Trends in Food Science & Technology 46 (2015) 286–294

Contents lists available at ScienceDirect

Trends in Food Science & Technology

journal homepage: http://www.journals.elsevier.com/trends-in-food-science-and-technology

Efficient management of the water resource in the fresh-cut industry: Current status and perspectives

Lara Manzocco, Alexandra Ignat, Monica Anese*, Francesca Bot, Sonia Calligaris, Fabio Valoppi, Maria Cristina Nicoli

Dipartimento di Scienze degli Alimenti, University of Udine, Via Sondrio 2/a, 33100, Udine, Italy

A R T I C L E I N F O

Article history:
Received 20 January 2015
Received in revised form
10 September 2015
Accepted 21 September 2015
Available online 25 September 2015

Keywords:
Fresh-cut washing
Water consumption
Water saving
Decontamination
Recycling

A B S T R A C T

Among the different food industries, fresh-cut produce manufacturing is one of the major water-intensive, due to the huge consumption of potable water to perform washing operations required to guarantee the safety and quality of the product. Reducing the water footprint of washing is thus a challenge for fresh-cut industries and food researchers. This review paper examines the current status of the water resource management in the fresh-cut industry and critically describes a comprehensive approach to the improvement of the water use efficiency by implementing strategies of water recirculation, reuse and recycling. In particular, advantages and limitations of chlorine and chlorine-free disinfectants to reduce water turnover in washing tanks were considered. In addition, particular attention was focussed on innovative technological solutions, based on either physical or chemical stresses, which could be exploited individually or in combination to treat wastewater deriving from fresh-cut washing and allow its recycling within the processing plant.

1. Introduction

Water is at the base of humankind's survival and living organisms depend upon it to complete their life cycle and further contribute to natural cycle (Hong-Bo, Li-Ye, Gang, Jin-Heng, & Zhao-Hua, 2007). Issues relevant to population increase, deterioration of surface water quality and climate changes are increasingly requiring to secure water supplies and alleviate environmental loads (EEC, 1991).

Food production and processing are known to account for the majority of water use globally (Foster et al., 2006). In this sector, the fresh-cut industry is one of the major water-intensive. Water consumption and wastewater volumes are generally in the range of 2–11 m^3/t and 11–23 m^3/t of fresh-cut product (FDM-BREF, 2006; Letho, Sipilä, Alakukku, & Kymäläinen, 2014; Ölmez, 2014). This represents not only a tremendous waste of water but also an impressive waste of energy since most of this water is cooled at refrigeration temperature to accomplish fresh-cut processing needs. Fresh-cut processing water is mainly discharged to surface water and make this industry difficulty fitting with nowadays global water scarcity.

This issue is expected to become particularly critical in the next years, due to the intensification of the demand for fresh-cut produce in developing countries. The minimization of water use and wastewater discharges are thus big challenges for the fresh-cut industry that will be increasingly required to implement sustainable strategies for water saving (Ölmez & Kretzschmar, 2009; Gómez-López, Gobet, Selma, Gil, & Allende, 2013).

By focussing on the eco-efficient management of water, new opportunities and technologies for the environmental performance improvement, that can be also cost-effective, are increasingly under study and possibly applicable for water saving in fresh-cut production. In any case, the actual contribution of these interventions to the sustainable development of fresh-cut vegetable washing strictly depends on the benefits justifying their cost (Fig. 1).

Any innovation allowing washing operations with increased eco-efficiency is required to guarantee, or increase, the safety and quality characteristics of the product in line with industry norms. Yet there must be a return on the investment. Beside tangible profit, non tangible benefits could also come from the opportunity the company may have to build an eco-friendly image. In addition, there is the possibility that some countries will be more specific on the type and amount of certain chemicals allowed in the wastewater discharges and known to be ecologically undesirable. This

* Corresponding author.
E-mail address: monica.anese@uniud.it (M. Anese).

http://dx.doi.org/10.1016/j.tifs.2015.09.003

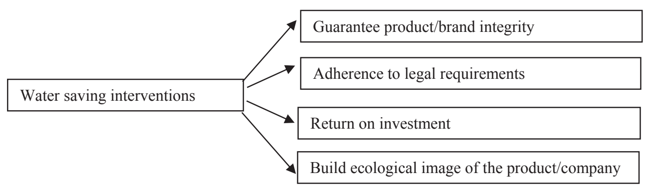

Fig. 1. Requirements for sustainable water saving intervention.

approach could eventually contribute to justify additional costs involved in water saving interventions.

This review paper analyses the current status of the water resource management in the fresh-cut industry, identifying possible strategies for improving water use efficiency and increase the overall sustainability of the production.

2. Water management in a typical fresh-cut vegetable production

Fig. 2 shows the flow of the product in a typical fresh-cut industry. Almost 90% of water is used to perform washing operations, including primary washing to remove gross contamination, a number of consecutive immersions of the product in washing tanks and a final rinse step (Letho et al., 2014). Subsidiaries activities requiring water supply are cleaning and sanitizing operations as well as domestic necessities (defrosting, toilets and staff usage). Current productions generally use water with different properties depending on the nature of the operation to be performed. Water added with chemical disinfectants, such as chlorine and its related compounds, is used to perform the washing steps. The latter include primary washing as well the consecutive passages in washing tanks. The number of passages depends on the organisation of the production flow. By contrast, the final rinsing of vegetables is performed with fresh tap water to remove disinfectant residues. Similarly, tap water is also used for plant cleaning and removal of disinfectants and detergents used to this aim.

3. Efficient water management

In the attempt to develop efficient strategies for water saving, the first step is performing a review of the water used within the industry, considering each operation requiring water. This implies a holistic review of what water is actually required for the different applications (Table 1) and the characterisation of effluent water qualities, also in relation to legal requirements. The output is the description of the water flows to/from the production process and represents the water management plan of the industry. By analysing the water management plan, eventual corrective actions for water conservation can be identified and possibly tested. For instance, major savings could be generated by simply controlling leaks or improving on-site cleaning and operating practices. It is evident that the follow-up of any corrective actions should be performed to assess their effectiveness and eventual drawbacks. Following the implementation of the identified water saving interventions, a novel water management plan with improved efficiency is expected to be produced. The main steps for cost-effective use of water resource have been summarised by Williams and Anderson (2006).

It is clear that special attention should be paid when analysing water needs and developing possible water saving interventions potentially applicable to the washing operation. Contrarily to a commonly diffused belief, these huge amounts of water are not required to decrease the vegetable microbial count. The microbial load of vegetables entering the fresh-cut industry may range from 5 to 9 Log units, depending on type of salad, cultivation system, harvesting and handling procedures among other factors (Ölmez & Kretzschmar, 2009; Barth, Hankinson, Zhuang, & Breidt, 2010). Cutting operations, typically performed to produce fresh-cut vegetables, are well known to further increase microbial counts, with effects on both product safety and quality (Ragaert, Devlieghere, & Debevere, 2007). An average reduction of *circa* 1 Log unit in microflora is generally achieved upon washing, due to the sole mechanical removal of microorganisms from the vegetable surface by the water turbulent flow (Allende, Selma, López-Gálvez, Villaescusa, & Gil, 2008). If washing would be performed using tap water only, water would rapidly become highly contaminated, reaching microbial counts in the same order of magnitude of the unwashed salad. Tap water should thus be continuously renewed to avoid microbial proliferation and vegetable cross contamination by spoilage and pathogenic microorganisms. This risk is conventionally controlled by adding water with disinfection chemicals, thus allowing in-tank recirculation of wash water over a longer time.

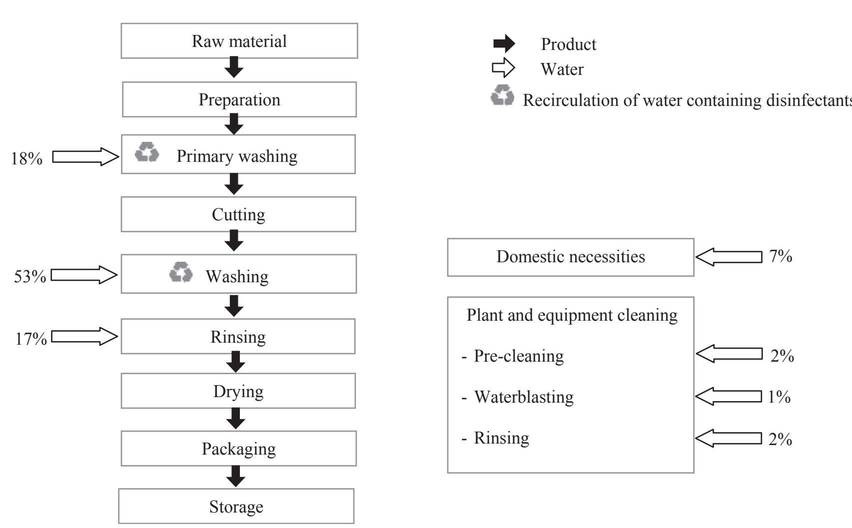

Fig. 2. Product flow and water needs in a typical fresh-cut salad production process. Water needs of each step are expressed as percentage (v/v) of the overall water required in the process.