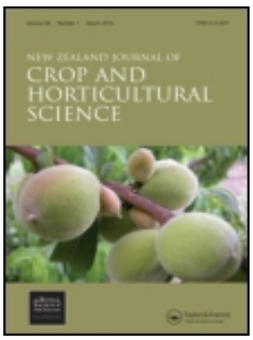

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Composition and nutritional evaluation of kiwifruit grown in Italy

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Abstract Different cultivars of kiwifruit *(Actinidia deliciosa)* (A. Chev.) C.F. Liang et A.R. Ferguson) were harvested in 4 consecutive years and analysed at harvest time. The cultivars were: 'Abbott', 'Bruno', 'Elmwood', 'Fatma', 'Gracie', 'Hayward', 'Monty', and two 'Hayward' clones—'Priori' and 'Tenna'. Major differences, not only between cultivars but also within cultivars, were observed for vitamin C content. 'Bruno' fruit had the highest and 'Abbott' the lowest mean vitamin C content. The main nutrients (water, sugar, acid, pectin, dietary fibre), individual sugar, and organic acid composition and indicative sugar : acid ratios are reported. In terms of sensory characteristics, 'Bruno' and 'Fatma' fruit were favoured over the other cultivars. The relatively high dietary fibre content of the fruit is mostly insoluble. With regard to the organic acids, there was a prevalence of citric acid.

Keywords *Actinidia deliciosa*; kiwifruit; kiwifruit composition; vitamin C content; organic acid composition; sugar composition

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INTRODUCTION

Compared with residents of most European countries, Italians eat comparatively large quantities of fruit. Fruit are available all year and are eaten as snack foods and, most importantly, as the final course of meals. Consequently, the Italian annual per capita consumption of fresh fruit is 73 kg (or 200–300 g/day). In 1989 the annual per capita consumption of kiwifruit in Italy was 2.3 kg, obviously kiwifruit is a significant item in the diet.

The present study was undertaken to determine the proximate composition and content of vitamin C of the various kiwifruit cultivars presently grown in Italy. For better and more rational utilisation of kiwifruit it will be necessary to take into account the nutritional quality of the cultivars, in particular their vitamin C, mineral, and dietary fibre content.

MATERIALS AND METHODS

Fruits were harvested in 4 consecutive years (1987–90) from mature kiwifruit vines *(Actinidia deliciosa* var. *deliciosa* (A. Chev.) C. F. Liang et A. R. Ferguson) of the different cultivars growing in the research orchards of the Istituto Sperimentale per la Frutticoltura at Fiorano, Rome, Italy. The characteristics of the cultivars have already been described (Bellini & Monastra 1986). The cultivars were: 'Abbott', 'Bruno', 'Elmwood', 'Gracie', 'Hayward', 'Monty', and 'Priori' (a 'Hayward' clone). For the last 2 years, fruit of 'Tenna' (another 'Hayward' clone), 'Lori', and 'Fatma' (Paglietta 1990) were also analysed.

Upon arrival of fruit at the Institute, fruit firmess was evaluated by an Instron UTM (plunger tip 8 mm), and was c. 0.5 kgf. Fruit were peeled, homogenised, and a sample analysed immediately for water, pectin, and vitamin C content. The homogenate was then freeze-dried and stored under refrigeration until analysed for other nutrients (protein, lipid, starch, dietary fibre, sugars, organic acids, and minerals). Energy content was calculated.

Official AOAC methods were used for determination of water, lipid (acid hydrolysis), and protein content (AOAC 1990). Dietary fibre was determined according to the AOAC gravimetric-enzymatic method (Prosky et al. 1988).

Organic acids

The sample (1 g freeze-dried or 10 g fresh material) was extracted in water (15 min under stirring), filtered, and injected. Determination was by HPLC according to the method of Morawski (1984). HPLC: Waters; column: Econosil C-18 (Alltech, 0.46 × 25 cm); mobile phase: ammonium phosphate pH 2.8; flow rate 0.9 ml/min; detector UV, 214 nm.

Free sugars

The sample (300 mg freeze-dried material) was extracted in water (30 min by sonication), filtered, and injected. Determination was by HPLC (Dionex mod. Biol LC); column: CarboPac PA1 (0.4 × 25 cm); eluant: 160 m*M* NaOH; flow rate 1.0 ml/min; detector: PAD (gold).

Vitamin C

The sample (5–10 g) was extracted in 5% m-phosphoric acid (15 min under stirring), filtered, and injected. Determination was by HPLC, according to Morawski (1984). HPLC: Waters; column: Beckman C-18 (0.46 × 25 cm); mobile phase: (a) 0.2*M* sodium phosphate, pH 3.5, (b) acetonitrile:water 50:50; flow rate 0.9 ml/min; detector UV, 254 nm.

Pectin

"Ethanol powders" were prepared according to the method of Huber (1984). Total polyuronides were determined colorimetrically, as described by Blumenkrantz & Asboe-Hansen (1973).

Table 1 Composition of fruit of nine kiwifruit cultivars (g/100 g FW).

Cultivar	Water	Sugar total	Acid total	Total dietary fibre	Pectin[a] (mg)
Abbott	82.05	11.58	1.99	2.64	564
Bruno	82.95	10.47	2.34	3.05	552
Elmwood	84.80	8.05	2.16	2.50	462
Fatma	79.58	13.29	3.05	3.12	602
Gracie	83.60	11.43	2.21	2.67	377
Hayward	84.05	10.51	1.92	2.60	392
Hayward cl. Priori	83.25	11.92	2.11	2.25	410
Hayward cl. Tenna	86.50	11.53	2.61	2.13	462
Monty	84.83	9.72	1.95	2.74	397

[a]As galacturonic acid equivalents.

Significance of differences was evaluated by the Kruskal-Wallis non-parametric analysis of variance.

RESULTS AND DISCUSSION

The proximate composition of kiwifruit is given in Table 1. Since in kiwifruit, as in all other fruit, water is the main component (80–87%) the concentration of the other nutrients is quite low. In each cultivar, protein and fat were determined only for the first 2 years and were found to be on the average 1.13 and 0.3 g/100 g fresh weight (FW), respectively (Adorisio et al. 1990). Typical amino acid content of 'Hayward' fruit is reported in Table 2 (Adorisio et al. 1990). Starch was not detected in any of the samples examined, i.e., the fruit were fully ripe.

Kiwifruit contain sizeable amounts of minerals. Potassium was the major mineral present at a level ranging from 3.60 to 3.86 mg/g FW, in large excess over sodium. Other minerals were present at similar (lower) levels in each cultivar (Adorisio et al. 1990).

The dietary fibre content of kiwifruit is one of the highest of all fresh fruit (from 2.25 to 3.12 g/100 g, mean 2.63 ± 0.3 g/100 g), being inferior only to that of prickly pear and quince and comparable to that of pear and persimmon. As in most fruit, dietary fibre is mostly insoluble, representing 70–75% of the total. Pectic compounds varied from a low of 3.77 mg/g for 'Gracie' to a high of 6.02 mg/g for 'Fatma', probably

Table 2 Protein amino acid content of 'Hayward' kiwifruit (Adorisio et al. 1990).

Amino acid	g/100 g protein
Lysine	5.24
Histidine	2.04
Arginine	8.68
Aspartic acid	13.86
Threonine	4.92
Serine	4.42
Glutamic acid	15.67
Proline	3.83
Glycine	5.29
Alanine	4.51
Cystine	2.86
Valine	5.51
Methionine	1.67
Isoleucine	4.74
Leucine	5.66
Tyrosine	3.77
Phenylalanine	3.86
Limiting amino acid	lysine
Chemical score (versus FAO egg)	0.76

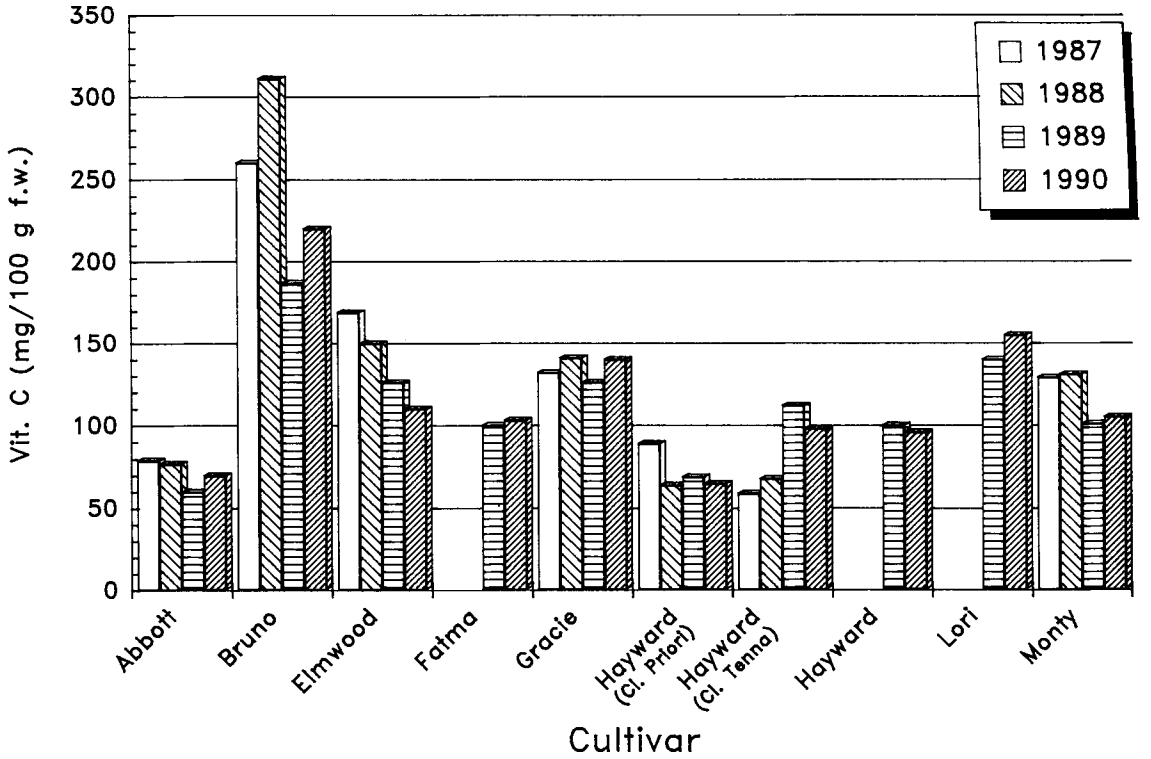

Fig. 1 Variation in the vitamin C content of various kiwifruit cultivars.

Table 3 Sugar composition (g/100 g FW) and ratios in fruit of eight kiwifruit cultivars.

Cultivar	Glucose	Fructose	Sucrose	Fructose+ glucose/ sucrose
Abbott	4.38	4.73	2.47	3.69
Bruno	2.92	2.79	4.76	1.20
Elmwood	3.46	3.58	1.01	6.97
Fatma	3.53	3.32	6.44	1.06
Hayward	4.38	4.68	1.45	6.25
Hayward cl. Priori	4.90	5.30	1.72	5.93
Hayward cl. Tenna	4.73	5.16	1.64	6.03
Monty	3.78	4.06	1.88	4.17

Table 4 Vitamin C (mg/100 g FW) content of fruit of 10 kiwifruit cultivars in 4 consecutive years. Values followed by a different letter are significantly different ($P < 0.05$).

Cultivar	Vit. C (mg/100 g FW) Mean	SEM	Range	Vit. C mg/fruit
Abbott	73.4a	2.25	58–83	38.2
Bruno	241.2f	14.41	177–326	132.7
Elmwood	147.5de	7.09	109–177	125.4
Fatma	101.3bc	1.18	98–103	26.3
Gracie	134.7d	1.99	125–145	98.3
Hayward	74.8a	2.39	62–91	59.1
Hayward cl. Priori	78.8ab	5.68	61–115	93.0
Hayward cl. Tenna	98.8b	0.75	97–100	66.2
Lori	147.8e	4.64	137–156	99.0
Monty	115.9c	3.61	100–138	70.7

reflecting between-cultivar differences in ripening and softening. Mean values (4.69 ± 0.84 mg/g) fall within previously reported ranges (Beever & Hopkirk 1990).

Like most other fruit, kiwifruit do not have appreciable amounts of sugars other than fructose, glucose, and sucrose. Fructose and glucose, present at approximately equal amounts in most cultivars (Table 3), were the major sugars present (40–45% of total sugars) in all cultivars except 'Bruno' and 'Fatma', in which sucrose prevailed (45–48% of total sugars). The ratios (fructose+glucose)/sucrose and sucrose/citrate varied accordingly.

Table 5 Organic acid content of fruit of nine kiwifruit cultivars (g/100 g FW).

Cultivar	Quinic	Malic	Citric	Sucrose/ citric
Abbott	0.45	0.41	1.06	2.33
Bruno	0.51	0.36	1.42	3.35
Elmwood	0.45	0.34	1.30	0.78
Fatma	0.71	0.34	1.95	3.30
Gracie	0.30	0.29	1.56	1.56
Hayward	0.39	0.24	1.20	1.21
Hayward cl. Priori	0.40	0.28	1.35	1.27
Hayward cl. Tenna	0.53	0.36	1.68	0.98
Monty	0.43	0.37	1.10	1.71

Variation in the vitamin C content of the cultivars studied is shown in Table 4 and Fig. 1. Major differences between cultivars can be observed. Fruit of 'Abbott' contain the lowest (73 mg) and fruit of 'Bruno' the highest (241 mg/100 g) vitamin C concentrations. Many of the differences between cultivars are statistically significant and have been found to be consistent over four growing seasons. Similar large differences between cultivars have been reported by other workers (Cotter et al. in press). There can also be large intra-cultivar variation in vitamin C content, as has also been reported by Ferguson & MacRae (1991)—such intra-cultivar variation is still largely unexplained. Some of the factors involved include environmental growing conditions, seasonality, storage stability, etc.

The content of organic acids (citric, malic, and quinic) ranged from 19.2 to 30.5 mg/g, with a marked prevalence of citric acid, comprising 55–70% of total organic acids (Table 5).

The quality of kiwifruit can be considered also in terms of sensory factors. It is known that the characteristic taste of fruit is determined largely by the content of sugars and organic acids (McBride & Johnson 1987). Furthermore, the ratio sugar/acid is considered particularly useful as an index of acceptability in many fruit. However, in our limited experience with an informal panel of members of the staff, for kiwifruit the ratio sucrose/citrate seems to be associated with better taste and could therefore become a good indicator of the fruit quality.

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