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ST. PAUL, MINNESOTA
UNITED STATES OF MINNESOTA

Preharvest food safety - Where do we start in dairy herds?

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Why preharvest food safety on-farm?

Though the food supply of the U.S. is often considered one of the safest in the world, food safety improvements are still needed. Several arguments can be presented in support of this statement. First, food-borne disease remains a significant cause of mortality and economic burden in the U.S. Second, due to continual exposure to media reports of food-borne disease outbreaks and food product recalls, consumers are increasingly demanding higher quality and safer foods. Third, expanded global trade links the U.S. to food safety developments in other countries. Countries that develop systems that produce safer foods will use this for market advantage, and food safety and quality is likely to become a barrier to market access. Fourth, recent identification of emerging pathogens and development of antimicrobic resistance in food-borne pathogens indicate a failure of current methods of monitoring and control to deal with these problems, especially those resulting from healthy-appearing animals.

Improving food safety in the U.S. is a multi-dimensional problem and has many potential solutions. Overall, a 'multiple barriers' approach to food safety has been proposed, partly in recognition that total control at any single phase of the 'farm to fork' food chain is not possible. This implies food safety responsibility from each segment of the food chain.

How is this responsibility manifested at the farm level? Food consumers expect risk-free foods and blame food processors if this expectation is not met. In response, food processors are beginning to demand certain raw product quality specifications from its suppliers, namely producers. Therefore, the immediate customer for producers is the food processor. What this means is that no longer can the producer focus only on economic profitability, primarily based on quantity of product produced. Increasingly, producers must also be concerned about the quality of the product produced and meeting specific stated demands of direct customers. . This has been termed a change from "quantity-oriented food production" to "quality-oriented food markets" (Blaha, 1999).

Where to start preharvest food safety on the dairy farm?

These food safety concerns apply as directly to the dairy production industry as other animal production industries. What food safety hazards should be considered for dairy food products? How can one evaluate the risks due to safety hazards on a specific client dairy? These questions may be addressed formally using a risk analysis framework (Bridges, 1998), with steps of identifying hazards and estimating risks associated with those hazards (risk assessment), making decisions regarding risk reduction (risk management), and communicating decisions to others to effect the changes needed (risk communication). Briefly, one way to identify and prioritize potential hazards is to use recent human food-borne disease information, summarized in Table 1. These human food-borne illnesses originate from a variety of sources, and it is not currently possible to estimate the proportion due to foods of dairy origin.

Table 1. Major food-borne pathogens by incidence (Shallow et al., 1999) and cost of human illness (Buzby et al., 1996) in U.S.

Pathogen	Incidence of human illness (per 100,000 population)	Annual cost of illness
Campylobacter	21.7	$0.6-1.0 bil
Salmonella	12.4	$0.6-3.5 bil
Shigella	8.5	?
E coli O157	2.8	$0.2-0.6 bil
Cryptosporidia	2.5	?
Yersinia	1.0	?
Listeria	0.5	$0.2-0.3 bil
Vibrio	0.3	?

For dairy operations, sources of human exposure to food-borne pathogens include milk and dairy products and beef products. Pasteurization of milk greatly reduces the human health risk from consumption of dairy products, but currently, there is no single kill step for beef products, as irradiation of beef products is still in the final rule-making process by USDA-FSIS. Routine implementation of irradiation (cold pasteurization) has the potential of dramatically reducing human food-borne disease illness due to beef products. In addition, transmission of disease through water, direct contact, and other vectors of disease should not be neglected, especially those resulting in risks to farm families and others (e.g., veterinarians) with farm animal contact.

Until a formal risk assessment of these microbial hazards is completed, the risks of these hazards occurring in dairy products can only be estimated in a relative sense. This is shown in Table 2, based on the incidence of human illness and relative importance of milk and dairy products or beef products as sources of infection, and then dairy-related pathogens are prioritized by relative need for monitoring and control efforts, using a model adapted from Blaha (1997).

Table 2. Major food-borne pathogens and risks of milk and beef to public health in U.S.

Pathogen	Incidence of human illness	Relative importance of milk as source	Relative importance of beef as source	Rank of need for monitoring and control
Campylobacter jejuni	1	+	++	5
Salmonella	2	+	+++	1
Shigella	3	-	-	-
E. coli O157	4	+	+++	2
Giardia lamblia	5	?	?	8
Cryptosporidium parvum	6	+	++	6
Toxoplasma gondii	7	-	-	-
Yersinia enterocolitica	8	+	+	7
Listeria monocytogenes	9	+	++	3

Vibrio	10	-	-	-
Trichinella spiralis	11	-	-	-

* Mycobacterium paratuberculosis is not a proven public health risk, but perceived concerns warrant need for monitoring and control 4

A much more complete understanding of the epidemiology of each of these key pathogens is needed before implementation of HACCP-type control strategies on dairy operations. What is especially needed, in order to prevent human food-borne disease, is the linkage between farm practice and raw product contamination.

Salmonella is the human food-borne pathogen with the greatest estimated economic burden of human food-borne disease, and, as the focus of the current HACCP monitoring program by the USDA-FSIS in slaughter plants (USDA-FSIS, 1999), is a primary target for on-farm interventions. A variety of animal species are reservoirs of infection, including cattle, swine, and poultry. Information from the NAHMS 1996 national dairy study indicates at least 28% of dairy operations have milk cows shedding Salmonella at any point in time, with about 5% milk cow fecal shedding prevalence (Wells et al., 1998). There is evidence of clustering of Salmonellas on certain dairy operations.

Salmonella can be controlled, but not eradicated on dairy operations. For non-host adapted serotypes, control measures include simultaneously removing carrier cows, improving sanitation (reduce environmental burden of cow feces, avoid use of recycled flush water, contamination of feeds with manure), pest control (birds and rodents), and by addressing feed-borne Salmonella (Smith et al., 1992). An approach for dairy cattle using identification and removal of *Salmonella* infection sources, and adoption of quality assurance programs to assure use of this process, seems more promising than a test and cull approach.

E. coli O157 remains a difficult enigma. Cattle are considered the primary reservoir of human infection, though other species including dogs, horses, flies, and birds have cultured positive as well (Hancock et al., 1998). From the NAHMS 1996 national dairy study, 24% of dairy herds had at least one culture-positive milk cow, with a milk cow prevalence of about 1% (Wells et al., 1998). These estimates are consistent with those from the NAHMS 1995 national feedlot study (63% of feedlots, with higher sampling per feedlot, and 1% of fecal samples). Typical duration of shedding is short.

Due to the epidemiology of this organism, *E. coli* O157 eradication does not appear to be possible using test and cull methods. From studies to date, risk factors associated with fecal shedding of *E. coli* O157 in dairy cows are unclear. Factors that may be involved include feed management and water management. Dietary factors appear to be involved; one clinical trial showed that fasted calves shed the organism longer than nonfasted controls (Cray et al., 1995). Similarly, pens of feedlot cattle that were on feed less than 20 days were more likely to have positive cultures than those pens on feed longer (Dargatz et al., 1997). Another study suggested cow drinking water as a source of *E. coli* O157 (Faith et al., 1996), water troughs have been identified as sources of E. coli O157 (Hancock et al, 1998). Increased host resistance through competitive exclusion may prove useful in the future.

Very little is known about the ecology of **Listeria monocytogenes** on dairy operations, though it is considered to be ubiquitous in many environments. Weber found 33% of 138 German cattle shedding in feces (1995). Sanaa found risk factors in France included poor quality of silage (pH > 4.0), inadequate frequency of cleaning the exercise area, poor cow cleanliness, insufficient lighting of milking barns and parlors, and incorrect disinfection of towels between milkings (1993).

While the zoonotic nature of **Mycobacterium paratuberculosis** remains unclear, domestic and international consumer demands raise the importance of on-farm control. The NAHMS 1996 national dairy study has estimated at least 22% of dairy herds have at least one test-positive cow with a milk cow prevalence of 3.4% (NAHMS, 1997). This prevalence in dairy herds is greater than that found in U.S. beef cow-calf operations. Control of infection is possible, though requires long-term commitment using currently available tests. Control is focused on fecal hygiene, especially towards susceptible young calves, identifying and removing infected animals and their manure, and reducing the risks of introducing infected cattle to the operation. A herd status program is developing in many states to identify low-risk herds to serve as replacements.

Campylobacter jejuni is the most common human food-borne disease in the U.S., and though has reservoir in many animal species, most human outbreaks are linked to poultry. From a subset of the NAHMS 1996 national dairy study herds tested using a PCR test, 100% of herds tested had positive cows with a prevalence of 43% in milk cows. The ecology of C. jejuni on-farm has not been well studied, though would be expected to relate to fecal hygiene. The effectiveness of on-farm control measures has not been shown.

While the food-borne significance of **Cryptosporidium parvum** remains in question, its importance as a water-borne pathogen adds it to this discussion. Many different species of animals shed C. parvum oocysts, including cattle. Oocyst shedding appears to be clustered in young calves (primarily less than 30 days of age) and efforts to detect shedding of oocysts from cows around the time of calving have failed to date (Atwill et al., 1998). The NAHMS 1991-92 national dairy heifer study estimated at least 90% of dairy operations were positive for C. parvum, with 22% of preweaned dairy heifers shedding oocysts at any one point of time and nearly 50% of calves shedding the pathogen 1-3 weeks of age (NAHMS, 1993). Because of the clustering of fecal shedding in very young calves, environmental control may be feasible, with focus on preventing calf feces from contaminating surface water.

Very little is known about **Yersinia enterocolotica** and **Giardia lamblia** on dairy operations in terms of prevalence or control measures.

What should producers do now?

1. Start with **control of animal pathogens of economic importance** to the dairy enterprise. Healthy cattle are a prerequisite for any on-farm food safety program. Some of these pathogens are (Salmonella) or may be proven to be zoonotic (M. paratuberculosis) as well.

2. **Implement existing quality assurance programs** to increase consumer confidence in producer's concern about food quality and safety. The Milk and Dairy Beef Quality Assurance Program for residue avoidance is a first step. The development of QA programs incorporating best management practices is continuing regionally (e.g., Northeast Dairy

Quality Assurance program) and producers need to remain educated and attuned to the issues to retain market access.

3. Evaluate opportunities to be an early adopter to pathogen reduction programs, especially in those areas with market niche opportunities. This will likely involve cooperation with direct customers (milk processors, meat processors) to **implement best management practices** designed to prevent or control some of the key pathogens discussed above. It will be important to evaluate the costs and benefits of these practices and make changes as needed. Probable areas for focus include:

   a) **Between-farm biosecurity** program, initially directed towards control of pathogens from farm to farm through introduced cattle. Beyond potential reduction of food-borne pathogens, this biosecurity practice also has animal health benefits (e.g., M. paratuberculosis and Salmonella).
   b) **Within-farm biosecurity** (biocontainment), largely directed towards preventing cattle from exposure to diseased cattle and from consuming fecal material. Components will likely include feed and water management, manure and carcass disposal, and control of disease in hospital pens, calving pens, and treatment areas. Again, animal health benefits are likely.
   c) **Animal identification and records** are almost certain to be required as part of verification procedures.

What is the veterinary role in development of pre-harvest food safety pathogen reduction?

These changes lay the course of a new pathway for agricultural producers of food products, as part of food production chains, focusing on meeting the quality and quantity specifications of customers. Dairy producers need veterinary assistance in meeting these quality specifications, opening new opportunities for veterinarians with the needed skills and abilities. It is worth repeating that 'veterinarians must continue to play a critical role in identifying, monitoring, and discovering new ways to protect the food supply from public health risks' (Buntain, 1997). Certainly the traditional role of **diagnosis and treatment of diseased animals**, sometimes zoonotic in nature, must be continued. Likewise, the veterinary role of **promoting herd health and productivity**, must be continued. A new role of **assisting dairy producers to provide milk and meat products with safety and quality characteristics that meet the consumer demand** is developing. Components of the veterinary role are likely to include on-farm pathogen reduction and residue avoidance programs adapted to the operation, setting up and interpreting data from monitoring system, and implementing verification protocols. These new veterinary roles will call for nontraditional veterinary skills, such as computing and database management, sampling, risk assessment, data interpretation, as well as enhanced veterinary skills of diagnostics and outbreak investigation.

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