Effect of maturity and storage on the sensory quality of buttercup squash

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Abstract

Trained squash panels were used to describe sensory differences between cultivars of buttercup squash with varying maturities, before and after a storage period simulating the time taken to reach Japanese markets.

A Japanese consumer panel was also used to indicate preferences for squash of different sensory qualities. The Japanese preference for sweet, dry-tasting squash of a deep orange colour indicated a partiality for mature fruit.

Penetrometer readings and number of days from flowering were used as measures of maturity, and sensory tests were linked with results of total solids, soluble solids, and colour measurements.

Less mature fruit had lower total and soluble solids, had pale yellow flesh, tasted less sweet, had less flavour and were moister than more mature fruit.

Storage of the fruit for four weeks gave a decrease in total solids, an increase in soluble solids and improved the flavour and texture of the fruit except in the case of fruit picked when it was too immature.

Additional key words: Cucurbita maxima, *post harvest, sweetness, texture, colour, solids*

Introduction

Buttercup squash, (*Cucurbita maxima*) has become the most widely grown cucurbit in New Zealand and has become an important export crop. The volume of squash exported to Japan rose from 400 t in 1979 to 45,000 t in 1991 (Porter and Allison, 1991) and 75,000 t in 1992.

Factors used to assess maturity have included time from maximum expansion of the fruit, the development of a brown corky appearance of the stalk, changes in the firmness of the skin as measured by penetrometer, (the firmness increases with maturity), the change of flesh colour from a yellow-orange to a strong orange colour which is shown by the a* reading in the CIELAB notation of colour measurement (Beever and Forbes, 1991), changes in the seed kernel from soft to crunchy, soluble solids increase, changes in the total solids, flavour and texture changes, skin colour changes from light green to black-green, ground-spot colour change from green to orange and days from flowering (King and Wishart, 1990).

The aim of this research was to understand better the relationships between maturity, storage and sensory quality in squash. This was to provide information for squash growers, exporters, and processors to enable them to optimise harvest dates and to produce fruit of the best possible quality.

Methods

This research was conducted over three seasons.

1989/90

In the first season the preferences of Japanese for fresh, steamed squash were estimated using a consumer panel made up of English language students from Japan who were asked to indicate their liking for Delica, the standard cultivar and three experimental hybrids of squash which differed considerably in their sensory properties (Harvey, 1990). At the same time, a trained taste panel was also given squash samples from the same fruit for assessment. This provided an accurate description of the squash for which the Japanese students had expressed their opinion.

1990/91

In conjunction with maturity studies carried out by horticultural consultants (Brooks R), squash (variety Nishiki) from a farmer's field in Canterbury was harvested on 24 April 1991 (crop sown 7 December 1990, mid-flowering date 10 February 1991, fruit 74 days from flowering.) Fruit of a range of penetrometer readings (5-11 kg) were subjected to sensory evaluation, using a trained taste panel, 1 week after harvest.

This range of fruit was used to provide fruit with a range of maturities.

Another set of fruit with similar penetrometer readings was stored for 4 weeks longer and then tasted. Colour measurements, solids and soluble solids were measured for all fruit on the day of tasting.

1991/92

In this season another method of establishing maturity was used. Buttercup squash was sown 4 December 1991 from two cultivars, (Delica and a new hybrid, Kaboten (Grant and Carter, 1991)). They were tagged at flowering and the fruit harvested approximately 30, 40, 50, 60 and 70 days after flowering at Crop & Food (formerly DSIR Crop Research) plots at Pukekohe near Auckland. Four fruit of similar size (2-2.5 kg) from each cultivar were harvested at each maturity and sent to DSIR Crop Research, Lincoln, for sensory evaluation. Of these 4 fruit, 2 were assessed 1 week from harvest and the other 2 were stored at 15-20°C for a further 3 weeks and then assessed a total of 4 weeks from harvest. Physical tests were also performed: colour of skin , ground-spot and flesh (using a Hunterlab Spectrophotometer); soluble solids (by refractometer); total solids (drying grated flesh at 80°C for 16 hours in an air oven) and weight before and after storage.

Results and Discussion

1989/90

The relationship between Japanese preference and trained taste panel score is shown in Figure 1. This shows that a Japanese preference for squash is positively correlated with sweetness (R^2 = 0.95, p = 0.05) and negatively correlated with coarseness and fibrousness (R^2 = 0.97 and 0.96, p = 0.05).

Effect of penetrometer reading and storage on sensory quality is shown in Figures 2 and 3 (from the 1990/91 season's research).

Figures 2 and 3 show the sensory scores for fruit at each penetrometer reading before and after storage. (These sensory scores were obtained from means of scores given by panellists using a 1500 mm line to rate the various attributes.) A high penetrometer reading

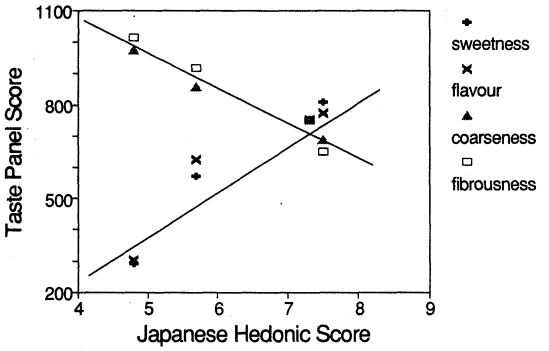

Figure1. Relationship between Japanese preference and trained taste panel score.

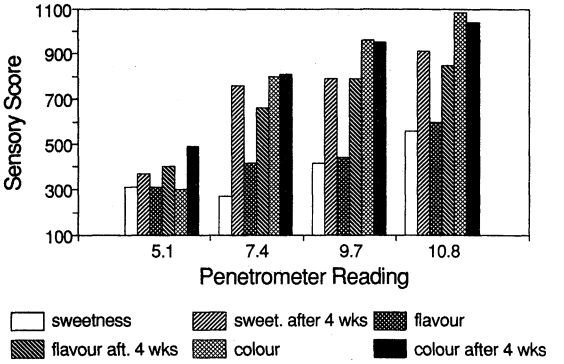

Figure 2. Sensory qualities of sweetness, flavour and colour of Buttercup squash before and after storage (4 weeks) in relation to penetrometer readings.

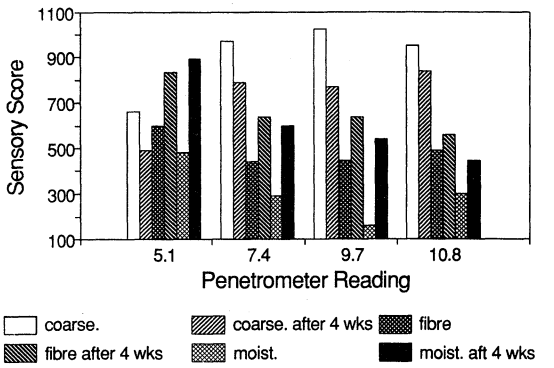

Figure 3. Sensory qualities of coarseness, fibrousness and moistness of Buttercup squash before and after storage (4 wks) in relation to penetrometer readings.

indicates that the fruit is firmer and more mature. A low reading indicates immature fruit.

These figures show that more mature fruit is sweeter and has more flavour, and that storage for 4 weeks improves the sweetness and flavour. However, fruit that was very immature (penetrometer score of 5.1) did not improve in flavour with storage. Figure 3 shows that mature fruit is coarser textured, and that the very immature fruit is more moist. This figure also shows that storage for 4 weeks reduces coarseness but increases fibrousness; the fruit becomes considerably more moist, especially the immature fruit. These results were supported by the total solids scores, which also decreased with storage and increased with maturity.

Table 1 shows the fruit tested, their weights (in grams), Brix readings, dry matters(%), penetrometer readings and corking scores. Corking is a maturity index indicating the extent to which the stem has shrivelled (10 = max. corking, 1=min). Corking of 75% has been considered necessary for maturity.

As expected, Brix scores are higher for fruit with higher penetrometer readings, i.e., for more mature fruit. After 4 weeks of storage, the Brix readings appear to have increased about 2 points for fruit of penetrometer reading of 7 or higher, but the fruit with a penetrometer reading of 5.1, which also had a low corking score, did not increase in Brix value with storage. However, with so few fruit tested this result should be treated with caution.

Table 1. Objective Tests on individual fruit (var. Nishiki) from 1990/91 season:

Penetrometer	Corking Score	Weight (g)	Weight 4 wk later (g)	Brix	% Dry matter
Fruit tested 1 week after harvest					
11.4	9	2080	-	15.2	31.5
9.7	9	1680	-	15.4	31.1
7.4	9	1850	-	11.8	26.3
5.1	2	2150	-	8.9	21.4
Fruit tested after storage at 15-20°C for 4 weeks					
10.6	9	1920	1726	19.2	29.8
9.7	9	1410	1251	17.1	26.4
7.4	9	1464	1309	13.3	22.9
6.0	5	1497	-	11.1	19.0
5.2	2	1491	1390	7.9	13.0

Dry matter increases with maturity. A dry matter of 25-30% is considered by the industry as an acceptable level for maturity. Dry matter appears to have decreased with storage.

1991/92

The season in Pukekohe was unusually cold, especially in March. These conditions affected this experiment in that although the first harvest (30 days from flowering) was normal, later harvests did not show the expected increase in maturity especially in the Crop Research hybrid, Kaboten. Soluble solids scores and penetrometer readings did not increase as expected.

Figure 4 shows how the two cultivars compared in their sensory attributes. Delica was always preferred because of its more advanced maturity resulting in greater sweetness and flavour and reduced coarseness and higher dryness.

Figure 5 shows a scatter plot for all fruit and indicates a strong correlation ($R^2 = 0.74$, $p<0.01$) between acceptability and sweetness.

The next three figures (6, 7 and 8) show the effect of days from flowering on sensory quality. Fruit is grouped on the basis of the number of days elapsed from flowering until the fruit was tasted, whether or not the fruit was still in the field or had been in storage for some of that time. Fruit of the same age from flowering was of similar sensory quality. Leaving the fruit in the field or picking it and storing it at ambient temperatures did not affect sensory quality. Fruit from both cultivars is averaged for these figures.

Sweetness score increases as days from flowering increases (Figure 6). Sweetness appears to reach a plateau after 70-80 days.

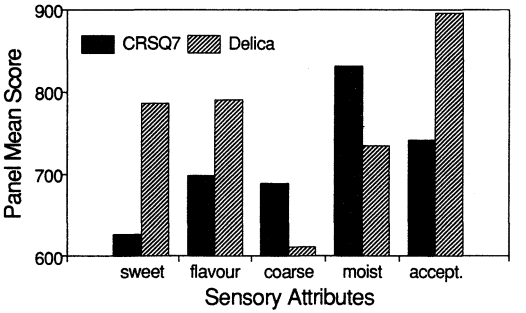

Figure 4. Effect of cultivar on sensory attributes.

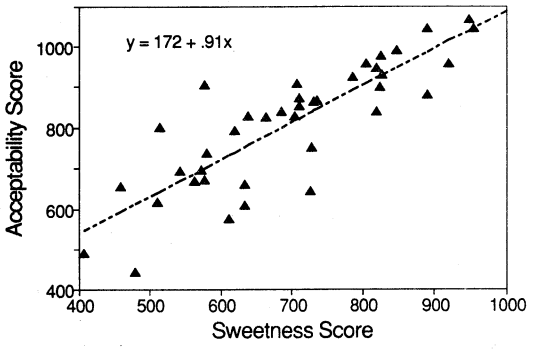

Figure 5. Relationship between acceptiblity and sweetness of individual fruit.

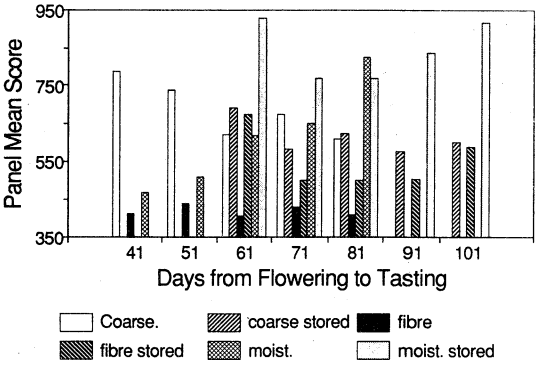

Figure 7. Effect of time since flowering on coarseness, fibrousness and moistness.

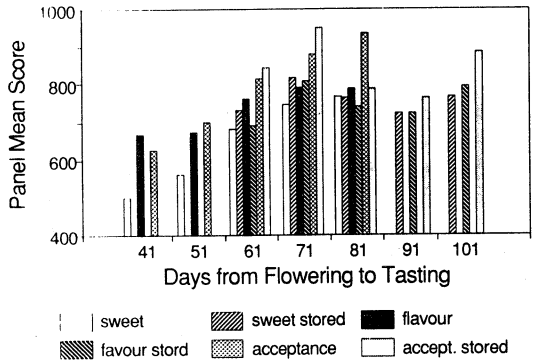

Figure 6. Effect of time since flowering on sweetness, flavour and acceptability qualities.

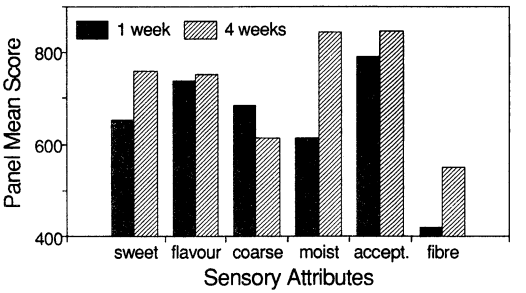

Figure 8. Effects of storage on sensory attributes.

Figure 6 also shows that sweetness, flavour and acceptability all increase as days from flowering increase. Both increased time on the vine and storage therefore have the same effect. However, these attributes tend to reach a maximum around 80 days.

Figure 7 shows coarseness decreasing with increased days from flowering, fibrousness not changing with maturity but increasing with storage especially when the 30 day maturity fruit was stored. Moistness was judged as increasing with days from flowering. This appears to be a contradiction when compared with the total solids scores in Table 2. Very immature fruit of low solids is moist but as it reaches commercial maturity and its peak solids content, it is perceived as dry by panellists, whereas fruit past commercial maturity is not as unpleasantly dry. This unpleasant dryness was also decreased by storage. This shows as an increase in moistness score with storage as the fruit respired and used its store of carbohydrates. This was reflected in the reduced weight and the reduced solids of stored fruit (Table 2).

Figure 8 shows the effect of storage on the sensory quality. There was an overall increase in sweetness.

Table 2. Results of Physical Tests on fruit from 1991/92 season - based on means of 4 fruit

Maturity (days from flowering)	Cultivar	Mean Penetro-meter Reading	Total solids (%)	
			1 wk after harvest	4 wk after harvest
30	Kaboten	7.5	25	17
	Delica	6.7	21	16
40	Kaboten	7.8	26	18
	Delica	7.2	26	21
50	Kaboten	8.3	24	22
	Delica	7.9	25	18
60	Kaboten	8.1	21	19
	Delica	9.2	21	24
70	Kaboten	9.4	20	18
	Delica	10.1	21	15

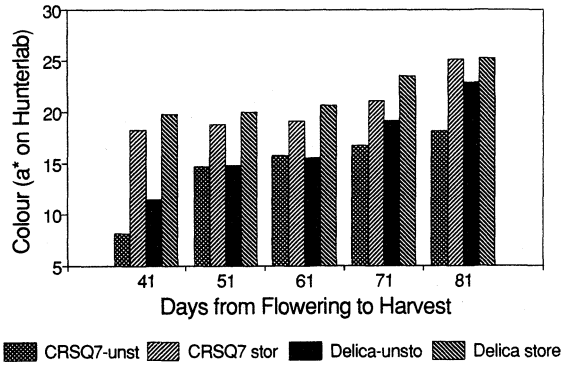

Figure 9. Effects of harvest date on colour of Buttercup squash.

The squash was not as dry, was less coarse but more fibrous but acceptability did not change significantly with storage.

The final set of results covers physical tests performed on fruit from the 1991/92 season. Penetrometer and soluble solids scores increased only slightly with days from flowering. This was assumed to be related to the cooler March conditions. Total solids reached a peak 40-50 days from flowering and then declined. Solids decreased with storage, particularly in the less mature fruit. Fruit lost 3-6% in weight in storage. This loss in weight combined with loss in solids is believed to be because the loss of carbohydrate due to the very high respiration rate of squash is greater than the amount of water being lost.

Colour was measured in a three-dimensional scale using L* a* b*. The L* value decreases as the colour becomes darker. Pale colours have higher L* values. The a* value goes from green to red, with green being negative and red positive. The b* value goes from blue which is negative to yellow which is positive. Orange squash flesh has a positive a* and b* value.

As the squash matured its flesh became darker (decreasing L* value). Both cultivars were similar in their L* readings (figures not shown), and storage had the same effect on colour as leaving fruit in the field (field temperatures in Pukekohe were similar to room temperatures of 15-20°C in Christchurch). Figure 9 shows that the squash flesh became redder with maturity and that storage also increased the redness component. Kaboten did not increase its red colour as much as Delica.

Ground-spot and skin colour were also measured but results are not presented here as they were not as useful as flesh colour for showing maturity development.

Conclusions

From this research the following conclusions can be drawn:

1. if squash is picked too early (penetrometer reading < 6) it will not improve with storage,
2. squash picked just before optimum sensory maturity will ripen with storage (at 15-20°C) equivalent to time in the field,
3. there is a considerable amount of variability between fruit in one crop. However, apart from very immature fruit which will not improve with storage, the uniformity of the sensory quality of the remaining fruit will improve with storage,
4. in the 1991/92 season experiment, fruit was of the best sensory quality 70-80 days from flowering. If transportation is expected to take 28 days, this period should be taken into account when estimating pick date. However, timing will vary with cultivar, site and season,
5. fruit intended for processing will have quite different requirements from fruit picked for sale as a fresh vegetable. If fruit of high dry matter is required, immature fruit should not be used but rather fruit of high penetrometer reading and at least 50 days from flowering, depending on the site and season. Fruit solids reach a peak, probably at the point at which the

stem corks, and then begin to drop. Storage of fruit rapidly decreases the solids content unless cool temperatures are used to reduce respiration. If fruit with high solids and low sugars are required, as for crisps, fruit should be harvested slightly earlier to avoid the increase in sugars that occurs as fruit ages. The peak for solids content occurs prior to the peak for sugars.

Further research should be carried out with more growing sites, larger numbers of fruit, and with heat accumulation units above the base temperature of 8°C being recorded, so that an improved understanding of the changes in squash with time on and off the vine can be obtained.

References

Beever, D.J. and Forbes, S.K. 1991. Post-harvest changes in quality of Buttercup squash in different storage conditions. DSIR Fruit & Trees Internal Report. 25pp.

Brooks, R.A. 1992. Buttercup Squash Research and Development Programme Review - A review of research projects commissioned by the New Zealand Buttercup Squash Council Inc 1989-1991. 22pp.

Grant, D.G. and Carter, B.V. 1991. Breeding of *Cucurbita* spp. in New Zealand. *Proceedings Agronomy Society of New Zealand 21*, 7-11.

Harvey, W.J. 1990. Sensory evaluation of Squash. DSIR Crop Research, Internal Report No.1. 28pp.

Harvey, W.J. and Graham, A.J. 1991. Sensory Evaluation of Squash. DSIR Crop Research Internal Report No 31. 16pp.

King, D. and Wishart, G. (editors) 1990. Buttercup Squash: cultural guidelines for export production. Published by New Zealand Buttercup Squash Council.

Porter, C. and Allison, J. 1991. Crop Profiles: a database of significant crops grown in New Zealand.