AWC_11/15_J005590

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How do we make kiwifruit taste nicer?

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Introduction

Flavour is a key aspect of fruit quality and is generally defined as a combination of aroma and taste sensations. While the roles of sugars and acids in fruit flavour are well known and described, the roles of volatile compounds that contribute to flavour and odour are more difficult to define.

The genus *Actinidia*[1], commonly known as "kiwifruit", comprises more than 70 species from around the world. The two most important commercial varieties, *Actinidia chinensis* var *deliciosa* (green-fleshed fruit) and *A. chinensis* var *chinensis* (yellow-fleshed fruit), are grown widely in many countries.

The New Zealand Institute for Plant & Food Research Limited orchards have a number of novel *A. chinensis* var *deliciosa* (A.del) and *A. chinensis* var *chinensis* (A.chin) cultivars. Many of these fruit have superior flavour, high taste and good postharvest qualities. To breed better flavour and higher quality kiwifruit, assessment of flavour volatiles from these fruit and their comparison with the current commercialized cultivars is a key research area.

The aim of this project is to study 72 flavour volatile compounds and use them to help determine critical species.

Methods and Materials

Data collection:

Kiwifruit from 14 *A. chinensis* var *chinensis*, and 10 *A. chinensis* var *deliciosa* cultivars were harvested in the 2014 kiwifruit season at PFR orchards in Te Puke and Kerikeri. Nine kiwifruits (firm x 3, medium firm x 3 and soft x 3) of each cultivar were selected for volatile collection. Among the 24 cultivars, 72 volatiles were identified and analysed with solvent injection using GC-MS (gas chromatograph/mass spectrometry). The concentrations of volatile compounds were recorded for data analysis.

Data preparation and analysis:

1. Full data set structure:

Data Structure

factor 2 levels	factor 24 levels	factor 3 levels	factor 5 levels	numeric Conc. of compounds			
Species	Cultivar	Firmness	EthyFactor	C1	C2	...	C72
A.chin	A.C_1	F	0	0	0	...	6.01772E-06
A.chin	A.C_1	M	0	4.66096E-05	0	...	0
A.chin	A.C_1	S	0	5.00621E-05	0	...	0
A .del	A.D_1	F	0	0.003134926	0.647058824	...	0
A .del	A.D_1	M	(0-0.1]	0.017642591	0.319327731	...	0.001143366
A .del	A.D_1	S	(0.1-0.4]	0.085910095	0.18487395	...	0.12667473

2. The average volatile compound concentration collected from each firmness group of each cultivar has been normalized by dividing its max concentration across all cultivars.

3. A multilevel Partial Least Square Discriminant (PLS-DA) analysis was performed on the full data set to look for possible clusters (Fig. 1). A reduced dimension plot shows firm, medium firm and soft fruit are reasonably separated. The dataset has also been split by fruit firmness and each firmness group analysed separately.

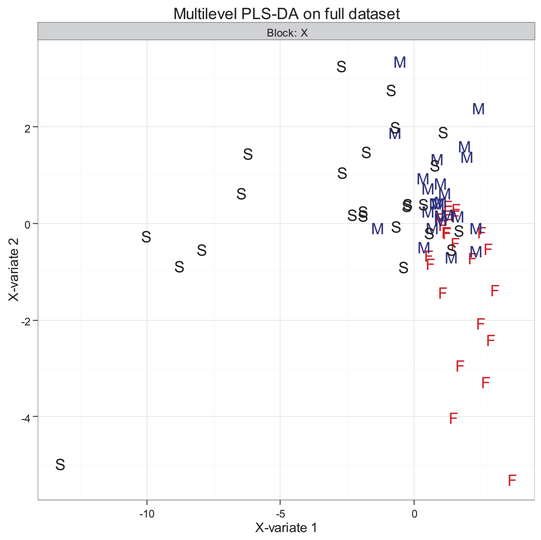

Figure 1: Reduced dimension plot from multilevel PLS-DA on the full dataset. Soft fruit and medium+ Firm fruit are well separated along dimension 1 (x-variate1), Firm and soft + medium fruit are well separated along dimension 2 (x-variate2).

4. A heat map for firm fruits were drawn to look for relatively dominant volatiles for each cultivar (Fig. 2).

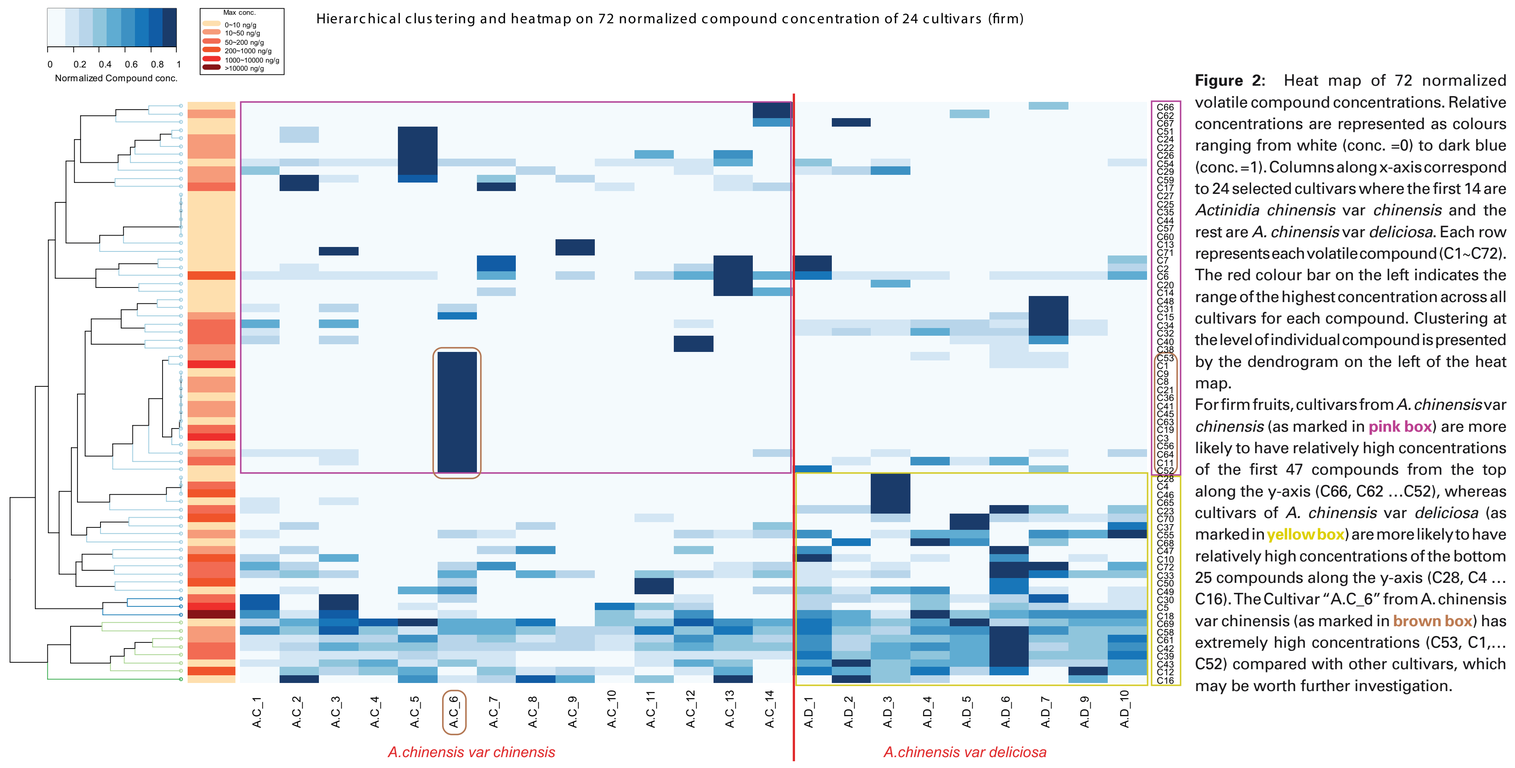

Figure 2: Heat map of 72 normalized volatile compound concentrations. Relative concentrations are represented as colours ranging from white (conc. =0) to dark blue (conc. =1). Columns along x-axis correspond to 24 selected cultivars where the first 14 are *Actinidia chinensis* var *chinensis* and the rest are *A. chinensis* var *deliciosa*. Each row represents each volatile compound (C1~C72). The red colour bar on the left indicates the range of the highest concentration across all cultivars for each compound. Clustering at the level of individual compound is presented by the dendrogram on the left of the heat map.
For firm fruits, cultivars from *A. chinensis* var *chinensis* (as marked in **pink box**) are more likely to have relatively high concentrations of the first 47 compounds from the top along the y-axis (C66, C62 …C52), whereas cultivars of *A. chinensis* var *deliciosa* (as marked in **yellow box**) are more likely to have relatively high concentrations of the bottom 25 compounds along the y-axis (C28, C4 … C16). The Cultivar "A.C_6" from A. chinensis var chinensis (as marked in **brown box**) has extremely high concentrations (C53, C1,… C52) compared with other cultivars, which may be worth further investigation.

5. Sparse-Partial Least Square Discriminant analysis (sPLS-DA) was undertaken for each subset to try to select dominant volatiles which separate the two species, example results for subset "firm fruits" are show on Fig. 3).

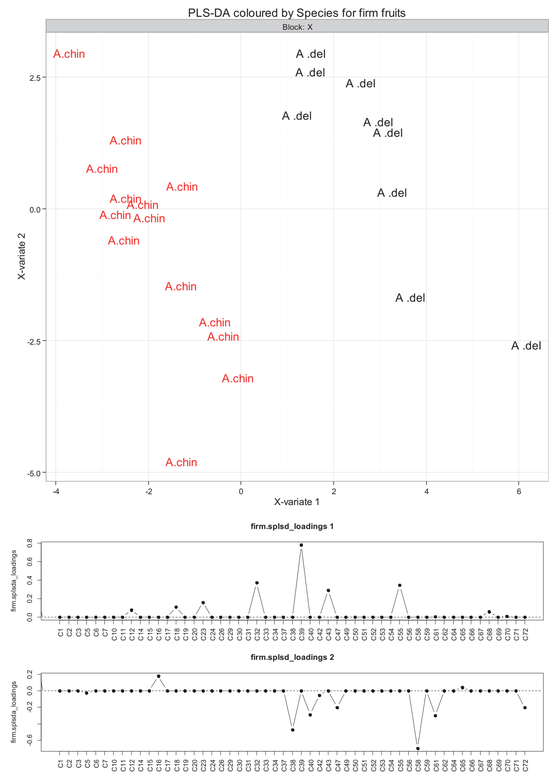

Figure 3: Top plot: PLS-DA sample plots for firm fruit, the two species clearly separate along dimension 1 (x-variate1); Bottom plot: Compound loading scores from the projected new dimensions 1 and 2. Peaks on each loading plot indicate dominant compounds.

Results

A. Volatile Compounds with a highest concentration bigger than 1000 ng/g FW are C1, C3, C5, C11, C18, C19, C21, C25, C29, C41, C45, C50, C53, C56 (summarized from Fig. 2).

B. In terms of distinguish the two species, dominant volatile compounds selected are C12, C18, C23, C32, C39, C43, C55, C61, C68, C70 (for firm fruits only, summarized from Fig.3).

A photo of the two kiwifruit species is shown below (Fig.4).

Figure 4: Left, fruit of *Actinidia chinensis var deliciosa* 'Hayward', the most important of all green-fleshed kiwifruit cultivars; Right, fruit of *Actinidia chinensis var chinensis* 'Hort16A' with almost hairless skin and bright gold flesh.

References

1. Ferguson AR 1990. The genus *Actinidia*. Kiwifruit: science and management. Auckland, Ray Richards in association with New Zealand Society for Horticultural Science 1990: 15–35.
2. R Core Team. 2012. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.
3. González I, et al. 2011. MixOmics: Omics data integration project. http://www. math. univ-toulouse. fr/~ biostat/mixOmics.

Conclusion and further work

Yellow-fleshed kiwifruit (*A. chinensis* var *chinensis*) have very different flavour from green-fleshed fruit (*A. chinensis* var *deliciosa*). This study has provided some indication of possible volatiles that are making the two species flavoured differently. More analysis need to be done to look for associations between volatiles, sensory profile and fruit attributes.

By studying the chemistry of volatile compounds along with its association with sensory and fruit attributes, it is possible to breed kiwifruit with better taste in the future.