A simple gaseous chlorine dioxide method for microbial decontamination on potatoes during storage

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Abstract

During harvesting, potatoes may become injured and susceptible to microorganisms. When in storage, bacteria and fungi that were potentially introduced during harvesting may contaminate potatoes.

The objective of the study was to develop a novel, simple gaseous chlorine dioxide (ClO_2) method that could effectively control microorganisms on potatoes during storage. Gaseous ClO_2 was generated by combining an equal amount of impregnates of sodium chloride and activating acids in a sachet without any solution or equipment. After activation, the sachet was placed in the application area. Decontamination efficiency of ClO_2 on natural microbiota including total bacteria, yeasts and molds, and inoculated *Pseudomonas aeruginosa* on potatoes was investigated. Different treatment using 2, 3, 4g of materials and various time intervals (2.5 and 5hr) to generate 16, 20, 24, 30, 32, and 40mg/l of ClO_2 was used.

Results were effective for yeasts and molds, showing over a 5 log CFU/potato reduction with a 4g treatment after 5 hr. The natural microbiota study also showed over a 5 log CFU/potato reduction. For *P. aeruginosa*, there was a slight increase in the reduction after 5 hr of the 4g treatment with almost a 6 log CFU/potato reduction. The lowest treatment tested (2g at 2.5hr) had reductions of 1.7, 1.9, and 2.3, log CFU/potato for total microorganisms, yeasts and molds, and *P. aeruginosa*, respectively. Gaseous ClO_2 did not affect the overall visual quality of the potato. The residue of ClO_2 decreased to < 1mg/l after 14 days consistently for each treatment, indicating ClO_2 dissipated naturally following the treatments over time.

In conclusion, gaseous ClO_2 showed positive results as a sanitization method on potatoes, which may be scaled up to help potato farmers to grow and prosper without having to deal with the loss of their crops in storage due to microbial contamination.

Introduction

Many potato farmers lose potatoes during storage due to the length of storage time and microbial contamination. During harvesting, potatoes may become injured and susceptible to microorganisms such as yeast, molds and bacteria. When in storage, bacteria and fungi that were potentially introduced during harvesting may contaminate some potatoes. As the potatoes are in such close contact during storage, the infection may spread throughout the entire storage facility.

Chlorine dioxide is one of the disinfectants used increasingly to control microbiological growth in a number of different industries. It is a water-soluble, strong oxidizing agent with an oxidation potential 2.5 times higher than that of chlorine and less affected by pH and organic matter (Beuchat et al. 2004;Han et al. 2004). It has also been reported in preventing potato spoilage without any significant risks of chemical residues or change of skin color. Generation of chlorine dioxide is usually inconvenient and relatively expensive due to needs of on-site instruments such as applicators, generators or reaction with acid. In this research, we have applied a simple, cheap pouch approach to deliver chlorine dioxide and evaluate it against natural flora, yeast and mold, and *Pseudomonas aeruginosa* on potatoes during storage .

Methodology

Fig. 1. Activation of gaseous ClO_2 (A) Impregnates of sodium chlorite and activating acid compounds and (B) Sachet where compounds are added to activate gaseous chlorine dioxide by mixing and shaking (supported by ICA TriNova, LCC).

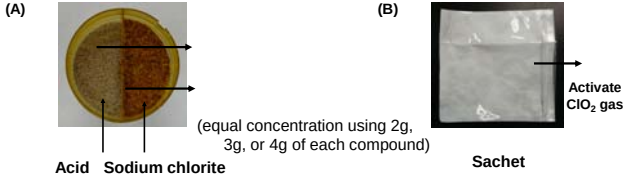
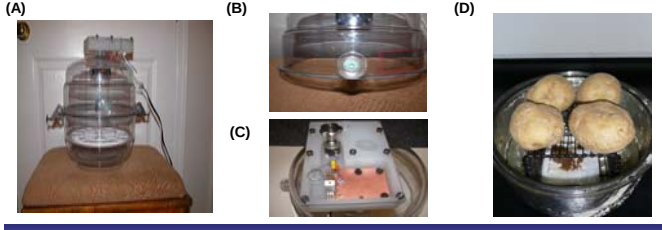


Fig. 2. Decontamination of potatoes using gaseous ClO_2 in the lab scale study. (A) assembled desiccator, (B) sandwiched port where needle is inserted for gas removal, (C) small installed fan used for circulation of gas within the desiccator with a control panel used to control the speed of the fan and (D) Potatoes and sachet in the desiccator



Results and Discussion

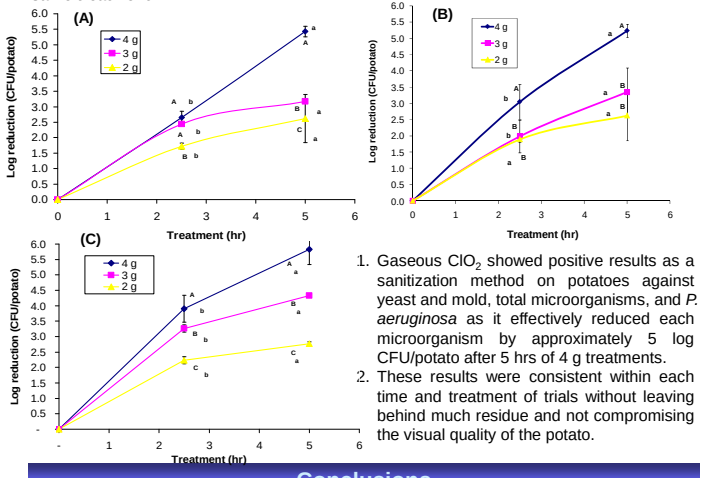
Table 1. Visual quality of potatoes treated with gaseous ClO_2 after 14 days using the hedonic scale .

Trial	Average
2g 2.5 hr.	9.00 ± 0.00
2g 5 hr.	9.00 ± 0.00
3g 2.5 hr.	8.67 ± 0.58
3g 5 hr.	8.33 ± 0.58
4g 2.5 hr.	9.00 ± 0.00
4g 5 hr.	9.00 ± 0.00

Table 2. Residue of ClO_2 on potatoes immediately following treatment and after 14 days of treatment .

Trial	Residue after 0 Days (mg/l)	Residue After 14 Days (mg/l)
2g 2.5 hr.	0.09 ± 0.02	0.02 ± 0.03
2g 5 hr.	0.11 ± 0.08	0.01 ± 0.01
3g 2.5 hr.	0.16 ± 0.01	0.02 ± 0.01
3g 5 hr.	0.17 ± 0.08	0.05 ± 0.06
4g 2.5 hr.	1.19 ± 0.57	0.86 ± 1.01
4g 5 hr.	0.66 ± 0.13	0.35 ± 1.53

Fig. 3. Microbial decontamination by gaseous ClO_2 on (A) natural flora (B) yeast & molds, and (C) inoculated *Pseudomonas aeruginosa* on potatoes at different times and treatments. Different capitalized letters vertically indicate a significant difference ($P < 0.05$) between different treatments over the same period. Different lower case letters horizontally indicate a significant difference ($P < 0.05$) between different times at the same treatment.



1. Gaseous ClO_2 showed positive results as a sanitization method on potatoes against yeast and mold, total microorganisms, and *P. aeruginosa* as it effectively reduced each microorganism by approximately 5 log CFU/potato after 5 hrs of 4 g treatments.
2. These results were consistent within each time and treatment of trials without leaving behind much residue and not compromising the visual quality of the potato.

Conclusions

Overall, gaseous ClO_2 effectively killed natural flora, yeast and mold, as well as *P. aeruginosa* on potatoes for each treatment in the present study. The application of gaseous ClO2 on a larger scale could be tested in the future. This study would help potato farmers to grow and prosper without having to deal with the loss of their crops in storage due to microbial contamination.

References

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•Han, Y., Selby, T.L., Schultze, K.K., Nelson, P.E. and Linton, R.H. (2004) Decontamination of strawberries using batch and continuous chlorine dioxide gas treatment. *J. Food Prot.* 67, 2450-2455.