



Heat Treatments to Control Micro-organisms in Meat Meal

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An important part of the rendering process is to destroy harmful micro-organisms and prevent them from re-entering the animal or human food chain.

For the rendering industry, these micro-organisms may be grouped as vegetative bacteria, spore-forming bacteria, moulds and viruses. Also present may be transmissible spongiform encephalopathy (TSE) infective agents. TSEs are believed to be prion proteins and not micro-organisms since they are not living organisms. TSE diseases do not occur in Australian livestock.

Vegetative Bacteria

Examples of pathogenic vegetative bacteria that may be in raw materials are *Salmonella*, *E. coli*, *Campylobacter*, *Staphylococcus*, *Yersinia*, *Streptococcus* and *Brucella*. All of these vegetative bacteria can infect animals and humans.

Vegetative bacteria are relatively sensitive to heat. Their heat susceptibility is measured as the D-value, the time required to reduce the population of a bacterium by 90% at a specified temperature. Table 1 lists D-values for some vegetative bacteria.

TABLE 1 D-values of selected pathogenic vegetative bacteria

Bacteria	D-value (minutes) at 65.5°C
<i>Brucella sp.</i>	0.1 - 0.2
<i>Mycobacterium tuberculosis</i>	0.2- 0.3
<i>Salmonella sp.</i>	0.02 - 0.25
<i>Salmonella senftenberg</i>	0.8 - 1.0
<i>Staphylococcus aureus</i>	0.2 - 2.0

Virtually all organisms within raw material is considered to be safely eliminated by using a heat process equivalent to 12 times the D-value of the organism.

For *Staphylococcus aureus* (one of the more heat resistant vegetative bacteria associated with mastitis in milking animals), a 12 times D-value process will take up to 24 minutes at 65.5°C. If the temperature of the process is increased by about 6°C, 10 times as many *Staphylococcus aureus* are killed in a given time. Thus, if the temperature is increased from 65.5°C to 95.5°C (an increase of 30°C), the time taken to kill 90% of the bacteria is 0.00002 minutes (based on D_{65.5} of two minutes).

A 12-D process at 95.5°C is 0.00024 minutes or 0.014 seconds.

It appears then, that any rendering system used in Australia is capable of destroying the most heat-resistant of the pathogenic vegetative bacteria. In question, however, is whether the centres of large particles are heated sufficiently to kill vegetative bacteria in a rendering vessel.

D-values may be greatly extended in low moisture, high fat environments. For example the D-value of *Salmonella senftenberg* in chocolate at 90°C is about 30 minutes.

Practical tests on rendering equipment operating at marginal temperatures – for example a MIRINZ low temperature rendering vessel operating at 80°C with a residence time of four minutes – have shown that inactivation of *Salmonella* in raw materials can be assured.

Pathogenic vegetative bacteria in raw material will be destroyed in the rendering systems used in Australia. If meat meal is contaminated by pathogenic vegetative organisms such as *Salmonella*, it must be due to re-contamination of the product after rendering.

Spore-forming bacteria

If conditions are too harsh for vegetative cells to survive, some bacteria may develop endospores within a vegetative cell. When and if conditions are more favourable, the endospores may outgrow as vegetative cells.

These spore-forming bacteria may be able to survive the heat treatments applied in rendering processes. If bacterial endospores survive rendering, and are present in meat meal, they are not likely to outgrow and return to the vegetative state because meat meal is too dry to support the growth of any bacteria. However, the endospores could survive for a long time in meat meal and could outgrow whenever the conditions become suitable.

Bacteria from the groups *Bacillus* and *Clostridium* are spore-formers. These groups include the pathogenic organisms *Bacillus anthracis* which causes anthrax, *Bacillus piliformis* which causes Tyzzer's disease, *Clostridium botulinum* which causes botulism, *Clostridium perfringens* which causes enterotoxaemia and *Clostridium tetani* which causes tetanus. Several other species of clostridia cause livestock disease.

Table 2 shows examples of the D-values of some pathogenic spore-forming bacteria

TABLE 2 D-values of selected pathogenic spore-forming bacteria

Bacteria	D-value (minutes) at 100°C	D-value (minutes) at 115°C
<i>Bacillus anthracis</i>	<0.8 - 1.6	
<i>Bacillus cereus</i>	5	
<i>Clostridium botulinum</i>	14 - 24	0.14 - 1.2
<i>Clostridium perfringens</i>	0.3 - 20	0.2 - 0.6

The D-values of spore-forming bacteria illustrated in Table 2 are a guide only and may be higher than indicated. Fat in rendered materials can have a protective effect on bacterial endospores and increase the D-values. D-values are also extended at low water content.

D-values are measured in a solution consisting of predominantly water or in a specific food.

Above 100°C, D-values are measured in moist conditions and under pressure. In a non-pressurised rendering vessel, temperatures above 100°C are only achieved in mixtures containing high fat and low water which will extend D-values.

While rendering systems will inactivate bacterial endospores to some extent, the thermal death rates of heat resistant endospores in mixtures of rendered materials are unpredictable.

Heat treatment applied at the centres of large particles could be much less than the apparent heat treatment measured in the liquid phase of a rendered mixture. As a result, the degree of inactivation of endospores during rendering is difficult to anticipate.

In experiments conducted to measure the degree of inactivation of endospores inoculated into raw materials, batch cooking at 100°C for 25 minutes produced a 5 log₁₀ (100,000 times) reduction in spores of *B. cereus*. This rate of reduction in numbers of endospores was achieved with a water content of 11% in the rendered material.

Other experiments on continuous dry rendering showed that *B. cereus* inoculated into rendered material at 100,000 spores/gram could be inactivated when the temperature reached 96°C.

Spores of *C. sporogenes* – a particularly heat-resistant spore – inoculated into rendered material at 1,500 - 2,100/gram were inactivated when the temperature reached 110°C - 115°C.

Spores of *B. anthracis* and *C. perfringens* are relatively heat sensitive. Practical experiments conducted on the more heat-resistant *B. cereus* demonstrate

these two pathogenic bacteria are inactivated in dry rendering systems.

Moulds

Moulds reproduce by forming spores. The spores are heat sensitive and are totally different from bacterial endospores.

Mould spores, although inactivated during rendering operations, are likely to re-contaminate meat meals after processing.

Although some moulds produce toxins poisonous to livestock and humans, these toxins are not hazardous in meat meal. Mould spores cannot grow in meat meal if the water content is less than 12%.

Prions

Prion proteins are believed to cause transmissible spongiform encephalopathy (TSE) diseases such as BSE and scrapie. Australia is free from these diseases and therefore inactivation of TSE-infective agents is not an issue for Australian renderers.

The heat conditions needed to inactivate TSE-infective agents are not clear. In the UK, meat meal is incinerated at 850°C to ensure destruction of BSE. In experiments on inactivation of BSE and scrapie, autoclaving at 134°C - 138°C for 60 minutes, did not completely inactivate the infective material in brain tissues.

Experiments have been conducted on rendering systems to test if normal rendering conditions can inactivate TSE-infective agents. Batch cooking systems, continuous dry rendering and wet rendering systems all inactivated BSE infective material.

Table 3 shows the conditions used in different rendering systems to inactivate BSE.

Subsequent experiments were conducted to test if rendering processes can inactivate scrapie. In these experiments, only batch cooking with a pressure cycle of 3-bar (200 kPa gauge) at 133°C for 20 minutes, and a particle size of 50mm, was able to inactivate scrapie. In the scrapie inactivation experiments, the dose of infective material was 100 times greater than the dose of BSE infective material used in the BSE inactivation experiments.

Deciding on appropriate heat treatments

Many objectives need to be balanced in rendering operations. These include efficient energy use, high labour and equipment productivity, ability to

TABLE 3 Rendering conditions at atmospheric pressure found to inactivate BSE

Type of rendering	Particle size (mm)	End-point temperature (°C)	Total time (minutes)
Batch cooker	150	121	150
Continuous dry (Rotadisc, Equacooker)	30	123	125
Continuous dry with added fat (Equacooker)	30	136	30
Wet rendering (wet pressing with meal dried in disc dryer)	20	101	120

process a range of raw material, product yield and product quality. Control of micro-organisms is also an important objective that renderers must satisfactorily balance with other objectives.

Batch-dry rendering, with a pressure cycle of 3-bar (absolute) at 133°C for 20 minutes, is the most effective type of rendering to inactivate pathogenic material. However, batch-dry rendering fails to meet other rendering objectives because it increases production time, causes damage to product quality, may cause loss of product through priming and introduces occupational health and safety risks.

Non-pressurised cooking may achieve an acceptable degree of microbial control. In New Zealand, authorities regard standard meal sterilising conditions as 121°C applied for 15 minutes. Pressure is not required but heat treatments must be applied with at least 15% moisture present. Equivalent sterilising conditions are allowed. For example 60 minutes at 115°C, or two minutes at 130°C are acceptable. However it is difficult to see how 130°C can be achieved in the presence of 15% water without using pressure.

New Zealand authorities have also defined approved sterilising conditions for wet rendered meals, dried in cascading rotary driers: inlet gas temperature >640°C, particle size <30x20x10mm, input moisture content of meal <57.4% and input temperature of meal >50°C.

Australian renderers use a wide range of rendering equipment and heat treatments. About half use batch cooking. From work conducted on inactivation of *Bacillus cereus*, batch cooking treatments of more than 60 minutes appear capable of achieving a 12 log₁₀ reduction of *Bacillus cereus* spores and, therefore, inactivate the less heat resistant spores of *Bacillus anthracis* and *Clostridium perfringens*.

About 40% of Australian renderers use continuous

dry rendering. The effectiveness of these systems is less certain, due to the possibility of particles travelling rapidly through the rendering vessel. The effectiveness, however, can be tested by sampling and testing product discharged from the heat treatment for *Clostridium perfringens*.

Clostridium perfringens is a common intestinal organism and is likely to be in raw materials in large numbers. If *Clostridium perfringens* is absent from processed materials, the heat treatment must be sufficient to inactivate both *Clostridium perfringens* and *Bacillus anthracis* which have similar heat resistance.

Other endospores may survive rendering processes with the possible exception of the 3-bar pressure treatment at 133°C for 20 minutes. Most highly heat-resistant bacteria are not pathogenic, except *C. botulinum* which has moderately high heat resistance and is pathogenic when its toxin is ingested. *C. botulinum* requires high moisture – at least 30% moisture in meat meal – and anaerobic conditions to grow and produce toxin. These conditions are unlikely to occur in meat meal.

Additional help and advice is available from Australian Meat Technology Pty Ltd. Phone:

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