Preharvest Food Safety: Animal Production

The demands for food safety "from inception to ingestion" have put new emphasis on control of foodborne pathogens at the production, the farm, level.

The chemical and physical hazards at the farm level (e.g., residues of drugs and pesticides, broken needles in muscle tissue) are of minor public heath significance.

Among the microbiological hazards, not all foodborne pathogens can be brought under some kind of control at the farm level.

Bacillus cereus, Staphylococcus aureus, Clostridium perfringens and *Clostridium botulinum* are ubiquitous.

Shigella is a human specific pathogen.

Brucella, Mycobacterium bovis, EHEC (e.g., *E. coli* O157:H7), *Salmonella* and *Campylobacter* are potential candidates for "on farm" control.

Brucellosis and tuberculosis, which are also animal diseases, have been eradicated in many industrialized countries.

The "enterics" such as *Salmonella,* EHEC and *Campylobacter* seldom cause animal disease, but they have a very broad host range and can not be eradicated. However, they can be controlled to some extent.

Lack of knowledge about the ecology of these organisms in the farm environment can be a serious obstacle to their control.

Table1: Prevalence of Pathogenic Microorganisms on the Farm.

Microorganism	Unit	% Positive[1]
Salmonella	Swine herds	15-38
Salmonella	Pigs	3-28
Salmonella	Dairy herds	16
Salmonella	Chicken	–1-10
Salmonella	Layer flocks	40-50
E. coli O157:H7	Feedlots	63
E. coli O157:H7	Feedlot cattle	2
Campylobacter	Chicken	80-100

[1] A herd is positive if one or more animals are positive.

The following discussion is focused on *Salmonella* which is the most studied of above microorganisms.

The quoted prevalences are 10 to 100 times higher than estimated prevalences in humans.

Colonization of Animals

Cows can get mastitis with *Salmonella* and *E. coli*.

Normal adult microflora reduces the risk of intestinal colonization of all animals (and humans).

Young chicks can become colonized after exposure to 1 - 5 *Salmonella*, and the organism spreads rapidly in the flock. Shedding of *Salmonella* starts 2 - 22 hours after exposure, peaks after 2 - 3 weeks and most birds become negative after 7 weeks. Four-week-old chickens do not become colonized after exposure to 100 *Salmonella* and among adults only a few become colonized after exposure to 10,000.

Campylobacter is seldom found in chickens until 2 - 3 weeks of age, then almost 100% become colonized and remain so for at least 4 weeks.

Among 8-week-old pigs fed 500 *Salmonella*, none became colonized; but if fed 50,000 (i.e., 5×10^4) *Salmonella* a few pigs became colonized. Increasing the number to 5,000,000 (i.e., 5×10^6) all pigs became colonized. Pigs showed no clinical signs; they shed *Salmonella* for 4-5 weeks, then intermittently.

Transport "stress" may increase shedding among pigs:

1 day awaiting slaughter	19% shedders
2 day	24%
3 day	48 %

It seems clear that, except for newborn, pigs and poultry are fairly resistant to *Salmonella* colonization. This is due to the adult intestinal microflora that develops in chickens at about 4 weeks of age, in pigs at 4-8 weeks of age and in humans at about 1 year of age.

Mixed cultures of adult intestinal bacteria provide partial protection against *Salmonella* colonization when fed to the young:

- 80% reduction in numbers of colonized animals have been accomplished in chickens
- 60% reduction in numbers of colonized animals have been accomplished in pigs

Using mixed cultures is somewhat a cumbersome procedure and has not found widespread use.

Sources of *Salmonella* in Animal Colonization

- The vertebrate intestinal tract is an important reservoir for *Salmonella*.
- *Salmonella* can be brought into herds/flocks with colonized shedding replacement animals.
  Example: Rodents can bring *Salmonella* into the farm environment. In *Salmonella*-positive poultry houses 24% of mice and 8% of rats were found positive. A mouse can become colonized by less than 15 *Salmonella*, and can shed more than 230,000 *Salmonella* per pellet for 10 months.
- Poultry and pig feeds are generally low in *Salmonella* with less than 0.1% of samples positive, probably below the infective level, but *Salmonella* can multiply if feed gets wet.
- Water is generally not a primary source of *Salmonella*, but may get contaminated (e.g., with sewage). *Salmonella* can remain alive in water for weeks.

Salmonella and other enteric pathogens can grow in water contaminated with very small amounts of feed or manure, they can even grow in fresh manure for a short time (few days).

The main factor controlling *Salmonella* in the farm environment is the water activity or equilibrium relative humidity of the environment. *Salmonella* and other enteric pathogens can grow at a water activity of higher than 0.93 which corresponds to a relative air humidity of 93%, and below that they die. Also, they die most rapidly at a water activity of 0.75.

"Wet Spots" in the farm environment spell danger.

In positive poultry houses there are several thousand times as many *Salmonella* in wet spots as compared to dry.

In dairy herds it has been found that recycling of *Salmonella* colonization is associated with pools of stagnant water. Wet cleaning of farm buildings is questionable unless the buildings can be dried fast and completely after cleaning.

The importance of moisture control for control of *Salmonella* on farms has not yet been fully understood.

E. coli O157:H7 survives for months in moist residues in troughs.

Strategies in Animal Production Food Safety

Eradication	Only possible with *Brucella abortus*, *Mycobacterium bovis* and a few other microorganisms and parasites
Exclusion	Bovine Spongiform Encephalopathy (BSE) and the above agents after their eradication
Control	The only strategy available for enteric, zoonotic pathogens

Tactics in Animal Production Food Safety

I. Slaughter of colonized and exposed animals
II. Quarantine and testing of replacement animals
III. Farm hygiene
IV. Vaccination
V. Mass treatment

- I and III are used in the Swedish *Salmonella* control program, seems to be quite expensive because limited knowledge about III
- II is not much used by individual farms
- IV has not proven very effective against foodborne zoonotic pathogens
- V competitive exclusion (CE) has limited use in control of *Salmonella* colonization of poultry, and that leaves III as the best option but at present it has a very limited scientific base

Example: California Egg Quality Assurance Plan

Components of production control:

- Purchase pullets and chicks from hatcheries participating in the National Poultry Improvement Plan (NPIP) or equivalent state plan.
- Chicks should be delivered with a certifying letter.
- Started pullets must be obtained from sources with an acceptable *Salmonella* prevention and control program.
- Chicks and pullets should always be transported in coops and trucks that are decontaminated between flocks.
- Obtain feed from mills that follow accepted feed industry Good Manufacturing Practices and the Recommended *Salmonella* Control for the Processors of Livestock and Poultry Feeds, 1988, by the American Feed Industry Association (AFIA) or an equivalent program.
- Use animal protein ingredients originating from rendering plants participating in the Animal Protein Producers Industry (APPI) *Salmonella* Reduction Education Program or equivalent.
- If used, medications, feed additives and pesticides must be administered according to approved label directions.
- Maintain an effective flock health program to include vaccinations, monitoring and periodic necropsy of mortality or cull birds.
- Maintain a farm rodent monitoring and reduction program.
- Pullet and layer buildings will be cleaned and disinfected before restocking. Third-party visual inspection of cleaning and disinfection is required. The inspection must be done by a certified quality control employee designated by the owner, or by a certified independent professional
- The farm will utilize a bio-security plan and train employees on proper procedures to execute the program. Document employee training and comprehension annually.

It is clear that this program aims at the exclusion of pathogens from the farm and elimination from the premises by cleaning; if pathogens gain access nothing prevents their spread.