EFFECT OF STORAGE ATMOSPHERE AND TEMPERATURE ON GRANNY SMITH APPLES

Investigations carried out by Stevenson, Watkins, and Blake (1961) over an 8-year period have been concerned with the storage behaviour of the Queensland grown Granny Smith apple in controlled atmospheres of oxygen and carbon dioxide. Experimental results have shown that this method of storage results in firmer fruit than that stored in air provided the concentration of carbon dioxide in the storage atmosphere is higher than that normally present in air. Superficial scald incidence was found to increase with increase in the amount of carbon dioxide present in the storage atmosphere, even though the fruit was wrapped in oiled paper wrappers. When fruit picked in mid-April was held in an atmosphere containing 5 per cent. oxygen with only a trace of carbon dioxide, little scald developed but the fruit was not so firm as that stored in atmospheres containing higher levels of carbon dioxide. With the discovery of scald-inhibiting compounds by Smock (1955, 1957) and Stevenson and Blake (1961) it was found that fruit treated with scald inhibitors could be stored satisfactorily in atmospheres containing high carbon dioxide concentrations.

This experiment was designed to study the effect of a number of different atmospheres, previously rejected because of their scald-inducing properties, on the storage behaviour of the Granny Smith variety over a range of storage temperatures.

Methods and Materials

Twelve half-bushel cases of fruit were obtained from each of six growers on the Granite Belt, surrounding Stanthorpe. The fruit was picked on April 19, 1961, graded and packed in the field, and transported by motor vehicle to Brisbane, where it was dipped in a solution containing 1000 p.p.m. ethoxyquin to act as a scald inhibitor. The cases were then repacked and stored in gas-tight drums at the Food Preservation Research Laboratory, Hamilton. Three storage temperatures—32°F, 34°F and 36°F—were used and replicates were held at each temperature in the following storage atmospheres:—

16% oxygen plus 5% carbon dioxide.

11% oxygen plus 10% carbon dioxide.

5% oxygen plus 5% carbon dioxide.

Normal storage atmospheres.

The cases were stacked into the experimental drums, which were then sealed. The required atmosphere in each drum was maintained by trickling small quantities of compressed air, diluted where necessary with nitrogen, into the drum by means of a capillary type manometric flowmeter. Daily checks were made on the atmospheres, and adjustments to the rate of flow made as

required. The drums were unsealed on November 27, 1961, and the fruit removed to atmospheric temperatures, in which it was held for seven days to simulate normal marketing delays before being examined for disorders.

Firmness was measured on five fruit taken at random from each case, by means of a Magness penetrometer using the 7/16 in. plunger. Readings were made on opposite sides of each fruit and the mean of the 10 readings recorded.

Results

The results are summarized in Table 1. Despite the use of a 1000 p.p.m. ethoxyquin dip as a scald inhibitor there was a considerable amount of superficial scald present. Hall, Scott, and Coote (1961) have shown that ethoxyquin is not so efficient as diphenylamine as a scald inhibitor and that the amount of inhibitor required increases as the susceptibility of the fruit to the disorder increases. In view of the relationship between carbon dioxide and scald incidence, stronger solutions of ethoxyquin are necessary to control scald under the experimental conditions. Storage temperature had no significant effect on the incidence of scald but the effect of atmosphere was highly significant. In all cases the fruit held in normal atmosphere storage was less affected than that held in controlled atmospheres.

Temperature had no effect on the incidence of soggy breakdown but fruit held in an atmosphere of 16% oxygen plus 5% carbon dioxide and normal storage atmospheres had significantly less soggy breakdown than that stored in 11% oxygen plus 10% carbon dioxide or in 5% oxygen plus 5% carbon dioxide. The number of total disorders present, comprising the total of fruit affected by scald, soggy breakdown, mould and bitter pit, was not significantly affected by storage temperature. However, fruit held in normal atmospheres or in 5% oxygen plus 5% carbon dioxide was less affected by disorders than that held in either 16% oxygen plus 5% carbon dioxide or 11% oxygen plus 10% carbon dioxide. The firmness of the fruit was significantly affected by storage atmosphere, all controlled atmospheres yielding firmer fruit than that stored under normal atmospheric conditions.

In all previous experiments with the controlled atmosphere storage of this variety, the incidence of core flush has been very slight. Towards the end of the storage period it has been present in all treatments to the same extent. In the 1961 investigations core flush was extremely severe and the incidence was recorded. Its severity was graded into absent, slight, medium and severe and a 0, 1, 2, 4 rating used. Ten fruit from each treatment were cut and the core flush recorded, using the above rating. The weighted core flush rating was then deduced by expressing the recorded incidence as a percentage of the maximum amount of core flush possible. Fruit stored in normal atmospheres was less affected by the disorder than that stored in 16% oxygen plus 5% carbon dioxide, which was in turn less affected than that stored in either 11% oxygen plus 10% carbon dioxide or 5% oxygen plus 5% carbon dioxide. In addition, fruit held at 36°F was less affected than that held at either 32°F or 34°F.

TABLE 1

EQUIVALENT PERCENTAGES OF DEFECTS, FIRMNESS AND WEIGHTED CORE FLUSH OF GRANNY SMITH APPLES AFTER REMOVAL FROM CONTROLLED ATMOSPHERE STORAGE

Storage Conditions	Superficial Scald	Soggy Breakdown	Total Disorders	Firmness (lb)	Weighted Core Flush
16% O_2 + 5% CO_2—					
32°F	31·8	0·3	33·1	11·28	40·0
34°F	24·6	1·2	29·0	11·50	41·7
36°F	11·9	0·9	14·1	12·07	20·0
11% O_2 + 10% CO_2—					
32°F	13·1	12·9	32·8	11·52	80·0
34°F	12·6	8·5	35·3	10·73	41·7
36°F	7·7	8·3	24·3	11·85	39·2
5% O_2 + 5% CO_2—					
32°F	0·8	0·4	1·9	11·55	70·0
34°F	6·7	1·0	12·7	11·70	60·0
36°F	5·9	0·4	7·3	12·72	30·0
Control—					
32°F	1·2	1·2	3·8	10·48	15·8
34°F	2·9	3·6	9·8	9·73	25·8
36°F	0·8	22·8	25·1	9·10	10·0

Superficial Scald—

Control sig. less than 16%O_2 + 5%CO_2 and 11%O_2 + 10%CO_2 (1% level)
5%O_2 + 5%CO_2 sig. less than 16%O_2 + 5%CO_2 (1% level)
5%O_2 + 5%CO_2 sig. less than 11%O_2 + 10%CO_2 (5% level)
11%O_2 + 10%CO_2 sig. less than 16%O_2 + 5%CO_2 (1% level)
No significant differences between temperatures

Soggy Breakdown—

16%O_2 + 5%CO_2 and 5%O_2 + 5%CO_2 sig. less than 11%O_2 + 10%CO_2 and Control (1% level)
No significant differences between temperatures
Interaction, Atmospheres × Temperature significant (5% level)

Total Disorders—

5%O_2 + 5%CO_2 and Control sig. less than 16%O_2 + 5%CO_2 and 11%O_2 + 10%CO_2 (1% level)
No significant differences between temperatures
Interaction, Atmosphere × Temperatures significant (1% level)

Firmness—

16%O_2 + 5%CO_2, 11%O_2 + 10%CO_2 and 5%O_2 + 5%CO_2 sig. firmer than Control (1% level)
5%O_2 + 5%CO_2 sig. firmer than 11%O_2 + 10%CO_2 (1% level) 36°F sig. firmer than 34°F (1% level)
Interaction, Atmospheres × Temperatures significant (1% level)

Weighted Core Flush—

Control sig. less than 16%O_2 + 5%CO_2 (1% level)
16%O_2 + 5%CO_2 sig. less than 11%O_2 + 10%CO_2 and 5%O_2 + 5%CO_2 (1% level)
36°F sig. less than 32°F and 34°F (1% level)
Interaction, Atmospheres × Temperatures significant (5% level)

Discussion

The results once again illustrate that superficial scald is one of the most serious problems of controlled atmosphere storage of the Granny Smith variety. Even though a number of scald inhibitors is available, care must be taken to ensure that adequate concentrations are used to give effective protection. Overall, the most satisfactory atmosphere appears to be one containing 16% oxygen plus 5% carbon dioxide. This atmosphere, which has performed well in earlier experiments, is easy to obtain and maintain by ventilation and no mechanical scrubbing device is required. Even though fruit stored under this atmosphere had significantly more disorders than that stored in normal atmospheres or an atmosphere containing 5% oxygen plus 5% carbon dioxide, if this incidence of scald is disregarded the incidence of other disorders is no greater than these atmospheres. Fruit stored in 16% oxygen plus 5% carbon dioxide was firmer than that stored in normal atmospheres and as firm as that stored in an atmosphere containing 5% oxygen plus 5% carbon dioxide. In addition, the incidence of core flush is considerably less in the 16% oxygen plus 5% carbon dioxide atmosphere. Provided adequate scald control is effected this atmosphere therefore appears to be the most suitable for this variety. Storage temperature had little effect on storage behaviour but fruit held at 36°F was firmer and less affected by core flush than that held at either 32°F or 34°F.

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