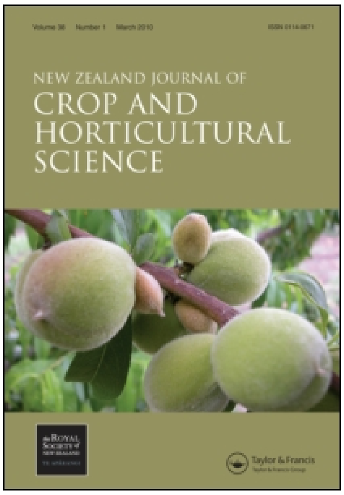
This article was downloaded by:
On: *2 August 2010*
Access details: *Access Details: Free Access*
Publisher *Taylor & Francis*
Informa Ltd Registered in England and Wales Registered Number: 1072954 Registered office: Mortimer House, 37-41 Mortimer Street, London W1T 3JH, UK



New Zealand Journal of Crop and Horticultural Science
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t918982744

Organic acid and sugar composition of three New Zealand grown tamarillo varieties (*Solarium betaceum* (Cav.))

Stewart Boyes[a]; Peter Strübi[a]
[a] Mt Albert Research Centre, The Horticulture and Food Research Institute of New Zealand, Auckland, New Zealand

Online publication date: 22 March 2010

To cite this Article Boyes, Stewart and Strübi, Peter(1997) 'Organic acid and sugar composition of three New Zealand grown tamarillo varieties (*Solarium betaceum* (Cav.))', New Zealand Journal of Crop and Horticultural Science, 25: 1, 79 — 83

To link to this Article: DOI: 10.1080/01140671.1997.9513990
URL: http://dx.doi.org/10.1080/01140671.1997.9513990

PLEASE SCROLL DOWN FOR ARTICLE

Full terms and conditions of use: http://www.informaworld.com/terms-and-conditions-of-access.pdf

This article may be used for research, teaching and private study purposes. Any substantial or systematic reproduction, re-distribution, re-selling, loan or sub-licensing, systematic supply or distribution in any form to anyone is expressly forbidden.

The publisher does not give any warranty express or implied or make any representation that the contents will be complete or accurate or up to date. The accuracy of any instructions, formulae and drug doses should be independently verified with primary sources. The publisher shall not be liable for any loss, actions, claims, proceedings, demand or costs or damages whatsoever or howsoever caused arising directly or indirectly in connection with or arising out of the use of this material.

New Zealand Journal of Crop and Horticultural Science, 1997, Vol. 25: 79–83
0114–0671/97/2501–0079 $2.50/0
© The Royal Society of New Zealand 1997

Short communication

Organic acid and sugar composition of three New Zealand grown tamarillo varieties (*Solanum betaceum* (Cav.))

STEWART BOYES
PETER STRÜBI
The Horticulture and Food Research Institute of New Zealand
Mt Albert Research Centre
Private Bag 92 169
Auckland, New Zealand

Abstract A study was made of three New Zealand grown tamarillo varieties—two red and one yellow. Fruit were analysed by high performance liquid chromatography for their sugar (sucrose, fructose, and glucose) and organic acid (citric and malic) content. The sweeter red variety, as assessed by the growers, 'Andys Sweet Red', had significantly higher sugar levels and sugar to acid ratio than the more astringent tasting 'Secombes Red', in agreement with the measured soluble solids and titratable acidity results. The yellow variety ('Goldmine') had high sugar and acid levels resulting in a sugar to acid ratio between that of the two red varieties.

Keywords tamarillo; organic acids; sugars

Downloaded At: 20:41 2 August 2010

INTRODUCTION

Tamarillo or tree tomato, known as *Cyphomandra betacea* (Cav.) Sendtn., has been transferred to *Solanum* and the equivalent name is now *Solanum betaceum* (Cav.) (Bohs 1995). Tamarillo is a semi-tropical fruit and grows well in northern New Zealand, in areas suitable for the growing of kiwifruit—Kerikeri, Bay of Plenty, and Gisborne. A study of the sugars and organic acids was done to account for taste differences noted by people in the tamarillo industry in three varieties: two red skinned varieties, 'Andys Sweet Red' and 'Secombes Red'; and one yellow skinned variety, 'Goldmine'. Tamarillo are an excellent source of vitamin A, B_6 (pyridoxine), C, and E (α-tocopherol) (Visser & Burrows 1983; Wills et al. 1986). Tamarillo have been described as three strains: yellow, red (red skin, yellow-orange flesh), and purple (red-purple skin, light orange flesh; El-Zeftawi 1979) but no named varieties have been analysed. Previous studies have looked at the differences between red and yellow tamarillo strains (Dawes & Callaghan 1970; Heatherbell et al. 1975; Wills et al. 1986). Interest in the development of new varieties has been maintained in tamarillo and recently a commercially successful cultivar has been named 'Red Beau' (Muggleston 1994).

A project was initiated in 1979 to produce a sweeter tamarillo for export (Williams 1984). Export of tamarillo reached a peak of 30 000–35 000 trays in 1990 from an annual production of 2000 t. Red and yellow tamarillo have been processed as juice, with interest in other processed products (Laurenson 1994).

H96028
Received 29 May 1996; accepted 8 November 1996

METHODS

Harvest and maturity indices

'Secombes Red' and 'Goldmine' fruit were harvested from one commercial orchard, whereas 'Andys Sweet Red' came from two orchards near Auckland, New Zealand. Fruit were picked in early August with attention given to the uniformity of colour within each variety. At harvest date the fruit were fully mature; the skin colour of the red varieties was fully developed with only traces of purple at the stem end of the fruit. The best maturity index for fruit maturity is colour (Lallu 1985; El-Zeftawi et al. 1988). The maturity of the red varieties was c. 24 weeks post-anthesis, based on the colour chart (Heatherbell et al. 1982). The yellow variety had a fully developed uniform golden-yellow skin, indicating full maturity at 24 weeks post-anthesis. Following transport to Auckland the fruit were kept at 4°C until preparation for analysis. All sample

Downloaded At: 20:41 2 August 2010

preparations were completed within 2 weeks of harvest and no fruit suffered low temperature scald or fungal damage.

The soluble solids (°Brix) and titratable acidity (TA) were determined on four individual fruit per variety. °Brix was measured by a handheld refractometer (Atago Model N1t) and TA was determined by titration with 0.1 mol/litre NaOH and expressed as g citric acid per 100 g fresh weight (FW) (International Federation of Fruit Juice Producers, Method no. 3, 1985).

Sample preparation

Fruit samples were prepared in a manner to preserve the sucrose content which involved the rapid inactivation of invertase. A transverse section including the skin was made with a sample borer, weighed (c. 1.5 g), and immediately immersed in liquid nitrogen. Seven sections from individual fruit were used per sample to give a total weight of c. 10.5 g. Following grinding to a smooth paste, the frozen sample was transferred to 200 ml of an extraction medium comprising 5:2:5 parts by volume of methanol, chloroform, and water (10.35 mol/litre methanol, 2.1 mol/litre chloroform; Redgwell 1980). Samples were stored frozen at −30°C until ready for analysis. Samples were homogenised by Ultra-Turrax for 30 s and spun in a refrigerated centrifuge at 1000*g* for 10 min. The supernatant was removed and a further 10 ml 12.4 mol/litre methanol was added to the precipitate. Homogenisation and centrifugation steps were repeated and the two supernatants combined. The sample was concentrated by vacuum evaporation at a maximum of 50°C and made up to the original fruit weight with millipored water and filtered through a Dynagard (Alltech) 0.2 µm cartridge directly to a high pressure liquid chromatography (HPLC) vial. Standards were added to some samples to test for efficiency of recovery. Recovery of the three sugars was consistent, with a variation from 90 to 95%, which was not taken into account in the calculation of results.

This preparation was also used for the analysis of organic acids. Twelve samples of each of 'Secombes Red' and 'Goldmine' varieties were analysed and 12 'Andys Sweet Red' samples from each of the two orchards. Sugars were determined using HPLC Zorbax-NH_2 column and measured by refractometer. HPLC analysis of organic acids by an Animex (Biorad) HPX–87C column with an identical double guard column gave baseline separation of citric and malic acids. Running conditions for the Animex column were an isocratic gradient of 2.88 mol/litre acetonitrile, 0.1 mol/litre calcium sulphate and pH adjusted to 2.5 with sulphuric acid. The column temperature was 80–85°C at a flow rate of 0.5 ml/min and acids were measured spectrophotometrically at 210 nm.

Statistical methods

The student *t*-test was used to calculate confidence levels. Variation of statistical deviation and differences in population numbers were assessed according to statistical analysis (Maindonald 1992). The relationship between some levels of sugars and acids were compared. The proportion of the variance of the Y response accounted for by the linear regression is quoted as the square of the coefficient of correlation (coefficient of determination). Data from 'Andys Sweet Red' fruit from the two orchards are not quoted separately as there were no significant differences in fruit composition between orchards.

RESULTS AND DISCUSSION

Fruit of equal maturity as assessed by skin colour and without injury were chosen for the analysis of soluble solids and TA and as a result showed a small range of values. The three varieties had a similar soluble solids content (measured as °Brix; Table 1). The TA of 'Andys Sweet Red' was 1.03 g/100 g FW; significantly lower than 'Secombes Red' and 'Goldmine' ($P < 0.001$). Titratable acidity of 2.1 and a °Brix to acid ratio of 4.7 in New Zealand grown tamarillo at eating ripeness (Dawes 1972) were significantly different from the three varietal levels recorded in this study. Italian grown tamarillo had TA of 2.10 and 2.26 at two harvest dates (Rotundo et al. 1983). The °Brix to acid ratio of 10.1 for 'Andys Sweet Red' would be expected to result in a sweeter taste than 'Secombes Red'.

HPLC organic acid analysis

'Andys Sweet Red' and 'Secombes Red' had similar levels of citric acid (Table 2), but 'Goldmine' had a significantly higher citric acid level than the two red varieties ($P < 0.05$). There was no significant difference between malic acid levels of the three varieties. Two small peaks were not identified but these peaks did not correspond to the elution times of tartaric, oxalic, or galacturonic acids. Traces of quinic and fumaric acids were found in all varieties. There was a weak correlation between citrate and malate levels for the red varieties ('Andys Sweet

Table 1 Soluble solids (°Brix) and titratable acidity (g citric acid/100 g fresh weight) of tamarillo (*Solanum betaceum*) varieties.

		Range	SD (n–1)	°Brix/acid
	°Brix			
Andys Sweet Red	10.40	10.1–10.5	0.17	10.1
Secombes Red	10.50	10.3–10.8	0.21	6.6
Goldmine	10.85	9.9–12.0	0.76	6.9
	TA			
Andys Sweet Red	1.03 [a]	0.99–1.08	0.03	
Secombes Red	1.60	1.51–1.71	0.08	
Goldmine	1.57	1.48–1.62	0.06	

[a]Lower than 'Secombes Red' and 'Goldmine' ($P < 0.001$).

Table 2 Organic acids (g /100 g fresh weight) of tamarillo (*Solanum betaceum*) varieties.

		Range	SD (n–1)
	Citric		
Andys Sweet Red	1.27	0.77–1.79	0.24
Secombes Red	1.35	0.85–1.80	0.28
Goldmine	1.71[a]	1.02–2.08	0.76
	Malic		
Andys Sweet Red	0.14	0.08–0.21	0.03
Secombes Red	0.13	0.07–0.17	0.03
Goldmine	0.15	0.08–0.21	0.04

[a]Higher than 'Andys Sweet Red' and 'Secombes Red' ($P < 0.05$).

Downloaded At: 20:41 2 August 2010

Red', $r^2 = 0.574$ and 'Secombes Red', $r^2 = 0.602$), but no significant correlation between these two acids in the 'Goldmine' samples. As in previous studies, citric and malic acid accounted for >95% of all organic acids (Heatherbell et al. 1975; Wills et al. 1986). 'Goldmine' had similar citrate levels to a study on New Zealand grown fruit by Wills et al. (1986).

Average malic acid levels by Wills et al. (1986) were slightly higher: 0.17 g/100 g fruit compared to an average of 0.14 g/100 g for the three varieties. This difference would not be accounted for by the maturity of the fruit, as from 20 to 25 weeks post-anthesis, tamarillo lose c. 10% of the citric and malic acids (Heatherbell et al. 1982). The citrate content of red tamarillo was significantly higher than that found in yellow tamarillo (Heatherbell et al. 1975) but similar citrate levels were found in red and yellow Spanish-grown tamarillo (Romero-Rodriguez et al. 1994).

Bitterness is also modulated by anthocyanins and has been suggested as the reason that yellow varieties with low anthocyanin levels are generally perceived as sweeter than reds (Heatherbell et al. 1982). Tamarillo at 16 weeks post-anthesis have similar levels of acids and sugars as at maturity, but are inedible, probably because of the high anthocyanin content (Heatherbell et al. 1982).

Sugar analysis

There was no significant difference between the fructose levels of the three varieties (Table 3) but higher glucose levels were measured in 'Goldmine' than in the two red varieties ($P < 0.05$). All varieties had 30% higher fructose than glucose levels (Fig. 1). There was a close correlation between the fructose and glucose levels of all varieties, but no significant correlation of fructose or glucose with sucrose levels for all varieties. The major difference in sugar composition was the lower sucrose levels of 'Secombes Red' compared to the other varieties ('Andys Sweet Red', $P < 0.001$ and 'Goldmine', $P < 0.005$). As a result 'Secombes Red' had a lower total sugar content (2.72) than 'Andys Sweet Red' (3.67) and 'Goldmine' (3.95 g/100 g).

The ratio of fructose plus glucose to sucrose, (F+G)/S, (Table 3) showed 'Secombes Red' had a significantly higher value than 'Andys Sweet Red' and 'Goldmine' ($P < 0.01$). The sugar to acid ratio of 'Andys Sweet Red', defined as (fructose + glucose + sucrose)/(citric + malic acids), was significantly higher than that measured in 'Secombes Red', in agreement with the °Brix to TA ratio.

Sugar levels of the red and yellow tamarillos were lower than in a study by Heatherbell et al. (1975). Higher glucose than fructose levels were found during growth from 16 to 25 weeks and individual and total sugar levels did not change markedly in the maturation period from 20 to 25 weeks (Heatherbell et al. 1982). New Zealand grown

Table 3 Sugar levels (g /100 g fresh weight) of tamarillo (*Solanum betaceum*) varieties. (f/g = fructose/glucose; sugar/acid = (fructose+glucose+sucrose) /(malic+citric).)

		Range	SD (n–1)	f/g	(f+g)/s	Sugar/acid
	Fructose					
Andys Sweet Red	1.079	0.750–1.412	0.247	1.423	1.019	2.60[d]
Secombes Red	0.910	0.615–1.246	0.223	1.302	1.581[c]	1.84
Goldmine	1.139	0.825–1.456	0.246	1.239	1.169	2.15
	Glucose					
Andys Sweet Red	0.774	0.489–1.226	0.232			
Secombes Red	0.707	0.454–0.972	0.193			
Goldmine	0.923[a]	0.682–1.144	0.159			
	Sucrose					
Andys Sweet Red	1.813	1.358–2.242	0.253			
Secombes Red	1.100[b]	0.604–1.657	0.325			
Goldmine	1.891	1.125–2.979	0.614			

[a]Higher than 'Andys Sweet Red' and 'Secombes Red' ($P < 0.05$).
[b]Lower than 'Andys Sweet Red' and 'Goldmine' ($P < 0.005$).
[c]Higher than 'Andys Sweet Red' and 'Goldmine' ($P < 0.01$).
[d]Higher than 'Secombes Red' ($P < 0.01$).

Downloaded At: 20:41 2 August 2010

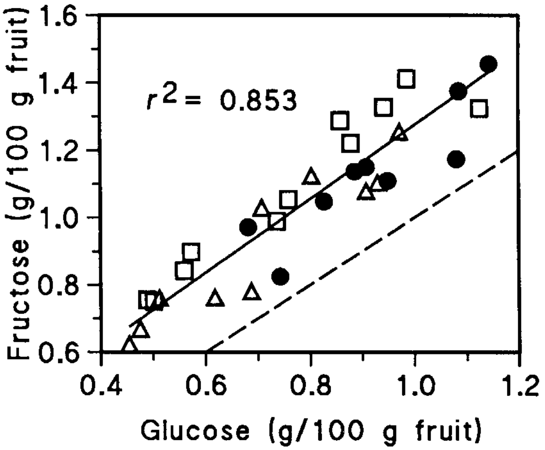


Fig. 1 Correlation of fructose and glucose levels. Fructose to glucose ratio was consistent for all three varieties of tamarillo (*Solanum betaceum* (Cav.)) with a significant coefficient of determination of 0.853. Dashed line shows equal fructose to glucose concentration level. □, 'Andys Sweet Red'; △, 'Secombes Red'; ●, 'Goldmine'.

tamarillo had fructose, glucose, and sucrose levels of 0.9, 0.8, and 1.7 g/100 g fruit (Wills et al. 1986), similar to an average of the three varieties in this study. Italian tamarillo showed slightly increased levels of the three sugars compared to New Zealand grown fruit (Rotundo et al. 1983).

Tamarillo at eating ripeness have low total sugars in comparison to other semi-tropical and tropical fruits (Wills et al. 1986). Kiwifruit which are known for their fruity slightly acidic flavour have a 2.5-fold total sugar content compared to tamarillo. Sugars, in 15% solution, have been given a relative sweetness of sucrose 100, fructose 150–160, and glucose 70–80 (Pancoast & Junk 1980). On this basis, 'Andys Sweet Red' would have a "sweetness index" of 410, 'Secombes Red' 310, and 'Goldmine' 440. In comparison kiwifruit have a sweetness index of 900–1100, pineapple 880, mango 1360, and banana 2000 (calculated from sugar levels; Wills et al. 1986).

CONCLUSION

The breeding of new tamarillo varieties may produce fruit which have a significantly different chemical composition and taste. There were no significant differences in any organic acid or sugar level of 'Andys Sweet Red' fruit harvested from two orchards. Whereas previous studies have compared only the red and yellow strains of fruit, this study has shown that there are significant compositional differences between two red varieties.

REFERENCES

Bohs, L. 1995: Transfer of *Cyphomandra (Solanaceae)* and its species to *Solanum*. *Taxon 44*: 583–587.

Dawes, S. 1972: Processing potential and composition of New Zealand sub-tropical fruits. *Food technology in New Zealand, April*: 22–23.

Dawes, S.; Callaghan, M. 1970: Composition of New Zealand fruit. 1. Tamarillo (*Cyphomandra betaceae* (Cav.) Sendt.). *New Zealand journal of science 13(3)*: 447–451.

El-Zeftawi, B.; Brohier, L.; Dooley, L.; Goubran, F.; Holmes, R.; Scott B. 1988: Some maturity indices for tamarillos and pepino fruits. *Journal of horticultural science 63(1)*: 163–169.

El-Zeftawi, B. 1979: Tamarillos. *Agnote,* Victoria. Department of Agriculture. Report no. 864/79.

Heatherbell, D.; Reid, M.; Wrolstad, R. 1982: The tamarillo: chemical composition during growth and maturation. *New Zealand journal of science 25*: 239–243.

Heatherbell, D.; Surawski, J.; Withy, L. 1975: Identification and quantitative analysis of sugars and non-volatile acids in tamarillo fruit (*Cyphomandra betaceae*). *Confructa 20*: 17–22.

International Federation of Fruit Juice Producers 1985: Zug. Switzerland. Method no. 3.

Lallu, N. 1985: Best maturity index for tamarillos is colour. *Horticultural news 6(12)*: 23.

Laurenson, W. 1994: A new look at tamarillo processing. *The orchardist 67(7)*: 50–52.

Maindonald, J. 1992: Statistical design, analysis, and presentation issues. *New Zealand journal of agricultural research 35*: 121–141.

Muggleston, S. 1994: Feijoa and tamarillo cultivars developed by HortResearch. *The orchardist 67(7)*: 47–49.

Pancoast, H.; Junk, R. 1980: Pp. 387–389 *in*: Handbook of sugars. Conn., United States, AVI Publ. Company Inc.

Redgwell, R. 1980: Fractionation of plant extracts using ion-exchange sephadex. *Analytica biochemica 107*: 44–50.

Romero-Rodriguez, M.; Vazquez-Oderiz, M.; Lopez-Hernandez, J.; Simal-Lozano, J. 1994: Composition of babaco, feijoa, passion-fruit and tamarillo produced in Galicia (NW Spain). *Food chemistry 49*: 251–255.

Rotundo, A.; Rotundo, S.; Gherardi, S. 1983: Tamarillo. *Revista di horticultura 45(8)*: 37–40.

Visser, F.; Burrows, J. 1983: Composition of New Zealand foods. I. Characteristic fruit and vegetables. *Bulletin of the New Zealand Department of Scientific and Industrial Research no. 235.*

Williams, P. 1984: Sweeter tamarillo needed for overseas markets. *Growing today 2(2)*: 18–19.

Wills, R.; Lim, J.; Greenfield, H. 1986: Composition of Australian Foods. 31. Tropical and sub-tropical fruit. *Food technology in Australia 38(3)*: 118–123.

Downloaded At: 20:41 2 August 2010