INTERMITTENT WARMING: A NEW TECHNIQUE FOR REDUCING INTERNAL BROWNING OF HARVESTED PINEAPPLES cv.*Mauritius*

Darshani Weerahewa and Adikaram N. K. B.
Department of Botany, OUSL and
Department of Botany, University of Peradeniya

INTRODUCTION

Internal browning is a physiological disorder in pineapple, also known as black heart or endogenous brown spot. Pineapple is a chilling sensitive fruit. When harvested fruit is exposed to low temperature 8-15°C during storage, transport, or when the developing fruit is exposed to cool winter periods in the field, development of internal browning occurs. The Characteristic symptoms are the formation of translucent, water soaked spots at the base of the fruitlets which turn brown at later stages. In severe cases, these areas turn black and spread to neighboring tissues. Internal browning is a major problem in the fresh fruit exportation from Sri Lanka via sea freight.

Various attempts have been made to control this disorder, however, total control of this disorder has not been possible. The treatment attempted include waxing of fruit to restrict the availability of oxygen (Rohrbach and Paull,1982), postharvest heat treatment (Weerahewa and Adikaram 2005), storage of fruit in modified atmosphere (Abdullah *et al.*,1985), treatment with 1-Methyl cyclopropane (1-MCP) and pre-harvest application of Calcium (Hewajulige *et al.*, 2003).

Intermittent warming, an interruption of low temperature storage with one or more periods of warm temperature, has been tried out as a treatment to reduce chilling injury in many fruits. This has been used successfully in commercial operations for lemon fruits in Israel. Warming of lemons at 7days at 13°C in every 21 days after cold storage at 2°C reduced chilling injury. When the Apples were subjected to intermittent warming at 20° C for 24 hours every 1,2 or 4 weeks during cold storage for 16 weeks, scald development was reduced. However, magnitude of effects varied among cultivars. Tomato fruits subjected to intermittent warming for 4 cycles of 6 days at 9° C and 1 day at 20° C prevented chilling injury and decay, enhanced surface colour but increased loss of firmness, delayed shriveling and resulted lowest losses at the end of storage and at post storage ripening. Intermittent warming delayed the onset of chilling injury by approximately 10 weeks and greatly enhanced the resistance to chilling injury development in oranges. The objective of this research was to investigate if internal browning of pineapple cv. *Mauritius* could be reduced by warming intermittently during cold storage.

MATERIALS AND METHODS

Fruits

Fruits of pineapple *(Ananas comosus)* cv.*Mauritius* (mature, fully green, devoid of any mechanical damage or diseases symptoms) harvested from the Gampaha District were used in experiments reported in this paper.

Development of Internal Browning of Pineapples in cv. *Mauritius*

Five samples of pineapples, each containing four replicate fruit, were placed in a cold room at 10°C and 85% RH. Another sample was kept at room temperature for 48 hrs as a control. One sample each was withdrawn from cold storage after 7,10,14,18 and 21 days and allowed to stand for 48 hours at room temperature. Individual fruit were then cut longitudinally into two halves and the intensity of internal browning was assessed visually using a seven-point scale developed by Teisson (1979) with slight modification: 0 - good flesh/core with no sign of

browning, 1 - formation of brown spots near the stalk end of flesh/core, 2 - the spots coalesce but covers 10% of the flesh/core, 3 - 25% of flesh/core brown coloured, 4 - 50% of flesh/core brown coloured, 5 - 75% of flesh/core brown coloured; 6- complete browning of flesh/core

Intermittent Warming of Pineapple cv.*Mauritius*

Two sets of pineapple each containing 10 fruits from cv. *Mauritius* were stored in a cold room at 10° C and 85% RH. The storage temperature was interrupted by withdrawing the one set of 10 fruit at every 6 days intervals from cold storage and exposing them to room temperature (28 - 30° C) for 8 hours. Intensity of internal browning was assessed using the scale (Teisson, 1979).

Determination of Some Physicochemical Parameters

Fruits were withdrawn from cold storage at 0, 7, 10, 14 and 21 days and hand peeled. Tissues were cut from the region surrounding the central core separately from each fruit, weighed, and the stored in sealed polythene bags in freezer (-20° C). Frozen samples were (100 g) taken separately from 10 replicate fruit which were cut into small pieces and homogenized separately for 3 minutes in a blender without adding water. The resulting slurry was squeezed through a muslin cloth to obtain a clear extract.

Total Soluble Solids

A hand refractometer (Leica model 10430) was calibrated to zero by adding a few drops of distilled water onto the prism surface. Then a drop of the extract was placed on the surface of the prism and the Brix value was taken within the range of 0-30 Brix. The average value was determined for replicate fruit.

Titratable acidity, firmness and pH

Titratable acidity was determined by the method described by Askar and Trepow in 1993. pH was determined using a pH meter (TOA Electronics Ltd, Japan HM 205). Firmness was measured using the hand held penetrometer

Statistical analysis

The non parametric data (Score values) were subjected to analysis using Kruscal –Wallis test.

RESULTS AND DISCUSSION

Internal Browning of Pineapples cv. *Mauritius*

Symptoms of internal browning first appeared at the periphery of the fruit core as small, light brown and translucent and diffused areas within 7 day of cold storage (Table 01). These areas gradually spread along the core into the flesh, affecting about 75% of the flesh and core, 21 days after cold storage.

Table 1.

Development of internal browning of Pineapples cv. *Mauritius* during cold storage

Period of cold Storage (d)	*Internal Browning*	
	flesh	*Core*
0	*0 b*	*0 b*
7	*0b*	*1.3 b*
10	*0 b*	*2.7 a*
14	*3.3 a*	*3.3 a*
18	*4.3 a*	*4.0 a*
21	*5.0 a*	*5.0 a*

Mean values (n=4) followed by the same letter within each column donot differ significantly at P<0.05 Kruscal Wallis test

Intermittent warming during cold storage on the development of internal browning of pineapple cv. *Mauritius*

Pineapples cv. *Mauritius* that were exposed to room temperature briefly every 6 days, during a period of 21 days of cold storage at 10° C showed a 75% reduction in internal browning compared to control fruit. In about 60% of the treated fruit, internal browning symptoms appeared as small, isolated, brown patches in the flesh tissue of the fruit. But in the rest of the 40% of the fruit, symptoms appeared as large, brown areas in the flesh tissue. There was no significant difference in the Total Soluble Solids, titratable acidity or pH between the treated and control fruit (Table 2).

Table 2. Effect of Intermittent Warming during Cold Storage on Internal Browning of Pineapple and Changes of Some Physicochemical Parameters.

Parameter	Intermittent warming fruit	Control fruit
Intensity of Internal Browning	2.5 a	8.2 b
Total soluble solids	11.7 a	12.7 a
% Titratable acidity	0.5 a	0.6 a
pH	4 a	3.9 a
Shell colour	4.5 a	4.5 a
Firmness	4.2 a	4.2 a

Mean values of internal browning and shell colour denoted by same letter in each row do not differ significantly at P 0.05 Mann-Whitney test

Other mean values denoted by same letter within the each row donot differ significantly at p 0.05 t-test

Shell colour score 0-green, 1-10%-yellow 2-25% yellow, 3-50% yellow, 4-75% yellow 5-100% yellow

Intermittent warming, an interruption of low temperature storage by one or more periods of warm temperature, has been used extensively as a method to reduce physiological disorders of many fruits: apple, tomato, lemon, zucchini, mango, pomegranate and peaches. The mechanism underlying this treatment is to interrupt loss of the process of chilling injury by warming the fruits intermittently during cold storage. Chilling injury is a result of two events occurring progressively as primary events and secondary events. The changes that are taken place in the cells during primary events are reversible but those in secondary events are irreversible. Therefore it is important to interrupt the low temperature prior to secondary events and thereby avoid the process of chilling injury. Internal browning symptoms were initiated in cv.*Mauritius* 7days after cold storage. Therefore periodical warming of fruit to room temperature was carried out every 6 days during cold storage at 10° C and 85% RH. Here most of the treated fruit showed only patches of browning in the tissue areas of fruit. But only an average of 40% of total fruit showed isolated, brown areas in the flesh areas of the fruit. This treatment did not affect the fruit ripening. Here the treated fruit appeared similar in shell colour development and firmness to the control fruit. The treated fruit had slightly lower TSS. Titratable acidity was less in treated fruit and this resulted in a higher pH. It has been reported that the chilling injury of peaches had reduced in fruits given intermittent warming.The mechanism underlying this was related to the reduced ethylene emission of fruits during the latency period of chilling injury (Fernández-Trujillo and Artés,1998).The similar mechanism could be possible in reduction of internal browning of pineapple cv.*Mauritus*. However, this has not been experimentally tested.

CONCLUSION

Warming of pineapples intermittently (every 6 days during cold storage at 10^0C) could be used as one of the methods for reducing internal browning of pineapple cv.*Mauritius*

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