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Review

Microbiology of organic and conventionally grown fresh produce

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ABSTRACT

Fresh produce is a generalized term for a group of farm-produced crops, including fruits and vegetables. Organic agriculture has been on the rise and attracting the attention of the food production sector, since it uses eco-agricultural principles that are ostensibly environmentally-friendly and provides products potentially free from the residues of agrochemicals. Organic farming practices such as the use of animal manure can however increase the risk of contamination by enteric pathogenic microorganisms and may consequently pose health risks. A number of scientific studies conducted in different countries have compared the microbiological quality of produce samples from organic and conventional production and results are contradictory. While some have reported greater microbial counts in fresh produce from organic production, other studies do not. This manuscript provides a brief review of the current knowledge and summarizes data on the occurrence of pathogenic microorganisms in vegetables from organic production.

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Introduction

Fresh produce is a generalized term for a group of farm-produced crops, including fruits and vegetables. These foods are an important component of a healthy diet. Consumption of fresh produce is widely promoted by governmental health agencies since it supplies essential nutrients such as vitamins, minerals, dietary fiber and phytochemical compounds at a relatively low calorie density. Furthermore, the consumption of fruits and vegetables has been strongly associated with reduced chronic diseases, risk of heart disease and cancer.[1–3] Alternative cropping systems have been developed because of society's increasing concerns about the sustainability of conventional agriculture, intensive use of chemical products and their potential risk to human health and the environment.[4,5]

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Organic agriculture has been on the rise and is attracting the attention of the food production sector in many parts of the world, since it revives eco-agricultural principles that are potentially more environmentally friendly and may provide products with few agrochemical residues.[6,7] Organic farming practices which use animal manure as fertilizer can increase the risk of contamination by enteric pathogenic microorganisms and, consequently, pose health risks becoming a major concern for consumers and governments. Furthermore, these foods are often consumed raw, increasing risk of infection if pathogens are present.[8]

Despite the growing demand for organic fresh produce and its health benefits, a number of foodborne disease outbreaks have been associated with the consumption of these foods.[8–14] However, the number of studies focusing on microbial safety of organically produced foods is low. This manuscript provides a brief review of the current knowledge and summarizes data on the risk of pathogenic microorganisms in vegetables from organic production.

Organic farming

The organic sector has expanded recently worldwide, due to policy support and a growing market demand for these products. Organic farming can be defined as an ecological production system that promotes and enhances biodiversity and biological cycle in soil, crop and livestock. It is based on minimal use of off-farm inputs and on management practices that restore, maintain and enhance ecological harmony.[15] The process of certification is also important in organic farming. Certification is intended to assure the consumers that a product marketed as organic was in fact produced according to organic production standards, which vary from country to country, based on their certifying bodies.[16]

Organic farming is regulated internationally by *Codex Alimentarius* Guidelines [established by the Food and Agricultural Organization of the United Nations (FAO) and the World Health Organization (WHO)] and by the International Federation of Organic Agriculture Movements (IFOAM) Basic Standards.[17] According to the IFOAM,[18] the principles of organic agriculture are: (i) health: organic agriculture should sustain and enhance the health of soil, plant, animal, human and planet as one and indivisible; (ii) ecology: organic agriculture should be based on living ecological systems and cycles, work with them, emulate them and help sustain them; (iii) fairness: organic agriculture should be built on relationships that ensure fairness with regard to the common environment and life opportunities and (iv) care: organic agriculture should be managed in a precautionary and responsible manner to protect the health and well-being of current and future generations and the environment.

Main sources of contamination of fresh produce by foodborne pathogens

Fresh produce can become contaminated with pathogenic microorganisms during pre-harvest (in the field) and post-harvest stages and this contamination can arise from environmental, animal or human sources. Pre-harvest sources include soil, irrigation water, inadequately composted or raw animal manure, dust, insects, presence of wild and domestic animals and human handling. Post-harvest sources include human handling, harvesting equipment, transport containers/vehicles, rinse water, improper storage and packaging.[8,11,19,20] Fig. 1 illustrates the main routes of fresh produce contamination in the field.

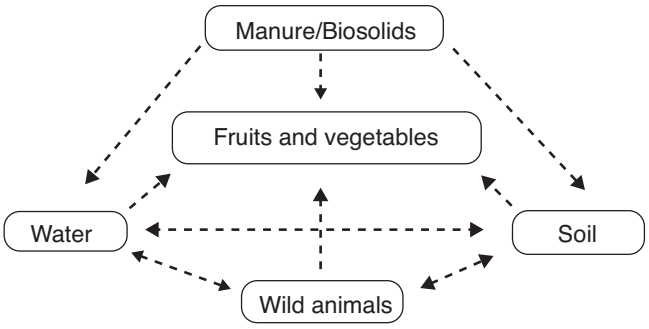

Fig. 1 – The sources and routes of contamination of fruits and vegetables.
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The soil is a habitat for many organisms, including human pathogens, which can contaminate plants through the seeds, roots or surface. Both conventional and organic produce can be fertilized with natural sources of nutrients such as animal manure and plant debris. Since animal manure is the main fertilizer type in organic farming, where no chemical treatment against bacteria is allowed, it gives rise to concern about the possible contamination of produce with microbial pathogens such as *Escherichia coli* O157:H7, *Salmonella* spp., and *Listeria monocytogenes*.[21,22] A key strategy used to reduce the concentration of enteric pathogens in manure is composting, the biological decomposition of organic matter by microorganisms under controlled conditions.[23] Compost can provide certain benefits to plants when applied to the soil. If composting is done incorrectly (i.e. for too short a time or at too low a temperature), the result can increase microbial proliferation and risk of pathogen contamination.[24,25]

The irrigation water can also be a source of contamination. The most common sources of water for irrigation include wells, rivers, reservoirs and lakes, all of which are susceptible to contamination by human pathogens. The presence of pathogenic microorganisms in irrigation water and their transfer to vegetables has been reported.[26–28] Moreover, vegetable cultivation in open areas allows the access of animals (birds, insects, rodents, domestic and wild animals), which can defecate in the fields and, therefore, be a source of contamination. Studies conducted by Islam et al.[29,30] showed that pathogens such as *S. Typhimurium* and *E. coli* O157:H7 can survive for a long period in soil (>150 days) and vegetables (>60 days) grown after experimental contamination using contaminated fertilizer (manure) or irrigation water.

Contaminated equipment, poor hygiene and improper post-harvest handling can compromise the microbial safety of a product. Proper storage conditions, including temperature,

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