

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

ALEXANDRE Elisabete M.C., FUNDO Joana, SANTOS Dora M., BRANDÃO Teresa R.S., SILVA Cristina L.M.*

Escola Superior de Biotecnologia, Universidade Católica Portuguesa
Rua Dr. António Bernardino de Almeida
4200-072 Porto, Portugal

*E-mail: clsilva@esb.ucp.pt

Abstract

Ozone is a potent oxidant and disinfectant agent with multiple industrial applications. The efficacy of ozone treatments has been recognised in the sanitation of equipments and water disinfections. Recently, ozone started to be used as an innovative food processing technology that guarantees product safety.

The objective of this work was to study the effect of ozone on the quality of fresh-cut green beans (*Phaseolus vulgaris*, L.) and green and red bell peppers (*Capsicum annuum*, L.). The quality factors analysed were enzyme (peroxidase) activity, colour and texture for green beans, and colour, texture and pH for bell peppers.

Experiments were carried out in pilot equipment. An ozone generator was interconnected to a container filled with tap water. Ozone was continuously incorporated in water and its content was indirectly measured by potential difference. Green beans and bell peppers were cut in small portions. Samples were immersed in ozonated and non-ozonated water baths and removed after different times till a maximum of 180 minutes. Data from both treatments were compared by analysis of variance.

For green beans, results showed that ozone treatment did not affect the colour, but significantly influenced texture (firmness) and peroxidase inactivation (at 7% significance level). After 40 minutes enzyme activity was reduced approximately 20%. This inactivation was verified for the rest of the sampling times.

Ozone treatment affected pH and texture (fracturability) of red bell peppers (at 1% significance level). The other quality factors were not significantly influenced by ozone.

Keywords:

Ozone; quality; fruits; vegetables

Introduction

Ozone (O₃) is an unstable form of oxygen. The molecule rapidly degrades to O₂ releasing a free reactive atom that, combined with another one, can form a bi-atomic molecule of oxygen (Guzel-Seydim *et al.*, 2004a). In nature, ozone is formed in the stratosphere by the electrical discharges that happen during lightning storms and by the sun's ultraviolet rays. At a laboratory scale, ozone can be either generated by ultraviolet sterilisation lamps (Mustafa, 1990) or by passing oxygen through an electrical charge.

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 acts at cell level, oxidizing sulfhydryl groups and amino acids of enzymes, peptides and proteins to shorter peptides. Another proposed mechanism involves oxidation of polyunsaturated fatty acids to peroxides (Victorin, 1992). Several studies demonstrated that ozone treatments increase shelf life of fruits and vegetables (Rice *et al.*, 1982). This fact may be explained by the antimicrobial effect of ozone and also by its potential action at enzymatic level. Enzyme activity is responsible for quality decay of foods. One of the most effective processes for enzyme inactivation in fruits and vegetables is blanching, which has as the main disadvantage the degradation of sensorial and nutritional attributes (e.g. colour, aroma, taste, texture, vitamin content, etc). 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 showed 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). Its application could be even more important in the case of fresh-cut fruits and vegetables in which cellular tissues disruption promotes microbial proliferation and degradation of quality attributes, thus affecting negatively the final product characteristics (Zhang *et al.*, 2005).

Application of ozone in food industries is an emerging and challenging technology that, together with the proven applications as sanitizer, may improve the value of fresh-like processed foods, yielding products that are economically important and attain consumers' demands.

The objective of this work was to investigate the effects of ozonated water treatments on the quality of fresh-cut green beans and bell peppers, throughout enzyme activity, pH, colour and texture (fracturability).

Material and methods

Green beans (*Phaseolus vulgaris*, L.) and green and red bell peppers (*Capsicum annum*, L.) were acquired in a local market. They were pre-washed and cut in small portions (2x1 cm for green beans; 4x10 cm for bell peppers). Samples were immersed in ozonated (ozone concentration of approximately 2 ppm) and non-ozonated (used as control) water baths and removed after different times, until a maximum of 180 minutes.

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

Total acidity of bell peppers was evaluated by pH measurements (GLP 22, Crison), after homogenisation and filtration of the samples (3 replicates).

The colour was measured using the Hunter (*L*, *a* and *b*) scale, with a colourimeter (CR-300, Minolta). In green beans, the measurements were done at external surfaces (10 replicates). In bell peppers, colour was evaluated at both internal/external surfaces (10 replicates) and in homogenised samples (3 replicates). The *Total Colour Difference*

[$TCD \equiv \sqrt{(a - a_0)^2 + (b - b_0)^2 + (L - L_0)^2}$, being index 0 indicative of initial reference values of fresh product] was the parameter considered for evaluation of colour as quality factor.

Peroxidase activity was assayed in green beans samples by spectrophotometric technique (spectrophotometer UV-1601, Shimadzu). The extract was prepared by homogenising 20 g of

green beans with 50 mL of distilled water and posterior filtration. Aliquots of 100 μL of extract and 2900 μL of a reaction mixture composed by 100 mL of buffer sodium phosphate 0,05 M (pH 6,5), 10 mL of guaiacol solution (1%) and 10 mL of H_2O_2 solution (0.3% v/v). The extract absorbance was determined for 180 seconds at 470 nm and 25°C, using 6 replicates.

Texture parameters (firmness and fracturability) were measured in a texturometer (TA-XT2plus, TA Instruments) in compression mode. For texture analysis of green beans, firmness was measured using a cylindrical probe (P2N, $\text{Ø}=2$ mm), which was pushed into the sample till a defined distance of 5 mm. Fracturability of bell peppers was measured fitting the texture analyser with a fracture wedge set (A/WEG) and defining a 15 mm cut distance. At least 30 replicates were done for each sample.

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).

Results and discussion

Total acidity

The effect of ozonated and non-ozonated water treatments on total acidity of bell peppers can be observed in Figure 1 (pH values were normalized in relation to fresh products' values). The results show that pH decreases as time of ozone treatment increases. After one hour, and for both bell peppers varieties, pH decreased about 8% in relation to fresh products. The ozone effect on pH was significant for red bell peppers (ANOVA, $p < 0.01$).

In samples treated with water (without ozone), pH values remained constant (about 5.3 and 6.0 for red and green peppers, respectively).

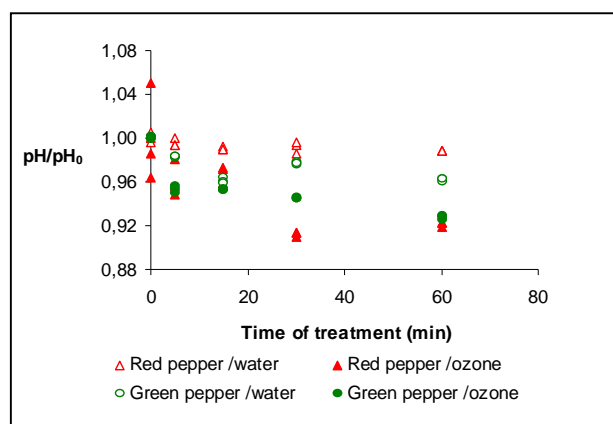


Figure 1. Influence of ozonated and non-ozonated water treatments on pH of green and red bell peppers (pH₀ represents pH of fresh untreated product).

Colour

Results of colour measurements are shown in Figure 2. The effect of ozone on total colour difference of the samples was not evident, which was confirmed by ANOVA results.

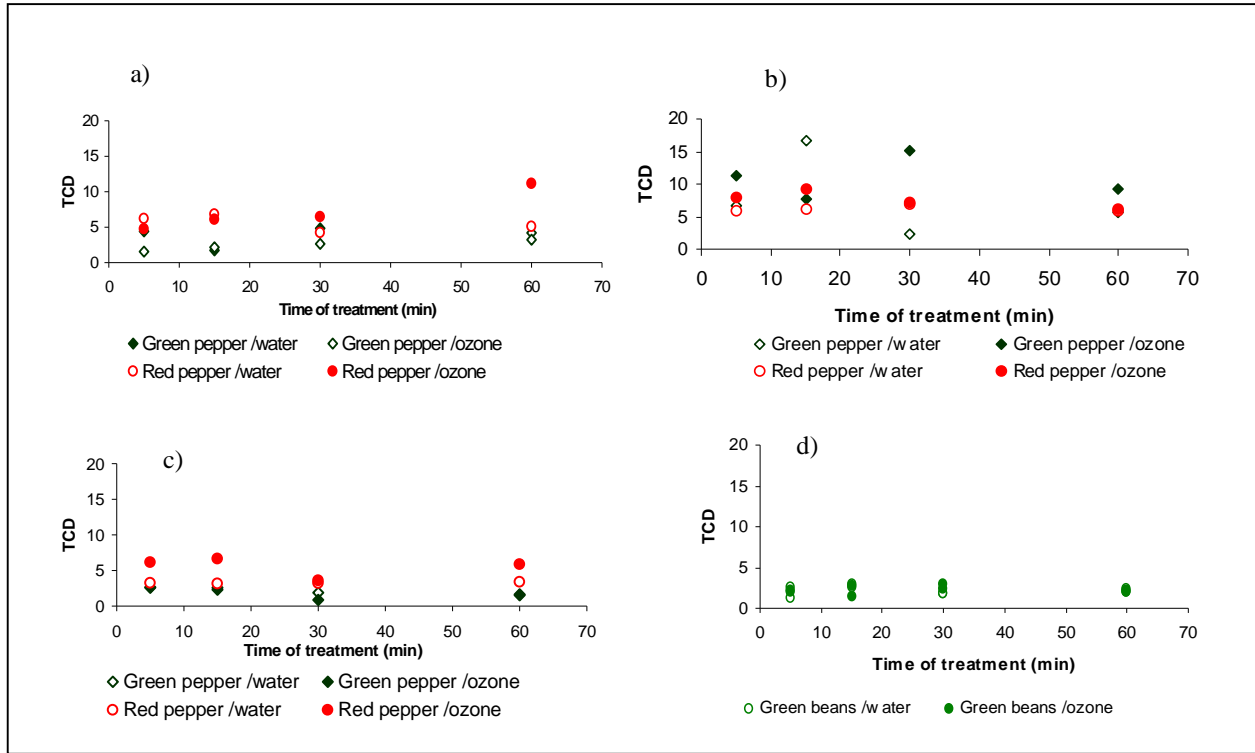


Figure 2. Influence of ozonated and non-ozonated water treatments on colour (evaluated by TCD) of bell peppers and green beans.

- a) Red and green bell pepper (internal surface)
- b) Red and green bell pepper (external surface)
- c) Red and green bell pepper (homogenised)
- d) Green beans (external surface)

Enzyme inactivation

Ozone affected peroxidase inactivation in green beans (Figure 3). This was also confirmed by ANOVA results (significance level of 7%). For treatment times lower than 40 minutes, A considerable experimental data dispersion was observed. For higher times and in samples treated with ozonated water, the results tend to stabilize around 20% of inactivation.

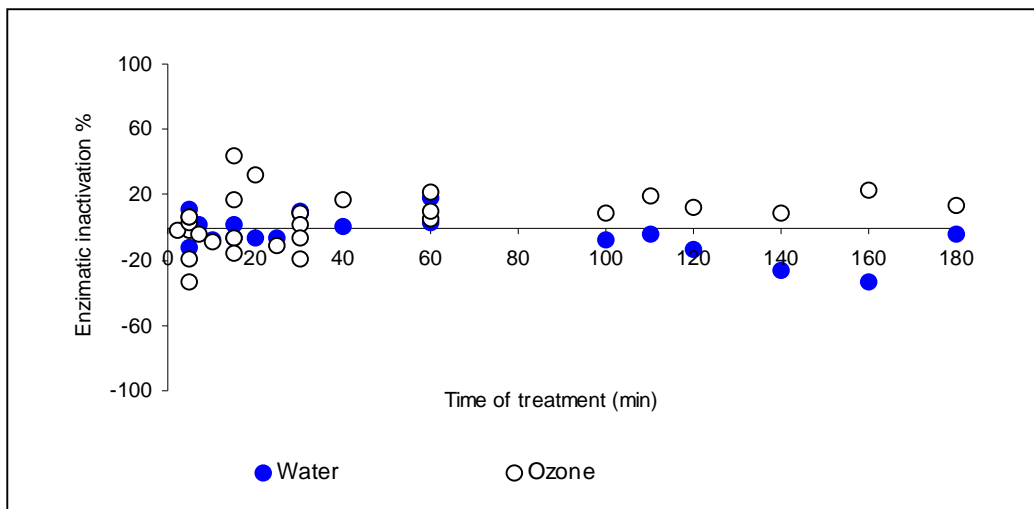


Figure 3. Influence of ozonated and non-ozonated water treatments on peroxidase inactivation in green beans.

Texture

Results of texture analysis (Table 1) showed that 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.

Table 1. Influence of ozonated and non-ozonated water treatments for different times, on texture parameters of green beans and bell peppers.

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
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

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.

The ozone effect on peroxidase inactivation was evident. 20% of 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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