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Review

Food Safety in Free-Range and Organic Livestock Systems: Risk Management and Responsibility

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ABSTRACT

Animal production systems that offer outdoor access to the animals have become increasingly popular in the Western world due to the growing general discontent of consumers with conventional bioindustrial farming practices. These open production systems offer improved animal welfare but may create new problems for animal health, resulting in increased food safety risks from bacterial, viral, or parasitic infections or environmental contaminants. Examples of these new problems include increased *Toxoplasma gondii* infections in pigs and high dioxin levels in eggs from free-range hens. In this review, the relation between positive and negative points of free-range and organic livestock production systems is discussed with reference to production in The Netherlands. We investigated how proponents of more animal welfare friendly systems deal with potential negative issues in public and whether any risk communication is used. Generally, we found that the existence of a dilemma is disputed or avoided in communication with the consumer. This avoidance could be detrimental for public trust in alternative animal production systems, should problems occur. To prevent future problems, it will be necessary to communicate about the relevant types and sources of the food safety risks to the consumers. The responsibility for protecting food safety should be properly divided among the various parties involved: producers, processors, governments, nongovernmental organizations, and consumers.

Niche markets such as those for organic foods are rapidly increasing worldwide, and one of the main reasons for changes in consumer purchases is the perceived health benefit of organic products *(34)*. For livestock products, additional purchase reasons for consumers include the environmental impact and superior animal welfare *(4)*. However, although animal health is seen as a vital part of animal welfare, there is growing evidence that the animal health situation on organic farms is not always better than that in conventional livestock production systems *(38)*. One example is the higher prevalence of subclinical mastitis in organic cow herds in Switzerland *(8)* compared with cows from conventional livestock systems. However, consumers of organic products often are not aware of these farm issues, which are not communicated because such problems are inconsistent with the public image of organic livestock production.

Production systems that are considered more animal welfare friendly, such as free-range and organic systems that allow outdoor access for farm animals, may create new or reintroduce old risks to public health *(13, 47)*. Adverse public health aspects related to outdoor housing can affect food safety *(45, 48)*, but a more open farming structure also may result in more risk of transfer of zoonotic pathogens to livestock, as happens with avian influenza outbreaks *(49)*. Compared with conventional (indoor) systems, outdoor husbandry systems are inherently less controllable from a hygiene (microbial) point of view and can be affected by pollutants (e.g., dioxins and heavy metals) that have not been an issue for most modern farmers *(69, 80)*.

An example of a health issue that can be directly connected to outdoor animal husbandry is the protozoan parasite *Toxoplasma gondii*. Because of the increased popularity of domestic cats in western countries, more cats are present in the farm environment. When cats infected with *T. gondii* defecate outdoors, a substantial load of infectious oocysts can be found in the environment *(15)*, resulting in a substantial risk of toxoplasmosis. The burden associated with this disease already is high. In The Netherlands, the cost of toxoplasmosis in disability-adjusted years of life per year was recently estimated to be similar to that of salmonellosis *(33)*, imposing a serious health risk to the society.

In general, food safety problems associated with free-range and organic farming have been controversial in animal production and require serious consideration *(85)*. In this review, we highlight possible solutions to these problems with recently described examples.

ORGANIC ANIMAL HUSBANDRY

The organic food movement originates from the 1930s and started as a reaction to the increasing use of synthetic

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fertilizers and pesticides in conventional agriculture systems. Sir Albert Howard, a British biologist, traveled to India intending to teach Indian farmers about conventional English agricultural science. Instead, he started to support traditional Indian farming practices after becoming interested in the connection between healthy soil and healthy human populations, livestock, and crops.

In this tradition, the Austrian philosopher Rudolf Steiner was the founder of biodynamic agriculture, a system in which farms are treated as unified organisms, emphasizing the interrelationships among soil, plants, and animals. This approach contributed significantly to the development of modern organic farming practices, and many organic farmers still adhere to the principles of the founding fathers of the organic agriculture systems.

In current organic husbandry systems, the animals are kept at lower stocking densities, have outdoor access, have obligatory straw bedding, and are fed organic feed and roughage (sows). According to the European Union regulations on organic farming, the use of antibiotics is restricted, the withdrawal times after medical treatments before delivery of products are doubled, weaning periods (pigs) are longer, tail, teeth and beak clipping are prohibited, and broiler chicken growers use breeds that grow more slowly *(22)*. Organic feed for the animals is grown without chemical pesticides or artificial fertilizers and is free from genetically modified organisms, and manure for fertilizer should come from organically kept animals. This system leads to products (e.g., milk, eggs, and meat) obtained from animals that, according to consumer perception, are grown under more humane conditions and contain fewer residues (e.g., pesticides and veterinary drugs) compared with animals grown in conventional rearing systems *(4, 34)*.

The intentions of organic livestock production have been formulated by the International Federation of Organic Agriculture Movements. The European Union (EU) member states have regulated organic animal husbandry via EU regulation 2092/91, published in 2000 *(22)*. In the United States, production of organic products is regulated via the U.S. Department of Agriculture (USDA) Organic Foods Production Act *(28, 86)*. In contrast to European regulations, the use of antibiotics is forbidden in organic livestock production in the United States, and when an animal has received medical antibiotic treatment, the animal loses its organic status and has to be sold as a conventional product *(40)*. Although organic animal husbandry is well defined, these regulations allow a large degree of freedom, resulting in a large number of farmers with their own ideas and practices. This variability should be taken into account when comparing organic livestock systems with conventional systems. Certification of organic production implies regulation based on the principles of organic farming but does not include food quality assurance programs, because when these regulations were made, the implications of these rules for food safety were not yet fully anticipated.

Organic farming was developed from an integrated vision of the interplay between humans, animals, plants, and the environment, resulting from negative attitudes associated with the modernization of conventional farming practices in western Europe. Governments (including those in the EU) have tried to embed this vision in regulations. These regulations were defined in contrast with the dominant regime (conventional farming practices) and ruled out specific treatments or practices. The vision was translated for legal and practical reasons into a set of prohibitions. However, application of these rules does not guarantee a successful alternative to conventional farming practices, and new or recurring risks may emerge as a result. Food safety and public health risks may serve as an example. Such side effects are the result of fundamental choices made in organic and free-range systems, e.g., granting animals outdoor access.

With some exceptions (Austria and Switzerland), less than 1% of the livestock in most countries is organic *(82)*. Consumer behavior is affected by various issues such as environmental concerns, animal welfare, personal health, sensory qualities, and product price *(4, 84)*. Marketing of organic products stresses these issues, but food safety aspects often are neglected, because they are in conflict with the consumer-held perception of the health benefits of organic products *(54, 71)*. Another potential negative aspect of organic systems is their environmental footprint. For example, although organic milk production systems reduce pesticide and phosphorus use, land use per tonne of milk is increased and methane emissions (important for global warming) are higher *(9, 16)*. There are many implications of these organic principles for food safety, and the current situation in The Netherlands is used here as an example.

HAZARD ANALYSIS

In the following paragraphs, we describe a number of possible hazards related to farming systems that allow animals outdoor access (e.g., free-range and organic systems) with respect to public health implications. Possible hazards of these housing systems on food safety and human health risks were identified through desk research, interviews, and a workshop with experts on animal welfare and food safety *(5)*. Most of the hazards identified are introduced through the outdoor rearing of animals, alternative bedding materials, and a lower level of hygiene (at a microbe level) associated with these types of farming.

Avian influenza. Avian influenza is currently considered a major threat to global public health. Outbreaks of this fowl disease have caused large economical losses, and in several outbreaks transmission to humans has occurred, with a high incidence of fatalities *(11)*. The virus is transmitted via mucosal surfaces such as the respiratory tract or ocular mucosa, and this influenza is not considered a foodborne disease. The 2003 outbreak in The Netherlands, which resulted in the culling of 30 million chickens and 87 human cases (of which 1 was fatal), is thought to have been initiated by transfer from wild fowl to a free-range laying hen farm *(19)*. Outdoor rearing of chickens is considered the most important risk factor for the introduction and spread of avian influenza and has led to the confinement of free-range chickens throughout Europe during the migratory bird season and during outbreaks in neighboring countries *(49)*.

Farms with vaccinated hens are exempt from these measures, but because of restrictions in the export of products from vaccinated animals, few farmers have vaccinated their chickens. Eggs from organic chickens that are raised in confinement because of veterinary reasons can still be sold as organic, diminishing the economic reason to vaccinate animals.

Campylobacter. Campylobacteriosis is a serious disease that is mainly caused by consumption of contaminated poultry, although numerous other sources should not be overlooked *(39)*. Several studies have been conducted on the prevalence of *Campylobacter* in organic versus conventionally reared farm animals *(28)*. In Dutch studies, 55% of fecal samples from organic pigs and 100% of fecal samples from organic broilers were culture positive for *Campylobacter (37)*. The study did not include controls from regular farms, nor did the researchers investigate whether the presence of the bacterium in the feces also resulted in the infection of meat from these animals. In Denmark, the occurrence and species distribution of thermophilic *Campylobacter* was investigated in feces of organic outdoor pigs and their outdoor environment *(41)*. *Campylobacter jejuni* was found in 29% of pigs in three consecutive trials and always had a lower incidence than did *Campylobacter coli* (0.3 to 46%). *C. jejuni* and *C. coli* were isolated from 10 and 29% of the environmental samples, respectively *(41)*. The diversity of serotypes found in the paddock environment indicated other nonpig sources, e.g., wild animals *(41)*. This pathway also was identified in another study *(57)*.

In a Swiss study of the presence of *Campylobacter* in pigs with outdoor access, only 0.2% of the samples were culture positive *(52)*. A higher fecal prevalence ($P < 0.001$) of *Campylobacter* was observed in antimicrobial-free (77%) than in conventional (28%) swine nursery farms in the United States *(76)*. Analysis of *Campylobacter* in bovine feces did not reveal significant differences between organic or conventional dairy herds nor did the investigators observe a difference in antibiotic resistance between the two types of management systems *(66)*. In contrast, *Campylobacter* infections are more common in chickens with outdoor access than in confined chickens. Engvall *(20)* found that almost 100% of the organically farmed flocks in Sweden were infected with *Campylobacter* compared with only 10% of the conventionally reared flocks. Danish and Dutch researchers confirmed these findings *(35, 65)*. Studies from the United States revealed a very high incidence of *Campylobacter* infections in both organic and conventionally reared chickens (76 versus 74%, respectively) but no difference between the two systems *(14)*. A study performed in 2003 by the Dutch Consumers Association revealed that 43% of regular and 49% of organic poultry meat were *Campylobacter* positive, whereas a similar study carried out in 2008 by this organization (available at http://www.consumentenbond.nl/morello-bestanden/209547/Rapport_Kipfilet_2008.pdf) showed a completely different picture: 25% of regular and 51% of organic chicken filets were positive.

Campylobacters are ubiquitous in birds, where they form part of the commensal microflora *(62)*. *Campylobacter* is not a direct health problem for chickens. Organic broiler chickens (81 days) live longer than conventional chickens (42 days), and the increased life span also increases the chance of becoming infected, e.g., through contact with feces of infected migratory birds *(62, 73)*. The assumption that the free-range environment is the source of infection was recently challenged in a British study *(12)*. The higher incidence of *Campylobacter* infections found in organic flocks also could be associated with a less vigilant farmer attitude toward general farm hygiene.

Studies comparing the antimicrobial susceptibility patterns of *Campylobacter* recovered from poultry from different production systems have yielded inconclusive results *(40)*.

***Salmonella*.** Salmonellosis ranks high among the various foodborne diseases *(55, 81)*. Meat, poultry, raw milk, and eggs have been identified as sources of *Salmonella*. In various studies, *Salmonella* seroprevalence has been compared in finishing pigs from conventional and organic housing systems, but no significant differences have been found *(60, 79, 87)*. No significant difference in *Salmonella* prevalence was found when comparing pastured and conventionally reared broilers *(72)*. However, Bailey and Cosby *(3)* found that 31% of carcasses from free-range chickens and 25% of carcasses from organic chickens were positive for *Salmonella*. These authors did not include a control group of chickens but referred to a USDA Food Safety and Inspection Service report citing a *Salmonella* prevalence rate of 9.1 to 12.8% in conventionally reared birds. No studies have been reported on *Salmonella* infections in organic eggs or organic milk. However, in a multifactor study on *Salmonella* at conventional and organic dairy farms in the midwestern United States, farm type (organic versus conventional) was not associated with *Salmonella* prevalence *(26, 27)*. However, this outcome may have been biased because there were few large organic farms available to adequately evaluate the role of large herd sizes on *Salmonella* prevalence *(27)*.

Although the *Salmonella* seroprevalence might not differ between conventional and organic animal production systems, elimination will be more difficult on organic farms because of the specific farming conditions on these farms *(58)*.

Enterohemorrhagic *Escherichia coli* O157:H7 and other bacteria. *E. coli* O157:H7 may cause hemolytic uremic syndrome that may lead to acute renal failure in children *(6)*. Undercooked ground beef is the major source of infection. Few data are available concerning organic farming and enterohemorrhagic *E. coli* O157:H7 infection. Prevalence estimates of *E. coli* O157 were similar for organic and conventional dairy cattle *(10)*. No references could be found comparing food pathogens in conventional versus organically produced beef *(28)*.

A comparison PCR assay for *Yersinia enterocolitica* in conventional and organic finishing pigs revealed a signif-

icantly lower incidence in the organic pigs (18 versus 29%, respectively) *(63)*.

Total counts of *E. coli* and *Listeria* in organic milk were equal or lower than those found in conventional milk used for cheese making in Finland *(53)*. The prohibition of the use of nitrate in the further processing of milk has raised concerns about the safety of organic cheese. Although bacteria such as enterohemorrhagic *E. coli* O157:H7 or *Listeria monocytogenes* can remain viable in cheese for prolonged periods *(2, 64)*, no references concerning this issue could be found with regard to organic cheese.

Microbiological analysis of organic meat products such as spreadable raw sausage and prepacked sliced meats, e.g., Bologna-type sausage and cooked ham, revealed that these products did not represent an increased health risk to the consumer as compared with conventional products *(51)*. Samples were tested for *Salmonella,* enterohemorrhagic *E. coli, L. monocytogenes, Enterobacteriaceae,* and coagulase-positive *Staphylococcus*.

The use of nitrate or nitrite as a preserving chemical for cured meat products is formally not allowed according to organic principles *(70)*. Nitrite, either added directly or derived from nitrate, is a very effective antimicrobial agent, e.g., for preventing *Clostridium botulinum* outgrowth, and to date there is no acceptable substitute. Experimenting with alternative antimicrobial agents may put the consumer at risk of foodborne infections. In some countries, the use of nitrite has been temporarily allowed for the production of cured organic meat products because otherwise a large part of the organically raised meat could not be processed as organic and would enter the ''cheap'' conventional food chain.

Paratuberculosis (Johne's disease) in cattle is considered to play a role in the pathogenesis of Crohn's disease in humans *(24)*. Although farm management practices on organic dairy farms theoretically create a higher risk for introducing *Mycobacterium avium* subsp. *paratuberculosis* infection on the farm, this higher risk was not supported based on a comparison of *M. paratuberculosis* seroprevalence on organic and conventional dairy farms *(42)*.

Parasites. Because of outdoor access, a number of farm animal species such as pigs and poultry will have a higher degree of parasite infections compared with animals reared in confinement *(43)*. Most of these parasites do not pose a direct food safety threat, with the exception of *Toxoplasma gondii* and *Trichinella spiralis (44, 47, 59, 77)*. Infection with *T. gondii* during pregnancy can lead to serious and sometimes fatal disease of the fetus or newborn. Individuals with latent infection may develop chronic ocular toxoplasmosis, leading to visual impairment. Undercooked meat has been considered one of the main sources of infection. Because of major changes in animal production hygiene, the rate of *Toxoplasma* contamination in pork meat has dropped drastically *(75)*. However, the introduction of production systems with outdoor access may lead to a reemergence of *Toxoplasma* infections in pigs *(29, 44)* and poultry *(17)*. In a large study on organic finishing pigs *(59)*, 85 (3%) of the 2,796 samples tested were seropositive for *T. gondii*; of the 41 farms, 19 (46%) were *T. gondii* negative and 22 (54%) were *T. gondii* positive. Although the actual number of seropositive animals is low, the meat (products) of one pig may be consumed by 200 to 400 people *(23)*.

Only one study has been reported on *Trichinella* infections in organic pigs, and no difference was observed between organic and conventional pigs *(77)*. No studies have as yet been reported concerning zoonotic parasites in organically kept animals other than pigs.

Environmental contaminants and drug residues. The absence of drug residues and food additives often is the reason used by consumers for buying organic products *(54)*. However, some contaminants may be more problematic in organic than in conventional products. Dioxins are considered the most toxic substances in the human food chain *(67)*. Exposure to dioxins occurs via the ingestion of animal products, including eggs. A maximum limit for dioxins in eggs has been set in the EU; it is forbidden to sell eggs in which the dioxin level exceeds 3 pg of dioxin toxic equivalents per gram of egg fat *(21)*. The dioxin content of eggs from free-foraging chickens is much higher than that observed in chickens kept in wire cages *(48)*. It is assumed that uptake of soil, insects, and worms leads to bioaccumulation of dioxins in egg fat. Bioaccumulation of other environmental contaminants such as lead, mercury, thallium, and pesticides such as DDT in eggs from free-foraging chickens also has been reported *(80)*. In May 2008, the Food Safety Agency from the United Kingdom issued a food safety alert concerning lead contamination in organic eggs from Waitrose Ltd. that was caused by consumption of lead shot by the free-foraging chickens *(25)*.

In view of the regulations, veterinary drug and pesticide levels in products from organic animals should be lower than those in products from regular systems. Limited studies on residues in meat and milk from organic productions systems support this statement *(30, 37)*.

RISK MANAGEMENT

The hazards described above are only a small sample of the risks that may be associated with free-range or organic animal housing systems. As long as we take these specific risks as given and unavoidable consequences, a number of options for risk management are available.

Risk management for avian influenza and especially the H5N1 type includes proper hygiene on farms with outdoor access for farm animals, regular monitoring, temporary indoor housing of chickens during avian influenza outbreaks or during wild bird migration season, and vaccination *(18)*. Prophylactic use of antiviral drugs can prevent transfer of disease to those individuals handling infected animals. Consumption of products does not lead to transfer of disease, which suggests that consumers cannot do much about risk management except to take the necessary precautions when slaughtering poultry themselves. However, restriction of visitors to farms or markets can play an important role in limiting the spread of avian influenza.

Once *Campylobacter* or *Salmonella* has been established on a free-range or organic poultry farm, it is very

difficult to get rid of it because, for example, the outdoor runs cannot be cleaned. Slaughtering of chickens from such systems also may lead to cross-contamination of chickens from conventional production systems if the same slaughterhouse is used. To date, no effective measures have been developed to protect chickens from developing *Campylobacter* or *Salmonella* infections via outdoor runs, and further research is needed in this area. In The Netherlands, organic laying hens are routinely vaccinated to prevent *Salmonella* infection *(78)*. Risk management should be practiced through the food chain and should involve all participants. Governments, nongovernmental organizations (NGOs), and retailers should make an effort to provide public education and warnings on the products. Consumers should take the necessary precautions during handling, storage, and cooking of meat *(56)*.

Consumers can do little about prevention of contact with *M. paratuberculosis* in dairy products; therefore, the responsibility for risk management lies with the farmers, milk factories, and government. Prevention in dairy herds involves the use of separate clean rooms for calving and immediate separation of calves from their mothers after birth. These preventive measures are in conflict with natural suckling systems in cattle, which are propagated by some organic dairy farmers but are not obligatory within the EU organic regulations. In The Netherlands, a national prevention program has been initiated that grants each farm a rating between 1 and 10, where 10 is the highest degree of freedom from paratuberculosis *(83)*. Few organic farmers participate in this program. Although the paratuberculosis situation in Dutch organic herds does not seem to differ from that found in conventional herds *(42),* it is mandatory to keep monitoring the prevalence so that measures can be taken if seroprevalence starts to rise again.

Monitoring of farms and adjustment of farm management can play an important role in the control of *Toxoplasma* infections *(45)*. Farms with a known positive *Toxoplasma* status should have their meat decontaminated, for example, by freezing *(45, 46)*.

Consumers should be educated to properly cook meat (above 65°C) and to prevent cross-contamination during meat handling in the kitchen. However, the results of a recent survey bring into question whether consumer education for the prevention of *Toxoplasma* infection is successful *(31)*. Unfortunately, studies in which a successful intervention via campaigns was reported did not include proper controls *(7)*.

Consumers can do little about avoiding the risk of dioxin exposure via eggs except by restricting their weekly intake. The control of dioxin levels in free-range or organic eggs is a responsibility of primary producers and egg packaging stations. A monitoring program as part of the farm management system can prevent eggs with high dioxin levels from entering the market. Retail stores should insist that only eggs participating in such control programs enter the market. Consumers should be aware of these quality assurance programs. Fortunately, organic food buyers consider themselves more responsible for their own health and are more likely to undertake preventive health action than is the general population *(68)*.

In general, the management of specific public health risks associated with organic animal production will remain difficult because high biosecurity levels often are not feasible. Farm monitoring and management is likely to be insufficient; thus, there will always be some risks for consumers of animal products from organic systems *(50)*.

Risk management could require a level of transparency and communication that will conflict with the public image of organic farming as beneficial for personal health. We investigated how several institutional organizations deal with this dilemma by analyzing their communication strategies.

CONSUMER COMMUNICATION

In addition to governmental bodies such as the Dutch Food Safety Authority (Voedsel en Waren Autoriteit) and the Netherlands Nutrition Centre (Voedingscentrum), information for the general public about organic farming in The Netherlands is provided mainly by NGOs. One of the main goals of these NGOs is to promote the organic way of life, and they provide information for consumers via campaigns, newsletters, Web sites, radio, and television. The Ministry of Agriculture, Nature, and Food Quality and the Ministry of Health, Welfare, and Sports do not address the public directly about organic farming but have delegated communication about this topic to the Food Safety Authority. This organization has published several studies on health aspects of organic products on their Web site. The Netherlands Nutrition Centre also provides consumers with information concerning health aspects of food.

Although scientific information about organic farming is available via a specialized Web site (Bioconnect.nl), it is meant for scientists and policy makers. This site is not often accessed by the general public because they are not the primary target group.

With regard to the health concerns described above, a study was performed to investigate how the communication channels available to consumers have addressed these health issues. This study was done by searching the Web sites of the various organizations for the subjects *Campylobacter, Toxoplasma,* and dioxins. The results are shown in Table 1. These NGOs, contrary to governmental bodies such as the Dutch Food Safety Authority and the Netherlands Nutrition Center, have not consistently addressed all of the food safety concerns we used as examples. The Dutch Food Safety Authority has addressed all food safety concerns, but accessibility of this information by the consumer is poor. The Netherlands Nutrition Centre also has addressed all three items we investigated in a separate section on their Web site dealing with food safety aspects of organic products. However, no advice is given on how consumers should deal with these items.

Four NGOs in The Netherlands are strong proponents of organic agriculture. Biologica is devoted to the expansion of the organic movement and aims to bring together all players in the organic field in The Netherlands, including farmers, manufacturers, traders, consumers, and researchers. Activities include consumer information, market develop-

TABLE 1. *Communication of food safety concerns related to organic food production to consumers in The Netherlands*

Organization	*Toxoplasma*	*Campylobacter*	Dioxin	Web site[a]
Biologica	No	Yes	No	http://www.biologica.nl/
Alert Animal Foundation	No	Yes	No	http://www.wakkerdier.nl/
Animal Protection Agency	No	No	No	http://www.dierenbescherming.nl/
Friends of the Earth	Yes	Yes	No	http://www.milieudefensie.nl/
Food Safety Authority	Yes	Yes	Yes	http://www.vwa.nl
Netherlands Nutrition Centre	Yes	Yes	Yes	http://www.voedingscentrum.nl/

[a] All Web sites accessed 11 February 2009.

ment, improvement of the organizational strength of the organic movement, and coordination of research in this field. Biologica coordinates all the research projects on organic farming that are funded by the Ministry of Agriculture in The Netherlands. The organization has an extensive Web site covering many aspects of organic farming and had 26,632 members in 2008. In an analysis of the Web site for food safety issues associated with *Campylobacter, Toxoplasma,* and dioxins, no hits were obtained when a search was performed using the keywords ''dioxin'' or ''*Toxoplasma*.'' The Web site does mention a study showing that a higher incidence of *Campylobacter* was found in the feces of organic broilers *(36)*.

The Alert Animal Foundation (Wakker Dier) is an NGO whose mission is to end industrialized animal husbandry in The Netherlands *(1)*. It provides consumer information and tries to persuade farmers, manufacturers, and stores to stop supporting industrialized animal husbandry. The organization communicates via radio advertisements and a Web site and had 19,821 members in 2008. The organization was instrumental in banning the sale of eggs from caged chickens in virtually all Dutch supermarkets as of 2003. For the three food safety items we investigated, only one Web site hit was found, citing a study performed in 2003 by the Dutch Consumers Association in which 43% of regular poultry meat and 49% of organic poultry meat was *Campylobacter* positive. This study was published in the monthly periodical of the Dutch Consumer Association, which is not subject to scientific peer review. The Alert Animal Foundation concluded that no difference existed between organic and regular meat.

All NGOs that were included in this study expressed their concerns about health aspects of dioxins on their Web sites, citing recent incidents of dioxin contamination of conventional animal feed. None of these NGOs mention Dutch publications concerning increased dioxin levels in eggs from free-foraging laying hens.

The Animal Protection Agency (Dierenbescherming) is the oldest and largest animal welfare organization in The Netherlands and had 195,368 members in 2008. One of its aims includes better conditions for animals in the bioindustry, and one of its goals includes the promotion of organic animal production. As to the food safety issues investigated, only one news item was found relating to *Toxoplasma,* which was posted on the Web site in 2004. This item was posted in reaction to media coverage of scientific research indicating that the incidence of *Toxoplasma* was higher in organic pigs than in regular pigs *(44)*. In the news item, the organization stated that no risk was present when consumers heated their meat properly. The organization also highlighted other sources of *Toxoplasma* infection, such as soil or vegetables contaminated with oocysts from cat feces. The organization did not mention that ready-to-eat products made from organic pig meat, such as raw sausages and ham products, may pose a risk to consumers because the preparation methods do not kill the *Toxoplasma* parasite *(45, 46)*.

Friends of the Earth Netherlands (Milieudefensie) is one of the largest environmental organizations in The Netherlands (88,139 members in 2008). One of its targets is the bioindustry. The organization strongly promotes organic farming, and since 1998 it has published an annual list of supermarkets showing the number of different organic products they carry. It also provides a special leaflet on food safety of organic products on the Web site, although the leaflet dates from 2001 and the information has not been updated with recent scientific studies. The organization does advise consumers to properly heat meat products before consumption to eliminate possible microbiological contamination of organic products.

None of the NGOs investigated addresses the public health problems that are associated with outdoor animal production in a straightforward way. Either the issue is absent from their communications or its validity is disputed. Instead, these NGOs promote the image of control, a strategy that is often used by firms to make consumers believe that their products are safe *(74)*. This strategy is risky because when food safety issues are not taken seriously, the occurrence of an incident affecting organic products becomes more likely and may have serious consequences for the market share of organic produce.

In a study of the basis of consumer choice between organic and conventional pork, consumers who chose the organic pork expected it to be better than conventional pork across all quality dimensions, including health *(32)*. What if these consumers were to suddenly find out that their assumptions are not correct? The more prudent course would be to base actions on the precautionary principle, which is currently not done. The essence of the precautionary principle in the food industry is that if there are reasonable grounds for concern that a food product or its production method has a potentially dangerous effect on the environment or on human, animal, or plant health and these risks can be avoided, food producers and processors should take all necessary measures to do so *(61)*. Risks should be

reduced to the minimum possible (e.g., freezing organic meat to destroy parasites), and producers and processors should offer proper communication to consumers about the risks of outdoor animal production and should provide advise on how consumers should deal with these risks (e.g., how to prepare organic products). If these measures were taken by the industry and a crisis still occurred, then the effect on the organic market share would be limited because the necessary measures were taken beforehand.

DISCUSSION

Animal welfare–friendly production systems with outdoor access for farm animals, such as free-range and organic systems, may create new or reintroduce old risks to public health. Without adaptations in the systems used or in the regulations surrounding them, risk management will continue to pose a dilemma for consumer communication.

The design of new animal production systems (with outdoor access) requires both a thorough analysis of possible risks and optimal communication of these risks throughout the food chain and appropriate partitioning of responsibility concerning these risks. Some risks are inherent to the choice of keeping animals in a more natural environment and could be judged as an inherent responsibility of the consumer, whereas other risks may be mitigated by further refinement or adjustment of the housing or farm management system used. In this review, we provided a number of examples in which food safety issues have clashed with improved animal welfare conditions. However, the number of studies on this topic is small and therefore a thorough statistical or meta-analysis is not currently possible. The comparison of microbiological studies described in our study is made difficult because of differing sample sizes, methodologies, and times and places.

Governments wanting to expand animal production systems with outdoor access should be sure that veterinary dogma and a zero tolerance for public health risks are implemented as the norm without any further changes. To this end, it might help if public health is not seen as an exclusive responsibility of the government.

Regarding the conflicting issues associated with animal welfare and food safety, we should deal with communication of food safety aspects to the consumer and try to provide the relevant background on types and sources of the risks and relate them to the distribution of responsibility to the various members of the food industry.

More effort must be expended to improve animal welfare in the current animal husbandry system. Organic farming is an important movement that could provide guidance on this topic for the whole agricultural sector. However, the proponents of organic methods must be aware that if food safety issues are not properly communicated, a food crisis could develop that might slow down improvements in animal welfare.

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