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Ready-to-eat vegetables: Current problems and potential solutions to reduce microbial risk in the production chain

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ABSTRACT

The popularity of the consumption of fresh ready-to-eat (RTE) products has increased globally. Simultaneously, the number of outbreaks and cases of foodborne illness associated with the consumption of contaminated fresh produce continues to escalate. Thus, it becomes clear that fresh and fresh-cut vegetables are not processed in ways that effectively eliminate human pathogens. Processing of fresh vegetables involves the application of several unit operations that can provide opportunities for cross-contamination whereby a small proportion of contaminated product may cause the contamination of a large proportion of processed product. Some of these unit operations where contamination and cross-contamination may occur are selection, cleaning, washing, trimming, peeling, cutting and shredding, sanitizing and packing. It is recommended that processors ensure that their suppliers (growers, harvesters, packers and distributors) adopt the principles outlined in the Code of Hygienic Practice for Fresh Fruits and Vegetables. A variety of intervention methods may be used such as mild preservation and/or disinfection techniques to enhance safety of minimally processed produce. Traditional methods of reducing microbial populations on produce involve chemical and physical treatments.

This review brings an overview of the main microbial risks faced by the producers and the available alternative strategies to reduce these risks. The information shown gives insights on microbial contamination throughout the processing operations involved in RTE vegetable production.

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1. Introduction

Fresh produce is popular worldwide because it is recognized as an important source of nutrients, vitamins and fiber for humans (Olaimat & Holley, 2012). In the last few years, the market for fresh ready-to-eat (RTE) vegetables has increased explosively (Betts, 2014). The main driving force for this market growth is the increasing consumer demand for fresh, healthy, convenient and additive-free prepared products (FAO, 2010). At the same time, outbreaks of foodborne illnesses associated with the consumption of fresh produce have increased (Callejón et al., 2015). The fresh produce production chain is complex and it encompasses different crucial steps where microbial safety may be affected (Fig. 1). Consequently, microbial contamination can occur during any of the steps in the farm-to-consumer continuum (production, harvest, fresh-cut processing, wholesale storage, transportation or retailing and handling in the home) and this contamination can arise from environmental, animal or human sources (WHO/FAO, 2008). A wide spectrum of pathogens and food vehicles has been documented in produce-associated outbreaks (EFSA., 2014a). Several studies aimed at investigating the presence of enteric pathogens in fresh RTE vegetables have shown that contamination with pathogens occurs infrequently (Pérez-Rodríguez, González-García, Valero, Hernández, & Rodríguez-Lázaro, 2014; Castro-Ibáñez, López-Gálvez, Gil, & Allende, 2015). In most of the studies, no pathogens have been found in fresh RTE vegetables (Althaus, Hofer, Corti, Julmi, & Stephan, 2012; Holvoet, Jacxsens, Sampers, & Uyttendaele, 2012; Allen et al., 2013; Jeddi et al., 2014; Castro-Ibáñez et al., 2015). However, the increased occurrence of food-related infections calls for better control of prevention strategies or the application of the intervention strategies needed at every step (Callejón et al., 2015). Thus, one of the main objectives of fresh-cut processing is to inactivate biological hazards, i.e. pathogenic microorganisms and viruses that could be present on the raw product and represent a threat to consumers' health (Nguyen-The, 2012).

Fresh vegetable processing includes several steps such as

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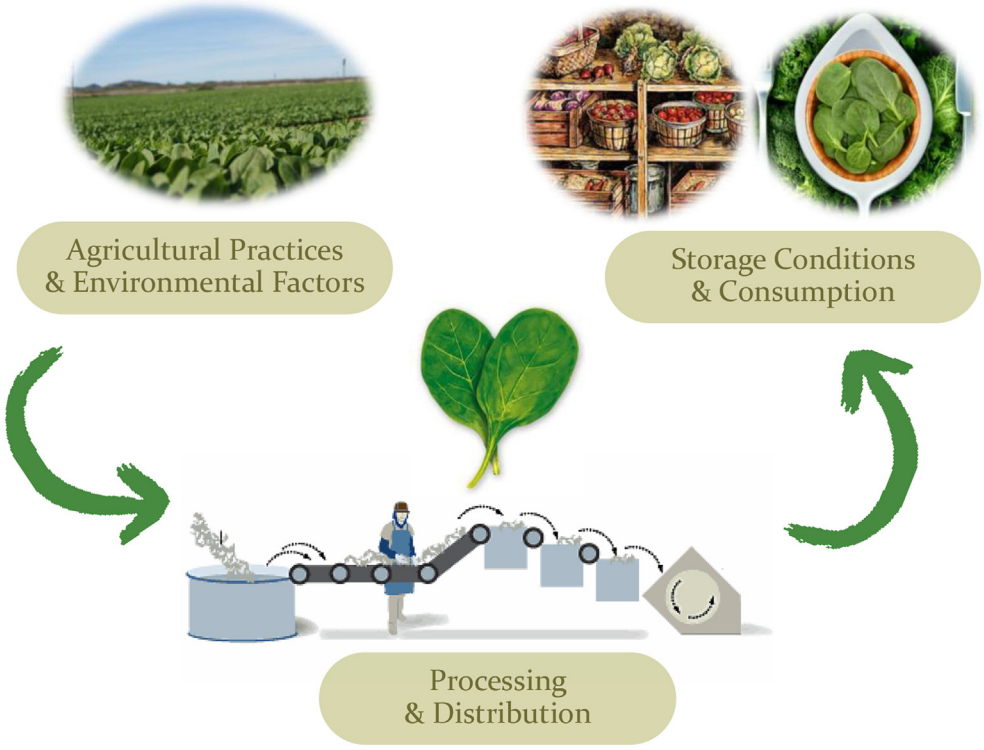

Fig. 1. Main step in the supply chain of fresh produce.

selection, elimination of external leaves, cutting, washing, rinsing, dewatering, packaging and storage (EFSA., 2014a) (Fig. 2). Fresh RTE vegetables are not subjected to any microbial inactivation such as surface pasteurization or cooking, which makes these commodities an important transmission route for foodborne pathogens (EFSA., 2014a). In order for these products to achieve fresh-like quality, safety and high nutritional value, the industry needs to implement different strategies by introducing or combining sustainable techniques, especially standard procedures for sanitation (Gil, Selma, López-Gálvez, & Allende, 2009). Hence, the main objective of the fresh fruit and vegetable processors throughout all fresh-cut processing operations is to assure food safety and quality maintenance (Osterholm et al., 2009).

The purpose of this review is to discuss the current knowledge related to the identification of biological hazards and the main risk factors as well as the potential mitigation strategies aimed at preserving the microbial safety of RTE vegetables.

2. Pathogenic microorganisms associated with fresh RTE vegetables

2.1. Pathogen prevalence on fresh RTE vegetables

As previously mentioned, increasing production and consumption of fresh vegetables have been accompanied by a rise in the number of produce associated foodborne outbreaks worldwide (Callejón et al., 2015). A wide spectrum of pathogens and food vehicles has been documented in fresh produce associated outbreaks (EFSA., 2014a). Leafy greens eaten raw as salads were considered the highest priority group in terms of fresh produce safety from an EU perspective (EFSA., 2013). A recent study using a risk-ranking model situated the combination of *Salmonella* spp. And leafy greens as the food/pathogen combination most often linked with foods of non-animal origin between 2007 and 2011 in the EU (Da Silva Felício et al., 2015). *Salmonella* spp. Has been detected

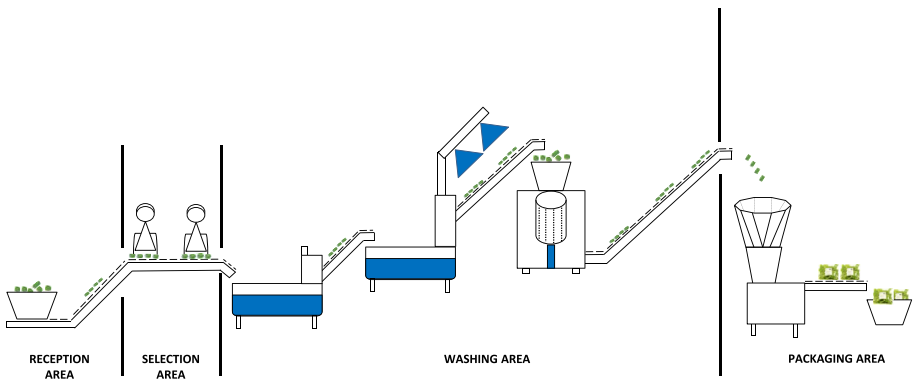

Fig. 2. Scheme of fresh vegetable processing steps.

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