

Effects of Antioxidants and Dehanding Methods under Different Temperature Levels on Control of Banana Crown Browning

Elawam S. Ismail¹, Mohamed E. ElKashif² Osman M. Elamin³ and Abas Elsir¹

Abstract

Two experiments were conducted at the National Institute for the Promotion of Horticultural Exports, University of Gezira, Sudan, during the period from 2000 to 2001 to investigate the effects of dehanding methods and antioxidants under two temperature levels on the control of banana crown browning. Dehanding methods included separation of hands under water or in air and cutting the hands using a knife under water or in air. The antioxidants were thiourea (1%), aluminum potassium sulfate (1%), ascorbic acid (150 ppm) and wax dissolved in petroleum ether. Dehanding by separation significantly reduced crown browning as compared to other methods. The best antioxidants in reducing crown browning were thiourea and potassium aluminum sulfate which are sulfur-containing compounds and had an antioxidant activity. Banana hands stored at 14°C had significantly less crown browning as compared to those kept at 35°C because the lower temperature reduced the activity of polyphenoloxidase enzyme which is responsible for banana crown browning. The interactions effects between antioxidants and temperature showed that the antioxidants followed the same trend mentioned previously within each temperature level, but were more effective in reducing banana crown browning at 14°C.

Introduction

Banana crown browning is an undesirable physiological phenomenon caused by enzymatic oxidation of phenolic compounds. It takes place rapidly following mechanical injury resulting from dehanding of the bunches (Robinson, 1996). Phenolic compounds are naturally found in banana fruit and are mainly localized in the latex vessels of the peel (Connie, 1974) and in the cell vacuoles (Marsojo *et al.*, 1999). The concentration of phenolic compounds in banana fruit usually reaches its maximum at full maturity and then decreases during ripening (Lambrecht, 1995). Oxidation of phenolic compounds is catalyzed by the enzyme polyphenoloxidase, which uses molecular oxygen (Palmer, 1963; Stern, 1996).

Banana crown browning can be prevented or reduced using suitable antioxidants or by preventing the direct contact between cut surfaces and atmospheric oxygen such as vacuum packing, dehanding under water (Longdon, 1987), or waxing (Kulkain *et al.*, 1996). Chemical antioxidants are commonly used to control crown browning such as sulfur containing compounds (Sapers, 1993) and L-ascorbic acid (Frank, 1980). Compounds containing sulfur act as inhibitors of polyphenoloxidase

¹Agricultural Research Corporation, P.O. Box 126, Wad Medani, Sudan

²National Institute for Promotion of Horticultural Exports, University of Gezira

³Faculty of Agricultural Sciences, University of Gezira, Wad Medani, Sudan

enzyme although their mechanism of action is not fully understood (Lambrecht, 1995). The most important of these chemicals are aluminum potassium sulfate (Mortuza and Hag, 1996), sulfur dioxide (Connie, 1974), and thiourea (Sapers, 1993).

Banana crown browning causes degradation in fruit quality and renders the produce unmarketable and not competitive in international markets. Therefore, the objective of this research is to determine the effectiveness of different antioxidants and dehanding methods under different temperatures on the control of banana crown browning.

Materials and Methods

Two experiments were carried out at the National Institute for the Promotion of Horticultural Exports, University of Gezira, Wad Medani, Sudan, during the years 2000 and 2001, to evaluate the effects of four dehanding methods and four antioxidants on the control of crown browning of banana fruit held under two temperatures. Treatments were arranged in a completely randomized design with four replications.

Fruits were obtained from a private orchard in Wad Medani area along the west bank of the Blue Nile. Banana fruit bunches of the local cultivar Dwarf Cavendish were harvested at the full three quarters mature green stage and brought to the laboratory.

Dehanding methods experiment

Banana bunches were dehanded using the following methods:

1. Cutting with knife under water.
2. Cutting with knife in air.
3. Dehanding by separation under water.
4. Dehanding by separation in air.

The hands were then placed on the shelves of the ripening room set at either 14 or 35⁰C. Readings of banana crown colour were taken daily till crown colour was stable, i.e. no more change in crown colour.

Antioxidants experiment

Banana hands were washed in tap water to remove dust and latex and then disinfected in a solution of 150 ppm of sodium hypochlorite. The hands were then dipped in the antioxidants solutions described below. Wax solution was prepared by dissolving ordinary wax in petroleum ether and then was applied directly to the crown using a brush. The antioxidant solutions were:

1. Aluminum potassium sulfate (1% solution).
2. Thiourea (1% solution).
3. L-ascorbic acid (150 ppm).
4. Wax solution (solvent was petroleum ether).
5. Water as a control.

Then the hands were allowed to dry for a few minutes and held at temperatures of either 14 or 35⁰C till the fruits were ripe.

Determination of crown colour:

Crown colour was rated according to a scale of 1 to 7 as follows: 1 = White, 2 = Light creamy, 3 = Creamy, 4 = Pale brown, 5 = Brown, 6 = Dark brown, and 7 = Black.

Results and Discussion

Effects of dehanding methods and temperature on banana crown colour

The main effects of dehanding methods on banana crown colour are shown in (Figure 1). There were significant differences between the dehanding methods. Dehanding of banana bunches by separation under water gave the best results, whereas cutting the hands by knife in air gave the worst.

Banana crown browning is caused by oxidation of phenolic compounds which is catalysed by the enzyme polyphenoloxidase and requires molecular oxygen (Stern, 1996). Dehanding by separation under water gave the best results because separation did not damage the cells and hence no significant amounts of phenolic compounds leaked out of the cells. Also, water prevented the immediate contact between the phenolic compounds, if any, which might have leaked out and the enzyme. Therefore, crown browning was significantly reduced by dehanding the bunches by separation under water because it prevented the access of both the phenolic compounds and atmospheric oxygen to the enzyme polyphenoloxidase which is an oxygen-dependent enzyme (Palmer, 1963).

Dehanding the bunches by separation in air and cutting the hands by knife under water gave similar results and were worse than separation under water (figure 1). However, cutting the hands by knife in air gave the worst results because the large amounts of phenolic compounds which leaked out as a result of cutting the cells were in direct contact with both the enzyme and atmospheric oxygen.

The interactions between dehanding methods and temperature were not significant.

Effects of antioxidants and temperature on banana crown colour

The main effects of antioxidants and temperature on browning of banana crown are shown in (Table 1). Antioxidants had significant effects on banana crown colour, and all of them gave better results than the control. The best results were obtained by thiourea, followed by aluminum potassium sulfate, wax and the worst results were obtained by L-ascorbic acid as compared to the control. Thiourea and aluminum potassium sulfate were sulfur-containing compounds which had been reported to reduce banana crown browning, although their mechanism of action was not fully understood (Connie, 1974). This was probably attributed to their ability to complex with the enzyme polyphenoloxidase or to replace its prosthetic group (Corse, 1964). Also, these compounds might have reacted with the intermediate compounds of oxidation reactions and hence prevented crown browning because of their reducing capacity (Lambrecht, 1995). Our results are consistent with those reported by Connie (1974) who showed that thiourea reduced enzymatic browning as compared to other antioxidants tested. Aluminum potassium sulfate which was second to thiourea in reducing browning is routinely used as an antioxidant in banana postharvest handling to control banana crown and finger browning (Sapers, 1993; Mortuza and Hag, 1996).

Wax acted through physical insulation of the crown and thus prevented the direct contact between atmospheric oxygen and phenolic compounds and hence reduced browning, although its effects were moderate (Table 1). Banana hands treated with wax turned to full yellow colour after a week in storage at 14°C but the fingers were still firm and unripe. However, full ripening was complete after 10 days in

storage. Since wax was dissolved in petroleum ether, and the wax solution resulted in acceleration of yellowing and ripening of banana fruit, then it is suggested that either wax, petroleum ether, or a combination of both of them had a positive effect on ripening in a way which mimics ethylene action. Further research work is needed to study this phenomenon.

Ascorbic acid was more effective in reducing crown browning than waxing during the first three days, but browning suddenly increased afterwards (data not shown). This was probably due to the oxidation of ascorbic acid after the third day in storage at 35°C. Mc Evily and Lyenger (1992) reported no darkening of processed fruits until all ascorbic acid was oxidized. They attributed the oxidation of both ascorbic acid and phenolic compounds to the action of polyphenoloxidase enzyme.

The main effects of temperature on crown browning are shown in Table 1. Results indicated that browning was more intense at 35°C as compared with 14°C. This was probably due to the direct effect of temperature on the activity of polyphenoloxidase enzyme which was inactive under relatively low temperatures (Mc Evily and Lyenger, 1992). Connie (1974) reported that banana fingers were subjected to chilling injury at temperatures at or below 13°C but crown colour did not change to brown because the temperature was not suitable for the action of the enzyme polyphenoloxidase. However, if banana fruits were subjected to low temperatures and then returned to ambient conditions, the crown colour will turn brown faster than those which were not previously exposed to low temperatures.

The interactions effects between antioxidants and temperature on banana crown colour were significant (Table 2). They showed that the antioxidants followed the same trend mentioned previously within each temperature level, but were more effective in reducing banana crown browning at 14°C as compared to 35°C.

Financial analysis was conducted to calculate the cost of these antioxidants, very little amount of these materials were added. Results indicated that the cost of these antioxidants ranged between 0.12, 0.2 and 0.02 Sudanese Dinars/Kg banana for thiourea, aluminum potassium sulfate and ascorbic acid respectively. This increase in the cost is negligible compared with the value added resulted from improving the appearance of banana product (Table 3).

Recommendations

Banana crown browning can be greatly reduced by dehanding the bunches in water basins and dipping them in solutions of thiourea or potassium aluminum sulfate, and then transported or stored at 14°C.

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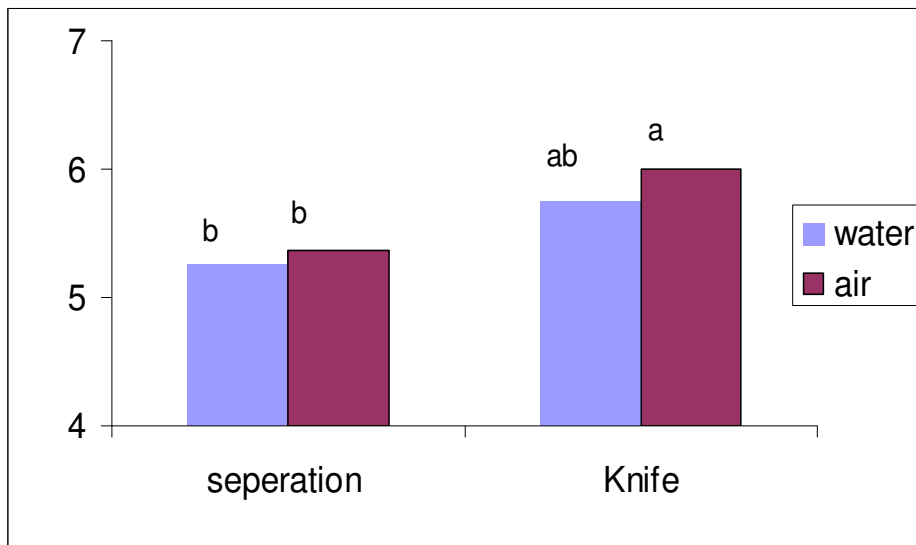


Figure 1. Main effects of dehanding methods on banana crown browning

Table 1. Main effects of antioxidants and temperature on browning of banana crown.

Antioxidants	Days in storage				
	1	2	3	4	5
	-----Crown colour-----				
Thiourea	1.00	1.33 e	1.75 e	1.79 e	1.79 e
Aluminum potassium sulfate	1.00	1.66 d	2.25 d	2.37 d	2.37 d
Wax	1.00	3.16 c	3.75 c	4.00 c	4.04 c
Ascorbic acid	1.00	3.00 b	4.12 b	4.50 b	4.66 b
Control	1.00	5.00 a	6.04 a	6.45 a	6.62 a
Temperature (°C)					
14	1.00	2.52	3.12	3.25	3.41
35	1.00	3.17	4.13	4.26	4.28

Means within each column having the same letter(s) are not significantly different at probability level of 0.05 according to Duncan's Multiple Range Test.

Table 2. Interaction effects of temperature and antioxidants on banana crown colour after 5 days in storage.

Antioxidants	Temperature (C ⁰)	
	14	35
----- Crown colour -----		
Thiourea	1.41 f	2.16 e
Aluminum potassium sulfate	2.16 e	2.58 e
Wax	3.48 d	4.50 c
Ascorbic acid	4.00 d	5.33 b
Control	6.50 a	6.75 a

Means within columns having different letters are significantly different at probability level of 0.05 according to Duncan's Multiple Range Test.

Table 3. Cost of Antioxidants (SD/Kg of Banana product) for Reducing Crown Browning.

Treatment	Price (\$/kg)	Price (\$/g)	Concn. (g/litre)	Price(SD/L/50 kg banana)	Cost(SD/kg banana)
Thio-urea	24.7	0.0247	1	5.76	0.12
Ascorbic Acid	29.0	0.029	0.15	1.04	0.02
Aluminum potassium Sulfate	41	0.041	1	9.84	0.2

Exchange rate 1US\$=SD 240