jpht
Research Article

Journal of Postharvest Technology
01 (01): 029-035, October' 2013
www.jpht.info

Evaluating the Effects of Biodegradable and Conventional Modified Atmosphere Packaging on the Shelf Life of Organic Cavendish Bananas

Adams Abdul-Rahaman[1] and Chris Bishop[2]
Department of Agricultural Engineering, Wa Polytechnic, P. O Box 553 Wa, Upper West Region Ghana
[2]Postharvest Unit, Writtle College United Kingdom.

Received : June, 2013
Revised : July, 2013
Accepted : August, 2013

Keywords:
Banana,
Biodegradable MAP,
Conventional MAP,
CO_2,
O_2,
Consumer acceptance.

Abstract

The physiological disorders in banana fruits result in the reduction of fruit quality and the market value that can manifest as diseases in consumer packages. This study investigates the effects of the use of Biodegradable (Bioflex) Modified Atmosphere Packaging (MAP) and LDPE Conventional MAP on rate of ripening (colour changes) and overall consumer acceptance of Cavendish banana fruits at 20°C and 80% RH for eight days. Banana fruits stored in Biodegradable MAP showed quite lower weight loss as compared to others. Fruits stored in Conventional MAP and without Package ripened rapidly as compared with Biodegradable MAP. The CO_2 concentration for the Biodegradable MAP and Conventional MAP were 12% and 9.8% respectively. The O_2 $_C$oncentration decline gradually to 5.2% for Biodegradable MAP compared with 2% for the Conventional MAP. Moreover, fruits stored in Biodegradable MAP showed superior consumer acceptability.

INTRODUCTION

The demand for the good quality fresh fruits by consumers coupled with human health concerns in recent times has led to an increase in production of fruits crops such as organic bananas. Liu (2009) reported that based on the high demands for organically produced fresh fruits and vegetables, world organic exports represented an estimated 2.2% in 2007. The banana industry is a very important source of income, employment, and export earnings for major banana exporting countries in the tropics. Due to postharvest fruit losses in transit and an increase in population there is an imbalance of demand and supply, therefore world banana exports and imports were projected at about 29.3 million tonnes in 2010 based on annual gradual increase of 2% from 2001 global trade of both Conventional and organic banana fruit (FAO, 2003).

The fresh produce sector is a fast growing sector of agriculture across the world, and with the consumer shift toward fresh fruits and vegetables, the relative importance of the sector is likely to increase further. It is estimated that the postharvest losses of most tropical crops due to inefficient packaging are about 15 – 25% (FAOSTAT, 2006) Attempts to use improved packages have produced inconsistent commercial results. Both temperature management and relative humidity control is critical in the Conventional Modified Atmosphere Packaging (MAP), since condensation inside the package can result in rapid deterioration of fresh commodities. Zagory and Kader (1995) reported that when properly applied, MAP could provide benefits such as increased shelf life and eating quality, since as the fruit respires, the O_2 level decreases and the CO_2 level increases in the MAP bags resulting in the retardation of the consumption of respiration substrates such as organic acids and sugars. The MAP technology is widely used to extend shelf life of fresh produce by reducing moisture loss due to low O_2, high CO_2 and high RH within the package, resulting in lower respiration rate and retarded microbial growth (Gorny, 2003 ; Wang, 2006). However, Day (2001) indicated that MAP often results in

Email: nupayala@yahoo.com

development of undesirable fermentation because of insufficient permeability of the packaging film resulting in the formation of ethanol, off flavours, foul odours and poor quality of the product, including microbial growth which might be harmful to consumers. Several assessments carried out on selected fresh products showed that O_2 concentrations lower than 7% under modified atmosphere packaging inhibited microbial growth, decay and influenced postharvest physiology and quality (Ben-Yehoshua and Kader, 2000). This research therefore seeks to evaluate the effects of the use of Biodegradable films and Conventional modified atmosphere-packaging materials on the shelf life of organic bananas and provide recommendations on alternative packaging to reduce losses.

Materials and Methods

Plant Material

Fully mature unripe organic Cavendish banana fruits (Musa Cavendish) were procured from Savid S.A., a commercial grower in the Dominican Republic. The fruits on arrival in the UK were pre-packed at a commercial colour stage 1 that indicates that fruits were completely green. The banana fruits were transported to the Writtle College Postharvest Unit's laboratory. The experiment was a Completely Randomized Design (CRD) with equal replications. Five fingers of organic banana fruits were placed in a Biodegradable MAP, Conventional MAP, and five fingers with no package were used as the control. Each of the three treatments was replicated five times and stored at 20 $\pm$ 1^{o}C temperature and 80 $\pm$ 5% RH for eight days. The initial weight was measured after the heat sealing of the bags. Weight was measured on a daily basis and the percentage weight loss was calculated during the storage period. Colour was also scored on the first day of the trial and readings were then taken on a daily basis.

Gas measurement

All the measurements of the CO_2 and the O_2 were carried out with a Portamap gas analyzer, and the bags were re-sealed immediately after micro-perforations. The Biodegradable (Bioflex) packaging was provided by the same company as the LDPE Conventional MAP bags (Fresh Technologies UK). The permeability of was achieved by micro perforation. The bags did require a commercial composter to biodegrade. All bags were of a similar thickness of 20-27 microns.

Assessment of Colour and Physical Appearance

The colour of the banana fruits was observed carefully on first day and compared with a commercial Standard Colour Chart before storage. Absolute figures of between 1 and 7 were scored each day for completely green to completely yellow, visually indicating the degree of ripeness. The appearance of the package and their contents was evaluated following a rating scale where: **1** = fresh look and no condensation, **3 =** fresh look with some condensation within the package**, 5 =** wet with some condensation on both fruit surface and package, and **7 =** completely wet package.

Sensory Evaluation

For the sensory evaluation, the triangle test was used to determine whether untrained panelists could observe any differences that exist between the Biodegradable MAP and the Conventional MAP fruit**.** Fresh-cut pieces of Banana were tasted by a twelve member panel who were asked to assess the sweetness, on a 1 to 3 point scale (where 1 = starchy to 3 = sweet). The texture was assessed on the same type of 3 point subjective scale as being soft to firm and the overall consumer acceptability was rated on a five point scale (where 1 = unsalable to 5 = very good).

Data Analysis

Data was subjected to an analysis of variance (ANOVA) to test whether there were any significant differences at 5% alpha level between the treatment means. The analyses were performed using the Microsoft Excel Analysis Toolpak computer software. The results produced by the daily measurement of the CO_2 and the O_2 concentration within the bags were analyzed to determine if there were any significant differences between the packaging treatments.

Results

Weight loss of fruits

The percentage weight loss for fruits stored in the Biodegradable MAP on day 2 was 0.6% as compared with 0.7% and 1.5% for Conventional MAP and control samples, respectively. Thereafter there were accelerated differences in percentage weight loss in control fruits without a package, which showed the highest percentage weight loss of 6.5%, compared to fruits in the Biodegradable MAP and Conventional MAP with 1.8% and 3% respectively on day 8 (Figure 1).

Colour and Rate of Ripening

The fruits stored in the Biodegradable MAP maintained fresh green peel colour for the first two days and changed gradually from colour rating 2 on day 2 to commercial ripeness at colour stage 6 on day 8 (Figure 2). The banana fruits in the Conventional MAP showed faster ripening, going from colour stage 2 on day 2 to colour stage 7 on day 8. For banana fruits stored without packaging, the ripening rate was the most rapid, changing from colour stage 3 on day 2 to colour stage 7 on day 6. The results showed significant differences were observed on day 6 and 8 between treatments at ($P< 0.05$) critical level.

Sensory assessment

The sensory evaluation regarding the peel firmness by the panelists showed that there were no significant differences between the fruit peel firmness of the organically produced banana fruits in the different packaging treatments. However, there were significant differences in sweetness ratings by the panelists. For the overall consumer acceptability, highly significant differences were observed with 9 panelists out of the total 12 members rating the fruits stored in Biodegradable MAP higher (Figure 3).

Gas analysis

Daily measurements of the percentage CO_2 concentration in Biodegradable MAP and Conventional MAP indicated that there was an initial increase in the CO_2 in the Biodegradable MAP to 17.2% on day 4 and then a decline to 12% on day 8 (Figure 4). A gradual increase in the CO_2 in the Conventional MAP was also observed for the first four days to 11%, which decreased gradually thereafter to 9.8% on day 8. The results showed that there were significant differences in the CO_2 evolution for the treatments of organic banana fruits in Biodegradable MAP and Conventional MAP. The percentage O_2 concentrations in the Biodegradable MAP showed a sharp decline initially from 20% on day 1 to 5.2% on day 8 (Figure 5). In addition, the O_2 concentration in the Conventional MAP demonstrated a continuous decrease throughout the trials from 18.9% on day 1 to 2% on day 8. The type of packaging film used in the storage of organic bananas at 20°C showed that significant differences were evident in the O_2 concentration between treatments.

Discussion

The results for the organic banana fruits demonstrated that the highest percentage weight loss of 6% was found in the fruits stored without package (control) when compared with fruits stored in Biodegradable and Conventional MAP with 1.8 and 3% weight loss, respectively, after 8 days .The lower percentage weight loss of banana fruits stored in Biodegradable MAP could be influenced by physiological features in packages. The findings of Cia et al. (2006) agreed with the results of this research that MAP could be used to decrease the catabolic activities and degradation processes. A similar observation was made in earlier research on the use of modified atmosphere packaging to slow down the physiological metabolism of mature Cavendish banana fruits which reduced the weight loss in packs (Kader, 1986). The lower percentage weight loss of fruits in the Biodegradable MAP could also be due to the differences in gas concentration within the package and the improved retention of moisture. Ahmad et al. (2001) found that the combined effect of the gas concentration and the high retention of moisture in MAP for storage of pre-climacteric banana fruits resulted in reduced weight loss and maintained fruit quality. The higher percentage weight loss of the control treatment was associated with more rapid ripening and this could be attributed to the increased respiration rate when fruits were exposed to ambient air at 20°C. In this investigation, the storage temperature at 20°C may have contributed to the relatively high weight loss of fruits in the packages and condensation in the Conventional MAP bags. The results produced in this experiment demonstrated that there were more rapid colour changes for the organic Bananas in the Conventional MAP and the control than for the fruits stored in Biodegradable MAP. In this experiment increased CO_2 concentration in the Biodegradable MAP resulted in slower fruit colour changes and rate of ripening. The results agreed with the findings of similar research that storage of Bananas in Low Density Polyethylene (LDPE) MAP can delay ripiness, manage supply and improve quality at market (Rahman et al., 1995; Turner, 2005).

In this study, the score results produced by the taste panelist indicated that fruits stored in the Biodegradable MAP showed superior consumer acceptability. Research conducted on the consumer-oriented quality showed that tasting panels with sensory descriptive analysis could be used to confirm the acceptability of the quality characteristics (Conner, 1994., Shewfelt et al., 1997). The enhanced shelf life of Organic banana in the Biodegradable MAP could be due to the higher CO_2 production and the reduced O_2 consumption within the package. This was reported in earlier research on the use of a Biodegradable Modified Atmosphere Packaging with higher CO_2 evolution and low O_2 production for the extension of shelf life of freshly harvested fruits (Sirinivasa et al., 2002). The levels of the gases inside the MAP also varied with many factors rather than the storage duration and temperature such as the film thickness and the fruit maturity stage. Thomson and Burden (1994) found that when banana fruits were stored in polythethylene film bags with the film thickness more than 30μ the level of CO_2 exceeded 5% which caused deterioration. However, Cia et al. (2003) reported that LDPE MAP with low thickness maintained the quality of fruits. In this investigation, the first part of the statement fail to support the results, the Biodegradable MAP used for the storage of the fruits had a thickness of 20-27μ which maintained fruit quality throughout the storage period.

Conclusion

In this study, during storage of organic bananas for 8 days at 20°C, the Biodegradable MAP resulted in slower ripening and colour changes than the Conventional MAP. The gas composition changes in the Biodegradable MAP was correlated with a reduced rate of respiration and less condensation in the package. In addition, the reduced weight loss of the organic Cavendish Banana fruits in the Biodegradable MAP and the results of a blind taste test on consumer acceptability showed that the use of Biodegradable MAP is beneficial for storage of organic Cavendish Banana fruits at 20°C. Therefore, based on the results obtained in this research, it can safely be suggested that the use of Biodegradable MAP offers the promise of successful extension of shelf life and can be adopted for commercial application.

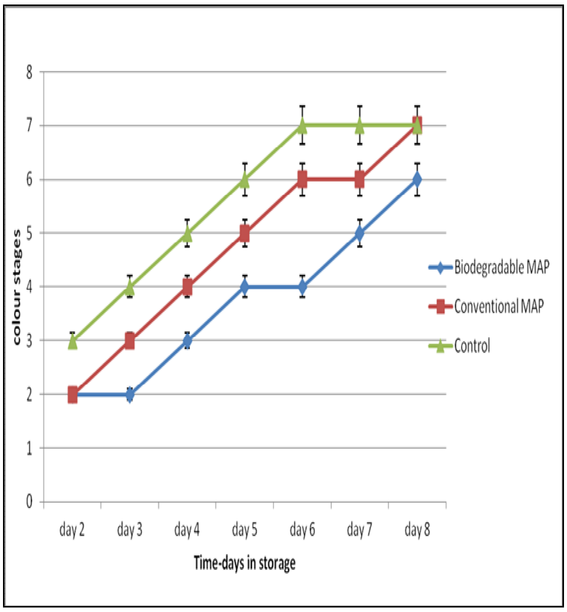

Figure 2: Average colour of Organic banana Fruits stored at 20C in Biodegradable MAP Conventional MAP and Control for Eight days

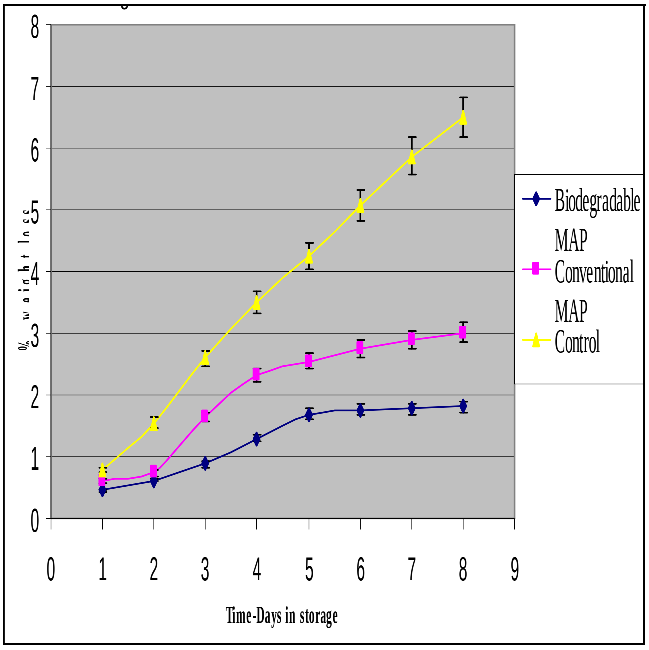

Figure 1. Percentage weight loss of Cavendish Bananas in Biodegradable MAP, Conventional MAP and control at 20 ºC for Eight days.

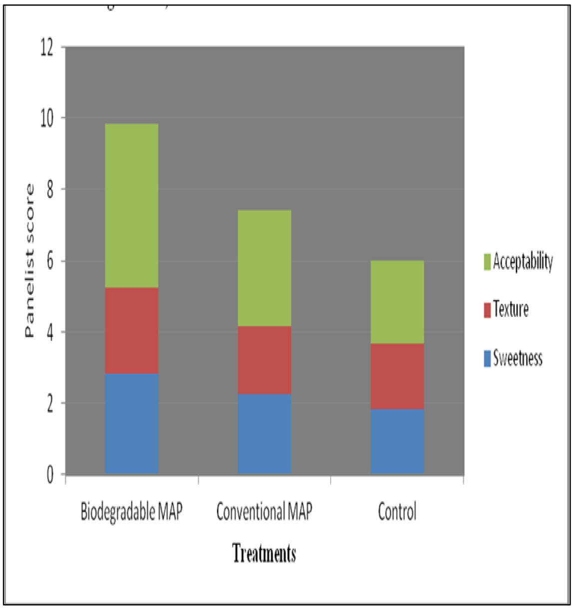

Figure 3: Consumer Evaluation of Organic banana fruits texture, sweetness and overall acceptability in Biodegradable MAP, Conventional MAP and Control stored for Eight days.

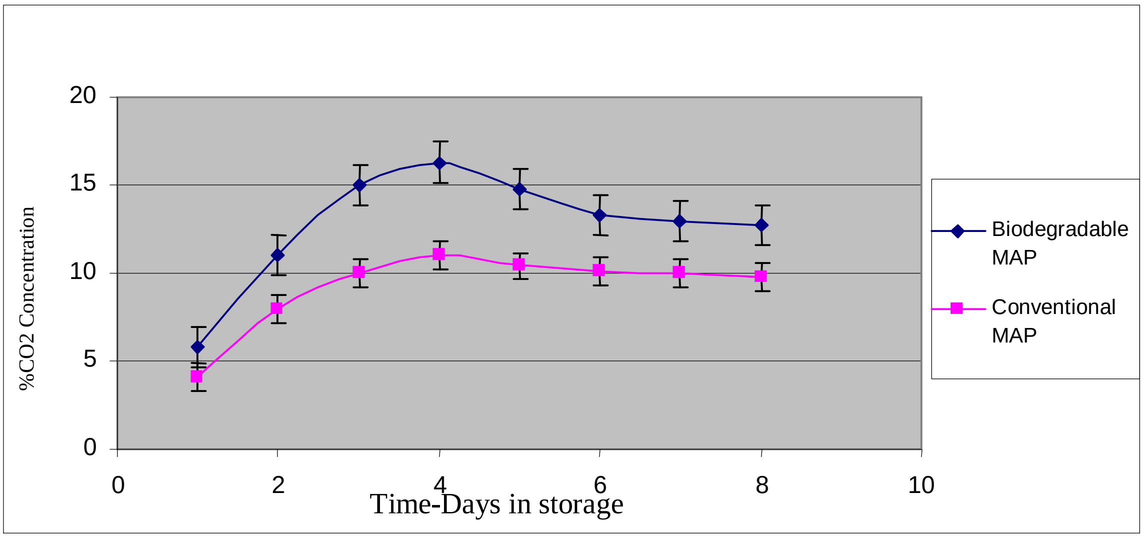

Figure 4. Percentage CO_2 of organic Cavendish Banana fruits in Biodegradable and Conventional MAP at 20°C.

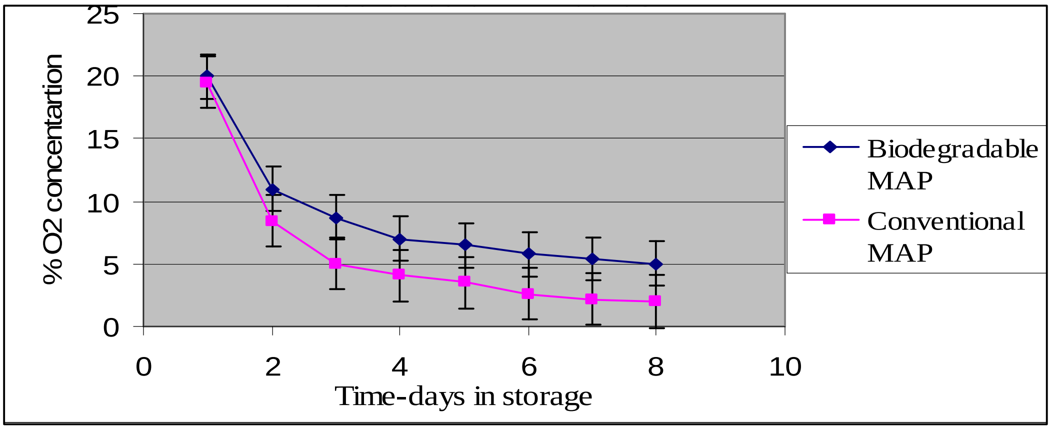

Figure 5. Percentage O_2 of organic Cavendish Banana fruits in Biodegradable and Conventional MAP at 20°C

References

Ahmad, S., Clark, B. and Thompson, A.K. 2001. Banana harvest maturity and fruit position on the quality of ripe fruit. Annals of Applied Biology, 139: 329-335.

Ben-Yehoshua, S. and Kader, A.A. 2000. Effects of Superatmospheric Oxygen Levels on Postharvest Physiology And Quality Of Fresh Fruits And Vegetables. Postharvest Biology and Technology, 36: 1-13.

Brown, B.I. and Scott, K. J. 1985. Cool storage conditions for custard apple fruits. Journal of Primary Industries, 13: 23-31.

Cia, P., DaSilva E.A.B, Sigrist, J.M.M. Sarantopóulos, C.I.G.L., Oliveira L.M. and Padula,M. 2003. Effect of Modified atmosphere packaging on the quality of 'Fuyu' persimmon. Brazilian Journal of Food Technology, 6: 109-

118.

Cia P., Benato E.A., Sigrist, J.M.M. Sarantopóulos, C. Oliveira L.M.and Padula, M. 2006. Modified atmosphere packaging for extending the storage life of 'Fuyu' persimmon. Postharvest Biology and Technology, 42: 228-234.

Conner, M.T. 1994. An individualised physiological approach to measuring influences. In: Mac-fie, H.J.H. Thomson, D.M.H. (eds.). Measurement of Food Preference. Blackie Academic and Professional. London, pp. 167-201.

Day, B.P.F. 2001. Fresh Prepared Produce: GMP for High Oxygen MAP and Non-Sulphite dipping. Guideline No.31. Campden and Chorleywood Food Research Association Group, Chipping Campden, Gloshister, UK, P.76.

Gorny, J.R. 2003. A summary of CA and MA requirements and recommendations for fresh-cut (minimally processed) fruits and vegetables. Acta Horticultuare, 600: 609-614.

FAO. 2003. Medium-term prospects for agricultural commodities, projections to the year 2010.

FAOSTAT. 2006. FAO Statistics Division 2006. Food and Agriculture Organization of the United Nations. Production yearbook. FAO Rome.

Kader A.A. 1986. Biochemical and physiological basis for effects on controlled and Modified atmospheres on fruits and vegetables. Food Technology, 40, 99-104

Liu, P. 2009. Certification in the Value Chain for Fresh Fruits: the Example of the Banana Industry. FAO Commodity Studies No.4. FAO, Rome.

Rahman, N., Yuquing, A. and Thompson, K. 1995. Temperature and MA packaging effect on the ripening of banana. In: Proceeding of the International Conference on Postharvest Technology for the Fresh Fruit and Vegetables, pp. 313-321.

Shewfelt, R.L.,Erickson, M.E. Hung, Y.C., malundo, T.M.1997.Applying quality concepts in frozen food development. Food Technology, 51: 56-59.

Srinivasa, P. Revathy Baskaran, M. Ramesh, K. Harish P. and Tharaathan R. 2002. Storage studies of mango packed using Biodegradable chitosan film. European Food Research and Technology, 215: 504-508.

Smith, J. P., Hoshino, J. and Abe, Y. 1995. Interactive packaging involving sachet technology. In: Active Food Packaging; Rooney, M.L., (Ed.), Blackie Academic and Professional, Glasgow, pp. 143-173.

Thomson A.K. and Burden., O.J. 1994. Harvesting and fruit care. In: Bananas and Plantains (Ed. Gowen, S. Chapman) Hall London. pp. 389-478.

Tuner, D.W. 2005. Bananas and Plantains. In: Postharvest physiology and storage of tropical and subtropical fruits (Ed. S.Mitra). CABI, India. pp. 47-77.

Wang, Y.C. 2006. Biochemical basis of the effects of modified and controlled atmospheres. Stewart Postharvest Review, 5: 1-4.

Zagory D. and Kader A. A.1995 Principles and practices of Modified Atmosphere Packaging of Horticultural Crops. Food Technology, 42: 70-77.