

Factsheet SALMONELLA

This factsheet focuses on *Salmonella* contamination in protein meal from oilseed crushing facilities for feed application. The purpose of the document is to provide *Salmonella* related information and guidance to the feed material producer on how he can continuously minimize the occurrence of *Salmonella* contamination in his product.

This factsheet is to be used in combination with the auditor checklist for Salmonella control.

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1.0 Nature of the hazard

Biological hazard

2.0 Classification

Salmonella are bacteria that belong to the family of Enterobacteria, and are pathogenic for humans and animals. The genus is composed of two species: *S. enterica* and *S. bongori*. These species are divided into subspecies, which again are divided into serotypes. Some serotypes can further be phage typed. Worldwide, more than 2400 serotypes have been described. These serotypes vary in infection pathway, occurrence, symptoms and the level of antibiotic resistance.

From an epidemiological point of view *Salmonella* can be classed into three main groups:

- Strains that only infect humans and are responsible for typhoid fever with septicaemic dissemination, which are not pathogenic for other animal species.
- Strains specifically adapted to particular species of vertebrates (poultry, sheep etc.), some of which are pathogenic for humans.
- Strains that do not have a specific preferred host and infect both humans and animals. This is the group in which the main agents of the *Salmonella* currently encountered are found.

3.0 Origin

Salmonella have characteristics which explain their widespread distribution in the environment:

- They are carried by a large range of hosts (humans, mammals, birds, reptiles and insects)
- *Salmonella* can be found in soil, water, air, surfaces etc.
- Incoming agricultural commodities

They have a very high survivability in the environment.

4.0 Food and feed safety risks

When consumed by humans, *Salmonella* can cause salmonellosis. The symptoms of salmonellosis include nausea, vomiting, abdominal cramps, diarrhea, fever, and headache. The public health significance may vary depending on the serotype, route of infection, ability to spread and cause disease in humans and animals and the virulence of the serotype.¹

Salmonella-contaminated feed can cause illness in animals that consume the feed. Whether *Salmonella* causes illness in an animal depends, amongst others, on the serotype. *Salmonella* serotypes that cause disease in a particular species are referred to as pathogenic for that animal species.

Considering the prevalence of *Salmonella* in feed and the amount of feed consumed, it is assessed that contaminated feed on most occasions does not give rise to infections in food producing animals. The risk of carryover of the *Salmonella* contamination in feed material to the animal and subsequently, transmission to the human is small.^{2 3}

Other factors that determine the introduction of *Salmonella* via feed to animals or humans are the feed storage conditions, transport, the prevalence and concentration of *Salmonella* in the feed, the health status of the animals, animal to animal transmission, the feeding strategies and good hygiene practices at farm level. Furthermore, the handling in the supply chain downstream plays an important role, eg. the slaughter of the animals in the abattoir, cooling and hygiene conditions during transport of animal products, their storage and retail as well as the proper preparation of the food in the kitchen by the consumer.⁴

As described in Food Law Reg. (EC) 178/2002, article 15 the operator shall not place feed on the market that is unsafe and that has an adverse effect on the human or animal health. Therefore the operator shall take the necessary effective, proportionate and targeted measures to continuously minimize the possible *Salmonella* contamination and protect health (recital 17).

The mere finding, with a presence – absence test does not necessarily indicate a threat to human health.⁵

¹ [Reg.\(EC\) No 2160/2003 on the control of Salmonella and other specified food- borne zoonotic agents- annex 3, page 15](#)

² <http://www.dtu.dk/english/~media/Institut/Foedevareinstituttet/Publikationer/Pub-2013/Report-Assessment-of-the-human-health-impact-of-Salmonella-in-animal-feed.ashx>, page 22,37

³http://www.bfr.bund.de/cm/343/4_sitzung_der_bfr_kommission_fuer_zusatzstoffe_erzeugnisse_und_stoffe_in_der_tierernaehrung.pdf

⁴ [Foodborne Pathogenes and Disease, vol., 2004, Davies et al., The role of contaminated feed in the epidemiologie and control of Salmonella Enterica in porc production-post intervention recontamination of feed : mill to mouth, page 206](#)

⁵ [Codex Alimentarius- principles for the establishment and application of microbiological criteria for foods \(CAC/GL 21- 1997\), §5.1 Microorganisms, parasites and their toxins/ metabolites of importance in a particular food](#)

5.0 Controlling and minimizing Salmonella contamination

The producer of the feed material shall put in place, implement and maintain a permanent written procedure or procedures based on the HACCP principles⁶ in line with article 6 of the Regulation (EC) 1831/2005.

The goal of the feed material producer should be to significantly reduce the incidence of *Salmonella* in all aspects of production and to minimize the (re-) contamination of the finished product by applying the HACCP system. While the complete eradication of *Salmonella* may not be possible, control is possible and should lead to a continuous reduction of the level of contamination in line with defined targets.

The monitoring plan shall focus on process control in combination with the control of the finished product, in order to assure a continuous flow of safe product. The microbiological end control of the finished product has the function to validate and verify the feed safety of the process line/ parameters and therefore, the protein meal produced. This preventive approach offers more control than microbiological testing of the end product only, because the effectiveness of microbiological examination to assess the safety of foods is limited.⁷

The main factors affecting microbial growth and survival of *Salmonella* are pH, a_w and temperature. Other important factors include the competing micro flora, the initial number of *Salmonella* and their physiological state.

The following technological procedures will impact the *Salmonella* contamination of the end product and result in bactericidal or bacteriostatic effects. These preservation techniques include:

- heating (various time/temperature combinations), application of high hydrostatic pressure
- pH modification (acidification, application of organic acids)
- Controlled moisture content resulting in a low a_w value (The meal is treated in the desolventizer-toaster with steam and/or indirect heat to, among others, minimize the risk of microbiological contamination. Following the meal is dried and cooled. A moisture content of 12-13%, homogeneously distributed in the meal, results in an a_w value far below 0.95)

Some of these preservation techniques do not have a bactericidal effect, but multiplication of organisms is prevented.

However, it needs to be stressed that the protein meal can always be re- contaminated after the killing step(s).

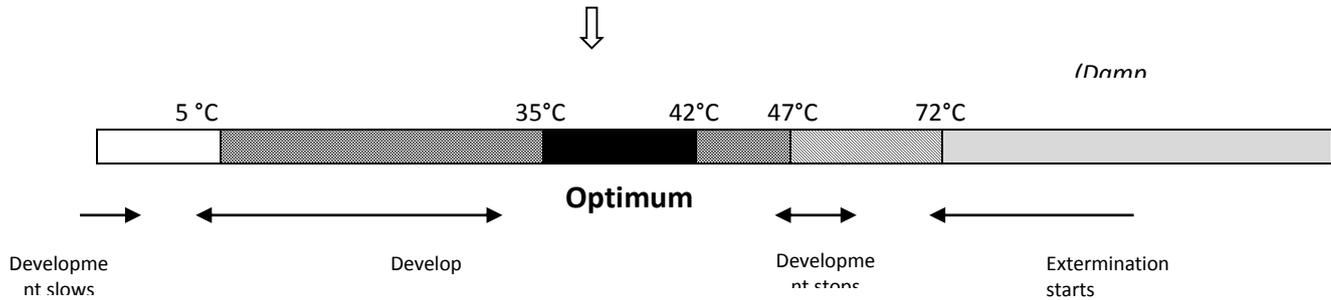
Due to the environmental contamination, high volumes of protein meal and technical limitations, it is not feasible to completely avoid contamination of the vegetable protein meal. Therefore it is not sensible to test feed batches 100% free for *Salmonella* and consequently, it will be impossible to guarantee *Salmonella*-free batches of feed. However, strict process controls, including in-line monitoring, should provide for an acceptable, minimal number of positive cases. An acceptable, low contamination level of *Salmonella* is a realistic and efficient approach, where the obtained risk reduction bears comparison with the cost of intervention.

⁶ <http://www.efsa.europa.eu/en/efsajournal/doc/720.pdf>- Chapter 8. Strategies to control *Salmonella* in the feed-chain

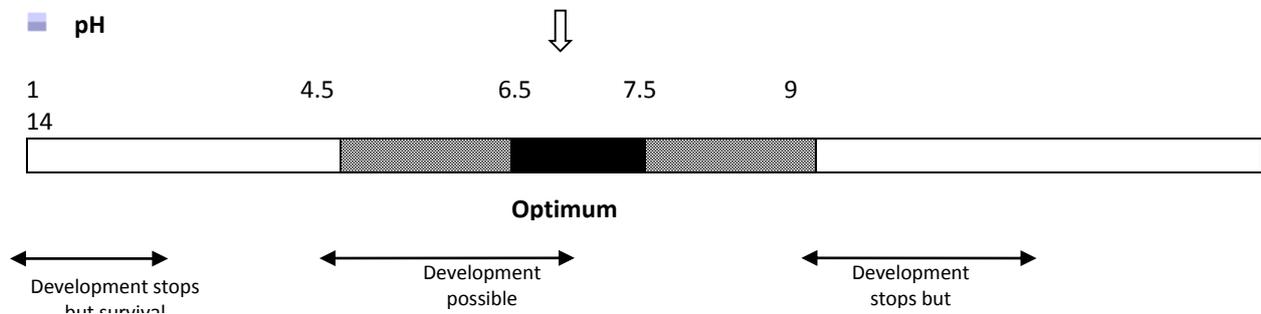
⁷ Codex Alimentarius- principles for the establishment and application of microbiological criteria for foods- Introduction (CAC/GL 21-1997)

5.1 Development factors

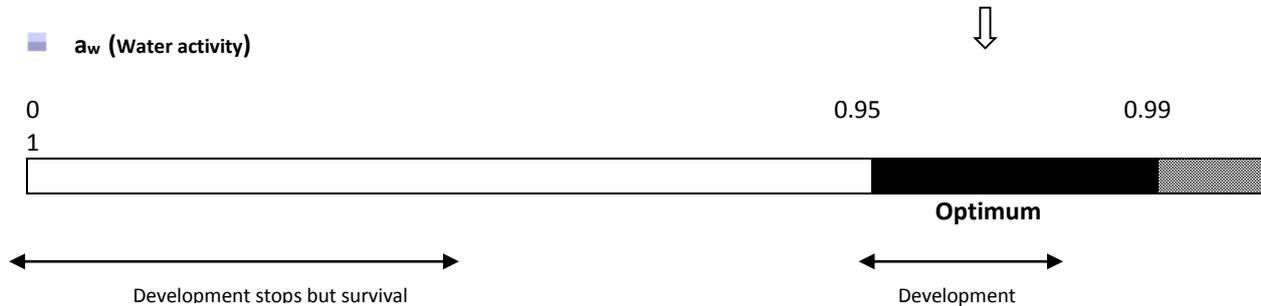
Temperature



pH



a_w (Water activity)



5.2 Control measures to minimize the contamination of protein meal with Salmonella

To minimize the risk of *Salmonella* contamination in vegetable protein meal the following elements should be evaluated:

- Possible ingress or spread of *Salmonella* in the processing facility.
- Good hygiene practices and controls in the area after the desolventiser – toaster (DT) in order to avoid re- contamination after the hexane/ heat treatment (killing step)
- Hygienic design principles for building and equipment.
- Growth of *Salmonella* within the facility.
- Quality of cooling air.
- Products added back to the meal after the DT.
- The water content of the finished protein meal.
- Condensation in the processing line and environment in order to avoid spot contamination of the meal.
- The pest prevention programme.

- Validation of control measures to inactivate *Salmonella*.
- Availability of procedures for verification of *Salmonella* controls and corrective actions.

Based on his risk assessment the operator has to decide which measures or combination of measures have to be implemented in order to accomplish the goal of *Salmonella* reduction. Some of these measures can be easily applied while others ask for significant investments.

EFISC and FEDIOL have developed the “checklist *Salmonella* control during oilseed crushing” in order to provide guidance to the operator. Emphasis is placed on Good Manufacturing Practices (GMPs), Hazard Analysis and Critical Control Points (HACCP), prerequisite programs and robust continuous improvement activities. The checklist provides additional guidance in addition to the [EFISC Code](#) and the FEDIOL [sector document on vegetable oil and protein processing](#). The checklist does not intend to include all different plant types but rather serves to highlight important practices for the control of *Salmonella* in protein meal and to verify the implementation thereof.

5.3 Decontamination of the finished product in case of *Salmonella* contamination

The operator shall consider National legislation and/ or requirements in case decontamination is applied on the final product due to *Salmonella* contamination.

The following measures can be taken in case of *Salmonella* decontamination:

- **Thermal treatment** of the contaminated meal is an option to reduce the *Salmonella* contamination. The effectiveness of the thermal treatment is influenced by the Aw, PH, exposure time and the kind of *Salmonella*. The following website provides a tool for the heat treatment of *Salmonella* by providing the D and Z values for *Salmonella* <http://www.hs-owl.de/fb4/ldzbase/index.pl>
- **Treatment with organic acid** is a technique to reduce the *Salmonella* contamination in the contaminated meal. The use of organic acids varies between different countries depending on differences in legislation or other factors and is in some EU countries not allowed. The operator shall check if the use of organic acid is allowed. The operator should follow the instructions of the organic acid supplier for the correct use of the product.

6.0 Serotypes

In case of a *Salmonella* incident serotyping will be carried out.

The information from Community monitoring systems shows that the five most frequent *Salmonella* serotypes in human salmonellosis are *Salmonella* Enteritidis, *Salmonella* Hadar, *Salmonella* Infantis, *Salmonella* Typhimurium and *Salmonella* Virchow.

Once the serotype is known it allows the operator to define the necessary action in proportion to the risk of the *Salmonella* contamination.

The requirements regarding *Salmonella* contamination vary by Member State within the EU. As Member States have quite diverging views on whether to differentiate between *Salmonella* serotypes, each operator has to take into account the EU and current national requirements. Based on this, the operator should determine the necessary actions that he has to take.

7.0 More facts

- <http://en.wikipedia.org/wiki/Salmonella>
- [FDA bad bug book](#)

8.0 Reference documents

- [European Food Safety Authority. 2008. Microbiological risk assessment in feeding stuffs for food-producing animals. Scientific Opinion of the Panel on Biological Hazards. The EFSA Journal 720:1-84](#)
- [DG Sanco- Opinion of the Scientific Committee on Veterinary Measures relating to Public Health On Salmonellae in Foodstuffs \(April 2003\)](#)
- [Salmonella control Guidelines- AFIA- \(November 2010\)](#)
- [Control of Salmonella in low moisture foods- GMA- February 4, 2009](#)
- [FDA- Compliance Policy Guide Salmonella in Food for Animals](#)
- [DTU Food- Assessment of the human health impact of Salmonella in animal feed](#)
- [NGFA - industry guidance testing animal feed or ingredients for Salmonella](#)
- FEFAC, COPA- COCEGA, FEDIOL, COCERAL- Common set of principles for the management of Salmonella risk in the feed chain

9.0 Acknowledgements

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Annex 1- Report DTU Food- National Food Institute- Assessment of the human health impact of Salmonella in animal feed

Page 37- 7. Conclusions and recommendations

1: Assessment of the association between Salmonella in animal feed and Salmonella infection of Danish broilers, table-egg layers, cattle, farmed fish, slaughter pigs and humans.

Feedstuffs constitute a source of *Salmonella* infection in animals as supported by many studies.

Considering the prevalence of *Salmonella* in feedstuffs and the amount of feedstuff consumed, it is assessed that contaminated feed on most occasions does not give rise to infections in food-producing animals.

Which particular factors or combination of factors that determine whether an introduction of *Salmonella* via feed become established in a farm is not fully revealed, but storage conditions of feed, the prevalence and concentration of *Salmonella* in the feed and feeding strategies are anticipated or known contributing factors.

In regions and/or animal populations in which *Salmonella* infections occur endemically, other factors for introduction and spread of *Salmonella* are considered more important than contaminated feedstuffs. In Denmark, this is assessed currently to be the case in pig production.

In low prevalence situations, an introduction of *Salmonella* via contaminated feed can result in large outbreaks which may spread to humans via contaminated food of animal origin. Such outbreaks are observed from time to time in e.g. Sweden and Finland, and similar outbreaks in Denmark can be expected in low prevalence animal populations such as laying hens and broilers.

In cattle in Denmark, *S. Dublin* and *S. Typhimurium* are the most important serovars and feedstuffs do not appear to play a major role for their introduction and dissemination. Feed contaminated with other serovars has been described as the source of infections in cattle in several studies, some of which also documented a spread to humans via contaminated food.

Only a very few studies on the role of *Salmonella* contaminated fish feed could be found through this review and none provided any evidence for *Salmonella* transmission from fish feed to humans. Consequently, the risk is assessed to be negligible.

Several studies comparing serovars found in feed with those found in animals and humans conclude that the most frequently occurring *Salmonella* serovars in humans are rarely isolated from animal feedstuffs. However, many serovars found in feed are also found in humans and a study has estimated that around 2% of human infections in Denmark can be attributed to feed borne serovars.

The implication of animal feed as an indirect source of human salmonellosis has been described in several case studies, where outbreaks in animals and/or humans have been traced back to contaminated animal feed. However, determining the overall contribution of contaminated animal feed to human illness, relative to other sources of contamination, is difficult with currently available data.

2: Identification of factors, associated with animal feed (pH, structure etc.), that determine whether exposure to *Salmonella* lead to infection in broilers, table-egg layers, cattle, farmed fish and slaughter pigs.

Based on available data, oil-based feed materials such as soy-, rapeseed- and sunflower seed products are considered the most important sources of *Salmonella* contamination from feed. Animal derived protein sources are also frequently contaminated with *Salmonella*, but their use except for fish meal is currently very limited. In contrast, non-processed cereals are considered to be of very low importance. In general, however, data on *Salmonella* occurrence in feed materials are scarce.

Many studies have shown a significantly higher risk for *Salmonella* occurrence in pig herds using heat treated and pelleted feed as compared to pig herds fed meal feed. The protective effect of meal feed is attributed to the increased production of organic acids and lowered pH in the pigs' gut. This association is assessed to outweigh the likely higher occurrence of *Salmonella* in feed materials (i.e. non-pelleted) used by farmers mixing their own feed based on e.g. oil-based products. Only few studies on the occurrence of *Salmonella* in home-mixed feed are available.

Coarser grinding and barley rather than wheat in a similar way lower the risk for *Salmonella* in pigs.

In Denmark, poultry are only given dried feed. For pigs more than 40% of the feed is applied as wet feed. In cattle most feed is fed as a mixture of fodder concentrates and coarse fodder. Additionally, pelleted feed is supplied for milk-producing cattle.

3: Assessment of available preventive measures, control methods and methods to reduce *Salmonella* in animal feed.

Compared to pig- and cattle production strict biosecurity measures and eradication of *Salmonella* in the poultry breeding stock has in many countries successfully led to a low frequency of vertical *Salmonella* transmission in the egg and broiler production, which is why introduction of *Salmonella* to the poultry flocks through feed is particularly undesirable and heat treatment of feed for poultry meat production is routinely applied in many countries including Denmark.

The effect of heat treatment on *Salmonella* depends on the temperature, the treatment time, the humidity and the initial *Salmonella* concentration. However, the effect of heat treatment in feed mills may be hampered due to the risk of recontamination from e.g. dust in the mill environment after processing. Persistent contamination of feed mill equipment has also been identified as a significant source of feed contamination leading to outbreaks in animals.

E. coli has been proposed as a reliable indicator for the presence or absence of *Salmonella* after heat treatment. However, only few scientific publications provide statistical evidence for this.

The effect on *Salmonella* of adding organic acids to the feed has been demonstrated repeatedly. The effect depends on storage time, temperature and moisture. Since the water content of commercial feed is generally low, the action of the acids is not always optimal and it is not clear whether it is an in-feed or a gastrointestinal effect against *Salmonella* that is the major reason for protection when fed to animals.

Due to low test sensitivity and high volume of feed used, it will be impossible to guarantee *Salmonella*-free batches of feed and the currently applied sampling procedures can only reliably identify highly contaminated lots of feed materials and compound feed. The real challenge lies therefore with the risk managers, to define an acceptable level of contamination so that batches with a contamination level above that limit can be handled in a cost-effective manner, where the obtained risk reduction bears comparison with the cost of intervention.

Feed producers should strive to reduce the occurrence of *Salmonella* in compound feed for all food-production animals. HACCP based programs and establishment of microbiological criteria (as laid down by the feed hygiene regulation) along the feed production chain should prevent (re-)contamination of feed and thereby ensure the quality of the end product.

4: Evaluation of the systematic review process as a tool to address the public health impact of *Salmonella* in animal feed.

The purpose of this review was to evaluate and summarize the evidence for an association between *Salmonella* occurrence in animal feed and human salmonellosis. We chose the systematic review process in order to evaluate the available information, using transparent and repeatable methods. The goal was to minimize the impact of study biases on the review conclusions and to convey to the reader not only the conclusion, but also enough information for the reader to appraise the value contained in the conclusion.

The studies on which we based our answers to the study questions were of a very varied nature including everything from simple descriptive studies of monitoring data to randomized controlled trial studies. In addition, very few studies attempted to answer the same question. This made it very difficult to perform a strict systematic review, where the purpose is to appraise and compare studies providing evidence for and against a specific hypothesis (i.e. answer to a study question), respectively.

This was further complicated by the fact that most studies providing evidence for an association between *Salmonella* contaminated feed and infections in animals and/or humans were case-based studies (i.e. case stories) mainly describing outbreaks caused by contaminated feed. Obviously, studies providing no evidence for such an association cannot be found in the literature, although every incidence of animals being fed *Salmonella* contaminated feed without being infected, in theory, could be considered as such.

Still, it is also possible that many of the observed infections in animals and humans actually do originate from contaminated feed. The association has just not been identified due to the complexity of the transmission pathways and the limited amount of data on *Salmonella* in feed, or the association has simply not been reported in the available literature. This means that the available literature most likely gives a biased picture of the true situation.

So although we from the beginning of the study were aware that this systematic review could only be a qualitative appraisal (as opposed to e.g. a meta analysis) of relevant literature, we found even this to be very difficult. We conclude that study questions to be addressed by systematic reviews should be very specific, and studies to be included should preferably have the same objectives, be conducted using well-described and appropriate study designs, and provide statistical measures for the investigated association. Studies based on a description of monitoring data or case-based studies can very well provide evidence for the association under investigation, but they are not suitable for a systematic review due to the reasons discussed above.

Exclusion of seemingly relevant research findings due to poor quality is a major concern to readers of systematic reviews. During the quality assessment step, we excluded 32 references, which we consider not to have influenced the conclusions drawn. However, it cannot be excluded that useful references may have been excluded during the title screening, if the title did not indicate its relevance for the subject.