

Effect of ozone on the quality of fresh-cut green beans (*Phaseolus vulgaris* L.) and bell peppers (*Capsicum annuum* L.)



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Introduction

Ozone (O_3) is an unstable form of oxygen. The molecule rapidly degrades to O_2 , releasing a free reactive atom that, combined with another one, can form a bi-atomic molecule of oxygen (Fig. 1) (Guzel-Seydim *et al.*, 2004a).

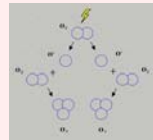


Figure 1. Ozone formation by corona discharge

Ozone is recognised as a strong oxidant and potent disinfectant agent, which has several applications in the food industry, such as food surface disinfection, sanitation of food plant equipment and reuse of wastewater. Due to the high reactivity, penetrability and spontaneous decomposition to a non-toxic product, ozone, both in gaseous and aqueous phases, was recognized by the US government as a safe antiseptic technology of foods (Kim *et al.*, 2003; Dufresne *et al.*, 2004).

Ozone may be used as an alternative non-thermal treatment, with the potential of increasing shelf life and quality retention of the processed foods. Several studies have shown that ozonation is in fact an appropriate method to guarantee food quality and safety (Khadre *et al.*, 2001; Guzel-Seydim *et al.*, 2004b; Manousaridis *et al.*, 2005).

Objective

Study of ozonated water treatment effect on the quality of fresh-cut green beans and bell peppers (total acidity, enzyme activity, colour and texture).

Material and methods

Green beans (*Phaseolus vulgaris*, L.) and green and red bell peppers (*Capsicum annuum*, L.) were acquired in a local market. They were pre-washed and cut into small portions (2x1 cm for green beans; 4x1 cm for bell peppers).

Pilot plant equipment with continuous ozone production was used in assays. An ozone generator (OZ5, SPO3, Sociedade Portuguesa de Ozono) interconnected to a container (volume of 158 L) filled with tap water, formed a closed circuit rig apparatus.

Ozone was continuously incorporated into water (at ~ 15°C), and its content was indirectly measured by potential difference (SZ 265, B&C Electronics).

Samples were immersed in ozonated (~ 2 ppm) and non-ozonated (used as control) water baths and removed after different time intervals, until a maximum of 180 minutes.

The experimental results obtained from ozonated and non-ozonated water treatments were compared by analysis of variance (two-way ANOVA, Analysis Tool Package, Excel 2000, Microsoft®, USA).

Total acidity was evaluated by pH measurements (GLP 22, Crison), after homogenisation and filtration of the samples.

Enzyme activity peroxidase activity was assayed by spectrophotometric technique (spectrophotometer UV-1601, Shimadzu).

Colour was measured using the Hunter (L, a and b) scale, with a colourimeter (CR-300, Minolta).

The TCD [$TCD = \sqrt{(L-a)^2 + (b-b_0)^2} + (L-a_0)$], being index 0 indicative of initial reference values of fresh product] was the parameter considered for evaluation of colour as quality factor.

Texture

firmness and fracturability were measured in a texturometer (TA-Xt2plus, TA Instruments) in compression mode.

Green beans: firmness was measured using a cylindrical probe (P2N, $\phi=2$ mm), which was pushed into the sample till a defined distance of 5 mm (30 replicates).

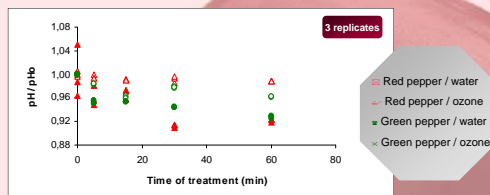
Bell peppers: fracturability was measured fitting the texture analyser with a fracture wedge set (AWEG) and defining a 15 mm cut distance (30 replicates).

Results and Discussion

Total acidity

- pH values were normalized in relation to fresh products' values (pH_0).
- The ozone effect was significant for red bell peppers (ANOVA, $p < 0.01$).
- pH decreased as time of ozone treatment increases. After one hour, pH decreased about 8% in relation to fresh products, for both bell pepper varieties.
- In samples treated with water (without ozone), pH values remained constant (about 5.3 and 6.0 for red and green peppers, respectively).

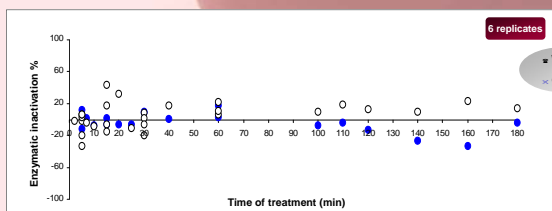
Influence of ozone on pH → green and red bell peppers



Enzyme inactivation

- Ozone affected peroxidase inactivation in green beans (ANOVA, $p < 0.07$).
- Treatment times lower than 40 minutes showed a considerable experimental data dispersion.
- For higher times, and in samples treated with ozonated water, the results tend to stabilize around 20% of inactivation.

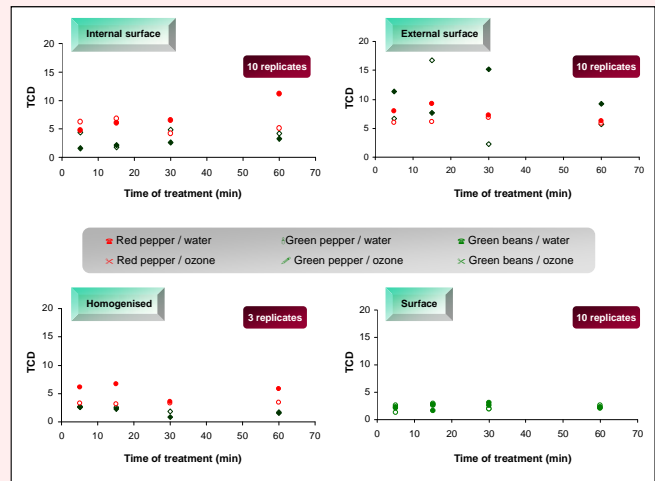
Influence of ozone on enzyme inactivation → green beans



Colour

- The effect of ozone on TCD of the samples was not evident (confirmed by ANOVA results).

Influence of ozone on colour → green beans, green and red bell pepper



Texture

- Ozone treatment increased firmness of green beans samples (ANOVA, significance level of 7%) and decreased fracturability of red bell peppers (significance level of 1%).
- For green bell peppers, the texture parameters were not significantly affected.

Influence of ozone on texture → green beans, green and red bell pepper

Product	Time (min)	Water		Ozonated water	
		Firmness (N)	Fracturability	Firmness (N)	Fracturability
Green beans	0	0.0572 ± 0.0063	-	0.0572 ± 0.0063	-
	5	0.0577 ± 0.0049	-	0.0595 ± 0.0066	-
	15	0.0574 ± 0.0079	-	0.0584 ± 0.0066	-
	30	0.0551 ± 0.0061	-	0.0593 ± 0.0054	-
	50	0.0561 ± 0.0103	-	0.0575 ± 0.0066	-
Green bell pepper	0	0.567 ± 0.086	3.471 ± 0.386	0.591 ± 0.109	3.287 ± 0.565
	15	0.543 ± 0.083	3.150 ± 0.693	0.478 ± 0.053	2.816 ± 0.291
	30	0.470 ± 0.072	3.143 ± 0.422	0.492 ± 0.064	2.879 ± 0.440
	50	0.556 ± 0.102	2.982 ± 0.424	0.551 ± 0.114	3.053 ± 0.623
	180	0.418 ± 0.074	3.224 ± 0.533	0.462 ± 0.074	2.977 ± 0.496
Red bell pepper	0	0.418 ± 0.074	3.224 ± 0.533	0.462 ± 0.074	2.977 ± 0.496
	15	0.438 ± 0.077	3.552 ± 0.354	0.433 ± 0.084	2.796 ± 0.453
	30	0.364 ± 0.057	3.072 ± 0.380	0.458 ± 0.071	2.919 ± 0.467
	50	0.428 ± 0.087	3.418 ± 0.633	0.494 ± 0.072	2.988 ± 0.327
	180	0.418 ± 0.074	3.224 ± 0.533	0.462 ± 0.074	2.977 ± 0.496

Conclusions

- Ozone treatment influenced the total acidity of green and red bell peppers. The pH values of fresh products decreased about 8%.
- Colour of the all studied vegetables was not affected by ozonation.
- 20% of peroxidase inactivation was attained in green beans treated with ozonated water.
- Firmness of green beans and fracturability of red bell peppers were affected by ozone treatment.
- Further studies are required to determine the optimal ozonation conditions (time of treatment and ozone concentration) for maximum quality retention of food products.

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Acknowledgments

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