Assessment and validation of alternative systems to sodium hypochlorite in pre-prepared food industries

Summary

The growing demand from consumers for safe and convenient foods with high nutritional value has in recent years led to an increase in the consumption of foods that are pre-prepared, ready to consume and cook, and which retain their nutritional properties and freshness. There is no stage in the processing of these products that ensures that the microorganisms present are completely eliminated, and the disinfection stage is the only one in which microbiological contamination can be reduced to ensure their safety. The most widely used disinfectant is currently chlorine, in the form of sodium hypochlorite. The effectiveness of chlorine on plant matter is limited to 1-2 logarithmic reductions, even at high doses. It is also highly reactive, reacting quickly with organic matter, air and light. For this reason, the water is usually hyperchlorinated (at between 50 and 200 ppm). This can produce chlorine gas in the installations and can lead to the production of excessive amounts of undesirable and potentially toxic by-products (mainly trihalogenated compounds) if it comes into contact with organic matter. It has been banned in some EU countries as a result. Other alternatives to sodium hypochlorite have recently been investigated, including ozone, chlorine dioxide and peracetic acid, among others.

Objectives

The **primary aim** is to establish an alternative disinfection procedure that ensures consumer safety, maintains quality, extends the shelf life of the product, and is more environmentally friendly. As a result, the following specific objectives were set:

1. Description of the current disinfection process in the beneficiary industry
2. Study the effect of temperature (difference in temperature between product and water) on the effectiveness of the disinfectant
3. Evaluate the effectiveness of disinfectants or alternative technologies, and study how organic matter affects its effectiveness on a leafy vegetable and a fruit under laboratory conditions.
4. Validation of the selected system in a pilot plant. Effect on product quality
5. Implementation and validation of the new system in industry. Determination of the product's shelf life
6. Preparation of a protocol of general measures

Description of the actions carried out in the project

The actions that were carried out are fully linked to the objectives, and are set out below:
ACTION 1. Description of the current disinfection process, by preparing a questionnaire and visits during the product preparation process.
ACTION 2. Study the effect of temperature (difference in temperature between product and water) on the effectiveness of the disinfectant
ACTION 3. Assess the effectiveness of disinfectants or alternative technologies taking into account the values of organic matter obtained in action 1, to simulate real conditions
ACTION 4. Validation of laboratory results in the pilot plant
ACTION 5. Implementation and validation of the new system in industry
ACTION 6. Preparation of a protocol of general measures

Final results and practical recommendations

In the first phase of the project, the disinfection system currently used by the company was studied by means of process diagrams and the completion of a questionnaire (Action 1). In addition, data were obtained in situ at two different points in time for the microbiological and physico-chemical quality of the washing water in two processing lines (leaf and vegetables), and for the microbiological quality of the end product. As regards water quality, the vegetable line had a lower COD and turbidity than the leaf line. This line has an automated dosage of calcium hypochlorite and a fixed pH, with parameters that were maintained at the points in time analysed. Meanwhile, in the vegetable line, which has no automation system, the free chlorine is reduced as more plant matter enters. However, the minimum

values found were not lower than the recommended minimum value of 10 ppm. The results showed that the microbiological quality of the water in the two washers of the two lines complies with Royal Decree 140/2003. The plant matter was reduced by between 1 and 2 logarithmic units of mesophilic aerobic microorganisms, and neither *Salmonella* spp. nor *L. monocytogenes* were detected in the plant samples analysed. The permitted limits for chlorate and perchlorates in the end product were also not exceeded. Regular checks of the free chlorine levels and automation of the system are recommended in view of these results.

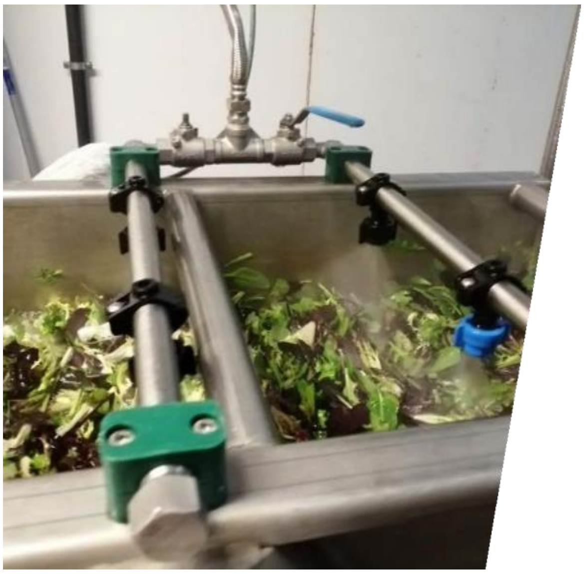
For the temperature differential between the water and plant matter (Action 2), the good practice guidelines recommend that the water temperature be 4-5°C above the temperature of the plant matter in order to prevent the internalisation of microorganisms due to this differential. The results showed lower levels of *S. enterica* (artificially inoculated in the laboratory), which were similar regardless of the temperature differential applied. This project therefore found no evidence to indicate that the disinfection system is less efficient with negative differentials or differentials other than those recommended.

The effectiveness of various products available on the market for the sanitisation of washing water for plants was evaluated (Action 3). In the first phase, the shoots were artificially inoculated in the laboratory with *S. enterica* and they were then washed with the products tested at different doses, simulating the conditions in the plant obtained in the first action in the project. The products assessed included commercial formulations based on hydrogen peroxide, organic acids, chlorine dioxide, inorganic salts and peracetic acid. Ozone applied in liquid form was also evaluated using an in situ generation system. Both the effects on plant contamination and the survival of pathogens in the washing water were evaluated. The results showed that when applied at a dose of between 80-100 ppm, peracetic acid, an equilibrium mixture that also contains hydrogen peroxide and acetic acid, was the product with the most similar results to chlorine, for both shoots and tomatoes. This product has the advantage of leaving no residue. The effectiveness of the best disinfectants against *L. monocytogenes* was evaluated, and in general, their effectiveness was similar to that observed for *S. enterica.* In the second phase, the best disinfectants were evaluated in uninoculated plant matter, and their effect on microorganisms and on the visual quality of the product was studied. In this case, the reductions were more limited than those observed in studies with artificial inoculation, but the trend was the same. Despite being very effective, one of the products evaluated damaged the shoots (leading to discolouration and the loss of a 'fresh' appearance). Peracetic acid was the product selected for the next phase.

Tests were carried out to validate the process obtained under laboratory conditions at the pre-

prepared food pilot plant at the Fruitcentre facilities (IRTA-Lleida). The most suitable parameter (conductivity, redox potential or pH) for automated dosage of the product was studied (Action 4). With sodium hypochlorite, there was a (non-linear) correlation under the test conditions between the redox potential and the concentration of free or residual chlorine, which was affected by the level of organic matter. With peracetic acid, the correlation was with the pH level. In practical terms, this means that these parameters could be used to automate the process, although they should be verified and adjusted in the plant for the different plants.

When used in a more rational way, at a constant dosage and with an adjustment of its pH, sodium hypochlorite remains just as effective as the system currently used by the company. The most promising alternative product was peracetic acid, which provided similar results in terms of the microbiological quality of the water and plant matter. Furthermore, peracetic acid does not have the drawback of the formation of disinfection by-products, leaves no residue and is more environmentally friendly. The shelf life of the product was unchanged compared to the company's current system.



Sodium hypochlorite remains the most economical and effective product as regards viability for implementation in industry. The new procedure saves on hypochlorite because it is used more rationally, but increases the consumption of phosphoric acid due to the need for a pH adjustment. Peracetic acid has a higher supply cost, but has other advantages compared to hypochlorite, such as reduced costs on the line because it is less corrosive, the fact that it does not require pH adjustment, and it is also more environmentally friendly, which is consistent with the company's objectives. With sodium hypochlorite, the product must be rinsed and this is also advisable for peracetic acid. The product manufacturer's instructions must always be followed, as the formulations differ depending on the supplier. When implementing the system, it is necessary to take the renewal of the water into account in order to ensure that the concentration of the product remains within the operating limits.

All the data obtained was used to draw up a disinfection protocol adapted to the company's current production line and a more general protocol, which is expected to be announced in the near future.

Conclusions

This project has shown the importance of adding a disinfectant to washing water for plant products, which is usually recirculated. The disinfectant maintains the microbiological quality of the water and prevents cross-contamination. Sodium hypochlorite must obviously be used rationally; chlorination should be performed as it is used up with organic matter, and to prevent an initial hyperchlorination that could be insufficient and produce chlorine derivatives that are restricted by food legislation. Under current conditions in the company, both the water and the end product complied with the current legislation on food safety and the presence of chlorates.

Under the conditions tested in this project, there was no evidence in the shoots and tomatoes that the temperature differential between the washing water and the plant matter is a factor that has a negative effect on the effectiveness of disinfectants. However, some differential should still be maintained or at the very least, the temperature of the washing water should not be lower than that of the plant matter.

Taking microbiological and quality criteria into account, the products tested were as effective as hypochlorite or less so. A commercial product based on peracetic acid proved to be the most promising alternative. The end product had microbiological contamination levels similar to those found in the system currently used, and the washing water complied with the applicable legislation. No pathogenic microorganisms were detected in the tests performed.

Leader of the Operational Group

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Subject area(s) of application

☒ Food quality/processing and nutrition

☒ Supply chain, marketing and consumption

Geographical area(s) of application

PROVINCE(S): All over Catalonia

REGION(S): All

Dissemination of the project: publications, seminars, multimedia, etc. (State links)

Advertising on the Ametller Origen website

https://ametllerorigen.cat/es/noticias/proyecto-sostenible-sistemas-de-desinfeccion/

V Specialisation seminar on fruit and vegetable processing: How to add value to your products (2019). Training course for Agricultural Schools. Annual agricultural training plan.

Valuing the garden through transformation. Course organised by Barcelona Provincial Council

More information on the project

PROJECT DATES	TOTAL BUDGET
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