



Mana Kai Rangahau

-5 MAY 1994

3 May 1994

Ms Liz Shaw
New Zealand Buttercup Squash Council Inc
NZ Horticultural Export Authority
P.O. Box 1417
WELLINGTON

Dear Ms Shaw

...

On behalf of Winna Harvey, Tricia Hannan and myself, I am pleased to enclose two copies of our report entitled *Sweetness and Colour of Buttercup Squash: Possible climatic, maturity and storage influences*. We trust that the New Zealand Buttercup Squash Council will find the report informative.

You will note that I have sent you numbers 1 and 2 of seven numbered copies. Of the remaining five, 2 have been kept by Crop & Food Research for their records and 3 have been distributed to the authors. Should you require further copies, they can be obtained as described on the title page.

Crop & Food Research looks forward to being of service to the Council in the future.

Yours sincerely

A handwritten signature in blue ink that reads "Paul Hurst".

Paul Hurst
Postharvest Biochemist

Encl.

Postal Address
Crop and Food Research
Private Bag 4005, Levin, New Zealand

Location Address
Levin Research Centre
Kimberley Rd, Levin



Mana Kai Rangahau

5 May 1994

Ms Liz Shaw
New Zealand Buttercup Squash Council Inc
NZ Horticultural Export Authority
P.O. Box 1417
WELLINGTON

Dear Ms Shaw

... Further to our telephone conversation this morning, I am pleased to enclose an extra ten copies of the report *Sweetness and Colour of Buttercup Squash: Possible climatic, maturity and storage influences*.

At your suggestion, I have sent one copy directly to Dr Bill Jermyn, the Council's R&D manager. I have also e-mailed Bill a note, suggesting that in the future researchers be given more explicit instructions re report delivery.

Please note that to comply with Crop & Food Research's publications policy, the extra copies are clearly labelled as such - but they are identical in all other respects to the original seven.

Crop & Food Research is pleased to have fulfilled the Council's request.

Yours sincerely

A handwritten signature in blue ink that reads "Paul".

Paul Hurst
Postharvest Biochemist

Encls.

Postal Address
Crop and Food Research
Private Bag 4005, Levin, New Zealand

Location Address
Levin Research Centre
Kimberley Rd, Levin

Sweetness and colour of buttercup squash

Possible climatic, maturity and storage
influences

A report prepared for
**New Zealand Buttercup Squash
Council**

W Harvey¹, P Hurst², P Hannan²
April 1994

¹ Private Bag 4704, Christchurch

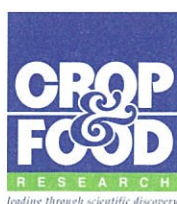
² Levin Research Centre, Private Bag 4005, Levin

Confidential

Copy 11 of 11 extra for client.

Circulation of this report is restricted. Consult the authors and
Institute's Scientific Editor about obtaining further copies. This
report may not be copied in part or in full.

*New Zealand Institute for Crop & Food Research Limited
Private Bag 4704, Christchurch, New Zealand*



FoodInfo Confidential Report No. 70

**Sweetness and colour of
buttercup squash**

W Harvey, P Hurst and P Hannan

CONTENTS

	Page
1 EXECUTIVE SUMMARY	1
2 INTRODUCTION	3
3 APPROACH	4
4 CONCLUSIONS	8

1 EXECUTIVE SUMMARY

Flesh sweetness and colour are important sensory attributes of squash. We have investigated in 'Delica' squash, grown in three localities, the effects of maturity and storage on the factors (sugars and carotenoids) that determine the sweetness and colour of squash flesh. Identifying which conditions favour high sugar and carotenoid levels may offer the opportunity to maximise flesh sweetness and colour by harvesting and postharvest strategies. Our main findings were:

- * Total sugar levels in freshly harvested fruit in Pukekohe were higher than in fruit from either Hawke's Bay or Lincoln. Total sugar levels increased on a fresh-weight basis during on-vine maturation at all sites, as did total dry matter accumulation.
- * Sugar composition changed with time on the vine. Sucrose, rather than glucose or fructose, was the predominant sugar and hence responsible for most of the sweetness of fully mature squash. On a fresh weight basis sucrose levels increased as much as 5-fold during on-vine maturation, whereas glucose and fructose levels remained relatively constant.
- ((* Total sugar levels increased up to 2-fold during a 4-week postharvest storage period.
- * Starch levels were lower in Pukekohe squash than in Hawke's Bay and Lincoln squash, as were total dry matter levels. Starch levels accounted for between 30 and 65% of flesh dry matter, depending on location. Starch levels increased rapidly during early stages of maturity, slowed down and then fell as time on the vine continued.
- * Starch levels dropped substantially in squash from all sites during storage. Starch conversion to sucrose seems to be responsible for the postharvest sweetening of squash.
- * Carotenoid levels increased with both on-vine maturity and postharvest storage. Pukekohe squash tended to have higher carotenoid levels than Hawke's Bay and Lincoln squash, particularly in earlier-harvested squash.

These findings suggest that, although both squash sweetness and colour are influenced by climatic conditions as a consequence of geographic location, it should be possible to largely overcome these by harvesting and postharvest strategies. For example, squash grown in Canterbury may need more storage and perhaps some extra postharvest warmth, compared with Pukekohe grown squash, to attain acceptable sweetness and colour levels.

Enhanced postharvest conversion of the large reserves of starch into sugars offers potential for greatly increasing the sweetness of New Zealand grown buttercup squash. Technology to achieve this is not currently available, and should be the focus of future research work. As a dry texture is also considered desirable, total dry matter would need to be monitored alongside sweetness development.

Sweetness and colour of buttercup squash
A report prepared for New Zealand Buttercup Squash Council
W Harvey, P Hurst, P Hannan
FoodInfo Confidential Report No. 70
New Zealand Institute for Crop and Food Research Limited

2 INTRODUCTION

The New Zealand squash industry exports mainly to Japan. Taste and colour are quality factors important for marketing squash in Japan, and it is crucial that these factors meet consumers' expectations. Currently, there is a suggestion that fruit from New Zealand is not as sweet as that from Mexico.

Sweetness arises from the level of sugars (glucose, fructose and sucrose) in the flesh, and because the sweetness factor of these individual sugars is not the same (glucose is only half as sweet as sucrose and fructose is 1.2 times as sweet as sucrose), sweetness will be determined not only by the total level of sugars but also by the proportions of the different sugars. In other crops, sweetness can be influenced by other factors such as climatic conditions and conversion of starch reserves into sugars during pre- and postharvest maturation. Although some work has been done on the effects of maturity and storage on the sugar composition of New Zealand 'Delica' squash, none has been done the effects of these parameters on starch levels.

Squash owe their flesh colour to the group of pigments called carotenoids. Whilst overseas studies have reported that the carotenoid content of squash increases after harvest, there is no information on the effect of fruit maturity on this postharvest increase. Moreover, some of the carotenoids in squash have vitamin A activity, so it is important from both visual appeal and nutritional standpoints to examine those factors that might influence the carotenoid content of New Zealand grown squash.

3 APPROACH

* In the 1993-94 squash season, we obtained 'Delica' squash grown at three Crop & Food Research locations - Pukekohe, Hawke's Bay, and Lincoln - representing three of the regions of commercial squash production. To study the effect of on-vine maturation, we tagged squash at flowering and then harvested them at 10-day intervals from 30 days after flowering (daf) up to 70 daf. These squash were sent to Lincoln at ambient temperature and tested 1 week from harvest ('at harvest' in the graphs). To study the effect of storage, we tested similar aged squash after a total of 4 weeks in storage (1 week at ambient 15-20°C plus 3 weeks at 14°C; 'stored' in the graphs) to simulate the time spent taken to travel from New Zealand to Japan.

At each designated time, we took individual flesh samples of 4 squash and freeze-dried them. We measured the starch, glucose, fructose and sucrose levels by standard enzymatic methods. We extracted the carotenoids with an organic solvent and measured their concentration in the yellow-orange extracts using a spectrophotometer. All concentrations in the graphs are displayed on a dry weight basis and are the average of 4 squash with the degree of uncertainty about the averages represented by the lines above the bars.

Sugars

Total sugar (glucose + fructose + sucrose) levels are shown in Figs. 1-3.

At harvest, levels were higher in Pukekohe squash than in squash from Hawke's Bay or Lincoln. These results suggest a climatic influence, as confirmed by meteorological data from the three sites.

Total sugar levels at harvest tended to rise with on-vine maturity at Pukekohe. At the other two sites, although total sugars at harvest appear relatively constant, they are in fact increasing because of a marked increase in dry matter with increasing maturity. We found that during on-vine maturation the sugar composition changed markedly (data not shown). Glucose and fructose levels remained the same, whereas sucrose increased. In early-harvested squash (30 daf) glucose and fructose levels were higher than sucrose levels; at 40 daf they were about equal; in late-harvested squash sucrose predominated.

Over and above this on-vine maturity effect, there was a postharvest effect. Irrespective of daf, the levels of all sugars increased after storage. In Hawke's Bay and Lincoln squash this increase was about 2-fold. In squash from Pukekohe, the postharvest increase was less but total sugars still accounted for 28-30% of dry matter. These results indicate that a carbohydrate reserve was being mobilised into sugars. Generally, the pattern of more glucose and fructose than sucrose in early squash and more sucrose than glucose or fructose in late squash, seen in on-vine squash, was maintained in stored squash.

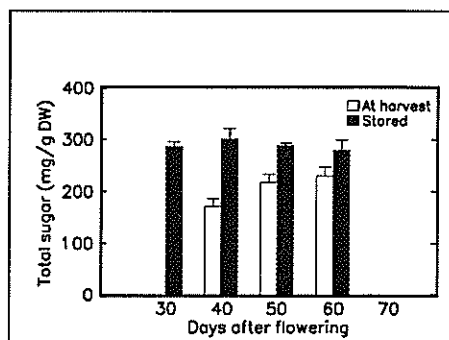


Figure 1. Total sugar levels in Pukekohe grown squash.

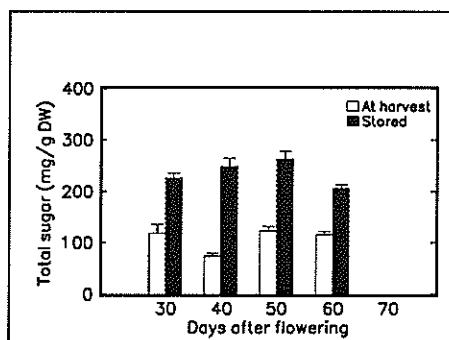


Figure 2. Total sugar levels in Hawke's Bay grown squash.

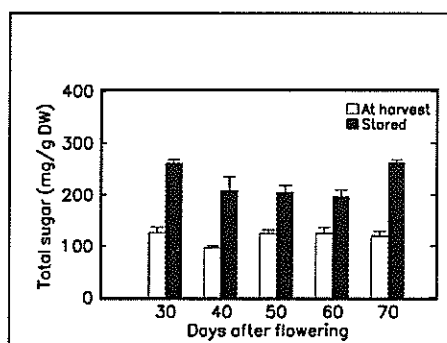


Figure 3. Total sugar levels in Lincoln grown squash.

Starch

Squash starch levels are shown in Figs. 4-6.

At all sampling times, we found starch levels in Pukekohe squash at harvest were lower than in both Hawke's Bay and Lincoln squash at harvest. In the former, starch accounted for around 30-50% of dry matter, whereas in squash from the two latter sites the starch content was around 50-65% of dry matter. Starch levels dropped with increasing on-vine maturity in Pukekohe, as the fruit began to behave like stored fruit, but this trend was less apparent in Hawke's Bay and Lincoln.

Irrespective of daf, we found the starch level in Hawke's Bay and Lincoln squash decreased markedly after storage. In Pukekohe squash there was a substantial decrease in starch content of 40 daf-stored squash but with 50 and 60 daf squash storage had no effect on starch levels. However, the starch levels in these squash were still less than levels in corresponding Hawke's Bay and Lincoln squash.

Overall, our sugar and starch results indicate that the interconversions of sugars and the mobilisation of starch into sugars are complex during both on-vine and off-vine maturation. However, it seems reasonably clear that the well-established increase in sweetness of squash maturing on the vine is due to a redistribution of sugars towards sucrose as well as an increase in total sugar. On the other hand, postharvest sweetening seems to result from conversion of starch into sugars, predominantly sucrose.

We suggest that both squash maturity and postharvest conditions could be managed to maximise sugar levels.

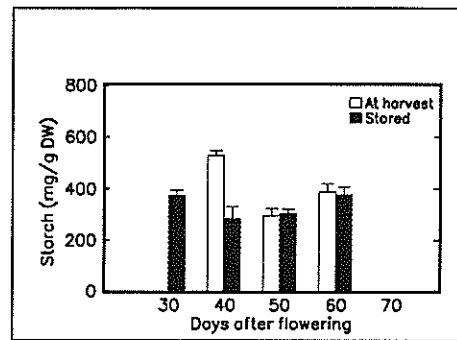


Figure 4. Starch levels in Pukekohe grown squash.

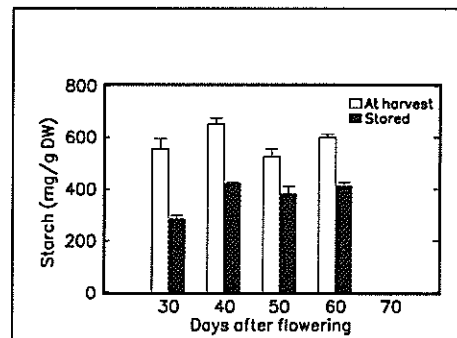


Figure 5. Starch levels in Hawke's Bay grown squash.

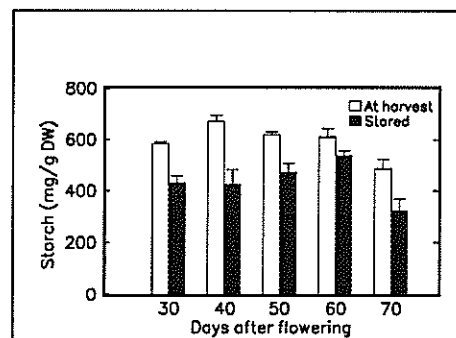


Figure 6. Starch levels in Lincoln grown squash.

Carotenoids

Carotenoid levels of squash grown in Pukekohe, Hawke's Bay and Lincoln are shown in Figs. 7-9.

We found that the carotenoid content of squash flesh increased with increasing on-vine maturity at all sites. For example, 70 daf squash from Lincoln had three times the level of 30 daf squash. The carotenoid content of Pukekohe squash did not increase to the same extent during on-vine maturation as at the other two sites but Pukekohe squash had higher levels than did similar aged squash from Hawke's Bay and Lincoln. These results suggest a climatic/maturity effect on carotenoid synthesis.

The carotenoid content of squash from all three sites and from all harvest times increased with storage. We found the highest levels in Pukekohe 60 daf-stored squash, followed by Lincoln 70 daf-stored squash. The 60 daf-stored squash from Hawke's Bay appear anomalous (Fig. 8) in that the carotenoid level is less than 50 daf-stored squash. However, we believe that, for some reason, the 60 daf squash behaved like less mature squash, as evidenced by the higher starch level (Fig. 5) in these squash compared with 50 daf squash.

From these carotenoid measurements, we conclude that carotenoid synthesis in squash is possibly influenced by climatic conditions but it is certainly influenced by maturity and certainly continues after harvest.

Accordingly, we suggest there is potential to maximise squash flesh colour by both harvesting and postharvest strategies.

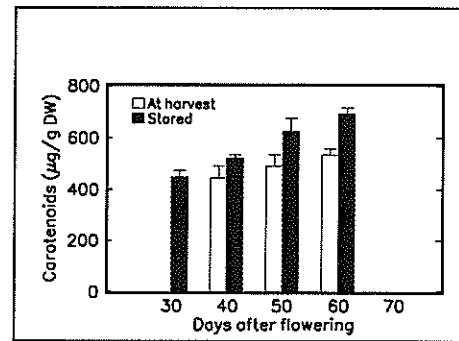


Figure 7. Carotenoid levels in Pukekohe grown squash.

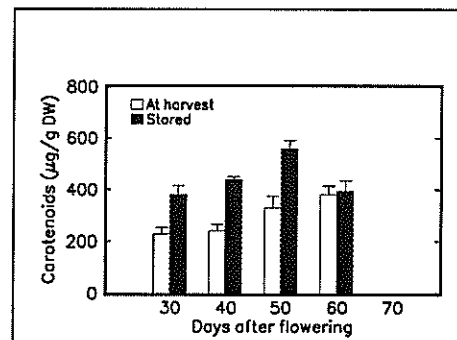


Figure 8. Carotenoid levels in Hawke's Bay grown squash.

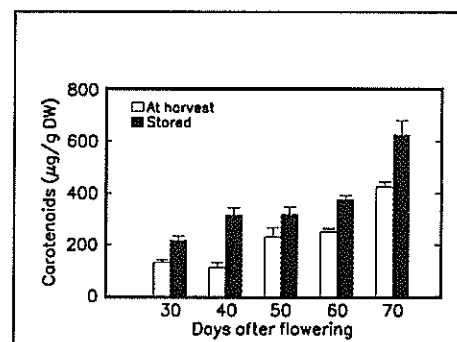


Figure 9. Carotenoid levels in Lincoln grown squash.

4 CONCLUSIONS

We found differences in sugar, starch and carotenoid levels of squash grown in three sites in New Zealand. Generally, Pukekohe grown squash of a given age (days after flowering) were sweeter, with more sugar and less starch, than squash of a similar age from Hawke's Bay and Lincoln. Squash from Pukekohe also had more carotenoids, giving rise to more deeply coloured flesh, than squash from the other two sites.

We believe these differences are due mainly to differences in maturity of the crops, as a consequence of climatic differences, rather than non-climatic differences in geographic location (e.g. soil type and fertility, water availability, etc.). Although the squash were harvested at the same number of days after flowering at the different sites, they were not equally mature because the crops had received widely differing amounts of warmth during their growth (growth-degree-days, GDD). For example, 30 daf squash from Pukekohe is roughly equivalent, in GDD received, to 40 daf Hawke's Bay and 50 daf Lincoln squash.

What this means is that Pukekohe squash at harvest had more sugar and were of a deeper flesh colour simply because they had received more warmth than had squash from the other sites. Squash from Hawke's Bay and Lincoln, once they had reached a certain on-vine age had the potential to sweeten and colour-up in storage.

Fruit from Hawke's Bay and Lincoln do not appear as mature at harvest as fruit of similar age from Pukekohe. However, because of the very large improvements which occur in both sweetness and colour during transport to Japan, these changes should be considered when fruit from these areas is being graded for export.

Collectively, our findings indicate, that while both squash sweetness and colour are influenced by geographic location, it should be possible to largely overcome this influence by harvest and postharvest strategies. Squash grown in cooler, southern locations will need longer on-vine maturation and/or postharvest storage than squash grown in warmer, northern locations.

Fully-mature New Zealand grown squash, even those from Pukekohe, have a large pool of starch. Enhanced postharvest conversion of some of this starch into sugars offers potential for increasing the sweetness of New Zealand buttercup squash. Technology to achieve this is not currently available - but it should be the focus of future research.