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ROLE OF DIFFERENT ANTI-MICROBIAL AGENTS AND AERATION ON WATER STORAGE OF BANANAS

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The objective of this research studies was to test the effect of different anti-microbial agents on decay and rotting of water stored bananas. Two experiments were conducted in this regards. First experiment was to examine the effect of storage in distal water, distilled water with 0.13% H_2O_2, and with added aeration on the ripening of banana fruit. In second experiment the influences of different concentrations of chlorine were evaluated. After 4 weeks of storage fruits were removed from the storage environment and ripening was initiated with ethylene. Bananas immerged under water with added aeration showed good peel colour and less rotting but a higher intake of water than control. Addition of H_2O_2 in water proved to be the worse treatment in controlling the decay development and also affected the peel colour of the bananas. Chlorine treated fruit did not show any decay or rotting but their peel colour and other ripening processes were severely affected. The current investigations confirm that dipping bananas in chlorine for long periods badly damages their peel. Chlorine treatment proved not to be suitable for banana storage. It seems that the aeration treatment might be suitable if excessive intake of water could be minimized.

Key words: Aeration, anti-microbial agents, climacteric, splitting, water storage,

INTRODUCTION

The major technical problems in postharvest handling and distribution of fresh fruits and vegetables are associated with their perishability as living organisms. They are subject to various biochemical changes, which lower their quality and finally make them unacceptable on a commercial basis. Such deterioration may develop as a result of excessive water losses due to evapo-transpiration; the normal respiration cycles resulting in senescence; physiological disorders such as chilling injury in tropical fruits and fruit rot due to the attack of microbes (Farooqi, 1985). The combination of CA storage and temperature control has proved very successful in extending the postharvest life of fresh fruits but it is little expensive special facility which is not available therefore it may not be appropriate for use in many banana growing rural areas. It has been reported that in certain rural areas of Jamaica, water storage is a practice with breadfruit, which has been shown to extend their storage life (Thompson *et al.*, 1974a). The reasons for the slower rate of deterioration of water-stored breadfruit (Thompson *et al.*, 1974a) and potatoes (Samotus, 1971) are not clear from the literature but could be related to CO_2 /O_2 movement in and out of the product. Relative humidity showed a significant impact on the ripening of bananas without the treatment of ethylene. It was reported (Ahmad *et al.*, 2006) that bananas kept at medium and high humidity ripened later with good eating quality. Delayed ripening of bananas in high humidity storage compared with those held as a control at low humidity was also reported by Littman, (1972). From the literature, a hypothesis has been developed that if fruits are permanently coated with a film of water, modified atmospheric conditions could be developed within the fruit, which could be helpful in extending of their postharvest life. The initial results showed that water storage resulted in splitting of bananas due to excessive intake of water (Ullah 1999). Microbial infestation of water-stored bananas emerged as another serious problem in making the successful initiated application of this technology (Ullah *et al.*, 2006). Therefore this research study was initiated to explore the effect of different anti-microbial agents in reducing decay and rotting of water stored bananas for safe storage. Two experiments were carried out to test the effect of different anti-microbial agents on decay and rotting of water stored bananas. A treatment of aerated water was also included to see that rotting of bananas and other storage disorders might be linked to lower dissolution of O_2 into water and to examine if aerated water affects the rate of intake of water by the bananas.

MATERIALS AND METHODS

The research was carried out in the laboratory of Cranfield University, Silose College, UK. Pre-climacteric Cavendish bananas from Ivory Coast were obtained from C. E. Wilkinson in Bedford for experimentation.

Experiment No. 1

The following treatments were included in first experiment:

1. Distilled water with 0.13% concentration of hydrogen peroxide (H_2O_2).
2. 100ppm solution of chlorine made from sodium hypochloride.
3. Distilled water with added aeration as shown in Figure 1.
4. Control (distilled water only)

Commonly fruit and vegetables are washed with the 100ppm chlorine solution therefore this concentration was used and 0.13% H_2O_2 was also used by the Samotus (1971) to submerge the potatoes in water.

Buckets containing 25 litres of water were placed in a chamber at 13±1°C for 24 hours before starting the experiment to settle the temperature of water. The required concentrations of chemicals were prepared immediately before the start of the experiment. Bananas were cut into fingers and treated with 500 ppm of thiabendazole and dried in air at room temperature. Banana fingers were individually marked, weighed and immersed in these solutions for four weeks at 13±1°C. After four weeks of storage, the bananas were removed from storage environment and exposed to 1000 ppm ethylene in air for 24 hours to initiate the ripening process and stored in air at 16±1°C for ripening.

Colour stages (ripening) of banana fruit were assessed according to peel colour changes compared with a standard commercial colour chart as described by Thompson (2003). The colour dark green and fully yellow was assigned the stage 1 and 6, respectively. Other quality parameters were measured at colour stage 6.

After storage, fruits were weighed, using a Precisa 6000D digital balance with ±0.01g resolution, before

$$\text{Weight change } \% = \frac{W_0 - W_1}{W_0} \times 100$$

and after storage. The cumulative weight gain or loss % was calculated as follows:

Where:

W_0 = Weight before storage.

W_1 = Weight after removal from the storage.

The peel color was measured by colorimeter (Minolta model CR-200/Cr-2006). Positive 'a' values corresponding to the degree of redness while 'a' negative value corresponding to the degree of greenness. 'a' positive of values represents the degree of yellowness and negative one represents the blueness. Firmness was measured using an Instron Universal Testing Machine (Model 2211) with an 8mm cylindrical probe. Total soluble solids percentage was measured using a refractometer (Atago Co. Ltd, model PR-1). Randomized complete block design with four replications was used for statistical analysis.

Figure 1. Pre-climacteric bananas stored in aerated water.

Table 1. Effect of different aseptic agents and aeration on bananas stored under water for four weeks at 13°C and ripened to colour stage 6 at 16°C (Experiment1)

Factors studied	Treatments				Statistics	
	Water	Water + H_2O_2	Water + chlorine	Water + aeration	LSD (P=0.05)	CV%
Weight increase % during storage	+6.1	+6.9	+6.2	+6.8	0.45	6.0
Weight loss % during ripening	8.2	19.6	10.3	7.0	1.13	8.0
Peel colour a*	-2.2	+5.0	+4.5	-2.4	0.5.0	6.0
Peel colour b*	+35.0	+25.6	+12.8	+48.2	2.84	8.0
Firmness (N)	4.5	3.8	8.7	5.1	0.57	8.0
TSS %	17.3	17.6	9.2	21	1.12	6.0
Starch %	45	40	65	20	4.41	8.0

Note: a* values represent the green b* values represents the yellow

Experiment No. 2

In second experiment pre-climacteric bananas were obtained from same source as experiment 1 and 0, 12.5, 25, 50, 75 and 100 ppm solutions of chlorine were used to immerge the bananas. Same procedure was adopted for the treatment and analysis of fruit.

RESULTS

Experiment 1.

Weight Changes during storage (Weight loss %)

Bananas immersed in water with added aeration and 0.13% of H_2O_2 showed a significantly higher intake of water compared to bananas held under other storage conditions (Table 1).

Weight loss during ripening

Bananas showed a significant decrease in weight during ripening after removal from storage, particularly those that had been immersed in water with 0.13% H_2O_2 (Table 1). Lower weight losses were observed in bananas stored under water with aeration followed by those held in water without aeration.

Peel colour

Bananas stored under water with H_2O_2 started changing colour which continued for the first five to seven days of storage and at the end of which their peel colour was severely damaged. Bananas stored under water with chlorine gradually changed colour, turning brownish black in the second week of storage. The bright yellow colour of bananas stored under water with aeration suggests that they ripened normally when treated with ethylene after removal from water.

Fruit firmness

Bananas immersed in water with chlorine retained their firmness compared to other bananas. Added aeration in water helped bananas to retain their firmness better than those held in water without aeration (Table 1). Bananas stored under water with H_2O_2 had the lowest firmness.

TSS and Starch

Bananas stored under water with aeration showed the highest accumulation of TSS and lowest starch percentage, which reflects their rate of ripening. Bananas stored under water with chlorine showed the lowest accumulation of TSS and highest starch percentage (Table 1).

Fungal Infections

Bananas stored in all the treatments showed symptoms of crown rot or physical splitting except two replications stored under water with artificial aeration. Fruits under water with added H_2O_2 exhibited symptoms of anthracnose disease with pinkish growth on the surface of the fingers. Control fruit showed more splitting and cracking of the skin, which developed into rotting during the ripening process. Owing to this severe rotting, four replications of control fruit were discarded because these were not able to analysed for the different physicochemical parameters.

Experiment 2.

Weight changes (%) during storage and ripening

Immersing bananas in water having with different concentrations of chlorine did not significantly affect their rate of weight change either during storage or ripening. There was, however, an indication that control bananas (without chlorine) gained more weight during storage under water and apparently lost more weight during ripening after removal from water (Table 2)

Peel colour

Peel colour of bananas confirmed the findings of the previous experiment. Different concentrations of chlorine showed significantly different a* and b* values. It was observed that bananas showed a gradual increase and decrease in a* and b* values respectively with an increase in the concentration of the chlorine solution, which is related to damage (Table 2).

Table 2. Effect of different concentrations of clorine on water storage of bananas for four weeks at 13°C fallowed by ethylene treatments for 24 hours and ripened to colour stage 6 at 16°C (Experiment 2).

Factors studied	Concentrations of chlorine (ppm)						Statistics	
	0	12.5	25	50	75	100	LSD (P=0.05	CV%
Weight increase % during storage	+5.4	+5.1	+5.0	+5.0	+5.1	+5.2	NS	5.0
Weight loss % during ripening	11.8	11.3	11.6	11.3	10.8	11.0	NS	4.0
Peel colour a	-3.1	-2.5	-1.7	+2.1	+2.3	+4.0	0.95	12.0
Peel colour b	+35.6	+31.7	+27.0	+23.2	+22.6	+16.9	1.01	3.0
Firmness (N)	2.9	3.4	3.8	4.2	5.3	7.7	0.37	5.0
TSS %	19.4	17.3	16.8	15.5	14.7	13.1	1.02	4.0
Starch	35.0	36.0	38.0	51.0	59.0	7.3	4.40	6.0

Fruit firmness

The firmness of bananas showed the same trend as was observed for peel colour. Bananas immersed in different concentrations of chlorine showed significantly differences in fruit firmness. Bananas were found to be softer with a decrease in the concentration of chlorine (Table 2). No relevant reference could be found in the literature to support this observation.

TSS and starch (%)

TSS and starch contents of bananas were significantly different for different concentrations of chlorine (Table 2). Bananas immersed in 100 ppm chlorine showed the lowest TSS and highest starch contents. The results showed a trend, as the lower the concentration of chlorine the higher the TSS and the lower the starch content.

DISCUSSION

As it was expected all bananas immerged in water showed splitting which confirmed the previous finding (Ullah *et al.*, 2006). This effect might be due to the influx of water into the banana fruit to maintain equilibrium between the water and water vapour pressure deficit of the fruit. This effect has been reported by Thompson *et al.* (1974a) in the storage of breadfruit under water. Earlier, Thompson *et al.* (1974b) had also showed both splitting of plantains and slower ripening during storage under high humidity conditions. It can be assumed that a major portion of water intake is through the cut portion of the banana hands or through ends of the banana fingers.

These experiments were undertaken to examine the effects of different anti-microbial agents on controlling the fungal and other spoilage encountered during water storage of bananas. Unfortunately, none of the agents tested proved successful in overcoming these problems. Bananas treated with chlorine did not develop any spoilage but their peel colour was severely affected. It could be due to conversion of chlorine into hydrochloride ions that influenced the colourations.

The weight losses during ripening confirm the findings of Stover and Simmonds (1987), that during normal ripening the peel loses water both to atmosphere and to the pulp, ultimately resulting in higher weight losses of the fruit at this stage than at the pre-climacteric stage. The high weight loss of bananas stored under water with 0.13% H_2O_2 was probably due to the rotting of the bananas as replications with decay development showed more weight loss than bananas without decay symptoms.

The reasons for the higher a* and lower b* values of peel colour of bananas treated with either H_2O_2 or chlorine could not be confirmed from the literature. It might be possible that these chemicals severely affected the carotenoid contents of these bananas and encouraged the accumulation of tannins ((Thompson, 1996). Bananas immersed in water with aeration and those immersed in water as a control were analysed at the same time. The peel colour of the control fruit suggested that they were not at stage 6. The results of TSS and starch contents also confirm that the ripening process of these bananas was initiated but delayed compared to the bananas stored under water with aeration. This was probably due to the exchange of gases through the water.

The softening of bananas immersed in 0.13% H_2O_2 could be attributed to higher weight losses and decay development during ripening. The tissues of the peel might lose their integrity due to the higher rate of water losses and decay developments. A possible reason for the bananas held under water with chlorine being firmer could be the failure of these bananas to ripen, which is also shown by their TSS and starch contents. These fruits remained compact, showing comparatively more resistance to rupture of the peel even though they also showed a high weight loss (10.3%).

The lower TSS and higher starch contents of the bananas immersed under water as the control and those immersed in 0.13% H_2O_2 also indicates that the ripening process of these bananas was slower than those held under water with added aeration. The lower TSS contents and higher starch contents of bananas treated with chlorine suggested that this treatment badly affected their ripening processes.

The extent of peel damage increased with the increase of concentration of chlorine confirmed the findings of previous experiment. Bananas immersed in 12.5 ppm solution showed slight damage to the skin but this damage was not obvious before ripening.

Chlorine is known to be a good anti-microbial chemical and is currently used commercially for treating different fruits and vegetable. Normally, fruits and vegetables treated with chlorine are dipped for only a few seconds or a few minutes at the, but the bananas used in this experiment were immersed in chlorine solutions for weeks. The current investigations confirmed that chlorine treatment severely affected the peel colour development of banana but effectively reduced their rotting. The severity of colour destruction decreased with a decrease in the concentration. Likewise, deformation, firmness, TSS and starch content were also significantly affected by the increase of chlorine. The lowest TSS and highest starch values of bananas immersed in 50 ppm, 75 ppm and 100 ppm chlorine solutions indicated the adverse effects of chlorine on the suppression of the ripening processes.

Water storage conditions are clearly and totally cheaper than CA and MA storage for delaying ripening initiation in pre-climacteric and climacteric fruit but question remains whether this technique can be used simply by adding aeration to get the good quality fruit. Intake of water from cut portion had a major effect in quality due to splitting. From this work it is concluded that it would be better to find another system of minimizing the intake of water from cut portion. It might be possible by sealing the cut portion by petroleum jelly. Overall situation indicated that water storage is not recommended to increase the shelf life of banana at this stage but it might be applicable after further investigation.

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