Managing *Salmonella* in feed and the feed mill

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Rick Carter

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Introduction

Manufacturers of broiler and layer feed aim to produce feed that meets customer's expectations including consistently achieving bird production targets. This requires feed to be consistently 'fit for purpose' which includes meeting a number of quality determinants, e.g.

- nutrient content - ensure analyses match specifications
- physical quality - uniform mash texture, density and appearance as well as acceptable and consistent pellet/crumble durability

Failure to meet quality criteria may compromise bird performance which could make the feed 'unfit for purpose'. However, 'fit for purpose' should also include 'safety'. Feed safety encompasses the use of ingredients considered to be safe along with the manufacture, storage and distribution of the feed to help ensure safety for the animals consuming the feed, and of course safety for people consuming food products derived from the fed animals, e.g. meat and eggs. This requires identification of hazards that may cause adverse effects to animals or people, and analysis of the risks in terms of likelihood of occurrence and severity of effects. Hazards are typically classified as physical, chemical and biological. Controlling feed safety risks may entail hazard prevention, elimination

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Table 1: Feed mill line *Salmonella* survey data.

Mill location	Reference, number of mills & country					
	Davies & Wray, 1997[1] 10 mills, U.K.		Jones & Richardson, 2004[2], 3 mills, U.S.A.		Parker, 2008[3] 17 mills, Australia	
	No. of samples	% +ve for *Salmonella*	No. of samples	% +ve for *Salmonella*	No. of samples	% +ve for *Salmonella*
Intake pits & augers	282	24.1	-	-	-	-
Intake pit	-	-	-	-	79	0
Elevator	-	-	-	-	220	1.4
Ingredient bins & augers	637	12.7	-	-	-	-
Grinder	198	15.7	-	-	-	-
Mixer	348	11.8	178	8.8	241	0.8
Conditioner	-	-	-	-	57	7.0
Pellet press	308	7.5	168	4.8	576	1.4
Cooler	430	20.2	188	3.2	755	2.6
Out-loading bin	484	15.1	95	5.3	303	0
Out-loading area	210	10.5	-	-	-	-
Warehouse/bagging out area	202	8.4	-	-	-	-
Wild bird droppings (from 6 mills)	51	19.6	-	-	-	-

[1] samples were fine spillage, dust, fatty material from cooler;
[2] samples were feed collected twice during both early spring & summer;
[3] samples were feed material collected and analysed over a 4-year period

or reduction. The production of 'safe feed' should apply to commercial feed manufacturers as well as non-commercial, on-farm mixed feed production. Control measures need to be practical and achievable with effective preventative actions involving 'multiple hurdles' being preferable to correcting non-conformances after their occurrence.

Salmonella

Biological hazards include microbiological contaminants such as mould and *Salmonella*. *Salmonella* is a notorious biological hazard due to its potential to contaminate food products. *Salmonella* subspecies enterica are Enterobacteriaceae. There are over 2,500 different strains of *Salmonellae*, i.e. serovars, e.g. *S. typhimurium*. They can be further classified by phage typing (PT), i.e. their susceptibility to bacteriophages, e.g. *S. typhimurium* PT9. Avian host adapted specific serovars cause serious infections and disease in poultry, i.e. pullorum disease (*S. pullorum*) and fowl typhoid (*S. gallinarum*). Whilst non-host adapted paratyphoid serotypes (e.g. *S. typhimurium*) may also cause disease, birds carrying these non-host adapted paratyphoid *Salmonellae* generally display no symptoms but can cause illness in people consuming contaminated chicken meat or eggs. Food 'poisoning' caused by *Salmonellae* is manifested as acute gastro-enteritis with young, old, and immuno-compromised people being most susceptible. *Salmonellae* can be ingested by the bird, multiply in the gut, and then spread and persist in the environment thus becoming a source for other birds. A range of hatchery and farm biosecurity and hygiene measures are needed to control *Salmonellae* infections in poultry, with feed and feed mill hygiene aimed at keeping the feed free of the bacteria.

Feed and feed mills

Salmonella entry points include feed, litter, drinking water, purchased stock, trucks, the environment, pests (e.g. rodents and beetles), wild birds, other livestock and domestic animals, equipment, and people. Feed has been referred to as a "major source of introduction" of *Salmonella* into commercial production and "close to 80% of the *Salmonella* serotypes isolated during routine monitoring of feeds and feed ingredients were the same serotypes found weeks later during the monitoring of breeding flocks and their offspring". It has been stated that "It is no good to try and be completely *Salmonella* free if no feed decontamination is undertaken".

Feed mill surveys have been published showing the percentage of samples detected with *Salmonella* from various points along the feed milling process (Table 1). Of particular relevance from an Australian study is that the incidence of combined *Salmonella* detections from feed ingredients, mill processing equipment, and final feeds decreased by 15% per year over the 4-year survey period during which feed quality management systems based on HACCP (Hazard Analysis and Critical Control Point), GMP (Good Manufacturing Practice) and Good Hygiene Practices, were implemented across all feed mills in the survey.

Programme

Good manufacturing practices including operational procedures are aimed at producing feed that is safe and of consistent quality. A key element of feed 'safety' is to produce feed that is microbiologically safe, and so the basic premise of a feed

Figure 1: Monitoring of feed ingredients and delivery trucks are needed to ensure that *Salmonellae* do not enter the mill via feed ingredients. Maintain storage silos to ensure that raw materials are not affected by moisture ingression and have a bin cleaning and sanitation programme.

mill *Salmonella* control programme is to produce feed that is free of all *Salmonellae*. Hazard analysis and critical control point determination is needed to systematically identify, analyse and control the *Salmonella* hazard.

Three essential elements of a *Salmonella* control programme have been defined as;

1. Prevent contamination entering the mill

It is well known that *Salmonellae* can enter the feed milling system from feed ingredients and from the excreta of wild birds and rodents, with insects also being vehicles for the spread of bacteria. With no heat kill step in the production of mash feed, management of feed ingredients is paramount. Feed ingredient supplier management systems including monitoring of ingredients for Total Enterobacteriaceae Counts (TEC) and *Salmonella* are required. Delivery truck monitoring and hygiene are also needed. A thorough rodent and wild bird control programme is required to exclude this source of contamination of feed ingredients, the milling system, and final feed. Other wild or domestic animals should not be allowed inside the feed mill boundary as they may also carry *Salmonellae*.

2. Reduce multiplication within the mill environment

This step is very important when feed is predominantly in mash form as there is no heat kill step. This requires comprehensive and effective mill hygiene procedures to keep each point along the milling process dry and clean with minimal dust accumulation. Roofs, ceilings and walls should not allow water ingression. Maintenance of mill cleanliness must be a part of the mill's GMP programme. Whilst regular cleaning procedures should be scheduled, physical cleaning should be a normal component of daily work functions, e.g. feed or feed ingredient spills should be cleaned up immediately to promote a good 'cleaning culture'. Each point along the milling process requires its own set of *Salmonella* preventative and corrective actions, i.e. feed ingredient receival, storage, milling, batching and mixing, mash feeds, pelleted feeds, pellet cooler, conveying to out-loading bins and/or bag packing bins, out-loading and feed delivery ('Feedmill *Salmonella* Control Programme', Kemin). A programme of aseptic sampling of feed material and dust, including surface swabbing, at points along the milling process for TEC and *Salmonella* testing, is required in order to determine where microbial contamination and multiplication are occurring so that targeted corrective and preventative actions can be implemented.

3. Have procedures in place to kill the bacteria

Appropriately formulated organic acid and organic acid-formaldehyde based liquid products may be used to treat contaminated and higher risk ingredients. Exposure to steam heat in the pelleting process can kill *Salmonellae*, but effectiveness will depend on a number of factors including temperature, moisture, and the time exposed to temperature. The line survey data in Table 1 suggest that the pelleting process has limitations. *Salmonella* inhibitor products (Sal Curb, Kemin) are useful in mash feeds and are also used in pelleted/crumbled feed as a supportive adjunct to the pelleting heat kill step. Powdered inhibitor products can be flushed or added into points along the feed milling process to contribute to overall feed mill hygiene. Powder dusting equipment can also be used to distribute powdered *Salmonella* inhibitor products into enclosed spaces such as bins and silos and

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generally into places along the milling process that are difficult to access. Powder dusting can also be used for surfaces such as flat storage areas.

Examples of some items that require consideration in a feed mill's *Salmonella* control programme include (see Kemin's 'Feedmill *Salmonella* Control Programme' booklet for detailed preventative measures and preventative actions, monitoring actions, corrective actions and records):

Feed ingredient suppliers

- establish and maintain an approved supplier system
- approved suppliers should ideally have an audited quality management system that includes monitoring and controlling *Salmonellae*
- ensure a delivery truck hygiene programme is in place; the use of dedicated vehicles is desirable

Feed ingredient receival

- establish a sampling and TEC/ *Salmonella* testing schedule
- powder inhibitor product flush treatments for ingredient intake pits and augers
- inhibitor product powder fogging of ingredient storage bins & flat storage areas

Liquid inhibitor product treatment of high risk feed ingredients

- e.g. when used in critical diets
- routine treatment or as required based on testing and/or prior history
- treat at the supplier's premises or at the feed mill
- may require designated storage bins

Mixer and pellet press

- mixer cleaning regime - removal of accumulated material & inhibitor product treatment
- ensure press is operating at required designated conditions
- use of press diverter, or inhibitor product treatment of initial batches if no diverter available
- press and diverter cleaning schedule including dust control around the pellet press

Post-pellet press hygiene

- identify any equipment that allows build-up of feed and penetration of moisture
- mixer application of a powder inhibitor flush of the production line
- cooler cleaning schedule including powder inhibitor product fogging
- bucket elevator boot clean-out schedule & powder inhibitor product addition into boots
- cleaning schedules for out-loading bins, bag packing bins, and bagged feed warehouse areas including powder inhibitor product fogging

Inhibitor product treatment of critical feeds

- e.g. breeder feed, starter feed, pullet rearing feed, mash feed
- finished feed testing schedule for *Salmonella* and total Enterobacteriaceae

Feed delivery transport

- routine truck cleaning including inhibitor product powder fogging treatment
- use of dedicated vehicles

Feed mill pest control programme

- grounds around mill to be well drained
- no long grass in or around the mill site
- immediately remove spilt feed and feed ingredients from all locations in and around the feed mill
- cover intake pits when not in use
- extensive, controlled and managed use of bait stations for rodents
- have systems in place to prevent wild bird entry, e.g. intake pit area and out-loading area entry and exit doors, mesh bird netting use where practical
- exclude domestic and wild animals

Figure 2: Maintain hygiene and vermin control in the finished feed area.

Conclusions

A low level of participation in feed mill and feed hygiene is associated with higher *Salmonella* risks. Increasing levels of participation and intervention are associated with progressively reduced risk. Whilst interventions can be ratcheted up or down, the 'default' level of participation and intervention options need to be determined by analysing and assessing the risk of the *Salmonella* hazard in relation to any adverse effects and consequences.

Appropriate preventative and corrective measures and actions are required to control *Salmonella* in feed and in the feed mill environment. The preventative programme should create multiple hurdles for *Salmonella* with the right combination of hurdles cumulatively helping to ensure the production of *Salmonella* free feed. AF

*Dr Rick Carter (rick.carter@kemin.com) is Technical Services Manager with Kemin Animal Nutrition and Health Asia. Certain statements may not be applicable in all geographic regions. Product labeling and associated claims may differ based upon regulatory requirements. A list of references is available from the author.

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