Research demonstrates not so sweet berries under high temperatures on the Sunshine Coast

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- Sugars are a major component of flavour and taste in strawberries.
- Higher temperatures decreased the levels of sugar in berries when the plants were grown on the Sunshine Coast.
- Efforts need to be made to develop heat-tolerant cultivars with high and stable concentrations of sugar.

The quality of strawberry is strong related to the levels of sugars, acids and volatiles in the fruit. Quality is expected to decrease under global warming due to the impact of higher temperatures on the chemistry of the berries. Experiments were conducted to determine the effect of temperature on soluble solids content (SSC) on the Sunshine Coast. There was a strong relationship between SSC and temperatures in the eight days before the fruit were harvested. Soluble solids content decreased from 8.6 to 6.8% as the average daily mean temperature increased from 14.5° to 19.5°C. There is an urgent need to develop heat-tolerant cultivars with high sugar levels at the end of the season.

The main scenarios for global climate change include an increase in the concentration of carbon dioxide (CO_2) and an increase in average temperatures. Higher temperatures will affect many aspects of growth and development in strawberry. Fruit quality is strongly related to the levels of sugars, acids and volatiles in the berries. For instance, studies by Oohashi and colleagues (2018) in Japan demonstrated that fluctuations in the taste of strawberry were due to variations in soluble solids content (SSC) of the fruit across different inflorescences.

Research conducted overseas has indicated that sugar levels are often lower after periods of warm weather. This article explores the relationship between fruit sugars and temperature on the Sunshine Coast. Plants were grown at Nambour and information collected on yield and fruit quality over the season. The results of the experiment showed that SSC decreased as the temperature before harvest increased.

What we did

An experiment was conducted to investigate the relationship between fruit sugars and temperature in strawberry on the Sunshine Coast. Plants of five cultivars (‘*Strawberry Festival*’, ‘*Florida Fortuna*’ (‘*Florida Radiance*’), ‘*Florida Brilliance*’, ‘*Florida Beauty*’ and ‘*Red Rhapsody*’) were planted in the open field at Nambour in April 2021. Information was collected on marketable yield, average fruit fresh weight, and soluble solids content (SSC) and titratable acidity (TA) in the fruit from July to October. Additional information was collected on the concentration of the main fruit sugars (fructose, glucose and sucrose) from August to October. Fruit that weighed less than 12 g fresh weight were considered non-marketable. Data were also collected on maximum and minimum temperatures, solar radiation and rainfall at the site.

What we found

The average daily maximum temperature from April to October in 2021 ranged from 21.9° to 28.4°C, while the average daily minimum temperature ranged from 10.3° to 16.9°C. Average daily solar radiation ranged from 12.3 to 20.8 MJ/m^2 and total monthly rainfall ranged from 4 to 190 mm. Maximum temperatures were close to the long-term values, whereas minimum temperatures were 2° to 4°C higher than the long-term values. Average monthly solar radiation was similar in the two periods. It was drier in June, August, September and October in 2021 compared with the long-term data.

1.

2.

Figure 1. Ripe and unripe strawberry fruit - fruit sugars increase as the fruit ripen.
Figure 2. Warm weather decreases fruit size and fruit sugars.
Photo credit : QDAF.

The five cultivars had different productivity and fruit quality (Table 1). Marketable yield was lower in '*Florida Beauty*' and higher in the other cultivars. Average fruit fresh weight was lower in '*Strawberry Festival*', '*Florida Fortuna*' and '*Florida Beauty*' and higher in '*Florida Brilliance*' and '*Red Rhapsody*'. There were only small differences in average seasonal soluble solids content (SSC) and titratable acidity (TA) across the five cultivars (Table 1). Mean (± SE or standard error) SSC pooled across the five cultivars was 7.6 ± 0.05% and mean TA was 0.59 ± 0.005%.

Fructose (mean ± SE of 30.2 ± 0.2 mg/g FW) and glucose (27.1 ± 0.3 mg/g FW) were the main sugars in the fruit, with lower concentrations of sucrose (0.05 ± 0.02 mg/g FW) and maltose (less than 1 mg/g FW). The mean concentration of all the sugars was 57.4 ± 0.5 mg/g FW. Overall, fructose accounted for 52.8 ± 0.1 % of all the sugars. There was a strong linear relationship between SSC and total sugars ($P < 0.001$, $R^2 = 0.77$). Soluble solids content increased as the concentration of all the sugars increased. Values of R^2 in linear regressions range from zero (no relationship) to one (strong relationship).

Soluble solids content decreased over the season, with an increase at the last harvest ($P < 0.001$, $R^2 = 0.77$). There was a strong negative relationship between SSC and temperatures in the eight days before the fruit were harvested (Figure 1; $P < 0.001$, $R^2 = 0.72$).

Soluble solids content decreased from 8.6 to 6.8% as the average daily mean temperature increased from 14.5° to 19.5°C. Data from the last harvest were excluded from this analysis.

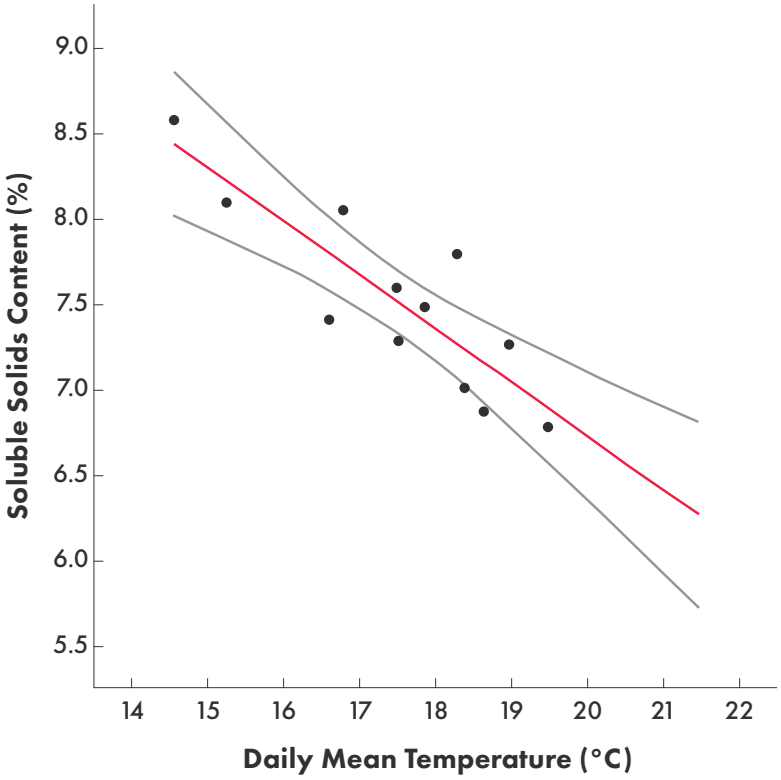
Plant growth and cropping can affect sugar levels. However, plant growth was stable over the last few harvests and not declining. Weekly yields were also lower in the last harvests. These results suggest that changes in plant growth and cropping are not responsible for the low sugar levels at the end of the season.

Conclusions

Fruit quality in strawberry is strongly related to the levels of sugars, acids and volatiles in the berries. There was a strong relationship between soluble solids content (SSC) and temperatures in the eight days before the fruit were harvested. Soluble solids content decreased from 8.6 to 6.8% as the average daily mean temperature increased from 14.5° to 19.5°C. These data agree with the results of studies conducted overseas. For instance, Davik et al. (2006) examined the performance of ten cultivars across eight experiments in Norway. They found that there were strong negative relationships between sugar content and maximum ($P = 0.030$) and minimum temperatures ($P = 0.002$). P values in a regression below 0.05 indicate a significant relationship between the two variables.

Table 1. Variations in total marketable yield, and mean seasonal average fruit fresh weight, fruit soluble solids content (SSC) and fruit titratable acidity (TA) in five strawberry cultivars in Queensland. Average seasonal fruit fresh weight is the long-term average value of fruit weight in a cultivar pooled across all harvests (marketable fruit). Fruit weighing less than 12 g were non-marketable. Data are the means of six replicates per cultivar and were collected from 14 July to 6 October.

Cultivar	Marketable yield (g/plant)	Average fruit fresh weight (g)	Soluble solids content (%)	Titratable acidity (%)
Strawberry Festival	493	21.2	7.9	0.63
Fortuna (Florida Radiance)	483	22.5	7.2	0.57
Florida Beauty	367	21.5	8.2	0.61
Florida Brilliance	440	23.8	7.1	0.54
Red Rhapsody	507	25.0	7.5	0.61



Lower sugar levels under higher temperatures probably reflect higher respiration in the fruit under warm nights and quicker fruit development under warm days and nights.

There is an urgent need to develop heat-tolerant cultivars with high sugar levels at the end of the season.

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Queensland Government

Figure 1. Relationship between soluble solids content (SSC) and average daily mean temperature in the eight days before the fruit were harvested in Queensland. SSC = 12.99 – 0.3132 × Temperature ($P < 0.001$, $R^2 = 0.72$, $N = 12$). Data are the means of five cultivars with six replicates per cultivar. Black lines show 95% confidence intervals. The value from the last harvest was excluded from the analysis.