Effects of Modified Atmosphere Packaging on Selected Phenomena Affecting Quality of Fresh, Edible Bamboo Shoots

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ABSTRACT

*Changes in phenomena affecting quality of fresh bamboo shoots (**Dendrocalamus asper,** **Schultes f.**) due to modified atmosphere packaging were evaluated. After harvest bamboo shoots were peeled, and stored in the open (unpacked) or packaged in polyvinyl chloride wrap (thickness 5 µm) or polypropylene bags (thickness 15 µm) at two different temperatures (9 and 28 °C) and shelf life was determined. Unpacked samples had very high weight losses (5% per day) at both temperatures limiting their shelf life to less than 2 days. Both types of packaging reduced water loss significantly (polyvinyl chloride: 0.5% per day at both temperatures, polypropylene: 0.09% and 0.14% at 9 and 28 °C respectively). Samples stored at room temperature started to discolor within 1-2 days while packed samples in the refrigerator showed the first signs of discoloration only after 5-7 days of storage. Refrigeration was also effective to inhibit fungal growth. Our results show that application of cold storage or packaging alone yields no, or only a limited extension of shelf life but their combined application yields a shelf life extension till 2 weeks.*

Keywords: *Modified atmosphere packaging, bamboo shoots (Dendrocalamus asper,* Schultes f.*), postharvest.*

INTRODUCTION

In Asia edible bamboo shoots are mainly consumed locally and only a small part is exported, normally in canned form or preserved in some other ways. Export of fresh bamboo shoots is limited by the extreme perishability of this crop, while the demand for fresh bamboo shoots is expected to rise due to the increasing of consumer demand for unprocessed foods.

Fresh bamboo shoots are fast respiring, have high water losses and are therefore very perishable. Modified Atmosphere Packaging (MAP) has been shown to give a considerable extension of shelf life for a wide range of commodities and especially passive MAP is a technique that can be applied at very low cost (Beaudry, 1999; Zagory, 1998). Recent research in Australia on fresh bamboo shoots (*Bambusa oldhammii*) showed that various kinds of packaging materials could significantly reduce weight loss and extend shelf life (Kleinhenz et al., 2000; Midmore and Kleinhenz, 2000). However, these studies lacked any measurements on carbon dioxide and oxygen conditions inside the package, important parameters that need to be known to further optimise the packaging.

The aim of the present work is to investigate the effect of different storage temperatures and various kinds of packaging materials on shelf life of fresh bamboo shoots (*Dendrocalamus asper,* Schultes f.), a species that is widely cultivated not only in Indonesia, but also in e.g., Burma, Thailand and India. Quality of the shoots was assessed in terms of weight loss, discoloration, and fungal infection. Furthermore the gas conditions inside the package were determined using a gas sensor system.

MATERIALS AND METHODS

Fresh bamboo shoots (*Dendrocalamus asper*, Schultes f.) were harvested from local plantations in Semarang, Central Java and brought to the laboratory. Due to the short transportation period no refrigeration needed to be applied during this period. After arrival shoots were directly peeled and non-edible parts were cut off with a stainless steel knife and the edible part was cut into smaller pieces (weight about 150 g/piece). Subsequently samples were dried with paper tissue.

Cut samples were placed in polypropylene (PP) bags with a thickness of 15 µm (Garuda, Indonesia) or wrapped in a polyvinyl chloride (PVC) wrap with a thickness of 5 µm ('Cling Wrap', PT Indomas Susemi Jaya). As a control unpacked bamboo shoots samples were used. Samples were stored at room temperature (28 °C) or in a refrigerator (9 °C).

Weight loss

Weight of the samples was measured using an electronic balance. Relative weight loss at day *n* was calculated as

$$\frac{initial\ weight - weight\ day\ n}{initial\ weight} x100\%.$$

In some cases small amounts of condensation were observed in packed samples but no correction was made for this.

Determination package atmosphere

From the packed bamboo shoots the O_2 and CO_2 concentration was determined inside the package using a sensor system (Vernier, USA). The O_2 concentration was measured by inserting the O_2 sensor into the package while the CO_2 concentration inside the package was determined by injecting a 2 ml sample from the package into a 45 ml dilution tube connected to the CO_2 sensor. Sensors signals were digitalized using a 12-bit A/D-converter and read in via computer (Pentium-MMX, 200 MHz) using the software package Data Logger (version 4.5).

Discoloration

External discoloration of the bamboo shoots was visually assessed during the experiment. Discoloration was rated on a 5-point scale from 0 = white surface color, 1 = some yellow stain, 2 = some dark spots, 3 = moderately discolored and 4 = highly discolored (Kleinhenz et al, 2000).

Quantitative microbial load

A direct plating technique was used to quantify fungal infection on bamboo shoots (Narciso and Parish, 2001). This method is more sensitive than standard disintegration method and allows fewer opportunities for contamination to occur (Narciso and Parish, 2001). Samples were cut in small dice of about 1 cm^3 and then plated on hard agar (PDA). After incubation for 5 days at 28 °C fungal contamination was rated as the percentage of surface of shoots covered with fungal mycelia (0 = 0% to 5 = 100%). Samples stored at room temperature were analysed at days 0, 3, and 7 while refrigerated samples were in addition analysed at days 10, 15 and 20.

Data analysis

Data were analysed using Microcal™ Origin © version 6.0.

RESULTS AND DISCUSSION

Weight loss

Figure 1 shows the relative weight loss of packed and unpacked samples. Relative weight loss increased nearly linearly with storage period as R^2-values of the linear fits ranged between 0.961 and 0.989. For unpacked samples weight loss averaged 5% per day at both temperatures. Unpacked samples, both refrigerated and non-refrigerated, showed a rapid decrease in quality mainly due to extensive water loss. The high losses are due to the peeling and cutting as well as transpiration of the bamboo shoots.

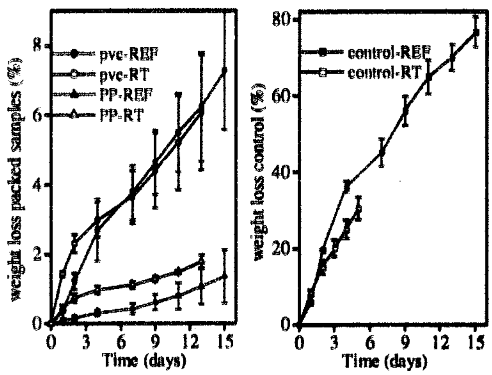

Figure 1. Relative weight loss of packed (left panel) and unpacked (right panel) samples. Note the different y-scale of both panels.

Weight loss of packed samples was much lower; PVC packed samples lost about 0.5% weight per day while PP packed samples only lost 0.09% and 0.14% per day at 9 and 28 °C, respectively. Packaging reduced weight loss by a factor 10 - 50. Weight loss of the PP packed samples is lower as compared to the PVC samples, which is as expected since PP plastic has a lower water vapour transmission and its thickness (15 μm) was higher as compared to the PVC wrap (5 μm).

Discoloration

Figure 2 shows the color development in the bamboo samples along the storage period. Samples stored at room temperature (both packed and unpacked) showed severe discoloration while in contrast for refrigerated (in particular PP-packed samples) discoloration was strongly inhibited. At room temperature control samples start to discolor within a single day and after 3 days samples were brown-black. Packaging had almost no effect on the onset of discoloration but the rate of discoloration was reduced.

Refrigerated unpacked samples discolored at a much slower rate than room temperature samples. Packaging inhibited discoloration completely for 4 (PVC) or even 6 (PP) days. Chen and co-workers have attributed the discoloration in bamboo to enzymatic browning caused by phenylaline ammonialyase and peroxidase, activated by tissue injury due to harvesting (Chen et al., 1989).

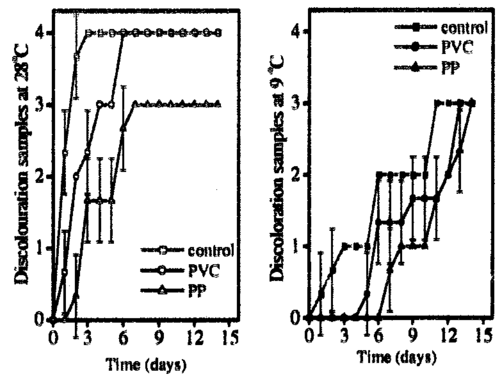

Figure 2. Color development of samples stored at room temperature (left panel) or in the refrigerator (right panel).

Fungal infection

Figure 3 shows fungal contamination of the samples. Refrigerated samples showed no sign of contamination during the entire course of the experiment. In contrast, samples stored at room temperature showed fungal infection within 3 (control and PVC) or 7 (PP) days. Obviously, a modified atmosphere packaging can retard fungal growth and work more effectively in combination with a low temperature.

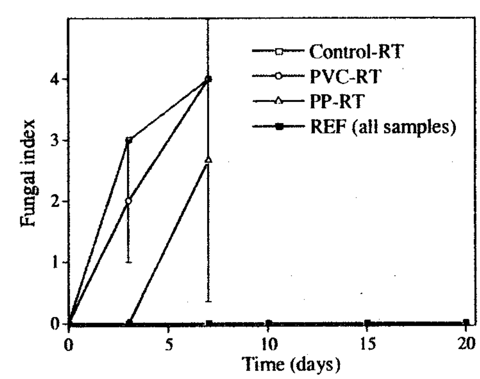

Figure 3. Fungal contamination of samples. Refrigerated samples do not show any sign of contamination up to 20 days.

Gas conditions inside package

Figure 4 shows the CO_2 and O_2 concentrations in the packages stored in the refrigerator. For both packages the O_2 concentration shows a decreasing trend while the CO_2 concentration increases. However, inside the PVC wrap the decrease in O_2

and increase in CO_2 are much smaller as compared to the PP package.

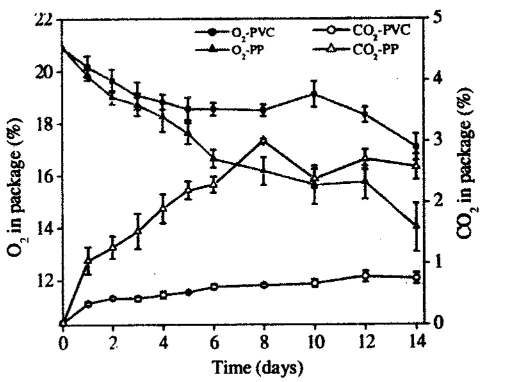

Figure 4. Gas concentrations inside the packages stored in the refrigerator. Build up of CO_2 and the depletion of O_2 is highest in PP packed samples

Inside the refrigerated packages a modification of the gas conditions occurs due to respiration by the samples. PP-packed samples showed the strongest increase in CO_2 (2.5%) and decrease in O_2 (14%) in agreement with its higher thickness and lower gas permeability. To extend shelf life of the bamboo shoots further a stronger increase in CO_2 and decrease in O_2 is needed (Beaudry, 1999); these conditions can be obtained by using a film packaging material that is less permeable to CO_2 and O_2. However the H_2O vapour permeability of this film should be sufficiently high in order to prevent condensation, as already in the current experiment using thin types of plastics small amounts of condensation were observed occasionally.

Our results show that MAP must be combined with storage at low temperatures to optimally extend shelf life of bamboo shoots, i.e., MAP is not a substitute for low temperature storage. This observation is in qualitative agreement with the work of Kleinhenz and Midmore (2002) who found that only a combination of cooling and packaging can lead to a substantial extension of the shelf life of bamboo shoots. Similar results were obtained for a variety of other crops (Zagory, 1998; Zagory, 2000).

CONCLUSIONS

Our results give a clear indication that refrigerated, MA-packed fresh bamboo shoots have a much longer shelf life (2-3 weeks) and maintain their quality better as compared to unpacked samples or samples stored at room temperature. Unpacked samples released such high amounts of water that they would become unmarketable within less than 2 days. Results obtained in this research agree qualitatively with data obtained by other research groups on other bamboo species (Kleinhenz et al, 2000; Midmore and Kleinhenz, 2000) but for the first time gas measurements inside the modified atmosphere package were established.

REFERENCES

Beaudry, R.M. 1999. Effect of O_2 and CO_2 partial pressure on selected phenomena affecting fruit and vegetable quality. Postharvest Biology and Technology. 15: 293–303

Chen, R.Y., Liu, M.S., Chang, T.C., Tsai, M.J. 1989. Postharvest handling and storage of bamboo shoots *(Bamboo oldhamii* Munro*)*. Acta Horticultura. 258: 309-316.

Kleinhenz, V., Gosbee, M., Elsmore S., Lyall, T. W., Blackburn, K., Harrower, K., Midmore, D. J. 2000. Storage methods for extending shelf life of fresh, edible bamboo shoots *(Bambusa oldhamii* Munro*)*. Postharvest Biology and Technology. 19: 253-264.

Kleinhenz, V., Midmore, D.J. 2002. Improved management practices for culinary bamboo shoots: Local and export markets. Report for the rural industries research and development corporation, RIRDC Publication No 02/035.

Midmore, D.J. Kleinhenz, V. 2000. Physiological studies on edible bamboo. Asian Foods Newsletter, 6: 6-8.

Narciso, J.A., Parish, M.E. 2001. Direct plating: A method for detecting fungal contamination in paperboard cartons. Journal of Food Safety. 21:141-150

Zagory, D. 1998. "An update on modified atmosphere packaging of fresh produce". Packaging International 117.

Zagory, D. 2000. "What modified atmosphere packaging can and can't do for you". Washington State University 16th annual Postharvest Conference and Trade Show.