Preventing Salmonella contamination in oilseeds-based animal feed

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Oilseeds byproducts are invaluable sources of protein and energy in livestock rations. They contain critical nutrients, such as essential amino acids, and enable the formulation and production of high-density rations designed to meet animal production requirements.

Salmonella contamination is a problem that may be encountered in the utilisation of oilseeds byproducts in animal feed. Contaminated feed can transfer the *Salmonella* bacteria to livestock and then on to the end consumer.

There is no silver bullet solution to the problem of *Salmonella* contamination, as each site is unique and the variables may differ. Mitigation strategies to reduce the risks of contamination should be based on a number of step-wise processes and approaches. Adapting systematic procedures and control measures within a general framework offers the best possible route to a successful outcome.

Types of *Salmonella* contamination

There are many types of contamination that may be broadly categorised as follows:

- Microbial contamination via bacteria (e.g. *Salmonella*, *Listeria*, *E. coli*) and fungi (moulds and yeasts).
- Chemical contamination via dioxins, PCBs, mycotoxins, pesticides, PAH4/BaP.
- Foreign matter contamination via glass, wood, metal, soil, insects and mineral oil.

Sources of contamination

Salmonella is spread by vectors either living (e.g. humans, birds, rodents, reptiles, and insects) or non-living (water, soil, air, surfaces, and vehicles).

Salmonella risk in oilseeds byproducts

Oilseeds byproducts are among the highest risk raw materials for *Salmonella* contamination worldwide. Contamination can occur at any stage during the production process, from growing the crop to harvesting, processing, transport or storage. The European Commission assigns most oilseeds byproducts a level four risk classification (the highest risk level) for *Salmonella*.

South African statistics by the Animal Feed Manufacturers' Association (AFMA) indicate approximately 6 to 7% *Salmonella* contamination in local soya bean meal and 3 to 4% contamination in sunflower meal, with lower contamination levels in local cotton and canola meals.

Salmonella habitat

Salmonella is a genus of gram-negative bacteria that falls into the family *Enterobacteriaceae* (the same as *E. coli*). They prefer anaerobic (absence of oxygen) conditions but can survive in aerobic (oxygenated) environments. *Salmonella* bacteria are highly motile, using flagella around the cell body to move quickly and easily in a fluid environment inside a host.

The bacteria may be carried by a range of vectors, living and non-living, and have an extremely high survival rate and resistance level. There are serovars that can remain dormant at a site for more than two years before becoming detectably active. *Salmonella* is well distributed in the environment.

These bacteria are susceptible to heat, and contamination of oilseeds byproducts is primarily via recontamination after processing/production as the heat generated during extraction/extrusion is sufficient to ensure bacterial kill-off.

Salmonella bacteria may be split into two groups: *Salmonella enterica* that affect warm-blooded species such as humans, livestock and animals; and *Salmonella bongori* that affect cold-blooded species such as reptiles.

Salmonella enterica is the group of most concern in the food and feed industry, as zoonotic serovars in this group are pathogenic to humans and livestock.

Biofilm formation

Most bacteria, including *Salmonella*, can survive outside their hosts for extended periods of time in difficult environmental conditions. This is done through a mechanism known as biofilm production. When conditions are stressful (e.g. during times of low moisture or low temperatures) *Salmonella* will cluster together and form a protective barrier (biofilm) to prevent desiccation and death.

These biofilms are made from the aggregates of flagella and bacterial walls, composed primarily of water, proteins and polysaccharides. Channels in the biofilm allow for the flow of nutrients and water into the biofilm matrix, to sustain bacterial growth and replication. Biofilm has strong adhesive qualities to living and inert surfaces, allowing for bacterial attachment to various surfaces and sustained survival for reasonably long periods. Inside the biofilms, bacterial communities form, grow and sporadically release high concentrations of bacteria.

These communities can communicate with other bacterial communities via quorum sensing, signalling information about population densities and environmental risks and triggering specific gene activations for enhanced survival. The formation of biofilms also triggers stress gene activation for increased resistance.

Biofilms are highly resistant to antibiotics, antimicrobials, disinfectants, immune cells and environmental changes, making eradication extremely challenging. It is estimated that 80% of bacterial infections are related to biofilms. Biofilm formation facilitates systemic and recurrent *Salmonella* contamination. Current research therefore focuses on compounds with the ability to break down biofilms, clearing a pathway for antimicrobials and disinfectants to reach and destroy the bacteria.

Figure 1: Biofilm lifecycle.

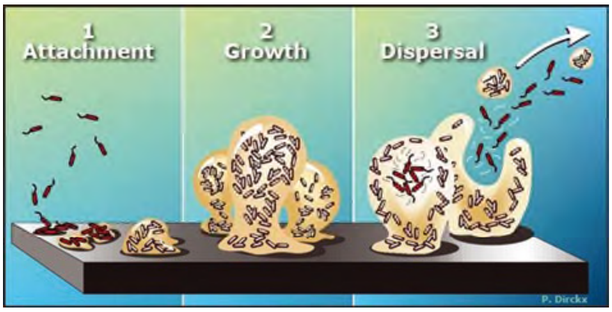

Table 1: Biofilm chemical composition.

Sample no	Components	Percentage of matrix
1	Microbial cells	2% to 5%
2	DNA and RNA	< 1% to 2%
3	Polysaccharides	1% to 2%
4	Proteins	< 1% to 2% (including enzymes)
5	Water	Up to 97%

Salmonella contamination

Salmonella detection in swabs, raw materials, final products and dust is generally split into three categories:

- Repetitive detection with two or more consecutive *Salmonella* positive results on a specific sample or sample type.
- Recurrent detection with two or more *Salmonella* positive results on a specific sample/sample type within the last six testing periods.
- Systemic detection with two or more *Salmonella* positive results in different samples/sample types/areas within a testing period.

Procedures after positive test results

Standard testing: Routine testing procedures and numbers, based on production volumes, when there are no positive samples detected or confirmation testing is negative.

Intensive testing: Positive sample detection necessitates sample retesting to confirm the result. A positive result for *Salmonella* on a retested sample requires intensive investigation. The historical data must be examined and if it has previously tested positive for similar/same sample type, the sample must be categorised as 1-repetitive, 2-recurrent or 3-systemic non-compliance. Ventilation, general management practices, maintenance and calibration, sanitation, employee traffic and flow and equipment must be evaluated. After the evaluation, an action plan should be written up and implemented.

In-depth testing: If, after intensive investigation, samples continue to test *Salmonella* positive, a more in-depth investigation and a full review of all processes are required. A hold-and-test policy is often put in place for all final products. To move out of this phase, there must be three to five consecutive days of testing showing negative results for *Salmonella*. Once the processes have been reviewed, the action plan is updated, implemented and regularly checked.

Hygiene protocols

Following a hygiene programme is critical to ensure the safest and best quality product is produced and maintained, until consumption. Hygiene programmes follow standard steps organised into sections. Other steps and changes can be taken to adapt to conditions, and raw material suppliers and feed manufacturers will often follow similar procedures and steps, with customised adaptations for individual variables.

Sanitation and cleaning: Scheduled and regular cleaning of buildings and equipment, to prevent dust and waste accumulation. Procedures should preferably involve dry cleaning (where possible) followed by disinfection, to prevent moisture accumulation and microbial growth.

Dust control and air flow: Ensuring good air flow and ventilation design is a recommended practice, especially to prevent contamination from high risk areas to final product areas. Dust control should focus on removal of accumulated dust in processing and storage areas. Dust and sweepings should be disposed of correctly, as they have a high risk of *Salmonella* contamination.

Pest control: Practical measures to control pests should be taken and documented. Ensuring good drainage and weed/vegetation control around the facilities helps control pests. Pest control companies are often used to manage these risks.

Materials handling: The receiving, handling, storage and processing procedures for raw materials and final products should be documented, including procedures for non-conformance, such as high-moisture materials and over/under-processed materials.

Moisture control: Roofs, ceilings and walls should be leak-proof and storage points kept dry. Moisture condensation points should be prevented as far as possible.

Disinfection: High risk areas (critical control points) should follow a documented disinfection programme to ensure microbial contamination risks are managed. Should any *Salmonella* positives be ascertained, additional actions and disinfection procedures may need to be performed and documented.

Test results should be kept on record to track trends and risk levels. Final product decontamination may also need to be performed in some cases, and products to prevent re-contamination of final products after production (e.g. formaldehyde and organic acid products) are often used.

The market

Buyers and traders increasingly require proof of a hygiene control programme from suppliers that have qualified as approved and preferred. Where this is not the case, having a good hygiene programme in place increases customer confidence in products and demonstrates product quality in the competitive market.

Export products often require validation by third parties, involving evaluation of the quality/hygiene programme in place. Accreditation (such as HACCP) may also be required. Having a quality and safety programme in place gives producers a competitive edge.

References available from the author. For more information, send an email to maja.sakkers@kemin.com.