Modelling Microbial Load Reduction in Foods due to Ozone Impact

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Introduction

Fruits and vegetables contain a great diversity of microbial flora and are frequently involved in food-borne outbreaks. Mesophilic microorganisms, coliforms, yeasts and molds are populations commonly found in those products, which are responsible for quality degradation and safety compromise. Since fruits and vegetables are often consumed uncooked or unwashed, the microbiological contamination should be reduced to minimize risks.

Blanching is one of the most effective processes for inactivation of microbial and enzymes responsible for quality decay in fruits and vegetables, thus resulting in products with extended shelf life. Although it has the main disadvantage of degrading sensorial and nutritional attributes and, from an industrial point of view, this process may be extremely energy consuming [1]. Alternatively, challenging non-thermal technologies such as UV-C radiation, ultrasounds and ozone treatments may be promising, since quality can be better retained while safety, from a microbiological point of view, can also be attained.

Ozone, due to its powerful oxidizing effect, is one of the most potent disinfectant agents. In 1997 it was recognised by U.S. Food and Drug Administration as a GRAS substance (i.e. Generally Recognised as Safe) for use as a disinfectant or sanitizer in foods and food processing [2]. Ozone is effective against some gram positive bacteria, gram negative bacteria, some yeasts and spores [3, 4, 5]. When dissolved in water, ozone has been applied as a convenient washing treatment of fruits and vegetables, promoting shelf life extension of food products [6, 7]. Besides several studies assess the ozone impact at microbial loads [8, 9], scarce information is available on modelling the kinetic behaviour of food contaminants. Such models may contribute to determine the extent to which the process should be applied in order to improve safe standards and process design.

Objective

The main goal of this work was to study the impact of ozone in aqueous solution on the following combinations of microorganisms and foods: *Listeria innocua* in red bell peppers, total mesophiles in strawberries and total coliforms in watercress. Modelling of microbial load reduction throughout treatment time and due to ozone effect were also objectives.

Materials and Methods

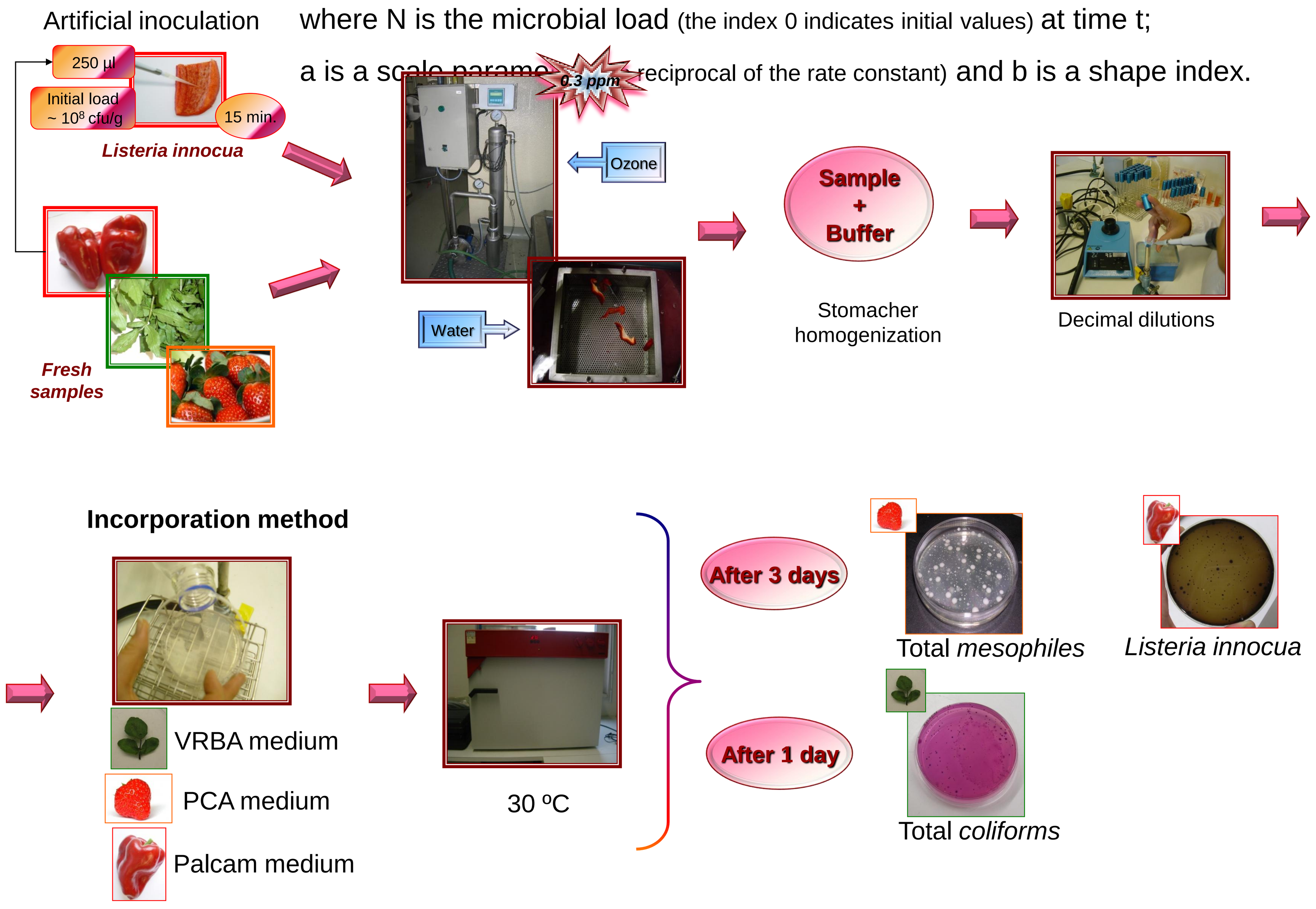
- Strawberries (*Fragaria ananassa* D.), watercress (*Naturtium officinale* R.Br.) and red bell peppers (*Capsicum annuum* L.) were purchased in a local market.
- A pilot plant ozone generator was used in experimental assays (ozone concentration of 0.3 ppm).
- Native total mesophiles (initial load averaged 5.6 x 10^7 cfu/g) were evaluated on strawberry samples and total coliforms (initial load averaged 3.9 x 10^8 cfu/g) in watercress samples.
- Red bell peppers were artificially contaminated with *Listeria innocua* (initial load ~ 10^7 cfu/g).
- Strawberries, red bell pepper and watercress safety was evaluated in terms of total *mesophyles, Listeria innocua* and total *coliforms*, respectively.
- Contaminated samples were cut in small pieces and were emerged in ozonated water for 1, 2 and 3 minutes.
- Water washings for the same periods of time were carried out as control of the ozone treatments (T=15 ºC)
- A Weibull-based model was assumed for microbial load reduction [10, 11]:

$$\log\left(\frac{N}{N_0}\right) = 1 - e^{\left(\frac{t}{\alpha}\right)^{\beta}}$$

where N is the microbial load (the index 0 indicates initial values) at time t;

a is a scale parameter (reciprocal of the rate constant) and b is a shape index.

Experimental description



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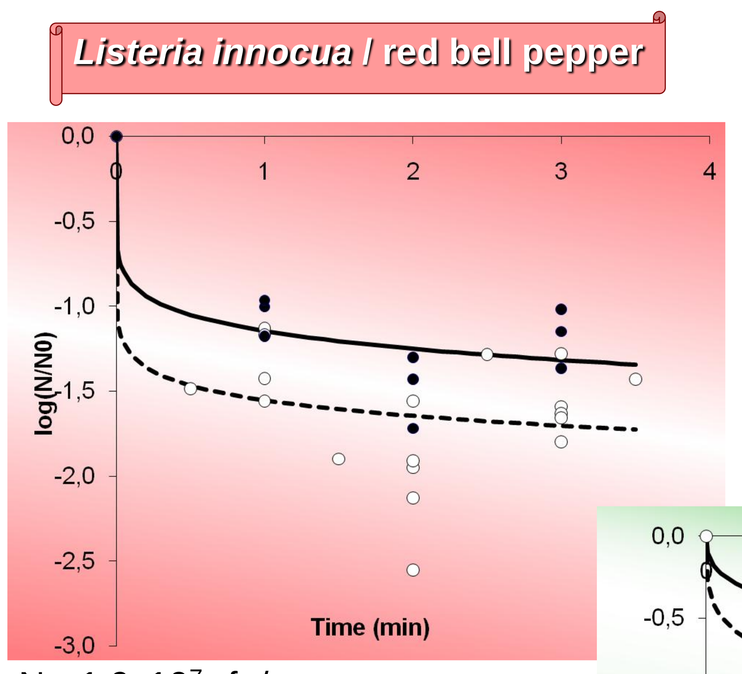
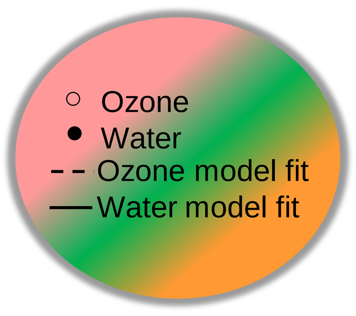
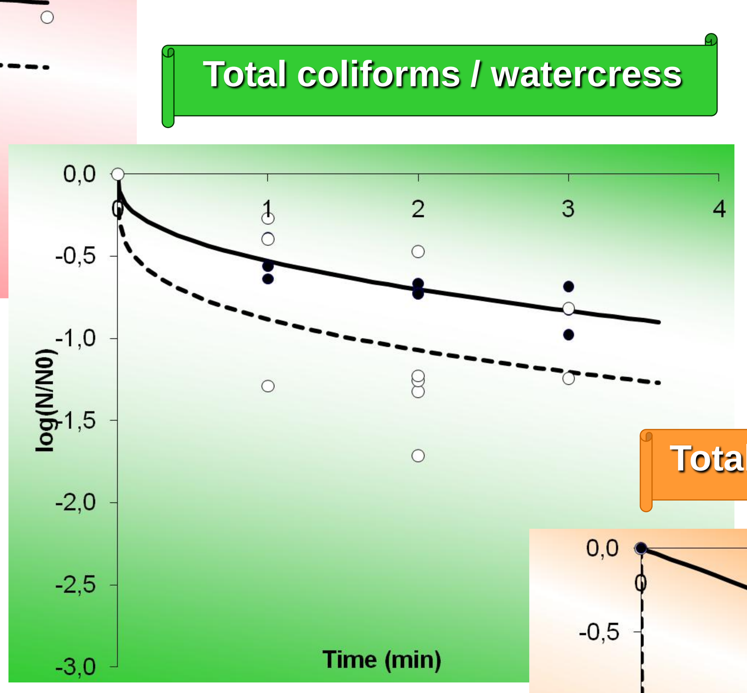
Results and Discussion

- The impact of ozone is higher than water, this meaning that higher reductions were attained with this oxidizing agent
- The difference between water and ozone is particularly evident for mesophiles/strawberries, and for short contact times. Overall, total coliforms/watercress are less susceptible to both type of washings.
- All data was satisfactorily fitted to a Weibull model and parameter estimates are in Table 1. Quality of regressions were assessed by residual analysis (randomness and normality of residuals) and on the coefficient of determination, R^2.

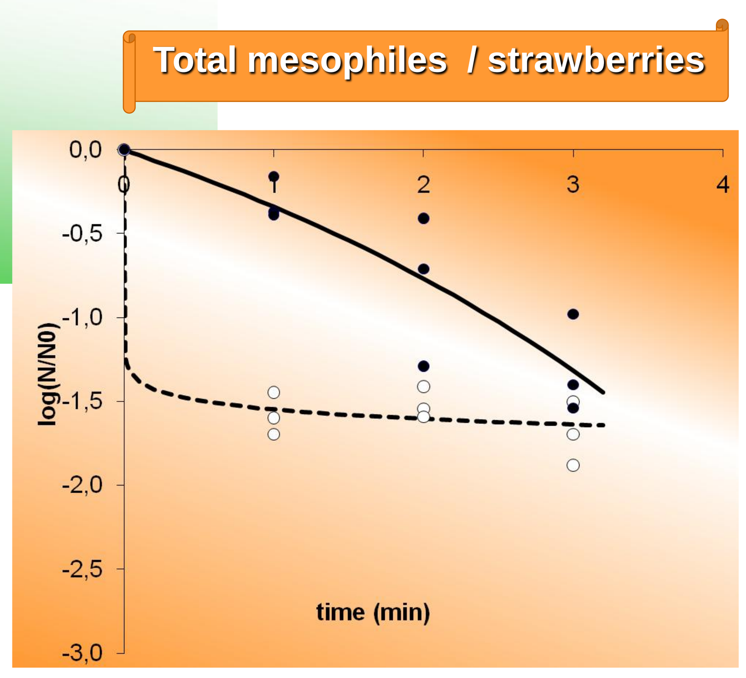


N_0=1.9x10^7 cfu/g





N_0=3.9 x10^8 cfu/g



N_0=5.6x10^7 cfu/g

Table 1: Parameter estimates obtained from the best fittings of Weibull model to data

Microorganism / Food	Treatment	Regression results		
		α (min)	β	R^2
Listeria innocua / Red bell pepper	Water washing	22.27	0.087	0.77
	Ozonated water	3.33	0.054	0.81
Total mesophiles / Strawberry	Water washing	3.59	0.960	0.83
	Ozonated water	7.60	0.033	0.97
Total coliforms / Watercress	Water washing	14.32	0.321	0.94
	Ozonated water	9.69	0.201	0.57

Conclusions

Ozonated-water washings are more effective in reducing the microbial load of fruits and vegetables when compared to simple water dipping. Total coliforms in watercress are less sensitive to both deionized-water and ozonated-water washings.

A Weibull-based model was adequate in describing the reduction of microbial loads and may contribute to design more effective sanitizing processes.

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