AMINONews®

By Jens-Erik Zerrahn (jens-erik.zerrahn@evonik.com)
Technical Director Key Accounts, Evonik Nutrition & Care GmbH

Heat Treatment in Feed Processing to control Salmonella

Food hygiene has been getting increasing attention over the last years all across the entire food chain, from producer to consumer. All stakeholders involved are allocating vast resources to monitoring food hygiene, as the impact of compromised food safety involves huge monetary and image losses, putting the business at risk.

Background

Pork meat processors are randomly taking meat juice samples from every farm and delivery of pigs to monitor salmonella status. All meat detected salmonella positive cannot be distributed as fresh meat, but has to undergo further processing to assure food safety for consumers, which is adding processing costs.

These added costs involved in processing meat detected salmonella positive are partly passed on to the pork producers, who are met with price deductions per kg pork meat sold to the slaughterhouse.

Furthermore, slaughterhouses might oblige pig farm operations that have been identified as salmonella positive to engage consultants and veterinarians to identify the reasons for and sources of salmonella and to implement counteracting measures.

Occurrence of salmonella on pig farms originates most commonly as two types: the feed-borne (or exotic) types or the naturally occurring types. Presence of salmonella often leads to gastrointestinal infections, compromised performance and increased production cost.

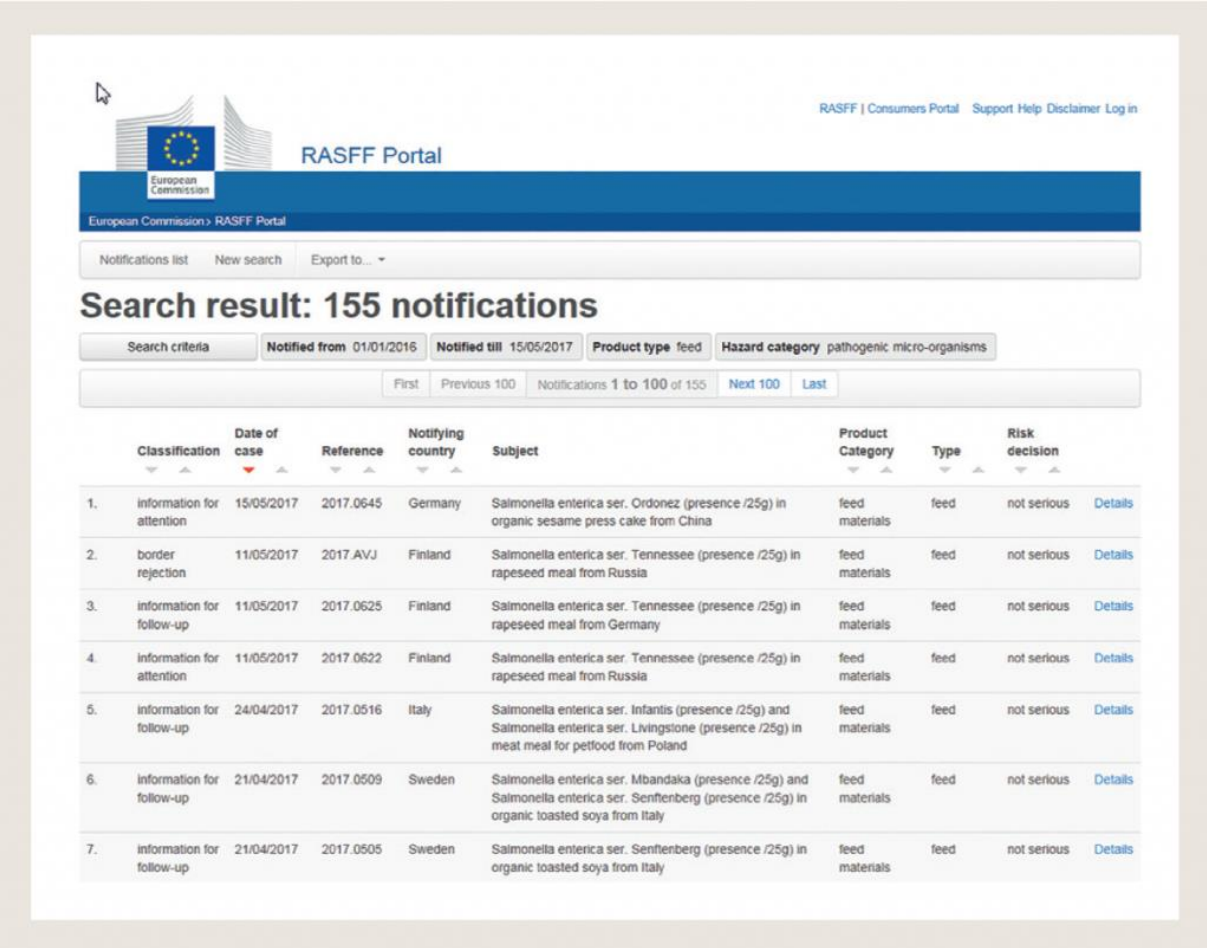
Conclusively, low salmonella contamination levels are in everybody's interest.

In order to reduce the risk of feed-borne salmonella, the feed industry in Denmark agreed to integrate a heat treatment of 81°C for minimum 1 min of all feeds in the feed manufacturing process as of 1993.

At the EU level, control of salmonella has been embedded in Regulation (EC) No. 2160/2003 on the control of salmonella and other specified food-borne zoonotic agents. This regulation aims to ensure that proper and effective measures are taken to detect and to control salmonella at all relevant stages of production, processing and distribution at the farm level, including feed produc- tion, in order to reduce the prevalence.

In the case that salmonella or other undesired substances are detected in feed or food materials, the EU rapid alert system RASFF is activated to inform all stake- holders in the value chain. The RASFF portal is updated and accessible at https://ec.europa.eu/food/safety/rasff_en.

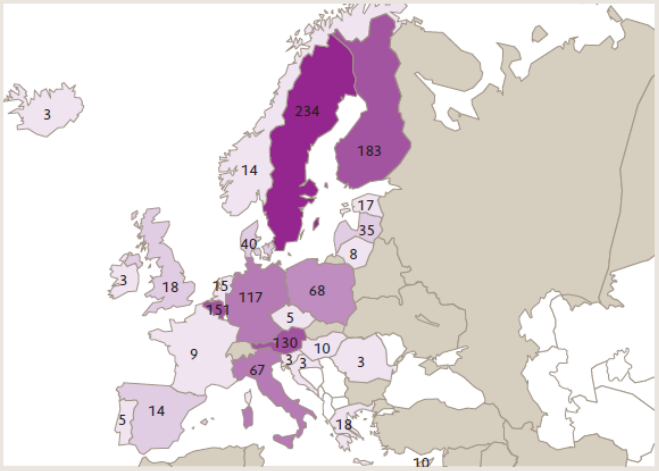
The RASFF portal offers the option to search for results. Since January 2016, we have had 155 notifications of pathogenic microorganisms in feed samples, of which most of the cases were related to salmonella (Figure 01).



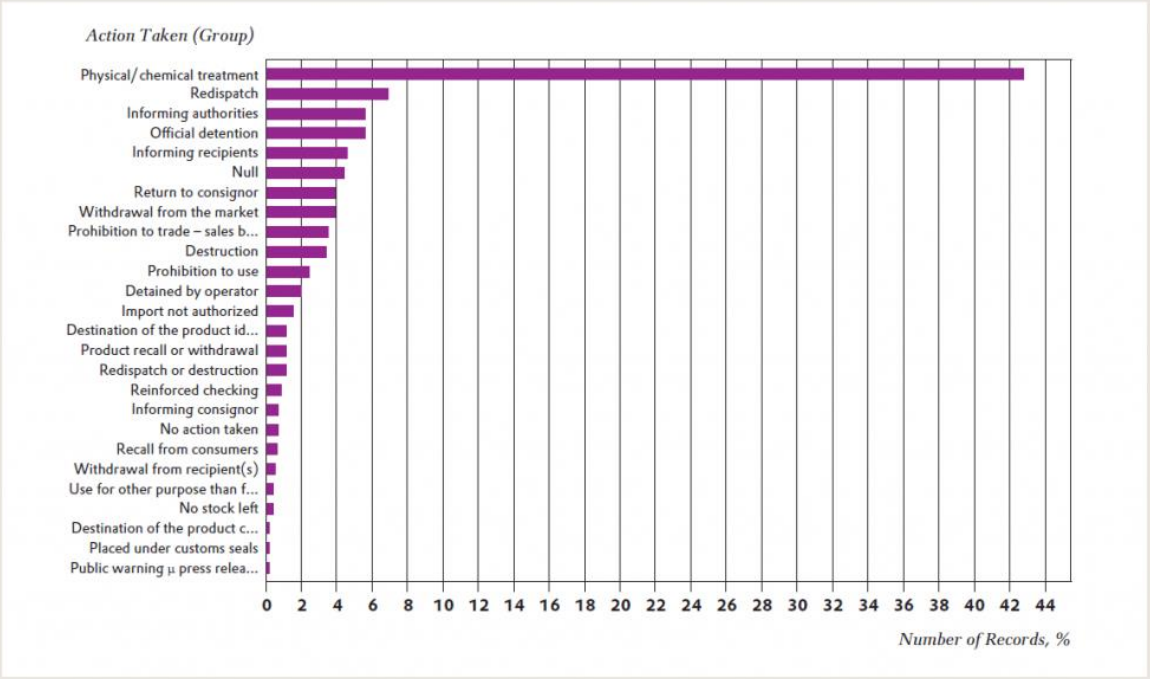
	Classification	Date of case	Reference	Notifying country	Subject	Product Category	Type	Risk decision	
1.	information for attention	15/05/2017	2017.0645	Germany	Salmonella enterica ser. Ordonez (presence /25g) in organic sesame press cake from China	feed materials	feed	not serious	Details
2.	border rejection	11/05/2017	2017.AVJ	Finland	Salmonella enterica ser. Tennessee (presence /25g) in rapeseed meal from Russia	feed materials	feed	not serious	Details
3.	information for follow-up	11/05/2017	2017.0625	Finland	Salmonella enterica ser. Tennessee (presence /25g) in rapeseed meal from Germany	feed materials	feed	not serious	Details
4.	information for attention	11/05/2017	2017.0622	Finland	Salmonella enterica ser. Tennessee (presence /25g) in rapeseed meal from Russia	feed materials	feed	not serious	Details
5.	information for follow-up	24/04/2017	2017.0516	Italy	Salmonella enterica ser. Infantis (presence /25g) and Salmonella enterica ser. Livingstone (presence /25g) in meat meal for petfood from Poland	feed materials	feed	not serious	Details
6.	information for follow-up	21/04/2017	2017.0509	Sweden	Salmonella enterica ser. Mbandaka (presence /25g) and Salmonella enterica ser. Senftenberg (presence /25g) in organic toasted soya from Italy	feed materials	feed	not serious	Details
7.	information for follow-up	21/04/2017	2017.0505	Sweden	Salmonella enterica ser. Senftenberg (presence /25g) in organic toasted soya from Italy	feed materials	feed	not serious	Details

Figure 01:

Searching for data in the RASFF offers the opportunity to search for the frequency of incidents, incidents recorded per EU member state and the action taken to decontaminate the feed. The implementation of the EU regulation on the control of salmonella varies between member states. In Sweden and Finland, all imports of soybean meal are subject to thorough analysis for salmonella before the feedstuffs are released for use in feed production. This procedure explains why the number of incidents in these countries is higher (Figure 02).



02A
Records per country



02B
Action taken

SALMONELLA: WHAT IS THE ORIGIN?

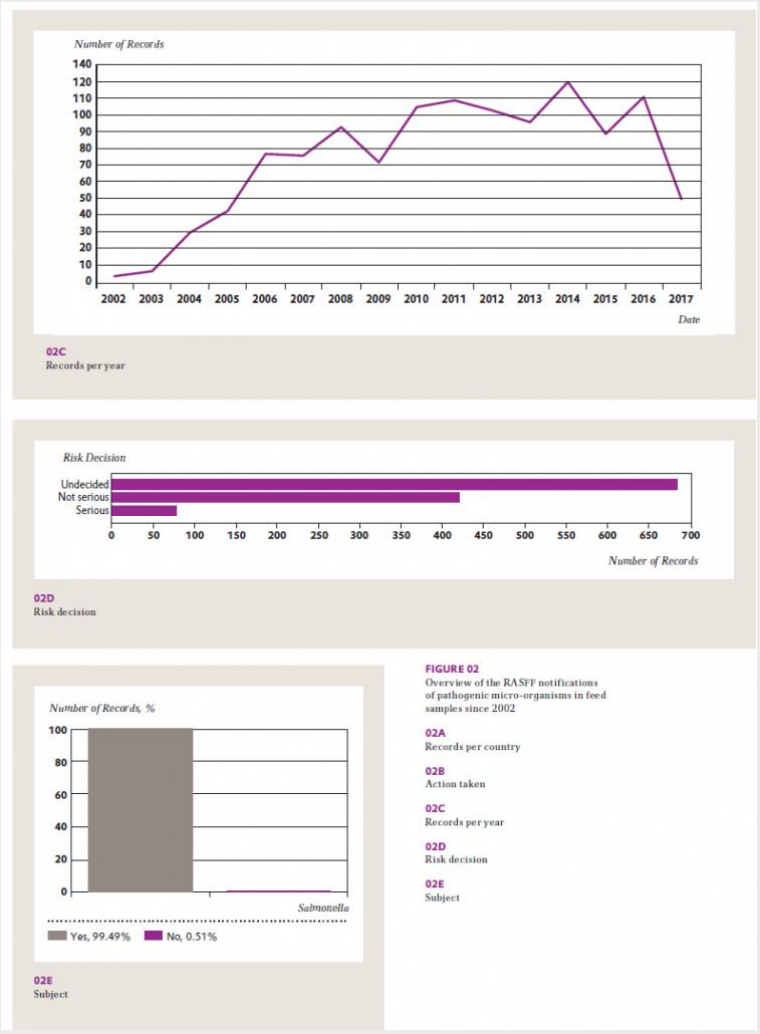
Salmonella is part of the family Entero-bacteriaceae. The genus salmonella consists of two species, Salmonella bongori in cold-blooded animals which is hence not relevant in livestock production, and Salmonella enterica, present in warm-blooded animals. Salmonella enterica can be divided into six subspecies, of which the subspecies, S. e. enterica is the most relevant in animal production. This subspecies contains more than 2,500 serovars (also called serotypes). In

practice, a serotype Salmonella enterica sub-species enterica serotype Typhimurium is abbreviated to Salmonella Typhimurium.

The transmission of these more than 2,500 serotype types of Salmonella at the farm level can roughly be divided into two groups: transmission by animals and humans and by feedstuffs.

Transmission of salmonella by animals and humans is most frequent, and mostly, routes of transmission are identified as transmitted by rodents by birds, from pig to pig backwards in production within a farm, by trading and mixing pigs between farms, introduction by farm workers and visitors or other infection routes.

Closed production systems having their own nucleus for breeding and not introducing breeding animals to the farm directly – and if so solely by using quarantine units outside the farm in which purchased breeders are kept for a surveillance period – reduce their risk of introducing salmonella onto the farm.



Farms operating the housing sections by implementation of all-in and all-out management procedures reduce the risk of a “backwards infection”, with older animals infecting younger, unexposed animals and maintaining the salmonella presence on farm, by emptying the complete housing unit and applying cleaning and disinfection routines.

Feeding measures such as low protein diets, acidification, probiotics and a coarser particle size all support intestinal health and help keep a low bacterial challenge in the environment.

When analyzing the serotypes of salmonella found in meat juice of samples from gut lymphoid glands or caecum samples collected during the processing of finishing pigs in the slaughterhouse in Denmark in the period from 1993 to 2011, Wingstrand (2012) found that the dominating serotypes were S. Typhimurium, S. Derby and S. Infantis, as shown in the below Table 1.

Table 01: Overview of salmonella type found in meat juice of pork carcass (Wingstrand, 2012)

SEROTYPE	FREQUENCY OF SALMONELLA POS SAMPLES ANALYZED IN PORK CARCASS
Salmonella spp. total	17.3%
Salmonella Typhimurium	6.2
Salmonella Derby	8.4
Salmonella, other	2.6

Salmonella serotypes found in feed-stuffs, often referred to as feed-borne salmonella types, represent the other group, which by far is easier to cope with. These types are predominantly found in vegetable proteins like soy and rapeseed products (Wierup and Häggblom, 2010).

Li et al (2012) compared the 25 most common salmonella serotypes found in the different categories of animal feeds collected under the Feed Contaminants Program 2002 – 2009, initiated by the American Food and Drug Administration, and compared them to the 20 most common salmonella serotypes found in human infections in 2009 as reported by the Centers for Disease Control and Prevention. Comparing the list of serotypes in feeds and in humans, as shown in Figure 3, demonstrates that there is only a partial consistency in the serotypes isolated in animal feeds and those serotypes causing human infections, which supports the theory that other transmission routes of salmonella into farms do exist.

Wong et al. (2006) came to similar conclusions in his Danish studies looking at the ranking of serotypes in soy-based feeds, also finding the serotypes Agona, Senftenberg, Kentucky, Newport, Tennessee, Infantis, Mbandaka and Oranienburg as being the most frequent and impacting serotypes in soy-based feeds.

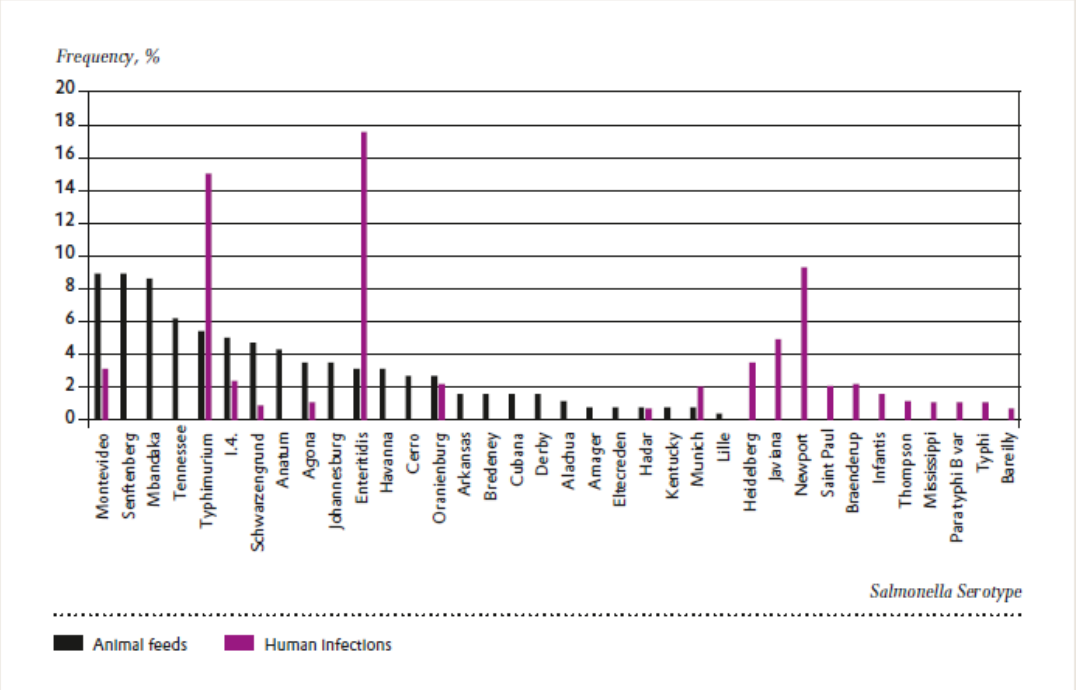


Figure 03: Most common serotypes of salmonella found in animal feeds and 20 most common serotypes found in human infections (after Li et al., 2012)

Salmonella Contamination routes into Feed

The contamination risk with salmonella from raw materials being received at the raw material storage facilities at the feed mill is the highest for animal-derived products, aside from processed raw materials like oil meals, byproducts from cereals and byproducts from the food industry (Li et al., 2012). The more often raw materials are handled, the higher the contamination risk (Jones, 2011). Aside from contamination via raw materials, other routes of contamination also exist.

Morita et al. (2006) studied the contamination vectors and environmental factors of salmonella in three different areas of processing: receiving raw materials and processing and storage of finished oil meal, in a rapeseed and soybean meal processing facility at commercial scale, processing approximately 700,000 tons annually. Within each area in processing, operators, processing floor, dust in the air and rodents were analyzed for salmonella presence and serotype involved.

Table 02: Salmonella contamination in different areas of an oil meal plant (modified after Morita et al., 2006)

AREA	CATEGORY	SAMPLE SOURCE	NO. OF SAMPLES EXAMINED	NO. OF POSITIVE SAMPLES	POSITIVE RATE (%)
Receiving	Processing floor	Swab of floor (on line)	28	0	0
		Swab of floor (off line)	10	0	0
	On equipment	Swab	20	1	5
	Rodents	Intestinal content	6	0	0
		Mesentry lymph node	6	0	0
	Dust in the air	–	10	0	0
Processing	Processing floor	Swab of floor (on line)	52	34	65
		Swab of floor (off line)	30	10	33
	On equipment	Swab	20	2	10
	Rodents	Intestinal content	28	13	47
		Mesentry lymph node	28	1	4
	Dust in the air	Air sampler	10	0	0
		Dust in the collected air	178	51	29
Storage	Processing floor	Swab of floor (on line)	22	6	27
		Swab of floor (off line)	10	1	10
	On equipment	Swab	20	1	5
	Rodents	Intestinal content	7	0	0
		Mesentry lymph	7	0	0
	Dust in the air	–	10	0	0

The findings of this study as summarized in Table 02 show that the contamination risk for salmonella is elevated during processing involving higher ambient temperature and moisture, as most contaminations were identified on flooring, on equipment and in the intestines of rodents caught in production. In comparison, contamination risks were much lower in areas receiving raw materials, as well in the areas for storage of final products.

Additional measurements were conducted by analyzing salmonella prevalence on shoes and tools used in the oil meal plant like brooms and hand gloves showing relatively high salmonella contamination levels.

The fact that the risk for salmonella contamination is related to incoming raw materials, transmission by rodents and birds and dust building up in manufacturing with elevated temperature and humidity explains why the feed industry is very cautious in implementing very strict feed-hygiene standards.

Heat Treatment can inhibit Salmonella

Salmonella can be inhibited by heat, low pH or other antibacterial substances.

In order to inhibit salmonella eventually present in feedstuffs, feed producers either analyze imported feedstuffs for salmonella prior to unloading the vessels and if positive initiate a treatment with organic acids (e.g., propionic acid), or generally heat treat all feeds during feed processing.

The feed mill is divided into two parts: a red zone, which is considered a risk/contaminated zone, and a green zone post heat treatment, which is considered a low-risk or decontaminated, clean zone. The red zone involves bulk

storage of feedstuffs in silos and warehousing of packaging materials such as minerals, premixes, concentrates, feed additives and other feed materials. The red zone also involves transport of ingredients for grinding and mixing.

After leaving the mixer and entering the conditioner, the meal is heated by adding steam up to about 60 °C. After this, the meal is transported to another conditioner or expander, in which steam is added to elevate the temperature up to min 81 °C, and reaches its highest temperature in the pellet press as friction delivers additional mechanical energy as heat. Mounting a boa compactor to the pellet press further increases friction and release of heat. After this heat treatment, the feed enters the green zone of the feed mill, which is physically totally separated by walls from the red zone. In Figure 04, the impact of heat and exposure time on salmonella inhibition shows that most predominant serotypes are inactivated at temperatures above 77 °C within a very short time.

In the green zone, the feed is transported to the cooler, followed by transport to final goods silos for onward loading into trucks for bulk deliveries or to packaging.

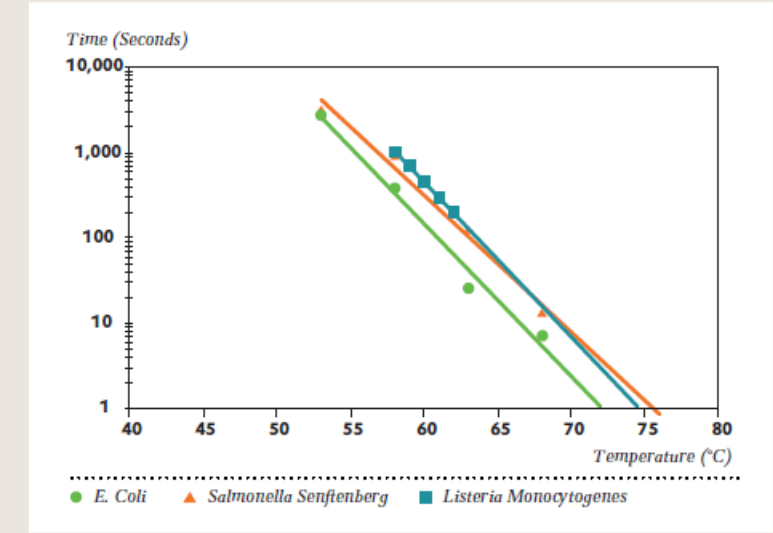


Figure 04: Impact of heat and exposure time on salmonella inhibition

Conclusions

Factors related to farm-management practices are the dominating factor for introducing salmonella into the food chain.

Implementation of HACCP principles in the feed industry aiming at maintaining high feed-hygiene standards and including processing steps in feed production with heat treatment of feeds at min 81 °C do significantly minimize the risk of distributing salmonella-contaminated compound feeds.

Within the European Union, the feed industry is obliged to follow Regulation EC (183/2005), which defines the HACCP principles to be implemented maintaining high feed hygiene in alignment with the European Commission's "White Paper on Food Safety."

In brief, the HACCP principles include:

1. Identify any hazards that must be prevented, eliminated or reduced to acceptable levels;

2. Identify the critical control points at the step or steps at which control is essential to prevent or eliminate a hazard or reduce it to acceptable levels;

3. Establish critical limits at critical control points which separate acceptability from unacceptability, for the prevention, elimination or reduction of identified hazards;

4. Establish and implement effective monitoring procedures at critical control points;

5. Establish corrective action when monitoring indicates that a critical control point is not under control;

6. Establish procedures to verify that the measures outlined in points (1) to (5) are complete and working effectively. Verification procedures shall be carried out regularly;

7. Establish documents and records commensurate with the nature and size of the feed businesses to demonstrate the effective application of the measures set out in points (1) to (6).

References

Jones, F. T. (2011): A Review of Practical Salmo- nella Control Measures in Animal Feed. Poultry Science Association, Inc.

Li, X., Bethune, L. A., Jia, Y., Lovell, R. A., Proescholdt, T. A., Benz, S. A., Schell, T. C., Kaplan, G., McChesney, D. G. (2012): Surveillance of Salmo- nella Prevalence in Animal Feeds and Characteriza- tion of the Salmonella Isolates by Serotyping and Antimicrobial Susceptibility. Food-Borne Pathogens and Disease, Vol 9 (8).

Morita, T., Kitazawa. H., Lida, T., Kamata, S. (2006): Prevention of Salmonella Cross-Contamination in an Oil Meal Manufacturing Plant. Journal of Applied Microbiology. ISSN 1364-5072.

Wierup and Häggblom (2010): An Assessment of Soybeans and Other Vegetable Proteins as Source of Salmonella Contamination in Pig Production. Acta Vet Scand, 52(1):15.

Wingstrand, A. (2012): Evaluering af salmonella- handlingsplanen for svin (SHIV) 2009-2011.

Ministry of Environment and Food, Danish Veteri- nary and Food Administration.

Wong, L. F., Arp, V., Hald, T., Wingstrand, A. (2006): Salmonella Contamination in Soy-Based Animal Feed – A Food Safety Issue. Proceedings of the 11th International Symposium on Veterinary Epidemiology and Economics. Available at www.sciquest.org.nz.

The content of this document is for the information and assistance of Evonik's customers and is not applicable to products marketed or sold in the United States. Evonik markets its products in compliance with applicable local laws, but it is the user's responsibility to ensure that the use of and any claims made for this product comply with all relevant requirements. This document may not be published in the United States without the express written consent of Evonik Operations GmbH.

Evonik Operations GmbH
Animal Nutrition Business Line

animal-nutrition@evonik.com
www.evonik.com/animal-nutrition