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The effect of cooking on the composition and colour of New Zealand grown oca

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Abstract

Oca (*Oxalis tuberosa* Mol.), known as yam in New Zealand, has been grown commercially for more than a century. More recently, yellow and orange cultivars have been introduced to complement the traditional pink cultivar. This study investigates the composition and colour of three introduced lines, a hybrid between two of these lines and a local yellow cultivar, including the first reported measurements of oca vitamin C content. The CIE $L^*a^*b^*$ colour of the skin and tissue were measured in the raw tubers and after boiling and baking, the most common way to cook the tubers. The skin and the tissue of all the cultivars were a very similar orange–yellow when cooked. The soluble oxalate, vitamin C, pH and titratable acidity were also measured in the raw and cooked tissue. On a dry matter basis, the mean soluble oxalate of the raw cultivars was 935.5 ± 125.7 mg/100 g DM rising to 1364.8 ± 217.5 mg/100 g DM when baked; in contrast, the mean vitamin C content of the raw tubers was 109.8 ± 28.9 mg/100 g DM falling to a mean of 62.4 ± 12.1 mg/100 g DM when the tubers were baked.

Keywords: Oca; Yam; *Oxalis tuberosa*; $L^*a^*b^*$ colour; pH; Titratable acidity; Soluble oxalate; Ascorbic acid; Boiling; Baking

1. Introduction

Oca (*Oxalis tuberosa* Mol.) is a starchy tuber crop that is cultivated in the Andean region from Venezuela to Argentina (Sperling & King, 1990). It is thought to have originated in central or southern Chile (Vietmeyer, 1991). Oca has also been grown commercially in New Zealand where it is known as "yam" (Martin, Halloy, & Deo, 1997; Vietmeyer, 1991). Oca currently grown in New Zealand has a narrow genetic base as it was introduced over a century ago (Martin et al., 1997; NRS, 1989). Pink–red tubers are the most common cultivar in the shops. Red, pink, yellow, orange and mixed coloured cultivars of oca have been introduced, recently, into New Zealand. Commercial growers are interested in developing new lines that may increase the appeal of oca to consumers. In New Zealand, oca are commonly served steamed, boiled or baked like potatoes (King, 1988). The flavour of oca varies from very bitter to sweet and it has also been described as tangy, acid or nutty (Sperling & King, 1990; Vietmeyer, 1991). Sangketkit, Savage, Martin, Searle, and Mason (2000) showed a positive correlation between the oxalate level and a bitter taste after steaming and baking the tuber. Previous studies showed that the oxalate level in oca is moderately high and is only found in the form of soluble oxalate (Ross, Savage, Martin, & Vanhanen, 1999; Sangketkit, Savage, Martin, Mason, & Vanhanen, 1999). Oca are cooked before consumption. Oxalate content was not changed by boiling or steaming, but was increased by baking (Albihn & Savage, 2001; Sangketkit, Savage, Martin, & Mason, 2001).

Oxalate is not a nutrient, once absorbed the blood will transport it directly to the kidneys to excrete in the urine as a waste product. The amount of oxalate excreted in the urine is an important risk factor in the development of calcium oxalate crystals, the most common component

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of kidney stones (Williams & Wandzilak, 1989). Urinary oxalate arises from a combination of absorbed dietary oxalate (10–15%) and as a result of endogenous formation from oxalate precursors such as glycoxylic acid (40%) and ascorbic acid (33–50%) (Hagler & Herman, 1973).

The vitamin C content of oca has not been recorded in the literature but unrelated tropical tuber crops, e.g. *Dioscorea* spp. contain 17 mg vitamin C/100 g FW and *Discorea pentaphylla* contain 2.6 mg vitamin C/100 g FW (USDA, 2004). Cooking and processing may lead to losses of this vitamin, as it is water soluble and degraded by heat treatments. The contribution of ascorbic acid to urinary oxalate is controversial. Baxmann, Mendonca, and Heilberg (2003) showed the intake of vitamin C supplements of 1 or 2 g/day may produce a significant increase in urinary oxalate. Traxer, Huet, Poindexter, Pak, and Pearle (2003) showed the ingestion of 2 g of ascorbic acid daily results in a moderate increase in urinary oxalate in normal subjects (20%) and stone formers (33%), whereas Auer, Auer, and Rodgers (1998) concluded that ingestion of large doses of ascorbic acid does not affect the risk factors associated with calcium oxalate kidney stone formation.

The pink tuber of oca is the most common cultivar sold in supermarkets in New Zealand. Occasional yellow tubers found in New Zealand oca crops have been multiplied up to form local lines. To widen the genetic base, other lines were introduced from South America (Martin, Savage, Deo, Halloy, & Fletcher, 2005; Ross et al., 1999), including the yellow lines 34 and 41, and the larger yellow–red cultivar 38 (Sangketkit et al., 2000). Inca Gold, a large golden tubered cross between lines 38 and 41, has been released by Crop & Food Research (Martin et al., 2005). This study focuses on a comparison of the colour and composition of the newly introduced tubers with the established cultivars and the effect of two common cooking methods on these parameters.

2. Materials and methods

2.1. Sample materials

The five cultivars of oca (34, 38, 41, Inca Gold, and yellow (a local commercial selection)) were grown in a Templeton silty loam soil at Crop and Food Research Ltd., Lincoln, Canterbury, New Zealand. The oca were planted on the 29th October 2003 and harvested on the 29th June 2004. Each cultivar was planted in three 10 m length rows. The plants were fertilized with 100 kg N/ha on the 27th January 2004. Washed and cleaned tubers of uniform shape were collected from each cultivar and stored at 10 °C until required for analysis.

2.2. Cooking treatments

The skin of oca is very thin and was not removed since unpeeled whole tubers are normally consumed. Whole oca were boiled (500 g of oca [approximately 15 tubers] added to 700 ml water) for 20 min or baked (baked in an oven set at 200 °C) for 60 min. Cooked samples were deep frozen at −20 °C in plastic bags for later analysis. Raw samples were stored in the dark at 10 °C.

2.3. Colour measurement

The skin and flesh colour of raw, boiled and baked oca were measured on each cultivar using the CIE $L^*a^*b^*$ colour system using a Minolta Chroma Meter (model CR-210, Minolta Camera Co. Ltd. Osaka, Japan). The CIE $L^*a^*b^*$ readings were calibrated against a standard white tile. Colour coordinates were recorded as: L^* = lightness (0 = black, 100 = white), a^* ($-a^*$ = greenness, $+a^*$ = redness), b^* ($-b^*$ = blueness, $+b^*$ = yellowness), a^* and b^* were used to calculate, chroma $C^* = [(a^{*2} + b^{*2})]^{1/2}$ hue angle $h_{ab} = [\tan^{-1}(b^*/a^*)]$.

2.4. Chemical analysis

Dry matter contents were measured, in duplicate, by drying in an oven at 105 °C for 24 h (AOAC, 2002). The pH and titratable acidity of a homogenised sample of the raw or cooked oca was measured using a Metrohm titroprocessor (702 SM Tritrino and 730 sample changer, Metrohm, Ltd., Herisau, Switzerland). The titratable acidity was determined using 0.1 M sodium hydroxide solution and expressed as mg citric acid/100 g DM. Vitamin C was measuring using an automated titrimetric method (Metrohm, Ltd., Herisau, Switzerland). 1.5 g of raw or cooked oca was mixed with 40 ml of aqueous buffer (3.84 g/L sodium acetate, 576.9 ml/L of 1 g/L oxalic acid) and homogenised with a hand held homogeniser. The homogenised samples were then titrated against 2,6-dichlorophenol indophenol (295 mg/L) and sodium carbonate (100 mg/L). The instrument was calibrated using vitamin C standards in a 1 g/L oxalate solution.

The oxalate was extracted by homogenizing the accurately weighed 5 g samples (chopped frozen for boiled and baked samples, cut in small pieces for raw) with approximately 50 mL of nanopure water for soluble oxalate analysis or 0.2 M HCl for total oxalate analysis and extracted hot in a water bath at 80 °C for 15 min. The extracts were allowed to cool and then transferred quantitatively into 100 mL volumetric flasks and made up to volume. Three extractions were carried out for each sample. The extracts were centrifuged at 3500 rpm for 15 min. The supernatant was filtered through a 0.45 μm cellulose nitrate filter. The chromatographic separation was carried out using a 300 × 7.8 mm ion exclusion column (Alltech Associates Inc., Deerfield, Illinois, USA) attached to a cation H^+ guard column (Bio-Rad, Richmond, California, USA). The analytical column was held at 25 °C. The equipment consisted of a ternary Spectra-Physics, SP 8800 HPLC pump (Spectra-Physics, San Jose, California, USA), a Waters, U6K injector (Waters Inc., Marlborough, Massachusetts, USA), a UV/VIS detector Spectra-Physics

SP8450 (Spectra-Physics, San Jose, California, USA) set on 210 nm. Data capture and processing were carried out using Cromatopac C-R3A integrator (Shimadzu, Corporation, Kyoto, Japan). The mobile phase used was an aqueous solution of 25 mM sulphuric acid. Before use the mobile phase was filtered through a 0.45 μm membrane filter and degassed using a vacuum. Samples (20 μL) were injected onto the column and eluted at a flow rate of 0.6 mL/min.

2.5. Statistical analysis

The data were analysed using one-way ANOVA (Minitab ver. 14.0). Where mean values were determined to be significantly different, a Fisher LSD at $p = 0.05$ was calculated.

3. Results

3.1. Colour measurements

The mean of five separate determinations of the colour of the skin and internal tissue of raw, boiled and baked oca are presented in Table 1. The skin of all cultivars had a yellow colour base since their hue angle values were close to pure yellow (90°), except for the red skinned cultivar 38, which had a higher a^* and a red base colour ($h_{ab} = 27.1°$) which is close to pure red (0°). Cultivars with yellow base colour were lighter (higher L^*) than the red-based cultivar (38). The lightness and the intensity of colour was the same for all the "yellow" cultivars (34, 41, Inca Gold, yellow), but there was a disparity of hue angle because the skin varied from yellow to orange. The flesh of all cultivars was in shades of yellow (h_{ab} was close to 90°) but cultivar 38 had the least yellow colour (lowest b^*) and the least intense colour (lowest C^*). The flesh was brighter than the skin for all cultivars.

After cooking, the skin and flesh of all cultivars had a similar colour in yellow shades but the skin and the flesh lost lightness and colour intensity, except for the skin of cultivar 38. In fact, the skin of cultivar 38 became yellow with a hue angle close to pure yellow (90°), the skin also became lighter and the colour intensity was the lowest of all cultivars. For the three numbered lines (34, 38 and 41) the b^*, C^* and h_{ab} values of the skin of baked oca were lower than for boiled oca because the skin of baked oca became brown or dark in places.

3.2. Chemical analysis

Chemical analysis of the oca was carried out on the raw and cooked tissue but the results are presented on a dry matter basis because the moisture content of the oca tubers changed when they were boiled and baked. The results on a dry matter basis are presented in Table 2. The dry matter contents of the raw oca were not significantly different among the five cultivars. The mean dry matter for raw oca was 13.7 ± 0.8 g/100 g FW, for boiled oca 13.5 ± 0.9 and for baked oca 22.6 ± 2.9. There was a 65% increase ($p < 0.05$) in dry matter after baking, but no change after boiling.

Table 1
The mean CIE $L^*a^*b^*$ coordinates for skin and flesh of raw or cooked oca

Cultivar	Skin colour					Flesh colour				
	L^*	a^*	b^*	C^*	h_{ab}	L^*	a^*	b^*	C^*	h_{ab}
Raw oca										
34	57.1^{a}	9.6^{bc}	37.4^{b}	38.6^{a}	75.6^{bc}	64.6	7.0^{b}	40.8^{a}	41.4^{ab}	80.3^{b}
38	34.3^{b}	30.8^{a}	15.5^{c}	34.6^{b}	27.1^{d}	64.3	4.5^{b}	33.7^{b}	34.3^{c}	81.5^{b}
41	57.0^{a}	11.4^{bd}	39.3^{ab}	40.9^{a}	73.8^{c}	63.1	8.9^{b}	43.9^{a}	44.8^{a}	78.5^{b}
Inca Gold	60.9^{a}	4.8^{d}	40.3^{a}	40.6^{a}	83.2^{a}	69.6	-0.3^{a}	40.6^{a}	40.6^{b}	89.5^{a}
Yellow	60.2^{a}	8.1^{c}	38.6^{ab}	39.5^{a}	78.2^{bc}	65.9	6.6^{b}	40.0^{a}	40.6^{b}	80.7^{b}
LSD	4.0	3.3	2.6	3.5	3.7	6.2	2.8	4.1	3.7	5.9
Boiled oca										
34	49.5^{b}	3.2^{a}	28.0^{a}	28.2^{a}	83.5^{c}	51.4^{b}	0.4^{a}	39.7^{a}	39.7^{a}	89.2^{a}
38	45.3^{b}	2.1^{ab}	24.1^{b}	24.3^{b}	84.2^{bc}	50.9^{b}	-1.3^{a}	32.9^{c}	33.0^{c}	86.4^{a}
41	45.3^{b}	0.4^{b}	30.1^{a}	30.1^{a}	89.1^{a}	50.8^{b}	-1.4^{a}	39.2^{ab}	39.3^{a}	88.0^{ab}
Inca Gold	54.8^{a}	-2.4^{c}	29.2^{a}	29.3^{a}	85.3^{ab}	58.1^{a}	-4.6^{b}	33.7^{c}	34.0^{bc}	82.2^{c}
Yellow	50.0^{b}	1.1^{b}	28.4^{a}	28.4^{a}	87.9^{ab}	53.3^{b}	0.1^{a}	38.4^{b}	38.4^{ab}	89.4^{a}
LSD	3.2	1.8	2.9	2.8	4.0	3.5	1.9	4.50	4.5	2.6
Baked oca										
34	44.1^{c}	8.7^{ab}	22.3^{b}	23.9^{b}	68.6^{c}	55.7^{a}	1.6^{a}	36.3^{ab}	36.4^{ab}	87.3^{bc}
38	42.8^{cd}	7.2^{b}	21.5^{b}	22.7^{b}	71.4^{c}	50.0^{b}	-0.4^{b}	32.6^{b}	32.6^{b}	88.8^{ab}
41	40.3^{d}	9.2^{a}	23.5^{b}	25.2^{b}	68.5^{c}	56.0^{a}	0.5^{ab}	39.3^{a}	39.6^{ab}	88.8^{b}
Inca Gold	52.0^{a}	0.8^{d}	33.3^{a}	33.3^{a}	88.3^{a}	56.1^{a}	-2.7^{c}	34.3^{b}	34.5^{b}	85.6^{c}
Yellow	49.2^{b}	4.6^{c}	31.8^{a}	32.2^{a}	81.7^{b}	57.2^{a}	-0.4^{b}	41.4^{a}	41.4^{ab}	89.4^{a}
LSD	2.7	1.7	3.3	3.2	3.9	3.2	1.2	5.2	4.9	1.8

Means in each column with different superscript letters are significantly different at the 5% level of significance.

Table 2
Dry matter (g/100 g FW), pH and titratable acidity (mg citric acid/100 g DM), soluble oxalate (mg/100 g DM) and vitamin C (mg/100 g DM) in the five different cultivars of raw or cooked oca (mean ± standard deviation)

Cultivar	Dry matter	pH	Titratable acidity	Soluble oxalate	Vitamin C
Raw oca					
34	14.6 ± 0.4	5.3 ± 0.2	$737.5^{c} \pm 44.4$	956.8 ± 18.0	$135.5^{a} \pm 8.5$
38	13.3 ± 0.1	5.1 ± 0.1	$825.0^{ab} \pm 37.3$	1021.1 ± 104.7	$101.5^{b} \pm 17.8$
41	14.1 ± 0.8	5.3 ± 0.3	$586.3^{d} \pm 42.7$	802.4 ± 145.6	$87.4^{bc} \pm 12.7$
Inca Gold	13.8 ± 0.6	5.2 ± 0.1	$754.7^{bc} \pm 7.2$	941.6 ± 37.4	$79.2^{c} \pm 6.1$
Yellow	12.7 ± 0.2	4.8 ± 0.2	$889.2^{a} \pm 75.0$	955.6 ± 194.5	$145.2^{a} \pm 12.1$
Mean	13.7 ± 0.8	5.2 ± 0.3	758.6 ± 112.3	935.5 ± 125.7	109.8 ± 28.9
LSD	1.3	0.4	84.7	217.9	22.0
Boiled oca					
34	$13.4^{b} \pm 0.1$	$5.1^{c} \pm 0.1$	$667.3^{a} \pm 7.4$	950.5 ± 305.2	$132.4^{a} \pm 4.2$
38	$12.6^{b} \pm 0.2$	$5.1^{d} \pm 0.1$	$521.7^{e} \pm 4.6$	932.1 ± 156.5	$115.2^{b} \pm 5.5$
41	$13.3^{b} \pm 0.3$	$5.3^{a} \pm 0.1$	$477.0^{d} \pm 2.7$	567.3 ± 151.4	$81.1^{d} \pm 5.9$
Inca Gold	$15.1^{a} \pm 0.9$	$5.3^{b} \pm 0.1$	$477.5^{d} \pm 2.4$	692.2 ± 82.9	$68.3^{e} \pm 4.0$
Yellow	$13.3^{b} \pm 0.1$	$5.0^{e} \pm 0.1$	$626.1^{b} \pm 12.2$	824.6 ± 197.4	$101.7^{c} \pm 1.8$
Mean	13.5 ± 0.9	5.1 ± 0.1	553.9 ± 81.5	793.3 ± 222.3	99.7 ± 24.1
LSD	1.2	0.1	12.6	351.2	8.2
Baked oca					
34	24.9 ± 3.6	$4.8^{d} \pm 0.1$	$665.3^{c} \pm 43.3$	1375.3 ± 67.8	$72.0^{ab} \pm 1.2$
38	23.5 ± 2.5	$4.8^{c} \pm 0.1$	$741.9^{b} \pm 9.6$	1365.5 ± 111.6	$57.0^{bc} \pm 14.0$
41	23.3 ± 4.3	$5.2^{b} \pm 0.1$	$643.2^{c} \pm 18.7$	1333.8 ± 156.7	$58.1^{abc} \pm 1.1$
Inca Gold	20.7 ± 1.3	$5.2^{a} \pm 0.1$	$634.1^{c} \pm 3.6$	1466.6 ± 478.0	$50.9^{c} \pm 12.3$
Yellow	20.6 ± 3.2	$4.7^{e} \pm 0.1$	$811.4^{a} \pm 5.9$	1282.7 ± 183.9	$74.0^{a} \pm 8.0$
Mean	22.6 ± 2.9	4.9 ± 0.1	699.2 ± 72.5	1364.8 ± 217.5	62.4 ± 12.1
LSD	8.0	0.1	39.6	448.5	16.5

Means in each column with different superscript letters are significantly different at the 5% level of significance.

The pH of raw oca was not significantly different among the cultivars, but the yellow cultivar was the most acid (4.8 ± 0.2) and cultivar 41 was the least acid (5.3 ± 0.3). Boiling oca had a no significant effect on the pH whereas when the oca was baked the pH decreased significantly from 5.2 ± 0.3 to 5.0 ± 0.1, on average, except for Inca Gold.

The total acidity of raw oca ranged from 586.3 ± 42.7 to 889.2 ± 75.0 mg citric acid/100 g DM. The mean TA of the five oca cultivars was reduced by 27% when they were boiled (758.6 ± 112.3 to 553.9 ± 81.5 mg/100 g DM) while the mean values for the baked oca (699.2 ± 72.5) were similar to the raw tubers.

One-way ANOVA showed there was no significant difference between total and soluble oxalate in the raw, boiled or baked samples of any of the cultivars (data not shown). This indicates that no insoluble oxalate was present in the tissue. There was no difference in the soluble oxalate content between the cultivars when they were raw or boiled. After baking the oxalate content of all the cultivars increased significantly ($p < 0.05$) by 45% to reach a mean of 1364.8 ± 217.5 mg/100 g DM.

The quantity of vitamin C in the oca differed significantly among the five different cultivars in both the raw and cooked samples (Table 2). The range of vitamin C was 79.2–145.2 mg/100 g DM in the raw oca. After boiling the quantity of vitamin C was statistically the same as in the raw tissue. The mean vitamin C contents of raw oca was 109.8 ± 28.9 mg/100 g DM and the overall mean value for the boiled oca was 99.7 ± 24.1 which suggests that very little vitamin C was lost when the tubers were boiled for 20 min. Baked oca contained significantly lower levels of vitamin C (mean 62.4 ± 12.1) when compared to the raw or boiled tubers.

3.3. Discussion

Colour is a very important sensory attribute of most foods since it influences the consumer's first judgment and the purchasing preference. Sangketkit et al. (2000) showed that raw oca with red coloured skins were preferred over yellow skinned oca by a panel of New Zealanders consumers and the preference for both colours increased with colour intensity (higher C^* values). Among the raw oca analysed in this study, the New Zealand consumer may have preferred cultivar 38 (the skin was very red) and then possibly cultivar 41 would have been chosen because it had the most intense yellow colour (i.e., higher C^* value). After cooking the flesh of all cultivars was orange-yellow, therefore the factor influencing the consumer would become the lightness of colour of the oca flesh (Sangketkit et al., 2000). However, all five cultivars had similar readings. The skin colour mainly influences the first purchase, for the consumer to buy the product twice, the memory of the taste when cooked is important (Sangketkit et al., 2000). The acidity of oca tissue may well influence a consumer's

appreciation of the baked tuber. Cultivars 34, 38 and yellow had a higher pH than Inca Gold and cultivar 41 when baked. This might mean that these three cultivars would give a more tangy taste when cooked.

The non-significant difference between the levels of soluble and total oxalate of raw oca confirms that all oxalates in raw oca cultivars are in the soluble form (Ross et al., 1999; Sangketkit et al., 1999). The results from this research also show that the amount of soluble oxalate and total oxalate in cooked oca is the same, thus the oxalate remains soluble during boiling and baking. The level of soluble oxalate in the raw oca in this study was 55% lower than values in the cultivars tested by Albihn and Savage (2001) but Sangketkit et al. (1999) observed a large variation of oxalate content among cultivars (ranging from 622.2 to1230.4 mg oxalate/100 g DM for the raw tubers). The oca analysed in this study were significantly larger in size than the tubers analysed by Albihn and Savage (2001). Larger oca would have lower skin to tissue ratios and Albihn and Savage (2001) showed that the skin contained a large proportion of the oxalates. It is also possible that variations in growing conditions have a large bearing on the overall growth of the tuber and the final oxalate concentrations. The oca analysed in this study were similar in size to the tubers currently present on the New Zealand market.

There was a small reduction in the oxalate content of the boiled tubers compared to the raw tubers when expressed on a dry matter basis (Table 2). These small reductions result from minor leaching losses into the cooking water. In almost all other foods there is a significant loss of soluble oxalates into the cooking water, including 66% for spinach leaves and 53% for silver beet leaves (Savage, 2002). Losses of soluble oxalates from leaves occurs because the cell walls are more easily degraded during cooking. Oca are always cooked whole with the skin intact and this means that the oxalate in the tissue is not easily leached into the cooking water when they are boiled. It is possible that the levels of oxalate in the tissue are influenced by growing conditions such as fertilization and watering regimes.

The level of ascorbic acid in raw oca was 109.7 mg/100 g DM, that is 15 mg/100 g FW. There appear to be no published references concerning the vitamin C contents of oca.

However, the values observed in this study are close to the amount of vitamin C found in the tubers of raw tropical yams e.g. *Dioscorea* spp. contains 17 mg/100 g FW and *Discorea pentaphylla* contains 2.6 mg/100 g FW (USDA, 2004). It should be noted, however, that even though oca are commonly called yams in New Zealand they are unrelated to these tropical yams. A very small amount of vitamin C (9%) was lost when the oca tubers were boiled. 43% of vitamin C was degraded when the tubers were baked at 200 °C for 1 h, reducing the mean vitamin C content to 62.40 ± 12.09 mg/100 g DM. There is a very large (twofold) variation in vitamin C content between cultivars and the selection of higher vitamin C content would be relatively straightforward.

It is interesting to note that overall, there was a 43% reduction in the vitamin C content of the baked tubers when compared on a dry matter basis to the levels in the raw tubers. At the same time there was a large overall increase (46%) in the soluble oxalate content of the baked tissue on a dry matter basis compared to the levels in the raw tissues. It is possible that enzymic breakdown of vitamin C to soluble oxalate may be occurring during the early warming phase of baking or that vitamin C or other constituents may be degraded to oxalates in the final high temperature stage of baking.

4. Conclusions

Oca is a popular vegetable in New Zealand and people have enjoyed eating the baked pink cultivar for many years. More recently yellow and orange cultivars have been introduced and these have raised interest in this tasty tuber crop. This study has shown that the different coloured cultivars contain similar amounts of natural oxalate, vitamin C and total acidity, which is important to give the characteristic tangy taste after cooking. It is interesting to note that following cooking the skin and the flesh tissue of all the cultivars develop the same yellow–orange colour. While people like to purchase oca with different colour skins the final cooked colour and taste are the characteristics that are most appreciated by consumers.

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