Resistive barrier discharge device to generate gas plasma for food decontamination

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Résumé

The present study intends to analyse the superficial decontamination power of gas plasma generated at atmospheric conditions by a Resistive Barrier Discharge (RBD) device. Different atmospheric conditions and treatment times were considered. The plasma oxidation power was assessed by measuring the absorbance associated with the primary and secondary oxidation products of sunflower oil. Moreover, the inactivation of natural microflora and some pathogens on the outer skins of fresh fruit and surface of the shell eggs was investigated. Main results indicated that the treatment time was positively correlated to the primary oxidation products, while the Relative Humidity levels showed to play a role in the production of the secondary ones. The efficiency of plasma treatment to decontaminate both fresh pears and table eggs was highly dependent on the exposure time and RH values.

Introduction

The decontamination efficacy and mechanism of the gas plasma towards different type of microorganisms together with the techniques able to generate the ionized gas at atmospheric conditions were widely investigated [1, 2, 3]. The possibility of achieving the decontamination at low levels of temperature and pressure makes the technique promising for the superficial treatment of food products. The gas plasma potentiality was confirmed by the results of some recent researches conducted on the main microorganisms infecting fruits [4], vegetables [5], grains and legumes [6] and shell eggs [7]. In order to study the optimal treatment conditions, the present work intends to analyse the gas plasma produced by an RBD device in terms of oxidative power (towards sunflower oil samples) and decontamination efficacy (towards fruit and shell eggs).

Materials and methods

The analysed gas plasma was generated between three pairs of parallel plate electrodes made of brass (one of the two electrodes was covered by a 5 mm thick glass sheet used as high resistive materials to prevent arc) (Fig.1). The voltage at electrodes was produced by three high voltage transformers and power switching transistors. The maximum volume of the treatment chamber was about 70 dm^3 and the generated plasma species were driven towards the product by three fans. Electrical and chemical characterization of the gas plasma produced by the above described device were conducted in a previous work by Ragni et al., 2010 [7]: with an input DC voltage of 19V, the discharge was characterized by a potential difference of about 15kV, while the analysed emission spectrum showed, as expected with the air gas, the formation of very reactive species such as the positive ion N_2^+ and NO and OH radicals.

In order to understand the power of the oxidative species generated during treatments characterized by three different durations (30, 60 and 90 min) and two different levels of the relative humidity (RH= 35% and 65%, 21°C), oxidative tests were conducted with sunflower oil samples (10 ml each placed in a Petri dish). The absorbance for conjugated dienes and trienes in control (treatment time= 0) and oxidized samples were measured at 232 nm and 270 nm, respectively [8].

The decontamination efficacy was evaluated on fresh pears and shell eggs containing only the indigenous microflora or deliberately contaminated with pathogens (*Salmonella* Enteritidis, *Escherichia coli* and *Listeria monocytogenes*). Food products were exposed to gas plasma for 0, 10, 20, 30, 45, 60 and 90 min at 35% and 65% RH values, and the surviving cells of the target microorganisms were enumerated by plate countings onto unselective and selective media.

Results and discussions

The oxidative behaviour of the sunflower oil showed that the absorbance associated to the primary oxidation products content significantly increased by increasing the treatment time of exposure. However, this content was not correlated with the relative humidity of the discharge atmosphere. The absorbance associated to the secondary products significantly decreased among treatment times, and the relative humidity showed to play, although not always clear, a role in the production of conjugated trienes (their decrement was often significantly lower for the samples treated with highest RH values).

Results of the microbiological analysis showed that gas plasma was effective against both natural microflora and target pathogens. In general the decontaminating efficacy was enhanced by increasing the treatment time and in the presence of humid air. Surface reductions by 1.5 and 2.5 log units/fruit of total spoilage flora and moulds, respectively were observed in about 45 minutes of treatment at 65% RH for fresh fruit.

Maximum cell reductions ranging between 1.5 and 4.5 log units/eggshell depending on the microbial species were achieved for table eggs following the longest treatment. During a 50-day storage at 25°C cell loads of both control and treated eggs decreased down to undetectable levels. However, such a viability loss was much faster in gas plasma treated ones.

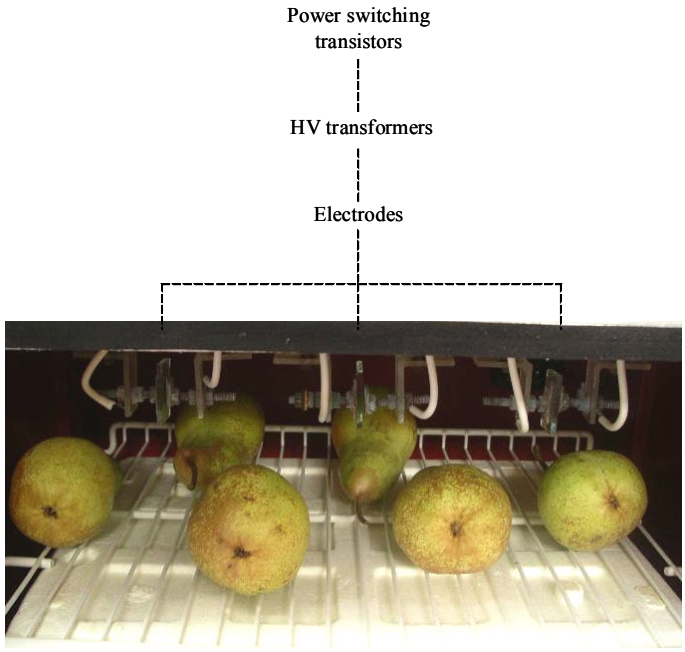

Fig. 1: Particular of the electrodes of the Resistive Barrier Discharge device during the superficial treatment of *Abate* pears.

Conclusions

The RBD gas-plasma prototype proved to generate a low temperature after-glow gas mixture able to significantly reduce the native flora and the inoculated pathogens on the surface of fresh pears and shell eggs. About the oxidation power, further investigations on the transformation of primary to secondary oxidation products should be carried out to clarify also the gas plasma role in the possible food quality modifications.

References

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