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Parasite contamination of berries: Risk, occurrence, and approaches for mitigation

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ABSTRACT

Fresh fruits and vegetables, including berries, are essential components of a healthy diet and are relevant in the prevention of chronic non-communicable diseases such as cancer and heart disease. Associations between diet and health are becoming an increasing focus of consumers, and, in response, consumption of fresh berries has been increasing rapidly in recent decades. However, increased consumption of berries may be associated with an increased risk of acquiring foodborne infections, including parasites. In this review, we describe how parasite contamination of berries may occur at several points on the farm-to-fork pathway, starting from the use of contaminated water for irrigation and pesticide application, and contact with animal and human faeces during cultivation, through contaminated harvesting equipment, and including unhygienic practices of berry pickers in the production field or others handling berries prior to consumption. Parasite transmission stages tend to be robust and therefore likely to survive from contamination in the field, through the various stages of harvesting, packaging, and sale, until consumption. We describe outbreaks of parasitic disease associated with consumption of berries – so far only described for *Cyclospora* and *Trypanosoma cruzi*, both of which are briefly introduced – but also show from survey data summarised in this review that sporadic infections or undetected outbreaks associated with contaminated berries may also occur. In addition, we describe methods for assessing whether berries are contaminated with parasite transmission stages, with emphasis on the challenges associated with analysing this particular matrix. Emphasis on current possibilities for mitigation and control are addressed; avoidance of contamination and implementation of good management practices and a hazard analysis and critical control points (HACCP) approach are essential.

Contents

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1. Introduction

Foodborne diseases are major public health concerns throughout the world, irrespective of the wealth index of countries. Although preventable, foodborne diseases cause significant morbidities, ranging from mild to severe, and in some cases resulting in mortality. There is also an associated deleterious effect on the socio-economy; in addition to the suffering from disease and costs incurred for treatment, the absence of affected people from the workplace has a negative consequence on the economy and productivity among people with sub-clinical infections might also be reduced (Torgerson, 2013). Furthermore, outbreaks of disease associated with fresh produce not only harm that industry but shake the confidence of consumers in a food group that is of importance in a healthy diet.

Although the combined effect of foodborne parasitic diseases globally was estimated to be the loss of almost 12 million disability-adjusted life years (DALYs) (Torgerson et al., 2015), relatively scant attention has been paid to the parasitic foodborne diseases. This is probably due to various factors, including: i) many parasites have complex lifecycles and thus investigations can be complicated and difficult; ii) the diseases caused by foodborne parasites often have long incubation periods, and thus source attribution of most foodborne parasitic diseases is difficult (FAO/WHO, 2014); iii) for many foodborne parasites, standard laboratory analyses are lacking or poor (Robertson, 2014); iv) doctors seldom consider the possibility of foodborne illness having a parasite aetiology.

A panel of experts appointed by Food and Agriculture Organization and World Health Organization (FAO/WHO) published a multicriteria-based ranking of foodborne parasites, which considered the most important parasites transmitted by food on a global scale. Of the 24 parasites included in this exercise, the top 15 parasites, in descending order, were *Taenia solium*, *Echinococcus granulosus*, *Echinococcus multilocularis*, *Toxoplasma gondii*, *Cryptosporidium* spp., *Entamoeba histolytica*, *Trichinella spiralis*, Opisthorchiidae, *Ascaris* spp., *Trypanosoma cruzi*, *Giardia duodenalis*, *Fasciola* spp., *Cyclospora cayetanensis*, *Paragonimus* spp., and *Trichuris trichiura* (Fig. 1) (FAO/WHO, 2014). With the exception of *Paragonimus* spp., Opisthorchiidae, and *Trichinella spiralis*, all these “top 15” parasites have the potential to be transmitted via fresh produce (FAO/WHO, 2014).

A similar exercise conducted to prioritize foodborne parasites in Europe gave a slightly different picture (Bouwknegt et al., 2018), with the top 15 parasites being *Echinococcus multilocularis*, *Toxoplasma gondii*, *Trichinella spiralis*, *Echinococcus granulosus*, *Cryptosporidium* spp., *Trichinella* spp. other than *T. spiralis*, *Giardia duodenalis*, Anisakidae, *Toxocara* spp., *Taenia solium*, *Ascaris* spp., Opisthorchiidae, *Taenia saginata*, *Entamoeba histolytica*, *Diphyllobothrium* spp. However, again, the majority of these can be transmitted by fresh produce.

In this review, we take a specific area of the fresh produce industry, berries, and consider their importance as a vehicle for transmission of parasites. The reason we believe that berries are of particular importance is that consumption of this type of fresh produce has increased enormously in recent years, and berries are frequently imported from countries where some parasitic infections are endemic that may be considered rare or unusual in importing countries. Furthermore, berries are often consumed raw and, indeed, some types of berries are difficult to wash prior to consumption without affecting their quality. Thus, contaminating parasites are difficult to remove and may be viable and infectious when consumed.

Having provided further details on the growth in berry consumption, we consider not only how berries may become contaminated, but also adhesion of parasites to berries and their survival on this matrix. Outbreaks associated with consumption of contaminated berries are then described, economic impacts associated with such impacts, methods to detect parasite contamination of berries and the results of surveys, and, finally, potential approaches to control are discussed.

2. Berry production

From a botanical perspective, a berry is a stoneless fruit that is produced from one flower with a single ovary; such a definition excludes some fruit that most consumers would consider to be berries (e.g., strawberries, raspberries), but includes produce such as aubergines, cucumbers, and bananas. For the purposes of this review, we do not use the botanical definition, but consider berries as fruits derived from a variety of plants and which are characterized by a high surface-weight ratio and the entire fruit, including seed, can be consumed in a succulent form (Codex Alimentarius, 2000). These tend to be relatively soft fleshed, small diameter pieces, and lack a peel or inner core, such as, for example, strawberries, raspberries, blackberries, and blueberries.

One characteristic of this type of fresh produce is that some species can be harvested from the wild and also cultivated. In addition, although berries may be grown on a large-scale, it is also common that they are grown on small production sites; such situations may be more vulnerable to pathogen contamination due to less advanced infrastructure, and reduced ability to follow the principles of good agricultural practice (GAP) and good handling practice (GHP) (Ganpat et al., 2014; European Commission, 2006).

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