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Risk profiling of wash waters in vegetable processing industry towards possible allergen carry-over

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ABSTRACT

The carry-over of food allergens via reuse of water in the food industry deserves more attention. The lack of quantitative knowledge on this topic, hampers reliable estimations of the potential risk for the produce processing industry. Wash water samples from three vegetable processing industries were collected and significant protein concentrations were determined in the water (0–596 μg/ml). The influence of several product and process parameters on the protein carry-over from the vegetable to the wash water was studied. The type of process, batch or semi-continuous, had an impact on the protein carry-over, as well as the degree of cutting and the surface area of the vegetable. It was shown that the protein carry-over to the wash water is higher at acid pH. In the vegetable processing industry acid is often added to the wash water to prevent enzymatic browning in e.g. celeriac.

1. Introduction

In the vegetable processing industry, wash water is often reused for environmental and economic reasons. This means that several batches of vegetables are washed in the same water or that water is recirculated without thorough purification or treatment. Reusing water may cause several food safety hazards, which need to be included in the food safety management system of a company.

Many studies discussed the chemical and microbiological quality of wash waters. However, when it comes to *reuse* of wash water, the information is scarce. The (few) published articles discussing reuse or recirculation of wash water in fresh produce generally focus on cross-contamination of microorganisms and the chemical quality of the wash water (e.g. different methods for water disinfection) (Gil, Selma, Lopez-Galvez, & Allende, 2009; Holvoet, Jacxsens, Sampers, & Uyttendaele, 2012; Lopez-Galvez et al., 2012; Luo, 2007; Ölmez & Kretzschmar, 2009; Selma, Allende, Lopez-Galvez, Conesa, & Gil, 2008). Moreover, in the legislation and guideline documents, an attempt is made to define microbial and/or chemical criteria for the reuse of water. However, water reuse also implies a risk for carry-over of allergens. Only one paper discusses the possible carry-over of allergens via wash waters (Kerkaert, Jacxsens, Van De Perre, & De Meulenaer, 2012). The lack of scientific knowledge on carry-over of allergens via reuse of wash water is a critical gap in allergen management.

Food allergy is an abnormal immunological response to a food component (Johansson et al., 2001). Celery is one of the fourteen food ingredients listed in the EU Directive on allergen labeling (2007/68/EC). Usage of celery as an ingredient must be indicated on the label of a foodstuff in the EU. Yet, nothing is stated about unintentionally added allergens (via cross-contamination) in the directive. However, food producers are responsible for producing food safe for all consumers through EU Regulation 178/2002.

According to the European Food Safety Authority (EFSA, 2004), celery is a frequent cause of pollen-related food allergy, particularly in European countries. About 30–40% of patients with food allergy in Switzerland and France are sensitized to celery root (EFSA, 2004), and it is the most frequent cause of food anaphylaxis in Switzerland (Wang, Li, Yuan, Wu, & Chen, 2011)." In a study of André, Andre, Colin, Cacaraci, and Cavagna (1994), conducting 60 cases of severe reactions to food over a period of 9 years (1984–1992) in France, celery was shown to be responsible for 30% of the anaphylactic reactions. Furthermore, in Germany, 70% of patients with a pollen-related food allergy have a positive skin prick test or RAST to celery (Jankiewicz et al., 1996). Six celery proteins have been described as allergens, Api g 1–6 (IUIS Allergen Nomenclature Sub-Committee, n.d.), Api g 1 being the major allergen (Hoffmann-Sommergruber et al., 1999). Their molecular weights range between 7 and 58 kDa (IUIS Allergen Nomenclature Sub-Committee, n.d.). The MWCO of ultrafiltration, commonly used in wastewater treatment, is 1–100 kDa (Dow Water, n.d.), meaning the celery allergens would probably be retained by finer ultrafiltration. Thermal processing of celery has an impact on the allergenicity of the major allergenic protein Api g 1, whereas the profilin Api g 4 is less affected, and the carbohydrate determinants are heat stable (Ballmer-Weber et al., 2002; Jankiewicz et al., 1997). The allergenicity of celery is, thus, not completely reduced by heat treatment (Ballmer-Weber et al., 2002). No further vegetables are included in the EU Directive on allergen labeling (2007/68/EC). However, several other vegetable

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proteins have been described as allergens in the literature, e.g. carrot (Ballmer-Weber et al., 2001; Moreno-Ancillo, Gil-Adrados, Cosmes, Dominguez-Noche, & Pineda, 2006), green beans (Pastorello et al., 2010; Zoccatelli et al., 2010) and lettuce (Hartz et al., 2007; San Miguel-Moncin et al., 2003). The only treatment for allergic patients is complete avoidance (van Putten et al., 2006), which means correct labeling of food products is of great importance for the allergic consumer.

The general lack of knowledge on allergen carry-over via wash water and wash water reuse, hampers reliable estimations of the potential risk for the produce processing industry, such as fresh-cut, frozen or canned vegetables. Thus, Kerkaert et al. (2012) calculated that the threat of a potential carry-over of allergenic proteins from celery to wash water and from the water to other vegetables is indeed relevant.

Consequently, a database concerning the carry-over of (allergenic) proteins in industrial wash waters in the vegetable processing industry is developed. The impact of several process and product parameters on the protein content of the wash waters is investigated. The evaluated process parameters are batch or semi-continuous processing, the number of washing steps and the pH of the wash water. Evaluated product parameters are the processing level of the vegetable, the surface area of the vegetable and the impact of blanching of the vegetable as heat treatment. The insight in the impact of these parameters on the possible transfer of (allergenic) proteins to wash water will lead to a better established allergen management and risk estimation of the reuse of wash water. In a following work, the protein transfer from the wash water to a second batch of vegetables will be studied, and the potential risk of cross-contamination for sensitive consumers estimated.

2. Materials and methods

2.1. Sampling of industrial wash waters

Samples were collected from three Belgian vegetable processing industries. Two companies produce chilled fresh-cut vegetables with means of batch processing. The third company produces frozen fresh-cut vegetables (blanched depending on the type of vegetable) with semi-continuous processing. Sampling of the wash water was carried out before adding vegetables into the production line (blank water sample) and at the end of a production batch (worst case water sample). The samples were collected in plastic bottles and stored at −18 °C until analyzed.

2.1.1. Batch processing

Sampling was performed for each vegetable (i.e. cabbage, carrot, celeriac, iceberg lettuce, and white part of leek) or vegetable mix (i.e. lettuce line: several kinds of lettuce washed after each other; lettuce mix: mixture of several types of lettuce washed simultaneously; mussel vegetables: celery and onion; soup vegetables a: leek, carrot and celery; soup vegetables b: white part of leek, celery, onion; wok vegetables: ten different vegetables) on two different production days to get insight into the variability of the protein concentration in the water. Samples were collected from one, two or three wash water baths depending on the production line (Fig. 1). The total number of samples from the batch processes was 112. In the two companies, no water purification takes place before the water is reused for a second batch of vegetables.

2.1.2. Semi-continuous processing

Samples were taken once in one or several production units (i.e. prewashing, washing, water transport, blancher, cooling) for each vegetable (i.e. carrot, cauliflower, celeriac, zucchini, green beans, onion, peas and spinach). The total number of samples from the semi-continuous process was 26. In the semi-continuous process two kinds of water were used, i.e. recup and process water (Fig. 2). The company has a water treatment installation where the recup water underwent anaerobic and aerobic digestion and sand filtration, and for the process water additional ultrafiltration, reversed osmosis and UV treatment was applied. The recup water was used for the initial washing step aimed at removing soil and physical dirt. The process water is potable water and was used for the final washing step and in the cooling section of the blancher. The water exiting the cooling section is recirculated to the pre-heating section of the blancher. The water leaving the pre-heating section is collected in a reservoir together with water from the water transport section. The water in the reservoir is recycled in the water transport section, and excess reservoir water goes to the water treatment installation.

2.2. Analysis of industrial wash waters

After sample collection, samples were frozen at −18 °C until analysis. Thawing was performed over night at room temperature. The water samples were filtered over a tea strainer to get rid of residual vegetable pieces. The pH of the samples was monitored using a LAB 850 pH-meter (Schott Instruments, LSB, Kontich, Belgium) and the crude and non-protein content was analyzed with the AOAC International Official Method 981.10 (1981), as described by Kerkaert et al. (2012). Prior to determination of the protein content, the samples were concentrated by evaporation, resulting in a detection limit (LOD) of 11 μg protein/ml wash water for the Kjeldahl method. 50 or 80 ml of sample, for the crude and non-protein content determination respectively, was evaporated until 1–5 ml was left for destruction. All samples were analyzed in duplicate and the conversion factor 6.25 was used to convert nitrogen to protein. The net protein content was obtained by subtracting the non-protein content from the crude protein content (Fig. 3).

2.3. Database, additional data collection on washing processes and statistical analysis

The net protein concentrations of the blank water samples (before adding vegetables into the production line) were subtracted from the net protein concentrations of the worst case water samples (at the end of a production batch) to obtain the final net protein concentrations (carry-over from the vegetables to the wash water) (Fig. 3). All protein concentrations mentioned in the Results section are final net protein concentrations, unless else mentioned.

The measured pH and final net protein concentrations were compiled in a database together with specific process information. This additional information on the washing processes was collected by interviewing the quality or production manager of the companies. The questions asked were related to the product and process parameters, e.g.

- Process chart, i.e. number of wash baths (batch process), type of unit operations (semi-continuous process)
- Vegetable mass and volume of wash baths (batch process), or vegetable and water flow (semi-continuous process), to be able to calculate the vegetable-to-wash-water ratio for the different batches
- Vegetable cutting (intact, peeled/scraped, size of pieces or grating)
- Contact time between the vegetable and the wash water.

The influence of different process and product parameters on the protein carry-over from the vegetable to the wash water was

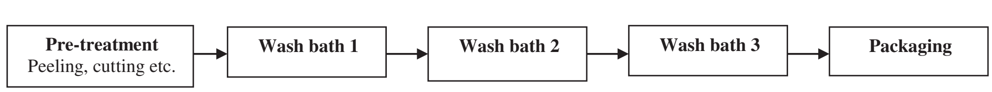

Fig. 1. Overview of the batch process. Water samples were taken in the different wash baths (differing number of wash baths were present on different production lines).