Microbial food safety standards in organic farming – A review

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The main goal of organic farming is production of healthy food in healthy environment that implements in positive effects in humans and nature. The emphasis in organic food production is given to food production without any use of chemicals, from initial steps to the market, and should take into the account minimal risks for human and animal health and welfare. In spite of the fact that organic agriculture is as safe as conventional agriculture, the absence of preservatives, use of manure and presence of pathogens that might recycle and concentrate in organic food production, make organic agriculture theoretically more prone to microbial contamination risks. With new lifestyle of increasing consumption of organic food in Europe, it is expected that new and emerging pathogens may cause severe food borne diseases. In this paper, we outlined a current status of microbiological food safety management, traceability and standards in emerging food safety concern of organic foods. To date, the organic community and public bodies did not develop regulations and standards that would directly or indirectly address food safety problems, although guidelines already cover production, processing, labelling and marketing of organic foods.

Key words: organic farming, microbial risk, food safety

INTRODUCTION

Organic food production has become rapidly expanding business with good long term prospects. Many consumers are willing to pay premium prices for organic food, convinced that they are helping the earth and eating healthier.

According to the SOEL-Survey (www.organic-europe.net/europe_eu/statistics.asp) more than 24 million hectares are managed organically worldwide. Currently, the major part of this area is located in Australia (about 10 million hectares), Argentina (almost 3 million hectares) and Italy (almost 1.2 million hectares). The percentages of land under organic management, however, are highest in Europe where more than 170.000 farms are run organically and 5.5 million hectares are under organic management, which corresponds to almost 2 percent of the total agricultural land (FAO 2002). The main driving force for the development of organic farming is a growing market as well as policy support. The European sales of organic products were estimated to have expanded by about 8 percent in 2002 (Organic Monitor 2003) to reach approximately ten to eleven billion Euro (www.organicfqhresearch.org/research_projects/research_fibl.html). After years of tremendous organic sales growth, in many European countries the market is now maturing. However there is no single common and homogenous market for organic food all over Europe. The individual national organic markets are at different stages of development. This leads to clear differences in terms of per capita consumption of organic produce all over Europe. Switzerland can be considered as the clear organic market leader in Europe, or even the world. However, competition between the countries of Europe is growing and the annual growth rates between1999 and 2002 differs clearly by country. The highest growth rate in the last years could be observed in France and the United Kingdom. Product groups with the lowest market growth are cereals. Highest growth is expected for meat and convenience products. The majority of experts anticipated higher demand than supply for fruit and vegetables, but no clear trends emerged for other product categories (Willer and Richter, 2004). Faced with the food safety problems, many consumers are turning to organic foods in hopes of finding a healthy alternative, but there is currently no consistency in organic food labelling and no guarantee that foods labelled as organic are actually microbiologically safer than conventional foods (Fisher 1999, McMahon and Wilson 2001, La Torre et al. 2005, Yiridoe et al. 2005, Magkos et al. 2006). In spite of the fact that microbial analyses of organic vegetables showed no significant variation between organic and conventional foods, analyses were focused only to coliform and fungal analyses. (Sagoo et al. 2001, McMachon and Wilson 2001, Sagoo et al. 2003, Mukherjee et al. 2004, Franz et al. 2005). Although most studies are showing that organic vegetables are acceptable microbiological quality, a national outbreak of salmonellosis in United Kingdom in 2001 highlighted unsatisfactory microbial quality of organic vegetables due to high level of *Salmonella Newport* and *L. monocytogenes* in ready-to-eat salad vegetables (Sagoo et al. 2003). Furthermore, the quality of animal food products in relation to human health, particularly the risk of zoonotic infections faces major challenges as relevant scientific evidence, however, is scarce, while anecdotal reports abound (Vaars et al. 2005, Magkos et al. 2006). No analyses were performed to investigate the presence of enteric viruses in organic foods.

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It is not clear whether routine monitoring of food specimens for viral contamination will be feasible either for organic or conventional foods. It is difficult, therefore, to weigh the risks, but what should be made clear is that 'organic' does not automatically equal 'safe'. This paper gives an overview of the present state of the art in the issues of organic farming, microbial risks, food safety and legislative measures related to organic farming.

What is organic farming?

Organic farming can be defined as an approach to agriculture where the aim is to create integrated, humane, environmentally and economically sustainable agricultural production systems. Maximum reliance is placed on locally or farm-derived renewable resources and the management of self-regulating ecological and biological processes and interactions in order to provide acceptable levels of crop, livestock and human nutrition, protection from pests and diseases, and an appropriate return to the human and other resources employed. External inputs, whether chemical or organic, are reduced as much as possible (CGSB 1999; www.irs.aber.ac.uk/research/Organics). In other words, organic farming can be defined as ecological agriculture, reflecting its reliance on ecosystem management rather than external inputs. The key characteristics of organic farming include:

a) protecting the long term fertility of soils by maintaining organic matter levels, encouraging soil biological activity, and careful mechanical intervention;
b) providing crop nutrients indirectly using relatively insoluble nutrient sources which are made available to the plant by the action of soil micro-organisms;
c) nitrogen self-sufficiency through the use of legumes and biological nitrogen fixation, as well as effective recycling of organic materials including crop residues and livestock manures; weed, disease and pest control relying primarily on crop rotations, natural predators, diversity, organic manuring, resistant varieties and limited (preferably minimal) thermal, biological and chemical intervention;
d) the extensive management of livestock, paying full regard to their evolutionary adaptations, behavioural needs and animal welfare issues with respect to nutrition, housing, health, breeding and rearing; careful attention to the impact of the farming system on the wider environment and the conservation of wildlife (CGSB 1999; www.info.gov.hk).

Food safety and organic food production

3.1. Legislative measures

Organic (ecologically) produced food usually refers to food that is produced according to organic standards throughout production, handling, processing and marketing stages and certified by a certification body or authority of the countries of origin. The Codex Alimentarius Commission has established guidelines for the production, processing, labelling and marketing of organic food in Europe that are implemented by individual member state. The international umbrella organisation of organic agriculture is the International Federation of Organic Agriculture Movements (IFOAM). The organisation has about 750 members in about 100 countries, which are listed in its membership directory. The IFOAM Basic Standards define how organic products are grown, produced, processed and handled. They reflect the current state of organic production and processing methods. The IFOAM Basic Standards provide a framework for certification bodies and standard-setting organisations worldwide to develop their own certification standards and cannot be used for certification on their own (EC – Directorate General for Agriculture, 2001). In the member states of the EU, the labelling of plant products as organic is governed by EU Regulation 2092/91 (europa.eu.int/eur-lex/en/consleg/pdf/1991/en_1991R2092_do_001.pdf), which came into force in 1993, while products from organically man aged livestock are governed by EU Regulation1804/99 (/www.organic-vet.reading.ac.uk/Cattleweb/health/stan.htm), enacted in August 2000. They protect producers from unfair competition, and they protect consumers from pseudo-organic products. Plant and animal products and processed agricultural goods imported into the EU, may only be labelled as organic if they conform to the provisions of EU Regulation 2092/91. The EU Regulation on organic production lays down minimum rules governing the production, processing and import of organic products, including inspection procedures, labelling and marketing for the whole of Europe. Each European country is responsible for enforcement and for its own monitoring and inspection system. Applications, supervision and sanctions are dealt with at regional levels. At the same time, each country has the responsibility to interpret the regulation on organic production and to implement the regulation in its national context. (Kilcher et al. 2004). In organic farms and food processing plants the control system is regulated. If the farm passes the control system, the control organisation divides to farmers a certificate which confirms that the organic food production is in accordance with valid regulations.

The Certificate could be passed if:

- the food and food production contains no GMO,
- the food was not subject of ionizing radiation,
- the food contains minimum 95% of organically produced components and only 5% of other components. Allowed additives are given in Rules on organic, production and processing of agricultural products and/or foods,
- the food contains no more then 5% of components from conventional production,
- the food production process was included in the control system,
- the food production is harmonized with orders for ecological food production

As an example, In Slovenia, in the year 2003, the control system was performed on 1.415 farms (1.6% of all farms in Slovenia). The most frequent faults recognised through the control system were:

- defectiveness in medical treatment, purchasing, register of procedures, etc.,
- disorders by release of all animals,
- dunghill disorders,
- obscured and bad aired stable,
- the use of prohibited forage,
- failure in animal breeding,

- prophylaxis animal treatment,
- the use of forbidden substances,
- bad cropping system,
- the use of forbidden seeds (http://www.kmetzav-mb.si/eko/stran5_2.htm).

Concerning Food safety management and traceability, all supermarket chains have well-established quality assurance systems to meet the stringent requirements of EU food legislation of quality assurance for maintaining food safety at all stages in the supply chain (Retrieved from http://www.nri.org/NRET/SPCDR/). There are minimal efforts worldwide to inform organic producers and food handlers of microbial risks on the farm and to consumers and potential interventions. A consistency between the Canadian General Standards Board (CGSB) organic standard in the production of microbiologically safe food and the potential for the CGSB organic standard to include considerations for microbial food safety was investigated by Food safety Network in Canada. It was demonstrated that microbial food safety standards in some cases are achieved indirectly under organic production. The main difference between the US guidelines and the CGSB standard is the focus on the process rather than the safety of the final product and the lack of discussion of microbial considerations in the CGSB standard. Specific omissions include worker hygiene and recommendations for safe use of processing and irrigation water (Ceylan et al. 2003). In Europe, levels of food safety awareness, including organic or ecological food differ across the member states – not only among consumers but throughout the food chain. Unfortunately, people seem to think that organic food implies safe food that is certainly not the case.

3.2. Microbial risks associated to organic farming

It is evident that the quality and safety of the final product, whatever, conventional or organic, depends on the raw material used. Pathogenic microorganisms can be introduced at any point in the food chain: a) in production (manure, unfinished composting, water source), b) from environmental sources during the processing, c) during handling and food preparation (human sanitation or cross-contamination with other foods). Microbiological contamination arising from the use of natural fertilisers can affect both organic and conventional agriculture. It is of special concern that due to rather closed system on organic farm, recycling and concentration of certain pathogens occur. Untreated or improperly treated manure or biosolids used as fertilisers or soil nutrient agents can lead to contamination of products and/or water sources (www.resource-eet.com). Animal and human faecal matters are known to contain a range of human pathogens. Organic produces and nearby water may be contaminated with pathogens if the manure is improperly treated and used as fertiliser in organic farming. In spite of the fact that raw manure is prohibited to use within 60 days of harvesting, this prohibition does not include the use of raw manure obtained from organic animals. It has been shown that organic farms that used manure or compost aged less than 12 months had a prevalence of *E.coli* 19 times greater than of farms that used older materials (Mukherjee et al. 2004). Even though maturation of manure can reduce microbial risks, researchers have shown that most pathogenic organisms like *E.coli, Campylobacter* and *Salmonella* can survive up to 60 days or more under compost conditions and in the soil, depending on temperature and soil conditions. Additionally, some pathogens, such as hepatitis A virus have higher thermal thresholds than others (Diver, retrieved from www.sare.org; 2000). Another risk in production of organic food is avoidance of fungicide use that may lead to the growth of moulds and subsequent production of mycotoxins in crops. A risk of contamination of crops and vegetables with human pathogens is introduced through contamination due to rainfall or via roots or naturally present openings in epithelial tissue. In this case the pathogens manifest throughout the plant endophytically, resulting in very high concentrations of the pathogen in the plant. Since the pathogen is present in the plant, the pathogens cannot be removed by washing during processing. At this point the product is a potential threat for consumer health, especially in case of freshly consumed vegetables (Beuchat 2002). Pathogenic microorganisms may enter the food chain especially through poor sanitation conditions and hygiene during food production or processing, mainly via: contacts with human faeces or faecal contaminated water, contacts with faecal soiled materials (including hands), contacts with vomit or water contaminated with vomit, contact with environments in which infected people were present, even if the surface was not directly contaminated with stool or vomit or by aerosols generated by infected people (DiMatteo 1997; www.wholefoods.com/issues). With new lifestyle of increasing consumption of organic food in Europe, it is expected that, new and emerging pathogens that may cause severe food borne diseases such as *E.coli* (STEC), *L. monocytogenes*, *Campylobacter jejeuni*, *M.avium subsp. paratuberculosis* among bacteria; HEV and TBEV among viruses, *Cryptosporidium parvum* among parasites and toxins mainly arisen from *Fusarium sp.*, may cause severe food borne diseases.

3.2.1. Bacteria

Escherichia coli (E.coli)

Of a special importance in risk assessment in *organic* food production is a G (-), aerobic bacillus, E.coli, enterohemorrhagic serotype 0157:H7 (STEC), an emerging pathogen that did not exist 25 years ago. *E. coli* (STEC) has emerged as a pathogen that can cause foodborne infections and fatal illness in humans. STEC is a rare variety of *E. coli* that produces large quantities of one or more shiga-like toxins that cause severe damage to the lining of the intestine. The pathogenecity of *E. coli* (STEC) is ascribed to a number virulence, and new toxins are still found (Trabulsi et al. 2003), with especially small ruminants representing the most important reservoirs of it (Beutin et al. 1996). *E. coli* (STEC) has caused recent severe outbreak in Europe, Japan and USA with very significant impacts on control methods strongly affecting European food producers. It could be excreted in large numbers to the waters where hygiene is poor, the general environment via sewage. It is flourished in cattle, pigs and chickens. Associated foods are mainly alfalfa sprouts, unpasterised fruit juices and vegetables like lettuce. Although it was reported that prevalence of *E.coli* in certified organic produce was in a level not statistically different from that in conventional samples, organic lettuce had the largest prevalence of *E.coli* (Saghoo et al. 2003, Mukherjee et al. 2004, Franz et al. 2005). On the contrary, Franz and colleagues reported that a trend of faster decline was found in organic than in conventional soil (Franz et al. 2005). Vulnerable groups are mostly the very young an elderly people that may develop the haemolytic uremic syndrome leading to permanent loss of kidney function. In elderly people, the mortality rate is as high as 50%. Although the infective dose is unknown it is presumed to be as few as 10 bacteria (www.cfsan.fda.gov). Michael Doyle at the Universtiy of Georgia found that organically grown products are more likely contaminated with *E.coli* than conventional products. It was demonstrated that the products more likely to be contaminated were sprouts and bagged lettuce where up to a third of the samples were *E.coli* contaminated (www.afic.org). Research into the epidemiology and survival of STEC on the organic farm is just beginning and the common association of STEC with healthy ruminants calls for a highly precautionary approach (Patriquin 2000).

Campylobacter spp.

Campylobacter is the most common identified cause of foodborne disease in conventional as well as in organic food production. This G(-) aerophilic bacterium has been found mainly in poultry, red meat, unpasteurised milk and untreated water. Although it doesn't grow in food it spreads easily, so only a few bacteria in a piece of undercooked chicken could cause illness. It is strongly believed that there is an important association between poultry meat and human *campylobacter* infection, many studies also point to numerous other sources and vehicles of infection. Whereas no *Campylobacter* was detected in organic vegetables, *Campylobacter* species were highly prevalent in both the conventional and organic poultry operations (McMahon and Wilson 2001, Luangtonkum et al. 2006). Moreover, there are indications that although the respiratory health status is better in organic broilers, organic flocks are more often infected with *Campylobacter* than are conventional flocks (Rodenburg et al. 2004, Van Overbeke et al. 2006). In the pig, the occurrence of *C. jejuni* varied considerably between the conventional and organic groups of outdoor pigs. Furthermore, transfer of *C. jejuni* to the outdoor pigs from the nearby environment was not predominant according to the subtype dissimilarities of the obtained isolates (Jensen et al. 2006). In the milk of dairy cattle, *Campylobacter* isolates were obtained from organic and conventional dairy farms, respectively (Helbert et al. 2006). In man, campylobacter infections don't usually cause vomiting, but diarrhoea can be severe and bloody with abdominal cramps, muscle pain and could cause rheumatoid arthritis (Hannu et al. 2004).

Listeria monocytogenes

Listeria monocytogenes is a Gram-positive bacterium, motile by means of flagella. Some studies suggest that 1-10% of humans may be intestinal carriers of *L. monocytogenes*. It has been found in at least 37 mammalian species, both domestic and feral, as well as at least 17 species of birds and possibly some species of fish and shellfish. It can be isolated from soil, silage, and other environmental sources. *L. monocytogenes* is quite hardy and resists the deleterious effects of freezing, drying, and heat remarkably well for *a bacterium* that does not form spores. *L. monocytogenes* has been associated with raw milk, supposedly pasteurized fluid milk, cheeses (particularly soft-ripened varieties), ice cream, raw vegetables, fermented raw-meat sausages, raw and cooked poultry, raw meats (all types), and raw and smoked fish. The ability of *L. monocytogenes* to grow at temperatures as low as 3°C permits the multiplication in refrigerated foods. In spite of the fact, that there are few data available concerning this pathogen in relation with organic production, an evidence exists that organically grown lettuce may be contaminated with *L. monocytogenes* during cultivation (Sagoo et al. 2003, Loncarevic et al. 2005). The infective dose of *L. monocytogenes* is unknown but is believed to vary with the strain and susceptibility of the victim. From cases contracted through raw or supposedly pasteurized milk, it is safe to assume that in susceptible persons, fewer than 1,000 total organisms may cause disease. *L. monocytogenes* may invade the gastrointestinal epithelium. The manifestations of listeriosis include septicemia, meningitis (or meningoencephalitis), encephalitis, and intrauterine or cervical infections in pregnant women, which may result in spontaneous abortion (2nd/3rd trimester) or stillbirth. The onset of the aforementioned disorders is usually preceded by influenza-like symptoms including persistent fever. It was reported that gastrointestinal symptoms such as nausea, vomiting, and diarrhea may precede more serious forms of listeriosis or may be the only symptoms expressed. When listeric meningitis occurs, the overall mortality may be as high as 70%; from septicemia 50%, from perinatal/neonatal infections greater than 80%. In infections during pregnancy, the mother usually survives (www.cfsan.fda.gov). Even though there is no data presenting the higher risks of organic produce than the conventional one, a special caution should be taken into account concerning listeriosis in associated foods.

Mycobacterium avium subsp. paratuberculosis

Many species of *Mycobacteria* that normally live as environmental saprophytes, the environmental mycobacteria (EM) are opportunist causes of disease in humans and animals (Zumla and Grange 2002). Although *Mycobacterium avium subsp. paratuberculosis* infection has had its greatest effect on domestic agricultural animal species, it can also have a significant impact on wildlife species. The possibility exists that milk and dairy products from cattle with Johne's disease as well as from healthy animals could be a potential vehicle of transmission of *Mycobacterium avium subsp. paratuberculosis* (*M. paratuberculosis*) to humans (Gerlach 2002, Grant 2003). Furthermore, results of three different experimental approaches to assess the effect of pasteurisation time/temperature conditions on the viability of *M. paratuberculosis* (laboratory pasteurisation studies, a national survey of commercially pasteurised milk, and processing of naturally infected milk through commercial-scale pasteurising plant) provide firm evidence that this organism is capable of surviving commercial milk pasteurisation on occasion. Hence, both raw and pasteurised cows' milk are potential vehicles of transmission of *M. paratuberculosis* to humans (Grant 2003). A potential source of infection may be other biological materials as blood and manure (Manning 2001). Therefore a special concern should be addressed to the organic milk production about this emerging pathogen. Many, but not all cases are associated with some form of immune deficiency. In recent years, four aspects of EM disease have become particularly relevant to human health: (1) the high prevalence of EM disease in patients with AIDS; (2) the emergence of Buruli ulcer, an ulcerative skin disease caused by *Mycobacterium ulcerans*, as the third most prevalent mycobacterial disease; (3) the effect of infection by EM on the immune responses to BCG vaccination and on the course and outcome of tuberculosis and leprosy; (4) the controversy over the involvement of mycobacteria, notably *M. avium subspecies paratuberculosis*, in human inflammatory bowel disease (Zumla and Grange 2002, Greenstein 2003).

Salmonella spp.

This G (-) aerobic bacilli has been known to cause illness for over 100 years. In the environment, it can be found in water, soil, insects, factory and kitchen surfaces and animal faeces. In organic food production, associated foods of potential risk are raw, unwashed vegetables, sprouts, eggs, unpasterised milk and dairy products as well as many other types of foods, including vegetables and fruits (Sagoo et al. 2003, Mukherjee et al., 2004). It was recently showend, that pigs reared under organic conditions were susceptible to *Salmonella* infections as the conventional pigs and that *Salmonella* persists in the paddock environment where could cause substantial infection of the environment (Jensen et al. 2006). Moreover, the rate of decline of *Salmonella* presence in the organic soil was few in organic soils (Franz et al. 2005). Infective dose of *Salmonella* for human is as few as 15 – 20 cells, depends on age and health of the host and strain differences among the members of the genus. Inflammation of small intestine is a cause of disease, presumably as a consequence of enterotoxin production within the enterocytes (LeJeune and Davis 2004, Kennedy et al. 2004).

Shigella spp.

Shigella are G (-), nonmotile, nonsporeforming rod-shaped bacteria. *Shigella* rarely occurs in animals; principally is a disease of humans except other primates such as monkeys and chimpanzees. Environmental sources of the organism are frequently in water and soil polluted with human faeces (Santamaria and Toranzos 2003). Faecally contaminated water and unsanitary handling by food handlers are the most common causes of contamination. Contamination of raw vegetables, milk, dairy products and poultry as well as other food is usually through the faecal-oral route. The *Shigella spp.* are highly infectious agents. Infective dose is as few as 10 cells, depending on age and condition of host. The disease is caused when virulent *Shigella* organisms attach to, and penetrate, epithelial cells of the intestinal mucosa. After invasion, they multiply intracellularly, and spread to contiguous epithelial cells resulting in tissue destruction (Fernandez and Sansonetti 2003). Some strains produce enterotoxin and Shiga toxin (like the verotoxin of *E.coli* O157: H7) (www.cfsan.fda.gov; Bielecki 2003).

3.2.2. Viruses

Foodborne and waterborne viral infections are increasingly recognised as causes of illness in humans. This increase is partly explained by changes in food processing and consumption patterns, e.g. increased consumption of ecologically produced food. The European directive establishes no specific microbiological criteria concerning the presence of viruses, mainly because quantitative methods for their detection are not yet available, although it is shown that the presence of viruses has been detected in foods that met bacteriological standards. It is not clear whether routine monitoring of food specimens for viral contamination will be feasible. A major problem concerning viruses in organic and conventional production is the use of irrigation water that is fecally contaminated and in most cases contains enteric viruses that persist inside watered vegetables that is eaten raw. The emerging viral pathogens associated with organic food are:

Foecal-orally transmitted hepatitis viruses: hepatitis A virus (HAV), hepatitis E virus (HEV). For HAV and HEV, the primary source of virus is in faeces and the faecal-oral route is the predominant mode of transmission.

Hepatitis A virus (HAV)

Hepatitis A is caused by HAV, a 27-nm ribonucleic acid (RNA) agent that is classified as a picornavirus. Only one serotype has been observed among HAV isolates collected from various parts of the world. HAV causes both acute disease and asymptomatic infection. HAV does not cause chronic infection. Total antibody to HAV develops in response to infection and confers lifelong immunity from future HAV infection (Bower et al. 2000; reviewed by Koopman et al. 2002). Faeces can contain up to 108 infectious virions per ml and are the primary source of HAV. Virus has also been found in saliva and urine during the incubation period in experimentally infected animals, but transmission by saliva or urine has not been reported to occur. Cold cuts and sandwiches, fruits and fruit juices, milk and milk products, vegetables, salads, shellfish, and iced drinks are commonly implicated in outbreaks. Water, shellfish, and salads are the most frequent sources. Contamination of foods by infected workers in food processing plants and restaurants is common. Since the fatality rate of HAV infections increases with age, risks of more serious illness are higher for older people, not being exposed to the virus in early age. Complications of hepatitis A include fulminant hepatitis, in which the case fatality rate can be greater than 50% despite medical interventions such as liver transplantation; cholestatic hepatitis, with very high bilirubin levels that can persist for months; and relapsing hepatitis, in which exacerbations can occur weeks to months after apparent recovery (Hutin et al. 2000; reviewed by Koopman et al. 2002). Persons with other forms of hepatitis (like hepatitis B) are at higher risk of hepatitis following the superinfection with HAV. Viremia occurs during the preclinical and clinical phases of illness, and HAV has been transmitted by transfusion (before screening of blood and blood products for HAV was initiated) and by injection drug use (Hutin et al. 2000; reviewed by Koopman et al. 2002).

Hepatitis E virus (HEV)

HEV is the major etiologic agent of enterically transmitted non-A, non-B hepatitis worldwide. It is a spherical, non-enveloped, single stranded RNA virus that is approximately 32 to 34 nm in diameter. HEV belongs to a genus of HEV-like viruses (unassigned genus). HEV is transmitted primarily by the faecal-oral route and faecally contaminated drinking water is the most commonly documented vehicle of transmission (Labrique et al. 1999). Although hepatitis E is most commonly recognized to occur in large outbreaks, HEV infection accounts for >50% of acute sporadic hepatitis in both children and adults in some high endemic areas (Kranczynski et al. 2001). Risk factors for infection among persons with sporadic cases of hepatitis E have not been defined. Unlike hepatitis A virus, which is also transmitted by the faecal-oral route, person-to-person transmission of HEV appears to be uncommon. However, nosocomial transmission, presumably by person-to-person contact, has been reported to occur. Virtually all cases of acute hepatitis E in the United States have been reported among travellers returning from high HEV-endemic areas. Although HEV is often a self-limiting disease with a relatively low overall death rate (0.5 to 3.0%), the death rate during pregnancy approaches 15 to 25% with possibilities of foetal death, abortion, premature delivery, or death of a live-born baby soon after birth (Smith 2001, Chibber et al. 2003). HEV is transmitted primarily by the faecal-oral route and waterborne epidemics are characteristics of hepatitis E. Recent studies have documented that sporadic acute hepatitis E also occurs in industrialised countries with no history of travel to areas endemic for HEV leading to suggestions that HEV may be endemic at low levels in developed countries (Ceylan et al. 2003). Moreover, cases of acute human hepatitis linked to novel HEV variants have been reported in Europe and Japan (Yazaki et al. 2003). There are results showing 43,5% sewage samples positive in Barcelona (Spain), 20% in Washington (USA) and 25% in Nancy (France) thus indicating that HEV may be more prevalent that previously considered (Clemente-Casares et al. 2003). It has been recognised that HEV and HEV related viruses circulate in domestic animals native to industrial countries and should be considered as a potential public health hazard (Yazaki et al. 2003; Widdowson et al. 2003). This is well documented in swine, but also in chicken (Clemente-Casares et al. 2003). Moreover, it is likely that some foods like shellfish can act as vehicles for transmission of HEV (Smith 2001). Thus the possibility that farm animal species could represent reservoirs for human contamination through food and meat has to be considered seriously. As an example, a recent report indicate that several patients who contracted sporadic acute or fulminant hepatitis E in Japan had a history of consuming grilled or undercooked pig liver 2-8 weeks before the disease onset (Yazaki et al. 2003).

Tick-borne encephalitis virus (TBEV)

Tick-borne encephalitis virus (TBEV), an enveloped virus with a positive single-stranded RNA genome belongs to the Flaviviridae family. It is the causative agent of TBE which is one of the most dangerous neuroinfection in Europe and Asia. Although TBEV is an arbovirus usually transmitted by tick bite, it is an emerging foodborne pathogen, as it is known that approximately 10% of human infections were associated with consumption of goat, sheep and cow raw milk and raw milk products (Gritsun et al. 2003, Juceviciene et al. 2002). Very few food related studies have been carried out for TBEV. It is currently mainly a problem in the Southern and Eastern parts of Europe. Generally the best protection against virus diseases is vaccination (Kreil et al. 1998), however the prophylactic use of probiotics may be a valuable complement to vaccination in endemic TBEV areas, where consumption of raw milk from goats and sheep is common. Probiotics may also be used in prophylactics in western European countries to prevent entry through gastrointestinal tract, especially in those countries (e.g. France) where raw goat milk is used in dairy production. With the new lifestyle trends in Europe (more ecological or organic food production, processing and consumption) there is a potential for much higher incidence of foodborne infections by TBEV.

3.2.3 Moulds

The most frequent toxigenic fungi in Europe are *Aspergillus*, *Penicillium* and *Fusarium* species. They produce aflatoxin B1 transformed into aflatoxin M1 found in the milk, as well as Ochratoxins and Zearalenone, Fumonisin B1, T-2 toxin, HT-2 toxin and deoxynivalenol (vomitoxin), which are of increasing concern in human health. These toxins are produced by only a few species of fungi, in a limited range of commodities. Aflatoxins are potent carcinogens, produced by *Aspergillus flavus* and *A. parasiticus* in peanuts, maize and some other nuts and oilseeds. Ochratoxin A is a kidney toxin and probable carcinogen. It is produced by *Penicillium verrucosum* in cereal grains in cold climates, by *A. carbonarius* in grapes, wines and vine fruits, and by *A. ochraceus* sometimes in coffee beans. These mycotoxins are under continuous survey in Europe, but the regulatory aspects still need to be set up and/or harmonised at European level (Pitt 2000). They are found in foodstuffs and are not destroyed by normal industrial processing or cooking since they are heat-stable. Some of their metabolites are still toxic and may be involved in human diseases. Their toxic effects (liver, kidney and hematopoetic toxicity, immune toxicity, reproduction toxicity, foetal toxicity and teratogenicity, and mainly carcinogenicity) are mostly known in experimental models, the extrapolation to humans being always inaccurate (Creppy 2002). Of the main potential risks arised from moulds in organic food production are ochratoxin A (OTA) mycotoxin producing *Aspergillus* and *Penicillium* species (Petzinger and Ziegler 2000). A major problem in organic food production is *Fusarium sp*. producing fusarial toxins as toxic metabolites. Dominant mycotoxins of this group include trichothecenes, moniliformin, zearalenone, and fumonisins. Recently, special attention has been paid to these toxins because of their harmful effects on both animals and humans (Čonkova et al. 2003). Fumonisins, which may cause oesophageal cancer, are formed by *Fusarium moniliforme* and *F. proliferatum*, but only in maize. Trichothecenes are highly immunosuppressive and zearalenone causes oestrogenic effects; both are produced by *F. graminearum* and related species. Current reporting probably underestimates the effect of mycotoxins as a cause of human mortality (Pitt 2000).

3.2.4. Parasites

The major protozoan species that affect humans are *Entamoeba histolytica*, *Acanthamoeba sp*., *Neagleria sp. Giardia intestinalis*, *Cryptosporidium parvum*, *Cyclospora cayetanensis*, *Toxoplasma gondii*, *Isospora/Sarcocystis sp. Encephalitozoom intestinals* and *Enterocytozoon bieneuisi*. These parasites exist in the environment as oocyst, cysts or spores, which are the transmissive stages in many environmental conditions, e.g. water, soil, food as well as being infective stages to subsequent generation of hosts (Sinski

2003). Of a special importance in potential risks in organic food production is *Cryptosporidium parvum* and *Cryptosporidium hominis* that are obligate enteric protozoan parasites which infect the gastrointestinal tract of animals and humans. The mechanism(s) by which these parasites cause gastrointestinal distress in their hosts is not well understood. The risk of waterborne transmission of *Cryptosporidium* is a serious global issue in drinking water safety. Oocysts from these organisms are extremely robust, prevalent in source water supplies and capable of surviving in the environment for extended periods of time. Resistance to conventional water treatment by chlorination, lack of correlation with biological indicator microorganisms and the absence of adequate methods to detect the presence of infectious oocysts, necessitates the development of consistent and effective means of parasite removal from the water supply (Carey et al. 2004). *Cryptosporidium parvum*, a single-celled animal, i.e. protozoa, is an obligate intracellular parasite. It has been given additional species names when isolated from different hosts. It is currently thought that the form infecting humans is the same species that causes disease in young calves. The forms that infect avian hosts and those that infect mice are not thought capable of infecting humans. *Cryptosporidium sp.* infects many herd animals (cows, goats, sheep among domesticated animals, and deer and elk among wild animals). The infective stage of the organism, the oocyst is 3 μm in diameter or about half the size of a red blood cell. The sporocysts are resistant to most chemical disinfectants, but are susceptible to drying and the ultraviolet portion of sunlight. Some strains appear to be adapted to certain hosts but cross-strain infectivity occurs and may or may not be associated with illness. The species or strain infecting the respiratory system is not currently distinguished from the form infecting the intestines. Infectious dose is less than 10 organisms and, presumably, one organism can initiate an infection. The mechanism of disease is not known; however, the intracellular stages of the parasite can cause severe tissue alteration. *Cryptosporidium sp*. could occur, theoretically, on any food touched by a contaminated food handler. Incidence is higher in child day care centers that serve food. Fertilising salad vegetables with manure is another great risk for human infection. Large outbreaks are associated with contaminated water supplies. Intestinal cryptosporidiosis is characterized by severe watery diarrhea but may, alternatively, be asymptomatic. Pulmonary and tracheal cryptosporidiosis in humans is associated with coughing and frequently a low-grade fever; these symptoms are often accompanied by severe intestinal distress (www.cfsan.fda.gov).

3.3. Reducing occurrence and risks of pathogens on the organic farm

Very few scientific studies have sought to compare the microbiological quality of organic versus conventionally produced food. And of those carried out, their results have not been conclusive due to limitations such as relatively small number of samples and failure to address seasonal and regional variations in the produce. The globalization of the food market has hampered the implementation of control measures to assure safe food. Food standards agency of European Union considers that there is not enough information available at present to be able to say that organic foods are significantly different on their microbial safety to those produced by conventional farming. In the French study on Quality and Safety of Organic foods carried out by AFSSA in 2004, the results are partly based on literature and partly on subjective expert opinions therefore the results are not conclusive as well. It is clear that in general, food safety risk management in organic production needs more specific monitoring and more restrictive standards are needed. Moreover, more research is required on pathogen survival inside the organic food chain. The provisional recommendations would include: 1) Prolonged period of manure maturation to up to one year before use and not mixing it with any fresh one to avoid reintroduction of pathogens into the food chain. 2) Exclusion of domestic and wild animals from production fields. 3) Usage of clean water in the farm processes. 3) Ensurance that contaminated water or livestock waste cannot enter a field via runoff or drift. 4) Insurance of proper sanitary conditions and hygienic practices by farm workers. 5) Keeping good records.

Health and safety measures that should be followed to reduce occurrence and risks of pathogens on the organic farm include also:

- Knives and other implements must be kept sharp - this reduces the risk of injury from using too much force when trimming and harvesting
- If machinery is used, moving parts should be enclosed with guards, where possible
- Adequate health and safety training should be provided if new technologies and/or working practices are introduced, e.g. if fertilisers or pesticides are recommended, measures should be in place for smallholders who cannot read instructions
- Recommended fertilisers and pesticides should be packed in sizes that women can carry
- Latrines should not be located near open water sources used for irrigation or drinking water
- Properly located latrines should be available near to sites of production - this enables smallholders to use these facilities when they need to, so discouraging the incidence of defecation in the field, which increases the risk of faecal contamination
- Smallholders should be trained in basic sanitation and personal hygiene to prevent unintentional transmission of food-borne illnesses to others, e.g. *Salmonella spp.*, *Shigella spp.*, *E. coli* and hepatitis A viruses - farmers should be informed that good hygiene protects them from illness
- Farmers with open sores, boils or infected wounds on parts of the body that might come into contact with others, or with fresh produce, must not take part in harvesting, sorting or packing (Retrieved from http://www.nri.org/NRET/SPCDR/).

Food safety begins on the farm therefore maintaining good agricultural practice (GAP) followed by good manufacturing practice (GMP) in food processing and handling is essential to reduce the occurrence and risks of pathogens on the organic farm. The HACCP system that monitors critical steps in the organic food chain should be introduced as it identifies where problems might occur and allows the food handler to take appropriate precautions to prevent contaminations. Codes for good agricultural practice can be obtained from www.fao.org/DOCREP/006/Y5224E/y5224e04.htm, www.ruralni.gov.uk/environment/countryside/Codes_of_Good_Agriculture_Practice/ and www.fact-index.com/g/go/good_agricultural_practices.html.

CONCLUSIONS

Consumers have the right to choose, but is the statement of marketing organic food as a "safe, natural" alternative to conventional food states a truth? No, we do not have the system that gives us totally safe food. Food quality and safety are of concern to every individual. The production of safe food can only be achieved trough a co-ordinated effort at all points along the farm-to-fork chain. Since food production begins at the farm, it is the responsibility of all primary producers, organic and conventional, to take efforts to minimise microbial risks from their products. Specific measures would include ensuring adequate facilities and training to ensure worker hygiene and recommendations for processing food and processing water. And with both conventional and organic systems, verification through microbial testing is required to demonstrate that actions match words. Growers need to be aware of the microbiological problems that can occur and need to take steps to help protecting the health of the consumer, as well as health of their families, business and livehoods.

The responsibility for ensuring consumer expectations that their food would be enjoyable, nutritious and safe is consistently met rests with governments, industry and the consumers themselves.

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