final report

Project code: A.COP.0031

Prepared by: Peter Horchner

Symbio Alliance

Date submitted: October 2006

PUBLISHED BY
Meat & Livestock Australia Limited
Locked Bag 991
NORTH SYDNEY NSW 2059

Salmonella in meat meal

Meat & Livestock Australia acknowledges the matching funds provided by the Australian Government to support the research and development detailed in this publication.

Abstract

Salmonella testing at four rendering plants processing red meat meal was undertaken to determine possible areas of improvement. A range of practical preventive measures was developed in the form of a salmonella problem solving guide. The problem solving guide was based on outcomes of the plant testing, discussions with processors and a risk assessment derived from a literature review. The perception that some cases of human salmonellosis could be traced back to meat meal is not well founded. There appears to be no correlation between our findings, poultry serovars and human cases of salmonellosis.

Executive summary

Salmonella occurs in meat meal from time to time. It is one potential source of contamination of poultry feed and could be a source of contamination of poultry and eggs. Since Salmonella is known to be transmitted to people via poultry meat and eggs there is a perception some cases of human salmonellosis could be traced back to meat meal. Industry required information in order to address this perception.

There was also a need for renderers to have tools to help identify and eliminate potential sources of contamination of meat meal with salmonella.

Four rendering plants were chosen to participate in collection of data which would assist in identifying:

1. The extent of the problem;
2. The types of Salmonella serotypes present; and
3. Where/how/why Salmonella was present.

In addition to a literature review of salmonella in meat meal, an assessment of data from the National Enteric Pathogen Surveillance Scheme (NEPSS) was also undertaken.

Results from the plant testing showed fifteen (15) different Salmonella serotypes were identified within the project. However, there appears to be no correlation between our findings, poultry serovars and the reported human cases of salmonellosis. *S. typhimurium* continues to be the leading serovar in poultry and humans and this was not found in meat meal or environmental samples this project. The perception that human salmonellosis can be traced back to meat meal is not well founded.

General observations of the salmonella data and plants showed that unless there is heavy contamination of meal prior to the press then preventive measures are best actioned post press. In addition, a literature review and risk assessment was undertaken to determine suitable tools to reduce the potential problem. Strategies to reduce the incidence of salmonella in meat meal were developed and a “Salmonella Problem Solving Guide” developed.

Industry can benefit immediately from this project. In referring to the separate report on Salmonella Serotypes, industry can provide compelling arguments to groups who perceive that meat meal is a leading cause of human salmonellosis. To further benefit industry and demonstrate that the industry is being proactive in addressing any potential issues, renderers and meat meal operators can utilise the Salmonella Problem Solving Guide.

Contents

1 Background

Salmonella occurs in meat meal from time to time. It is one potential source of contamination of poultry feed and could be a source of contamination of poultry and eggs. Since Salmonella is known to be transmitted to people via poultry meat and eggs there is a perception some cases of human salmonellosis could be traced back to meat meal. As a result domestic specifications for meat meal include requirements for meal to be Salmonella-free and many countries require that imported meat meal is Salmonella-free.

Industry requires specific scientific information, based on historical data from several sources in order to address the perception of the risk of transmission of salmonella in meat meal to poultry, eggs and subsequently humans.

There is also a need for renderers to have tools to help identify and eliminate potential sources of contamination of meat meal with salmonella. In order to achieve this however, data would be required on the extent of the potential problem and to identify areas that can be improved.

2 Project Objectives

- To assess the extent of the risk of transmission of salmonella in meat meal to poultry, eggs and subsequently humans.
- To develop strategies to reduce the incidence of salmonella in meat meal.

3 Methodology

3.1 Methodology - Risk of transmission of salmonella

In addition to a full literature review of salmonella in meat meal, an assessment of data from the National Enteric Pathogen Surveillance Scheme (NEPSS) was undertaken. Methodology for this assessment, as well as the outcome report have been presented as a separate final report to MLA, entitled “Salmonella serotypes in meat meal - A review of available data”.

3.2 Methodology - Strategies to reduce the incidence of salmonella in meat meal

3.2.1 Project steps

One of the aims of this project was to provide renderers with tools to help identify and eliminate potential sources of contamination of meat meal with salmonella. In order to achieve this, the following steps were undertaken:

1. Sampling the environment and product for salmonella and enterobacteriaceae at four (4) rendering plants. This data was analysed to identify where problem areas exist. In total, two testing rounds were undertaken.
2. Identification of possible preventive measures that could be practically implemented

Sampling of the environment and product was undertaken in two rounds of testing. The second round of testing was initially designed to confirm if the preventive measures identified in step 2 were successful. Subsequently the preventive measures in the SPSG were to be reviewed. However, many of the preventive measures would require time for some of the plants to implement, and others were unlikely to show improvement. Therefore round 2 of testing was

conducted purely to gain more data and to provide more feedback from the processors on the SPSG and how to implement it.

The second step above was ultimately, to provide a “Salmonella Problem Solving Guide” In addition to information collected from plants, a risk assessment was undertaken to confirm these preventive measures. The literature review and risk assessment would provide the technical foundation for the guide.

3.2.2 Plant testing methodology

Detailed sampling methodology for this project is provided in Appendix 1. The sampling was based on discussions with plants and an initial literature review (Appendix 2).

Four (4) plants were selected for sampling of salmonella and enterobacteriaceae. Samples were collected by three methods:

- sponge of surfaces
- scraping of surfaces
- ‘grab’ of product.

Emphasis for collection was on ‘process’ sampling via sponge and scraping. Only two environmental nonproduct contact surfaces were sampled. It was considered that this method of contamination was of less importance than direct process contamination. Samples were collected where possible, depending on safety and accessibility, from the cooker outlet to loadout. This was to obtain an overall picture of processes where contamination could occur.

A total of two hundred and eighty (280) samples were collected at four plants during March and June 2006. The total samples consisted of:

- sponge 163
- scraping 69
- product 48.

Two (2) sponge samples were collected from environmental nonproduct contact surfaces (hand rails). The remaining 278 samples were from product and nonproduct contact surfaces along the production chain. Examples of product contact surfaces were surfaces of screws and chutes where product continually contacts the meat meal. Examples of nonproduct contact surfaces were covers over screws where product normally does not come into direct contact with the product but may occasionally come in contact or where cake or dust may break off and drop directly into the meat meal.

The sponge samples consisted mainly of surface material but could include softer underlying cake or dust which broke off. The 69 scraping samples were collected from product and nonproduct surfaces as for sponges. The 48 product samples were collected along the process chain. These included samples from the first production run in the morning.

3.2.2.1 Microbiological testing

All samples were tested for salmonella and enterobacteriaceae at a NATA accredited laboratory. Positive salmonella samples were serotyped at a reference laboratory.

The sponge samples were recorded as positive or negative for salmonella in 300 cm^2. The scaping and product samples were recorded as positive or negative in 50 g of product, or in 25 g if insufficient material was available.

The enterobacteriaceae were recoded as numbers per cm^2 for sponges and per g for scrapings and product.

3.2.2.2 Data analysis

The number for enterobacteriaceae were taken as equivalent for cm^2 and g.

4 Results and Discussion

4.1 Results and Discussion - Risk of transmission of salmonella

Results and discussions have been presented in a separate report to MLA.

4.2 Results and Discussion - Strategies to reduce the incidence of salmonella in meat meal

The two (2) handrail samples have been excluded from the following results. One was salmonella positive, the other negative.

The results for the 2 rounds of collection are shown in Table 1.

Table 1 Percentage salmonella positive

	Sponge (%)	Scraping (%)	Product (%)	Total (%)
Round 1	23.8	32.4	16.7	24.6
Round 2	13.0	22.9	20.8	16.9
Total (%)	18.6	26.1	18.8	20.5

The Salmonella problem solving guide was discussed with the four plants before the second round of collection. No plant made any alterations before the second collection.

General observations of the salmonella data showed the following (note that sample sizes were small and there was no significance to these results).

- Sponge and scraping contamination rate of equipment pre and post press or dryer are similar
- The first product produced for the day may be heavily contaminated (again not significant)
- Salmonella contamination occurs along the process chain with possibly less towards the end of the chain

Enterobacteriaceae results for both rounds of testing are shown in Table 2.

Table 2 Enterobacteriaceae (log_{10}) results

	Sponge (%)	Scraping (%)	Product (%)	Total (%)
Round 1	1.06	1.41	0.96	1.13
Round 2	0.69	1.28	1.33	0.96
Total (%)	0.89	1.34	1.14	1.04

Table 3 shows the salmonella and enterobacteriaceae results for the four plants. The correlation between salmonella and enterobacteriaceae was high at 0.84. The mean log_{10} enterobacteriaceae value for the 39 salmonella negative product samples was 1.05 while the 9 positive samples was 1.56 ($p = 0.08$ one-tail).

Table 3 Comparison of salmonella and enterobacteriaceae results at the 4 plants

Plant	Salmonella (%)	Enterobacteriaceae (log)
A	20.0	1.31
B	41.7	1.34
C	9.2	0.77
D	9.9	0.74

A review of other salmonella and enterobacteriaceae correlations in the literature were summarised to determine whether enterobacteriaceae could be a useful indicator, as results from this current study seemed inconclusive:

- Van Schothorst (1986), in analysing studies in the Netherlands, reported that measures taken to reduce the number of enterobacteriaceae in the line environment of rendering plants were also very effective in reducing and finally eliminating the salmonella from this environment and consequently the end product. Monitoring critical control points (CCP) in the line and the environment with an enterobacteriaceae test can be an efficient tool in salmonella prevention through good hygiene practices (GHP).

- Michanie et al (1989) found a correlation of 0.81 between salmonella and enterobacteriaceae in meat and bone meal. They concluded that enterobacteriaceae counts were not good indicators of the presence of salmonella in meat and bone meal, however, they could be used to assess hygienic quality.

- Veldman et al (1995) surveyed the incidence of salmonella and enterobacteriaceae in poultry feeds. The enterobacteriaceae isolated were shown to be useful markers of the rate of contamination with salmonella and the efficiency of decontamination of the feedstuffs by pelletisation.

- Reusse et al (1976) assayed the enterobacteriaceae contents of fish meal as a criterion for the absence of salmonella. Neither enterobacteriaceae nor salmonella statistically showed uniform distribution in fish meal. Consequently, assaying for enterobacteriaceae is not suitable to draw any reliable conclusions upon the salmonella contents of fish meal.

This project shows that enterobacteriaceae may be useful as a process control indicator for salmonella. However, a dedicated trial comparing salmonella, enterobacteriaceae and aerobic plate count is suggested before any recommendation can be made.

Product and equipment temperature readings using an infra red ray gun were taken along the process chain to determine whether salmonella could survive part of the process. The following are examples of temperatures recorded at each plant:

- out of press, 101^{o}C, 101^{o}C, 100^{o}C, (125^{o}C out of dryer)
- product along first screw from press/dryer, 85^{o}C, 82^{o}C, 82^{o}C, 75^{o}C
- product into silo, 47^{o}C, 53^{o}C, 56^{o}C, 58^{o}C.

The potential for pre press salmonella contamination carrying over to the final product is negligible as the mechanical action of the press causes the product to be heated to >90^{o}C and coupled with a moist atmosphere undoubtedly destroys most salmonella. Unless there is heavy contamination of meal prior to the press then preventive measures are best actioned post press.

Colonies (1–3) from 50 of 57 salmonella positive samples were forwarded to a reference laboratory for serotyping. The completed samples are divided into pre and post press or dryer. All pre press or dryer serotypes were found post press or dryer at the relevant plant except for one subspecies. The most common serotypes were *S.* Cerro , *S.* Ohio, *S.* Amsterdam and *S.* Havana. A matrix of serotypes is presented in Table 4.

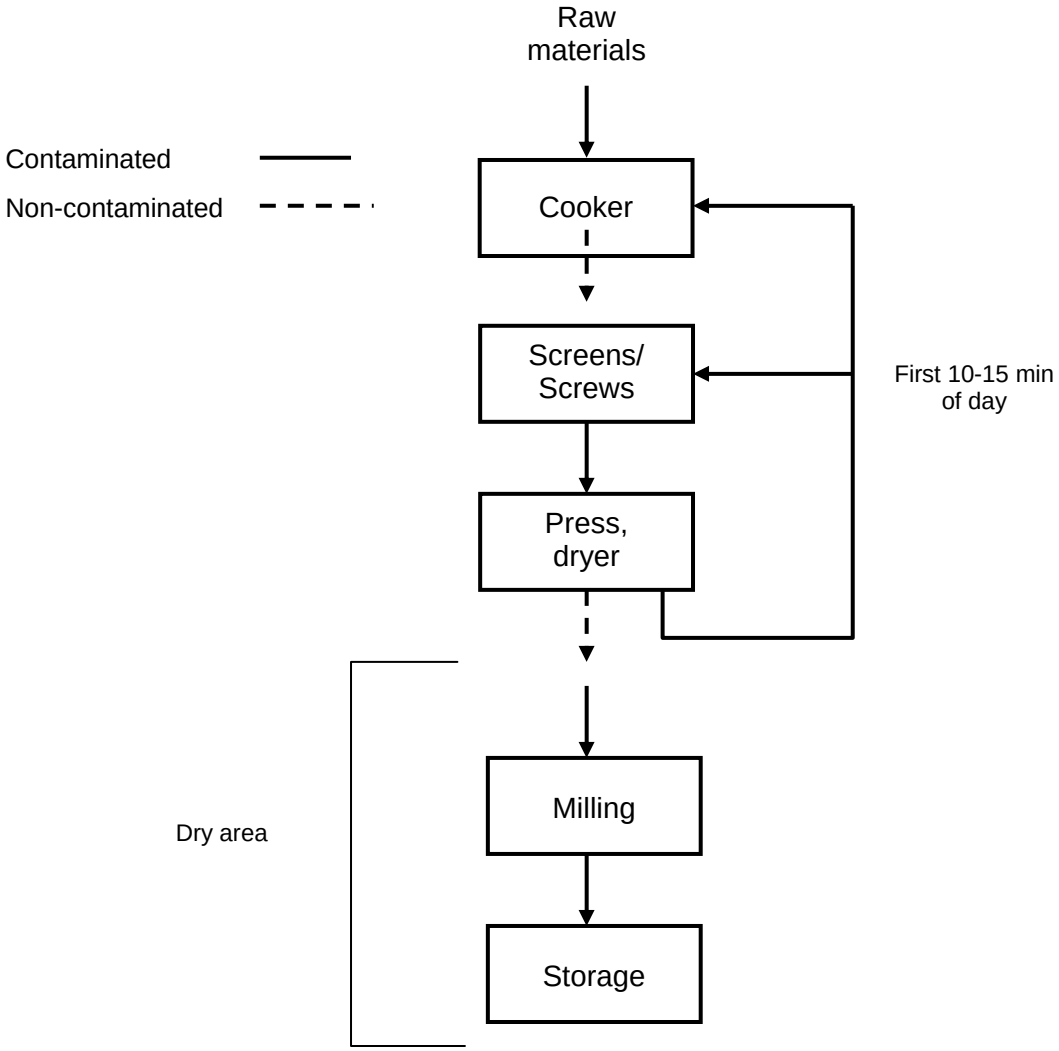
Table 4: Distribution of salmonella serovars, pre and post press or dryer

Samples	S. Agona	S. Amsterdam	S. Anatum	S. Bredeney	S. Cerro	S. Havana	S. Johannesburg	S. Kentucky	S. Mbandaka	S. Ohio	S. Tennessee	S. Westhampton	S. Zanzibar	S. subsp4,12:d:-	S. subsp. I (16:1,v:-)
Pre															1
Pre			2												
Pre										1					
Pre		1													
Pre										3					
Pre	3														
Pre					1										
Pre							3								
Post					1								1		
Post											1		2		
Post													3		
Post					1										
Post					3										
Post				1	2										
Post													3		
Post					2										
Post		1			2										
Post										2				1	
Post										2					
Post		1						1	1						
Post									3						
Post			3												
Post												1			
Post										2					
Post									1	1					
Post									2						
Post													1		
Post										3					
Post											1				
Post										1				1	
Post		3													
Post								3							
Post									3						
Post		1													
Post		3													
Post								1							
Post					3										
Post					2										
Post		3													
Post									1	2					
Post					2										
Post							2								
Post	1				1										
Post						2									
Post						3									
Post						2									

Post			3												
Post						3									
Post			3												
Post						3									
Sum	4	13	11	1	20	13	5	5	11	17	2	1	10	2	1

A flow diagram summarising the salmonella free and contaminated areas along the chain is presented in Figure 1.

Figure 1: Overview of salmonella contamination



There appears to be no correlation between our findings, poultry serovars and then human cases of salmonellosis. *S. typhimurium* continues to be the leading serovar in poultry and humans and this was not found in the feed from this project.

4.3 Salmonella Problem Solving Guide (SPSG)

The SPSG has been developed and delivered to MLA as a separate document, submitted with the milestone report. The guide focuses on preventive measures. In addition to information from plants, a risk assessment was undertaken to confirm these preventive measures. The full risk assessment is provided in Appendix 3.

5 Success in Achieving Objectives

Plant data has been collected in order to determine Salmonella serotypes present in feed, as well as determining the best methods of reducing the presence of Salmonella.

A scientifically based “Salmonella problem solving guide” was prepared for renderers as a tool to reduce the presence of Salmonella. This has been tested and reviewed by all plants involved.

6 Impact on Meat and Livestock Industry – now & in five years time

The results of this project will greatly assist the feed industry in defending the perception that meat meal is a major contributor to the transmission of Salmonellosis to animals and humans.

It is anticipated that he adoption of the Salmonella Problem Solving Guide through the rendering industry will greatly reduce the risk of Salmonella in meat meal. Nonetheless, the industry must be vigilant in monitoring for the presence of Salmonella as well as its serotypes in order to reduce any future risk of transmission.

7 Conclusions and Recommendations

1. This project has assessed the extent of the risk of transmission of salmonella in meat meal to poultry, eggs and subsequently humans. While fifteen (15) different Salmonella serotypes were identified within the project, there appears to be no correlation between our findings, poultry serovars and then human cases of salmonellosis. *S. typhimurium* continues to be the leading serovar in poultry and humans and this was not found in the feed from this project.

2. General observations of the salmonella data showed that:
    - Sponge and scraping contamination rate of equipment pre and post press or dryer are similar
    - The first product produced for the day may be heavily contaminated
    - Salmonella contamination occurs along the process chain with possibly less towards the end of the chain
    - Unless there is heavy contamination of meal prior to the press then preventive measures are best actioned post press.

3. Enterobacteriaceae may be useful as a process control indicator for salmonella.

4. Strategies to reduce the incidence of salmonella in meat meal were developed. The resultant Salmonella Problem Solving Guide provides scientifically and industry tested tools to assist renderers.

8 Appendices

8.1 Appendix 1 Sampling Methodology

Objective

The overall plan is to obtain objective evidence, for example, sampling of the environment and product to assist in problem solving and implementation of preventive measures.

The emphasis shall be on the process, for example, sampling of product contact surfaces and nonproduct contact surfaces where contamination of the product may occur along the chain.

Each plant will be appraised first up by discussion with management, visual inspection of potential problem areas and suitable areas to sample.

The sampling areas at each plant shall be flexible depending on the operation, potential risk of contamination, suitability of collection points and safety.

Overall sampling plan

Round	Plants	Product samples	Environment samples	Total samples
1	4	6	30	144
2	4	6	30	144
				288

Each sample shall be tested for salmonella and enterobacteriaceae.

Plants

Four plants shall participate in the project. All plants process in-house beef byproducts only.

Product sampling

Product samples shall be collected from each of the 3 sites below within each plant:

1 Earlier process station
2 Storage bin
3 Bag or bulk final product.

The product samples shall be collected at the following times:

1 T_0 First up before processing commences
2 T_1 T_0 plus 2–4 h.

The sampling of product at site 1 at T_1 above shall only be carried out if safety issues are addressed. For example: the equipment is stopped or product can be collected at inspection holes.

Environmental sampling

The environmental sites are divided into 2 groups:

1 Product contact surfaces
2 Nonproduct contact surfaces.

Thirty (30) environmental samples shall be collected at each plant. Examples are shown below but are not limited to these sites. Areas of particular importance may include poor hygienic design of equipment, condensation contamination and cross contamination of raw and cooked product.

1 Product contact surfaces
1 Percolator (where relevant)
2 Surge bin (where relevant)
3 Screw or press
4 Mill
5 Screen
6 Storage bin

2 Nonproduct contact surfaces
1 Inside moisture exhaust ducting
2 Handrails at end-product area

The environment samples shall be collected first up ie before processing commences but may also be collected 2–4 h after operations commence depending on the process and safety.

Product sampling methodology

An approximate 200 g grab sample shall be collected by inverting a Stomacher bag, taking the sample, re-inverting, tie with a rubber band then stored at <5^{o}C until delivery to the laboratory within 24 h.

Environment sampling methodology

Surfaces shall be sampled by the sponge method or by collecting scrapings.

For the sponge method, a media moistened sponge shall be rubbed 10 times in one direction then 10 times at right angles on an area of approximately 30 cm x 10 cm (300 cm^{2}). The sponge bag shall be stored at <5^{o}C until delivery to the laboratory within 24 h. Where sample sites are smaller than 300 cm^{2}, the approximate area will be recorded on the sample collection sheet.

For the scrapings method, meat meal (200 g) adhering to the surface shall be removed by a paint scraper into a Stomacher bag. The scraper shall be sterilised between samples by heating with a bunsen burner (or equivalent heat), using fire safety precautions.

The environmental samples shall only be collected if all safety issues are addressed.

Consumables:
- Approximately 70 x Stomacher bags
- Approximately 220 x bioMerieux sponges (MDK-MS, 130 x 70 x 25 mm, 20/box)
- Oxoid Maximum Recovery Media

Temperature recordings

An infra red gun shall be used to record temperatures of product and environment at each collection point.

Laboratory testing

Symbio Alliance will undertake the salmonella and enterobacteriaceae testing. The method shall be the Australian Standard for Salmonella. A 50 g subsample will be taken from the original 200 g sample.

Three colonies from each positive sample shall be isolated for serotyping at the Queensland Health Scientific Services.

Recording

Sampling and laboratory data shall be recorded on standard forms.

Data analysis

Data shall be analysed by standard statistical methods.

Sampling form

Plant …….. Date ……. Sampler …….. Page ……..

No.*	Area**	Description of site

* Number plus type of sample eg 21SP (SP = sponge, SC = scraping, PR = product)
** Area number according to plan

8.2 Appendix 2 Literature review – salmonella in meat meal

Contents

Introduction

Since the early 1950s it has been recognised that rendered animal by-products both in Australia and overseas are commonly contaminated with salmonellas (Boland 1979). The use of such contaminated products as ingredients of rations fed to meat producing animals is obviously undesirable. As well as the risk of clinical salmonellosis occurring in animals, with possible mortality or loss of production, there is the potential for infection of humans by the meat from these animals (Williams 1975).

It is well established that the time/temperature processing conditions of dry rendering and drying after wet rendering are sufficient to kill all salmonella (CSIRO 1990). It is generally believed that the product is recontaminated after cooking, due to unsanitary conditions in the processing area and/or due to recontamination with salmonellas originating from the raw materials (Report 1969).

The common assumption is that salmonella occurring in food animals are those found in animal feeds and that the animal serovars are then passed into the human food chain, causing disease to humans. While this holds for some serovars/strains there are a number of inconsistencies (Murray 1994).

Lee (1974) reported that more than 70% of successfully investigated case of human salmonellosis from 1966 to 1970 were associated with poultry products and pig meat and it was suggested that the salmonellas found in man have a pathway of infection from animal feedstuffs to the poultry and pig animal reservoirs, and through pig and poultry products to man.

Many surveys have been conducted to determine the prevalence of salmonellas in meat meals, bone meals and meat-and-bone meals within the past decade, however, although great variations in results was reported, it appears that 20% of meat meal samples contaminated with salmonellas represents a realistic average under good manufacturing practices (Bensink 1979). A survey by Australian Renderers' Association (ARA) of accredited rendering plants in 2004 showed 7.5% contaminated meat meal compared with 31% in 1991.

A wide range of salmonella serotypes occurs in meat and bone meals and this fact does not support the hypothesis that contamination is derived directly from raw material because some of the serotypes are rarely recovered from livestock species which are the source of this raw material (Timoney 1968).

Rendering systems

There are an estimated 110 rendering plants operating 122 different rendering systems. A survey of 114 Australian renderers in 1996 obtained the following information on principal rendering systems used in Australia (Guide 2003) – Table 1.

Table 1: Australian renderers

Type of rendering	Number of plants
Batch dry rendering	60
Continuous dry rendering	43
Wet rendering	19

Most of the 60 plants using batch dry rendering are small and most do not export but there are several larger plants that can supply pressure cooked meal if required by customers. Most rendering plants use nonpressure systems unless they are manufacturing a product for a market which specifically requires a pressure cycle (eg EU). Investigations of continuous dry rendering

systems without pressure treatment have shown that spore forming bacteria can be inactivated without pressure treatment at end point temperatures of 100–115^{o}C.

Regulations

There are no commonwealth or state regulations on the production of meat meal apart from local government environmental requirements. Certain importing countries have requirements for the production of meat meal. In order to export the renderer must be registered with AQIS to export.

The Australian Renderers Association Inc produced a Code of Practice for Hygienic Rendering of Animal Products. AQIS requires registered export rendering plants to follow this Code.

There is an Australian Standard for Hygienic Rendering of Animal Products (AS 5008:2001).

Previous trials

Trials were conducted at 2 batch-dry-rendering plants (Boland 1979). The results are shown in Table 2.

Table 2: Rate of contamination of samples

Sample description	Plant A % pos.	Plant B % pos.
Freshly cooked product in percolator or surge bin	0	0
(Scraping from percolator and surge bin)	(53)	(67)
Product at exit from surge bin	12.5	15
Product at press and mill	36	40
Stored product	61	69

It is evident from these results that there was heavy contamination of material which had been adhering to the surfaces of percolators and surge bins overnight. This appears to have been responsible for the contamination of samples taken at the exit from the surge bin (Boland 1979). Possible occasional contamination of surfaces from flies, worker's boots or implements then multiplication (Boland 1979).

Bensink (1979) collected 20 production line and environmental samples from each of 8 export renders. In addition, 20 meat and bone samples were collected immediately prior to bagging from each renderer. 71.2% (range 33–90%) of production line and environmental samples were contaminated with salmonellas while 69.5% (range 20–100%) of end product was contaminated. Of the production line and environmental samples, 53.8% of inline samples were positive and 83.1% of environmental samples were positive. There was a marked difference in results between the 8 renderers. A visual assessment of each plant did not explain these differences, however, one plant with the lowest positives for inline, end product and environment did not recycle any product which fell on the floor during processing. The most frequent isolated salmonella serotypes from meat and bone meal were: *S.* Havana, *S.* Eimsbuettel, *S.* Ohio and *S.* Singapore.

Hess et al (1970) found that cleaning the environment did not reduce salmonella contamination in the finished product. However, cleaning of the processing line followed by fumigation with formaldehyde did result in a significant reduction in the prevalence of salmonellas.

Bensink and Boland (1979) conducted trials on 2 batch dry-rendering systems. Plant A was crowded, difficult to keep clean, poor hygiene and no physical separation between raw and

cooked product. Plant B was spacious, good hygiene and completely separated. The results are shown in Table 3 and 4 and Figure 2.

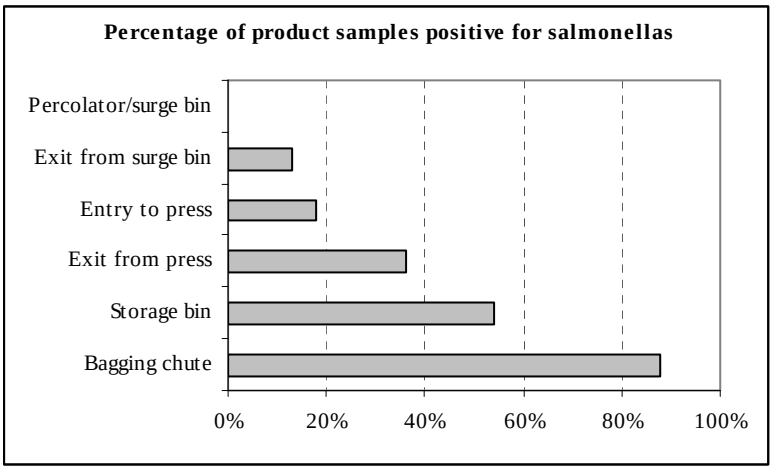
Table 3: Product results

	Plant A		Plant B		Total	
Site	***Positive***	***%***	***Positive***	***%***	***Positive***	***%***
Percolator	0/28	0	0/5	0	0/33	0
Surge bin	0/7	0	0/6	0	0/13	0
Exit from surge bin	7/56	13	3/20	15	10/76	13
Entry to press	3/12	25	1/10	10	4/22	18
Exit from press	13/33	39	6/20	30	19/53	36
Entry to mill			5/6	83		
Exit from mill			5/5	100		
Storage bin	4/10	40	9/14	64	13/24	54
Bagging chute	13/18	72	22/22	100	35/40	88

Table 4: Scrapings results

	Plant A		Plant B		Total	
Site	***Positive***	***%***	***Positive***	***%***	***Positive***	***%***
Percolator	8/14	57	5/10	50	13/24	54
Surge bin	10/20	50	8/11	73	18/31	58
Exit from surge bin			7/9	78		

Figure 2:



The cooked product became contaminated immediately after leaving the surge bin and the rate of contamination increased as the product moved along the processing line. In Plants A and B 53% and 67% respectively of the scraping material left overnight in the percolator and surge bin was found to be contaminated with salmonellas. The contamination rates were very similar between Plants A and B despite the differences in the construction, hygiene and processing procedures.

Bensink and Boland (1979) raised the possibly of some uncooked product getting through and contaminating the line.

Lack of correlation between good and bad plants and salmonella – ie separation and hygiene may have little effect unless combined with other measures (Bensink and Boland 1979). The

good plant was cleaned thoroughly after sampling commenced without any apparent reduction in salmonella.

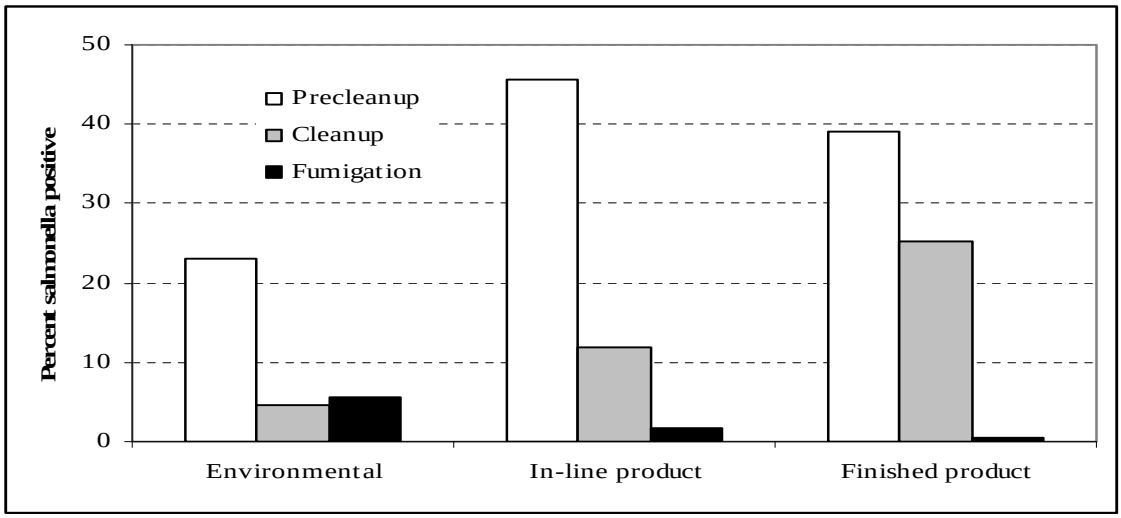
The most frequently isolated serotypes were: *S. A*natum, *S.* Havana, *S.* Eimsbuettel and *S.* Derby (Bensink and Boland 1979).

Hess et al (1970) conducted a trail on decontaminating a rendering plant that had been salmonella 'free' and then became 'positive'. The salmonella results before and after interventions are shown in Table 5 and Figure 3.

Table 5: Salmonella intervention results

Period	Environmental samples - % positive	In-line product samples - % positive	Finished product samples - % positive
Precleanup	23.0	45.7	39.0
After cleanup	4.5	11.9	25.2
After fumigation	5.5	1.8	0.6

Figure 3: Salmonella intervention results



Test data showed the product was being contaminated from the equipment and environment immediately after the cooker. Hygienic cleaning and operating procedures were implemented in this area. The fumigation was with formaldehyde gas and formalin spray. These chemicals are banned from use today.

Timoney (1968) surveyed 5 rendering plants to determine the routes of contamination of meat and bone meal by salmonellae. At 3 plants the results strongly suggest that the most important source was contaminated percolators and not direct contamination by raw products, dust etc. Whilst it is certain that no salmonella survived the cooking process, the presence of so many salmonella in the percolators indicates contamination of this environment by indirect means, probably from nonsterilised raw material. Following contamination, the surfaces and contents of the percolators would prove an ideal growth environment for salmonella – moisture, warmth and nutrient being readily available. The more varied assortment of serotypes at this point suggest a long history of repeated contamination at different times, since the range of serotypes in the raw material is less varied. The salmonella in the raw material probably vary from time to time depending on the character and sources of the livestock slaughtered. In one plant using solvent

extraction and an enclosed process line without percolators yielded 6 out of 8 positive salmonella samples in the raw material but all 27 end product samples were negative.

Morris et al (1970) studied salmonella in 4 fish meal rendering plants. Table 6 shows salmonella isolated from samples collected at 5 min intervals from the beginning of processing. Control procedures initiated after June consisted of reprocessing all the meal from the first 45 min of production. This was also shown in samples collected from the respective months in the warehouse where the incidence dropped from about 20% positive to 0%.

Table 6: Salmonella in fish rendering plants

Time (min)	May	June	July	August
0	+	+	–	–
5	+	+	–	–
10	+	+	–	–
15	+	+	–	–
20	+	–	–	–
25	+	–	–	–
30	+	–	–	–
35	+	+	–	–
40	–	–	–	–
45	–	–	–	–
50	–	+	–	–
55	NT	–	–	–

The moisture level of meat meal between 4% and 10% provides too little moisture to support microbial growth. Salmonella found within meat and bone meal is not stable and research shows that samples positive for salmonella declined by 2% per week from the time of manufacture (Guide 2003)

Loken (1968) tested 1395 product samples and 1901 environmental samples from 7 rendering plants. Salmonella were isolated from 17% bulk samples and 19% environmental samples. The calculated correlation between the frequency of isolation of 34 different salmonella serotypes was highly correlated between products and environmental samples (r = 0.89), but not correlated between environmental and flies (0.13) and product and flies (0.08). The most common serotypes were *S.* Bredeney, *S.* Cerro, *S.* Binza and *S.* Senftenberg.

Tompkin and Kueper (1973) found a linear relationship between the detection of salmonella and total plate count from 10^4 through 10^7 per gram. This is of practical value for in-pant control purposes and evaluating improvement. However, it is important to realise the limitations of the total plate count and that it be used to supplement salmonella testing.

A CSIRO survey (1991) of 6 renderers taking 5 samples of final product at 2 h intervals found a slight increase in salmonella contamination over the day. At some plants the incidence was sporadic while others were constant with positives at each of 12 sampling times. There was no relationship between TAC, spore formers, enterobacteriaceae and salmonella counts. After salmonella samples were stored at 2-5^{o}C for 6 mth there was only a 25% decrease in positives.

Relationship between salmonella and enterobacteriaceae

The family enterobacteriaceae is a large biochemically and genetically related group of bacteria. Members of the family are Gram-negative non-sporeforming bacilli which grow in the presence or

absence of oxygen. The family includes many bacteria that are found in the human or animal intestines as commensals or pathogens, including coliforms, salmonella, shigella, proteus and yersinia

van Schothorst (1986) reported that studies in the Netherlands have shown that all measures taken to reduce the number of enterobacteriaceae in the line environment of rendering plants were also very effective in reducing and finally eliminating the salmonella from this environment and consequently the end product. Monitoring critical control points (CCP) in the line and the environment with an enterobacteriaceae test can be an efficient tool in salmonella prevention through good hygiene practices (GHP).

Michanie et al (1989) found a correlation of 0.81 between salmonella and enterobacteriaceae in meat and bone meal. They concluded that enterobacteriaceae counts are not good indicators of the presence of salmonella in meat and bone meal, however, they could be used to assess their hygienic quality.

Veldman et al (1995) surveyed the incidence of salmonella and enterobacteriaceae in poultry feeds. The enterobacteriaceae isolated were predominately thermotrophic. They were shown to be useful markers of the rate of contamination with salmonella and the efficiency of decontamination of the feedstuffs by pelletisation.

Reusse et al (1976) assayed the enterobacteriaceae contents of fish meal as a criterion for the absence of salmonella. Neither enterobacteriaceae nor salmonella statistically showed uniform distribution in fish meal. Consequently, assaying for enterobacteriaceae is not suitable to draw any reliable conclusions upon the salmonella contents of fish meal.

Interpretation of data

Kilsby and Pugh (1982) showed the importance of understanding the microbial composition of food during processing and how these arise. Provided no further cross contamination occurs after the percolator and surge bin then as meat meal is comminuted and mixed along the line then the variance decreases and the prevalence increases. Possibly this is this what happened with the data reported by Bensink and Boland (1979) whereby there was a continuous increase in salmonella loading along the line or simply the meal was further contaminated along the line. This is exasperated by presence/absence tests especially if the level of contamination is low. An understanding of these changes is essential in identifying critical control points along the process chain.

Sources of contamination

The following are examples of sources of contamination as reported in the literature:

- Cooked material adhering to the surfaces of percolators and surge bins left overnight was found to be a significant early source of contamination (Bensink and Boland 1979)
- Timoney (1968) suggested that multiplication of salmonellas occurred on percolator surfaces and that the whole production was seeded with salmonellas from this source (Timoney 1968)
- Hess et al (1970) found that contamination of the product occurred before it reached the surge bin
- Earlier work (unpublished data) indicated that considerable leakage of raw material on to cooked material can occur due to faulty seals in the cooker (Bensink and Boland 1979)
- Batch dry rendering systems suffer from the disadvantage that because of the nonuniformity of the raw material a standard cooking cycle with a controlled end point may on occasion result in an under cooked product and it is possible that not all salmonellas are destroyed in these batches (Bensink and Boland 1979)

- Once salmonellas are introduced in the processing line there is a possibility that multiplication of these organisms occurs if sufficient moisture accumulates in any of these areas (Hansen et al 1962)
- Bensink and Boland (1979) found that in a plant (B) with good sanitation etc but a high contamination rate that a thorough cleaning with detergent-sanitiser followed by a hot water rinse (80^{o}C) after the sampling program commenced without any apparent reduction in the incidence of salmonella contamination
- Bensink and Boland (1979) air samples did not yield salmonellas and it seems that the airborne route is not a significant source of contamination
- Clise and Swecker (1965) reported similar findings and concluded that airborne contamination could not be a major contributing factor
- Bensink and Boland (1979) found 11/12 (92%) of insects contaminated with salmonellas but the significance of insects as a potential source contamination was difficult to assess
- Loken et al (1968) found infected flies near rendering plants but it was impossible to determine whether or not the flies contributed to the contamination or were victims
- Arnold (2002) in a survey of plants found rodents and the surge bin to be problems.
- CSIRO (1991) survey found the main method of recontamination was from build up of material in locations which have the conditions necessary for bacterial growth. Problems can arise at start-up and breakdowns with not enough heat to kill salmonella. Other problem areas include: screw conveyors or bucket elevators, moisture condensing on underside of covers and fully enclosed bins which are not ventilated.

Methods of producing clean meat meal

The following are methods of producing clean meat meal as reported in the literature:

- Hess et al (1970) found that cleaning the environment did not reduce salmonella contamination in the finished product
- Hess et al (1970) found that cleaning of the processing line followed by fumigation with formaldehyde did result in a significant reduction in the prevalence of salmonellas.
- Bensink and Boland (1979) found no correlation between generally accepted good and bad construction, hygiene and procedures
- Moyle (1966) found no correlation between plant sanitation and the incidence of salmonella
- Timoney (1968) found more salmonella in the cleaner plants (46/106 cf 7/83).
- Moyle (1966) suggested that factors such as separation of raw material and cooked product and plant sanitation may have little effect on the rate of contamination, unless combined with other control measures
- Moyle (1966) postulated that the presence of unsaturated fatty acids from putrefying material in unhygienic plants limits the multiplication of salmonella
- Moyle (1966) suggested frequent cleaning and sanitising of the percolator is critical to the prevention of salmonella. Also included was a better designed percolator to prevent contamination from the environment or if this is not possible then physical separation of the percolator area from the raw materials area.

Preventive measures

The following are preventive measures as outlined by CSIRO (1990):

Equipment

- percolators, presses, mills, storage hoppers, conveyors
- screws and bins covered but ventilated to prevent condensation
- meal cooled to prevent micro growth in warm meal
- spillage, leakage etc prevented
- lines passing through uncooked areas sealed
- aerosols from blow lines receival bins, gut washing screens, effluent screens

- thorough cleaning
- dry areas kept dry
- scrape dry areas, no water
- equipment marked
- separate raw/cooked

Vermin
- program

Personnel
- wash hands, boots
- change clothing if possible
- separate facilities
- signs

Dust and moisture
- positive pressure
- vacuum cleaner
- meal cooled before storage
- condensation avoided
- vented bins
- solid plate walkways

Storage
- clean and dry
- bag straight after cooled

Bags
Use new or sterilised bags

Presses
If the material left in the barrel overnight is moistened, either by condensation or washwater, and contaminated with salmonella, the bacteria will multiply rapidly. To prevent contamination of product when starting production the next day, collect and later recook or repress all the material coming through the presses until full operating temperature is reached which will take about 20 minutes.

Centrifuges
No problems

Conveying system
The build-up of meal in screw conveyors and bucket elevators is the most likely source of recontamination. Dead ends in conveyors should be eliminated. The risk is greatest immediately beyond the presses when steam from the hot meal condensates on conveyor casings or collects in elevator buckets. Preventive measures include:
- conveyors are inspected regularly and are scraped clean of accumulated material, which should be rerendered
- conveyors are protected with secure overlapping covers to prevent entry of washwater
- extraction fans and ducts are installed over conveyors
- water is not used for cleaning dry material conveyors.

Salmonella relationship between animals, feedstuffs and humans

Murray (1994) compared the most common serovars and phage types from humans with the frequency from animal feeds, food animals and red meats during the period 1987–1992. Correlations between serovars of humans and animals and red meats were calculated as follows:

Humans vs cattle	0.99
Humans vs sheep	0.86
Humans vs pigs	0.65
Humans vs chickens*	0.96
Humans vs red meats	0.13

* live meat chickens and includes some chicken meat

Correlations between phage types of humans and animals and red meats were calculated as follows:

Humans vs cattle	0.90
Humans vs sheep	0.81
Humans vs pigs	-0.05
Humans vs chickens*	0.24
Humans vs red meats	0.53

Calculated correlations were very low between serovars in animal feeds and humans, animals and red meats.

The results show that certain serovars and phage types appear to be better adapted to one group of animals than another and not necessarily have the same capability to spread to humans (Murray 1994).

Calculated correlations between salmonella serovars affecting humans (n = 1616) and serovars found in meat and meat products (n = 237) was 0.36 and the correlation between humans and total foods (n = 291) was 0.34 (NEPSS 2000).

It is important in any correlation analysis to understand that correlation analysis measures and assesses the degree of association between variables. It must be stressed that a high correlation does not necessarily imply a causal relationship. For example, a 0.99 correlation between cattle serovars and human serovars does not mean the majority of human serovars are derived from cattle serovars. It may mean that cattle and humans are susceptible to the same serovars.

Sampling programs

The Code of Practice for Hygienic Rendering of Animal Products requires 1 sample per week forwarded to an accredited laboratory for testing for the presence of salmonella in 25 g. The weekly sample comprises daily subsamples. The level of contamination is unsatisfactory if more than 3 of the latest window of 10 samples are positive for salmonella. Corrective action is taken together with daily salmonella sampling. This regime is continued until no more than 3 samples are positive in a window of 10 samples.

The operational curve (Appendix C) shows that if the contamination rate is 18% then there is a 90% probability of not invoking corrective action and daily salmonella sampling. Similarly if the contamination rate is 36% then there is a 50% probability of not taking action. The chart also shows tightened sampling plans. For example, if there are 10 samples and only 1 is allowed before corrective action then at the 90% probability this action is reached at about 6% contamination.

The Australian Standard for Hygienic Rendering of Animal Products, AS 5008:2001, (2001) require validation of the heat treatment by testing for the absence of *Clostridium perfringens* spores in rendered product immediately on completion of the heat process. It takes approximately 6 min at 110^{o}C to obtain a 6D reduction in *C. perfringens* spores.

Bulk samples

In-line and end product samples have been collected in various research projects. Approximately 50–100 g of sample is collected while 25 g is used for testing. In some instances samples may be pooled.

Scraping of product remaining on equipment has also been sampled.

Swab samples

Swabs of construction and equipment contact surfaces and the surface of product remaining on equipment have been collected.

Morris et al (1970) used cotton tipped swabs for sampling equipment and bulk fish product at various stages of processing in a fish rendering plant. Swab samples were put directly into 10 mL of tetrathionate broth containing 1:100 000 dilution of Brilliant Green. The cultures were kept at room temperature until taken to the laboratory.

Loken et al (1968) used swabs for environmental samples. These were cultured in SBG Sulfa Enrichment broth. They also used dry cotton swabs where there was inadequate material for bulk sampling.

Environmental samples

Material (eg spilt meat meal, dust) and swab samples of the environment are taken. Air samples are collected on exposed agar plates while whole insects are tested.

Resistance of salmonella to heat

Salmonella is normally easily killed by moist heat. Cooking of edible food routinely requires a 6 $\log_{10}$ reduction (6D) in salmonella. For example cooking at 70^{o}C for 10 s equates to 6D reduction. During rendering a final temperature of 110^{o}C for 1 s equates to 10mD.

Kirby and Davies (1990) found an increased survival rate of dehydrated *S. typhimurium* LT2 cells (a_w <0.57) when challenged to heat of 135^{o}C for 30 min as compared to normal cells. Results also showed approximately 50% of dehydrated cells survived heat challenges of 100^{o}C for up to 1 h.

References

Arnold T (2002) Producing salmonella-free meal, Render, Feb p 10

Bensink JC (1979) Salmonella contamination of meat and bone meal, AVJ, 55:1, 13-15

Bensink JC and Boland PH (1979) Possible pathways of contamination of meat and bone meal with salmonella, AVJ, 55:11, 521-524

Boland PH, Salmonella in meat and bone meal (1979) Australian Advances in Veterinary Science, 1979, p 33-34

Clise JD and Swecker EE (1965) Publ. Hlth Repts 80:899

CSIRO (1990) Control of salmonellae in meatmeal, Meat Research Newsletter, Number 90/2

CSIRO (1991) Microbiological status of Australian meat meal, CSIRO Meat Research Laboratory, Cannon Hill

Hansen R, Jacobs NJ, Wilder OHM and Niven CF (1962) Am Meat Found. Bull. 53:3

Hess GW, Moulthrop JI and Norton HR (1970), New decontamination efforts and techniques for elimination of salmonella from animal protein rendering plants, J Am vet med assoc 157:1975

Michanie S, Isequilla P, Last J and Quevedo F (1989) Enterobacteriaceae as indicators of the presence of salmonella and the hygienic conditions of meat and bone meals, Rev. Argent. Micro., 21(1):43

Kilsby DC and Pugh ME (1981) The relevance of the distribution of micro-organisms within batches of food to the control of microbiological hazards from foods, J Appl. Bact, 51:345

Kirby RM and Davies R (1990) Survival of dehydrated cells of *Salmonella typhimurium* LT2 at high temperatures, J Appl Bact, 68:241

Lee JA (1974) Recent trends in human salmonellosis in England and Wales: the epidemiology of prevalent serotypes other than *Salmonella typhimurium*, J Hyg Camb
72:329

Loken KI, Culbert KH, Solee RE and Pomeroy BS (1968), Microbiological quality of protein feed supplements produced by rendering plants, Appl. Micro. 16(7):1002

Meat Research News Letter No. 90/2 (1990)

Morris GK, Martin WT, Shelton WH, Wells JG and Brachman PS (1970), Salmonellae in fish meal plants: relative amounts of contamination at various stages of processing and a method of control, Appl Micro, 19(3):401

Murray CJ (1994) Salmonella serovars and phage types in humans and animals in Australia 1987–1992, Aus Vet J, 71(3):78

Reusse U, Hafke A and Geister R (1976) Assaying the enterobacteriaceae contents of fishmeal as criterion for absence of salmonella, Zentralbl Bakteriol, 162(3-4):288

Report (1969), Nat Acad. Sci. Washington DC, Publication No. 1683

Timoney J (1968) The sources and extent of salmonella contamination in rendering plants, Vet Rec 83:541

Tompkin RB and Kueper TV (1973) Factors influencing detection of salmonellae in rendered animal by-products, Appl Micro, 25(4):485

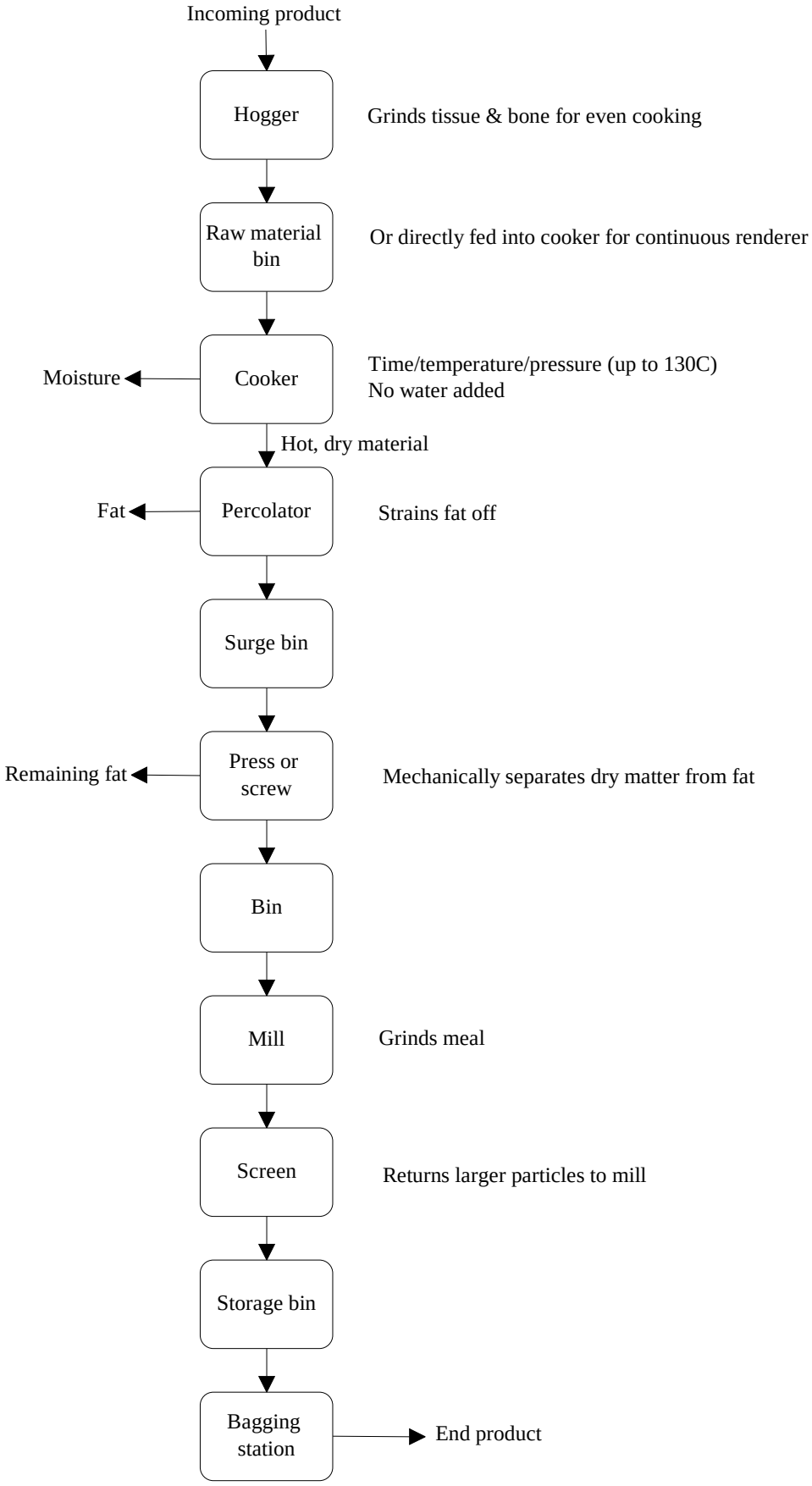
van Schothorst M (1986) Do we have to live with Salmonella? Food Tech Aust 38(2):64

Veldman A, Vahl HA, Borggreve GJ and Fuller DC (1995), A survey of the incidence of salmonella species and enterobacteriaceae in poultry feeds and feed components, Vet Rec, 136(7):169

Williams BM (1975), Environmental considerations in salmonellosis, Vet Rec, 96:318

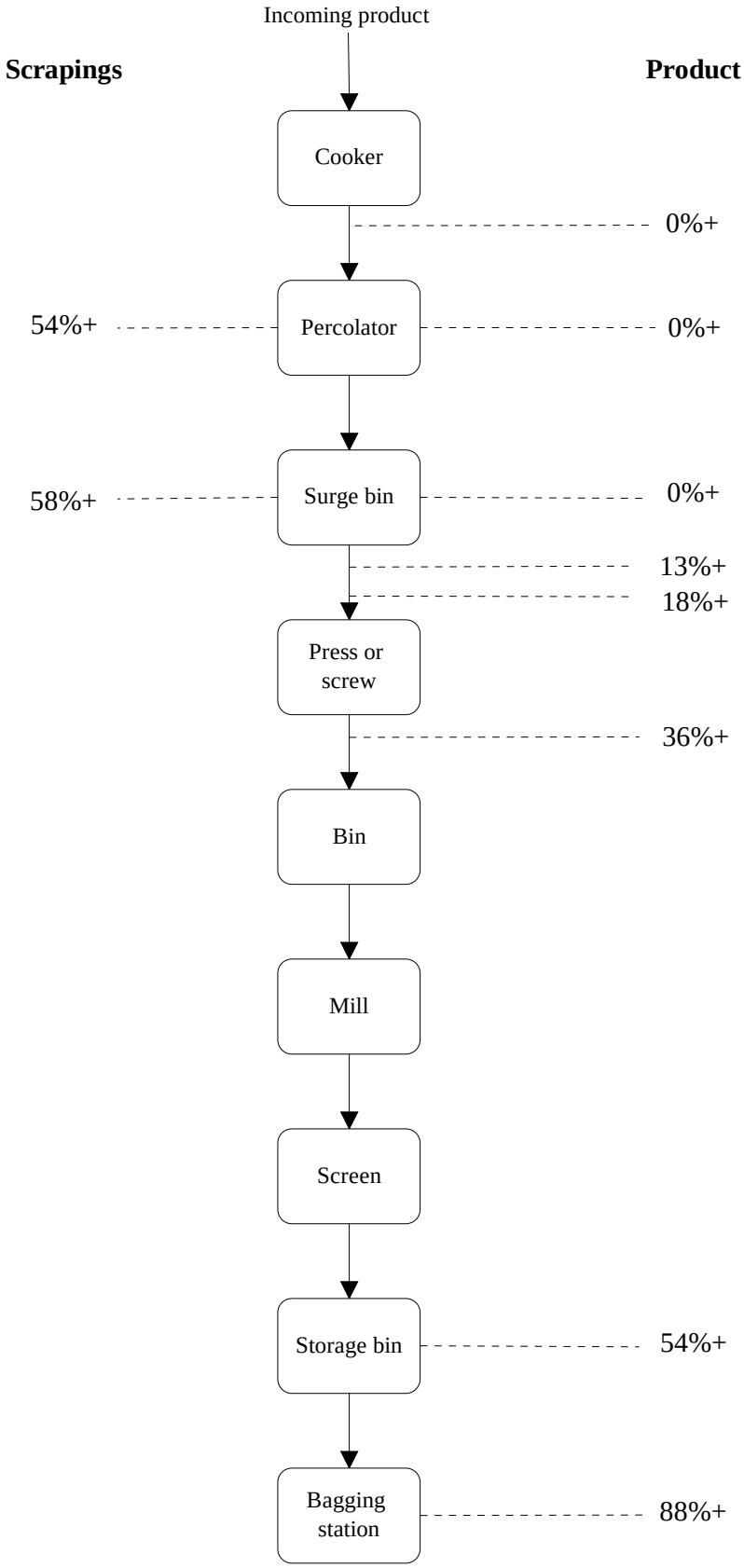
Appendix A

Batch or continuous dry rendering process

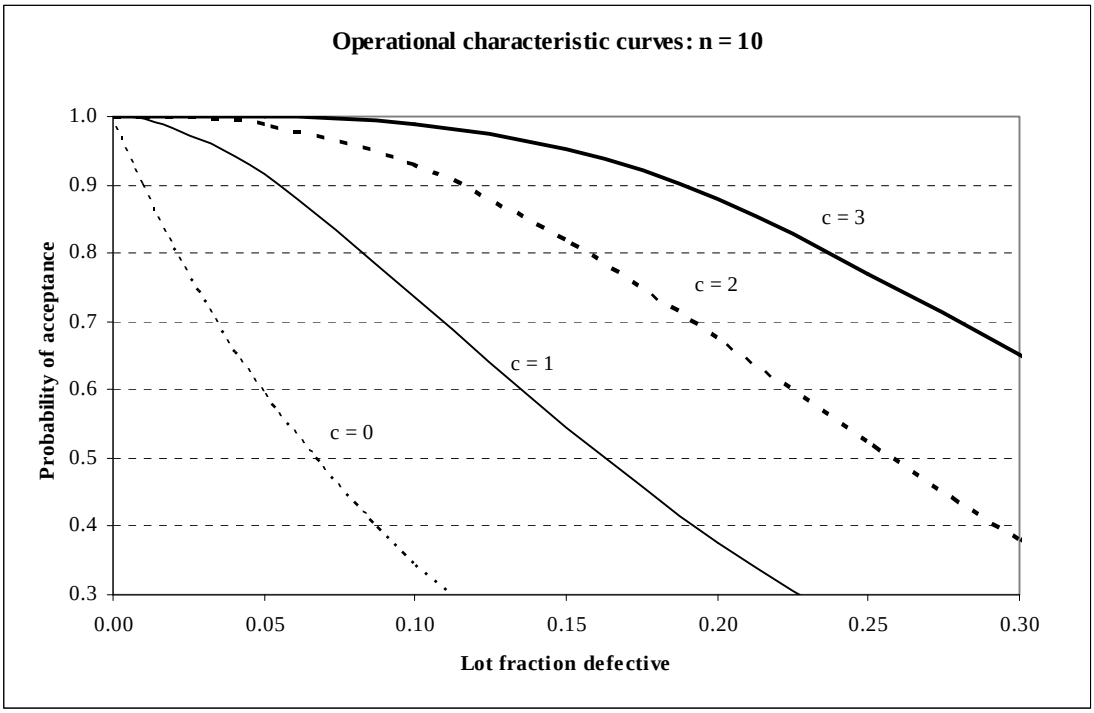


Appendix B

Salmonella levels (Bensink and Boland 1979)



Appendix C


Operational characteristic curves: n = 10
Probability of acceptance
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.00
0.05
0.10
0.15
0.20
0.25
0.30
Lot fraction defective
c = 3
c = 2
c = 1
c = 0

8.3 Appendix 3: Risk Management process – salmonella in meat meal

Introduction

A risk management process was undertaken to identify, analyse, evaluate and treat risks associated with salmonella contamination of meat meal during the rendering process.

Information and data has been gathered from:
- literature review
- informal discussions with researchers and interested persons
- round 1 samples from 4 beef renderers (1 batch dry, 2 dry continuous, 1 wet continuous) attached to abattoirs
- round 1 information from the 4 renderers.

This risk management process shall develop preventive measures to be implemented by each renderer for a short period. Round 2 samples will then be collected. The risk management process will then be reviewed and modified if necessary.

Methodology

The methodology used was consistent with the standard *AS/NZS 4360:2004 Risk management*.

Team

Symbio Alliance

Preparation

Scope

- Meat meal production at 4 beef renderers
- From the cooker outlet to loadout augers.

Objectives

- To develop preventive measures to produce meat meal with nil or minimal salmonella contamination
- The preventive measures must be practical and economical
- To trial these preventive measures
- To evaluate the outcomes in round 2
- To review the outcomes and develop systems that may be used by industry.

Risk criteria

The Australian Standard for Hygienic Rendering of Animal Products AS 5008:2001 states ‘The level of contamination in samples is unsatisfactory if more than 3 of the most recent 10 samples are positive for salmonella’.

The Australian Renderers Association Inc. (ARA) Code of Practice for Rendering of Animal Products (1996) has the same criteria as AS 5008:2001.

The Australian pig and poultry industries negotiate if necessary with renderers on the salmonella status of purchased product.

Certain importing countries require nil salmonella contamination.

Identify and analyse risks

Product description

Meat meal is a finely ground meal made from animal products. It usually contains bone thus is commonly called meat and bone meal.

The moisture content is about 5%. It is stored in bags or bulk.

The shelf life is about a year provided it is kept cool and dry.

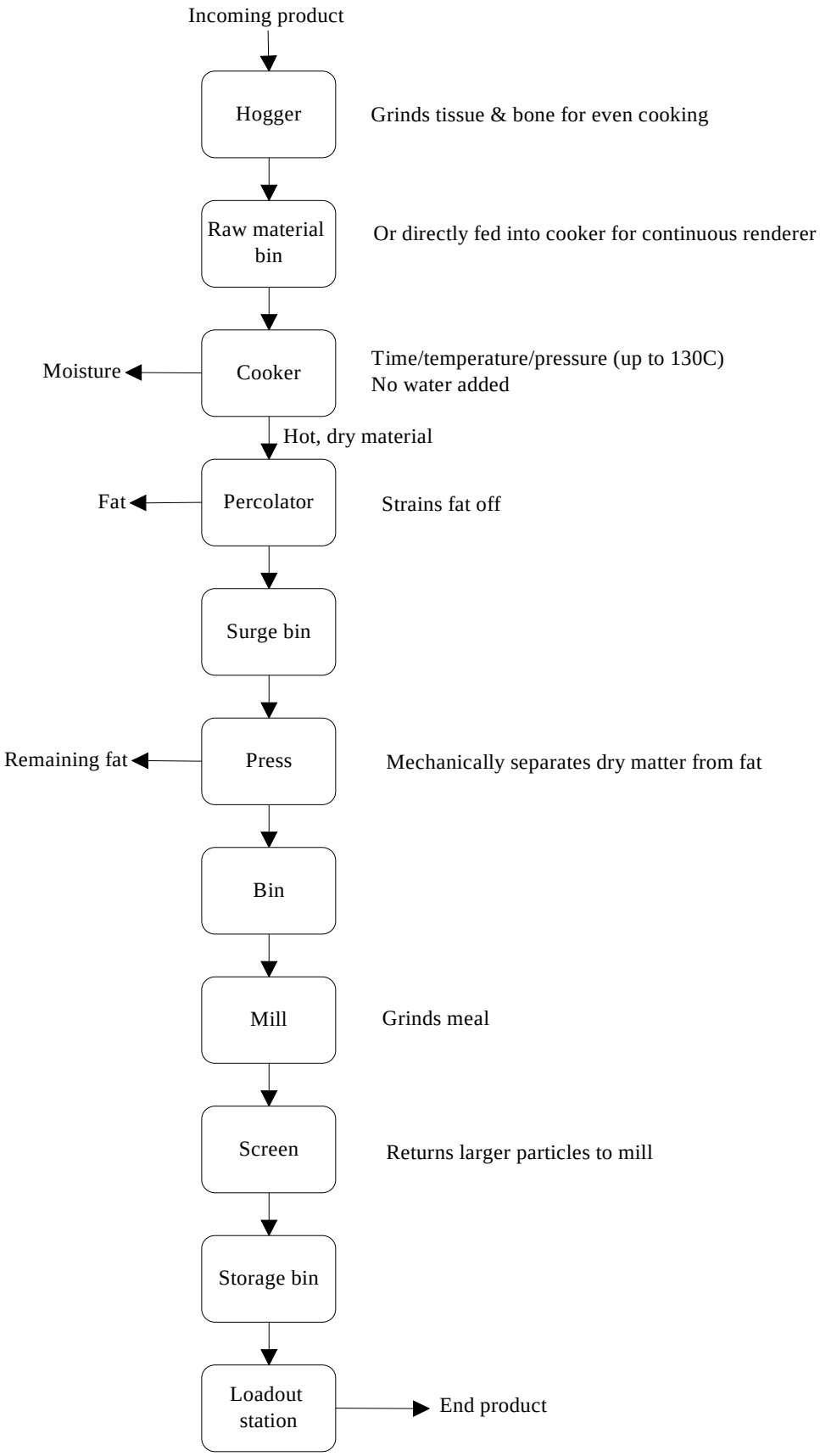
Meat meal is commonly used in poultry and pig feeds. Meat meal prepared from ruminants is banned from usage in ruminants in Australia.

Process flow

The following flow diagram represents a typical batch or dry rendering process.

A continuous wet or low temperature rendering process is a similar process whereby the incoming product is heated to about 95^{o}C for a short period, fat extracted by sieves and centrifuge, then dried by a hot air dryer at about 125^{o}C. The dry milling process is then the same as for dry rendering.

Batch or continuous dry rendering process



Risk analysis

This exercise involves:
- using planned and lateral thinking to identify items where a potential salmonella hazard may occur under present conditions
- recording control measure(s) presently in place for each item
- risk rating each item under present conditions.

Risk comprises the likelihood of an event happening and the consequence(s) if the event happens. In this plan the risk (R) = likelihood (L) x consequence (C) with a qualitative rating for L and C being 1 for low through to 5 for high.

Definitions: Risk – the chance of something happening that will have an impact on the objectives
Likelihood – the probability or frequency that something will happen
Consequence – the outcome or impact of an event.

Item	***Potential hazards under present conditions***	***R***	***L***	***C***	***Present control measures***
Cooking of meat by-products	Insufficient cooking temperature/time before emptying out of cooker. This could allow salmonella contaminated product to be processed as meat meal. This contaminated product would heavily contaminate all equipment.	1	1	1	Temperatures of the meal is monitored to prescribed temperatures as validated for each renderer. This validation is based on the destruction of *C. perfringens* spores which have a far higher temperature requirements than salmonella cells. It is generally accepted that product from the cooker is salmonella free.
Transfer of meal from cooker to press via screws, sieves, elevators	Build-up of meal on equipment thus the potential for salmonella growth during processing or during shutdown This build-up would contaminate meal	25	5	5	No control measures to prevent the build-up of meal on equipment during operations Some use exhaust ducting to extract steam thus reducing the moisture content of the meal Some use hot water wash down at end of production to clean screws and sieves but this does not completely remove caked on meal Some recycle the first lot to improve meal quality, not to heat equipment and possibly destroy salmonella on equipment Heat of meal would destroy salmonella in direct contact but not sufficient heat to fully destroy on equipment
Transfer of meal from cooker to dryer	Build-up of meal on equipment thus the potential for salmonella growth during processing or during shutdown	25	5	5	No control measures to prevent the build-up of meal on equipment during operations Heat of meal would destroy salmonella in direct contact but not

	This build-up would contaminate meal				sufficient heat to fully destroy on equipment.
Environmental contamination	Cross contamination from uncooked material, dust, insects, wash down splash could contaminate the meal with salmonella The potential is low due to the volume of contamination compared to the volume of meal	4	2	2	Partial separation of uncooked and cooked areas Handwash and foot wash procedures Maintenance of seals on cookers Exhaust fans Separate tools for wet and dry areas
Pressing/drying	Build-up of meal on equipment with growth during shutdown. This material would contaminate meal with salmonella during the first run until the temperature was high enough to destroy the salmonella Presses/dryer normally produce meal at 100^{o}C /125^{o}C at the outlet provided the press/dryer is at normal operating temperature. The meal would then be free of salmonella. A large amount of heavily contaminated recycled meal could result in contaminated meal being produced	25 3	5 1	5 3	No control measure to prevent contamination of the first meal produced after shut down or during extended times between batches or during breakdowns When the press/dryer is fully heated then no control measure is required as the inherent heat from pressing/drying is sufficient to destroy salmonella
Addition of recycle pre press/dryer meal to the cooker	First up recycle material from the cooker is often returned to the cooker for quality reasons. The cooking process destroys all salmonella	1	1	1	No control measures required
Addition of recycle post press/dryer meal to the process after the press or dryer	First up recycle material from the press of dryer could be heavily contaminated with salmonella from overnight growth Spilt meal from the floor etc could be heavily contaminated with salmonella	25	5	5	No control measure
Addition of meal products from a separate on-site rendering plant to pre	Products have an unknown salmonella status thus potential for contamination	25	5	5	No control measure

or post press/dryer Addition of spilt meal etc as above					
Milling – from press/dryer to loadout	Build-up of meal on equipment thus allowing growth of salmonella Insufficient residual heat from the press/dryer to destroy salmonella	25	5	5	No control measures to thoroughly clean equipment daily. Some do air blowing to remove loose dust.
Maintenance of equipment	Contamination of equipment with salmonella by maintenance staff	15	3	5	Routine hygiene of clothing, handwash and foot bath
Design of equipment	Equipment not designed to prevent build-up of meal on surfaces eg screws Equipment not designed to be totally cleaned each day	25 25	5 5	5 5	No control measures No control measures
Construction	Total separation of cooked and uncooked areas thus potential for salmonella contamination of final product	15	3	5	Some close to total separation of uncooked and cooked areas
Training	Staff and employees not fully aware of separation requirements and need to keep dry areas dry	5	1	5	Industry and in-house training is adequate Low staff turnover, specialised job
Control of operations	Staff not fully carrying out control duties due to workload, shift work etc	5	1	5	Staff supervision is adequate Low staff turnover, specialised job

Evaluate risks

The higher risk items are extracted for further evaluation and placed as far as possible into groups. It was arbitrarily decided that a risk of 10 or above was considered high risk.

Post cooker to press or dryer

Item	*Present control measures*	*R*
Transfer of meal from cooker to press via screws, sieves, elevators	No control measures to prevent the build-up of meal on equipment during operations Some use exhaust ducting to extract steam thus reducing the moisture content of the meal Some use hot water wash down at end of production to clean screws and sieves but this does not completely remove caked on meal Some recycle the first lot to improve meal quality, not to heat equipment and possibly destroy salmonella on equipment Heat of meal would destroy salmonella in direct contact but not sufficient heat to fully destroy on equipment	25
Transfer of meal from cooker to dryer	As above	25

Pressing/drying

Pressing/drying	No control measure to prevent contamination of the first meal produced after shut down or during extended times between batches or during breakdowns	15

Recycled meal

Addition of recycle post press/dryer meal to the process after the press or dryer	No control measure	25

Added products

Addition of meal products from a separate on-site rendering plant to pre or post press/dryer Addition of spilt meal etc as above	No control measure	25

Post press/dryer to loadout

Milling and storage	No control measures to thoroughly clean equipment daily. Some do air blowing to remove loose dust.	25

Equipment

Maintenance of equipment	Routine clothing, handwash and foot bath	15
Design of equipment	No control measures to prevent build-up of meal on equipment No control measure to allow total cleaning each day	25

Construction

Construction	Some close to total separation of uncooked and cooked areas	15

Risk treatment

Identify and assess options

Optional control measures and their risk are now identified and assessed for the risks identified in the Evaluate risks section above.

Post cooker to press or dryer

Item	***Present control measure***	***R***	***Optional control measure***	***R***	***L***	***C***
Transfer of meal from cooker to press via screws, sieves, elevators	No control measures to prevent the build-up of meal on equipment during operations Some use exhaust ducting to extract steam thus reducing the moisture content of the meal Some use hot water wash down at end of production to clean screws and sieves but this does not completely remove caked on meal Some recycle the first lot to improve meal quality, not to heat equipment and possibly destroy salmonella on equipment Heat of meal would destroy salmonella in direct contact but not sufficient heat to fully destroy on equipment	25	None required The intervention step of pressing/drying heats the meal to >90^{o}C destroys most salmonella See press/dryer below	25	5	5

Pressing/drying

Pressing/drying	No control measure to prevent contamination of the first meal produced after shut down	15	Recycle first meal of day to pre press/dryer until outlet meal is >90^{o}C This temperature destroys most salmonella	3	1	3

Recycled meal

Item	***Present control measure***	***R***	***Optional control measure***	***R***	***L***	***C***
Addition of recycled meal to the process after the press or dryer	No control measures to prevent cross contamination	25	Cease this procedure	1	1	1

Added products

Item	*Present control measure*	*R*	*Optional control measure*	*R*	*L*	*C*
Addition of spilt meal on the floor etc or other products eg edible renderings to the process before or after the press or dryer	No control measure	25	Cycle this product through the cooker	1	1	1

Post press/dryer to loadout

Item	*Present control measure*	*R*	*Optional control measure*	*R*	*L*	*C*
Milling and storage	No control measures to thoroughly clean equipment daily. Some do air blowing to remove loose dust.	25	Discourage survival and growth of salmonella by keeping the dry area very dry eg no water wash down, remove moisture by exhaust fans Discourage survival and growth of salmonella on equipment and meal on surfaces with dry acid or similar agent applied last of shutdown.	6 6	2 2	3 3

Equipment

Item	*Present control measure*	*R*	*Optional control measure*	*R*	*L*	*C*
Maintenance of equipment	Routine clothing, handwash and foot bath	15	Extra care with hand washing, foot baths, one-use clothing and dusting disturbed equipment with dry acid or other agent	6	2	3
Design of equipment	No control measures to prevent build-up of meal on equipment No control measure to allow total cleaning each day	25	No practical cheap method except total redesign for salmonella prevention	25	5	5

Construction

Item	*Present control measure*	*R*	*Optional control measure*	*R*	*L*	*C*
Construction	Some close to total separation of uncooked and cooked areas	15	No practical control measure unless redesign and rebuild for most renderers	15	3	5

Assess risk treatment options

Item	Action	Comments	Residual risk after action
Addition of recycled meal to the process after the press or dryer	Cycle this meal through the press or dryer	For example the first produced meal out of the press or dryer	
Addition of spilt meal on the floor etc or other products eg edible renderings to the process before or after the press or dryer	Pass this product through the cooker	Product may have a heavy load of salmonella which may not be destroyed by the press or dryer	
Pressing/drying	Recycle first produced meal through the press or dryer until outlet meal is >90^{o}C	Monitor outlet meal temperature	Needs validation as may have partly heat resistant salmonella
Milling and storage	Discourage survival and growth of salmonella on equipment and meal on surfaces with dry acid or similar agent applied last of shutdown. Prevent moisture contamination of product in the dry area by: - exhaust fans to remove moisture - prevent water splash into screws etc	Need procedure to do correctly each time Follow manufacturer's recommendation or validated method	This is a hurdle which must be used in conjunction with the other measures. This hurdle does not kill all salmonella but discourages their growth. As above
Maintenance of equipment	Measures to be taken by maintenance staff: - care with hand washing, foot baths, one-use clothing - dusting disturbed equipment with dry acid or other agent	Need procedure to do correctly each time	Low risk of contamination by contamination from personal gear and disturbance of meal caked on equipment
Design of equipment	None required at present No practical method except total redesign to prevent build-up of meal on equipment plus ease of cleaning		
Construction	None required at present No practical control measures ie total separation of fresh and cooked meal unless redesign and rebuild.		

Risk treatment plan

1 Dryness

- This applies to the post press or post dryer area
- The concept is to reduce the moisture content of the meal to a level that inhibits salmonella growth – a 'hurdle'
- No washing down in this area or splashing of water into equipment
- Sufficient exhaust fans to remove moisture and condensation
- Protect any external equipment or silos from rain
- Any equipment that contains moist material must be cleaned and dried.

2 Recycle

- This applies to the first meal out of the press or dryer at start-up
- The concept is allow time for the press or dryer to heat up and produce meal >90^{o}C thus destroying salmonella
- Recycle the meal into the cooker or pre press or pre dryer

3 Added product

- This applies to meal that has become contaminated eg spilt on the floor or products from other rendering operations eg meal from an edible renderer
- The concept is to destroy all salmonella as the bacterial load is unknown
- This product is to be added to the cooker

4 Flushing

- This applies to the post press or post dryer equipment
- The concept is to inhibit the growth and/or destroy salmonella on equipment – a 'hurdle'
- A mixture of meal or similar product and dry acid is flushed through the equipment last of the day's production. Follow the manufacturer's recommendation or validated method

5 Maintenance

- This applies to maintenance staff who work on equipment in the post press or post dryer area
- The concept is to prevent contamination of equipment which contacts meal
- Staff must use hygienic procedures when repairing or adjusting equipment eg wash hands, boot wash, separate clothing.
- Apply a dusting of dry acid to the equipment after repairs.

Implementation

The risk treatment plan shall be used to develop a salmonella problem solving decision tree for use by renderers.

Monitoring

Each renderer shall continue with their present salmonella sampling plan.

After the trial implementation period, Symbio Alliance shall resample the same points at each renderer.

Review

The risk assessment was reviewed after the second round of sampling and modification made to the salmonella problem solving decision tree.