The effect of storage temperature on the outturn of buttercup squash

A report prepared for
The NZ Buttercup Squash Council Inc. Results of experiments undertaken in 1997 as part of TBG contract no. BSC601 'Optimising the Outturn of New Zealand Buttercup Squash in Export Markets'

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1 EXECUTIVE SUMMARY

Storage rots and weight loss continue to be major contributors to the variable outturn of export buttercup squash. In experiments undertaken at Levin Research Centre, we investigated the influence of storage temperature on the quality of squash. Bins of 150 fruit were held at 5, 8, 12, 18 or 25°C for 3, 6 or 9 weeks, after which the fruit were assessed for weight loss, storage rots, skin colour, flesh colour and carbohydrate content. The storage rooms were held at between 75% and 80% relative humidity to remove the effect of RH on fruit quality.

In this experiment, weight loss was constant between temperatures, but storage rots were more prevalent in squash stored at 5, 8 and 25°C than in those stored at 12 or 18°C. Both skin and flesh colour change were temperature dependent. By far the greatest skin colour change occurred in fruit stored at 25°C, with fruit becoming quite yellow after 6 weeks. Glucose and fructose levels were high in fruit stored at 5°C, but sucrose levels were highest in fruit stored at 25°C for 9 weeks.

In a second experiment, we stored 12 fruit at each of 5, 8 and 12°C for 3 or 6 weeks, after which they were transferred to a shelf-life room at 20°C. Fruit were assessed at intervals for symptoms of chilling injury, including the development of surface pitting and rots.

No fruit stored for 3 weeks exhibited either surface indentations typical of chilling injury or storage rots before shelf-life assessment. Fruit initially stored at 5 and 8°C developed chilling injury symptoms during subsequent shelf-life assessment at 20°C. Surface indentations appeared in 7 out of 12 fruit stored at 5 or 8°C within 7 days, and rots were apparent on at least 4 fruit after 12 days, at 20°C. No fruit stored at 12°C for 3 weeks developed surface indentations or rots after a further 3 weeks at 20°C.

2 INTRODUCTION

The New Zealand Buttercup Squash Council (NZBSC) has been concerned at the variation in the quality of squash arriving in Japan. In particular, storage rots and weight loss during shipment have resulted in outturn as low as 70% of the export packed weight. In early 1997, NZBSC contracted Crop & Food Research and Massey University, with the support of Technology for Business Growth funds, to undertake studies to investigate whether adoption of new and existing postharvest technologies by the industry could improve the outturn of export squash and thus improve returns to the New Zealand industry. These technologies were:

i Controlled environment storage, aimed at reducing weight loss and the incidence of rots

ii Surfactants, aimed at reducing the soil inoculum load on fruit and the incidence of rots

iii Wax coatings, aimed at reducing moisture loss.

The project is for three years, with three phases consisting of:

i Experimentation

ii Commercial verification

iii Development and testing of a decision support model based on the information collected from phases 1 and 2 and designed to assist packers and exporters manage the handling of their produce.

This report presents the results of the first year of experiments which investigated the effect of storage environment on subsequent outturn.

3 METHOD

3.1 Experiment 1 - Storage time, temperature and humidity

In April 1997, we placed fruit, previously packed for export in the Manawatu region, into WP45 crates. Five crates, containing ten fruit each, were stored at 5, 8, 12, 18 or 25°C (relative humidity 75-80% at each temperature) for 9 weeks. Three replicates were stored at each temperature.

All fruit were assessed for the incidence of rots after 3, 6 and 9 weeks of storage. The total number of fruit with 1 or more rots larger than 15 mm diameter, and the total number and size of rots per replicate, were recorded. The species of fungi visible on fruit surfaces were also identified.

At the same time, we marked and weighed a further six fruit from the same source, measured their skin and flesh colour and stored them at 5, 8,. 12, 18 or 25°C (relative humidity 75-80% at each temperature) for 9 weeks. Three replicates were stored at each temperature.

After 3, 6 and 9 weeks of storage, we re-weighed two fruit from each temperature and replicate (30 fruit in all) and measured their skin and flesh colour, using a Minolta Chromameter set on the L* a* b* scale. L* measures the intensity of the colour, with higher numbers indicating a lighter colour, a* measures colour on a red-green scale, and b* measures colour on a blue-yellow scale. We also froze flesh samples from these fruit for analysis of carbohydrate content.

3.2 Experiment 2 - Incidence of chilling injury

Chilling injury is a physiological disorder of subtropical fruits which occurs when they are stored at temperatures below their optimum. Symptoms vary between fruit species, but in cucumbers, which are related to squash, the flesh cell structure may collapse and result in pitting of the fruit surface and increased incidence of disease (Wang 1990).

The recommended temperature for the storage of squash is 12-13°C. We have found no publication in the scientific literature that either describes the symptoms of chilling injury in squash or that has indicated that it occurs at temperatures below but near 12°C. Nagao *et al.* (1991) observed no chilling injury in Japanese-grown squash stored at 7.5°C, but as the potential for chilling injury is a major factor limiting low temperature storage, it was important to test squash fruit for their susceptibility in New Zealand conditions.

In parallel with experiment 1 and using fruit from the same export bins, we stored 12 fruit at each of 5, 8 and 12°C for 3 or 6 weeks, after which time we transferred the fruit to a shelf life room at 20°C and assessed squash for the development of chilling injury symptoms.

4 RESULTS

4.1 Experiment 1

4.1.1 *Weight loss*

Weight loss increased with time of storage, but varied little with the temperature of storage (Figure 1). The majority of weight loss occurred in the first 3 weeks of storage, reaching averages of between 9.1% and 11.9% for the five storage temperatures. The equivalent range was 14.4% to 17.0% after 6 weeks and 17.6% to 21.2% after 9 weeks.

4.1.2 *Storage rots*

The incidence of storage rots for the five storage temperatures is shown in Figure 2. Rot levels were 3.3% or below after 3 weeks storage for all temperatures, but increased markedly in fruit stored at 5°C (36.7%) and 8°C (29.3%) for six weeks. Between 6 and 9 weeks storage, the incidence of rots in fruit stored at 25°C also increased markedly (42%), but levels were lower for fruit stored at 12°C and 18°C (10.6% and 5.3% respectively).

Fusarium was the most common rotting fungus identified on the squash, at all temperatures, and became more prevalent with time. *Botrytis* was also common at 5°C and 8°C. Other fungal species identified included *Penicillium*, *Phoma*, *Colleotrichum* and *Rhizopus*.

4.1.3 *Skin colour*

Changes in skin colour, as measured by b*-value, were more rapid in fruit stored at higher temperatures (Figure 3a). Fruit stored at 25°C yellowed most rapidly. The mean b*-value for fruit stored at 8°C for six weeks was higher than that for 18°C but it declined to below that for 12°C during the next 3 weeks.

4.1.4 *Flesh colour*

Flesh colour became redder (a*-value increased) with time for all storage temperatures (Figure 3b). The a*-value increased faster at high temperatures than at low temperatures.

4.1.5 *Carbohydrates*

Flesh samples were analysed for glucose, fructose and sucrose content (Figure 4). Glucose levels were low at harvest, but increased with time in storage. Levels in fruit stored for 6 and 9 weeks at 5°C were particularly high (130-140 μmol/g fresh weight) compared to those stored at higher temperatures (60-100 μmol/g fresh weight). Levels were slightly higher after storage at 25°C than after storage at 8, 12 or 18°C. Fructose levels followed a similar pattern to glucose, but levels were lower in fruit stored at 25°C than in those stored at lower temperatures. Sucrose levels also rose during storage at all temperatures, with the highest levels being in fruit stored at 25°C for 9 weeks. Levels in fruit stored at 12°C were lower than those stored at any other temperature.

4.2 Experiment 2

Fruit initially stored at 5 and 8°C developed chilling injury symptoms during subsequent shelf life assessment at 20°C (Figures 5 and 6). No fruit stored for 3 weeks exhibited either dark indentations on the surface typical of chilling injury or storage rots before shelf-life assessment. Dark indentations appeared in 7 out of 12 fruit at each temperature within 7 days, and rots were apparent on at least 4 out of 12 fruit after 12 days, at 20°C. No such symptoms appeared in fruit which were initially stored at 12°C.

Of the fruit stored initially at 8°C for 6 weeks, four had dark indentations and five had rots before shelf-life assessment. After 7 days at 20°C, all fruit exhibited dark indentations, and 8 had rots.

5 CONCLUSIONS

Surprisingly, weight loss was largely independent of storage temperature, but weight loss did increase with time in storage. We controlled the humidity of the coolrooms in which the fruit were stored at between 75 and 80% relative humidity. It is possible that weight loss is affected more by humidity than temperature and we will investigate this during the coming season.

Storage temperature had an impact on the level of rots in fruit. We noted chilling injury symptoms in fruit stored at 5 and 8°C and subsequently held at 20°C. In many chilling-sensitive crops, the symptoms do not appear during storage at the injurious temperature, but only after subsequent removal to higher temperatures. Our results are consistent with this observation.

Chilling injury no doubt contributed to the high level of rots at these temperatures. Fruit stored at 18°C had the lowest incidence of storage rots, but their flesh yellowed more quickly than those fruit stored at 12°C.

Our study supports the recommendation contained in the Squash Council's Cultural Guidelines (1991) for storing fruit at 13°C. The variability in storage life of export squash is likely to be a consequence of non-adherence to these guidelines, variability in humidity, differences in cultural practices, or crop handling damage during harvest or packing.

6 PROPOSALS FOR NEXT SEASON

During the 1997/98 season, we plan experiments to investigate the effect of humidity on weight loss and storage rots in buttercup squash. As we have established that the temperature range 12-18°C is the optimum for minimising rots in squash, we will store fruit at 12 and 18°C in combination with relative humidities of 65%, 80% and 95%. We will measure weight loss, incidence of storage rots, skin and flesh colour change, and carbohydrate content.

Also in the coming 1997/98 season, we will monitor the temperature and relative humidity of commercial shipments of buttercup squash to Japan from at least one packing shed. We plan to use the services of Jun Ishii for this work, particularly for the assessment of squash quality and for collecting the temperature and humidity loggers in Japan.

7 ACKNOWLEDGEMENTS

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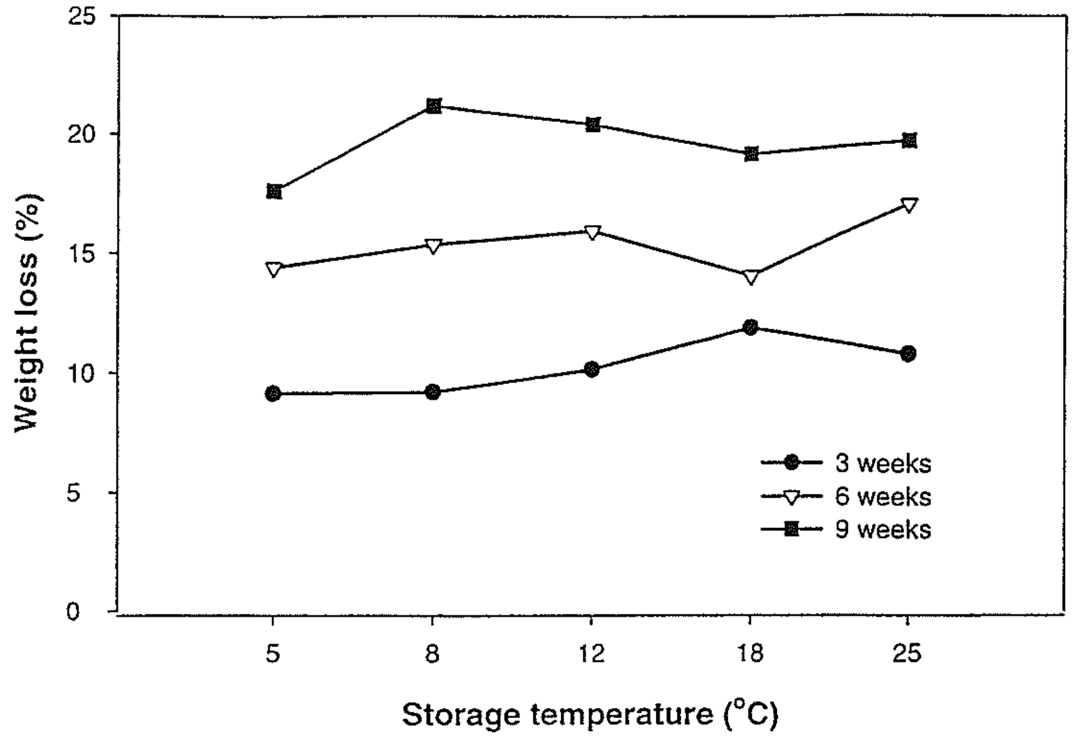


Figure 1. Weight loss in squash stored at 5, 8, 12, 18 or 25° C for 3, 6 or 9 weeks

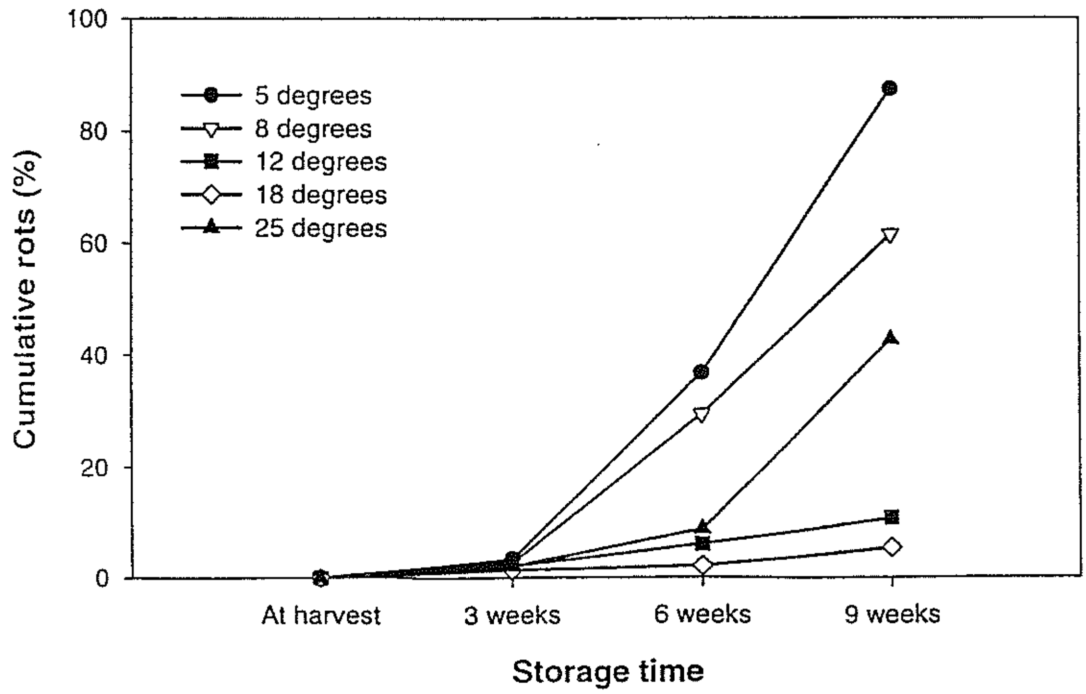
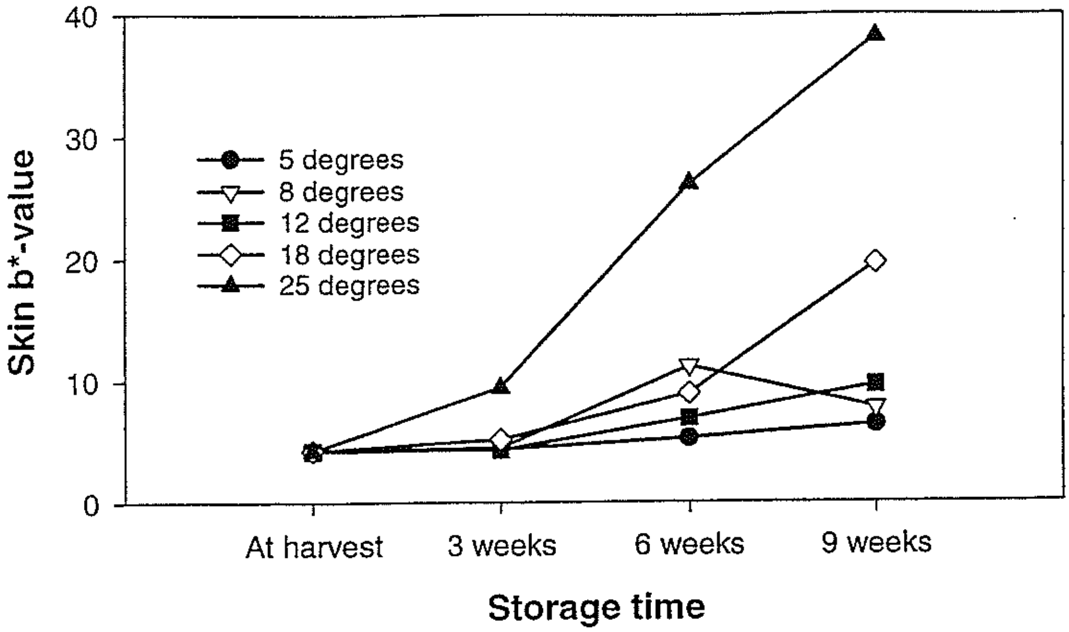


Figure 2. Cumulative rots in squash stored at 5, 8, 12,18 or 25°C for 3, 6 or 9 weeks

(a)



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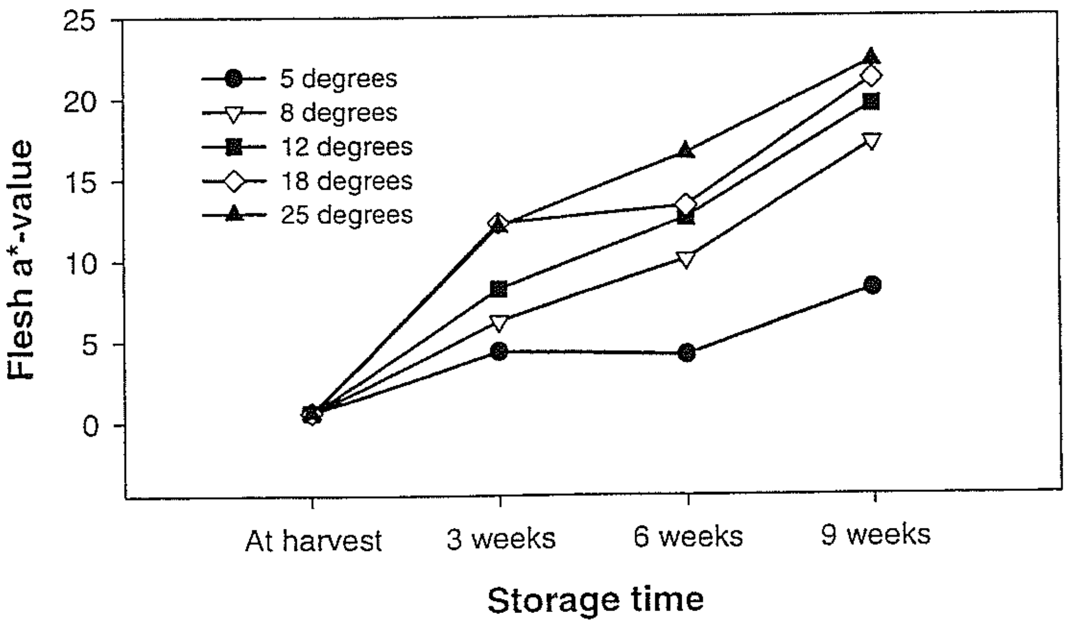

Figure 3. Skin and flesh colour changes in squash stored at 5, 8, 12, 18 or 25°C for 3, 6 or 9 weeks

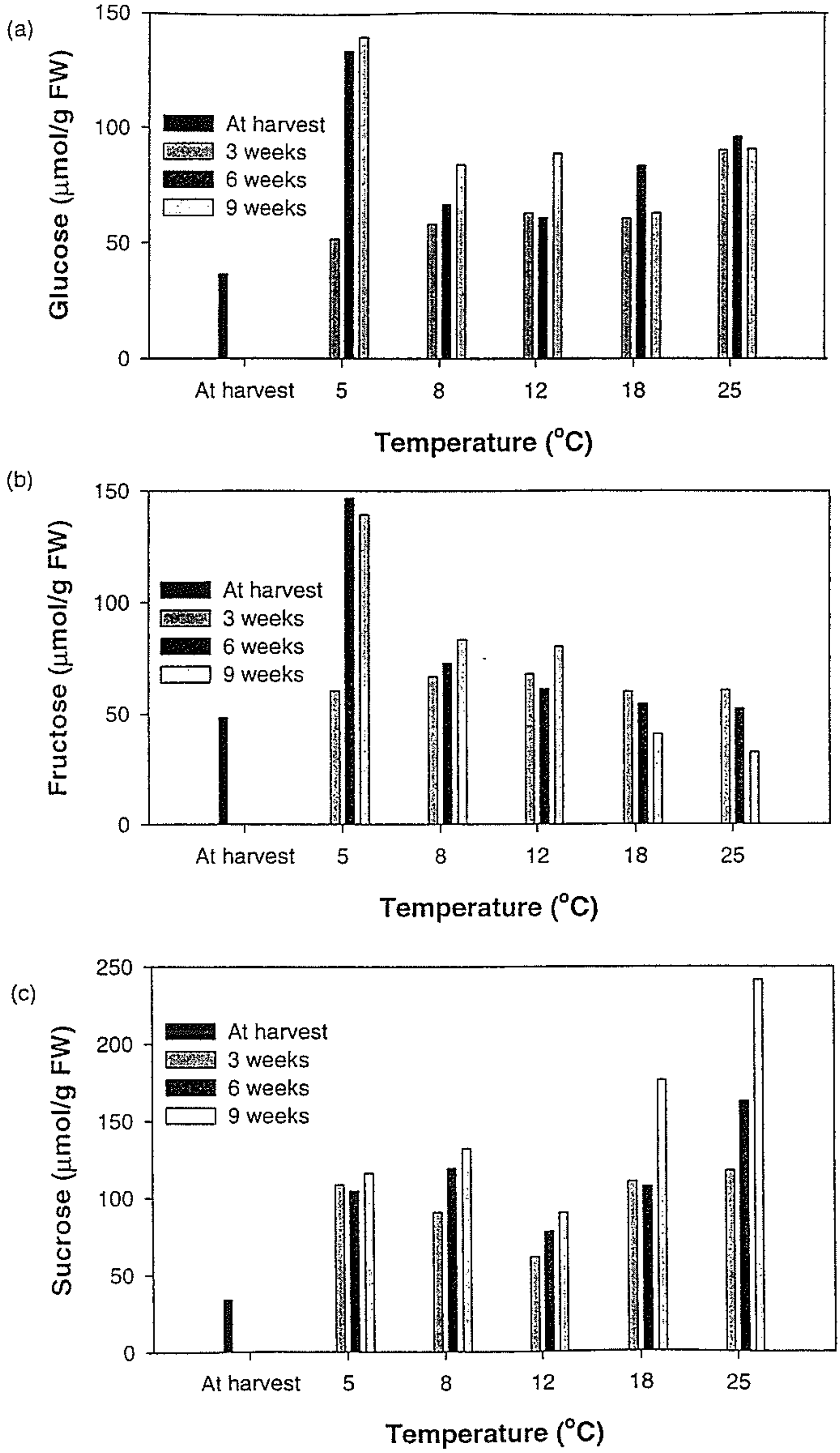

Figure 4. Changes in glucose, fructose and sucrose contents in squash stored at 5, 8, 12, 18 or 25° C for 3, 6 or 9 weeks

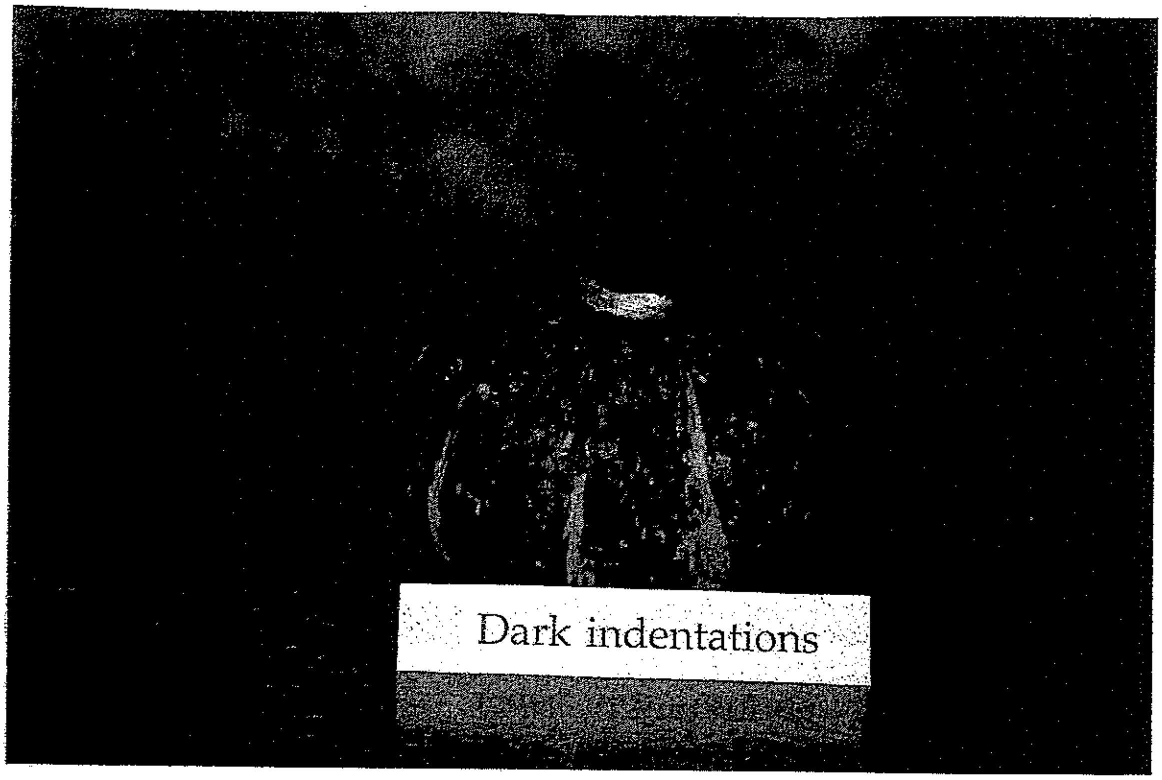

Figure 5: Dark indentations in the surface of a squash stored at 5°C for 3 weeks and then held at 20°C for 10 days. This symptom is typical of chilling injury as seen in fruit related to squash, such as cucumber.

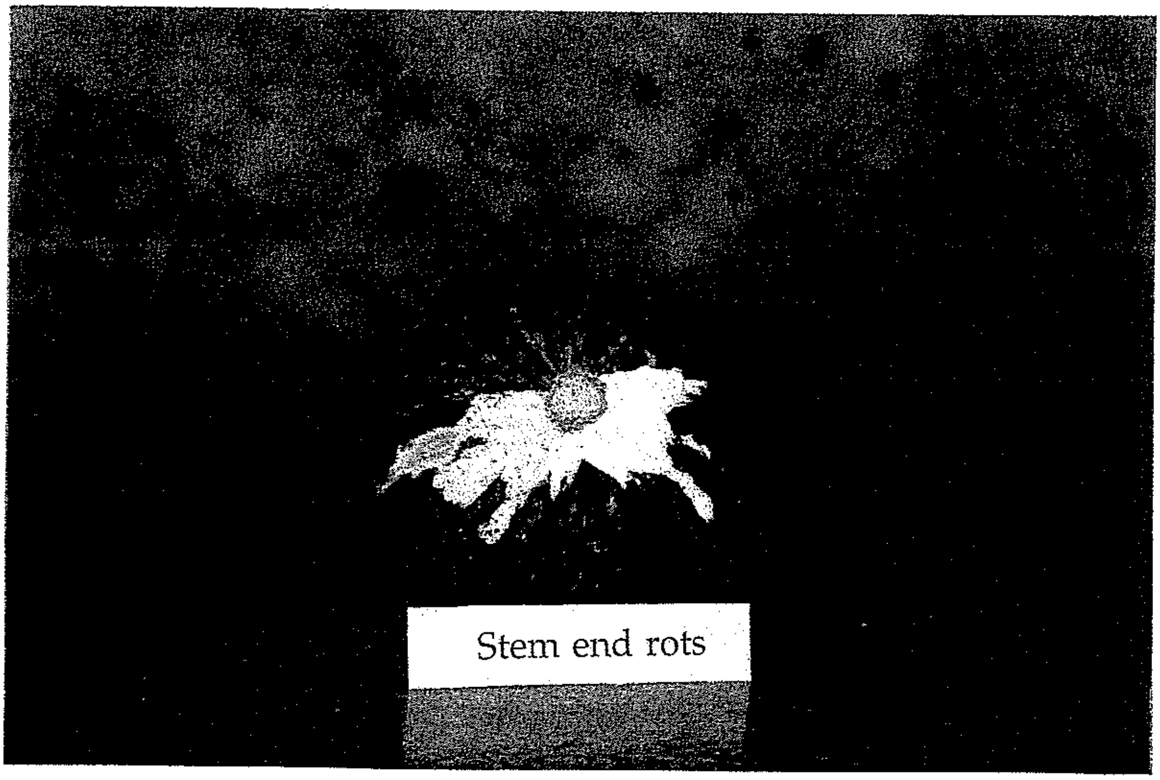

Figure 6: Stem end rot in a squash stored at 5°C for 3 weeks and then held at 20°C for 10 days. The incidence of rots tends to increase in chilling-sensitive fruits when they are stored below their optimum temperature.