Suitability Study of Using Thermoplastic Starch Coating Material for Harum Manis (MA128) Mango in Post Harvest Management

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In this study, plasticized starch with glycerol was used to coat Harum Manis (HM) mango fruits and observed for basal end rot (BER) incidences caused by the common pathogen Botryodiplodia theobromae Pat. *and the possible effect of coating on the sugar content of the mangoes. The starch coating of mango fruits delayed the onset of BER infection by at least four days after incubation period. Coating without incubation gave superior results compared to coating after incubation. Both methods however only showed BER symptoms on day seven after opening of closure after incubation. All the fruits manifested symptoms of BER on day 11 in all the treatments. Coating HM mangoes with the starch formulation did not give any significant effect in the rate to reach maximum sugar content.*

Introduction

Packaging serves many functions such as presentation, protection, handling, transport and communicating information. Effective packaging of food products allows for longer shelf life and delivery of a higher quality product to consumers. Packaging options have expanded from the traditional materials such as glass, wood, metal and paper to new high technology synthetic polymers engineered to meet specific requirements (Birston, 1982; Birley, 1982; Pearson, 1982). Some polymers derived from natural sources have been engineered for certain products and are already in the market (Otey,1976). Some of these polymers are edible and play an instrumental role in packaging such as in food, pharmaceutical and other industries today. Many of these polymers are used singly and some in combination with synthetic polymers to create a class of active packaging (Aminabhavi *et. al.*, 1990) commonly referred to as edible film.

Edible films have great potential in a number of different areas. They can coat surfaces, separate different components, or act as casings, pouches or

wraps. They can preserve and improve product quality by forming oxygen, aroma, oils or moisture barriers, carrying functional ingredients, such as antioxidants or anti-microbials and improving appearance, structure and handling. The use of wax as a coating material on fruits and vegetables, such as cucumbers and apples, has played an important role in protecting against moisture loss and enhancing aesthetic value of the products (Nathan, 2001). Shellac has also been widely and successfully used for coating citrus fruits and studies are being conducted to incooperate preventing citrus disease pathogens using the material (McGuire and Hagenmaeir, 2001).

In recent years, great interest has been generated in exploiting starch-based packaging material to substitute some synthetic materials given the fact that starch is inexpensive and renewable resource, biodegradable and incinerable. However, the brittle nature and low water-barrier capcity has impeded its commercial utilization. Efforts have been made to improve these properties, either chemically modifying the starch, blending it with conventional plastics, natural polymers or homogenized it with plastisizer.

Starch has free hydroxyl groups, which may readily undergo a number of reactions such as esterification and etherification. Amylose and amylopectin are acetylated following the pyridine-acetic anhydride procedure to obtain thermoplastic materials with a reinforced hydrophobicity (Sagar and Merrill, 1995). Grafting of monomer like acrylonitrile (Yoon et al., 1992) and compositing ethylene-co-acrylic acid (Fanta et al., 1992) onto starch have also been attempted. To plasticize starch, plasticizers are added such as acid amino (Stein and Greene, 1997) or glycerol (Van Soest and Knooren, 1997).

Starch material has been applied to coat fruit for the purpose of improving appearance and/or preventing weight loss and fruit pathogen. A study on using starch material found that starch material coating was effective in reducing the russetting of apple (Rogoyski, 1999).

Anti-microbial substances are widely used by the food industry in order to preserve products that are usually perishable with a relatively short life time. Recent studies have incorporated these substances into the packaging material, that could possibly extend the shelf life of foods. Study on anti-microbial films based on Na-alginate and K-carrageenan indicated that strong inhibition activities on *Escherichia coli* and *Streptococcus aureus* (Choi et al., 1999).

The Harum Manis (HM) mango, registered as MA128 under the Department of Agriculture (DOA), is the popular variety grown in large scales in Perlis. The variety however, due to its sweetness, has the problem of high incidence of insiduous fruit rot (IFR) before and after reaching the consumers (Jabatan Pertanian, 2000). Although the actual cause of this IFR malady is still controversial, the DOA through their observation recommended for earlier harvest of the fruits at the 7th week after wrapping instead of the 8th week. This practice somehow was found to be effective in reducing the IFR but the disadvantage is that the consumers have to wait from 5-6 days before before

they can enjoy the true quality of HM mango. This 5-6 days **"waiting period" or storage period** however posed another problem to HM mango where they are subjected to a common fungal infection by the pathogen *Botryodiplodia theobromae* Pat. ususally infecting the basal end of the fruit thus giving its name basal end rot (BER). This is a very common fungus infecting wounds on fruits caused by mechanical damage or other unintended damage. Basal end rot is a significant post-harvest problem causing post-harvest losses during storage period prior to reaching the consumers. Losses have been reported to be in the range of 10-20% and has been known to reach up to 30% if the harvest is in the rainy season (Kamaruddin, 2002, pers comm).

This study was done with the following objectives:

1. To develop starch-based protectant for coating of Harum Manis mango fruits
2. To study the incidence of fungus on fruits
3. To study the effect of coating on sugar content

Materials and Methods

Materials

Corn starch and glycerol purchased from HmbG Chemicals were used without further purification. Distilled water was used to solute the starch. Harum Manis mangoes used in this study were directly supplied by Pusat Pengumpulan Bukit Bintang, Batu Pahat in Perlis. The sugar content analysis was done using the Brix Meter (ATAGO Hand Refractometer model N-50E) with the Brix reading range between 0 – 50%.

Methods

Treatment : Coating Fruits With Starch

There were five samples labelled A, B, C, D and E and each sample consisted of 30 fruits which were about the same age (opened at the 7th week after wrapping). The fruits were washed accordingly following the procedure set by the DOA where they were placed in a concrete tank, 6 m X 4 m filled with water and washed off debris and other impurities. The fruits were then taken and placed on several racks to be air dried assissted with a blower using industrial fan.

The fruit samples designated to be treated with the starch were dipped accordingly in the clear starch solution and the excess starch were wiped off from the fruits carefully using disposable plastic gloves. The fruits were then left to air dry for about four hours. The samples were treated as follows:

Sample	Treatment	Note
A	Coated after incubation	Incubation – fruits left in carbide enclosure for 48 hrs
B	Incubated but not coated	Incubation – fruits left in carbide enclosure for 48 hrs
C	Coated before incubation	Incubation – fruits left in carbide enclosure for 48 hrs
D	Not coated and not incubated	The fruits were just left in the open
E	Coated but not incubated	No carbide incubation – left in the open

Recording Basal End Rot Symptom

Basal end rot symptoms were recorded using simple visual observation on the presence of brown to black, soft blemish on the surface of the fruits and was indicated as + or – in the data sheet. The severity of infection was not taken into account since the significant part of this study was only to observe when the fruits start to show the blemish. The numbers of fruits showing the symptoms (+ or -) were recorded every two days and the numbers are cumulative.

Data for Sugar Content

The data for sugar content were taken using the Brix meter. The flesh from the mango fruits were cut into small pieces and were squeezed by hand to let the juice drop onto the prism in the Brix meter. The reading was done by observing through the eyepiece to record the corresponding refracted index.

Results and Discussion

Basal End Rot Incidence

In this experiment, the day 0 was considered as the day when the plastic cover used as closure for incubating the mangoes was removed. Basal end rot symptoms were observed based on the brownish to black, soft blemish on the surface of the fruits, particularly at the basal end of the fruit. Similar blemish at other parts of the fruits were also considered. Due to the nature and complexity of qualitative assessment anticipated in this experiment, only numbers with + or – BER symptoms were recorded.

At day 0, none of the fruits showed any symptom of BER infection in all the samples. However, on day 2, eight fruits (27%) and five fruits (17%) showed symptoms in samples B and D respectively (Fig. 1). Fruits in sample B were not coated but incubated while fruits in D were not coated as well as not incubated. As expected, fruits in samples B and D started to show more symptoms on day 4 with a cumulative total of 18 fruits (60%) showing symptoms in both samples. On day 7, 22 fruits (73%) and 24 fruits (80%) showed BER symptoms in samples B and D respectively and by day 9 all the fruits in both samples were overwhelmed with BER symptoms (Fig. 1). As for the other samples, there was a slight delay in onset of BER infection. Fruits in sample C started having the symptoms on day 4 with two fruits (7%) showing the symptoms while sample A and E started having the symptoms on day 7 with two fruits (7%) and one fruit (3%) respectively. However, on day 9, all the five samples showed symptoms of BER infection and by day 11, all the fruits were overwhelmed with BER infection.

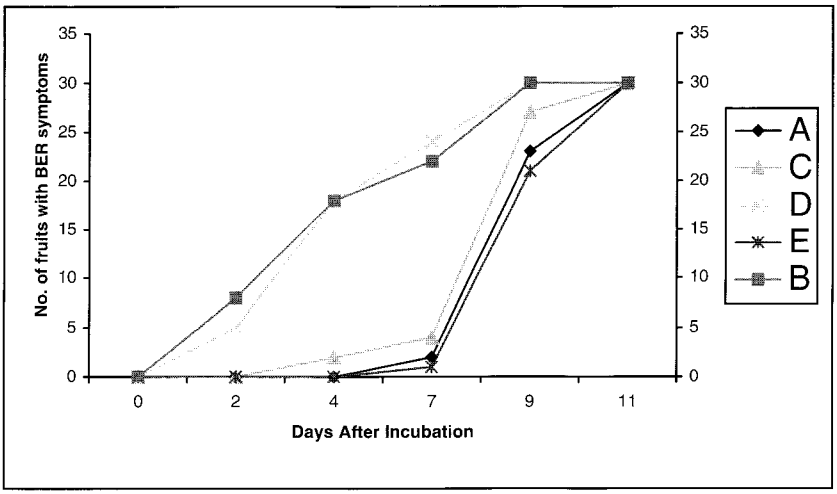

Figure 1: Graph Showing Incidence of Basal End Rot (BER) on Harum Manis (HM) Mango Against Days After Incubation

In this observation, it can be concluded that coating the mangoes with the starch formulation will delay the onset on BER infection by at least four days after opening of the cover. This was evident in sample C where the fruits were coated first and then incubated. However, in sample A where the fruits were incubated first before being coated and sample E where the fruits were coated but not incubated further delayed the onset of BER infection as only on day 7 they showed symptoms with two fruits (7%) and one fruit (3%) respectively. This further strengthen the fact that coating with the starch formulation gave a reasonable protection against the fungal infection. It was also noted that fruits

which were coated but not incubated showed the best results in this experiment. This was probably due to the fruits not being put under any coverage for incubation with the carbide and thus not being subjected to the high humidity and temperature which are the two important factors in influencing fungal infection.

Sugar Content

The average sugar content were plotted against time (days) for all the samples (Fig. 2). From the graph, it is clear that there was an increase in sugar content for a certain period of time before they started to decrease in all the samples.

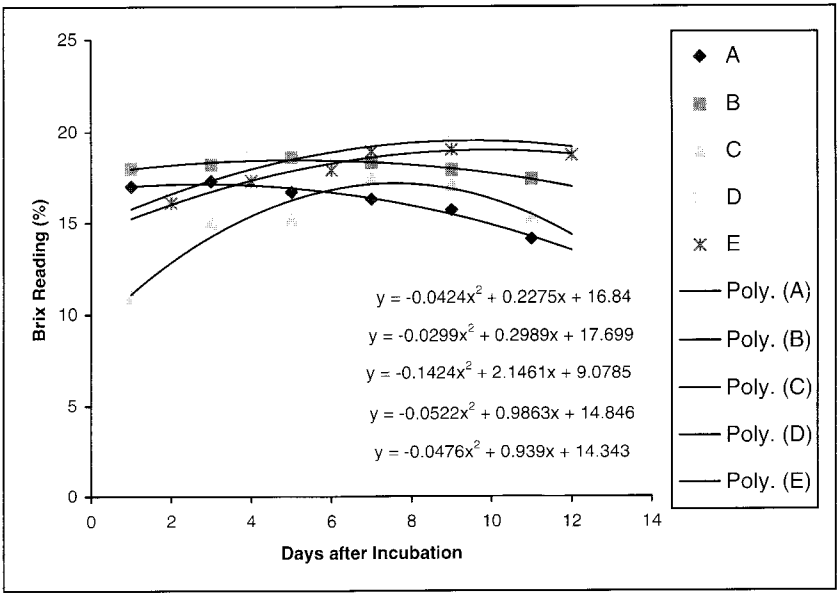

Figure 2: Polynomial Graph Showing Sugar Content Reading Against Days

Derivation of the quadratic equation from the polynomial graph above was employed to determine the time when the sugar content was at maximum level, and was tabulated in Table 1.

Sugar content is the main factor that influences the taste of HM and is often used to best describe the quality of fruits. Sugars, such as glucose, fructose, maltose and sucrose supply energy for nutrition. After harvest, mango fruits are frequently high in starch and low in sugar. Continuous ripening generally result in a decrease in starch and an increase in sugar content. Monitoring sugar content however could explain ripening process.

Table 1: The Time (days) Sugar Content At Maximum Level in Samples

Sample	No. of days for max. sugar content in Harum Manis
A	2.7
B	5.0
C	7.5
D	9.4
E	10.5

In this experiment, the effect of incubation, greatly influenced the increase in sugar content of the samples as evident in samples A and B (Fig. 2). Although fruits in sample C were incubated but they seemed to have taken a slightly longer time to reach maximum sugar content. This could have been due to the batch selected to be samples C were not homogenous with the rest of the samples. They could have been harvested too early.

Incubation process increased ripening rate. The maximum level of sugar was generally achieved faster for incubated samples than in non-incubated as shown in Table 1. After incubation process, the sugar content was almost at the highest level while for non-incubated, the process of ripening was still increasing until nine days.

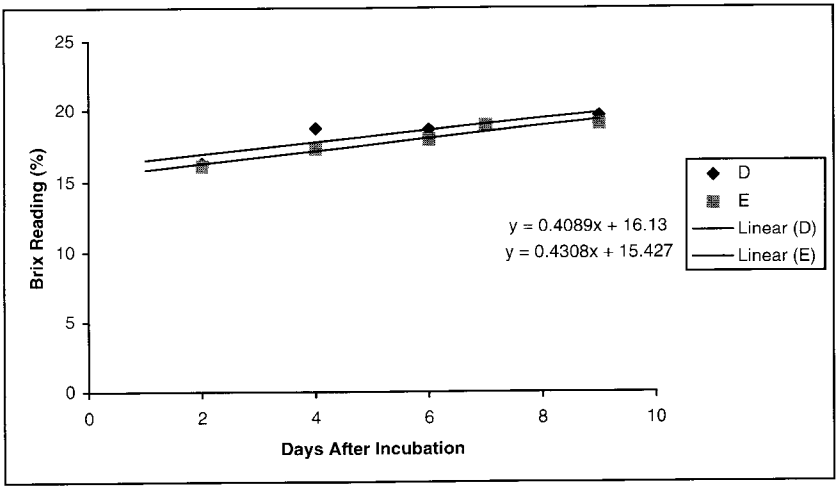

Figure 3: Linear Relationship of Sugar Content for Samples D and E Before Reaching Maximum Level

Coating did not indicate any effect on sugar content. This conclusion was drawn because in samples D and E where both were not incubated but coated and not coated respectively, both samples had similar rates reaching maximum sugar content. Similarly, in samples B and C where both were incubated but B was not coated while C was coated, both samples reached maximum sugar content at the same rate. Only incubation gave a significant effect on the rate to reach maximum sugar content but not the coating.

Plotting sugar content in D and E (Fig. 3) against time before they achieved maximum level was essential to explain the delay in sugar producing since both samples were not incubated.

The result showed there was only a negligible difference in the sugar producing rate for coated and uncoated mangoes which was 0.43 and 0.41 respectively.

Conclusion and Recommendation

It was indicated in this experiment that coating with the prepared plasicized starch with glycerol did delay the onset of the fungal pathogen *B.theobromae* in manifesting the BER symptoms. Since BER is the main problem in storage of HM mangoes prior to reaching the consumers, it is a worthwhile investment to apply the starch to the mangoes during storage. It was also indicated that the coated mangoes performed better without the 2-day incubation period with carbide which was evident in sample E. This could be due to less exposure to the humid and slightly increased temperature during that period. Since there was no significant implication as to the sugar content of the mangoes, perhaps there is no need to impose the mangoes to the 2-day incubation period with the carbide. However, there is also a caution as to the technique of starch application because it was time consuming. Result also recommended that the application technique need to be looked into especially pertaining to time saving and simplicity of application.

As far as the effect of starch to the sugar content of the HM mangoes, coating seemed to have delayed the ripening of mangoes as observed in sample C. But this was only a single observation and did not concur with samples A and B. However, further experiments need to be conducted to reaffirm the effect. Although Choi et al., (1999) recommended some anti-microbial substances to be added into food packaging materials, in this experiment we chose not to add any form of anti-fungal or anti-microbial substances into the starch formulation simply because of our concern for health related implications.

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