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The effect of postharvest time-temperature integral on quality parameters of buttercup squash

Part A of a two-part report prepared for
The New Zealand Buttercup Squash Council Inc.

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1 EXECUTIVE SUMMARY

The quality of early-season squash exported from New Zealand is of concern to the industry. Early-season squash often receive premium prices in the Japanese market because they fill a niche that competing countries cannot supply. However, some of this fruit may be harvested too early to ripen adequately during shipment and is thus of a low quality when sold. Low quality fruit may suppress prices for subsequent shipments.

During the 1994/95 season, we studied the effects of age at harvest and accumulation of heat units in storage on a range of quality parameters in squash, including carbohydrate content, skin and flesh colour, dry matter content and weight loss.

Squash grown at Levin Research Centre were pollinated between 28 January and 1 February 1995 then individually labelled. Half of these labelled fruit were harvested on 1 March (early-harvest) and the other half were harvested on 20 March (mid-harvest).

Fruit from each harvest were randomly allocated to predetermined degree-day treatments, individually weighed and stored for approximately six weeks. The treatments were achieved by storing the fruit at combinations of 12, 15, 20 and 25°C to attain a range of time-temperature integrals between 116 and 760 degree-days, with an 8°C base. After the squash had attained their estimated degree-day allocation, they were weighed, the skin and flesh colour was measured and the incidence of decay noted. Samples were collected for later analysis of dry matter content and carbohydrate levels.

A close correlation was established between the level of sucrose and number of degree-days for both harvests. The rate of accumulation of sucrose (approximately 0.3 mg/g/degree-day) and levels at harvest were similar between harvests .

Glucose and fructose levels followed different patterns to sucrose. Levels in early-harvest fruit were low, increased rapidly, peaked at 100-120 mg/g between 375 and 525 degree-days, then declined to approximately 50% of this level. Mid-harvest fruit also contained low levels of glucose and fructose at harvest, but increased to a peak of only 60-66 mg/g at 190 degree-days, then declined gradually.

The skin of both the early and mid-harvest fruit became lighter in colour at similar rates during storage, but the early-harvest fruit had darker skin at harvest. The skins of the early fruit were more yellow at harvest than mid-harvest fruit, but their subsequent rate of yellowing was slower.

Although the flesh of fruit from both harvests became redder with storage, the early-harvest fruit were initially less red. The rate of change in flesh colour in the early-harvest fruit appeared to decline with increasing storage.

Percentage weight loss increased with increasing number of degree-days. There was little difference in weight loss between harvests.

Dry matter content was lower at harvest in the early-harvest fruit and declined slightly faster during storage than in the later harvested fruit.

No incidence of decay was recorded for either harvest.

It appears that squash harvested only 30 days after pollination accumulate sucrose and lose weight at the same rate as squash harvested 50 days after pollination. However, fruit harvested later have higher dry matter content, redder flesh and darker, less yellow skin colour during storage.

2 INTRODUCTION

A decision on when to harvest a crop of buttercup squash is generally based on observation of the crop and a subjective assessment of maturity. However, the effects of fruit age at harvest, and subsequent storage conditions on quality attributes such as sweetness, colour and dry matter content are poorly understood. To guarantee premium quality squash for export, it is important that such attributes are consistent and meet the needs of the consumer.

During the 1994/95 squash season, we undertook an experiment at Levin Research Centre as Part A of a two-part study to determine whether maturing squash on or off the vine affects subsequent quality. We stored fruit of known age at a range of temperatures to assess the effects of age at harvest and postharvest time-temperature integral on the quality of buttercup squash.

3 METHOD

Buttercup squash (cultivar 'Delica') were grown at Levin Research Centre during the 1994/95 season. They were sown on 1 December and weeded regularly until pollination began in late January. A total of 260 flowers, pollinated between 28 January and 1 February inclusive, were labelled with numbered plastic-coated labels. Six labelled fruit were randomly allocated to each of a range of treatments based on the date of harvest and predetermined numbers of degree-days of postharvest storage. Half of the labelled fruit were harvested on 1 March (28-32 days after pollination, 'early-harvest') and the other half were harvested on 20 March (47-51 days after pollination, 'mid-harvest').

Harvested fruit were individually weighed and stored at their allocated temperatures, to generate a range of time-temperature integrals (Table 1). These integrals were calculated by multiplying the nominal storage temperature in °C, minus 8°C, by the number of days at that temperature. A threshold temperature of 8°C was used, as previous research has suggested that it is the minimum temperature for the growth of squash plants.

Table 1: Times and temperatures used to generate the time-temperature integrals used in this study.

Initial time (days)	Initial temp (°C)	Final time (days)	Final temp (°C)	Nominal Degree-days	Actual Degree-days (Early harvest)	Actual Degree-days (Mid harvest)
0	-	0	-	0	0	0
42	12	0	-	168	129	116
21	12	18	15	210	207	190
21	12	14	20	252	273	230
42	15	0	-	294	316	321
21	15	18	20	364	375	429
21	15	17	25	434	458	471
42	20	0	-	504	524	526
42	25	0	-	714	762	760

For four of the integrals generated, a constant temperature was used for the entire storage period. For the other four integrals, a combination of temperatures was used. To calculate the number of degree-days accumulated by each treatment more precisely, actual room temperatures were logged during the experiment and these data were used for plotting against the parameters measured (Table 1).

After storage, the squash were weighed, skin and flesh colour measured with a Minolta CR 200 Chromameter, the incidence of storage rots noted and flesh samples collected for later analysis of carbohydrate and dry matter content.

4 RESULTS AND DISCUSSION

4.1 Carbohydrate analysis

Sucrose content increased linearly in relation to the number of degree-days of storage (Figure 1). The postharvest rate of accumulation of sucrose was similar for the two harvests (approximately 0.3 mg/g/degree-day). Although the levels of sucrose at harvest were slightly higher in the mid-harvest fruit when a linear regression was fitted to each of the two sets of data, this difference (26 mg/g) was not statistically significant.

Glucose and fructose levels followed a different pattern to sucrose (Figures 2 and 3). Levels were higher in the early-harvest fruit, as they increased from initially low levels to a peak of 100-120 mg/g between 375 and 525 degree-days, then declined rapidly to 40-60 mg/g at 760 degree-days. Mid-harvest glucose and fructose levels peaked at 60-66 mg/g at 190 degree-days, then declined gradually.

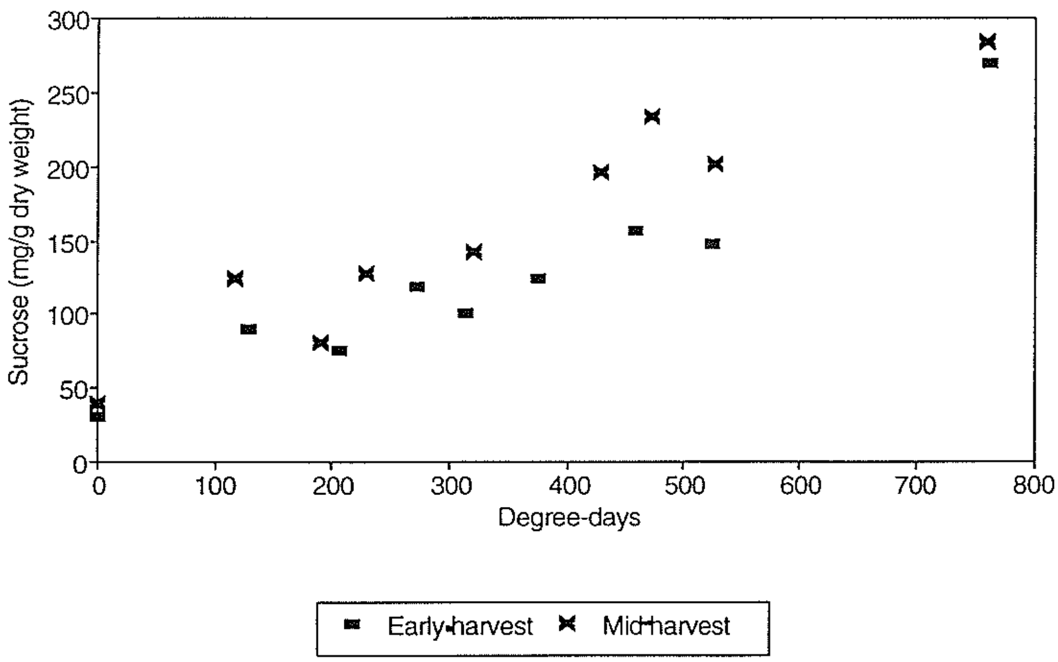

Figure 1. The effect of postharvest degree-days on the sucrose content of squash harveted 30 (early-harvest) and 50 (mid-harvest) days after pollination.

4.2 Skin and flesh colour

The L, a, b colour system was used to measure changes in colour of the skin and flesh of the squash. For skin colour, the L-value was used to determine changes in lightness and the b-value was used to measure the rate of yellowing. Fruit colour from both harvests became less intense with storage and at similar rates (Figure 4). However, the skin was darker at harvest (lower L-value) for the early-harvest fruit.

The rate of skin yellowing differed between the two harvests. The b-value of early-harvest fruit changed little during storage (Figure 5), although the initial colour was similar to that of the later harvested fruit. The mid-harvest fruit became more yellow (increasing b-value) during storage.

Changes in flesh colour occurred at similar rates between the two harvests, but early-harvest fruit had less red flesh at harvest (lower a-value, Figure 6). The rate of change in flesh colour declined with storage and the a-value of the early-harvest fruit never reached the same level as the mid-harvest fruit.

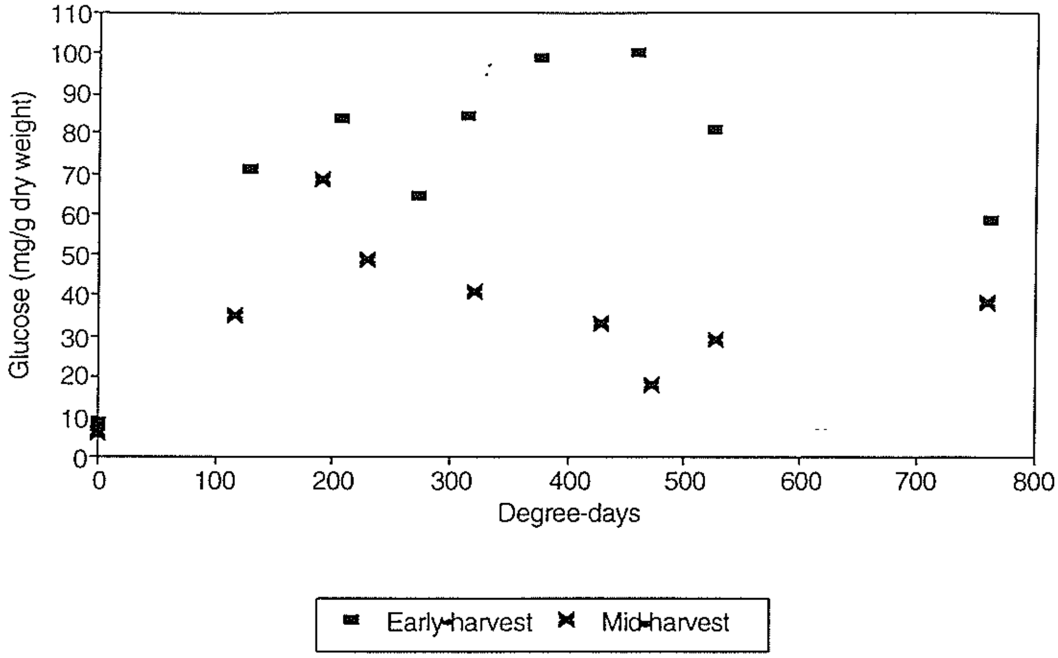

Figure 2. The effect of postharvest degree-days on the glucose content of squash harvested 30 (early-harvest) and 50 (mid-harvest) days after pollination.

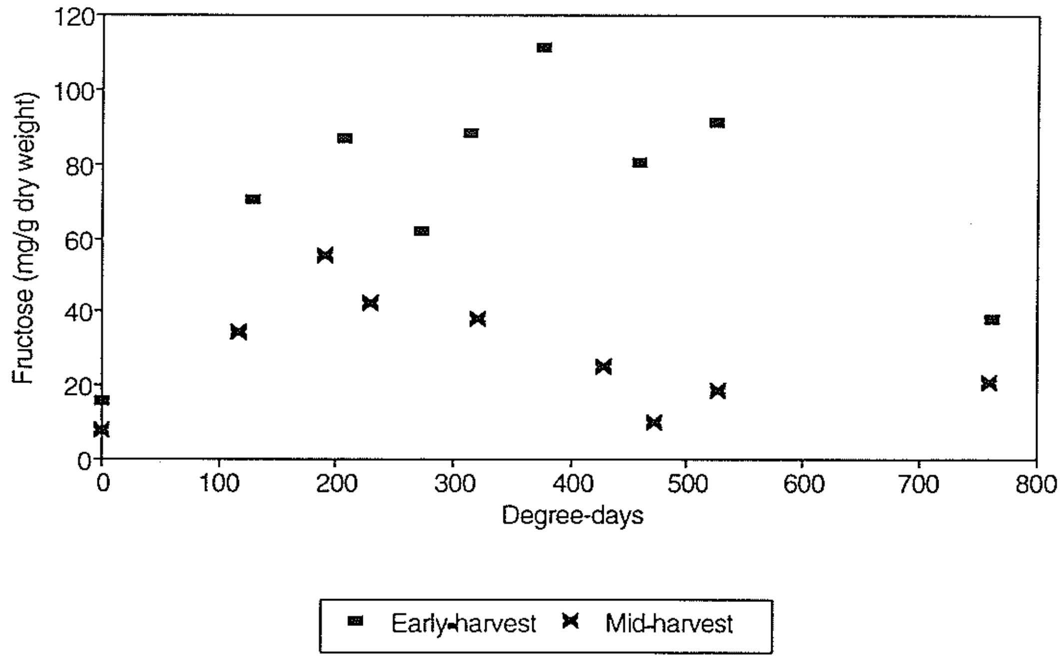

Figure 3. The effect of postharvest degree-days on the fructose content of squash harvested 30 (early-harvest) and 50 (mid-harvest) days after pollination.

4.3 Weight loss

Weight loss increased linearly with number of degree-days (Figure 7). There was no discernIble difference in the rate of weight loss between the two harvests (0.009% per degree-day between 100 and 760 degree-days). Weight loss was rapid during the first 100 degree-days, reaching 4.5% before the first stored squash were weighed.

4.4 Dry matter content

The dry matter content of the early-harvest squash was lower at harvest than the mid-harvest squash (Figure 8). Levels declined during storage of fruit from both harvests, although the decline was faster for the early fruit. At the end of the experiment, early fruit had declined to a mean of 20.4% and the mid-harvest fruit to a mean of 27.9%.

4.5 Storage rots

There was no incidence of storage rot among the fruit assessed in this experiment.

5 CONCLUSIONS

Sucrose and dry matter accumulate while fully-expanded fruit remain attached to the vine, contributing to the improvement in flavour which is often noted by consumers. Dry matter content ceases to accumulate at harvest, although sucrose accumulation continues as a result of the conversion of starch to sugars. Postharvest rates of accumulation of sucrose appear independent of age at harvest.

Glucose and fructose levels remain at low levels while the fruit mature on the vine, but increase for a period of time after harvest. This is particularly evident in the early-harvest fruit and these sugars may contribute significantly to sweetness.

Squash flesh becomes redder during storage, influenced by the time-temperature integral. Early-harvest fruit do not develop the intensity of colour seen in mid-harvest fruit which is associated with an increase in the level of carotenoids.

The rate of weight loss during storage is more affected by storage temperature (see last year's report, 'Strategies for improving the sweetness of export buttercup squash') and humidity than the age of fruit at harvest.

Skin colour is an important quality criterion for the marketing of squash and the lightening of skin colour that occurs in the field is not desirable. Furthermore, an earlier study for the New Zealand Buttercup Squash Council suggested that fruit left longer on the vine develop storage rots faster than fruit harvested earlier. These findings and other environmental factors such as the possibility of late frosts must be taken into account when making decisions about when to harvest the crop.

It is likely that the trends in carbohydrate content, skin and flesh colour, weight loss and dry matter content will be similar throughout New Zealand, but the values may differ due to such factors as cultivar, soil temperature, rainfall and sunlight hours. This possibility should be taken into account when applying these results to other districts.

6 ACKNOWLEDGEMENTS

I wish to thank Sandy Wright for her statistical advice during the planning stages, Willi Borst for completing the assays and Paul Hurst for advice on biochemical aspects of the study and commenting on the report.

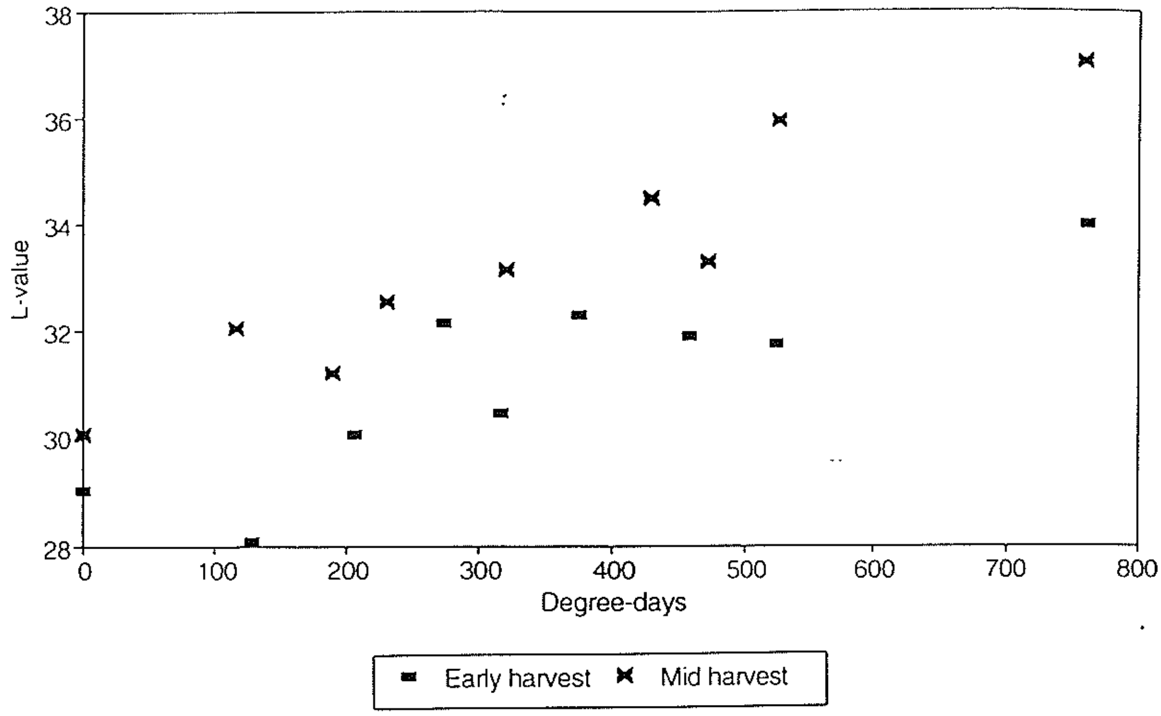

Figure 4. The effect of postharvest degree-days on the skin colour (L-value) of squash harvested 30 (early-harvest) and 50 (mid-harvest) days after pollination.

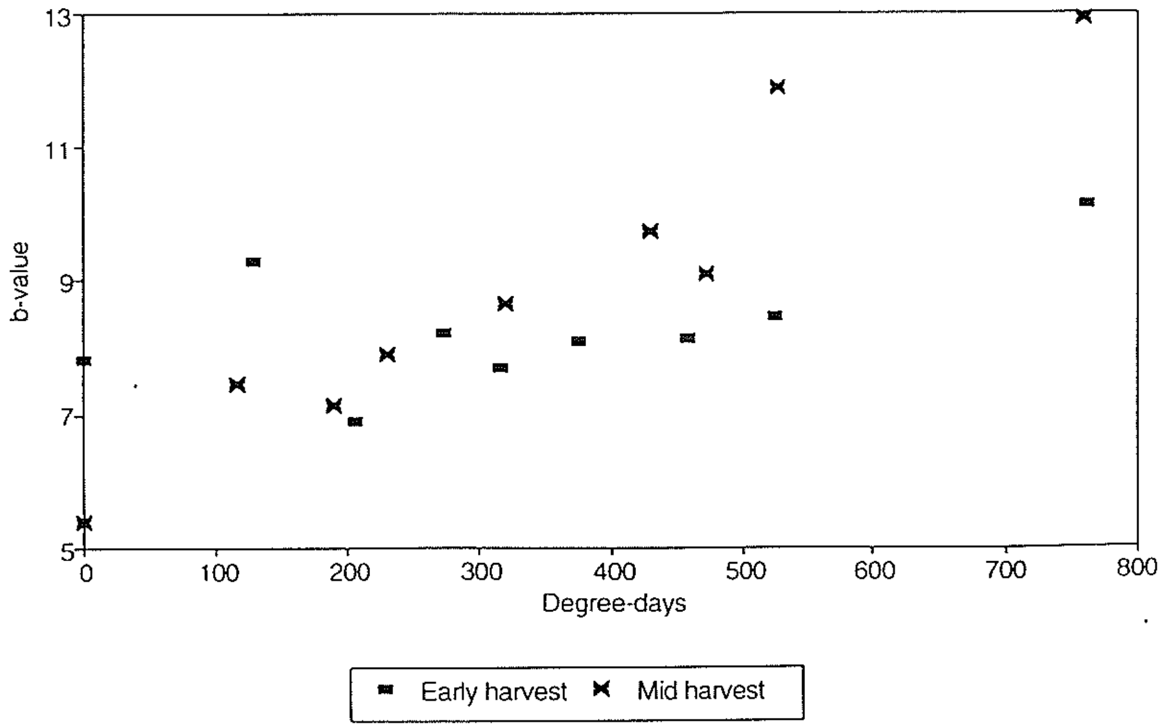

Figure 5. The effect of postharvest degree-days on the skin colour (b-value) of squash harvested 30 (early-harvest) and 50 (mid-harvest) days after pollination.

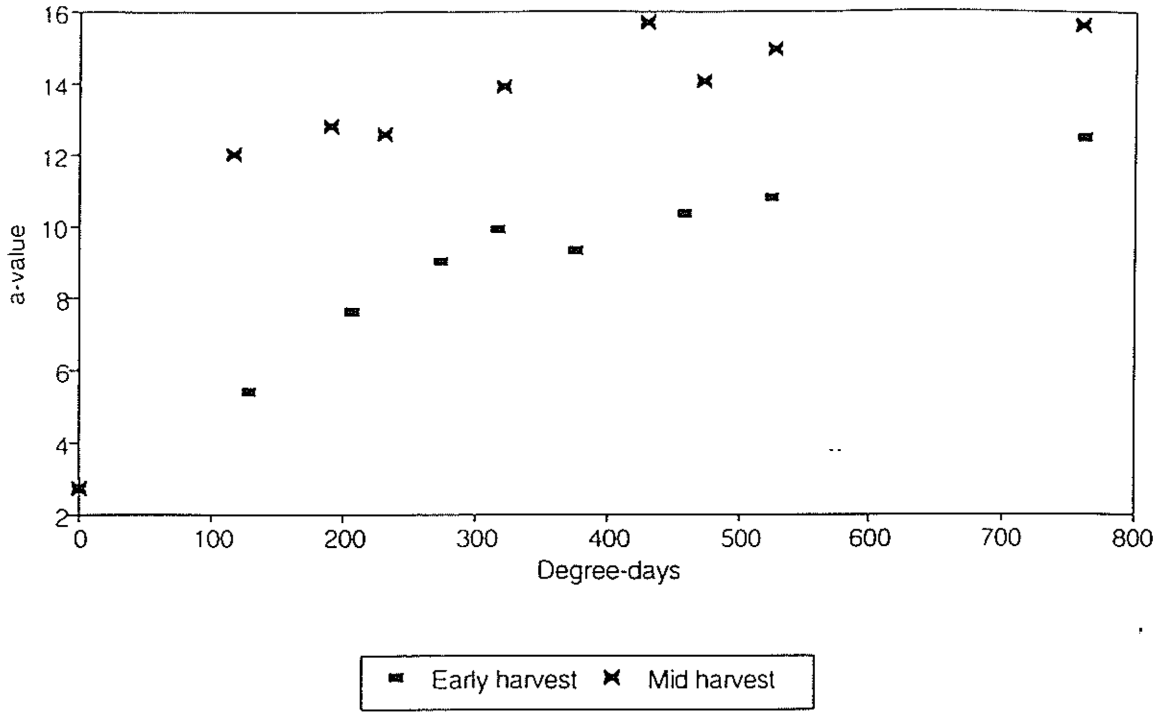

Figure 6. The effect of postharvest degree-days on the flesh colour (a-value) of squash harvested 30 (early-harvest) and 50 (mid-harvest) days after pollination.

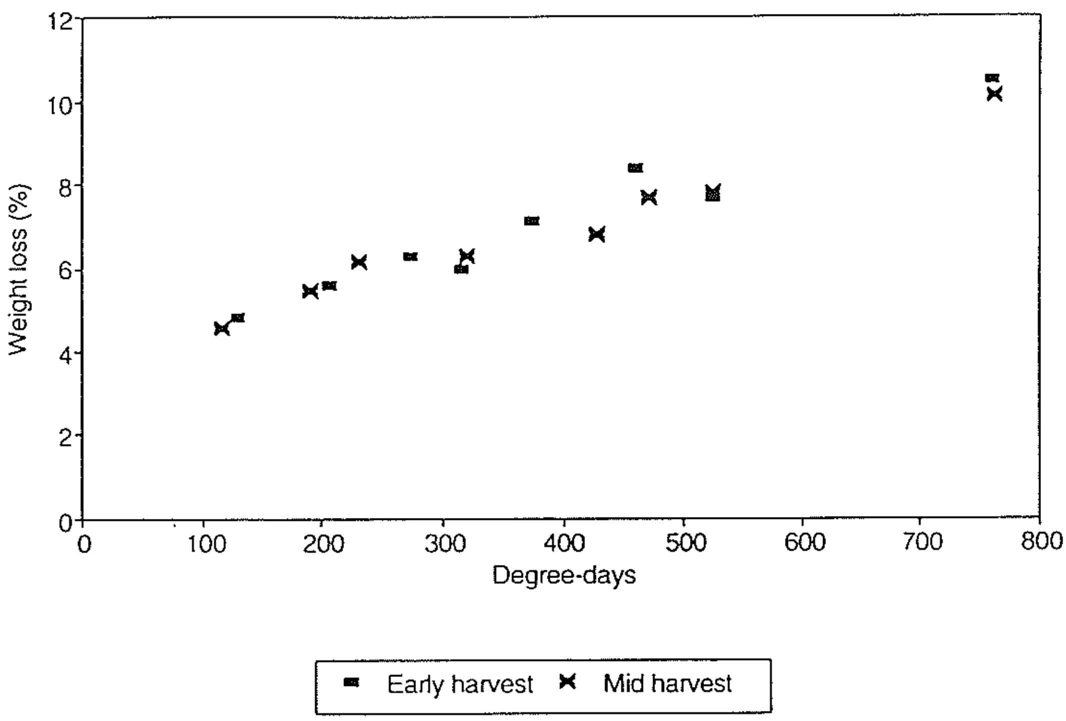

Figure 7. The effect of postharvest degree-days on weight loss in squash harvested 30 (early-harvest) and 50 (mid-harvest) days after pollination.

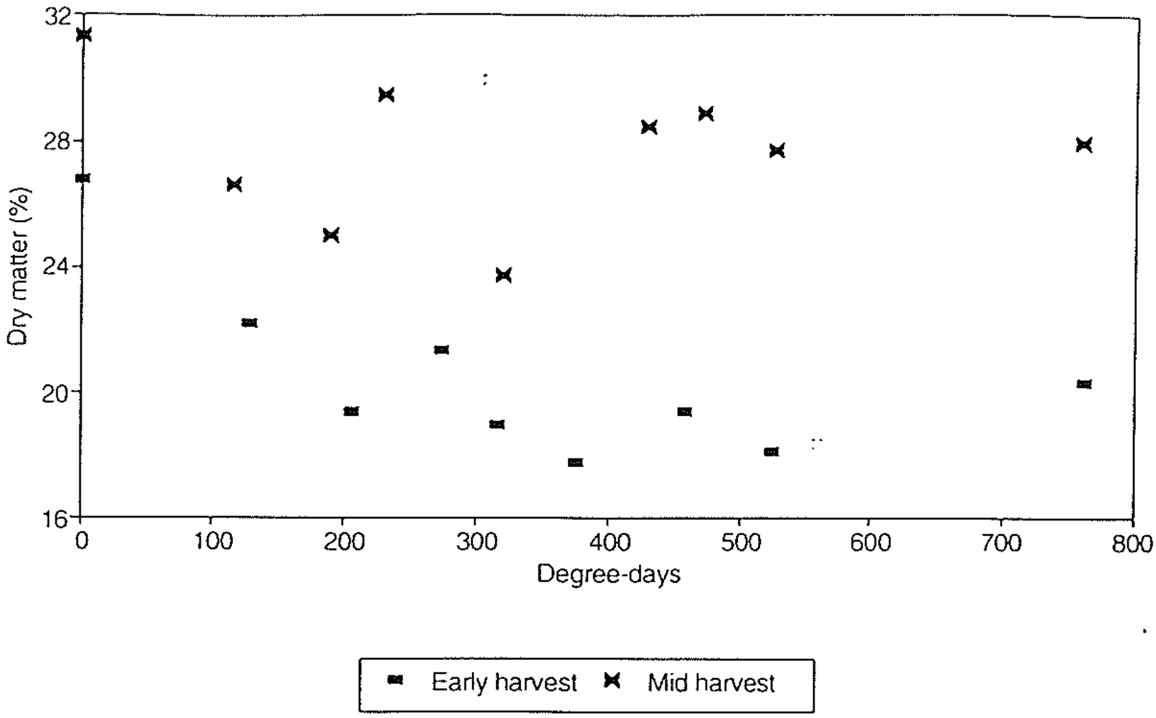

Figure 8. The effect of postharvest degree-days on dry matter content in squash harvested 30 (early-harvest) and 50 (mid-harvest) days after pollination.