

# Microbiological safety of food of animal origin from organic farms

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## Abstract

The organic food sector and consumer interest in organic products are growing continuously. The safety and quality of such products must be at least equal to those of conventional equivalents, but attaining the same standards requires overcoming a particular problem identified in organic food production systems: the occurrence of bacterial pathogens such as *Salmonella*, *Campylobacter*, *Listeria monocytogenes*, *Staphylococcus aureus* and pathogenic *Escherichia coli*. These food-borne microorganisms were detected in the production environments of such food. The prevalence of pathogenic bacteria in organic livestock and products may be higher, but may also be the same as or lower than in like material from conventional farms. Furthermore, the incidence of antimicrobial-resistant bacteria was more often detected in conventional than in organic production. The aim of this review was to present the recent information on the microbiological safety of food of animal origin produced from raw materials from organic farms.

**Keywords:** organic food, organic farming, food safety, food-borne pathogens.

## Introduction

In recent years, the organic food sector has been growing continuously in many world regions, especially in the European Union (EU) (29, 32). The newest data at the time of writing put 69.8 million hectares under organic agriculture in 181 countries worked by approximately 2.9 million farmers, while in 1999 this area covered 11 million hectares and involved only 200,000 producers. In Europe, 4.4 million bovines, 5.2 million sheep, almost 1 million pigs, and 50 million poultry were reared organically in 2017. Compared to 2008, increases of 75.8%, 73.6%, 47.6%, and 103% were reported, respectively (45). One of the main reasons for changes in consumer habits is the belief that organic products provide health benefits. The safety and quality of such products must be at least equivalent to those of conventional foods, and as consumption of them increases, the potential effect of any safety and quality deficits in organic produce is greater. Livestock in organic agriculture has access to fresh air, and although such a husbandry system is more animal welfare-friendly, it may also create a higher risk of exposure to zoonotic

pathogenic agents from the environment (29, 32). The main differences between traditional and organic animal husbandry derive from the latter's prioritising ecological principles, and are in housing (lower animal density and access to outdoor areas), feeding (mostly organic feed) and making possible animal expression of natural behaviour (e.g. nesting) (44).

Prophylactic application of antibiotics to animals is not allowed either in conventional or organic production systems. Such preparations are only permitted for use in animal treatment under strict conditions when the use of phytotherapeutic, homeopathic or other products is not possible or ineffective (8, 9). However, analysis of food for the presence of antibiotic residues reported that the established acceptable limits have occasionally been exceeded (6, 23). According to Bacanlı and Başaran (2), the presence of antimicrobial substances in foodstuffs is growing. Due to specific restrictions on the use of antimicrobials in organic livestock production, there is a higher risk of contamination of such products with bacterial pathogens and consequently an increased microbial hazard. However, the studies in this area are inconsistent (46). Many intestinal bacteria (e.g. *Campylobacter*, *Salmonella*,

and *Escherichia coli*) that can cause serious diseases in humans do not cause any symptoms in animals. They are part of the commensal intestinal microflora and occur at a relatively high level in the faeces of healthy animals. This is especially important for Shiga toxin-producing *E. coli* (STEC), including O157, which can induce severe disease in people even when they are present at a very low level (<100 CFU) in food (14, 31). The possibility of the occurrence of bacterial pathogens such as *Salmonella*, *Campylobacter*, *Staphylococcus* and pathogenic *E. coli* has been identified as a particular problem for organic food production systems. Among foods of animal origin, poultry meat and eggs are often associated with the highest risk of food-borne disease, hospitalisation and death in humans. Most infections connected with this food category are caused by *Salmonella* and *Campylobacter*. It has been found that pork and pork products are two of the main sources of *Salmonella*, whereas the most important food-borne pathogens from bovine products are Shiga toxin-producing *E. coli* strains (31). In the case of dairy farming, *Salmonella*, *Campylobacter*, *Listeria monocytogenes* and *Staphylococcus aureus* are the major threats besides pathogenic *E. coli* (24, 25).

The microbiological safety of organic food depends on the presence of food-borne microorganisms in the production environment or secondary contamination of the products by these pathogens. Such contamination often occurs during the early stages of primary production (3). The prevalence of pathogenic bacteria in organic livestock and food products may be higher, equal to, or lower than their prevalence in conventional equivalents (31, 32).

The aim of this review is to summarise, based on a screening of the recent literature, the information on the microbiological safety of food of animal origin produced from raw materials obtained from organic farms. As there have been a limited number of such studies carried out in Poland, the data utilised in this article are mostly from other countries.

### Contamination with *Campylobacter*

*Campylobacter* is one of the main agents of bacterial gastroenteritis, usually causing self-limiting diarrhoea (11, 20). It is also associated with extra-intestinal infections that include bacteraemia, haemolytic uraemic syndrome, reactive arthritis and meningitis (11). In 2018, the number of confirmed human campylobacteriosis cases in the European Union was 246,571, including 719 in Poland. There were 522 food-borne campylobacteriosis outbreaks in the EU with 2,335 persons involved. Two of the most common sources of these bacteria were broiler meat and unpasteurised cow's milk. The monitoring data on *Campylobacter* in food demonstrated the highest proportion of test-positive units to be in fresh meat from broilers (37.5%). Such food products were also reported

as one of the main sources of *Campylobacter* outbreaks in 2018 (13). Harvey *et al.* (18) described seven outbreaks caused by *Campylobacter* which were associated with organic raw meat and cream.

*Campylobacter* was present more often on free-range chicken farms than on farms with caged rearing, but the contamination level of meat was similar (32). Heuer *et al.* (21) and Rosenquist *et al.* (38) also reported higher percentages of *Campylobacter* prevalence on free-range farms (100% and 54.2%, respectively) than on farms using conventional poultry housing (36.7% and 19.7%, respectively). Likewise, a higher prevalence of *Campylobacter* was observed in antimicrobial-free swine breeding (77.3%) than in conventional pig production (27.6%) (42). Esteban *et al.* (12) demonstrated a higher incidence of *Campylobacter* in non-organic animal breeding than in organic, but in both types the percentages of bacteria-positive samples were similar, i.e. 76.7% and 70.6%, respectively. Economou *et al.* (11) examined 369 raw chicken meat samples from free-range and conventional poultry farms and showed a higher prevalence of *Campylobacter* on the latter (29.4%) than the former (25%). In both types of animal production, the most common was *C. jejuni* (60.4% and 53.3%, respectively), followed by *C. coli* (38.5% and 40%, respectively). Wild birds and soil were considered an important source of infections for the free-range poultry farms in this study (11).

### Contamination with *Salmonella*

Salmonellosis remains the second most commonly reported gastrointestinal infection in humans in the European Union (41). In 2018, 91,857 confirmed cases were identified, with 9,064 infections in Poland. In total, 1,580 food-borne outbreaks of salmonellosis were described. *Salmonella* caused 30.7% of all food-borne outbreaks of gastrointestinal infection in the EU with 11,581 humans involved. Most of these outbreaks were caused by *S. Enteritidis* and *S. Typhimurium*. The highest levels of *Salmonella*-positive samples were identified in poultry meat and other meat intended to be cooked before consumption (13); however, Harvey *et al.* (18) reported two outbreaks which were associated with organic eggs contaminated with *S. Enteritidis* and resulted in 31 infected persons.

*Salmonella* was present in a relatively small number of organically reared birds tested post slaughter, which may support the theory that organic animals are less susceptible to colonisation by these bacteria (32). In a study in which 595 eggs and environmental samples from farms of caged and free-range breeding hens were tested, *Salmonella* was found more often in conventional (11 out of 208, 5.3%) than in organic production (10 out of 387, 2.6%). Eighteen out of all 21 *Salmonella* strains isolated were *S. Typhimurium* and one was *S. Enteritidis* (28). On the other hand, in another study the prevalence of *Salmonella*-positive pigs was higher on outdoor farms

than on farms rearing animals in pigsheds. It was assumed that there is a risk of the presence of *Salmonella* in meat from such farming systems (31). Tomang *et al.* (41) also demonstrated that *Salmonella* occurred more often in pork from organic pigs (8.3%) than in pork from non-organic animals (3.5%), but more isolates of *S. Enteritidis* and *S. Typhimurium* were noted on conventional than on organic farms, i.e. 76.6% and 28.3% of all *Salmonella* isolated, respectively. Furthermore, Hoogenboom *et al.* (22) detected *Salmonella* in 27% of samples obtained from organic pig farms, which was comparable with the analogous data from conventional farms. They also identified *Salmonella* on 20% of organic dairy farms and 11% of broiler farms (22). The study of Fossler *et al.* (15) showed a similar prevalence of *Salmonella* on organic and conventional dairy farms (5.2% and 4.8%, respectively). Esteban *et al.* (12) demonstrated an even lower percentage of *Salmonella* on poultry farms under both systems, i.e. 2.9% (organic) and 1.7% (conventional).

### Contamination with Shiga toxin-producing *Escherichia coli*

Pathogenic *E. coli*, especially *E. coli* O157:H7, are food-borne pathogens that cause outbreaks of haemorrhagic colitis, which often leads to haemolytic uraemic syndrome in children and the elderly (37). In 2018, 8,161 cases of STEC infection in humans were confirmed in the EU, but only 5 individuals were identified as infected with the pathogen in Poland. A total of 43 food-borne STEC outbreaks affecting 381 humans were reported, mainly caused by bovine meat and milk products (13). Three outbreaks due to *E. coli* O157:H7 were reported in the USA associated with organic raw meat and cream, which resulted in 18 persons infected (18). In Denmark in 2003–2004, 25 people were infected with STEC O157 after consumption of organic milk from a small dairy (27).

Equal or lower rates of STEC prevalence were detected in livestock from organic farms compared to animals from conventional ones. According to Lucke (32), the differences in the prevalence of these bacteria were associated with the feeding of animals. It has been supposed that the greater amount of roughage in the livestock diet in organic farming may reduce the *E. coli* level in the colon (32). Similar rates of incidence of *E. coli* O157:H7 in beef from organic and conventional farms were found by Reinstein *et al.* (37). In their study, the prevalence of these bacteria was 14.8% in beef from organic and 14.2% in beef not from organic production. The results obtained by Cho *et al.* (7) showed a greater difference – *E. coli* O157 was detected in 8.4% of samples from organic dairy cattle farms and in 3% from conventional farms. Hoogenboom *et al.* (22) showed the presence of this pathogen on 2 out of 10 organic dairy farms. There are also studies that demonstrated the absence of STEC, including *E. coli* O157, on organic cattle and poultry farms (12, 34, 47).

### Contamination with *Listeria monocytogenes*

Another important food-borne pathogen is *L. monocytogenes*, which is responsible for listeriosis, a disease especially dangerous for infants, pregnant women, the elderly, and immunosuppressed individuals (1). Listeriosis is characterised by high mortality; thus, the presence of these microorganisms is monitored in food and food production environments (19, 26). In 2018, 2,549 confirmed human cases of listeriosis in the EU were reported by 28 member states (128 in Poland), of which 15.6% were fatal. This makes listeriosis one of the most serious food-borne diseases in the EU. *L. monocytogenes* was detected in ready-to-eat food made of bovine meat and much less frequently in meat from other animal species, and in milk products (13). Pradhan *et al.* (36) reported two cases of human infection related to raw organic milk consumption.

*L. monocytogenes* was detected on both organic and conventional poultry farms at similar levels of 26.5% and 26.7%, respectively (12). Most of the bacteria were of the 4b serogroup, which is responsible for the majority of human listeriosis outbreaks (12, 48). Similarly, Gücükoğlu *et al.* (16) demonstrated the presence of *L. monocytogenes* in 60 out of 240 (25%) organic chicken meat samples. Most of the isolates were of the 1/2a serogroup (71.9%), followed by 1/2b (21.8%), 4b (4.2%) and 1/2c (2.1%) (16). The 1/2a serogroup is considered to be the most prevalent in food among all *L. monocytogenes* identified (48). Schwaiger *et al.* (39), who tested almost 1,000 swab samples as well as eggs on various kinds of chicken farms, did not detect *L. monocytogenes* at all. Other *Listeria* species such as *L. innocua* and *L. seeligeri* were noted on conventional and organic farms at the levels of 1.8% and 1.3%, respectively (39). Likewise, no significant differences in the prevalence of *Listeria* spp. were found by Jones *et al.* (28) between eggs or in the farm environments of flocks of caged layers and those of free-range layers. Detection of *L. monocytogenes* was achieved in 2 out of 7 *Listeria*-positive samples among 249 samples tested (28). Pesavento *et al.* (34) demonstrated the absence of *L. monocytogenes* in 300 samples of eggs collected from organic and free-range farms.

### Contamination with *Staphylococcus aureus*

*Staphylococcus* bacteria, especially *S. aureus*, are involved in food-borne infections of humans and in food poisoning (43). The disease caused by staphylococci is due to the production of enterotoxins during bacterial growth (34). In 2018, 8.4% of 15,598 food samples were reported as *Staphylococcus* spp.–positive in 15 European countries. Furthermore, 46 out of 3,908 such samples (1.2%) were contaminated with staphylococcal enterotoxins (13).

The occurrence of *S. aureus* is common in farm environments as well as in meat or eggs, depending on

the farm's production profile. On organic farms, the bacteria occur less frequently. In microbiological analyses of eggs deriving from organic and free-range chicken farms, *S. aureus* was detected in 4 out of 300 (1.3%) samples (34), whereas eggs from conventional farms were positive for these bacteria at the level of 10.5% (23 out of 220 samples) (35). Carrel *et al.* (5) tested meat from various retailers and also demonstrated a lower prevalence of *S. aureus* in organic samples (16.7%) compared to those from conventional production (35.1%). Similarly, Haskell *et al.* (17) detected *S. aureus* at a higher level in raw poultry meat from conventional farms (27.4%) than in this meat from antibiotic-free farms (13%). Also in the case of dairy products, the percentage of *S. aureus*-positive samples was higher for the non-organic (44.8%) than for the organic products (31%) (30). There are also studies that demonstrated the complete absence of *S. aureus* in livestock raised in an ecology and welfare-promoting system (10).

### Contamination with antimicrobial resistant bacteria

One of the most important problems in terms of food safety and public health is the occurrence of antimicrobial-resistant bacteria (32). It seems that the restriction on the therapeutic use of antibiotics in organic animal production lowers the incidence of antimicrobial resistance in bacterial isolates from organically farmed animals compared to those bred in an unrestricted system (46). Most studies showed a low prevalence of methicillin-resistant *S. aureus* (MRSA) in livestock on organic farms as well as in such poultry and pork (32). The incidence of MRSA may present a real problem and a risk to human health (44). Van de Vijver *et al.* (44) examined approximately half of all organic pig farms in the Netherlands and detected MRSA on 20.8% of them. On conventional farms, MRSA was more widespread, noted in up to 70.1% of herds. It suggests that antibiotic usage contributed significantly to the higher MRSA prevalence in herds reared intensively (4). The observations of Haskell *et al.* (17) confirmed these findings and showed a higher level of MRSA in meat from non-organic farms (15.7%), while in antibiotic-free farmed meat MRSA was not detected at all. Antimicrobial resistance of *Campylobacter* also occurred less commonly in organic herds than in conventional breeding. It was found that 45% of *Campylobacter* isolates from organic pig farms showed antimicrobial resistance compared to 80% from farms not using organic methods (22, 32). Thakur and Gebreyes (42) also demonstrated a higher prevalence of erythromycin and tetracycline resistant *Campylobacter* isolates from conventional pig farms (77% and 83.4%, respectively) than in those from organic farming (34.5% and 56.2%, respectively). However, the presence of *Enterobacteriaceae* bacteria, in particular *E. coli*, with genes encoding extended-spectrum  $\beta$ -lactamases (ESBL) was similar on both

organic and conventional farms (32). Stuart *et al.* (40) detected ESBL-producing microorganisms in 100% of chicken meat samples from non-organic and in 84% of samples from organic farms. The rates of resistance to trimoxazole, ciprofloxacin and tobramycin were the same in both farming systems and were 56%, 14%, and 2%, respectively. Nevertheless, bacteria resistant to tetracycline were more prevalent on conventional (73%) than organic (46%) holdings (40). Millman *et al.* (33), who examined chickens from various types of farming including conventional and organic for the presence of antimicrobial resistant *E. coli*, demonstrated comparable rates in both categories. However, resistance to the antimicrobials such as cefazolin and ampicillin was detected more often in the bacteria isolated from chickens from the organic farms (43% and 33%, respectively) than in bacteria from intensively farmed chickens (30% and 24%, respectively). On the other hand, resistance to gentamicin, ampicillin-sulbactam and trimethoprim-sulfamethoxazole was more frequent in conventionally reared chickens (24%, 18%, and 9%, respectively) than in organic poultry (13%, 13%, and 0%, respectively) (33). Similarly, the prevalence of antimicrobial resistant *Salmonella* was significantly lower on organic pig farms (54.7%) compared to isolates from conventional farming (97.9%) (41). The isolates were most often resistant to tetracycline (97.9% vs 54.7%), followed by ampicillin (95.7% vs 39.6%), gentamicin (76.6% vs 15.1%) and streptomycin (59.6% vs 54.7%). However, resistance to ceftiofur, cephalothin and colistin was observed only in *Salmonella* isolated from organic farms (15.1%, 15.1% and 1.9% of strains, respectively) (41).

The incidence of antibiotic resistance is lower in organic production than in the conventional approach. The maintenance of animal health in organic farming is mainly based on prophylaxis, through management factors such as hygiene measures and lower livestock densities (14). The less frequent occurrence of antimicrobial resistant bacteria in free-range livestock may also be due to the more restrictive use of antibiotics. Moreover, animals in such farming systems demonstrated a higher resistance to colonisation by some of the bacterial pathogens (32).

### Conclusions and perspectives

The above data relate mainly to livestock and food production environments. As very few studies focus on pathogens from organic food products, especially ready-to-eat food, further studies on organic food safety are necessary. Consumer interest in organic food is growing. Thus, the presence of pathogenic bacteria in this kind of food, especially those belonging to the species referred to in the present article, may be a potential problem and cause a public health risk. Therefore, further studies are needed to assess the microbiological safety of food produced from organically farmed animals.

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