Physicochemical properties of fruit of chokecherry (*Prunus virginiana* L.), highbush cranberry (*Viburnum trilobum* Marsh.), and black currant (*Ribes nigrum* L.) cultivars grown in Saskatchewan

A. M. Zatylny, W. D. Ziehl, and R. G. St-Pierre[1]

Department of Plant Sciences, University of Saskatchewan, 51 Campus Drive, Saskatoon, Saskatchewan, Canada S7N 5A8. *Received 2 April 2004, accepted 10 December 2004.*

Zatylny, A. M., Ziehl, W. D. and St-Pierre, R. G. 2005. **Physicochemical properties of fruit of chokecherry (*Prunus virginiana* L.), highbush cranberry (*Viburnum trilobum* Marsh.), and black currant (*Ribes nigrum* L.) cultivars grown in Saskatchewan.** Can. J. Plant Sci. **85**: 425–429. Physicochemical properties of the fruit of chokecherry (*Prunus virginiana* L.), highbush cranberry (*Viburnum trilobum* Marsh.), and black currant (*Ribes nigrum* L.) were assessed from fruit harvested from replicated cultivar trials at Saskatoon, SK, and at Yorkton, SK, in 1999 and 2000. Fruit weight, total solids, soluble solids, pH, titratable acidity, percent pit, estimated percent flesh, and Hunterlab colour characteristics were measured. Fruit of the chokecherry cultivars ranged in their 10-fruit weights from 6.6 to 9.2 g, percent pit from 9.4 to 16.0%, estimated percent flesh from 17.2 to 23.7%, and pH from 3.86 to 4.25. Mean total solids and soluble solids contents were 35.2% and 18.3°Brix, respectively, and did not differ among the cultivars. Hue angle, chroma and L values of chokecherry fruit juice extracts ranged from 34.6 to 88.2°, 15.3 to 23.9, and 23.3 to 51.1, respectively. Fruit of the highbush cranberry cultivars ranged in their 10-fruit weights from 4.1 to 7.3 g, percent pit from 4.6 to 9.0%, estimated percent flesh from 10.9 to 14.0%, soluble solids content from 10.2 to 13.3°Brix, and pH from 2.89 to 3.13. The hue angle and *L* values of the fruit juice extracts of the highbush cranberry cultivars ranged from 16.0 to 18.2°, and from 15.5 to 21.3, respectively. Mean total solids content and *L* values were 18.9% and 18.0, respectively; both measurements did not differ significantly among the cultivars. Fruit of the black currant cultivars differed only in their 10-fruit weight, pH and titratable acidity which ranged from 7.5 to 12.8 g, 2.85 to 3.04, and 3.04 to 4.03%, respectively. Mean total solids and soluble solids contents of black currant fruit were 22.3% and 15.8°Brix, respectively. Black currant fruit juice extracts had a mean hue angle, chroma and *L* values of 13.2°, 12.6 and 9.8, respectively.

Key words: Chokecherry, *Prunus virginiana*, highbush cranberry, *Viburnum trilobum*, black currant, *Ribes nigrum*, native fruit

Zatylny, A. M., Ziehl, W. D. et St-Pierre, R. G. 2005. **Propriétés physiochimiques des fruits des variétés de cerisier de Virginie (*Prunus virginiana* L.), de viorne trilobée (*Viburnum trilobum* Marsh.) et de gadellier noir (*Ribes nigrum* L.) cultivés en Saskatchewan**. Can. J. Plant Sci. **85**: 425–429. Les auteurs ont évalué les propriétés physicochimiques des fruits du cerisier de Virginie (*Prunus virginiana* L.), de la viorne trilobée (*Viburnum trilobum* Marsh.) et du gadellier noir (*Ribes nigrum* L.) à partir des fruits récoltés lors des essais de cultivars effectués en double à Saskatoon (Saskatchewan) et à Yorkton (Saskatchewan) en 1999 et en 2000. Le poids des fruits, les solides totaux, les solides solubles, le pH, l'acidité, la proportion du fruit représentée par le noyau, la proportion estimative de chair et la couleur Hunterlab étaient les paramètres retenus. Les fruits de cerisier de Virginie présentaient les variations suivantes : poids de 10 fruits de 6,6 à 9,2 g, proportion du fruit représentée par le noyau de 9,4 à 16,0 %, proportion estimative de chair de 17,2 à 23,7 % et pH de 3,86 à 4,25. La concentration moyenne de solides totaux s'établissait à 35,2 % et celle de solides solubles à 18,3 °Brix. Elles ne variaient pas d'un cultivar à l'autre. L'angle de phase, la saturation et la valeur L du jus des fruits de cerisier de Virginie fluctuaient respectivement de 34,6 à 88,2°, de 15,3 à 23,9 et de 23,3 à 51,1. Le poids de 10 fruits des cultivars de viorne trilobée fluctuait de 4,1 à 7,3 g, le noyau représentait 4,6 à 9,0 % du fruit, la proportion estimative de chair s'élevait de 10,9 à 14,0 %, les solides solubles mesuraient de 10,2 à 13,3 °Brix et le pH variait de 2,89 à 3,13. L'angle de phase et la valeur L du jus des fruits de la viorne trilobée fluctuaient respectivement de 16,0 à 18,2° et de 15,5 à 21,3. La concentration moyenne de solides totaux et la valeur L s'établissaient respectivement à 18,9 % et à 18,0. Ces deux mesures ne variaient pas de façon significative d'un cultivar à l'autre. Les fruits du gadellier noir ne présentaient des variations que pour le poids de 10 fruits, le pH et l'acidité, soit de 7,5 à 12,8 g, de 2,85 à 3,04 et de 3,04 à 4,03 %, respectivement. La concentration moyenne de solides totaux et celle de solides solubles s'établissaient respectivement à 22,3 % et à 15,8 °Brix. Le jus des fruits du gadellier noir avait des valeurs de 13,2°, de 12,6 et de 9,8 respectivement pour l'angle de phase, la saturation et la valeur L.

Mots clés: Cerisier de Virginie, *Prunus virginiana*, viorne trilobée, *Viburnum trilobum*, gadellier noir, *Ribes nigrum*, fruits indigènes

The chokecherry (*Prunus virginiana* L.) is a shrub or small tree native to and widespread across Canada and most of the United States (Vilkitis 1974). It is a true cherry and a close relative of the domesticated cherries. The highbush cranberry (*Viburnum trilobum* Marsh.) is a member of the honeysuckle family (Caprifoliaceae). This native shrub is found north to Alaska and from coast to coast throughout southern Canada and the northern United States (Stang 1990). The

[1]*Correspondence should be sent to the following address: Richard St-Pierre, 1410 Ewart Ave., Saskatoon, Saskatchewan, Canada S7H 2K6 (e-mail: rgstpierre@sasktel.net).*

fruits of both the chokecherry and highbush cranberry were widely used by native North Americans and early settlers (Stang 1990; Wilkinson 1990). The fruit are still used today for jellies, syrups and beverages. Superior selections of both chokecherry and highbush cranberry have been selected from wild stands and are now beginning to be grown under cultivation; breeding of these fruits has never been undertaken. A number of black currant (*Ribes nigrum* L.) cultivars appear to be very winter hardy and may be suitable for production on the Canadian prairies. Very few black currant cultivars have been grown in Saskatchewan and none have been formally tested. The need for agriculture diversification on the Canadian prairies has driven the evaluation of potential new horticultural crops including various native fruit species. Consequently, the Native Fruit Development Program at the University of Saskatchewan established replicated cultivar trials of these fruits for evaluation.

The objective of this study was to undertake a basic physicochemical characterization of the fruit of a number of cultivars of chokecherry, highbush cranberry, and black currant presently under evaluation in replicated cultivar trials in Saskatchewan. No basic physicochemical data for fruit of chokecherry and highbush cranberry are available, and the data which are available for black currant are limited and are associated with different cultivars grown in northern Europe. This research will permit a comparison of some basic attributes of fruit quality among the cultivars evaluated in Saskatchewan, as well as provide a basis on which any new cultivars or future selections may be evaluated and compared. Additionally, any information on the physicochemical properties of fruit of these cultivars will provide a knowledge base that may be of some benefit to the developing fruit processing industry in Saskatchewan.

MATERIALS AND METHODS

Cultivar evaluation trials of chokecherry, highbush cranberry and black currant were planted in the fall of 1994 at the University of Saskatchewan horticulture field plots in Saskatoon, SK. A black currant trial also was established near Yorkton, SK. The selection of cultivars for these trials was based on the availability of sufficient plant material from commercial propagators. The chokecherry cultivars included Boughen Yellow, Copper Schubert, Garrington, Goertz, Lee Red, Mission Red, and Robert. The highbush cranberry cultivars included Alaska, Andrews, Garry Pink, Manitou, and Wentworth. The black currant cultivars included Boskoop Giant, Consort, Magnus, Topsy, Wellington, Willoughby, and three open-pollinated seedlings of the cultivar Öjebyn (25-23-23, 5-23-42, and 5-24-9). In regards to the black currant cultivars, the selection was based on those cultivars recommended for garden production in Saskatchewan. It is important to note that, at the time the cultivar evaluation trials were established, sufficient plant material of the newer cultivars (Ben Alder and Ben Nevis, for example) was not available for purchase in Canada.

The trials were arranged in a randomized complete block design with three blocks. Five plants per cultivar were planted in a row within each block.

Fruit were harvested from one to two plants per cultivar selected randomly from each block. Harvested fruit were put into plastic containers (25 × 19 × 8 cm) (Item Code PCA 9745, PCA Canada, Scarborough, ON) and placed on ice packs (Cryopak Corp., Vancouver, BC) in an insulated wooden container designed for temporary storage and transport from the field. Fruit were stored in this field cooler for up to 7 h before being frozen at –40°C in the plastic containers.

Physicochemical analyses on the fruit were conducted on two to three subsamples of the fruit harvested from each block from the field, depending on the analysis. Ten-fruit weight was determined by weighing 10 frozen fruit. Total solids content was determined according to the Association of Official Analytical Chemists (AOAC) method 920.151 (AOAC 1995) in which 15 g of fruit were dried in a vacuum oven at 70°C for 24 h. The percent pit of chokecherries and highbush cranberries was measured gravimetrically by separating fruit flesh from the pit. Twenty-gram samples of fruit were blended using dull blades with approximately 50 mL of 60°C distilled water for 20 s. For highbush cranberry, 0.1 g of pectic enzyme (Wine Art Inc., Richmond Hill, ON) was added to the distilled water prior to blending. Pectic enzyme was used only on fruit of highbush cranberry because it was the only fruit that required its addition to facilitate the release of juice. The blended sample was strained and the flesh remaining on the pits was manually removed. The pit weight as a percentage of the whole fruit weight was reported. The estimated percent flesh was calculated on a dry basis as the percent total solids content minus the percent pit.

Measurements of pH, soluble solids and colour were conducted on extracted juice from the fruit. For chokecherry, 50 g of fruit flesh was manually macerated with 100 mL of distilled water. The samples were then centrifuged at 7200 × *g* for 10 min, and the resulting supernatant was utilized for pH, soluble solids, and Hunterlab colour analyses. Soluble solids readings of chokecherry juice were multiplied by a dilution factor of three to account for the effect of adding water to the fruit prior to measurement. Juice extracts of highbush cranberry were obtained by manually macerating 50 g of fruit and decanting the liquid portion. Black currant juice was obtained by placing 50 g of fruit in cheesecloth bags and manually squeezing out the juice. The pH was measured, and soluble solids content was determined by refractometer as per AOAC method 932.12 (AOAC 1995). The colour of the juice extract was determined with a MiniScan XE colourimeter (Hunter Assoc., Reston, VA). Hunterlab L, a and b values were recorded. Juice colour was presented as the hue angle $[\tan^{-1}(b/a)]$, and colour vividness by the chroma $[(a^2 + b^2)^{0.5}]$. The Hunterlab *L* value is a measure of the lightness of the sample.

Titratable acidity was measured only for black currant fruit according to a slightly modified version of AOAC Method 920.149 (c) (AOAC 1995). Frozen fruit (150 g) were boiled for 1 h and then centrifuged at 7200 × *g* for 10 min. The volume of the supernatant was made up to 1 L. The diluted supernatant was filtered through Whatman #4 filter paper and employed in the analysis as per AOAC Method

942.15 B (AOAC 1995). Titratable acidity was calculated as percent citric acid.

Subsample means were used in the statistical analysis. Data were checked for normality prior to analysis. The statistical analysis was performed using the mixed procedure (Proc Mixed) of SAS Version 6.11 (SAS Institute, Cary, NC). Year and site (where applicable) were considered as random factors. Cultivar mean separation was accomplished by the least significant difference (LSD) test.

RESULTS AND DISCUSSION

Chokecherry

Fruit of the chokecherry cultivars differed significantly in their 10-fruit weights, percent pit, estimated percent flesh, pH, and in the colour characteristics of their fruit juice (Table 1). Ten-fruit weights of the cultivars ranged from 6.6 to 9.2 g. Fruit of Goertz and Robert had significantly greater 10-fruit weights than that of Mission Red and Boughen Yellow. The percent pit was lowest for the fruit of Goertz (9.4%) and highest for that of Boughen Yellow (16%). The estimated percent flesh ranged from 17.2 to 23.7%, and was 24% lower for fruit of Boughen Yellow than the average of the remaining cultivars which did not differ significantly from each other. Total solids content did not differ significantly among the cultivars. Fruit pH among the cultivars ranged from 3.86 to 4.25. The pH of the fruit of Garrington was significantly greater than that of Boughen Yellow, Copper Schubert, Mission Red and Robert. Large significant differences among the cultivars existed in the hue angle of the juice extracts, ranging from 34.6 to 88.2°. When ripe, chokecherry fruit can range in colour from yellow, to red, to black. Fruit of Garrington and Goertz are black, fruit of Mission Red, Copper Schubert, Robert and Lee Red are red, and those of Boughen Yellow are yellow. Chroma and L values of the fruit juice also differed among the cultivars ranging from 15.3 and 51.1, respectively, for Garrington to 23.9 and 23.3, respectively, for Boughen Yellow. Fruit juice of Garrington, in particular, stood out as having colour characteristics that were distinctly different from those of the other cultivars. The fruit juice extract of Garrington had a hue angle 1.8–2.5 times lower (indicating a more red colour) and was 40–54% darker (as indicated by a significantly lower *L* value) than that of all the other cultivars. Fruit juice of Garrington also was significantly more vivid in colour (as indicated by a higher chroma value) than that of all the other cultivars but Goertz. The juice extract of Boughen Yellow was visually assessed as being pale yellow while that of all other cultivars ranged from pale red-pink for Lee Red, to red for Garrington. However, fruit juice of Boughen Yellow and Lee Red did not differ significantly in their hue angle. The chroma and *L* values indicated that the juice extracts were greyish in colour for these two cultivars. It is possible that, because of the pale colour of the fruit of these two cultivars the dilution of the juice extracts prior to measurement further reduced the colour intensity of the juice to such an extent that the colour assessment by the colourimeter was no longer meaningful.

The combination of a high fruit weight and low percent pit value, as in the cultivar Goertz, is desirable for processing as the amount of useable flesh would be maximized. The fruit of the cultivar Boughen Yellow would not be very well suited for processing because of its low fruit weight, large percent pit and low estimated percent flesh. In addition, rapid browning following maceration of the fruit flesh of Boughen Yellow was observed, which would be a concern during the processing of this cultivar. However, the fruit of Boughen Yellow may be suitable for wine-making.

Highbush Cranberry

Highbush cranberry cultivars differed significantly in their 10-fruit weights, percent pit, estimated percent flesh, soluble solids content, pH, and in the hue angle and *L* value of their fruit juice (Table 2). Ten-fruit weights of the cultivars ranged from 4.1 to 7.3 g. Manitou was the largest-fruited of the cultivars evaluated and had a significantly greater 10-fruit weight than all other cultivars but Alaska. The percent pit and estimated percent flesh ranged from 4.6 and 14.0%, respectively, for Manitou to 8.0 and 10.9%, respectively, for Garry Pink. The percent pit of the fruit of Manitou was 32–43% lower than that of the other cultivars. Manitou and Wentworth had a significantly greater estimated percent flesh than the other three cultivars. Percent total solids did not differ among the cultivars. Fruit of Manitou had the highest soluble solids content and those of Andrews and Garry Pink the lowest. Fruit pH ranged from 2.89 for Manitou to 3.13 for Andrews. Highbush cranberry juice extracts ranged in hue angle from 16.0° for Alaska to 18.2° for Manitou. Although significant, these differences in colour are not large for practical purposes. *L* values of the fruit juice extracts ranged from 15.5 to 21.3. Fruit juice of Manitou was significantly lighter (as indicated by a higher *L* value) than that of all the other cultivars by 13–38%. The cultivars did not differ in the chroma value of their fruit juice extracts.

The high fruit weight, high percent flesh and low percent pit combined with a high soluble solids content and high acidity of the fruit of Manitou suggest that this cultivar may be the most suited of the cultivars tested for processing. This cultivar was originally selected from wild stands in Manitoba for its large fruit size (Darrow 1975).

Black Currant

Black currant cultivars varied little in their fruit physicochemical properties. Significant differences among the cultivars only existed for fruit weight, pH and titratable acidity (Table 3). Ten-fruit weight of the cultivars ranged from 7.5 g for Magnus to 12.8 g for the selection 5-23-42. Black currant selections 5-23-42, 25-23-23 and the cultivar Wellington had significantly greater 10-fruit weights than Magnus, Topsy, Boskoop Giant and Consort. Black currant fruit ranged in pH from 2.85 for Wellington to 3.17 for the selection 5-24-9. The fruit of Consort, Wellington and Topsy had a significantly higher titratable acidity than the three numbered selections. Fruit of the black currant cultivars did not differ in their total solids and soluble solids contents, nor in the colour characteristics of their fruit juice. The range for pH (2.92–3.17) that we measured was slightly higher than that (pH 2.66–3.01) found by Heiberg et al.

Table 1. Fruit physicochemical properties of chokecherry cultivars harvested from the University of Saskatchewan (U of S), Saskatoon, SK, in 1999 and 2000

Cultivar	10-fruit weight (g)	% pit (wt/wt)	Estimated% flesh (dry basis)	Total solids(%)	Soluble solids (°Brix)	pH	Colour		
							Hue angle (°)	Chroma	*L*
Boughen Yellow	6.9*ab*	16.0*d*	17.2*a*	33.2	16.4	3.86*a*	88.2*d*	15.3*a*	51.1*d*
Copper Schubert	7.8*abc*	13.1*bc*	22.9*b*	35.9	18.6	4.00*ab*	75.4*c*	18.7*ab*	44.9*bcd*
Garrington	7.7*abc*	13.6*c*	22.6*b*	36.2	18.8	4.25*c*	34.6*a*	23.9*c*	23.3*a*
Goertz	9.2*c*	9.4*a*	22.1*b*	31.5	19.5	4.15*bc*	61.5*b*	20.2*bc*	38.7*b*
Lee Red	8.2*bc*	11.7*b*	22.0*b*	33.7	18.8	4.08*bc*	79.8*cd*	17.9*ab*	46.7*cd*
Mission Red	6.6*a*	14.3*c*	23.7*b*	38.0	18.8	4.00*ab*	68.9*bc*	18.9*ab*	42.1*bc*
Robert	8.6*c*	14.5*c*	23.1*b*	37.6	17.3	4.05*ab*	73.5*c*	18.8*ab*	44.7*bcd*
Mean	7.9	13.2	21.9	35.2	18.3	4.06	68.8	19.1	41.6
SE[z]	0.48	0.90	1.03	1.36	3.21	0.079	3.57	1.28	2.92

[z]Standard error of the mean.
a–d Means within a column followed by the same letter are not significantly different using LSD ($P \leq 0.05$).

Table 2. Fruit physicochemical properties of highbush cranberry cultivars harvested from the University of Saskatchewan (U of S), Saskatoon, SK, in 1999 and 2000

Cultivar	10-fruit weight (g)	% pit (wt/wt)	Estimated% flesh (dry basis)	Total solids(%)	Soluble solids (°Brix)	pH	Colour		
							Hue angle (°)	Chroma	*L*
Alaska	6.8*cd*	6.8*b*	11.9*a*	18.7	11.9*b*	3.03*c*	16.0*a*	32.4	15.5*a*
Andrews	4.1*a*	6.8*b*	11.4*a*	18.1	10.2*a*	3.13*d*	17.6*cd*	37.5	18.8*b*
Garry Pink	6.3*bc*	8.0*c*	10.9*a*	19.0	10.9*a*	2.96*b*	17.1*bc*	36.5	17.7*b*
Manitou	7.3*d*	4.6*a*	14.0*b*	18.5	13.3*c*	2.89*a*	18.2*d*	40.1	21.3*c*
Wentworth	5.7*b*	7.1*bc*	13.2*b*	20.3	12.4*b*	3.04*c*	16.7*ab*	35.5	17.0*ab*
Mean	6.0	6.6	12.3	18.9	11.7	3.01	17.1	36.4	18.0
SE[y]	0.25	0.77	0.62	0.44	1.46	0.025	0.55	3.95	2.06

a–d Means within a column followed by the same letter are not significantly different using LSD ($P \leq 0.05$).
[z] Standard error of the mean.

Table 3. Fruit physicochemical properties of black currant cultivars harvested from Yorkton, SK and the University of Saskatchewan (U of S), Saskatoon, SK, in 1999 and 2000

Cultivar	10-fruit weight (g)	Total solids (%)	Soluble solids (°Brix)	pH	Titratable acidity (% citric acid)	Colour		
						Hue angle (°)	Chroma	*L*
25-23-23[z]	11.8*c*	20.4	15.1	3.04*d*	3.26*ab*	13.0	10.1	8.4
5-23-42[z]	12.8*c*	22.5	16.0	2.99*cd*	3.06*a*	13.4	13.7	9.9
5-24-9[z]	11.0*bc*	22.5	15.6	3.17*e*	3.04*a*	13.8	12.2	9.5
Boskoop Giant	8.1*a*	21.0	15.1	2.96*bc*	3.80*c*	14.0	12.3	9.6
Consort	8.3*a*	22.9	16.3	2.92*b*	4.03*c*	12.0	11.7	8.6
Magnus	7.5*a*	23.5	16.3	3.00*cd*	3.65*bc*	12.0	12.6	9.9
Topsy	7.6*a*	23.5	16.6	2.96*bc*	3.79*c*	12.9	11.4	9.5
Wellington	11.3*c*	21.4	15.5	2.85*a*	3.91*c*	13.4	15.6	11.4
Willoughby	9.2*ab*	22.7	16.0	2.99*cd*	3.68*c*	14.2	14.2	11.5
Mean	9.7	22.3	15.8	2.99	3.58	13.2	12.6	9.8
SE[y]	0.93	0.86	1.14	0.024	0.155 0.85	2.60	1.76	

[z]Open pollinated seedlings of the black currant cultivar Öjebyn.
[y]Standard error of the mean.
a–d Means within a column followed by the same letter are not significantly different using LSD ($P \leq 0.05$).

(1992). The range for titratable acidity (3.04–4.03% citric acid) measured in the current study was slightly lower, and the range measured for soluble solids (15.1–16.6°Brix) was slightly higher, than those (3.05–4.75% citric acid; 14.0–16.5°Brix) measured by both Heiberg et al. (1992) and Ness (1993). The cultivars characterized by Heiberg et al. (1992) and Ness (1993) were different from those in our trials, and were grown in Norway, so it is difficult to know if the slight differences in the characteristics measured were a result of genotype and/or environment. The three black currant selections evaluated in the current study were open-pollinated seedlings of the cultivar Öjebyn, a winter-hardy, compact black currant, resistant to powdery mildew and widely grown in Scandinavia and Poland (Audette and Lareau 1997; Brennan 1996). These selections show promise in regards to fruit size, although the fruit were found to be slightly less acidic than a number of the other cultivars evaluated.

This study has provided a basic characterization of the physicochemical properties of cultivars of chokecherry,

highbush cranberry and black currants currently being evaluated in replicated cultivar trials in Saskatchewan. This information was not previously available, will provide a basis for further cultivar evaluation and development, and will provide a knowledge base that may benefit the developing fruit processing industry in Saskatchewan.

Association of Official Analytical Chemists (AOAC). 1995. Official methods of analysis. 16th ed. Vol. 2. AOAC, Baltimore, MD.

Audette, M. and Lareau, M. J. 1997. Currant and gooseberries culture guide. Agriculture and Agri-Food Canada. AGDEX 236/20. Publication VQ 210.

Brennan, R. M. 1996. Currants and gooseberries. Pages191–295 *in* J. Janick and J. Moore, eds. Fruit breeding.Vol. II. Vine and small fruits. John Wiley and Sons, Inc., New York, NY.

Darrow, G. M. 1975. Minor temperate fruits. Pages 269–284 *in* J. Janick and J. Moore, eds. Advances in fruit breeding. Purdue University Press, West Lafayette, IN.

Heiberg, N., Måge, F. and Haffner, K. 1992. Chemical composition of ten blackcurrant (*Ribes nigrum* L.) cultivars. Acta Agric. Scand. **42**: 51–254.

Ness, A. 1993. Evaluation of blackcurrant cultivars in Norway. Acta Hortic.**352**: 387–392.

Stang, E. G. 1990. Elderberry, highbush cranberry, and juneberry management. Pages 363–382 *in* G. J. Galletta and D. G. Himelrick, eds. Small fruit crop management. Prentice Hall, Englewood Cliffs, NJ.

Vilkitis, J. R. 1974. Cherries. US For. Ser. Gen. Tech. Rep. **9**: 23–25.

Wilkinson, K. 1990. Trees and shrubs of Alberta. Lone Pine, Edmonton, AB. 191 pp.