Composition of Pecan Cultivars Wichita and Western Schley [*Carya illinoinensis* (Wangenh.) K. Koch] Grown in Australia

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Pecans from the cultivars Wichita and Western Schley [*Carya illinoinensis* (Wangenh.) K. Koch] collected over three years were analyzed for the following constituents: total lipid content; fatty acid profiles; sucrose content; protein; total dietary fiber; the minerals magnesium, calcium, potassium, sulfur, phosphorus, boron, copper, iron, manganese, sodium, zinc, and aluminum; vitamin C; and lipase and lipoxygenase activities. Year of harvest and cultivar had little effect on the composition of the pecans. Overall, protein content was the only constituent that differed between pecans grown in Australia and those grown in the United States. This difference is probably related to differences in growing location and horticultural practices between the two countries.

Keywords: *Pecan; Carya illinoinensis (Wangenh.) K. Koch; Australia; composition; lipid*

INTRODUCTION

The pecan [*Carya illinoinensis* (Wangenh.) K. Koch] is an indigenous crop of the United States, with commercial production having commenced just over 100 years ago (*1*). Since that time, commercial production of pecans has extended to Australia, South Africa, Israel, Argentina, Chile, and Brazil (*2*). Pecans have been commercially produced in Australia since 1969, with the largest orchard (Trawalla) encompassing 735 ha at Moree, New South Wales (NSW) (*3*). Total production of pecans at Trawalla averages 2200−2700 tons of nut-in-shell (NIS) per year (*3*). Wakeling et al. (*4*) have prepared a comprehensive review of the Australian pecan industry.

The composition of pecans plays an important role in maintaining quality. Oil is the major constituent of pecans, with common levels being 65.0−75.0 g/100 g (*5*). Pecan composition is known to vary depending on location, climatic conditions, horticultural practices, cultivar, season, and maturity level (*6*). Although most of these factors affect the overall composition of the resulting pecan kernel, some have been shown to affect a particular component more so than others. For example, the lipid content may vary widely depending on cultivar (*6*, *7*), season (*7*, *8*), location, horticultural practices, soil type, climate, and maturity (*6*). In conclusion, no study of the compositional profile of Australian-grown pecans has been conducted, although pecans have been commercially grown in Australia for 30 years (*3*).

Consequently, this study was designed to determine the composition of high-quality Australian-grown pecans. The two main cultivars grown in Australia (Wichita and Western Schley) were examined. The compositional study was conducted over three years to allow for fluctuations in composition due to seasonal variations and the alternate bearing of pecan trees (*9*). Compositional data are required to identify differences in the composition of Australian- and U.S.-grown pecans and to form the basis for further research into the quality of Australian-grown pecans.

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MATERIALS AND METHODS

Sample Collection. Pecan nut-in-shell (NIS) [*C. illinoinensis* (Wangenh.) K. Koch cv. Wichita and Western Schley] samples were collected in early June for each of the 1995, 1996, and 1997 seasons from the Trawalla Pecan Orchard, Moree, NSW, Australia. All samples were collected after on-farm drying to 8 g/100 g of NIS moisture and transported to the laboratory for analysis. Upon arrival, all samples were canned at a negative pressure of 60 kPa and stored at −18 °C until analyzed. Prior to analysis, pecans were cracked using a hand-held Texas Pecan Cracker (H&K Manufacturing, Conroe, TX).

Reagents. All reagents, except acetonitrile (HPLC grade), were of AR grade and were purchased from Sigma-Aldrich, unless otherwise stated.

Moisture Content. NIS and kernel moisture of the pecans was determined using Association of Official Analytical Chemists (AOAC) International method 40.1.04 (*10*). As the pecans were dried on the farm prior to testing, moisture content was tested only to convert other data to a dry weight basis.

Lipid Content. The total lipid content of pecan kernels was determined using a Soxhlet apparatus as described in AOAC method 40.1.05 (*10*).

Sugar Analysis. Sugar analyses were performed using the procedure of Wills et al. (*11*), using dry, defatted pecan kernels (2.5 g prepared in duplicate and defatted using a Soxhlet apparatus). The samples were assessed using a Waters HPLC equipped with a model 501 pump and a Rheodyne loop injector (20 μL) with a differential refractive index detector (Waters model 410, Waters, Milford, MA). An amine bonded phase column (Waters carbohydrate, 300 × 3.9 mm, Waters) was used with a mobile phase of 83% v/v acetonitrile/water. External standard solutions of glucose, fructose, and sucrose were prepared for identification (using retention times) and quantification purposes.

Protein Content. The protein content of pecan kernels was determined using the Kjeldahl method as described in AOAC method 40.1.06 (*10*).

Total Dietary Fiber Content. Total dietary fiber in pecan kernels was determined using a total dietary fiber assay kit

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Table 1. Mean ($n = 3$) Lipid, Sucrose, Protein, and Dietary Fiber Contents, plus Lipoxygenase (LOX) and Lipase Activities, and Vitamin C Contents for the Australian-Grown Pecan Cultivars Wichita and Western Schley (Dry Weight)

pecan cultivar	lipid[a] (g/100 g)	sucrose[a] (g/100 g)	protein[a] (g/100 g)	dietary fiber[a] (g/100 g)	LOX[a] (units/min/g)	lipase[a] (μequiv/g/h)	vitamin C[a] (mg/100 g)
Wichita[b]	73.45	1.95	4.91	2.85	2.4	1.3	0.90
Western Schley[b]	73.08	1.99	5.08	3.45	1.8	0.9	0.99
mean	73.26 ± 2.68	1.97 ± 0.75	5.00 ± 1.03	3.32 ± 0.61	2.1 ± 0.4	1.4 ± 0.3	0.95 ± 0.24

[a] ANOVA not significant ($p > 0.05$). [b] Values presented are the means of three years.

(TDF-100, Sigma Chemical Co., St. Louis, MO), which is based on AOAC method 993.19 (*10*).

Enzyme Activity. Lipoxygenase activity (LOX) (EC 1.13.11.12) in pecans was assessed according to the method of Chen and Whitaker (*12*) with the following modifications. Defatted pecan kernels were weighed and homogenized in a Waring blender with cold acetone (−20 °C) in a ratio of 1:10 (w/v). A unit of enzyme activity was defined as the amount of enzyme that produced a change in absorbance of 0.001/min at 234 nm. The protein content of each of the acetone powders was determined according to AOAC method 40.1.06, which involves the Kjeldahl technique (*10*). The specific LOX of the pecans was determined by dividing the total enzyme activity units by the protein content, expressed as absorbance increments per minute per gram of protein in the acetone powder used for the enzyme assay.

Lipase (EC 3.1.1.3) activity in pecans was assessed according to the method of Fitz-Gerald and Deeth (*13*). Defatted pecan kernels (2 g) were homogenized with distilled water (4 °C) for 2 min using a Waring blender. Lipase activity was expressed as microequivalents (μequiv) of free fatty acids produced per gram per hour.

Vitamin C Determination. Pecans for the assessment of ascorbic acid were prepared according to the modified method of Wimalasiri and Wills (*14*). Samples of dry, defatted pecan kernels (2 g) were blended with 25 mL of citric acid (3% w/v) in a Waring blender for 2 min and then made to a volume of 50 mL with citric acid (3% w/v). Analyses were carried out using an amine bonded phase column (Waters carbohydrate, 300 × 3.9 mm) and a Waters HPLC system as described for the sugar analyses, with a UV detector set at 254 nm (Waters model 481). The mobile phase was acetonitrile/water (70:30 v/v) with 0.01 M ammonium dihydrogen phosphate (pH 4.3, adjusted with orthophosphoric acid), at a flow rate of 2 mL/min. Sample calculations were based on comparisons of peak areas of recovered analytes with those of ascorbic acid external standards.

Fatty Acid Analysis. Fatty acid profiles of pecan oil were assessed by preparing fatty acid methyl esters (FAME) using a methoxide-catalyzed methanolysis based on the method of Bannon et al. (*15*). Pecan oil (50−100 mg) was esterified by using 0.25 M sodium methoxide/diethyl ether solution (3 mL; 1:1 v/v) and refluxing at 60 °C for 2 min. Samples were injected into a Perkin-Elmer GC (Autosystem) fitted with a flame ionization detector (FID) and a split/splitless injection port used in the split mode. A DB-23 fused-silica capillary column (30 m × 0.25 mm, 0.25 μm film thickness, J&W Scientific) was used, combined with a helium carrier gas linear flow velocity of 30 cm/s. The injector temperature was 230 °C, and the detector temperature was 230 °C. The column temperature was programmed as follows: initial temperature, 50 °C for 1 min; linear temperature increase of 10 °C/min from 50 to 140 °C; second temperature ramp from 140 to 170 °C at 5 °C/min; final ramp of 20 °C/min from 170 to 230 °C; final hold at 230 °C for 10 min. Identification and quantification of the FAME in the samples involved the use of the external standard method and FAME standard mixtures (Alltech Associates, Inc). Peak areas were determined using Perkin-Elmer integration software in a workstation. Ratios of amounts of polyunsaturated to monounsaturated to saturated fatty acids (PMS) were calculated by adding together the concentrations of each of the respective fatty acids.

Mineral Analysis. Samples for mineral analyses were prepared according to the modified nitric acid/perchloric acid digestion method of Baker and Smith (*16*). Pecan kernels were frozen using liquid nitrogen prior to grinding in a coffee grinder, to ensure pieces were <2 μm in size. Samples of pecans (300 mg prepared in triplicate) were mixed with nitric acid/perchloric acid solution (15 mL; 5:1 v/v) and slowly heated on a hot-plate from 100 to 210 °C. Upon reaching 210 °C, the solution was boiled for a further 30 min and then left to cool to room temperature. The remaining mineral solution was diluted to 25 mL with triple-deionized water and then analyzed using an inductively coupled plasma atomic emission spectrophotometer (ICP-AES) (SPECTRO, P & M, Spectro Analytical Instruments GmbH, Kleve, Germany).

Statistical Analysis. A factorial design consisting of the three seasons and two cultivars was used for this experiment. This design produced limited degrees of freedom in the error term, so small differences in the results may not necessarily be statistically significant. However, for the purpose of setting benchmark data on the composition of Australian pecans, the design is more than adequate. All data were analyzed using analysis of variance (ANOVA) techniques using the Statistix software package (version 4, Analytical Software, St. Paul, MN). For all measurements where significant ($p < 0.05$) F values were found, treatment means were compared using Fisher's least significant difference (LSD) procedure.

RESULTS AND DISCUSSION

There were no significant interactions ($p > 0.05$) between the cultivars or the seasons for any of the compositional data presented, so only main effects are presented. As this is the first time the composition of Australian-grown pecans has been investigated, the results for each of the components are detailed. The results from all of the compositional analyses (except minerals and fatty acid profiles) for each cultivar are presented in Table 1, and the results for the year of harvest are presented in Table 2.

Lipid. No significant difference ($p > 0.05$) in the lipid content (dry weight basis) was found for the cultivars tested or for the year of harvest (Tables 1 and 2). The lipid contents of the Australian-grown pecan cultivars Wichita (73.45 g/100 g) and Western Schley (73.08 g/100 g) are comparable to the values for Wichita (74.45 g/100 g) and Western Schley (73.10 g/100 g) pecans grown in the United States (*17*) and to the generally reported lipid content for pecans of 71.10 g/100 g (dry weight) (*5*). Differences in lipid content of pecans have been attributed to diverse factors such as year, location, horticultural practices, and soil type (*6*, *7*).

Sucrose Content. The sucrose content (dry weight basis) did not change significantly ($p > 0.05$) between cultivars (Table 1), averaging 1.97 g/100 g, which is comparable to that obtained by Fourie and Basson (*18*) (2.0 g g/100 g) and Wood and McMeans (*19*) (2.10 g/100 g). Glucose (0.01 g/100 g), fructose (0.02 g/100 g), and inositol (0.01 g/100 g) were also detected in pecans by Fourie and Basson (*18*). However, these sugars were not accurately quantified in this study (although they were detected) due to their low levels being close to the HPLC limit of detection for sugars. Sucrose was the only sugar detected in mature pecan kernels by Wood and McMeans (*19*), with fructose, glucose, and inositol detected only in immature kernels.

Table 2. Mean (n = 3) Moisture, Lipid, Sucrose, Protein, and Dietary Fiber Contents, plus Lipoxygenase (LOX) and Lipase Activities, and Vitamin C Contents for the Australian-Grown Pecans[e] (Dry Weight) Harvested in 1995−1997

year of harvest	lipid[c] (g/100 g)	sucrose[d] (g/100 g)	protein[c] (g/100 g)	dietary fiber[c] (g/100 g)	LOX[c] (units/min/g)	lipase[d] (μequiv/g/h)	vitamin C[c] (mg/100 g)
1995	72.09	2.65[a]	5.89	4.02	2.9	0.5[a]	1.15
1996	71.39	2.10[a]	5.24	3.03	1.0	1.9[b]	1.03
1997	76.31	1.17[b]	3.88	2.90	2.4	0.3[a]	0.68
mean	73.26 ± 2.68	1.97 ± 0.75	5.00 ± 1.03	3.32 ± 0.61	2.1 ± 1.0	1.4 ± 0.9	0.95 ± 0.24

[a,b] Means with the same letter in a column are not significantly different ($p > 0.05$). [c] ANOVA not significant ($p > 0.05$). [d] ANOVA significant ($p < 0.05$). [e] Values presented are the mean of two cultivars.

The sucrose content of Australian-grown pecans was significantly lower ($p < 0.05$) in 1997 than that of pecans harvested in 1995 and 1996 (Table 2). The sucrose contents of pecans harvested in 1995 and 1996 were not significantly different ($p > 0.05$). Pecan composition is known to vary depending on the year and climatic conditions (*6*). The harvest in 1997 was a particularly poor one for the Trawalla orchard, with the trees placed under stress due to excessive flooding of the orchard over a prolonged period of time (Crouch, 1997, personal communication). This may account for the lower sucrose levels present in these kernels. However, the sugar level of mature Australian-grown pecans seems to be similar to that of pecans grown in the United States.

Protein Content. No significant differences ($p > 0.05$) were found in the protein content with year of harvest or for the cultivars tested (Tables 1 and 2). The protein level of pecans grown in the United States has been reported to be 7.75 g/100 g by Santerre (*5*) and 9.46 g/100 g by Kays (*17*). These values are higher than the levels found for both Wichita (4.91 g/100 g) and Western Schley pecans (5.08 g/100 g) in this investigation (Table 1). Thus, it appears that growing location affects the protein content of pecans. The protein content did not change with year of harvest (Table 2), which is in contrast to the results of Kays (*17*), who found that protein content varied with year of production.

Total Dietary Fiber Content. The total dietary fiber content of pecans did not change significantly ($p > 0.05$) with year of harvest or cultivar (Tables 1 and 2). Little information is available about the dietary fiber content of pecans. Santerre (*5*) reported that the dietary fiber content of U.S.-grown pecan kernels was 1.6 g/100 g, which is lower than that found in this study of Australian-grown Wichita (2.85 g/100 g) and Western Schley (3.45 g/100 g) pecan kernels. These differences may be due to production differences between the two countries or variation in methodology (*20*).

Enzyme Activity. No significant differences ($p > 0.05$) for LOX for cultivar or year of harvest were found. The average LOX over the three pecan harvests (1995−1997) was 2.1 units/min/g (Table 2). LOX in pecans was reported by Senter et al. (*21*) and Nelson et al. (*22*), but the levels were not quantified. Information about the presence of lipoxygenase in other tree nuts is limited to studies on hazelnuts, which showed no activity (*23*).

The lipase activity did not significantly change ($p > 0.05$) between cultivars (Table 1). However, the lipase activity of pecans harvested in 1996 was significantly higher ($p < 0.05$) than in pecans harvested in 1995 and 1997 (Table 2). There was no significant difference ($p > 0.05$) in lipase activity between pecans harvested in 1995 and 1997. No information concerning lipase activity in pecans was available prior to this study. However, lipase activity has been determined in a number of other tree nuts including hazelnuts (*23*−*26*), walnuts (*27*), almonds and pistachios (*28*), and peanuts (*29*), but the majority of these tests were qualitative. Thus, no comparison of lipase activity with the results of this study can be made. Lipase levels in hazelnuts have been shown to vary depending on the cultivar tested and have been shown to have a negative effect on hazelnut quality (*23*). It is difficult to assess the relative lipase activity for nuts among the different studies due to the different methodologies and units used. In conclusion, this study shows that the lipase level in pecans is low and that the level did not change with cultivar or year of harvest.

The minimal LOX and lipase activity in pecans suggest that oxidation of lipids due to these enzyme systems would be unlikely, especially if the kernels were stored at low temperatures, with minimal contact with oxygen.

Table 3. Major Fatty Acids (>1 g/100 g) (n = 3) Present in Australian-Grown Wichita and Western Schley Pecans

pecan cultivar	fatty acid content (g/100 g of fatty acids)[a,d] $C_{16:0}$[c]	$C_{18:0}$[c]	$C_{18:1}$[c]	$C_{18:2}$[c]	$C_{18:3}$[c]	PMS[b] ratio
Wichita	6.56	2.38	57.28	31.50	1.73	3.63:6.31:1
Western Schley	6.65	2.57	53.38	34.24	1.74	3.83:5.73:1
mean	6.61	2.48	55.33	32.88	1.74	3.70:6.10:1

[a] Palmitic acid, $C_{16:0}$; stearic acid, $C_{18:0}$; oleic acid, $C_{18:1}$; linoleic acid, $C_{18:2}$; linolenic acid, $C_{18:3}$. [b] Ratio of polyunsaturated to monounsaturated to saturated fatty acids. [c] ANOVA not significant ($p > 0.05$). [d] Values presented are the mean of three harvests.

Vitamin C Content. Vitamin C (Tables 1 and 2) was assessed in this study due to its nutritional importance and the fact that it may act as a natural antioxidant. No significant differences ($p > 0.05$) were found in the vitamin C content for the cultivars tested (Table 1) or for the year of harvest (Table 2).

Santerre (*5*) reported the vitamin C level in pecans to be 2 mg/100 g, which is higher than the result reported here (0.95 mg/100 g). This suggests that Australian-grown pecans would have a lower vitamin C activity than U.S.-grown pecans. However, the levels obtained are of little nutritional significance.

Fatty Acid Analysis. No significant differences ($p > 0.05$) in the fatty acid contents were observed for cultivar or year of harvest (Tables 3 and 4). Fatty acid analysis of the pecan samples showed oleic acid to be the major fatty acid (55.33 g/100 g), followed by linoleic (32.88 g/100 g), palmitic (6.61 g/100 g), stearic (2.48 g/100 g), and linolenic (1.74 g/100 g) acid (Tables 3 and 4). Most previous studies on the fatty acid composition of pecans have been on older, more established pecan cultivars such as U.S.-grown Stuart, Mahan, Barton, and Hayes (*7*, *30*, *31*). Kays (*17*) and Rudolph et al. (*7*) found fatty acid levels for Western Schley similar to those reported here. However, the fatty acid contents of Egyptian-grown Western Schley pecans (*32*) varied from the results in this study with the level of linoleic acid being higher in the Egyptian pecans (42 g/100 g),

Table 4. Major Fatty Acids (>1 g/100 g) (n = 3) Present in Australian-Grown Pecans Harvested in 1995, 1996, and 1997

year of harvest	fatty acid content (g/100 g of fatty acids)[a,c]					PMS[b] ratio
	$C_{16:0}$[b]	$C_{18:0}$[c]	$C_{18:1}$[b]	$C_{18:2}$[b]	$C_{18:3}$[b]	
1995	6.63	2.40	52.73	34.58	1.76	4.02:5.84:1
1996	6.71	2.80	51.13	36.88	1.94	4.08:5.48:1
1997	6.49	2.23	62.13	27.17	1.52	3.29:7.13:1
mean	6.61	2.48	55.33	32.88	1.74	3.70:6.10:1

[a] Palmitic acid, $C_{16:0}$; stearic acid, $C_{18:0}$; oleic acid, $C_{18:1}$; linoleic acid, $C_{18:2}$; linolenic acid, $C_{18:3}$. [b] ANOVA not significant ($p > 0.05$). [c] Values presented are the mean of two cultivars.

Table 5. Minor Fatty Acids (<1 g/100 g) (n = 3) Present in Australian-Grown Wichita and Western Schley Pecans

pecan cultivar	fatty acid content (g/100 g of fatty acids)[a,c]					
	$C_{12:0}$[b]	$C_{14:0}$[b]	$C_{14:1}$[b]	$C_{16:1}$[b]	$C_{20:0}$[b]	$C_{20:4}$[b]
Wichita	0.01	0.05	0.03	0.21	0.12	0.03
Western Schley	0.01	0.06	0.02	0.20	0.12	0.03

[a] Lauric acid, $C_{12:0}$; myristic acid, $C_{14:0}$; myristoleic acid, $C_{14:1}$; palmitoleic acid, $C_{16:1}$; arachidic acid, $C_{20:0}$; arachidonic acid, $C_{20:4}$. [b] ANOVA not significant ($p > 0.05$). [c] Values presented are the mean of three harvests.

whereas the levels of all other fatty acids were lower. These results highlight the role of growing locality on the fatty acid composition of pecan kernels.

Additionally, the fatty acids lauric acid ($C_{12:0}$), myristic acid ($C_{14:0}$), myristoleic acid ($C_{14:1}$), palmitoleic ($C_{16:1}$), arachidic acid ($C_{20:0}$), and arachidonic acid ($C_{20:4}$) were detected in both Wichita and Western Schley pecans at concentrations of <0.3 g/100 g (Table 5). The concentrations of these fatty acids were similar to those found by Senter and Horvat (*31*) except for myristic acid ($C_{14:0}$) (1.2 g/100 g), which was present in lower levels in this study (0.05 g/100 g). This difference may be due to differences in cultivars or growing location. Senter and Horvat (*31*) also detected a further 18 minor fatty acids. Further investigations into the fatty acid composition of Australian-grown Wichita and Western Schley pecans may be necessary to detect the presence of the remaining 12 trace fatty acids as detected by Senter and Horvat (*30*).

Little useful comparison can be made based on individual fatty acids alone, so PMS ratio is often used for comparative purposes in a discussion of the fatty acid composition of foods (*33*). The PMS ratios for pecans obtained in this study were 3.63:6.31:1 for Wichita and 3.83:5.73:1 for Western Schley and are similar to the general pecan figures of 3.28:7.46:1 (*34*) and 2.5:6:1 (*35*). The only other tree nut that has a PMS ratio comparable to that of pecans is the almond (3.02:7.31:1) (*34*).

Mineral Content. No significant differences ($p > 0.05$) were found for calcium, potassium, sulfur, phosphorus, boron, copper, iron, or aluminum with respect to the year of harvest or the pecan cultivar (Tables 6 and 7). However, the levels of magnesium, sodium, and zinc changed significantly ($p < 0.05$) with year of harvest, whereas the levels of manganese, sodium, and zinc all changed significantly ($p < 0.05$) with cultivar. The concentration of each of the minerals tested during this study (Tables 6 and 7) is generally comparable to those of Sparks (*36*), Senter (*37*), and Furr et al. (*38*). However, the copper levels (0.5 mg/100 g) were lower than the values reported by Sparks (*36*) (1.0 mg/100 g), Senter (*37*) (1.1 mg/100 g), and Furr et al. (*38*) (1.5 mg/100 g), whereas the manganese levels were slightly higher in our study. Although the results for calcium in this study generally conform to those of Sparks (*36*) (36 mg/100 g) and Furr et al. (*38*) (61.8 mg/100 g), a value of only 5.8 mg/100 g (dry weight) as reported by Senter (*37*) is much lower than the value (55 mg/100 g) found in this study.

Conclusion. The results for this research have established the benchmark levels for the composition of Australian-grown pecans for the cultivars Wichita and Western Schley. There do not appear to be major compositional differences between the two cultivars, and the composition is not greatly affected by year of harvest. The results are also generally comparable to those previously published for pecans grown in other parts of the world. Where differences are evident, they are likely to be due to differences in cultivar, growing location, or horticultural practices. Protein content was the only constituent to differ markedly between Australian- and U.S.-grown pecans.

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Table 6. Mean (n = 3) Mineral Content of Australian-Grown Wichita and Western Schley Pecans (Dry Weight)

pecan cultivar	mineral results (mg/100 g)[e]											
	Ca[c]	Mg[c]	K[c]	S[c]	P[c]	B[c]	Cu[c]	Fe[c]	Mn[d]	Na[d]	Zn[d]	Al[c]
Wichita	48	120	467	118	306	1.1	0.3	2.5	7.2[a]	2.8[a]	6.2[a]	2.1
Western Schley	61	126	477	125	325	1.2	0.6	4.9	8.3[b]	4.7[b]	6.9[b]	2.1
mean	54 ± 9	123 ± 4	472 ± 7	122 ± 5	316 ± 13	1.2 ± 0.1	0.4 ± 0.2	3.7 ± 1.7	7.8 ± 0.8	3.8 ± 1.3	6.6 ± 0.5	2.1 ± 0.0

[a,b] Means with the same letter in a column are not significantly different ($p > 0.05$). [c] ANOVA not significant ($p > 0.05$). [d] ANOVA significant ($p < 0.05$). [e] Values presented are the mean of three harvests.

Table 7. Mineral Contents (n = 3) of Australian-Grown Pecans Harvested (Dry Weight) in 1995, 1996, and 1997

year of harvest	mineral results (mg/100 g)[e]											
	Ca[c]	Mg[d]	K[c]	S[c]	P[c]	B[c]	Cu[c]	Fe[c]	Mn[c]	Na[d]	Zn[d]	Al[c]
1995	56	137[a]	477	114	304	1.7	0.4	2.9	7.8	3.9[ab]	6.0[a]	2.2
1996	55	140[a]	469	126	308	1.5	0.6	2.7	7.2	4.4[a]	7.0[b]	2.7
1997	53	92[b]	471	124	335	0.4	0.5	5.6	8.3	3.0[b]	6.8[b]	1.4
mean	55 ± 2	123 ± 27	472 ± 4	121 ± 6	316 ± 17	1.2 ± 0.7	0.5 ± 0.1	3.7 ± 1.6	7.8 ± 0.6	3.8 ± 0.7	6.6 ± 0.5	2.1 ± 0.7

[a,b] Means with the same letter in a column are not significantly different ($p > 0.05$). [c] ANOVA not significant ($p > 0.05$). [d] ANOVA significant ($p < 0.05$). [e] Values presented are the mean of two cultivars.

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