The Role of Dietary Meat and Bone Meal in the Spread of BSE

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Wilesmith *et al.*, (1988) established that there was an association between the occurrence of bovine spongiform encephalopathy (BSE) and the use of meat and bone meal (MBM) as a protein supplement in cattle-feed: there has been a significant decline in the incidence of BSE in the UK following the introduction in 1988 of a ban on feeding ruminant-derived protein to ruminants. MBM is manufactured by the rendering industry, principally from ruminant tissue discarded by abattoirs. The neurohistopathological features of BSE (Wells *et al.*, 1987), and its experimental transmissibility (e.g. Dawson *et al.*, 1990; Fraser *et al.*, 1992) demonstrated that it belongs to a group of transmissible degenerative encephalopathies (TDE) which includes scrapie in sheep, and Creutzfeldt-Jakob disease (CJD) of humans. BSE was first observed in the UK in 1985 (Wells *et al.*, 1987) but scrapie has been endemic for centuries. Consequently, the assumption has been that BSE was caused originally by the presence of scrapie agent in meat and bone meal, even though it was the re-cycling of BSE infected bovine tissues through the rendering process that fuelled the epidemic subsequently. One problem with this hypothesis is that although BSE appears to be caused by a single strain of agent, it is unlike any strain of scrapie isolated from sheep to date (Bruce *et al.*, 1994). It may be that it is a minor, relatively thermostable, strain which survives the rigours of the rendering process (Taylor 1993).

BSE first appeared in the mid 1980's but MBM had been fed to cattle over previous decades. Among a number of factors which may have created the conditions for BSE to occur was the rapidly declining use of solvent extraction by UK renderers in the late 1970's and early 1980's given that the average incubation period for BSE is around five years (Wilesmith *et al.*, 1988). Solvent extraction had been commonly used as a secondary process in rendering, to enhance yields of tallow and produce low-fat MBM which had attracted premium prices. Neither the solvents used, nor the heating regimes to remove residual solvent, are likely to have had the capacity to massively reduce infectivity titres (Taylor 1989). However, given that solvent extracted tissues would already have been subjected to a standard rendering procedure, it may be that the combined effect of the two processes had been sufficient to depress the infectivity titre in MBM such that it did nor represent an effective dose for cattle in MBM.

Although a number of studies had been carried out on heat inactivation of TDE agents, none mimicked the conditions found in rendering. Consequently, industrial pilot-scale facsimiles of rendering procedures used throughout the EU were created. Typical raw materials were spiked with either BSE infected cattle brain or scrapie infected sheep brain, and were subjected to each type of rendering process using both the minimum and average temperature/time combinations for each process. The amount of infectivity in the spiked raw materials was $10^{1.7}ID_{50}/g$ for BSE agent and $10^{3.5}ID_{50}/g$ for scrapie agent. Tallow fractions were collected, and the processed solids were milled to produce MBM. All of the MBM samples were assayed in mice for residual infectivity, together with two tallow fractions from the BSE-spiked processes and two from the scrapie-spiked processes. With the MBM produced from BSE-spiked raw materials, infectivity was detected in four samples representing two types of processes but not in either of the tallow samples, one of which came from a process that produced BSE-infected MBM. One process that produced infected MBM consisted of a 50 minute cooking procedure at atmospheric pressure, with the final temperature reaching either 112°C or 122°C. The other was conducted under vacuum, with added pre-heated fat in the form of tallow; exposure times were either 10 or 40 minutes with the final temperatures reaching 120°C and 122°C respectively (Taylor *et al.*, 1995). As a result of these findings, the standards for rendering in the EU were revised; use of the vacuum system was discontin-

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ued and the minimum time/temperature combinations for other processes were revised (Commission Decision 1994). The scrapie-spiked studies are not yet complete but they have already shown that all MBM samples are positive, except for those produced by processes that involved exposure to steam under pressure. The two tallow samples are negative to date, including one derived from a process that produced infected MBM. It is understood that the EU has now taken the decision to sanction the use of MBM for feeding non-ruminants (feeding ruminant-derived protein to ruminants was banned in the EU in 1994) only if it has been produced by a cooking procedure involving pressurized steam at 133°C for 20 minutes.

In the scrapie-spiked studies, rendered tissue was also subjected to solvent extraction with hot heptane. After draining, it was exposed to dry heat and steam to drive off residual solvent. The level of infectivity in the rendered tissue, before solvent extraction, was low. However, infectivity was still recoverable after treatment with heptane, heptane plus dry heat, and heptane plus dry heat and steam. This tends to confirm the view that solvent extraction systems probably have little inactivating effect on scrapie-like agents (Taylor 1989). However, further quantitative laboratory studies on solvent extraction systems are in progress, and these should provide a more definitive answer.

The greater number of positive MBM samples in the scrapie-spiked, compared with the BSE-spiked, experiments may well be associated with the higher input titre but differences in thermostability between the two agents cannot be ruled out. As discussed earlier, there is uncertainty regarding the origin of BSE because no strain of scrapie with BSE-like properties has been isolated from sheep as yet. If, as has been postulated, the strain of scrapie that caused BSE originally is a minor but thermostable one, it may well have been selected from the mixture of strains in the spike to survive in a relatively purified state in the infected MBM.

An alternative possibility is that the rendering process alters the phenotype of a relatively common strain of scrapie agent (to the BSE phenotype) such that it is no longer recognizable as a scrapie strain. If either of these suggested scenarios are true, the strain type of the agent surviving in the scrapie-spiked MBM would be BSE-like and would confirm an association.

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