

Starch synthesis in strawberry fruit

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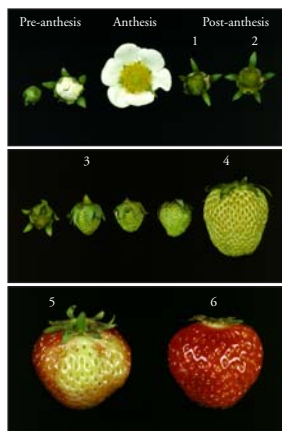
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Introduction

The physiology and biochemistry underlying carbohydrate metabolism in ripening strawberry fruits has not been addressed in detail. Likewise, the role of starch and its contribution to strawberry fruit quality has not been investigated. The research presented here aims to understand the potential role of starch synthesis and breakdown in contributing to the overall quality and sweetness of the end product.



Six different ripening stages (RS) of Strawberry cv. Elsanta were examined covering the range from immature green fruit (RS 1, c. 5 mm diameter, 7 days after anthesis) through to small green (RS 2, 12 days), mature green (RS 3, 18 days), white (RS 4, 22 days), pink (RS 5, 31 days) and red ripe stages (RS 6, 40 days).

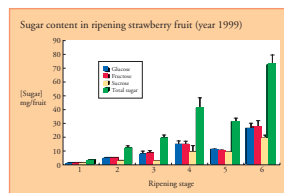
Conclusion

From the starch measurement studies, it can be estimated on all fruit basis that starch breakdown could contribute up to 2.5% of the sugar accumulation in ripe strawberry fruit. Light microscopy also revealed that the highest density of starch granules is located in the cortex of the immature fruit. ^{14}C -labelling experiments revealed that decline in starch appear to be independent of the rate of synthesis. Further work on the regulation of turnover is imperative. ADP-glucose pyrophosphorylase and fructokinase proteins, key enzymes of carbohydrate metabolism are present at all stages. In contrast sucrose synthase activity increased to mature green fruit and then declined as ripening progressed. This work shows, for the first time, the ripening stage-specific accumulation and utilisation of starch reserves during strawberry fruit ripening.

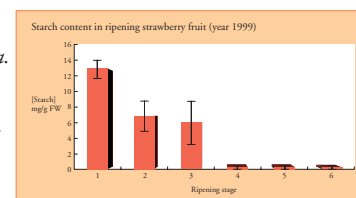
Acknowledgements
E. Benson, R. Hancock, Alison Roberts, R Viola, B. Williamson.
The work is funded by SERAD

Results

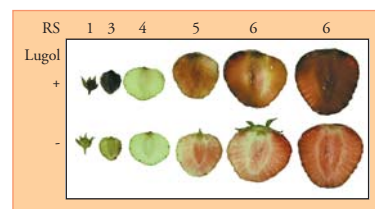
Frozen strawberry fruit (-80°C) were ground and soluble sugars were extracted with 80% ethanol. Sucrose and hexose sugar concentrations were quantified from the supernatant by High Performance Anion Exchange Chromatography. The remaining insoluble pellet was gelatinised and digested by amyloglucosidase for measurement of starch. Results revealed that the concentration of glucose, fructose and sucrose increased during fruit ripening.



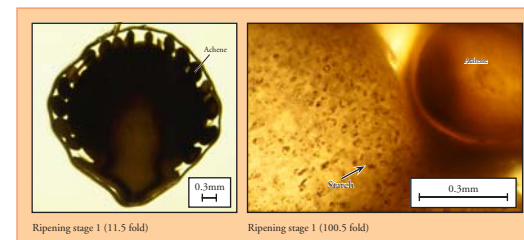
In contrast starch levels decreased by ca. 50% between RS 1 and RS 2, then reduced dramatically to a low level well before visible ripening.



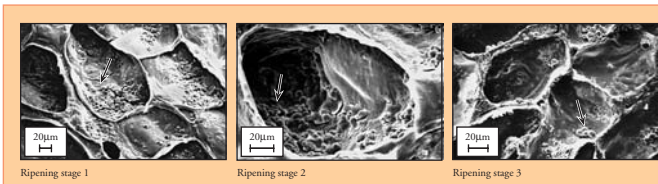
Starch specific staining (using Lugol solution) was carried out on the cut surface of halved fresh strawberry fruits at different ripening stages. The staining intensity was highest at the immature stage and decline as fruit ripened.



The examination of Lugol stained fruit sections under low magnification (11.5 fold) by light microscopy revealed that starch was localised mainly in the fruit cortex at RS 1. Higher magnification (100 fold) indicated starch was predominantly near the achenes in the cells layers immediately below the epidermis.

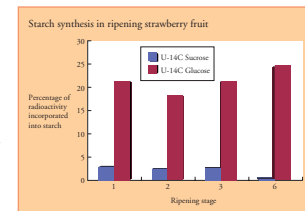


Scanning electron microscopy (SEM) studies of frozen microtome fruit sections show that starch granules are present within the cells of immature fruits at RS 1, RS 2 and RS 3. These granules were of a circular form (5-10 μm diameter). Of all the cells examined 90% of the fruit cells at RS 1 and 2 contained granules, compared to 25% of the RS 3 fruit cells. In addition, the number of granules per aggregate in the cells of RS 3 was also decreased.



Labelled starch precursors [^{14}C] glucose and [^{14}C] sucrose were supplied to strawberry fruit discs to monitor the rate of starch synthesis.

The percentage of [^{14}C] glucose incorporated into starch was greater than from sucrose. The rate of starch biosynthesis for [^{14}C] glucose and [^{14}C] sucrose did not alter significantly as fruit ripened.



To assess the presence or absence of enzymes on the starch biosynthetic pathway, Western blot and enzymatic analyses were performed. Fructokinase and sucrose synthase activity patterns are supported by western blot analysis (lanes loaded on μg (gFW)). ADP-glucose pyrophosphorylase protein was detected in all fruit ripening stages.

