSE agent, and what would be the resulting infectivity level.

MATERIALS AND METHODS

The Swiss rendering facilities were visited to inquire about treatment parameters (temperature, pressure, time, maximal particle size), and amount of rendered materials and produced MBM. Data concerning the importation of MBM were obtained from the Swiss Custom General Direction and the Swiss Co-operative Society of Cereals and Feedstuffs; those on the production of concentrate feeds in Switzerland were available for a manufacturers' association representing approximately 51% of the whole Swiss market.

Because preclinically BSE-infected cattle were inevitably slaughtered, a complete agent inactivation during rendering was not achieved, MBM remained allowed for pig and poultry feeding, and cross-contamination with MBM occurred during feed manufacture, a contamination of cattle concentrate feeds by BSE-infectious material has remained possible. This sequence of events was modelled as shown in Table I, and stochastic simulations were run with the support of a specific software (@Risk, Palisade Corp., Newfield NY, USA).

RESULTS

Approximately 140,000 tonnes of offal were disposed in 1994 in Switzerland, of which 70,000 tonnes were delivered to two different rendering facilities for the manufacture of MBM. Such processing fulfilled the prescribed treatment of at least 133 °C for 20 minutes at a pressure of 3 bar. Specified bovine offal (SBO) represented 2.71% of all offal disposed in 1994, an amount 11-fold higher than the one originating from analogous sheep and goat offal. In 1985, the offal from adult cattle represented 45.0% of the total amount of offal (calf 8.1%; sheep 1.3%; goat 0.3%; pig 36.8%; horse 0.6%; poultry 7.9%).

The domestic Swiss production of MBM remained almost unchanged over the last decade, totalizing approximately 32,000 tonnes yearly. In 1994, 47% (about 15,000 tonnes) of this production resulted from the rendering of offal; the remaining fraction originated from the processing of 60,000 tonnes of bones. The ratio of imported to exported MBM sharply decreased in 1991, accentuating a trend already noticeable in the previous year. This was the consequence of a drop in the importation, since the exportation remained constant. Declared as feedstuff, 9,700 tonnes of MBM were imported in 1989, whereas only 400 tonnes were introduced in 1995. In 1989, 10,200 tonnes of MBM were estimated to have been mixed into ruminant feeds. These data, although resulting from a rough estimation, are consistent with those on available MBM, as the difference in available MBM between 1990 and 1991 was 8,700 tonnes.

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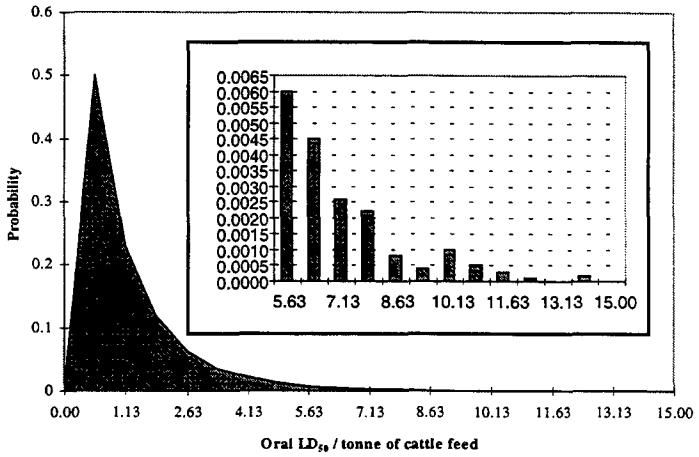
Table I
Model for the assessment on the risk of contamination of Swiss cattle concentrate feeds with BSE-infectious meat-and-bone meal (MBM) produced in Switzerland

	Definition	Values	Value or function used in @Risk[1]
A.	Estimated number of BSE-infected brains in a batch of offal	From 0 to 92 (Vicari et al., unpublished data)	1
B.	Brain weight of adult cattle	410-480 g	445
C.	BSE infectivity per gram of cattle brain	3,570 BSE cattle oral LD_{50}[2] / g brain By analogy from 139A scrapie mice oral LD_{50} (Kimberlin and Walker, 1989).	Beta(3.8,5.96)*10,70 0
D.	Infectivity per batch of offal to be rendered		= A * B * C
E.	BSE infectivity reduction by rendering of offal	At least 80-fold (Taylor et al., 1995)	800
F.	Produced MBM per batch of offal	One plant produced 0.6 tonne of MBM per batch, the other 1.2 tonne.	0.6
G.	Infectivity per MBM tonne		= D / (E * F)
H.	% cross-contamination during manufacture of cattle concentrate feeds	Maximum 0.3% Three samples of dairy cow concentrates out of 544 had 0.1-0.3% of MBM (Guidon, 1995).	Expon(0.0308)
I.	Infectivity per tonne of cattle concentrate feed		= G * H

[1] @Risk: Palisade Corp., Newfield NY, USA. [2] LD_{50},: lethal dose 50 %.

Approximately 13,000 batches of offal were rendered in 1994 in Switzerland. If every brain of the 92 preclinically BSE-infected cattle slaughtered in 1994 (Vicari et al., unpublished data) had been rendered in a different batch, 0.7% of the resulting MBM batches might have had a residual BSE infectivity (92/13,000). The levels of potential contamination of the cattle concentrate feeds owing to that initial inclusion of one BSE-infected brain in an offal batch and their probability of occurrence are shown in Figure 1. Fifty per cent of the contamination were less than 0.75 oral LD_{50} per tonne of cattle feed, and 95% were less than 3.8. The maximal contamination level was 13,9 LD_{50} with a probability of occurrence of 0.0002.

Figure 1
Probability distribution on potential contamination of Swiss cattle concentrate feeds with BSE-infectious meat-and-bone meal (MBM). This calculation considered that only one infected brain was included in a batch of offal to be rendered; 10,000 iterations



Even though such event is less probable, the presence of more than one BSE-infected brain in an offal batch increases the level of contamination proportionally to their number. With three infected brains in a batch, already 5% of the resulting contamination levels exceed the known critical threshold of 14 LD_{50} (Kimberlin and Wilesmith, 1994).

DISCUSSION

Based on the theory that BSE originated from scrapie, a large ovine population in comparison with the bovine one is considered one of the catalyzing factors in the development of the British BSE epidemic (Wilesmith et al., 1991). This element is usually assessed comparing sheep and cattle census. Fourteen per cent of rendered offal in the United Kingdom in 1989 was estimated to originate from sheep, and 0.6% in the United States of America

(USDA, 1991). The situation in Switzerland, with 1.3% of offal being of ovine origin, is comparable to that in the United States, which is regarded as BSE-free in spite of the occurrence of scrapie. It is worth mentioning that scrapie has only been diagnosed on five occasions in Switzerland. It thus seems that BSE in Switzerland could hardly have originated from sheep. Instead, consideration should be given to the proportion of rendered SBO, which represented 2.71% of all rendered offal in 1994 (bovine brain and spinal cord 0.09%), as it could be a possible explanation for the subsequent development of BSE in the country.

Before being prohibited, proportionally more of the available MBM had been used for cattle feeding in Switzerland (27%) than in the United Kingdom (10-20%) and in the United States (13%) (USDA, 1991). In absolute terms, however, the average MBM intake per year, calculated over all cattle in 1989, in Switzerland (5.5 kg) was similar to the British one (5.5 kg), and slightly higher than that of the United States (4.7 kg).

Since the inclusion of MBM is still allowed in feeds for other species, a cross-contamination of cattle concentrate feeds during their manufacture may have occurred, and could partly explain the occurrence of BAB cases. This hazard was modelled and quantitatively assessed. BSE infectivity has been demonstrated in cerebral substance, spinal cord, and retina of natural affected cattle, and distal ileum of experimentally challenged cattle (Fraser et al., 1992; MAFF, 1995; Wells et al., 1994). It is considered that, if organs and tissues other than brain and spinal cord were infectious, then their infectivity titre would be, at worst, about 10^5 fold less than the one of brain and spinal cord (Anon., 1996). Since the infectivity of spinal cord was reputed subsidiary to the one of brain, it seemed acceptable to assess the risk by considering the influence of brain only and disregarding the significance of other organs and tissues. No data have yet been published on the infectivity titre of bovine brain bioassayed in cattle, nor on its variation along the incubation period. Both are elements which critically influence the magnitude of the results. With more accurate data available, an update of the present simulations will be inevitable.

Rendering of SBO in Switzerland has always been carried out using batch pressure systems, and severe treatment conditions. The estimate of the infectivity reduction during the rendering process contemplated by the model (800-fold) is open to debate. A rendering process similar to that employed in Switzerland was shown to achieve an infectivity reduction of at least 80-fold (Taylor et al., 1995), so a reduction of 800-fold was considered a most-likely value. Any change of magnitude of this value will cause a variation of the final result of the same extent.

Owing to the rendering procedures employed in Switzerland, the most likely explanation for the occurrence of BSE in Switzerland remains the consumption of imported, contaminated MBM, as it has been previously postulated (Hornlimann et al., 1994). Descriptive epidemiological observations indicate that the ban on feeding animal-derived protein to ruminants was an efficient measure in restraining the spread of the disease. Nevertheless, because of a particular pathway of events, a potential contamination of Swiss cattle concentrate feeds with BSE-infectious material remained possible. As its quantitative assessment indicates, the average level of contamination per tonne of cattle concentrate feed would hardly have exceeded a critical threshold.

ACKNOWLEDGEMENTS

This study was funded by the Swiss Federal Veterinary Office and the Institute of Animal Neurology, University of Berne, Switzerland.

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