STUDY ON THE EFFECT OF DIFFERENT PACKAGING METHODS ON THE SHELF LIFE OF BANANA FRUITS

NORSHAHRUL AFZAN BT SHAHRUL AHMAD

FACULTY OF AGROTECHNOLOGY AND FOOD SCIENCE
UNIVERSITI MALAYSIA TERENGGANU

2008

LP 20 FASM 1 2008

1100066824
Study on the effec of different packaging methods on the shelf life of banana fruits / Norsharini Afzan Sharin @ Ahmad.

Lihat sebelah

STUDY ON THE EFFECT OF DIFFERENT PACKAGING METHODS ON THE SHELF LIFE OF BANANA FRUITS

Norsharini Afzan Binti Sharin @ Ahmad

This project report is submitted in partial fulfillment of the requirement of the degree of Bachelor of Science in Agrotechnology (Postharvest Technology)

FACULTY OF AGROTECHNOLOGY AND FOOD SCIENCE
UNIVERSITI MALAYSIA TERENGGANU

2008

This project report should be cited as:

Norharini, A. S. 2008. Study on the Effect of Different Packaging Methods on the Shelf Life of Banana Fruits. Undergraduate thesis, Bachelor science of Agrotechnology (Postharvest Technology), Faculty of Agrotechnology and Food Science, Universiti Malaysia Terengganu.26 p.

ACKNOWLEDGEMENTS

Be all praised to the Almighty ALLAH s.w.t for giving me the strength to have this project completed. First of all, I wish to express my sincere gratitude to my supervisor, Professor Madya Dr. Mohamed Senawi B. Mohamed Tamin for his constant willingness to provide ideas, advice and constructive comments throughout the study. I want to extent my gratitude to all my colleagues and friends for their invaluable help and cooperation during the laboratory works and writing process. Especially to my very best friend Uzaifa, Kharyati and Daniel for all their support, thank you very much. Last but not least, the most important persons in my life, to my beloved family especially my mother Puan Normah bt Ismail and my brother Masdi Asfany Bin Sharin, who give me advice, support and hundred percent of attention, thanks a lot.

ABSTRACT

This study investigates the protection afforded to bananas in 3 different methods of packages which is paper packaging, plastic film packaging and vacuum packaging. So, the use of packaging method can play important role in extending their shelf life and slower the ripening rate. Changes in skin colour, TSS and weight loss were assessed as quality indicators. The assessments were performed at 2, 4, 6, 8, 10 and 12 days. The effect of different packaging on banana fruits in various kinds of methods was examined as a means of reducing weight loss in fruits stored at ambient temperature. In addition, brown paper packaging was examined as a means of improving fruit colour development. This study shows that all the treatments are significantly difference with the control treatment (unpackaged bananas). Several beneficial effects were found: (1) vacuum packaging and plastic film packaging reduced the weight loss in bananas up to 12 days, thereby resulting in maintenance of fruit quality; (2) Vacuum packaging and plastic film packaging enabled banana fruits to be stored up to 12 days without adverse effects on visual and chemical qualities. Since vacuum packaging is costly, plastic film packaging may be of particular interest to producers or consumers who wish to improve their fresh fruits quality.

ABSTRAK

Kajian ini mengkaji perlindungan terhadap pisang dalam tiga kaedah pembungkusan yang berbeza iaitu dalam kertas pembungkus, dalam plastik filem serta pembungkusan vakum. Pembungkusan pisang memberi kesan yang berbeza kepada peringkat kematangan dan kadar kemasakan buah pisang. Perubahan warna pada kulit pisang, jumlah pepejal larut dan peratus kehilangan berat di kaji sebagai penunjuk kualiti kepada pisang. Data di ambil pada hari ke 2, 4, 6, 8, 10, 12 selepas pembungkusan dijalankan. Terdapat perbezaan peratus kehilangan berat pada setiap cara pembungkusan. Dalam kajian ini, didapati semua kaedah pembungkusan berbeza secara signifikasi dengan buah yang tidak dibungkus. Antara kesan positif yang dapat dilihat adalah : (1) pembungkusan vakum dan filem plastik menunjukkan kehilangan berat yang sedikit dalam tempoh simpanan 12 hari yang memberi tahap kualiti buah yang stabil; (2) pembungkusan vakum dan filem plastik membolehkan buah pisang disimpan lebih daripada 12 hari tanpa memberi kesan buruk kepada keadaan fizikal dan kandungan kimia. Oleh sebab pembungkusan vakum memerlukan modal yang besar, pembungkusan filem plastik mungkin menjadi pilihan pengguna dan pengeluar dalam meningkatkan kualiti produk segar terutamanya pisang.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF APPENDICES

LIST OF SYMBOLS

W	: Mass of fruit, kg
μm	: Micro meter
kg	: Kilogram
%	: Percentage
TSS	: Total soluble solids
PVC	: Polyvinyl chloride film

CHAPTER

INTRODUCTION

1.1 *Musa acuminata Colla* cv. Pisang Berangan

The word "banana" is a general term embracing a number of species or hybrids in the genus *Musa* of the family Musaceae (Zhang *et al.*, 2005). Bananas are grown in 122 countries (Olorunda, 2000), with a cultivated area of 3.8 million hectares and a total production of 56.4 million metric tonnes. Bananas are an important staple food that is critical to the nutritional and economic. India is the world's largest producer of banana with an annual production of 16.8 MMT (FAOSTAT, 2005).

In Malaysia, banana is the second most widely cultivated fruit, covering about 26,000 ha with a total production of 530,000 metric tonnes. About 50% of the banana growing land is cultivated with Pisang Berangan and the Cavendish type, and the remaining popular cultivars are Pisang Mas, Pisang Rastali, Pisang Raja, Pisang Awak, Pisang Abu, Pisang Nangka and Pisang Tanduk. Bananas are cultivated for local consumption by smallholders, and only about 12% of the total production is exported, mainly to Singapore, Brunei, Hong Kong and the Middle East.

Postharvest physiology is commonly defined as the study of living, respiring plant tissue that has been separated from the parent plant (Shewfelt, 1986). After harvest, the commodity is still living as it continues to perform metabolic reactions in order to maintain its physiological system and this causes a reduction of its quality and shelf-life. Bananas are perishable commodity, which generally have short shelf-life. The deterioration of fruit is associated with the physiological and biochemical activities and starts right from the moment and they are separated from the mother plant (Kader, 1986; Kays, 1991).As the quality loss of fresh bananas is mainly determined by physiological events (i.e., increased respiration), it is prior importance to create conditions into the packages that could slow down the respiration process.

Banana is a climacteric fruit that can be harvested mature green and ripened later. Fruit respiration rate is about 10-30 ml CO_2/kg.hr at 13 ^{0}C, and 20-70 ml CO_2/kg.hr at 20 ^{0}C. Banana respiratory activity decreases once fruit is harvested and it continues like that for a short pre-climacteric period. Extending this period is a commercial objective because fruits are easier to handle and they can kept longer in storage approximately 12 days after harvest.

Packaging is one of the most important steps in the long and complicated journey from grower to consumer. For this reason, packaging could help to maintain the taste and general appearance of fresh commodity. A great variety of methods are used for the packing of perishable commodities which include, vacuum, MAP, PVC film, paper and etc.

1.2 Justification of the study

In order to identify good strategies for banana postharvest handling and storage, it is necessary to have a clear understanding of the physiology and biochemistry of fruit ripening. During the ripening process, a fruit goes through a series of marked changes in colour, texture and flavour, which indicate that diverse changes in composition are taking place (Abdullah and Pantastico, 1990). This is the main attribute determining a produce shelf life. To reduce the effects of chemical and physical events, it is possible to act on processing or, more usually, on packaging. Therefore this study is conducted to determine the effects of different packaging material on the postharvest life of banana fruits.

1.3 Objectives

To investigate the effect of different packaging method in extending the postharvest life of banana fruits.

CHAPTER 2

LITERATURE REVIEW

2.1 Postharvest quality.

Appearance quality, firmness and shelf life are important from the point of view of wholesale and retail marketers. Subsequent purchase depends upon the consumer's satisfaction in terms of flavor quality of the products (Kader, 2000). Many compositional changes can occur during the ripening of vegetables that influence their appearance, texture and flavor. Some changes can be desirable, while others can be detrimental to the quality of the commodity (Maguire *et al.*, 2004; Kader, 1986). Moreover the selection of each quality attribute needs to be selected and evaluated depending on the commodity, the intended use for the consumer and the salability of the vegetable, where a single unacceptable attribute can cause the commodity to be unusable though other attributes are still acceptable (Shewfelt, 1986). However, fruits including pears and bananas go through the ripening process during the postharvest period and improved in eating quality because of an increase in juiciness, development of flavor and conversion of starch to sugars. Quality of bananas declines rapidly after they fully ripe.

2.1 Fruit Ripening

Banana fruit ripening is characterized by several biochemical and physiological changes due to 'organisation resistance' breakdown as well as a marked increase of membrane permeability, with accompanying cellular decompartmentation and metabolic deregulation (Theologies and Laties, 1978; Palmer, 1971). This lead to fruit softening, changes in peel colour, a massive breakdown of starch and its conversion into sugars, as well as changes in acidity, among others (Kanelis *et al.*, 1989). Most fruit tend to soften during ripening. This is the main attribute determining a produce shelf life.

Changes in colour are often the main criterion used by consumers to determine maturity stages in fruits and to decide whether they must be eaten the same day they are acquired or later. Green colour in banana is due to the presence of chlorophyll, a magnesium-organic complex. Degradation of chlorophyll by chlorophyllase activity result in fruit colour changes (Palmer, 1971). Chlorophyllase activity in banana peel increases sharply at the onset of the climacteric to a peak which coincides with the climacteric peak, and then falls to near zero in the post-climacteric period (Palmer, 1971).

2.2 Packaging and packages of fruits.

Packaging is a means of providing the correct environmental conditions for food during the length of time it is stored and/or distributed to the consumer. A good package has to keep the product clean and provide a barrier against dirt and other contaminants. It should prevent losses and its design should provide protection and convenience in handling, during transport, distribution and marketing. In particular, the size, shape and weight of the packages must be considered. Beside, it must provide protection to the food against physical and chemical damage (eg water and water vapors, oxidation, light) and insects.

Good packaging enhances consumer acceptability assuring better selling prices and extending the produce's shelf life (Montero, 1998). Bananas must be packed in such a way that convenient protection is guaranteed. Bananas are traditionally marketed by clusters or fingers. The use of materials, especially paper or seals with commercial specifications is allowed in the container as long as labeling or printing is made with non-toxic inks or glues. Packages must be made of special material which guarantees adequate produce handling and preservation. Normally bananas are packed with a net weight of 18-20 kg with 4-5% additional fruit required to compensate for any weight loss during storage. Package overfilling should be avoided because container materials may rub fruits thus producing mechanical damage, which will be noticed as peel darkening and disease development. Fruits must never be forced inside the package. Boxes, especially those intended for export market, should be designed in such a way that air circulation is allowed when boxes are piled up to prevent ethylene accumulation, as well as to maintain a uniform temperature (Montero, 1998).

There are several types of packaging materials available in a market nowadays. Singh *et al.* (1959) showed that polyethylene bags appeared to cause adverse chemical changes in loquat fruit. Since then, little research has been reported, and there is very limited information on the effect of packaging on several quality parameters. They are waterproof and chemically resistant and are used instead of paper sacks. Rodríguez *et al.* (2007) concluded that the use of paper packaging with an active coating offers an attractive option for protecting food from fungal infestation, which also shows promise for protection against Gram-negative bacteria.

Polyvinyl chloride (PVC) is a kind of universal synthetic resin, and widely used in industry, agriculture, architecture, utility, and commodity etc. Nunes *et al.* (1995) have examined the use of a PVC film to wrap the fruits immediately after harvest seem to be critical for maintaining the quality of strawberry.

The term vacuum is defined as space without matter in it. Vacuum packaging literally vacuums the air out of the bags or storage containers, and so slows the process of deterioration and offers an extensive barrier against corrosion, oxidation, moisture, drying out, dirt, attraction of dust by electric charge, ultra violet rays and mechanical damages, fungus growth or perishability etc. This technology has commendable relevance for tropical countries with high atmospheric humidity. In vacuum packaging, the product to be packed is put in a vacuum bag (made of special, hermetic fills) that is then evacuated in a vacuum chamber and then sealed hermetically in order to provide a total barrier against air and moisture. Gorris, de Witte, and Bennik (1994) packed minimally processed fruits and vegetables under moderate vacuum packaging for extended storage under refrigeration. Despite some loss of aroma volatiles, they found that lower O_2 content stabilized the produce quality and slowed down growth of spoilage microorganisms.

CHAPTER 3

METHODOLOGY

3.1 Materials

Green and fresh banana fruit (Musa acuminata Colla cv. Pisang Berangan) were obtained from the local market at Gong Pauh, Kuala Terengganu. De-handed bananas were placed in corrugated boxes and transported to the laboratory within an hour. In the laboratory, hands were selected for uniformity of size and were cleaned with tap water and were allowed to dry at ambient temperatures. Bananas used for the study varied from 0.12 to 0.16 m in length and 0.09 to 0.11 m circumference along the middle of the fruit length. Packaging materials used for this study are polyethylene bags with the thickness 0.12µm (26.2cm wide and 42cm long), brown paper with the thickness 0.97µm (25cm wide and 40cm long), polyvinyl chloride film (PVC) with the thickness 0.1 µm and the boxes (42.5cm x 26.5cm x 25cm).

3.2 Methods

Each hands of banana were placed in polyethylene bags and were sealed with a vacuum machine (Model DZ-400/2 ES). The other hands were packed in brown paper, and also wrapped with stretch polyvinyl chloride film (PVC). The samples were placed in corrugated boxes. These samples were allocated in a box at random according to the treatment and were stored at ambient temperature. The control fruit were placed in corrugated boxes without any treatment. There was being three replicates of each treatment. After every 2 days of storage, all boxes were taken out of storage for determination of weight loss, colour and total soluble solids.

3.2.1 Weight loss of banana fruits during storage.

All treatments were weighed using top pan balance (GF-3000) serial 14653591 made in Japan. The weight loss was calculated from the difference between the initial and final weight and expressed as a percentage of the initial weight, using the following equation:

$$\text{Weight loss} = \frac{(W_1 - W_2)}{W_1} \times 100$$

Where: W_1= initial weight, W_2= final weight

3.2.2 Skin colour measurement on banana fruits during storage.

The 3 fingers in every package of the treatments were randomly selected for skin colour analysis. Colorimetric measurements were recorded using a Minolta CR 300 colorimeter. The equipment provides an estimate of values "L", "a" and "b" recommended by CIE (1986). Values of "L", "a" and "b" were measured at the center of the sample. Numerical values of a^* and b^* were directly converted into chromaticity $[C^* = (a^{*2} + b^{*2})^{1/2}]$ according to McGuire (1992), which denotes the purity or saturation of the colour (Voss, 1992). The data of each measurement are the average of triplicate measures on equidistant points of each fruit.

3.2.3 Determination of total soluble solids of banana fruits during storage.

TSS is an index of soluble solids concentration in fruit. The juice of the sample was used to determine the soluble solids content. The banana was blend to extract the juice. The analysis was carried out using refractometer (Model 103, 0-32% Brixx) at ambient temperature. The values were expressed in percentage of total soluble solids (%).

3.2.4 Statistical analysis.

The data were subjected to ANOVA tests using the SPSS 11.5 for Windows. The difference between means was determined by Tukey's multiple range tests at a 95% confidence interval.

CHAPTER 4

RESULTS

4.1 Weight loss of banana during storage

Vacuum packaging (T1) minimised weight loss in bananas fruits during storage under ambient conditions. By day 12, untreated fruits (T0) had lost 29% of their initial weight, whereas fruits packed in brown paper (T2) lost 23%. By far the best results, in terms of minimising weight loss, were obtained in fruits packed in vacuum packaging and fruits wrapped with PVC film (T3), where less than 10% of the initial fruit weight was lost during 12 days storage (Fig. 4.1).

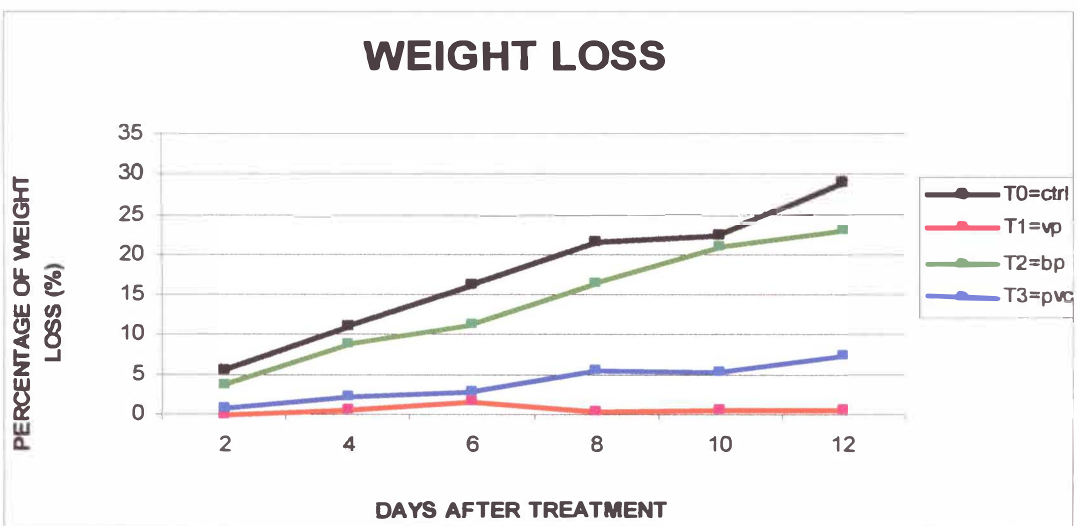

Figure 4.1: Percentage weight loss of banana during 12 days storage.

4.2 Skin color measurement on banana fruits during storage.

Untreated bananas (T0) fruit ripened quickly under tropical ambient conditions. By day 8, untreated fruits had become fully ripen with the skin turning completely yellow and the flesh deep-yellow to orange. By day 12, untreated fruits had turned brownish black. In contrast, bananas fruits packed with vacuum packaging (T1) and wrapped with PVC film (T3) did not show any signs of colour changes until day 12. There is no significance effect between T1 and T3 from day 1 to day 8 of storage. Ripening was inhibited in vacuum-packaged (T0) and PVC film-packaged fruits relative to those packed in brown paper (T2). Bananas packed in vacuum packaging or wrapped with PVC film did not become fully ripen after 12 days at ambient temperature (figure 4.2). The best results were obtained for fruits packed in vacuum packaging and wrapped with stretch PVC film.

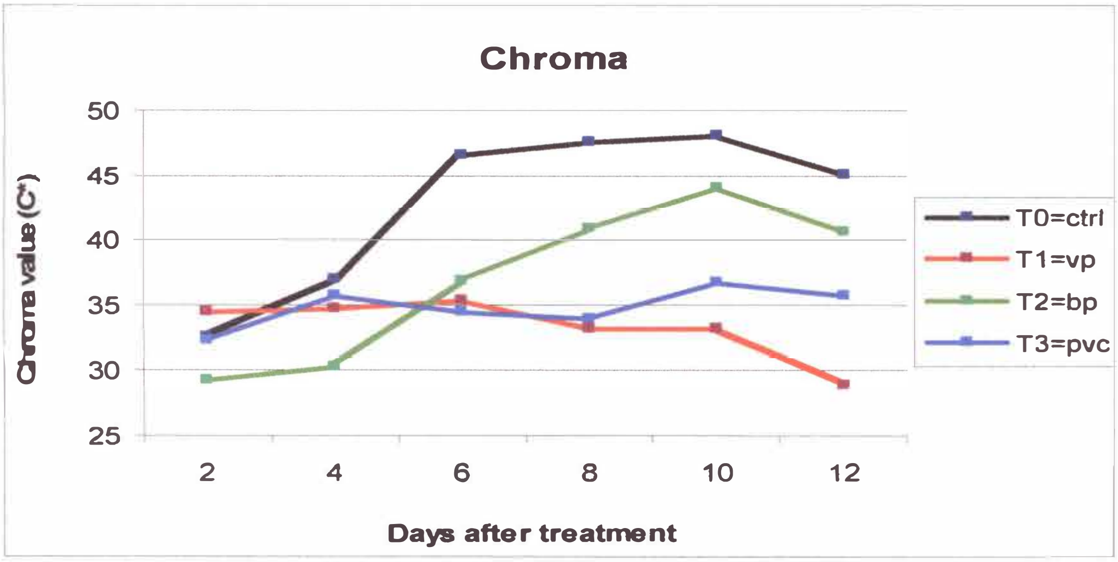

Figure 4.2: Chroma value during storage

4.3 Determination of total soluble solids (TSS) of banana fruits during storage.

Vacuum packaging (T1) and PVC film (T3) had no significant effect on changes of total soluble solids during 12 days storage while, untreated fruits (T0) had significance effects with all the treatment. TSS increased gradually with maturity of the banana fruits, vacuum packaging treatment significantly maintained the level of TSS as compared to the control at during 12 days storage ($P < 0.05$) .When stored at ambient temperature, fruits packed in brown paper showed an increase and those untreated fruits increased more obviously in TSS. The rate of TSS of the fruit in the brown paper packaging and control increased gradually with increasing maturity and storage time (Fig.4.3). The best results were obtained for fruits packed in vacuum packaging and wrapped with PVC film.

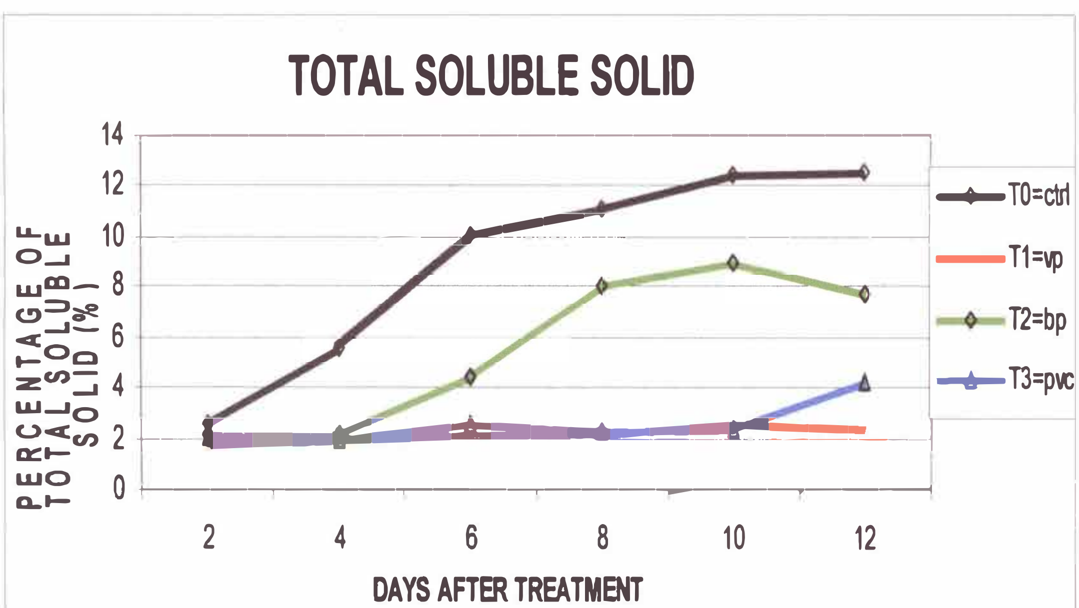

Figure 4.3: Total Soluble Solid (TSS) in banana during 12 days storage.

CHAPTER 5

DISCUSSION

5.1 Weight loss of banana during storage

The weight loss of bananas treated with packaging and stored at ambient temperature (AT) is shown in Table 1. The untreated fruits significantly (probability $P<0.05$) reduced the weight loss of fruits compared with fruits packed in brown paper, wrapped with PVC film and fruits packed with vacuum packaging. Tefera *et al.* (2006) reported that packaging fruits also reduced the weight loss of mangoes. On average, unpackaged bananas had about 29% more weight loss compared to packaged bananas after 12 days of storage.

This result confirms by the findings of Joshi (1983). Packaging treatments showed significant ($P<0.05$) differences for the weight loss of banana fruits by 12 days of storage. The highest weight loss percentage was recorded in fruits that did not apply with packaging treatments while least weight loss was observed in fruits packed in vacuum packaging and wrapped with PVC film. Miller *et al.* (1986) reported that bulk packaging inside polyethylene (PE) bags or individual PVC film reduced weight loss and extended the storability of the fruit.

By inhibiting respiratory and transpiratory water vapour losses, vacuum packaging substantially reduced weight loss in banana fruits during storage. The higher incidence of decay in fruits packed in vacuum packaging is presumably attributable to very high humidity around the fruits arising from the low permeability of polyethylene to water vapour (Bussel & Kenigsberger, 1975). Similar results have been reported for cultivated mango, plantain and banana packed in sealed polyethylene bags (Olorunda, 1976; Shillingford, 1978; Passam, 1982; Aworh & Ubebe, 1988). The trend in chemical changes observed in this study during ripening of wild mangoes is, in general, consistent with the findings of Aina (1990).

5.2 Skin color measurement on banana fruits.

Chroma (saturation index) values for all treatment decreased ($P < 0.05$) after 10 days of the maturaty period. Significant differences ($P < 0.05$) were found between the treatment and final chroma values of banana, indicating that pigment was formed during ripening. Green colour in banana is due to the presence of chlorophyll, a magnesium-organic complex. Degradation of chlorophyll by chlorophyllase activity results in fruit colour changes (Palmer, 1971). Chlorophyllase activity in banana peel increases sharply at the onset of the climacteric to a peak which coincides with the climacteric peak, and then falls to near zero in the post-climacteric period (Palmer, 1971). Knee (1980) reported that the chlorophyll breakdown was reduced clearly in reduced oxygen. However, this effect could not show any significant effectiveness when bananas was ripened in the normal air without ethylene treatment.

Use of different packaging method significantly affected color intensity in terms of chroma. The chroma value of control samples compared to the vacuum packaging showed that vacuum packaging preserved the color of the fruits during the storage. Among various packaging techniques adopted in the study, vacuum packaging and film packaging were observed to maintain the color intensity significantly for both pretreated samples due to lower O_2 level that prevented oxidative browning. Film packaging retarded ripening and extended shelf life of wild mangoes presumably is creating a beneficial modified atmosphere, with reduced oxygen and/ or elevated carbon dioxide tension, around the fruits. Such beneficial modified atmosphere packaging systems have been reported for a wide range of fruits and vegetables (Daun & Gilbert, 1974; Geeson *et al.,* 1985; Smith *et al.,* 1987; Aworh & Ubebe, 1988).

5.3 Determination of total soluble solids of banana fruits during storage.

There is no significance difference in percentage of soluble solids contents for vacuum packaging treatment and plastic film packaging ($P < 0.05$) at day 2 to day 10. Significant differences ($P < 0.05$) were found between the control treatment and paper packaging with vacuum and plastic film packaging. The short shelf life of banana fruits under ambient conditions is due to its high rate of respiration, susceptibility to microbial attack, especially when ripe, and moisture loss resulting in shrivelling (Joseph, 1990). Packaging banana in vacuum packaging and overwrapped with PVC suppressed decay and extended the shelf life of the fruits. Kader *et al.* (1989) reported that the role of packaging was primarily to reduce the respiration rate of fruit and vegetables by retarding their metabolic activities. Reduced respiration also retards softening, and slows down various compositional changes such as TSS, which are associated with ripening. Medlicott *et al.* (1992) found that there is a relationship between surface colour development and starch conversion into sugars in banana fruits. They observed the maximal sugar concentrations in bananas are related to their complete colour development. These results are consistent with previous work with other fruits including cultivated mango.

CHAPTER 6

CONCLUSSION

In conclusion, vacuum packaging and wrapped with stretch PVC film, delayed ripening, minimised weight loss and extended the shelf life of the fruits under ambient conditions, without adverse effects on visual and chemical qualities. It should be possible to integrate these treatments into the postharvest handling practices for bananas and other indigenous fruits in Malaysia. Since vacuum packaging is costly, plastic film may be of particular interest to producers or consumers who wish to improve their fresh fruits quality. Future studies should focusing more on the effects of the treatments on consumer acceptability of banana fruits.

REFERENCES

Aina, J. O. 1990. Physico-chemical changes in African mango *(Irvingia gabonensis)* during normal storage ripening. Food Chemistry 36: 205-12.

Aworh, O. C. & Ubebe, F. 1988. Effect of hot water dip, benomyl and modified atmosphere packaging systems on shelf life and quality attributes of 'Ogbomoso' mango*(Mangifera indica* L.). Nigeria Food Journal 6: 60-6.

Beuchat, L., B. Nail, B. Adler and M. Clavero. 1998. Efficacy of spray application of chlorinated water in killing pathogenic bacteria in raw apples, tomatoes, and lettuce. Journal of Food Protection 61(10):1305-1311.

Bussel, J. & Kenigsberger, Z. 1975. Packaging green bell peppers in selected permeability films. Journal of Food Science 40: 1300-3.

Daun, H. & Gilbert, S. G. 1974. Film permeation: The key to extending fresh produce shelf life. Package Engineering 19:50-3.

Geeson, J. O., Browne, K. M., Maddison, K., Shepherd, J. & Guaraldi, F. 1985. Modified atmosphere packaging to extend the shelf life of tomatoes. Jurnal Food Tectmol 2: 339-49.

Joseph, K. 1990. Physico-chemical quality attributes and shelf life of wild mango fruits *(Irvingia gabonensis*) as influenced by postharvest conditions. Ph.D.dissertation. University of Ibadan, Nigeria. 180p.

Kader, A. & S. Ben-Yehoshua. 2000. Effects of superatmospheric oxygen levels on postharvest physiology and quality of fresh fruits and vegetables. Journal of Postharvest Biology and Technology. 20: 1-13.

Kader, A. A. 1986. Biochemical and physiological basis for effects of controlled and modified atmospheres on fruits and vegetables. Journal of Food Technology 40:99–104.

Knee,M. 1980. Physiological response of apple fruits to oxygen concentrations. Application Biology 96(4):243-245.

McGuire, R.G., 1992. Reporting of objective color measurements. Horticulture Science 27: 1254–1255.

Medlicott, A. P., A. J. Semple, J. Thompson, H. R. Blackbourne and A. K. Thompson. 1992. Measurement of colour changes in ripening bananas and mangoes by instrumental, chemical and visual assessments. Tropical Agriculture Trinidad 69(2): 161-166.

New, J.H., Proctor, F.J. and Hewitt, V.J. 1978. Packaging of horticultural produce for export. Tropical Science 20: 21-34.

Joshi, G. D. 1983. Studies on changes in Alphono mango (*Manigifera indica L.*) fruits during transport and storage. Ph.D. dissertation. Indian Agricultural Research Satellite, New Delhi, India. 175 p.

Olorunda, A. O. 2000. Recent advances in post harvest technologies of banana and plantains in Africa. Acta Horticulture. 534p.

Olorunda, A. O. & Aworh, O. C. 1984. Effects of Tal Prolong, a surface coating agent, on the shelf life and quality attributes of plantain. Journal of Science Food Agriculture, 35: 573 -8.

Olorunda, A. O. 1976. Effect of ethylene absorbent on the storage life of plantain packed in polyethylene bags. Nigerian Journal Science, 10:19-26.

Passam, H. C. & Biunden, G. 1982. Experiments on the storage of limes at tropical ambient temperature. Tropical Agriculture, Trinidad. 59: 20-4.

Rao, D.L. and B.S. Chundawat, 1986. Effect of certain retardants on ripening changes of banana cultivar Lactan at ambient temperatures. Progressive Horticulture 18: 189–95.

Rowe,P. 1981. Breeding an intractable crop: *In:* Genetic Engineering for Crop Improvement. Working papers, The Rockefeller Foundation, New York. 59p.

Scott, K. J., Brown, B. I., Chaplin, G. R., Wilcox, M. E. and Bain, J. M. 1982. The control of rotting and browning of litchi fruit by hot benomyl and plastic film. Horticulture Science 16: 253-62.

Shewfelt, R. L. 1986. Postharvest treatment for extending the shelf-life of fruits and vegetables. Food Technology 40:70-79.

Shillingford, C. A. 1978. Effect of plastic coating and polyethylene wraps on banana fruit rot and quality. Tropical Agriculture of Trinidad 55: 173-9.

Smith, S. M., Geeson, J. D., Browne, K. M., Genge, P. M. & Everson, H. P. 1987. Modified-atmosphere retail packaging of Discovery apples. Journal of Science Food Agriciculture 40: 165 78.

Sousa, P. H. M., Maia, G. A., Souza Filho, M. S. M., Figueiredo, F. W., Nassu, R. T., & Souza Neto, M. A. 2003. Influences of concentrarion and the proportion of osmosis in the bananas processed. Elements of Agriculture Technologies 23: 126-130.

Tefera, T. Seyoum; K. Woldetsadik. 2007. Effect of disinfection, packaging, and storage environment on the shelf life of mango. Biosystems Engineering 96 (2): 201–212.

Theologies, A. and G. Laties. 1978. Respiratory contribution of the alternate path during various stages of ripening in avocado and banana fruits. Plant Physiology 62: 249-255.

Thompson, F. Mitchell, F. G. Runsey, T.R. Kasmire, R. F. Crisosto, C. H. 1998. Commercial cooling of fruits, vegetables and flowers. DANR Publication. No. 21567, University of California Davis, California 61p.

Voss, D. H. 1992. Relating colourimeter measurement of plant colour to the royal horticultural society colour chart. Horticulture Science 27 (12):1256–1260.

Zhang, P. Whistler, L. BeMilller, J.N. and B.R. 2005. Bananas starch: production, physico-chemical properties, and digestibility.Carbohydrate Polymers 59:443–458.

Zhuang, R., L. Beuchat and F. Angulo.1995. Fate of S. Montevideo on and in raw tomatoes as affected by temperature and treatment with chlorine. Applied and Environmental Microbiology 62:2127-2131.

APPENDICES 1

Analysis of weight loss during storage of banana fruits

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
DAY2	Between Groups	58.792	3	19.597	344.723	.000
	Within Groups	.455	8	.057		
	Total	59.247	11			
DAY4	Between Groups	223.868	3	74.623	102.724	.000
	Within Groups	5.812	8	.726		
	Total	229.680	11			
DAY6	Between Groups	432.211	3	144.070	67.771	.000
	Within Groups	17.007	8	2.126		
	Total	449.218	11			
DAY8	Between Groups	855.164	3	285.055	37.403	.000
	Within Groups	60.970	8	7.621		
	Total	916.134	11			
DAY10	Between Groups	1072.556	3	357.519	157.837	.000
	Within Groups	18.121	8	2.265		
	Total	1090.677	11			
DAY12	Between Groups	1562.435	3	520.812	258.749	.000
	Within Groups	16.102	8	2.013		
	Total	1578.537	11			

Types of packaging	Days after treatment					
	day2	day 4	day 6	day 8	day 10	day 12
vacuum	0.10^a	0.57^a	1.73^a	0.42^a	0.71^a	0.71^a
pvc	0.86^b	2.67^a	2.90^a	5.46^a	5.41^b	7.48^b
paper	3.64^c	8.82^b	11.3^b	16.48^b	20.96^c	23.01^c
control	5.64^d	11.13^c	16.24^c	21.60^b	22.34^c	28.99^d

Means are values averaged over three trials (n=3; mean value). Each trial involved three identical groups of 3 fruits per treatment. Values within a column with the same letter are not significantly different ($p<0.05$).

APPENDICES 2

Analysis of chromaticity on banana skin during storage.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
DAY2	Between Groups	34.274	3	11.425	4.067	.050
	Within Groups	22.471	8	2.809		
	Total	56.745	11			
DAY4	Between Groups	70.116	3	23.372	5.578	.023
	Within Groups	33.518	8	4.190		
	Total	103.634	11			
DAY6	Between Groups	282.809	3	94.270	8.997	.006
	Within Groups	83.822	8	10.478		
	Total	366.632	11			
DAY8	Between Groups	416.712	3	138.904	16.604	.001
	Within Groups	66.927	8	8.366		
	Total	483.639	11			
DAY10	Between Groups	461.745	3	153.915	11.358	.003
	Within Groups	108.408	8	13.551		
	Total	570.153	11			
DAY12	Between Groups	254.752	3	84.917	5.833	.021
	Within Groups	116.474	8	14.559		
	Total	371.226	11			

Types of packaging	Days after treatment					
	day 2	day 4	day 6	day 8	day 10	day 12
vacuum	34.45^{b}	34.75^{ab}	35.31^{a}	33.26^{a}	33.19^{a}	33.55^{a}
pvc	32.35^{ab}	33.60^{ab}	34.50^{a}	33.93^{a}	36.77^{ab}	35.90^{ab}
paper	30.07^{a}	30.29^{ab}	36.91^{a}	46.60^{b}	44.56^{bc}	41.25^{ab}
control	33.85^{ab}	36.99^{b}	46.60^{b}	43.81^{b}	48.90^{c}	45.36^{a}

Means are values averaged over three trials (n=3; mean value). Each trial involved three identical groups of 3 fruits per treatment. Values within a column with the same letter are not significantly different (p<0.05).

APPENDICES 3

Analysis of total soluble solid in banana fruits during storage.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
DAY2	Between Groups	.842	3	.281	.504	.690
	Within Groups	4.460	8	.558		
	Total	5.303	11			
DAY4	Between Groups	27.800	3	9.267	154.444	.000
	Within Groups	.480	8	.060		
	Total	28.280	11			
DAY6	Between Groups	120.437	3	40.146	38.726	.000
	Within Groups	8.293	8	1.037		
	Total	128.730	11			
DAY8	Between Groups	176.330	3	58.777	12.211	.002
	Within Groups	38.507	8	4.813		
	Total	214.837	11			
DAY10	Between Groups	222.117	3	74.039	13.486	.002
	Within Groups	43.920	8	5.490		
	Total	266.037	11			
DAY12	Between Groups	180.837	3	60.279	4.404	.042
	Within Groups	109.493	8	13.687		
	Total	290.330	11			

Types of packaging	Days after treatment					
	day 2	day 4	day 6	day 8	day 10	day 12
vacuum	1.80^{a}	2.00^{a}	2.20^{a}	2.13^{a}	2.53^{a}	2.40^{a}
pvc	2.03^{a}	1.93^{a}	2.60^{a}	2.27^{a}	2.40^{a}	4.27^{ab}
paper	2.13^{a}	2.13^{a}	4.47^{a}	8.07^{b}	8.93^{b}	7.73^{ab}
control	2.53^{a}	5.53^{b}	10.13^{b}	11.07^{b}	12.47^{b}	12.60^{b}

Means are values averaged over three trials (n=3; mean value). Each trial involved three identical groups of 3 fruits per treatment. Values within a column with the same letter are not significantly different ($p<0.05$).

CURRICULUM VITAE

Name	:	Norsharini Afzan bt Sharin @ Ahmad
Permanent Address	:	Bt.20 Jln Yan, Guar Chempedak, 08800 Gurun, Kedah Darul Aman.
Telephone Number	:	017-9880366
Date of Birth	:	07/08/1986
Place of Birth	:	Guar Chempedak
Race	:	Malay
Nationality	:	Malaysia
Religion	:	Muslim
Gender	:	Female
Education Background	:	
2005-2008	:	Universiti Malaysia Terengganu
2004-2005	:	Kolej Matrikulasi Negeri Sembilan
1999-2003	:	SPM, SMKA Sik
1993-1998	:	UPSR, SK Guar Chempedak

FAKULTI AGROTEKNOLOGI DAN SAINS MAKANAN
UNIVERSITI MALAYSIA TERENGGANU

BORANG PENGESAHAN DAN KELULUSAN LAPORAN AKHIR PROJEK PENYELIDIKAN TAHUN AKHIR

Nama Pelajar: NORSHARINI AFZAN BT SHARIN @ AHMAD

Program: S.M. SAINS AGROTEKNOLOGI (TEK. LPS. TUAI) No. Matrik: UK11915

Nama Penyelia: PROF. MADYA. DR. MOHAMED SENAWI MOHAMED TAMIN

Nama Penyelia Kedua (jika ada) : ....

Tajuk Projek: STUDY ON THE EFFECT OF DIFFERENT PACKAGING METHODS ON THE SHELF LIFE OF BANANA FRUITS

Dengan ini disahkan bahawa saya telah menyemak laporan projek tersebut dan semua pembetulan yang disarankan oleh pemeriksa-pemeriksa telah dibuat, laporan ini telah mengikut format yang diberikan dalam Buku Panduan Penyelidikan, Fakulti Agroteknologi dan Sains Makanan, Universiti Malaysia Terengganu pada tempoh masa yang diberi.

Tandatangan: ....(Penyelia Utama) .... (Penyelia Kedua) - jika ada

Nama: PROF. MADYA DR. MOHAMED SENAWI B. MOHAMED TAMIN
Pengarah
Pusat Perhubungan Universiti-Industri
Universiti Malaysia Terengganu
21030 Kuala Terengganu
Terengganu

Tarikh: 29/08/...

STUDY ON THE EFFECT OF DIFFERENT PACKAGING METHODS ON THE SHELF LIFE OF BANANA FRUITS - NORSHARINI AFZAN BT SHARIN @ AHMAD