Reducing Browning of Fresh-cut 'Maha' Carambola with Chemical Additives and Low-oxygen Atmospheres

Gustavo H.A. Teixeira[1], José F. Durigan[1], Timothy J. O'Hare[2], Ricardo E. Alves[3]
[1]Department of Technology, Faculdade de Ciências Agrárias e Veterinárias, Universidade Estadual Paulista, Via de acesso Prof. Paulo Donato Castellane, s/n, 14.884-900, Jaboticabal, SP, Brazil.
(**FAPESP** Proc. 00/13237-9 and **CAPES** Proc. BEX 0391/02-6).
[2]DPI Gatton Research Station, Locked bag 7, Mail service 437, Gatton, 4343 Qld, Australia.
[3]EMBRAPA Agroindústria Tropical, C.P. 3761, 60.511-110, Fortaleza, CE, Brazil.

INTRODUCTION

The greatest attraction to using carambola (*Averrhoa carambola* L.) in the fresh-cut market is the star shape that the fruit presents after a transverse cut. Carambola is well-suited for minimal processing, but cut surface browning is a main cause of deterioration. This problem is exacerbated as a result of mechanical injuries occurring during processing and is mainly induced by the leakage of phenolic compounds from the vacuole and subsequent oxidation by polyphenol oxidase (PPO) (Augustin et al., 1985). The use of browning inhibitors in processed fruits is restricted to compounds that are non-toxic, 'wholesome', and that do not adversely affect taste and flavour (Gil et al., 1998). In the past, browning was mainly controlled by the action of sulphites, but the use of this compound has declined due to allergic reactions in asthmatics (Weller et al., 1995). The shelf life of fresh-cut products may be extended by a combination of oxygen exclusion and the use of enzymatic browning inhibitors. The objectives of this work were to determine the effects of: (1) post-cutting chemical treatments of ascorbic, citric, oxalic acids, and EDTA-Ca; (2) atmospheric modification; and (3) combinations of the above, on the shelf life of carambola slices based on appearance, colour and polyphenol oxidase activity.

METHODS

'Maha' carambola fruit were washed with water and dipped in NaOCl solution at 200 $mg.L^{-1}$, for 5 minutes. Fruit were cooled in a cold room at 10^0C overnight. Extremities were removed from fruit using a sharp stainless steel knife and the fruit cut transversally in to slices (approx. 0.7 cm width) using a 'Tomato Witch' slicer. Slices were treated as follows: **Experiment 1:** Post-cutting chemical treatments (5 min dip): control (distilled water); 0.5% ascorbic acid; 1.0% ascorbic acid; 1.0% citric acid; 2.0% citric acid; 0.5% oxalic acid; 1.0% oxalic acid; 500 ppm EDTA-Ca, and; 1000 ppm EDTA-Ca. **Experiment 2:** Low-oxygen storage (flow rate 50 $mL.min^{-1}$): 20.3%, 11.3%, 4.7%, 2.3%, 1.4% and nitrogen (effectively 0.4% O_2). **Experiment 3:** Chemical treatment and low-oxygen combinations: control (distilled water and 21% O_2); distilled water and 0.4% O_2 (nitrogen); 1.0% ascorbic acid and 21% O_2; 1.0% ascorbic acid and 0.4% O_2 (nitrogen). **Assessments:** Visual appearance was subjectively rated immediately after withdrawal. Colour (hue, chroma, brightness) was determined immediately and after 6 hours exposure to ambient conditions. Polyphenol oxidase (PPO) activity was determined using the spectrophotometric method described by Adnan et al. [1986].

RESULTS

Post-cutting dips of 1% ascorbic acid (AA) and 2% citric acid (CiA) significantly slowed cut surface browning and maintained best colour of 'Maha' carambola slices. Ascorbic acid dips (0.5% and 1%) also reduced polyphenol oxidase (PPO) activity throughout storage at 4^0C, with 1% ascorbic acid inducing lowest activity (Figure 1). Low-oxygen atmospheres above 0.4% oxygen did not effectively prevent either cut surface browning or PPO activity. However, slices stored under nitrogen (effectively 0.4% oxygen) presented better visual appearance for up to 9 days without producing any off-flavours (data not shown). Carambola slices treated with 1% ascorbic acid and held in an atmosphere of 0.4% oxygen (nitrogen) had no significant browning or loss in visual quality for up to 12 days (Figure 2).

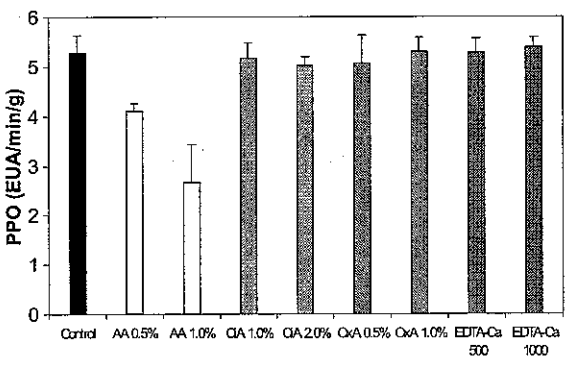

Figure 1. Polyphenol oxidase activity (Enzymatic Activity Units per minute per gram) of 'Maha' fresh-cut carambola after treatment with ascorbic acid (AA), citric acid (CiA), oxalic acid (OxA), and EDTA-Ca and storage at 4.6ºC for 9 days

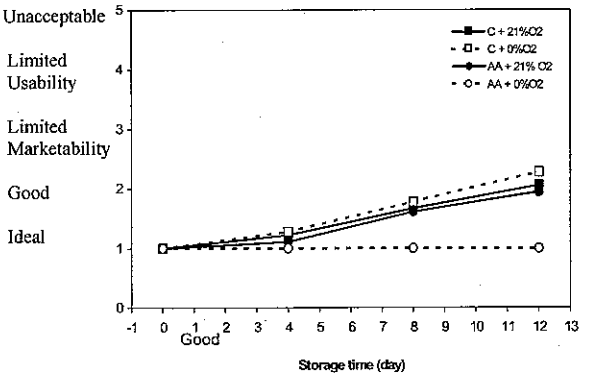

Figure 2. Visual appearance (score 1-5) of 'Maha' fresh-cut carambola slices after different treatments and storage at 4.1ºC for 12 days, immediately after withdrawal.

DISCUSSION

Ascorbic acid (1%) and citric acid (2%) were the most effective additives for controlling browning in carambola slices. Of the additives tested, ascorbic acid was most effective at minimizing PPO activity. It is probable that ascorbic reduced PPO activity by converting oxidized quinones back to the original phenolic compounds. Theoretically, PPO activity can be reduced by lowering pH below 4, and as such, citric acid should have reduced discoloration through pH lowering and also as a chelating agent. However, no reduction in PPO activity was observed, despite a significant reduction in visual browning (Figure 1). Atmospheres with low O_2 concentration can reduce cut surface browning through PPO inhibition, but low O_2 concentrations alone were not as effective as AA at preventing browning in carambola slices. Combining AA with low O_2 concentration (0.4%) was even more effective at reducing browning of the cut surface and increasing the shelf-live of fresh-cut carambola.

CONCLUSION

Browning of minimally processed 'Maha' carambola slices can be minimised to acceptable levels for up to 12 days by storage in a low-oxygen atmospheres (0.4% O_2) in combination with 1% ascorbic acid treatment. We believe slices with this treatment combination still maintain acceptable quality, even after exposure to ambient conditions for up to 6 hours.

REFERENCES

Adnan, T.A.B.T., M.A. Augustin, H.M. Ghazali, Polyphenoloxidase from Starfruit (*Averrhoa carambola*, L.). *Pertanika. 9*(2), 219-224, 1986.

Augustin, M.A., H.M. Ghazali, and H. Hashim, Polyphenoloxidase from guava (*Psidium guajava* L.). *Journal Science of Food and Agriculture. 36*(7), 1259-1265, 1985.

Gil, M.I., J.R. Gorny, A.A. Kader, Responses of 'Fuji' apple slices to ascorbic acid treatments and low-oxygen atmospheres. *HortScience. 32*(2), 305-309, 1998.

Weller, A., R.P. Bates, R.F. Matthews, C.A. Sims, Evaluatin of carambola cultivars for the lightly processed marked. *Proceedings of Florida State Horticulture Society*. 108, 320-324, 1995.