Review

An Overview of Microbial Food Safety Programs in Beef, Pork, and Poultry from Farm to Processing in Canada

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ABSTRACT

Canada’s vision for the agri-food industry in the 21st century is the establishment of a national food safety system employing hazard analysis and critical control point (HACCP) principles and microbiological verification tools, with traceability throughout the gate-to-plate continuum. Voluntary on-farm food safety (OFFS) programs, based in part on HACCP principles, provide producers with guidelines for good production practices focused on general hygiene and biosecurity. OFFS programs in beef cattle, swine, and poultry are currently being evaluated through a national recognition program of the Canadian Food Inspection Agency. Mandatory HACCP programs in federal meat facilities include microbial testing for generic Escherichia coli to verify effectiveness of the processor’s dressing procedure, specific testing of ground meat for E. coli O157:H7, with zero tolerance for this organism in the tested lot, and Salmonella testing of raw products. Health Canada’s policy on Listeria monocytogenes divides ready-to-eat products into three risk categories, with products previously implicated as the source of an outbreak receiving the highest priority for inspection and compliance. A national mandatory identification program to track livestock from the herd of origin to carcass inspection has been established. Can-Trace, a data standard for all food commodities, has been designed to facilitate tracking foods from the point of origin to the consumer. Although much work has already been done, a coherent national food safety strategy and concerted efforts by all stakeholders are needed to realize this vision. Cooperation of many government agencies with shared responsibility for food safety and public health will be essential.

Media headlines focusing attention on bovine spongiform encephalopathy and outbreaks of human foodborne disease caused by bacterial agents such as Escherichia coli O157:H7, Salmonella, and Campylobacter spp. (49, 57, 64) have in the last decade elevated food safety to a high-priority status for many national government agencies. Prominent food safety issues in North America, Europe, and Asia have escalated market demands for safer food and have had serious effects on international trade (67). Agri-food authorities worldwide are being pressured to identify major food safety priorities and to develop and implement targeted control programs (64, 68).

Hazard analysis and critical control point (HACCP) protocols, originally developed in the 1960s to ensure safe food for astronauts, provide a specific and systematic approach to food quality control by allowing identification of hazards and the points at which they can be controlled. HACCP principles have been internationally recognized and in 1993 were endorsed by the Codex Alimentarius Commission of the United Nations (in which Canada is represented by Health Canada [HC]), the Food and Agricultural Organization, and the World Health Organization (42). The concept of a gate-to-plate continuum, with HACCP principles applied at each step from the farm of origin to the product consumed, has been endorsed internationally but is implemented differently in different countries and regions (60).

Canada’s success in delivering safe and nutritious food to consumers has earned the Canadian agri-food industry its reputation and consumer confidence. Canadian farming has evolved through a combination of market demands and pressure from processors, new technology, veterinary expertise, and new research discoveries and training programs (49). All new farm practices have been voluntarily adopted (49). In the 1990s, Canadian agri-food commodity groups began initiating HACCP-like programs that have expanded into the refined programs currently being implemented (24). Food safety programs based on HACCP principles (processing level) or at least in part on HACCP principles (farm level) have been concurrently developed at all levels of government and at every step of the food production continuum from farm to consumer, requiring an intricate network of responsibilities and a high degree of coordination and cooperation among groups and agencies. Although
much information is available on individual agency or commodity web sites, no single comprehensive document synthesizes Canadian major food safety programs. Our objective was to review major microbial food safety (MFS) programs and policies in the production and processing sectors for beef cattle, pork, and poultry and to provide an informative up-to-date synopsis for policy makers and food safety communities in Canada and other countries.

DATABASE SEARCHES FOR INFORMATION

Web sites of major Canadian government agencies responsible for the development and implementation of MFS policies and programs were searched to identify information on “gate to plate” MFS initiatives, policy documents, descriptions of specific programs, and press releases. Individual web sites of national and provincial commodity groups were accessed to obtain information about their on-farm food safety programs and associated documents, such as producer manuals and press releases of new initiatives. Medical databases (e.g., PubMed, Medline, and Toxline), agricultural databases (e.g., Agricola and Commonwealth Agricultural Bureaux), and general science and veterinary science databases (e.g., Biological Digest, Education Resource Information Center, Biological Science, and Scholars Portal) were searched to obtain and evaluate relevant peer-reviewed publications.

Search criteria included “on-farm AND food AND safety,” “on-farm AND pathogen AND reduction,” “gate-to-plate” and other slogans, and other combinations of key words. Additional key words were “testing,” “microbiological,” “feed,” “hygiene,” specified province, “traceability” and “product tracing,” “HACCP,” “CFIA” (Canadian Food Inspection Agency), “processors,” and “producers.” Searches for specific MFS programs and policies for Salmonella, Escherichia coli (generic and pathogenic types), Campylobacter spp., and Listeria monocytogenes were conducted using “(country or province) AND (pathogen).” Several google.ca searches were also conducted using those previous key words. Copies of all relevant articles were obtained, and a review of their references was conducted to ensure pertinent information was not overlooked. In addition to these searches, selected government officials from HC and the CFIA responsible for developing or implementing the identified programs were contacted.

As agencies and groups developed and changed during the period when this work was done, some sites identified by the original search became defunct, and individual searches were conducted to locate information that had been available on the retired sites.

DEVELOPMENT OF CANADIAN HACCP-BASED FOOD SAFETY PROGRAMS

Federal food safety agencies. Two ministerial portfolios are jointly responsible for food safety in Canada. HC, under the jurisdiction of the Minister of Health, is responsible for establishing policies and standards regarding food safety and nutritional quality (50). The recently formed (2004) Public Health Agency of Canada, also reporting to the Minister of Health, is responsible for national oversight of surveillance of foodborne illness in humans (61, 62). Agriculture and Agri-Food Canada (AAFC) is responsible for providing information, research, technology, policies, and programs to achieve security of the food system (8).

In 1996, in response to mounting international pressure and a number of global foodborne crises, HC put forth initiatives directing the Canadian food industry to adopt HACCP principles. This scientific approach is designed to detect biological, chemical, and physical hazards before they occur and to implement control measures to prevent their occurrence (49). During this time, the CFIA, reporting to the Minister of Agriculture and Agri-Food, was established consolidating all food inspection–related resources at the federal level. In 1997, the Canadian Food Inspection Act was passed through the Canadian parliament, providing the CFIA with responsibility for enforcement of HC’s food safety policies and standards and all acts relating to agriculture and food (31). The CFIA has been promoting the adoption of HACCP principles within the food industry through a number of HACCP-based food safety programs. Two programs are described in this review; the third program, the Quality Management Program, applies to fish products and is beyond the scope of this review.

FSEP. Federally registered facilities inspected by the CFIA account for 95% of the meat produced in Canada (45). Traditional postmortem meat inspection and monitoring programs, although still required for international markets, do not detect the microbial hazards that have become important health risks in the last decade. Federally registered meat and other processing facilities adopted HACCP principles in the late 1990s (33) primarily to maintain open borders with the United States, where implementation of HACCP principles had become mandatory (29, 49, 67). Policies and standards for food processors established by HC are enforced in federally registered facilities through the Food Safety Enhancement Program (FSEP) of the CFIA. The FSEP HACCP program became mandatory in all Canadian federal meat-processing facilities in December 2005, when 86% of facilities either were already recognized by FSEP or were in the process of obtaining formal recognition (28). The Food Safety Enhancement Program Implementation Manual (24), authored by the CFIA, includes guidelines for interpretation of federal regulations. Provincial facilities, accounting for only 5% of the meat processed in Canada, are inspected either by provincial meat inspectors who operate under provincial legislation or by CFIA inspectors (British Columbia, Saskatchewan, and Manitoba) (23, 49). Provincial facilities may not export meat outside the province (23, 49).

OFFS programs. Although over half of the known infectious microbial agents may be transmitted from animals to humans (65) and live animals carry organisms responsible for outbreaks of human foodborne illness, Canadian food safety legislation and regulations are rarely directed at the farm sector, and no general licensing or inspection boards regulate primary producers (49). However, Canadian livestock commodity groups have proactively embraced HACCP principles, developing programs to re-
duce and prevent microbial, physical, and chemical hazards at the farm level. The Canadian On-Farm Food Safety (OFFS) Program, established by the AAFC in 1997, is administered by the Canadian Federation of Agriculture, a producer-funded organization (22). The Canadian OFFS Program, through its cost-shared funding, provided opportunities for national commodity groups to develop strategies and tools for educating producers and implementing OFFS programs. Commodity-specific OFFS programs, which promote a HACCP approach to identifying food safety risks and applying control measures to reduce them, have been developed and implemented in cooperation with the CFIA. By 2000, many large commodity groups had developed draft manuals for their OFFS programs and were evaluating them under selected pilot projects. This successful initiation of OFFS programs led to the establishment by AAFC of the Canadian Food Safety Adaptation Program in 2000, allowing national industry associations to access funding and implement food safety project initiatives beyond the farm to processing segments of the food continuum, e.g., marketing, distribution, and preparation of food (26). Since April 2004, these two programs merged and are now components of the Canadian Food Safety and Quality Program (CFSQP) (1, 2). The national On-Farm Food Safety Recognition Program was initiated in 2002 and is administered by CFIA with provincial and territorial government participation. This program provides a rigorous process of review, assessment, recognition, and on-going monitoring of the technical soundness and administrative effectiveness of OFFS programs. The federal, provincial, and territorial governments have established standard requirements for the development and maintenance of OFFS programs, including conformity assessment, auditor training, and a process for government oversight.

APF. In 2002, Canada’s provincial and territorial governments and the AAFC agreed on a strategy for putting Canada at the forefront of food safety by implementing a new program, the Agricultural Policy Framework (APF), with funding and support from all levels of government (1, 2, 5). This comprehensive plan had initial funding of $5.2 billion CD over 6 years to help Canada’s agri-food industry achieve the goals of building a national, sustainable agriculture system (1, 2, 5). The APF and its successor, which is currently under negotiation, will be central in the future Canadian agri-food industry (3). Its main goal is to integrate current initiatives (e.g., OFFS programs), building a new, flexible agri-food industry that provides producers with the tools they need to adapt to new situations and challenges (1, 2). The program has five components: business initiatives, food safety and quality, science and innovation, environment, and renewal (1, 2). The chapter on food safety and quality sets out the common goals, targets, indicators, and implementation measures in food safety, quality, and traceability for all segments of the food production chain from input suppliers to final marketers. The overall objective is the provision of a government-recognized uniform system for food safety and quality control at the national level. The federal government allocated $142 million CD over 5 years (2002 to 2007) in support of these initiatives (1, 2).

The APF’s sustainable agriculture vision includes development and validation of food safety standards, a national integrated enteric pathogen surveillance program, and an antimicrobial resistance surveillance program (2). Use of the APF will transform the agri-food industry, requiring the cooperation and teamwork of the industry stakeholders and a complex network of government agencies to enhance, enforce, and support the proposed strategies.

CFSQP. The APF’s CFSQP was initiated 31 March 2004, replacing both the Canadian OFFS Program and Canadian Food Safety Adaptation Program (1, 2). Until 2003, these programs were supported by the AAFC via the Canadian Adaptation and Rural Development fund (10). The CFSQP provides funding for national food safety and food quality systems, with a program for traceability and product tracing from gate to plate (1). Industry associations, national producer organizations, regional commodity groups, and producer initiatives will be funded by the CFSQP until 2008, when it is expected that a number of national commodity groups will have implemented CFIA-recognized OFFS programs (2). Funds have been available to support the development of national, HACCP-based food safety systems since December 2003 and for on-farm implementation of food safety and traceability systems since April 2004. These farm systems include producer workshops and assistance in meeting program requirements, implementing HACCP principles, and participating in traceability and product tracing programs (1, 2, 5).

CANADIAN APPROACH TO OFFS

Thirty national commodity-specific OFFS programs have been initiated, covering approximately 99% of primary agricultural commodities in Canada (34). Fourteen programs are related to livestock or poultry commodities. All of the programs have undertaken a generic hazard analysis, based on Codex HACCP principles (42) and CFIA’s FSEP methodology (24, 33), resulting in the development of good production practices and critical control points to minimize food safety risks. The national programs offer training programs for producers, manuals and record keeping systems, and certification at the farm level. Recertification at regular intervals is required, as described within individual commodity OFFS programs. In beef cattle, swine, poultry, and other livestock commodity programs, specific good production practices are prescribed for purchasing breeding stock, animal management, building design and sanitation, medical supply management, water management, biosecurity practices, animal marketing, traceability and notification, transport, and personnel training (19, 35, 41). Risk reduction plans in OFFS producer manuals identify biological, chemical, and physical hazards, address regulation of feed and water hazards, and suggest means of dealing with high-risk animals. Use of good production practices alone effectively controls or prevents some hazards such as broken needles in meat (27). A syn-
TABLE 1. Canadian On-Farm Food Safety (OFFS) programs of selected Canadian national food-producing animal groups, their status in the CFIA OFFS recognition program, and numbers of producers represented

<table>
<thead>
<tr>
<th>Commodity (reference)</th>
<th>OFFS program (year initiated) [date of technical review completion, stage 1]</th>
<th>No. of producers represented nationally</th>
<th>Commodity development group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table eggs (21)</td>
<td>Start Clean, Stay Clean (1999) [Feb 2004]</td>
<td>1,069</td>
<td>Canadian Egg Producers’ Council, Canadian Egg Marketing Agency</td>
</tr>
<tr>
<td>Turkeys (13)</td>
<td>Raising Turkeys-Producing Food (2003) [May 2006]</td>
<td>538</td>
<td>Turkey Research and Resource Bureau, Canadian Turkey Marketing Agency</td>
</tr>
<tr>
<td>Bison (14)</td>
<td>CBA On-Farm Food Safety Program (2001) [ongoing]</td>
<td>1,800</td>
<td>Canadian Bison Association</td>
</tr>
<tr>
<td>Veal (59)</td>
<td>Quality Assured Ontario Veal (2004) [did not enter the CFIA recognition processes]</td>
<td>NA</td>
<td>Ontario Veal Association, Fédération des producteurs de bovins du Québec</td>
</tr>
</tbody>
</table>

a NA, not available.

A synopsis of the OFFS programs of selected national food animal production groups, the number of producers targeted for inclusion, and the current status of their implementation is given in Tables 1 and 2.

No specific sampling and testing schemes or hazard specific mitigation strategies presently exist at the farm level, for any of these or other commodities, although more than half of the many biological hazards identified at the farm level, including *Salmonella*, can be transmitted from apparently healthy animals (49, 57). Biological hazards are still primarily controlled at the processing level or through cooking and safe food handling methods encouraged by product labeling and consumer education, i.e., at the consumer end of the gate-to-plate continuum.

TABLE 2. Current status of development and implementation of the OFFS programs in selected Canadian national food-producing animal groups (modified from the OFFS programs status report (34))

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Phase 1</th>
<th>Phase 2, development</th>
<th>Phase 3, implementation</th>
<th>Phase 4, official recognition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2 3 4 5 6 7</td>
<td>8 9 10 11 12 13</td>
<td>14 15 16 17</td>
</tr>
<tr>
<td>Hatching eggs</td>
<td>C C C C IP C</td>
<td>O O O O O O O C C NS NS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Table eggs</td>
<td>C C C C C C C</td>
<td>O O O O O O O C C NS NS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Broiler chickens</td>
<td>C C C C</td>
<td>C C C C C C C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hogs</td>
<td>C C C C R R O</td>
<td>O O O NA O O C C NS NS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dairy</td>
<td>C C C C C C C</td>
<td>O O O O O O O C C NS NS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beef</td>
<td>C C C C R R IP</td>
<td>O O O O O O O C C NS NS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sheep</td>
<td>C C C C IP C</td>
<td>IP O O O NS NS NS C C NS NS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turkeys</td>
<td>C C C C IP C</td>
<td>IP NA O O O O NS C C NS NS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bison</td>
<td>C C C C IP IP</td>
<td>IP O O NS NS NS NS C C NS NS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cervids</td>
<td>C C C NS NS NS NS NS NS NS NS NS NS NS NS NS NS NS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Veal</td>
<td>C C C IP NS NS NS NS NS NS NS NS NS NS NS NS NS NS</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a Phase components: 1, national strategy; 2, generic model; 3, producer materials; 4, pilot project; 5, auditor training materials; 6, producer training materials; 7, program management system; 8, producer awareness sessions; 9, producer training sessions; 10, auditor training sessions; 11, preaudit service; 12, on-farm audits; 13, certification scheme; 14, screening technical review; 15, technical review; 16, gap analysis management system; 17, implementation assessment. Status: C, complete; IP, in progress; NA, not applicable; NS, not started; O, operational; R, being revised.
The Canadian egg producers’ food safety program, “Start Clean–Stay Clean,” which completed the first stage of the CFIA recognition in 2004, is unique in that the Egg Producer Testing Program includes monitoring for *Salmonella* Enteritidis (21). The CFIA conducts random *Salmonella* Enteritidis tests in grading and production facilities and environmental sampling in barns, e.g., barn dust and feathers. If *Salmonella* Enteritidis is detected, all eggs are pasteurized and marketed as processed eggs. This program offers incentives such as compensation to help ease lost wages resulting from a positive *Salmonella* Enteritidis test result. Recently, Quebec has initiated a farm-to-slaughter *Salmonella* surveillance program in swine (63) that is similar to a Danish program (68).

A number of Canadian government-funded and industry-funded research projects are investigating baseline pathogen prevalence and antimicrobial resistance at the farm and processing levels (53–55, 62). A 3-year study on the prevalence of pathogens of public health concern on Ontario pig farms will be completed in 2007 (66). The results of this research may influence development of targeted MFS monitoring and control programs, setting specific targets and the means for achieving them.

Voluntary producer-led OFFS programs are in different stages of development or implementation for different livestock groups (Table 2). At present, there are no penalties to producers for violation of the program objectives, which might affect the level of uptake and compliance. Higher rates of implementation have been observed in swine and poultry producers than in beef cattle producers (personal communication with specialists involved with the implementation of OFFS programs). This difference may be due to the integrated nature of swine and poultry production systems and the experience of Scandinavian swine and poultry industries in implementing integrated control programs for *Salmonella* (68, 69), which prompted these commodity groups to be more proactive in adopting the principles of OFFS. Other factors such as the program availability, market demands, industry size, cost of implementation, and major disease occurrence (e.g., bovine spongiform encephalopathy in cattle in Canada in 2003) might also affect implementation of the OFFS programs. The lack of scientific evidence on the effectiveness (including cost-effectiveness) of food safety control measures or programs at the farm level represents an important challenge for the future (12, 43).

HACCP AND MICROBIAL TESTING AT PROCESSING

Microbial testing in federal meat facilities. Few Canadian baseline microbial studies have been conducted, and the CFIA’s reference standards for microbial sampling and testing at slaughter are based on those of the U.S. Department of Agriculture (USDA). Baseline *Salmonella* studies conducted in the United States in 1992 through 1997 served as a foundation for development of the USDA *Salmonella* performance standards (27). Prevalence studies revealed that *Salmonella* could be recovered from 2% of beef carcasses, 9% of pork carcasses, and 20% of poultry carcasses (27). A Canadian baseline study conducted by the CFIA in 1997 and 1998 revealed that 21.1% of chicken carcasses and 19.6% of turkey carcasses were contaminated with *Salmonella* (25). In this study, USDA methods were used to survey *Salmonella* and *E. coli* (biotype I) in broiler chickens and young turkey carcasses in federal facilities across Canada (25). The CFIA has adopted U.S. performance standards for *Salmonella* (27), generic *E. coli* (biotype I), and *E. coli* O157:H7 (16) in beef, pork, and poultry undergoing processing in Canadian federal facilities. Microbial food safety policies are described in the *Meat Hygiene Manual of Procedures* (27).

Generic *E. coli* testing verifies that the HACCP program in the facility is effective (27). Carcasses are selected and tested at random with sampling of every *n*th carcass on a continuous basis, with a minimum of one sample per week. The sampling technique varies with the animal species (27, 30), and results are assessed using the USDA's moving-time-window approach and statistical process control methods (30). When results persistently fall outside control limits, the facility must review its HACCP program and make appropriate changes (30). Facilities are subject to CFIA investigations if these actions do not correct the problem.

Ground beef is monitored monthly in every federal meat processing facility, both for generic *E. coli* and for *E. coli* O157:H7, an organism that has been the cause of many foodborne outbreaks in humans (29, 30). There is zero tolerance for *E. coli* O157:H7 in ground meat, i.e., no *E. coli* O157:H7 detectable using HC-recognized screening methods. If a sample has a positive test result, the entire associated lot is considered contaminated. Follow-up samples are required to reassess the effectiveness of the facility’s HACCP system, i.e., over a 1-month period sufficient samples are tested to provide a 95% level of confidence that the presence of *E. coli* O157:H7 in meat products is below detectable levels. Failure to provide evidence that corrective action has been taken results in loss of FSEP recognition of the facility, i.e., suspension of plant operations (29).

*Salmonella* testing at the processing level is a surrogate measure of pathogen reduction (27, 30). It is believed that intervention strategies aimed at reducing *Salmonella* in raw products might also be effective in reducing the incidence of other pathogens concomitantly present (27). Tests for *Salmonella* are conducted at each plant at least once each year. End-product testing may be conducted when there is reason to believe that the safety of a product has been compromised.

*L. monocytogenes* may contaminate ready-to-eat meat products but rarely at levels sufficient to cause illness in humans (51). HC’s revised policy on *L. monocytogenes* came into effect on 4 October 2004 (51). Ready-to-eat products are divided into three risk categories, with the high-risk category (products previously implicated as the source of an outbreak) receiving the highest priority for inspection and compliance activities (51). Intermediate- and low-risk designations are assigned on the basis of the shelf life of the product and on its ability to support growth of the organism. Because *L. monocytogenes* survives well in...
the production facility, twice yearly microbiological sampling in federally inspected facilities focuses on the environment and the food being processed at the time of sampling (51). Positive test results require changes to HACCP protocols and additional testing.

Microbial testing in provincial facilities. Many provincially registered production facilities still practice traditional methods of food safety inspection, including visual inspection and end-product testing (49). Microbial testing is most often conducted when there is a system deficiency, such as prolonged cooling of a carcass or suspicion of lot contamination. However, some provinces are developing HACCP-based processing programs and adopting microbial sampling guidelines. In 2004, Ontario adapted FSEP HACCP programs for small and medium-size provincially inspected food production facilities (58), and eight facilities were recognized early in 2006. Other provinces have allocated APF funds to develop similar HACCP Advantage programs, including Alberta (7), British Columbia (46), Manitoba (56), and Nova Scotia (6). Results have been reported for baseline studies of raw chicken (54), pork (55), and beef carcasses (53) in Ontario provincial abattoirs, and similar microbiological surveys are underway in Alberta (11).

MFS programs at the processing level have significantly evolved over the past decade, in part to address the demands of export partners. Future major challenges might be the evaluation of the effectiveness (including cost) of these programs for reducing microbial contamination of products of animal origin at the processing level and potentially the burden of foodborne illness in humans.

TRACEABILITY: PRODUCT TRACKING AND TRACING FROM GATE TO PLATE

In the food safety and quality chapter of the APF, the target is 80% of domestic products at the retail level traceable through the food chain by 2008 (1, 2). This stated target has prompted the development of various government-funded, industry-driven initiatives.

Can-Trace. This industry-led initiative was launched in 2003, driven by international market pressure and regulations concerning animal health, security, and food safety (38, 39). Can-Trace is directed by a steering committee now composed of representatives from more than 25 national trade associations, with the support and input of the provincial and territorial governments (38, 39, 49) and with GS1 Canada (formerly the Electronic Commerce Council of Canada) acting as secretariat (38, 39, 44). The primary mission of Can-Trace is to develop minimum requirements for national whole-chain tracking and tracing standards based on the European Article Numbering Uniform Code Council system and to foster open dialogue within the supply chain to enhance the implementation of a national framework for traceability (44). The voluntary standard provides users with guidance on the information or data elements to be exchanged between trading partners in the food supply chain. In November 2004, after pilot studies were conducted in the beef, pork, and produce sectors, the first version of the Canadian Food Traceability Data Standard was validated (38). Version 2.0 was released in February 2006 (4, 40).

National identification of food-producing animals. The Canadian Livestock Identification Agency (CLIA), funded by the AAFC and established in June 2005, represents all major livestock producer organizations and other organizations, including the Canadian Veterinary Association, and builds upon the foundations of the Canadian Cattle Identification Agency (CCIA), the National Livestock Identification for Dairy (NLID), and Agri-Traçabilité Québec (ATQ) (4). The CLIA is a voluntary program providing a multispecies livestock tracking and tracing service and setting national standards for compliance and enforcement of animal tracking and tracing information for its member organizations (4). The Canadian Cattle Identification Program for cattle and bison was established in 1998 by the CCIA to manage information for tracking beef and dairy cattle, sheep, and bison in all provinces except Quebec (17). This program, implemented by the Canadian Cattlemen’s Association, is regulated and enforced by the CFIA (17) and introduced via an amendment to the Health of Animals Regulations. Since January 2001, all cattle that move from the herd of origin must be individually identified with CCIA-approved eartags (31). The NLID distributes eartags to all Canadian dairy producers except those in Quebec (52). Radio frequency identification (RFID) eartags were introduced in 2004 by the NLID (52) and in 2005 by the CCIA (16).

By September 2006, all beef cattle permanently leaving the herd of origin must have a CCIA-approved RFID tag (18). Tags must be applied before the calves are 20 days old, and each tag remains with the animal until carcass inspection at federal and provincial plants, where it is retired (16). The CCIA program was extended to sheep in 2004 (the Canadian Sheep Identification Program) as mandatory for all lambs and sheep leaving the flock of origin and will be implemented in swine by 2008 (36).

ATQ. The ATQ, a mandatory traceability-product tracking program established in the province of Quebec in 2001, has already achieved traceability from farm to slaughterhouse for cattle, swine, and sheep and from farm to table for beef (9). A single system and central database are used for all species. Calves are tagged by 7 days of age with RFID eartags that provide date of birth, gender, and location of the animal (9, 49). All Quebec farms have been registered using the livestock premise identification system (Geographic Information Systems technology), coordinated through the ATQ (9).

Federal, provincial, and territorial government initiatives. In addition to these industry initiatives, the federal, provincial, and territorial governments have begun, in collaboration with an industry advisory group, the development of an enhanced Agriculture and Food Traceability Framework applicable to all livestock and poultry by December 2007 (7).
CHALLENGES AND OPPORTUNITIES FOR THE FUTURE

Consumers, many of which are generations away from the rural environment and alarmed by high-profile outbreaks of foodborne illness, are demanding transparency in the agri-food industry. They want assurance that their food is safe, and they want to know where the food comes from and how it is produced. A great deal of progress has been made in Canada toward ensuring food safety from farm to processing and beyond.

To meet increased consumer demands and to remain competitive in an increasingly globalized agri-food trade market, Canada must be proactive in its approach towards agri-food public health (47). Shared and fragmented roles and responsibilities for food safety and agri-food public health among different levels of government and different departments and agencies have been recognized as a major challenge for timely and effective development and implementation of integrated MFS programs and policies along the food production chain (47, 48). The need for improved communication and information sharing, enhanced coordination and collaboration, and strategic planning and performance measurement was identified and addressed at a meeting held in 2005 in Guelph, Ontario, which was attended by 77 key players representing federal, provincial, and territorial governments, industry, academia, and various associations (48). This group also recognized a need for a national food safety strategy and provided specific recommendations. One key recommendation was for a single food safety agency to improve and facilitate the efficient use of resources and set food safety priorities for Canada as a whole.

Much work has already been accomplished by the Canadian agri-food industry, and continued concerted efforts by all stakeholders are needed to prioritize, develop, implement, and evaluate the goals and targets of the recently initiated national food safety strategy by federal, provincial, and territorial governments.

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