Elderberry: Botany, Horticulture, Potential

Denis Charlebois[1]
Agriculture and Agri-Food Canada
Horticultural Research and Development Centre
430 Gouin Boulevard
Saint-Jean-sur-Richelieu, Québec, J3B 3E6 Canada

Patrick L. Byers
Cooperative Extension Service
University of Missouri
Springfield, Missouri 65802

Chad E. Finn
Horticultural Crops Research Laboratory
U.S. Department of Agriculture
Agricultural Research Service
3420 NW Orchard Avenue
Corvallis, Oregon 97330

Andrew L. Thomas
Southwest Research Center
University of Missouri
14548 Highway H
Mt. Vernon, Missouri 65712

[1] References to trademarks, illustrations of products or statements concerning medical properties do not constitute an official endorsement or approval of the use of such commercial products from the authors or their affiliated institutions. Any such references, illustrations or statements are included exclusively for purposes of information.

        2. *Sambucus nigra*
    - B. Site Selection and Preparation
        - 1. Soil Preference
        - 2. Site Preparation
        - 3. Irrigation
    - C. Orchard Establishment
    - D. Fertilization and Mycorrhizae
    - E. Pruning
        - 1. Maintenance
        - 2. Rejuvenation
        - 3. Corrective
    - F. Weed Control
    - G. Pests and Diseases
        - 1. Insects
        - 2. Mammals and Birds
        - 3. Fungal, Viral, and Bacterial Diseases
        - 4. Abiotic Stress
    - H. Harvest
    - I. Yield
        - 1. *Sambucus canadensis*
        - 2. *Sambucus nigra*

IV. PROPAGATION
- A. Selection and Breeding
- B. Seed Propagation
    - 1. Seed Germination
    - 2. Planting
- C. Vegetative Propagation
    - 1. Hardwood Cuttings
    - 2. Softwood Cuttings
    - 3. Root Cuttings
    - 4. Micropropagation

V. USES
- A. Folklore
- B. Utilitarian
- C. Food
    - 1. Chemical Composition and Nutritive Value
    - 2. Toxicity
- D. Traditional Medicine
- E. Modern Medicine
    - 1. Leaf
    - 2. Flower
    - 3. Fruit
    - 4. Antiviral and Antimicrobial Properties
    - 5. Anthocyanins and Antioxidant Capacity
- F. Ecological Value and Ornamental Potential
- G. Markets and Production Costs

I. INTRODUCTION

The elderberry or elder (*Sambucus* ssp.) in production or growing wild in the northern hemisphere, may have the widest range of applications of all small fruits. Members of the genus *Sambucus* have a multitude of uses including: river bank stabilization and windbreaks (Paquet and Jutras 1996); wildlife food and refuge; ornamental, crafts and games; versatile human food source, and multi-purpose medicinal (Vallès et al. 2004). While the scientific documentation related to elderberries has increased over the last two decades, few reviews have been published. Martin and Mott (1997) reviewed the selection, cultivation, and management of American elderberry for wildlife and habitat management. More recently, the ecology of the European elderberry in the British Isles was thoroughly reviewed by Atkinson and Atkinson (2002). Finally, Charlebois (2007) reviewed the medicinal properties of elderberries, some of which were already mentioned in Dioscorides' *Materia Medica* written around the first century. Despite a well established commercial production in many countries of Europe and an increasing interest in North America, little attention has been paid to the horticultural aspects of this genus and its potential as a food and a medicinal crop.

Recent works linking an antioxidant-rich diet to disease prevention (Prior 2003; Willcox et al. 2004; Scalbert et al. 2005; Zafra-Stone et al. 2007; Seeram 2008), along with the versatility of elderberry as a crop, a food, and a medicine, have generated a renewed interest in this genus. This paper reviews European and American elderberries.

II. BOTANY

A. Taxonomy

The American and European elderberries have been harvested by native people since before recorded history and have been written about around the world for centuries leading to a plethora of vernacular names (Table 1). The generic name *Sambucus* is apparently derived from the Greek word "*sambuke"* or the Latin word "*sambuca"* that designates either a kind of flute that was made out of elderberry twig (Marie-Victorin 1935) or a small harp (Rich 1859). Members of the *Sambucus* are small trees, shrubs, or herbs (Fernald 1970). Since no definitive taxonomic DNA studies have been conducted, and because species of this genus are difficult to delimit based solely on morphological characteristics, no clear consensus has been reached about the exact number of species it contains and, depending on the author, it can range from 9 to 40 (Bailey 1930; Marie-Victorin 1935; Lawrence 1951; Elias 1980; Hickey and King 1981; Stang 1990; Bolli 1994; Dzhangaliev et al. 2003). Thus, it is not unusual to find some confusion on delimiting species, subspecies, and varieties in regional floras (Bailey and Bailey 1976; Brinkman and Johnson 2008) or even in the scientific literature. Ourecky (1970) stressed more than 30 years ago the necessity of a taxonomic clarification of the genus *Sambucus*.

Bolli (1994) recently proposed a revision of *Sambucus* in which the phylogenetic tree was simplified by submerging many species to the rank of sub-species. By emphasizing morphological similarities within the group, Bolli (1994) concluded that only nine species are reputed to be part of this genus. He also proposed giving the two most economically important members of the genus, the European elderberry (*S. nigra* L.) and the American elderberry (*S. canadensis* L.) the status of sub-species. According to Bolli (1994), they should be designated as *S. nigra* ssp. *nigra* (L.) R. Bolli (European elderberry) and *S. nigra* ssp. *canadensis* (L.) R. Bolli

(American elderberry). Because Bolli's work lacks molecular information, the scientific and horticultural communities have been reluctant to adopt the new terminology. According to the USDA-ARS germplasm resources information network (GRIN) (USDA 2008a), 14 *Sambucus* species are recognized and the names *S. nigra* (European elderberry) and *S. canadensis* (American elderberry) should be used; a recommendation widely followed in the literature (European and Mediterranean Plant Protection Organization 2008; UDSA, ARS, National Genetic Resources Program 2008b) and retained in this review. The results reported by Clarke and Tobutt (2006) in their study on microsatellite primers tend to support the idea that American and European elderberries are two different species. Furthermore, it should be noted that numerous authors, such as Yatskievych (2006), disagree with Bolli's (1994) revision.

The genus *Sambucus* is most often included with the Caprifoliaceae (Guangwan et al. 2008; Hu et al. 2008). Bolli (1994) asserted that it possesses enough distinctive characteristics to warrant the recognition of a new family, the Sambucaceae. Except for some rare cases (Gasson 1979; Gustafsson 1995), this proposal has not been pursued. However, the genus was recently withdrawn from the Caprifoliaceae and placed in the Adoxaceae (Backlund and Bremer 1997; Donoghue et al. 2001; Donoghue et al. 2003), an affiliation supported by plastid gene sequencing (Savolainen et al. 2000) but not supported by Fourier transform infrared spectroscopy analysis (Hao et al. 2007). The exact taxonomical position of the genus *Sambucus* is likely to be continually debated as new methods are developed and more specimens are submitted to genetic analysis.

B. Distribution

1. *Sambucus canadensis*. The American elderberry is native to eastern North America and fossilized seeds can be traced back more than 16,000 years (Kneller and Peteet 1999). It is found from Florida, 25°N (Deam 1924; Bailey 1930; Allen et al. 2002; Wunderlin and Hansen 2008) in the United States to the northern part of the Gaspé coast of Québec in Canada, 49°N (Environnement Canada 2002) that marks the northern limit of its natural distribution. Experimental plots have been maintained in Normandin Québec (USDA hardiness zone 2; see The National Land and Water Information Service Agriculture and Agri-Food Canada 2000 for a correspondence between the Canadian and the USDA hardiness zones) where the wild type and some cultivars grow well but the fruits barely reach full maturity due to a short growing season. It has also been distributed by man beyond its native range and can be found in Central Mexico and most Mesoamerican countries such as Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, and Panama (Plant Gene Resources of Canada Agriculture and Agri-Food Canada 2007). Patches of *S. canadensis* can be found growing as far west as Manitoba in Canada (Hosie 1979) and Minnesota in the United States (Martin and Mott 1997; Small et al. 2004) and can be found up to an altitude of about 1500 m (Little 1980). The distribution along the eastern coast of North America is probably limited by its relative sensitivity to salt (Hightshoe 1988; Griffiths 2006). *Sambucus canadensis* has been reported to grow in the Himalaya at an altitude of 2200 m (Mehra and Bawa 1968). However, it is unclear from this paper if European elderberry was mistaken for American elderberry or if the specimens studied had escaped from culture. European elderberry has long been used as an ornamental plant in North America (Marie-Victorin 1935). It is also possible that the early settlers brought with them cuttings and seeds of European elderberry and that some of these might have become naturalized in North

America. A thorough genetic analysis would however be needed in order to validate this hypothesis.

2. *Sambucus nigra.* The European elderberry is widely distributed in Europe with an eastern limit near 55°E (Atkinson and Atkinson 2002). Distribution extends further north than its American counterpart reaching 63°N in Norway (Lid 1979; Hultén and Fries 1986). It has been reported to grow to 470 m in the British Isles (Halliday 1997) but probably reaches higher altitudes elsewhere on the European continent and in North Africa (Atkinson and Atkinson 2002). European elderberry reaches its latitudinal and altitudinal limits where the mean October temperature is around 7°C, which is probably limiting for seed maturation (Atkinson and Atkinson 2002). It has been introduced in various parts of the world such as North America, East Asia, New Zealand and South Australia (Hultén and Fries 1986; Kabuce 2007). A detailed distribution map can be found in Atkinson and Atkinson (2002).

C. Habitat

American and European elderberries are usually found in open or semi-open areas and along habitat edges (Martin and Mott 1997) where conditions are suitable for seed germination and plant growth. Their seedlings compete poorly with more aggressive species (Hayes 1987) and thrive best in full sun or partial shade (Grime et al. 1988). Examples of such areas are: along streams in floodplains (Schnitzler 1997), in wooded areas where they will take advantage of openings in the canopy (Hankla 1977), in abandoned farm fields, in disturbed sites and along roadsides where they are sometimes used as a windbreak. European elderberry has been shown to be relatively light demanding (Kollmann and Reiner 1996). American elderberry can however be found under a closed canopy (Rossell and Rossell 1999). Elderberry does best with ample moisture and will grow in swamps, bogs and in transition zones between wetland and upland (Conner et al. 1990). In North America, elderberry is often found in roadside ditches that provide a moist environment and adequate light. It will thrive under poor drainage (Himelrick and Galletta 1990; McLaughlin et al. 2008), but will not tolerate long periods of flooding.

Elderberry's adaptation to a wide variety of climatic conditions has allowed it to develop an extensive distribution range. As with many plants, it is at risk in winter, after its chilling requirement has been met when warm spells trigger deacclimation and the beginning of budbreak when freezing temperatures are still common. This can result in leaf death if the plant is subjected to subsequent severe frosts (Grime et al. 1988). In the southmost part of its range, American elderberry grows in areas with no definite winter season and where summer temperature can easily reach 40°C, and therefore may not undergo a dormant phase.

In the northern part of its range, the winter temperature can dip as low as -40°C. All exposed parts are then susceptible to winter kill and the amount of snow cover will determine the extent of damage. Temperatures as low as -20°C down to root level have been observed in Québec in a snow free orchard resulting in some plant death; however most of the genotypes evaluated survived with various levels of damage (D. Charlebois, unpubl.).

American elderberry is sometimes mistaken for red elderberry (*S. racemosa* ssp. *pubens* (Michx.) House syn. *S. pubens* Michx.); the two share the same habitats in southern Québec, but red elderberry ranges only as far south as Tennessee in the United States (Fernald 1970). The red elderberry flowers earlier than the American elderberry, with flowers appearing in April and May, at the same time as the leaves. It also has a much more pyramidal inflorescence compared with the generally flat-topped inflorescence of American elderberry. The berries of the red elderberry are red when ripe.

D. Morphology

The American elderberry is a deciduous, fruit-bearing multi-stemmed shrub or small tree that can reach up to 3 m tall in the northern part of its range and as tall as 4.5 m in more southerly regions (Elias 1980; McLaughlin et al. 2008). Exceptionally, plants can reach a height of up to 9 m (Maisenhelder 1958; Vines 1960; Hankla 1977; DeGraaf and Witman 1979) and up to 10 m in European elderberry (Atkinson and Atkinson 2002; Wilczyński and Podlaski 2005). An elderberry seldom develops a spread of more than 3 m. American and European elderberries form shrubs with numerous straight canes growing closely together from the base where numerous branches arise, giving these plants their bushy appearance (Atkinson and Atkinson 2002). Certain cultivars may develop a main trunk from which shoots emerge a few centimeters above the ground. New shoots usually appear from second or higher order branching but can sometimes arise directly from the base as a reaction to low temperature (Barnola 1972) or removal of the above-ground part of the plant. As it reaches 20 to 30 years of age, European elderberry will stop producing branches from the base and assume a more tree-like form (Bolli 1994). European elderberry can easily live up to 25 years (Atkinson and Atkinson 2002) but rarely more than 35 years (Wilczyński and Podlaski 2005). The longevity of either cultivated or wild American elderberry is unknown, but assumed to be similar to European elderberry.

The canes are weakly lignified, with the white pith in the centre accounting for most of their diameter, and consequently are somewhat brittle; a heavy load of snow or ice may cause canes to break. Small lateral branches often arise late in the growing season; these usually die at the onset of winter (Metcalfe 1948). Because of this natural dieback, some annual maintenance (see Pruning) is usually required in spring with a positive effect on fruit production (DeGraaf and Witman 1979). The bark is light brown, yellowish or grayish and covered with prominent lenticels (Hankla 1977; DeGraaf and Witman 1979; Foote and Joes 1989), and is more deeply furrowed and corky in European elderberry.

The cone-shaped buds are medium sized and slightly pendulous (Harlow 1954). The leaves are stipulate, opposite and odd-pinnately compound with 5 to 11 leaflets, usually 7 (American; Lawrence 1951) or 3 to 9 leaflets, usually 5 to 7 (European; Atkinson and Atkinson 2002). Leaves range in color from bright green to medium green and yellow, are from 10 to 30 cm long (Vines 1960), and are nearly hairless on the upper side but hairy on the underside, especially along the veins. Selections, particularly of *S. nigra*, have been chosen for their ornamental value. They have a range of leaf colors from lime green to deep purple and a range of dissection to the leaves such that many appear similar to the finely divided leaves of *Acer palmatum* Thunb. Leaflets are short stalked, finely serrated, lanceolate to elliptical in shape, from 6 to 15 cm (American) or from 3 to 9 cm (European) in length, and from 2.5 to 6 cm in width; the lower leaflets are frequently tripartite (Foote and Joes 1989). The petiole reaches 3 to 10 cm (American) or 3 to 4 cm (European) in length (Vines 1960; Radford et al. 1968; Atkinson and Atkinson 2002). The roots extend into the soil near the surface at a depth of some 20 cm. They are lateral, fibrous and fasciculate, and not extensively ramified. On two-year-old plants from cuttings, roots may attain a length of over 2 m.

E. Reproductive Biology

Reproduction is sexual, by means of seeds that are dispersed by birds and mammals (Brinkman and Johnson 2008) eating the fruits and later regurgitating or defecating the seeds (Thompson 1981), and asexual, by root suckering, rhizomes, and rooting (layering) of procumbent stems where they touch the soil surface.

Flower and the subsequent fruit clusters arise mainly on the terminal portion of one- and two-year-old canes (Stang 1990). The divergent stamens tend to prevent self-pollination (Robertson 1892; Marie-Victorin 1935; Hickey and King 1981). In southern Canada, flowering begins toward the end of June, well after the leaves have appeared, and continues through the first two weeks of July. In the United States, blooming starts in late April and also extends through July in the Carolinas (Radford et al. 1968). The date of full flowering is usually in mid-June in Missouri, and a bit later, in late June, in the Pacific Northwest (Finn et al. 2008). Over its entire distribution range in North America, American elderberry's main blooming period probably extends from June through August. A few new flower clusters usually appear sporadically throughout late summer and early fall (Maisenhelder 1958; DeGraaf and Witman 1979; Hightshoe 1988). In areas where no definite dormant season exists such as Florida, year-round flower and fruit production can be observed (Cerulean et al. 1986). Because of this late flowering habit, and because they do not produce their floral primordia until shoot elongation has started in the spring (Philipson 1946), elderberry is rarely affected by late spring frost, even in the northern part of its distribution range. Thus elderberry is an excellent choice for both flower and fruit production.

The flat-topped flower clusters, corymbs (Lawrence 1951) often described as cymes (Marie-Victorin 1935; Fernald 1970), can range from only a few centimeters up to 35 cm in diameter; the largest clusters are usually found on new canes. On unpruned plants, cluster size tends to diminish as the number of clusters increases (D. Charlebois, unpubl.; P.L. Byers and A.L. Thomas, unpubl.). Clusters are made up of 2,000 or more small (6 mm) creamy white flowers. Offshoots arising from old canes often bear small clusters of only a few flowers. The flowers, which are faintly perfumed in *S canadensis* but more so in *S. nigra*, are complete (pentamerous) but contain no nectar gland (Marie-Victorin 1935); however extrafloral nectaries are present in American (Radford et al. 1968; Fahn 1987) and European elderberry (Dammer 1890). In European elderberry, transpetal veins are absent (Gustafsson 1995). The ovary is inferior and may be trilocular, tetralocular or pentalocular (Bailey 1930; Marie-Victorin 1935).

1. Pollination

According to Marie-Victorin (1935), the stamens of elderberries are so divergent that self-fertilization is virtually impossible. While some claim that two or more cultivars are needed for optimal fruit production (Way 1965; Bailey and Bailey 1976; Poincelot 1980; Grauer 1990), a planting of a single cultivar will produce good results. Extensive observations of isolated wild plants that consistently produce fruit would seem to further the claim that American elderberry is self fertile (P.L. Byers and A.L. Thomas, unpubl). Such observations cannot however completely rule out the contribution of a pollinizer within pollinator flight distance.

Because the flowers do not have nectaries, they are attractive to pollinating insects seeking pollen only (Robertson 1892). Field observations made over three years in several orchards in Québec indicate that insects probably play a minor role in the pollination process (D. Charlebois, unpubl.). This is surprising considering that elderberries have showy flower clusters, a characteristic usually associated with the coevolution of pollinators.

American elderberry is among the plant species found in Florida that are not visited by apioid insects (Pascarella et al. 2001). A similar lack of interest from this insect group has also been observed in Québec (D. Charlebois, unpubl.). However, Way (1981) stated that honeybees, as well as wind, are responsible for pollination in American elderberries. The exact determination of insect involvement in the pollination process is difficult considering the confounding action of the wind and passive self-pollination (Vaissière 2005). In contrast, European elderberry is believed to be routinely insect-pollinated (Grime et al. 1988).

Observations made on wild and cultivated plants of various ages seem to indicate that the wind and plant density are probably the most important factors responsible for successful pollination (Guilmette 2006; Guilmette et al. 2007). Elderberry pollen grains are often found in traps from various observatories (Jäger 1989) indicating that they are easily carried by the wind. This contradicts observations made by Bolli (1994) suggesting that elderberry pollen grains would not normally travel much further than the inflorescence from which they originate. In view of the likely importance of wind as a vector in elderberry pollination, planting density will have a measurable impact on yield, especially when the planting is young and the bushes are small, with few flowers.

2. Fruit Ripening

Elderberry fruits are considered berry-like drupes (Fernald 1970; Cram 1982; Brinkman and Johnson 2008) but are most often referred to as berries. When they appear, they are green, relatively compact, and oblong. As they ripen over a period of six to eight weeks from July to September in most of the distribution range, they enlarge until they are spherical. They then gradually turn red and finally black with a hint of purple and a glossy appearance. The peduncles and pedicels can also turn red during the ripening process. Individual berries, which may range from 5.0 to 6.5 mm in diameter (Brindza et al. 2007), contain three to five oblong tan to yellowish one-seeded stones (Radford et al. 1968; Brinkman and Johnson 2008). Finn et al. (2008) reported individual ripe berry weights ranging from 46 to 135 mg with means of 81 to 90 mg across multiple cultivars in Missouri and Oregon. Larger fruits were observed in Québec on wild-type and cultivars with individual ripe berry weights ranging from 70 to 186 mg (D. Charlebois, unpubl.) reflecting regional variations.

If above-ground tissues in American elderberry are damaged or pruned, vigorous new shoots will arise from the root crown. These new canes flower a few to several days later, and produce single fruit clusters that ripen 14 to 21 days later than those on secondary stems (A. Thomas et al, unpubl.). Individual fruits usually remain attached to their pedicels for up to several days after becoming fully ripe, allowing for timely harvest and processing. The stalks tend to bend under the weight of the ripe berries, and fruit clusters occasionally become detached from the plant by the wind or the weight of birds feeding on them (Bir 1992). In such a case, individual canes should be identified and the larger clusters used for flower production. Fruits from bushes grown in less than full sunlight, as is often the case with wild plants, usually ripen later than those in full sunlight (Hill 1983). Cultivars do not ripen at the same time (Kollànyi et al. 2005; Mathieu et al. 2008b); thus cultivar selection can be exploited to manipulate harvest window and maximize harvest efficiency.

Elderberries go through important biochemical changes during ripening. Cultivars of American and European elderberries follow similar trends from fruit set to harvest. For instance, titratable acidity and total amino acid content decrease while total soluble solids, anthocyanins and phenols, and antioxidant capacity all increase (Künsch and Temperli 1978a; Kaack 1990a;

Mathieu et al. 2007; Mathieu et al. 2008a, b). Such knowledge allows a more efficient harvest schedule and a better use of the fruits by the processing industry.

The fruits of the native wild American elderberry not only ripen later than those of the various cultivars (Hayes 1984; Mathieu et al. 2008b) but also ripen less uniformly. This heterogeneity in the ripening process is attributable to a number of factors, including the age of the fruit-bearing canes, the amount of sunlight the fruit clusters receive, and possibly genetics. Berries on older canes that are exposed to the sun will ripen first. Uniformity of ripening is an important factor in elderberry cultivar development.

The American and European elderberries are endozoochorous, as has been reported for *S. ebulus* L. (Czarnecka 2005). Because the fruits are eaten by a variety of birds and mammals (Brinkman and Johnson 2008; Stiebel and Bairlein 2008), it is expected that their dispersal can be over long distances (Czarnecka 2005) even in less favorable environments such as woodlands where the light availability is not ideal for the optimal development of the species.

F. Plant Development

Because American and European elderberries occur naturally over wide areas it is difficult to describe their development using universal temporal references. Both species are among the first woody plants to leaf out in spring. For example, leaf emergence in American elderberry can occur in late February in Missouri (P.L. Byers and A.L. Thomas, unpubl.) to early April in southern Québec (D. Charlebois, unpubl.), while European elderberry will do so in February or March in the U.K. (Atkinson and Atkinson 2002). When both species were grown in the same environment in Oregon, *S. nigra* broke bud much earlier than *S. canadensis* and flowered over three weeks earlier (Finn et al. 2008).

Despite widely different flowering times, fruit ripening is rather synchronous for both species reaching full maturity in early August to mid-September depending on where they are grown (Atkinson and Atkinson 2002; Mathieu et al. 2007; Finn et al. 2008; Mathieu et al. 2008b). Little information is available about the development of elderberries over their entire distribution range and it is to be expected that these general patterns will vary to some extent. For example, in Florida, elderberries have sometimes been known to retain their leaves (Little 1980; Cerulean et al. 1986; McLaughlin et al. 2008), and to bear flowers and fruits all year (Little 1980) thus probably spreading harvest over a long period of time and impacting negatively on production. Annual variations in weather patterns will also affect the date of occurrence and the duration of the various developmental stages as described by Atkinson and Atkinson (2002). While Guilmette et al. (2007) demonstrated that flowering is independent of heat accumulation in American elderberry, full fruit maturity is likely to be delayed if unfavorable conditions occur (D. Charlebois, unpubl.).

III. HORTICULTURE

The first report of American elderberry cultivation in North America dates back to 1761 (Ritter and McKee 1964). Either as an ornamental or as a fruit producing plant, elderberries can be used singly, in groups, as hedges, as living fences or as screens (Galletta and Himelrick 1990). The use of elderberry in a variety of agroforestry production systems is also promising (A. Thomas et al., unpubl.).

A. Winter Hardiness

1. *Sambucus canadensis*. The American elderberry can be grown from USDA hardiness zone 2 to 10. Zone 2 is harsher than that of the northern limit of its natural range, but even in this zone, American elderberry has vigorous vegetative growth and the bushes frequently grow to a height of more than 1.5 m (D. Charlebois, unpubl.). However, in areas with significant annual snow accumulation, the rather brittle canes tend to break under the weight of the snow and the plant will benefit from being carefully wrapped up with burlap or string in fall and will probably need corrective pruning in spring to remove broken canes. Fruit ripening can also be an issue in northern climates where the growing season is too short even for the most precocious cultivar to fully ripen the crop (D. Charlebois, unpubl.). Under such climatic conditions and considering the vegetative growth potential of the plant, flower production might be a better choice than fruit production.

2. *Sambucus nigra.* According to Wilczyński and Podlaski (2005), European elderberry is less sensitive to winter temperature than many other woody species. Its natural distribution range suggests that it is probably as winter hardy as the American species *canadensis*. Both species can however be cultivated in colder climates. However, *S. nigra* has performed poorly in Missouri (A.L. Thomas and P.L. Byers, unpubl.), and it is uncertain if this is due to winter or summer hardiness. Ornamental genotypes of *S. nigra* are often described as being hardy to USDA zones 5 to 7.

B. Site Selection and Preparation

Although American and European elderberries are not demanding plants, care must be taken when selecting a location. For ornamental purposes, the tendency of this species to form thickets through suckering should not be overlooked and sufficient space must be available. In commercial plantations, fruit production will be compromised in sites with less than full sun. For fruit or flower production purposes, a location away from woods and other obstructions should be selected in order to allow free air movement; to reduce the incidence of disease, insect, bird problems (Stang 1990); and to promote pollen dispersion.

1. Soil Preference

Elderberry can be grown on a wide variety of soils. Excellent growth and yield could be expected in organic (muck) soil. Mineral soil will also provide good conditions for elderberry production. Sandy soils, while capable of supporting limited growth and production, offer little nutrients and insufficient water retention.

Elderberry can tolerate imperfect drainage; however repeated flooding will reduce growth and productivity. Air temperature and rainfall had a significant effect on vascular cambium growth in *S. nigra* (Wilczyński and Podlaski 2005). The impact of overly wet conditions will vary depending on when they occur; damage may be minimal if the plantation is flooded during dormancy. Growth begins as soon as the ground thaws (in the northern part of its distribution range), and ceases with the first frosts. On the other hand, an accumulation of water during dormancy will be much more harmful if it is accompanied by alternating cycles of freezing and thawing. Ice formation can cause serious injury to young cuttings and seedlings. An excess of water during the growing season, if prolonged, may cause asphyxiation of the roots, delayed growth, reduced productivity, encourage root-rot diseases and fungi, and even death. However, an excess of water of not more than a day or two is unlikely to do much damage. Elderberry plants respond favorably to planting on berms at sites with less than ideal soil drainage.

While no systematic studies have been conducted to assess optimal soil pH for elderberry production, European elderberry has been shown to grow in soils with a pH ranging from 4.2 to 8.0 (Atkinson and Atkinson 2002).

2. Site Preparation. Seedlings and newly planted elderberry cuttings do not compete well if surrounded by other vegetation (Roper et al. 1998). However, allelochemicals from European elderberry bushes have been held responsible for important crop losses in Italy (D'Abrosca et al. 2001). In preparation for planting, perennial weeds should be killed, pH adjusted between 5.5 and 7.5 (Coastal Zone Resources Division 1978; Hightshoe 1988) if necessary, and tile drainage or berms installed if excessive field moisture has been identified as being a problem. While the elderberry's adaptability to a diversity of sites makes it an attractive option for growers with sites that are not well suited for other crops, good agricultural practices will enhance production.

Sites where strawberries, mint, alfalfa, potatoes or tomatoes have previously been grown are not desirable, as those crops are frequently associated with the presence of *Verticillium*. Any practices designed to enhance soil fertility and organic matter content will be beneficial to the establishment and development of an elderberry plantation. Excellent results have been obtained on sites freed of weeds and sown with a mixture of slow growing grasses and clover the year before planting (S. Mercier, person. commun.). When compared to bare soil, such ground cover prevents soil erosion, moderates soil temperature and moisture fluctuations, improves water penetration, and requires less maintenance by suppressing weeds.

The use of plastic or organic mulches such as wood chips, sawdust and bark, is an attractive option to limit weed growth. Elderberries are shallow-rooted and the use of plastic mulch conserves soil moisture and promotes root growth near the surface of the soil. While such roots might be perceived to be at a greater risk of cold temperature damage, data gathered over a three-year period at Agriculture and Agri-Food Canada's experimental farm in L'Acadie, Québec, have not shown any negative impact on the growth or survival of elderberry bushes with black plastic mulch (D. Charlebois, unpubl.).

3. Irrigation. Elderberries possess an extensive, shallow root system that can take advantage of any nearby moisture. Tőkei et al. (2005) demonstrated that water uptake in elderberry was rather insensitive to soil water content and that transpiration was mainly governed by atmospheric conditions. When the cuttings are first planted, it is essential that they receive enough water to get them off to a good start. Hand watering may be useful in the absence of an irrigation system. The young cuttings should receive between 1.5 and 2.5 cm of water weekly. Warmer and drier sites will probably need additional moisture. Elderberries have done well when irrigated following the general guidelines for most perennial crop species; i.e. 2.5 cm water per week during the growing season with higher levels during fruit ripening and times of drought. However, no research has been done to accurately determine moisture needs. The effectiveness of various irrigation systems has not been experimentally investigated for elderberry. While trickle systems are effective in Missouri (P.L. Byers and A.L. Thomas, unpubl.) and other production areas, systems may need to be adjusted in response to root system development as plants age.

Elderberries are not very drought-tolerant (Atkinson and Atkinson 2002) and drought will cause damage that may range from slower growth, yellowing of foliage or premature leaf fall, to the death of the bush. European elderberry tolerates moderate drought by keeping a low maximum leaf water conductance (Vogt 2001). While it is rated as highly vulnerable to cavitation and drought-induced embolism, it has developed survival strategies to compensate (Vogt 2001).

Mulching and proper weed management are helpful in minimizing the adverse effects of an occasional shortage of water, but irrigation might be essential for commercial production of high-quality fruit in some areas. In Missouri, fruit ripening occurs in August, and is usually accompanied by very hot, dry weather which can cause rapid deterioration of fruit quality and yield if water is insufficient. In Mediterranean climates such as in Oregon's Willamette Valley, with almost no summer rainfall, irrigation is essential for elderberry production.

C. Orchard Establishment

A new plantation can be established from seeds, seedlings, or cuttings. One-year-old rooted cuttings are the type of stock that is most commonly selected, but older stock will also yield good results. The type of stock selected, its age, and consequently its size, are all factors that will directly affect the cost. One-year-old stock raised in plug trays facilitates mechanical transplanting but does not establish as quickly as older and larger transplants. While one-year-old cuttings are expected to produce a sizable crop as early as the second year in the field, seedlings will not do so until the third or fourth year (Bolli 1994).

The genetic variability inherent to seed propagation is not desirable from a commercial production perspective but may be preferred in situations such as wildlife plantings where genetic diversity is a consideration. In a breeding program, seedling populations are generated from which selections may be made for potential future cultivars. Seeds require stratification before they will germinate (see Stratification).

If bare-root seedlings/cuttings are used, roots should be soaked in water a couple of hours prior to planting (Martin and Mott 1997). When the rooted cuttings/seedlings are to be planted in bare soil, one only needs to open a furrow approximately 15 to 20 cm deep with a harrow or disc and place the plant material in it. Regardless of the type of stock, it is essential to ensure that each plant is planted upright with the root system completely buried. This precaution is particularly important in the case of plug cuttings that are at risk of being uprooted by frost heaving. The furrow may be left open to promote rainfall catchment.

If the plantation is small with no more than a few hundred elderberries, a metal rod may prove to be a practical method of making holes to receive the cuttings or seedlings. A mechanical strawberry planter or the like may also be used if a large number of cuttings are to be planted. However, it is important to ensure that the cuttings are set at a depth slightly above their collar and that the earth is properly tamped down around them.

No research on different planting dates for a single site has yet been conducted, but it seems that elderberries can be planted at any time of year, provided that they can be irrigated after planting. In general, planting during the dormant period yields the best results. Planting in the spring, even late spring, has produced excellent results in southern Québec and Missouri. Planting late in the fall (in November) has reportedly yielded excellent results in southern Ontario (R. Geier, person. commun.). Since American elderberry is hardy up to zone 2, fall planting may be advantageous in areas with well defined seasons by enabling growth to resume as soon as the ground thaws in the spring.

Decisions on planting density should consider the increased growth in diameter of the bushes that will occur as the fruits mature and ripen. A common practice in commercial blueberry and primocane fruiting raspberry production that should work with elderberry is to

Deleted: The

Deleted: also allow for

Deleted: spreading

erect a simple t-trellis made from rebar and strung with baling twine or wire that catches the fruit laden canes and keeps them from falling into the row middles. Appropriate pruning should enable the grower to keep the aisles between rows reasonably clear without adversely affecting fruit production.

Under most of its natural distribution range, cuttings set 1.5 m apart or less will form a nearly solid hedgerow before they reach full production capacity, while if they are set 2.0 m apart or more, each bush should be accessible from all around even when fully grown. Wider spacing ensures better air movement that can reduce the incidence of fungal diseases but allows more weed growth between plants. *Sambucus nigra* bushes spread more than *S. canadensis* and usually require more space between them. Spacing between rows will depend on the equipment at the grower's disposal (Kaack 1988). To determine row spacing, 2.0 to 2.5 m should be allowed for bush development adding the width of the equipment that will be used to maintain the aisles. Roper et al. (1998) recommend 2.1 to 2.4 m between plants and 3.0 to 3.6 m between rows of American elderberries. To illustrate: spacing cuttings 2.0 m apart in each row and leaving 4.0 m between rows will result in a maximum density of approximately 1,200 bushes/ha.

D. Fertilization and Mycorrhizae

In an English study, Atkinson and Atkinson (2002) found that European elderberry can grow in soils with a broad spectrum of nitrogen (N), phosphorous (P) and potassium (K) content ranging from 18 to 354 µg/g, 71 to 192 µg/g, and 24 to 610 µg/g, respectively. Under favorable conditions, elderberries grow at an impressive rate. New stems may add nearly 2 m to their length in the course of a single year. Growth of this order requires large amounts of N. To meet the needs of an elderberry plantation, Craig (1978) proposed a simplified fertilization method:

apply 0.10 kg of 10-10-10 fertilizer for every year of the plant's age, up to a maximum of 0.45 kg. Alternatively, KCl (potassium muriate) may be used and applied every year or every second year. Good results have been reported from an application of approximately 220 kg of KCl/ha every second year (R. Geier, person. commun.). Fertilizer should be applied early in the spring, around leaf-out time but no sooner than bud-break. As with all perennial fruit crops, since P moves so slowly into the soil, it should be adjusted prior to planting if a site is low in this element.

Nitrogen can be applied in any form. When the cuttings are set out, all that is required is to apply the equivalent of 0.30 kg N by hand near, but not touching, the base of each cutting. Where the cuttings are being planted through plastic mulch, an equivalent quantity may be applied immediately before the mulch is laid down. In the second year, application of 0.60 kg N around each plant should be adequate. The fertilizer should be applied in strips in the case of elderberries planted on plastic mulch, as their roots will already have spread beyond the mulch. In subsequent years, approximately 60 kg N/ha should be applied early in spring, at budbreak. Depending on how vigorous the bushes are this may be followed by a second application of 20-24 kg N/ha in late May or early June. In accordance with Craig's (1978) recommendations, the maximum application rate should not exceed 0.45 kg ammonium nitrate per plant per year. Yearly supply varying from 200 to 400 kg N/ha have been proposed for *S. nigra* (Strauss and Novak 1971; Groven 1975; Künsch and Temperli 1978b; Kaack 1988). For both species, planting density, vigor of the plants, and the age of the plantation will have a direct effect of N requirement.

Elderberry roots associate readily with mycorrhizal fungi when treated with a commercial inoculant for trees (D. Charlebois, unpubl.); however, the effect of such an association has not been evaluated to date. Hyphae from unidentified fungi have also been observed in roots of wild and cultivated American elderberries. No effort was made to identify the species present or to assess their relationship (mycorrhiza, pathogen, or other). A few authors have reported the presence of vesicular-arbuscular mycorrhizae in European elderberry (Harley and Harley 1987; Grime et al. 1988; Atkinson and Atkinson 2002).

E. Pruning

Under normal conditions, individual elderberry canes usually die between the third and fifth year (Deam 1924). Pruning is essential to control plant growth, to remove dead or diseased branches, to stimulate growth of new branches and canes, and to promote fruiting (Stang 1990).

1. Maintenance. Maintenance pruning should be done every year to remove dead or broken branches and manage growth. Removing dead branches not only facilitates harvesting but also helps reduce the incidence of diseases caused by insects, fungi or bacteria. Branches that are less than 30 cm tall are often removed, which facilitates passage of equipment and eliminates branches that produce fruit that is inefficient to harvest and often of lower commercial value. In some cultivars, such as ‘York’, the fruit load may be such that some branches will bend until they touch the ground. Problematic canes should be removed; ideally a better alternative would be to harvest the flowers from such canes and avoid overload.

2. Rejuvenation. Fruit yields will increase steadily during the first three years following establishment of cuttings. However, while the total quantity of fruit will increase, the fruit clusters will become smaller over that period (D. Charlebois, unpubl., P.L. Byers and A.L.

Thomas, unpubl.). Usually around the fourth year, productivity will decline due to a number of factors, with aging of the canes probably being the main one. Accordingly, the bushes should undergo some rejuvenation pruning in about the fourth year, or later if growth has been slow.

In elderberries, inflorescences form mainly at the terminus of branches. The vigor of the branch will have a direct effect on the size of the fruit cluster. Less vigorous branches will produce small fruit clusters that will be among the first to ripen. As a rule, new shoots and one-year-old canes bear large inflorescences that produce slightly larger berries, and those berries ripen usually less than a week later.

A healthy elderberry bush will withstand extensive pruning without difficulty. Pruning it to ground level will cause it to send up numerous vigorous shoots. However, while this is the simplest of all methods, it does result in substantially lower fruit production in the year that the pruning is done. Alternatively, pruning to the ground can be done every other year. The impact on production in subsequent years is currently under evaluation.

The method that probably has the most positive impact on fruit production is the selective removal of wood that is more than three years old. Another advantage of this method is that pruning can be adapted to individual cultivars. ‘Kent’ and ‘Victoria’, for example, tend to form a well-defined trunk, and for those cultivars it will be preferable to prune old branches right back to the trunk, while leaving 2 to 9 branches that are 1 to 3 years old (Stang 1990). However, erratic branching can make it difficult to clearly establish the age of individual canes. ‘York’ does not usually form a well-defined trunk and sends up large numbers of new shoots; it should not be pruned in the same as ‘Kent’ and ‘Victoria’. ‘Scotia’ might be described as intermediate in terms of its ability to form a well-defined trunk. The next step, for all cultivars, is to prune back the lateral and terminal branches to enhance the rigidity of the plant. This is labor-intensive and requires a high degree of familiarity with the cultivars on the part of the grower. If the plants are widely spaced and vigorous, and if they are being grown under favorable conditions, with good pest control, fertilization and irrigation, more canes can be left unpruned.

An intermediate approach is to prune all the branches to a height of somewhere between 60 cm and 1 m above ground level. This method is quick, does not entail any decision-making about the age or number of branches, and can be mechanized. Provided enough old wood is left, this type of pruning will promote the development of shoots that will grow into vigorous flower-bearing canes. With some cultivars, new shoot production will be stimulated as well.

3. Corrective. In a dense elderberry plantation, water stress during or after flowering may cause fruit abortion. Pruning out non-fruiting canes is a way of minimizing the impact of such stress. Canes that are infested with cane borers or other insect pests may also have to be pruned out in order to limit any further infestations (see Pest and Diseases).

All removed branches should preferably be disposed of in such a way as to avoid spreading disease and insect pests and keeping the plantation clean. If branches may be diseased or insect-infested, they should be burned. Simply shredding the pruned canes that have been left in the aisles is not sufficient to eliminate many insect pests that may be infesting them (Stokes 1981). However, from a practical standpoint, commercial elderberry growers often flail canes in the aisleway.

F. Weed Control

Elderberry plantations, especially new ones, should be kept weed-free. During the establishment period, competition from other vegetation will adversely affect the growth and survival of cuttings and seedlings. Once the bushes have become well established, however, they become competitive.

Plastic mulch may be a useful option for weed control within rows of elderberry bushes. A cover crop is useful in the aisles; a species that is an undemanding, slow-growing perennial that requires minimal mowing, water, and fertilizer, and one that provides a favorable environment for organic matter accumulation and reduces soil erosion by minimizing water and wind action should be selected. Proper site preparation before the elderberry cuttings are planted, including application of a non-selective postemergent herbicide, should serve to minimize weed growth until the selected ground cover has had time to become established. Once established, the ground cover will have to be mown frequently enough to keep the seedlings/cuttings clearly visible and plant debris should be raked away from the elderberry plants in order to discourage rodents from overwintering and feeding on the plants (Martin and Mott 1997). Since elderberries are shallow-rooted, mechanical activity in the planting, including mowing, tillage, and harrowing, should be reduced to a minimum to avoid soil compaction and root damage. On small plantations, weeds may be eliminated by cultivation.

Elderberries are considered a minor crop with the result that few herbicides are labeled for either pre-emergent or post-emergent weed management. Nonselective, post-emergent herbicides should be used very cautiously because the herbicide may be taken up by suckers emerging some distance from the parent plant, which will then show symptoms and be injured.

G. Pests and Diseases

1. Insects. Few insect pests were identified in small elderberry plantings consisting of 240 four-year-old bushes in southern Québec (D. Charlebois, unpubl.). However, some species have the potential for producing a measurable economic impact in larger-scale plantations. The currant borer, *Ramosia tipuliformis* (Clerck), attacks currants and elderberries (Pirone et al. 1960). Insects and mites that may be pests on elderberries include the elder shoot borer, *Achatodes zeae* (Harris) (Silver 1933; Buriff and Still 1972), of which the larvae feed on canes in which they hatch; the elder borer, *Desmocerus palliatus* (Forster), which in its adult stage eats elderberry pollen and leaves, and lays its eggs in canes near ground level; and *Aphis sambuci* L. common in Europe (Sansdrap 2000). Larval feeding by the elder borer causes the die-back of branches and sometimes the entire shrub (Pirone et al. 1960). Infested twigs should be pruned promptly and burnt. Eriophyid mites (Eriophyidae) feeding on leaves (Schooley 1995) and flowers, and causing flower abortion can significantly impact yield in the Midwestern U.S. (Finn et al. 2008). Vaněčková-Skuhravá (1996) reported that the eriophyid mite *Epitrimerus trilobus* (Nalepa) overwinters within and beneath leaf buds of *S. nigra* in the Czech Republic. However very little is known about eriophyid mite species that may infest elderberry in North America, including their life cycles.

The larvae of the cecropia moth, *Hyalophora cecropia* L., the eastern tent caterpillar, *Malacosoma americanum* (Fabricius), the forest tent caterpillar, *Malacosoma disstria* Hübner, sawflies such as *Langium atroviolaceum* (Norton) (Eaton and Kaufman 2007) and *Macrophya trisyllaba* (Norton) (Amett 2000) in North America, and *Macrophya ribis* (Schrank) in England (Atkinson and Atkinson 2002), the fall webworm, *Hyphantria cunea* (Drury), and the rusty tussock moth, *Orgyia antiqua* L., all eat elderberry leaves. Gall mites and the two-spotted spider mite, *Tetranychus urticae* (Koch), suck sap from the leaves. Sap beetles feed on the sap of the bush and juice from the fruits. Adult European snout beetles, *Phyllobius oblongus* L., eat the margins of leaves and buds of elderberry bushes, while their larvae eat the roots. Potato fleabeetle, (*Epitrix* sp.), green stink bug, (*Acrosternum hilare* (Say)), omnivorous-looper, (*Sabulodes aegrotata* (Guen)), grape mealybug, (*Pseudococcus maritimus* (Ehrhorn)), San Jose scale, (*Quadraspidiotus perniciosus* (Comstock)), and madrone thrips, (*Thrips madronii* (Moulton)), are all considered of minor importance (Pirone et al. 1960). Management strategies include hand removal, sanitation, and application of labeled insecticides at timely intervals. Care must be taken when using insecticides in order to avoid contaminating flowers (Guédon et al. 2008) or fruits.

Tingle and Mitchell (1986) have shown that leaf extract from *S. simpsonii* was effective in reducing egg deposition from the tobacco budworm (*Heliothis virescens* (Fabricius)). The insect repellent potential of European elderberry leaves has been known for centuries (Smith and Secoy 1981). It has also been reported for American elderberry leaves by Durand et al. (1981). According to Shahidi-Noghabi et al. (2008), it is a type 2 ribosome-inactivating protein that would confer European elderberry its insecticidal activity.

2. Mammals and Birds. American and European elderberries possess many features, such as fall ripening, small seeds, and short retention time on the plant when ripe, that are considered adaptations to maximize seed dispersal (Stiles 1980). Elderberries are considered to be fairly digestible (Short and Epps 1976). In some regions, mammals such as chipmunks, deer, rabbits, raccoons, squirrels, opossums, and woodchucks may eat elderberry leaves and fruits (Van Dersal 1938; Plummer et al. 1968; Hankla 1977). Some of these pests will even eat unripe fruits (Hankla 1977; Schaefer and Schmidt 2002). Browsing by mammals can sometimes be severe with serious reduction in yield but often insufficient to seriously affect growth. An electric fence will keep deer out, but will be ineffective against smaller animals. European elderberry leaves are thought to be toxic to mammals (Grime et al. 1988). Various farm animals will also feed on elderberries. Despite a claim made by Hankla (1977), no documented proof that elderberry vegetation can be fatal to wild or farm animals could be found.

American and European elderberries are also attractive to birds (Martin et al. 1951; Wyman 1969; Rajchard et al. 2007; Brookes 2008; Stiebel and Bairlein 2008) and a number of species eat the berries (Martin and Mott 1997). The presence of amygdaline, a cyanogenic glycoside in the fruit, has no bird deterrent effect (Struempf et al. 1999). If not harvested, European elderberries are usually stripped of their fruits by early November (Atkinson and Atkinson 2002). Netting, while effective is expensive to put in place and to maintain. Various bird-scaring systems are available such as noise cannons and distress calls, but unless a grower is vigilant about managing the frequency and placement of the various bird alarms, they rapidly become ineffective. Birds of prey are the elderberry grower's natural allies. Territorial birds like the eastern kingbird (*Tyrannus tyrannus* L.) can sometimes help discourage unwanted bird species in eastern North America. Trap crops may also be useful. Millet, rye and wheat have been reported to produce good results in attracting birds away from elderberries. If these crops are harvested early, grain residue should be left on the ground and disposed of only after the elderberries have been harvested. The efficacy of this approach is limited with bird species that mainly or exclusively feed on fruits. Depending on the size of the plantation and the seriousness of the bird problem, it may prove simpler for the grower to resign himself to the loss of a percentage of the crop than to install a bird-scaring system. As a last resort, prompt harvesting of ripe fruits should be considered (Stang 1990).

3. Fungal, Viral, and Bacterial Diseases. The following pathogenic fungi have been reported on *Sambucus* species in landscape or fruit production uses (Pirone et al. 1960).

Cankers. Cytospora leucosperma (Pers.: Fr.) Fr. [syn. *Cytospora sambucicola* Tehon & Stout], *C. chrysosperma* Pers.: Fr., *Diplodia* sp., *Nectria cinnabarina* (Tode) Fr., *Neonectria coccinea* (Pers.: Fr.) Rossman & Samuels [syn. *N. coccinea* Desm.], *Sphaeropsis sambucina* (Cooke) Sacc. Girdling of the infected twigs is usually followed by the death of its terminal portion. The infected material should be pruned and destroyed.

Leaf-spots. Ascochyta wisconsina Davis, *Phaeoramularia catenospora* (Atk.) [syn. *Cercospora catenospora* Atk.], *Cercospora depazeoides* (Desm.) Sacc., *Cercosporella prolificans* (Ellis & Holw.) Sacc., *Phyllosticta sambuci* Desm., *Mycosphaerella* sp., *Ramularia sambucina* Sacc., *Septoria sambucina* Peck. Infection is usually moderate requiring no particular intervention.

Powdery mildews. Erysiphe penicillata (Wallr.:Fr.) Link [syn. *Microsphaera alni* (D.C. ex Wallr.)], *Erysiphe grossulariae* (Wallr.) de Bary [syn. *M. grossulariae* (Wallr.) Lév.], *Phyllactinia guttata* (Wallr.:Fr) Lev. [syn *P. corylea* (Pers.) Karst.], *Podosphaera macularis* (Wallr.) U. Braun & S. Takam [syn. *Sphaerotheca humuli* (DC.) Burrill.].

Other fungal diseases. Thread blight caused by *Corticium koleroga* (Cooke) Höhn. [syn. *Pellicularia koleroga* Cooke] (Pirone et al. 1960; Hightshoe 1988), root-rots cause by *Helicobasidium purpureum* Pat., *Phymatotrichum omnivorum* (Duggar) Hennebert, and *Xylaria multiplex* (Kunze) Fr.; and wilt caused by *Verticillium albo-atrum* Reinke & Berthier have also been reported (Pirone et al. 1960). A verticillium wilt attacks weakened bushes and sometimes kills isolated canes, but as a rule the affected bush survives the infection. However, it is advisable to avoid establishing an elderberry planting on a site where a sensitive species, such as a member of the Solanaceae, has recently been grown. *Puccinia bolleyana* Schw. [syn *Puccinia sambuci* Arthur] have been reported on American elderberry (Kellerman 1904; Byers and Thomas 2005) and *Hyphodontia sambuci* (Pers.) J. Erikss [syn. *Corticium sambuci* Pers.] on European elderberry in Northern Europe. No description of the symptoms was however provided by the authors. Proper spacing and alignment of the plants usually help reduce the appearance and spread of such diseases.

Viruses and bacteria. Elderberries seem to be particularly good hosts for viruses (T. Jones, pers. comm.). Viruses infect various elderberry species in many countries in Europe and North America (Jones and Murant 1971; Uyemoto et al. 1971 and references within; Mamula and Miličić 1975; Van Lent et al. 1980 and references within). *Tomato ringspot* and *Cherry leaf roll* viruses infect American elderberry (Jones 1972; OEPP/EPPO 1996). It is impractical to control the vectors for elderberry viruses (nematodes, leafhoppers, aphids etc.) and therefore the best approach to control is to plant virus-free, clean stock. Filippin et al. (2008) recently reported for the first time the presence of phytoplasma in *S. nigra* but their presence was not correlated with any specific symptoms.

4. Abiotic Stress. Elderberry is not salt tolerant, an important point to consider if elderberries are to be planted along road sides where salt is used in the winter, or if they are to be irrigated with poor quality water. American elderberry tolerates air pollution and can be used as an ornamental in urban areas (DeGraaf and Witman 1979; Beaudry et al. 1982). European elderberry withstands various anthropogenic pollutants such as fluoride and sodium (Heinrich and Schaller 1987), ozone (Davis et al. 1981; Kline et al. 2008), sulfur dioxide (Rachwal 1983), and various heavy metals such as lead (Rachwal 1983; Novikova and Kosheleva 2007). However, ozone injuries have been frequently found in field-grown European elderberries in Poland (Godzik 1998) and in Ukraine in a closely related species, *S. racemosa* (Blum et al. 1988). *Sambucus racemosa* and *S. mexicana* have also been used as bioindicators for monitoring ozone (Campbell et al. 2007). Reduced growth will occur under deficient water supply, poor drainage, and soil compaction. Care must be taken to avoid exposure to herbicides and some plant growth regulators since reduced growth, leaf scorching, or death may occur from exposure to these chemicals (Marshall 1989).

H. Harvest

While mechanical harvesting is a possibility (McKay 2001) elderberries are not well suited for such a practice because the fruits do not separate readily from the pedicels. In the case of American elderberry, the crown is wide spreading the catcher plates on currently available mechanical harvesters, causing considerable fruit to fall to the ground. While it is likely that elderberries could be mechanically harvested, modifications in training systems and in existing mechanical harvesters will be necessary. At present, most of the crop is harvested by hand. Between 25 and 40 kg can be handpicked in an hour (Sansdrap 2000).

Extensive, structured pruning to enhance light exposure throughout the canopy will allow fruit ripening to be more uniform and will also increase harvest efficiency by fostering the formation of fewer but larger fruit clusters. The berries should be harvested when a majority of

Deleted: shorten the work of harvesting them are dark blue, almost black, in color. An individual plant can usually be harvested in two to three passes at five to seven day intervals over a period of two to three weeks.

Typically, the entire cluster is collected at harvest. This operation is more easily accomplished in the morning, when the peduncles are engorged with water and consequently tend to break more readily. The fruit clusters are collected into containers of capacity suitable to allow rapid cooling. Elderberries that are not immediately frozen should be refrigerated (Sansdrap 2000) and processed shortly after harvest, as fruit quality rapidly declines at room temperature.

Considering their rather small size and lack of appeal as a fresh product (Skirvin and Otterbacher 1977), elderberries are unlikely to be sold fresh. Elderberries do not form a consistent abscission zone between the pedicel and the fruit, and many fruits tear and leak when removed from the cluster, making marketing of the fresh cluster impractical for anything more than immediate local sales. Much of the crop is frozen immediately after harvest, which facilitates long term storage until processing. Alternately, the fresh fruits can be pressed and the resulting juice frozen.

If the stems are to be removed before the berries are frozen, the fruit clusters are simply shaken rapidly over a screen that will allow the berries to fall through while intercepting the stems. Cleaning is done by dumping the berries into a container of appropriate size until it is half filled. Enough water is then poured in to cover them. The container is gently shaken, causing stems, leaves, green berries and any insects that may have been gathered along with the berries to float to the surface of the water, while the ripe berries remain at the bottom. More water is then added, and all this unwanted material is poured out of the container. After this rinsing operation, the berries are poured out on to a screen, to form a thin layer. A fine water spray can be used to remove any sand and soil particles that may still cling to them. In addition, the berries are inspected at this stage, and any foreign bodies or unsatisfactory specimens are eliminated. After being left to drain for a few minutes, they may be packaged and immediately chilled and stored, either fresh or frozen.

Removing the fruit from the clusters is difficult when the fruit is fresh but simple once they are frozen. After the elderberries are frozen, the stems can readily be removed simply by mechanical agitation of the fruit clusters over shaking wire-mesh or a similar device such as a blueberry destemmer. Fruit quality can then be evaluated and plant debris and below grade fruits eliminated. The peduncles represent approximately 10 percent of fresh corymb mass.

I. Yield

1. ***Sambucus canadensis*****.** Yield data from wild populations are lacking although fruit has been harvested for thousands of years by native peoples. In one study, Caisse (1998) measured the productivity of wild American elderberries located in the Acadian peninsula (New Brunswick, Canada). She reported very low yields ranging from 0 to less than 250 g/plant. Considering the natural density of the plant over the studied area, this author evaluated the potential yield to be less than 12 kg/ha (0.012 T/ha) (Caisse 1998). Under natural conditions, the yield is likely to show large annual variations owing to the lack of control over the production parameters. The natural low density of the plant and the lack of control over predators seriously limit the plant from reaching its full production potential in the wild. Even with these limitations, large quantities of American elderberry are harvested from wild plants in the Midwestern U.S. (P.L. Byers and A.L. Thomas, unpubl.). Large quantities of European elderberries are also harvested from wild plants throughout Europe (Šišák 2006).

In managed plantings, significant fruit production will not occur in the year that the cuttings are planted (Stang 1990). This juvenile (non-reproductive) period can extend to three years if seedlings are used (Bolli 1994). During planting establishment, removing flower clusters as they appear will encourage vegetative growth. Way (1965) estimated a production of about 6.7 and 8.3 T/ha on a good site. These values are in agreement with those of Skirvin and Otterbacher (1977) who estimated a production varying between 7.5 and 15.5 T/ha. In USDA hardiness zones 5 and 7, production of between 1 and 3 kg per bush was obtained from cuttings in the second year in the field (Finn et al. 2008). However, in hardiness zone 8 in Oregon, yields as high as 6 kg/plant were achieved the year after planting and nearly 13 kg/plant two years after planting (Finn et al. 2008). Average yield may amount to as much as 9 kg per bush in the second production year (third year in the field), and peak at 11 kg the fourth year, and slightly decrease the fifth year if no pruning is performed (D. Charlebois, unpubl.). These yields are very close to those reported by Adams almost 100 years ago (Adams 1915). Unfortunately, increased fruit production is accompanied by smaller fruit clusters that results in higher harvesting costs. As the bushes age in subsequent years, productivity may be expected to decline gradually. Pruning to encourage vigorous growth is essential to keeping the elderberry plantation productive. Little is reported in the literature on the long term productivity of American elderberry; plants in trials in Missouri remained productive for 7 years (P.L. Byers and A.L. Thomas, unpubl.).

2. ***Sambucus nigra*****.** As with American elderberry harvesting fruit from wild elderberry populations has probably been going on for thousands of years in Europe. In a survey conducted from 1999 to 2004, Šišák (2006) reported an average of 32.8 kg/ha of fruits collected from wild elderberries in the Czech Republic. In a study conducted between 1997 and 2003 in Poland, Waźbińska et al. (2004) reported yields varying between 1.3 kg/bush for wild harvested genotypes and 16.6 kg/bush for cultivated 'Sampo' and 'Samyl'. Yield was dependant on site and cultivar with a 40% difference directly attributed to site. Kollànyi et al. (2005) reported yields varying between 5.2 and 23.0 kg/bush for various cultivars of *S. nigra* in another study conducted in Hungary between 2003 and 2004. Maximum yields for 'Sampo' and 'Samyl' were superior to those reported by Waźbińska et al. (2004). The average yield for the wild growing European elderberry was much higher than that reported by Caisse (1998) for American elderberry likely because the former was maintained under controlled conditions while the latter was evaluated in the wild.

IV. PROPAGATION

A. Selection and Breeding

European and American elderberries are grown throughout large areas of Europe, northern Africa, eastern Asia, and North America. Their hardiness and attractiveness, as well as their ecological, ornamental and commercial potentials, have spurred interest in developing cultivars that meet the demands of consumers. It is most likely that naturally occurring forms, such as 'viridis' and 'laciniata' (European and Mediterranean Plant Protection Organization 2008), or large-fruited types (Way 1965) have been used in the past to develop new cultivars.

Efforts in cultivar development to satisfy the needs of the ornamental plant and commercial fruit industries (Kaack 1989a) go back no further than the early 20th century (Stang 1990) with a peak in the second half of that century (European and Mediterranean Plant Protection Organization 2008). Breeding programs conducted around 1920 in the U.S. by the New York State Agricultural Experimental Station in Geneva, and around 1960 in Canada by

E.L. Eaton (Agriculture and Agri-Food Canada, Kentville, Nova Scotia research station), developed interesting cultivars for fruit production still used today. The following are among the better known cultivars: ‘Adams’, ‘Johns’, ‘Kent’, ‘Nova’, ‘NY21’, ‘Victoria’, ‘Scotia’, ‘York’ (Skirvin and Otterbacher 1977; Craig 1978). ‘Haschberg’, ‘Korsør’, ‘Samdal’, ‘Sampo’, and ‘Samyl’ are some of the better known European elderberry cultivars.

About 35 cultivars of European and American elderberries are described in the literature (Vines 1960; Wyman 1969; Bailey and Bailey 1976; Craig 1978; Krusmann 1986; Hightshoe 1988; Griffiths 1994; Hillier and Coomes 2002) and probably several hundreds have been evaluated. While European elderberry was dominating the market (Stang 1990), nowadays both species are about equally represented in the backgrounds of the commercial cultivars. In some cases, such as ‘acutiloba’, ‘aurea’, ‘chlorocarpa’ and ‘laciniata’, the relationship of the genotypes to the two species was unclear. Considering the extensive distribution range of both species, the information provided by nurserymen about growth, yield, and hardiness of any given genotype should be seen only as general information and important differences are likely to be observed in the various hardiness zones.

Only a few cases of natural or induced interspecific *Sambucus* hybrids have been reported, but Small et al. (2004) believe that hybridization is widespread in this genus. Most known interspecific hybrids concern European elderberry (Böcher 1941; Winge 1944; Chia 1975; Nilsson 1987; Simonovik et al. 2007). Such hybrids are usually sterile and therefore of limited horticultural interest. American elderberry has been described as a species that can vary in appearance by Deam (1924) and some rare, naturally occurring variants have been reported (Schneck 1880). Ourecky (1970) also mentioned a few cases of interspecific crosses involving *S. canadensis* and *S. nigra* from breeding programs.

Published information on *Sambucus* concerning the available and potential parents for specific traits and information on inheritance patterns is scarce. Breeding objectives for elderberry include large fruit size, firmer fruit texture, large fruit cluster size, small seeds, self fruitfulness, increased productivity (number and size of corymbs and fruit size), vigorous and strong canes, uniformity of ripening within and among clusters, attractive color (glossy, dark), better fruit and juice quality, increased nutraceutical content, resistance to shattering and diseases, immunity or tolerance to virus diseases, wider adaptation, and pendulous fruit clusters less prone to bird damage (Darrow 1975; Lee and Finn 2007; Kaack et al. 2008). The Danish breeding program is seeking plants that are low growing with strong upright shoots from the root or lower part of the bush, characteristics that improve harvest efficiency (Kaack 1989a). The Missouri State University/University of Missouri development program, in addition to the characteristics mentioned above, is seeking plants with tolerance to a species of eriophyid mite that causes a significant economic impact. The usual practices of pollen collection, emasculation of the female parent, and controlled pollination are followed. Emasculated blossoms are best isolated from chance pollen before and after pollination; this can be accomplished by protecting the cluster with a paper bag. Fruit clusters resulting from controlled crosses must be protected from bird depredation. Fruit is harvested when all berries in a cluster are fully ripe. Germinated seedlings can be transplanted to individual containers, and later planted into selection rows in the field. Seedlings frequently flower and fruit in the second season, allowing for rapid selection for a number of traits of interest. Advanced selections in the Missouri State University/University of Missouri program are further evaluated for three harvest seasons in replicated test plots (P.L. Byers and A.L. Thomas, unpubl.).

Elderberries can generally be multiplied by seeds or one of the following vegetative methods: layering; suckers; micropropagation; and softwood, hardwood, and root cuttings (Laurie and Chadwick 1931; Mahlstede and Haber 1957). Seedling production is usually not used to establish orchards for fruit production, but is useful for producing large numbers of plants for wildlife habitat or in breeding work. Thanks to their vigorous vegetative growth of up to 2 m in a single year, the use of cuttings is the most efficient propagation method. In some situations, where it is desirable to produce large numbers of a specimen in a short period of time, propagation by cuttings may not be adequate. *In vitro* or micro-propagation may be necessary in these instances. *In vitro* propagation also allows for meristemming or a combination of meristemming after heat therapy to eliminate viruses from the planting stock.

Regardless of the source of material used, it will take between 3 to 5 years to attain full fruit production (Stang 1990). Sources of certified pathogen-free tested material are limited at present; as the elderberry industry develops this may become a serious problem. Whether from seeds or from cuttings, appropriate procedures must be followed in order to produce certified pathogen-free material (European and Mediterranean Plant Protection Organization 2008). While elderberry seeds, seedlings, and cuttings are commercially available, elderberry nurseries and distributors are uncommon, and care must be taken to ensure that cultivars remain true to type. Finn et al. (2008) have determined that there was definitely a genotype x environment interaction for phenological, reproductive, and vegetative traits for a group of American elderberry genotypes grown in Oregon and Missouri. Their results suggest that, at least in these diverse environments, that the performance of a genotype in one environment is not predictive of how it will perform in the other. This means that it is important to trial cultivars in the region where they will be grown to determine if they will be commercially viable.

B. Seed Propagation

A mature American elderberry plant may produce several hundred corymbs, each with up to 2,000 fruits containing from three to five seeds. A single plant may thus supply several tens of thousands of seeds each year. American elderberry produces between 79,000 and 511,500 seeds/kg (Vines 1960; Stiles 1980) with an average of about 105,000 seeds/kg (Hankla 1977). Extracting seeds from elderberries is a relatively simple matter, and it may prove advantageous for the prospective grower to obtain seeds from ripe berries harvested from healthy, productive bushes.

The easiest way to extract elderberry seeds is to lightly mash the fruits in water with pectinase added to the slurry. In 24 to 72 hr the skin and flesh will be completely degraded. Water should be added and the remains of the flesh and skin, and any floating non-viable seed poured off. The seeds should then be allowed to dry. This avoids the risk of damage that a blender or food processor may inflict if not carefully managed. Seeds can also be extracted mechanically. If pectinase is unavailable, the ripe berries can be carefully puréed by hand or in a food processor or blender (Morrow et al. 1954); enough water added to ensure that the berries are reduced to a pulp and the seeds extracted. The processor or blender should be run long enough to separate the seeds from the pulp; depending on the number of berries and the quantity of water used, a few seconds should be adequate. Some seeds will be observed floating on the surface of the liquid. These are probably empty or unlikely to germinate and should be discarded. The purée can be strained through a sieve fine enough to ensure that the seeds, which are approximately 1 mm in diameter, will not pass through it. The residue should be rinsed with water several times and, if necessary, run through the food processor or blender again to eliminate the remaining fruit pulp. Filtration must be done after each rinse, the seeds then allowed to dry. Finally, the seeds should be shaken through a sieve to eliminate any remaining residue. The fruits can also be crushed, dried, and later planted with minimal processing with good results (Brinkman and Johnson 2008).

Seeds will remain viable for several years if kept in a closed container at a low temperature (4°C) (Young and Young 1992; Brinkman and Johnson 2008). As a rule, the fresher the seed, the higher the germination rate. Brinkman (1974) found that American elderberry seeds retain most of their viability after two years. Fresh European elderberry seeds are reported to have a germination rate of 62.5% following a stratification treatment (Clergeau 1992). The germination rate of various American elderberry cultivars varied between 40 and 60% (D. Charlebois, unpubl.). Rates as high as 70% and 95% have been reported by Davis (1927) and Adams (1927), respectively with American elderberry seeds sown soon after collection.

1. **Seed Germination.** Elderberry seeds will not germinate readily contrary to what Bailey (1930) reported. They contain a dormant embryo and thick but water permeable teguments (Young and Young 1986; Martin and Mott 1997; Hidayati et al. 2000; Brinkman and Johnson 2008), and consequently require a period of stratification at low temperature. The extent of the pre-treatment needed has been reported to vary considerably across the distribution range of the species (Bir 1992) and might not be necessary for seeds from southern source (Dirr and Heuser 1987). Untreated seeds can take up to two years before germinating. While inexpensive and simple, this material yields poor results. Scarification with sulfuric acid can be used prior to the stratification treatment (Heit 1967; Hankla 1977; Young and Young 1986). This treatment

weakens the teguments and enables the grower to omit the initial period of storage at room temperature. Barring the use of sulfuric acid, the following technique is successful. Seeds are placed in a sealed plastic bag containing a sterile and moist but not wet medium. Adding gibberellic acid to the watering solution increases germination rate (Hidayati et al. 2000). Peat moss is usually satisfactory but sand can also be used. Sixty to 90 days at room temperature followed by cold (4°C) storage for approximately 90 days will yield good results (Cram 1982; D. Charlebois, unpubl.). After that period, the bags may be placed in light at room temperature until the seeds germinate. This method offers the advantage of selecting only viable seedlings but requires their manipulation during transplantation. Alternatively, seeds can be sown in late fall or spring directly on a raised bed at a density of about 100 seeds per meter and thinned as necessary.

2. Planting. Seedlings may be transplanted into plug trays containing a commercial potting mix. Direct exposure to sunlight should be avoided, and care must be taken to ensure that the potting medium is kept moist. A starter fertilizer for woody plants may be used, according to the manufacturer's recommendations. Elderberries do not grow as well in pots as they do in the field and should be transplanted to their final location as soon as possible. When the seedlings have attained sufficient size, they may be transferred to the field. A good way to assess seedling development is to examine the root system. Depending on how well advanced they are, it may be advisable to keep them in containers for another year.

C. Vegetative Propagation

Elderberries are exceptionally well suited for propagation by means of cuttings. Mother plants for cuttings should be true to type and healthy. In particular, care must be taken to ensure the identity of mother plants since many cultivars cannot be distinguished solely on morphological features of the vegetative parts, and their tendency to produce suckers can sometimes be a source of confusion in nurseries when cultivars are planted too close to one another. Cuttings can also be removed from wild plants when elite specimens are found or for breeding purposes (DeGraaf and Witman 1979). Once the planting is well developed, cuttings may be taken during maintenance pruning operations. Elderberries are easily propagated from hardwood (lignified cuttings, taken in winter), softwood (immature, succulent cuttings, taken in summer), root cuttings, or suckers (Stang 1990; Schooley 1995).

1. Hardwood Cuttings. Hardwood cuttings commonly include 3 to 5 buds. In most cases, the taking of cuttings can be judiciously timed to coincide with the pruning of the bushes. Hardwood cuttings should be collected in November, after the leaves have fallen, to avoid the risk of harvesting material that has been winter-damaged. Cuttings taken in the fall need to be stored properly to retain their quality until they are stuck later in winter or early spring. The cuttings should be placed together in bundles, set upright in coarse sand or peat moss, in which they are buried to half their height, and stored in a cold room or cellar (around 0°C). Cuttings can also be harvested in late winter or early spring, while the elderberries are still dormant, and stuck directly into propagation beds. If harvested in April or May (after budbreak), hardwood cuttings should be treated as softwood cuttings (see following section) or set out directly in the field. If cuttings are taken in spring, the physiological condition of the canes cannot readily be determined, resulting in a variable percentage of successful cuttings. In very cold climates, the

Deleted: Collect hardwood cu

tips of canes may suffer winter damage. To address this problem, woody sections of cane, located several centimeters down from the apex should be selected from vigorous canes.

Soaking the bases of the cuttings in a solution of indolebutyric acid may be beneficial in stimulating rooting, although it is not essential. The cuttings are set upright in a trench, spaced between 7 and 10 cm apart, and covered with a medium, with the upper buds left protruding above the soil surface. The medium used should possess good water-holding capacity, but without allowing excessive water to accumulate; for that reason, sand is often selected as the planting medium for field and greenhouse rooting. A media with 50 to 75% perlite and 25 to 50% peat works well in greenhouse environment. New roots will appear within the first two weeks and cease to emerge after about a month (Wilson and Wilson 1977). According to these authors, the presence of leaves is necessary for the production of roots. Another method is to lay down a strip of plastic mulch and push the cuttings into the soil through the plastic, approximately 15 cm apart, with 2 to 4 cm of cane protruding. Alternatively, they can be set in their permanent location as just described. The great advantage of this last approach is that the cuttings need not be transplanted; the disadvantage is that not all the cuttings will root leading to gaps in the row. One way to minimize this problem when cuttings are in sufficient number is to place up to three cuttings at the same location and thin out successful cuttings that might be in excess.

During the two months after the cuttings have been set out in the field, they will produce foliage, followed by the appearance of new roots. The planting medium should be kept moist during this period. Growth of the new canes may be anywhere from 15 cm to 100 cm in the first year. If larger plants are required, the cuttings may be kept under these conditions for an additional year. Given favorable weather conditions and a suitable location, the success rate may be in excess of 95%; under more adverse conditions, such as a dry year, the rate may be as low as 20%.

2. Softwood Cuttings. Softwood cuttings are taken during the growing season, and usually comprise the terminal portion of a new green branch. A softwood cutting containing between two and three nodes will normally be satisfactory. Each node bears two opposite buds in the axils of the compound leaves. The first cutting taken from a cane ends in a non-woody portion that is frequently green, consists of a number of telescoped internodal spaces, and may include flower buds. Ideally, the basal end of the cutting should not be more than 10 mm in diameter, in order to maximize rooting. Cuttings larger than this tend to root less satisfactorily, and their abundant foliage makes them more sensitive to rot. They should always be taken from bushes that are healthy and vigorous.

The optimal period for softwood cutting is between the time the bushes are at the flower bud stage and the end of their flowering or the beginning of fruit set in southern Quebec, and in early summer before flowering in central U.S. In southern Québec (USDA hardiness zones 4 and 5), that period extends from late June to late July; in Missouri (USDA hardiness zones 5 and 6), that period is late May to early July. As cuttings are collected care must be taken to protect against overheating and desiccation. It is unlikely that taking too many cuttings from any particular bush might cause damage as elderberries are well able to withstand drastic pruning and only the ends of canes are used. Early removal of flower stalks on the parent plants may be one way to promote more vigorous vegetative growth. Techniques to improve rooting success of softwood cuttings include the following: avoid desiccation or overheating of cuttings during collection; remove all but the base two leaflets of each retained compound leaf, which reduces transpirational loss of water during the rooting period, and provide intermittent mist during the rooting period.

3. Root Cuttings. Collect root cuttings in early spring before growth begins. Root segments that are 15 to 20 cm in length and 3 to 5 mm in diameter are ideal. Place root segments in shallow pots of sterile media, cover with 2.5 to 3.0 cm of media, and keep warm and moist. Each segment will produce at least one plant.

4. Micropropagation. Elderberries can readily be propagated by means of *in vitro* culture, and the propagation medium may also be used for rooting (Brassard et al. 2004). Low mortality rates are observed during the acclimatization phase, and acclimatized plants adapt well to field growing conditions (D. Charlebois, unpubl.). Moreover, micropropagation is sometimes the only way to obtain virus-free material. In view of the cost of this propagation method and the technology involved, it is not within most growers' reach. However, a number of commercial laboratories could propagate exceptional individual plants on a large scale in a short time on a contract basis.

V. USES

Almost every part of the elderberry plant has some uses: fruits, flowers, leaves, roots, pith and bark (Vallès et al. 2004). Information related to human exploitation of *Sambucus* can be traced as far back as the Ancient Rome. Dioscorides (40 – 90 AD) mentioned the use of *S. ebulus* to color hair in his treatise *De materia medica* (Osbaldeston and Wood 2000). Pliny the Elder (23 – 79 AD) reported that numerous wind instruments and pop-guns were made out of elderberry

(Grieve 1931). Report of the medicinal uses of elderberry flowers and bark were already mentioned in the 17th century by Agustí (1617).

The elderberry is primarily valued as a food and medicinal plant and description of such uses are part of the long history of the Native American people and European culture. These characteristics have been documented by Gunther (1945), Vines (1960), and Moerman (1998). The species *nigra*, in particular, has been the subject of many traditions, some of which are current to this day. While the Native Americans had a long history of using the native *Sambucus* species, the European immigrants quickly recognized the similarity between *S. canadensis* and *S. nigra* and then used it similarly for folk medicine. Because of the similarities between these two species, the information presented next is to be taken as applicable to either one. Where possible, the name of the species referred to has been indicated.

A. Folklore

Elderberries appear frequently in European (Chrubasik and Chrubasik 2008), and North American folklore. This is apparent from the numerous uses to which elderberries have been put through the ages. Duke (1985) and Moerman (1998) provide excellent surveys of this field. Elderberries have fueled numerous legends and superstitions. According to a Scots verse, the Christ would have been nailed to a cross made of elderberry (Mabey 1996). Grieve (1931) reported different sources alleging that Judas hung himself on an elderberry tree. In Scotland, elderberries were often planted near old crofts and cottages to protect from witches (Vickery 1995). It is also believed to be imprudent to stand under the shade of an elderberry as its narcotic properties can put you to sleep (White 1876). An English saying states that English summer is not there until elderberry is in full bloom and that it ends when the berries are ripe (Grieve 1931).

Elderberries have also caught the attention of numerous writers. In his play “Cymbeline” (c.a. 1609), Shakespeare associated elderberry with grief (Grieve 1931). Probably the most famous reference to elderberry comes from the 1939 play “Arsenic and Old Lace” by the American playwright Joseph Kesselring in which lonely old men are murdered by poisoning with a glass of elderberry wine laced with arsenic, strychnine and cyanide. In the 1975 movie “Monty Python and the Holy Grail” this famous insult was coined: “Your mother was a hamster and your father smelt of elderberries”. More recently, we find Harry Potter, the well-known hero created by the English author J. K. Rowling, sipping a glass of elderberry wine in the company of his friends in the fourth novel in the series that bears his name.

B. Utilitarian

Formatted: Bullets and Numbering

Leaves, flowers, but particularly berries have been used by North American and European people to produce dyes for a wide variety of objects such as artifacts and leather (Stang 1990; Moerman 1998). While the fruits give a brown dye, using alum as a mordant gives a pale blue (Thompson 1969). The bark of elder can be used as a mordant as well as the source of a black dye when mordanted with iron (Thompson 1969).The flowers are still used by craftsmen to produce a yellow dye (Allen et al. 2002), and in the perfume industry (Durand et al. 1981). Leather was also tanned using tannin from the bark and the roots. Pigments from berries were used to produce a natural dye to stamp meat. Similarly, berries and leaves of *S. simpsonii* Rehder (syn. *S. canadensis* var. *laciniata* A. Gray) have been used to produce dyes for the wool industry (Smith 1993). Stems of American elderberry were used to make flutes, whistles, and spouts for collecting sap from sugar maple (Durand et al. 1981; Stang 1990). Twigs were also used to build pieces for looms (Durand et al. 1981). The leaves are said to have insect repelling properties (Durand et al. 1981). Elderberry pith has long been used as an easy-to-cut support to prepare histological sections (Marie-Victorin 1935; Hickey and King 1981). More recently, *S. nigra* agglutinin extracted from the bark (Broekaert et al. 1984; Greenwood et al. 1986) has been used in numerous biochemical and histological studies dealing with various forms of cancer (Dall'olio et al. 1996; Lekka et al. 2006).

Folk wisdom has discovered many uses for elderberries. Whistles, chanters and pop-guns can be made of the young shoots after the pith has been removed (Vickery 1995). Large hollowed out stems were crafted into blowguns by the Houma for hunting and fishing and by many people to make medicine blowing tubes. The Seminole people used root bark as a ritual purification emetic after funerals and by doctors after the death of a patient. Acjachemen Indians from California have been using *S. mexicana* branches to make clappersticks (Walker et al. 2004). The pith can be removed from the canes to turn them into reproduction sites for solitary bees, especially in the vicinity of alfalfa fields.

C. Food

Formatted: Bullets and Numbering

Nearly every part of the American and European elderberries has some culinary use. The berries are used in the preparation of pies, jelly, punch, wine or liqueurs. The flowers can be added to the batter used to make various items such as pancakes, muffins or waffles. The flower clusters are made into fritters. Elderberry flowers soaked in water with citrus make a delightful non-alcoholic cordial (Hibler 2004). Elderberry flower wine is a lovely pale yellow color and is reported to be delicious, and tea can be made from the flowers as well. The marinated flower buds are sometimes used as a substitute for capers (Lightfoot 1777; White 1876; Sansdrap 2000; Bubenicek 2002). The young shoots, when cooked, are similar to asparagus, although the green older parts are toxic. The pith from the canes can be used in soups as a thickener.

The fruits were used by Native American tribes and settlers as food source and as a fermentable fruit (Allen et al. 2002). In Europe and in North America, a number of commercially available products contain elderberry juice, puréed or dried elderberries. They are used as a food colorant (Zafrilla et al. 1998; Walker et al. 2006; Kammerer et al. 2007), and to enhance the nutritive value of some common foods. In particular, they are an ingredient in various juices, snack-bars, condiments and drinks. Europeans and Native Americans have long made wines, spirits, syrups, jellies, jams or pies out of elderberries, and harvesting from wild bushes is still practiced today in many countries (Ghirardini et al. 2007; Łuczaj and Szymański 2007).

1. Chemical Composition and Nutritive Value. The oldest published chemical composition analysis of American elderberry probably dates back to 1941 (Wainio and Forbes 1941). More recent comparative data are presented in Table 2. Kislichenko and Vel'ma (2006) found 16 amino acids, including 9 that are essential for humans, in *S. nigra* flowers, leaves and flower extract. Kaack et al. (2006) provided a comprehensive study of volatile compounds in *S. nigra* flowers and their relationship with sensory quality emphasizing differences between cultivars. Commercial elderberry juice concentrate is among the richest in total phenolics and highest in antioxidant capacity compared to other red fruit juice concentrates (Bermúdez-Soto and Tomás-Barberán 2004). European and American elderberries are rich in anthocyanins and phenols (Rimpapa et al. 2007; Mathieu et al. 2008a). Elderberries are noteworthy for their fiber, calcium, iron, phosphorus, vitamin B6 and vitamin A content. They also score high in terms of vitamin C content. One hundred grams of elderberries contain 60% of the recommended daily intake of vitamin A and vitamin C, and 12% of the recommended daily intake of vitamin B6 (USDA ARS 2008). These figures are likely to change for the various available cultivars, the management practices used and the environment they were grown in; however they illustrate the nutritious quality of elderberries.

The two major pigments found in European elderberry are cyanidin 3-sambubioside and cyanidin 3-glucoside (Bermúdez-Soto and Tomás-Barberán 2004). They also contain quercetin and flavonols but no ellagic acid derivatives (Bermúdez-Soto and Tomás-Barberán 2004; Lau et al. 2004). Elderberry flowers are also rich in quercetin, kaempferol (Brand-Garnys et al. 2007) and other glycosylated flavonoids (Lin and Harnly 2007). About 80 different chemicals have been isolated from elderberry flower extracts and essential oil (Toulemonde and Richard 1983; Merica et al. 2006). Elderberries are a good source of high biological value protein (Künsch and Temperli 1978a). Kaack (2008a, b) presented an extensive study of European elderberry aroma composition and sensory quality of flower and fruit juices processed from various cultivars. Marked differences were observed between cultivars that could be used to guide the processing industry.

The characterization of seeds oils of *S. canadensis, S. nigra*, and *S. racemosa* has been reported by Schuette and Brooks (1936), Gigienova et al. (1969), and Johansson et al. (1997), respectively. The amount of extractable oils is significant (c.a. 30% dry weight) for this last species, and wastes from various manufacturers could probably be used as food supplements or cosmetic agents (Johansson et al. 1997). Wastes from American and European elderberries processing could likely be used in a similar fashion. In fact, the oil content of European elderberry press residues can reach up to 12% and these residues are particularly rich in tocopherol (Helbig et al. 2008). Important amounts of anthocyanins can be extracted from elderberry pomace, an agroindustrial waste traditionally transformed into animal feed or organic fertilizer, which can advantageously be used by the food, cosmetic, and pharmaceutical industries (Seabra et al. 2008). Various N-phenylpropenoyl-L-amino acid amides have been identified in European elderberry leaves (Hensel et al. 2007). Their possible role in human health is currently under study. Different phenolic acids have also been isolated from European elderberry bark (Turek and Cisowski 2007) and flowers (Waksmundzka-Hajnos et al. 2007).

2. Toxicity. The canes, roots and leaves are not hazardous if properly prepared. The leaves contain hydrogen cyanide (HCN), and should not be used to make alcoholic beverages if their HCN content exceeds 25 ppm. Children who play with elderberry canes are potentially at risk of alkaloid or cyanide poisoning. Sixty mg of cyanide is enough to kill a man (Duke 1985). The berries, for their part, may be eaten raw in reasonable quantities without inconvenience; if consumed to excess, they may cause discomfort and vomiting (Li 2000). Cooking the fruits will eliminate these drawbacks.

Most plant parts but particularly leaves (Bourquelot and Danjou 1905) are thought to contain various cyanogenic glycosides and to be somewhat toxic (Hardin and Arena 1974; Tull and Miller 1991; Allen et al. 2002; Atkinson and Atkinson 2002). They can induce stomach aches, nausea, and vomiting if consumed in large enough quantity. Release of hydrogen cyanide has been reported during berries processing from European elderberry (Pogorzelski 1982). The presence of cyanogenic compounds is quite variable between populations of European and American elderberry (Jensen and Nielsen 1973; DellaGreca et al. 2000a, b; Bradberry and Vale 2007). They are even absent in many cases (Buhrmester et al. 2000). Some of the degradation

Formatted: Bullets and Numbering

compounds resulting from the oxidative degradation cleavage of cyanogenins found in European elderberry are thought to be harmless (Seigler 1976; DellaGreca et al. 2000b). The transformation of cyanogenic glycosides is performed by hydroxynitrile lyases to produce HCN, which has a role as a defense mechanism against herbivores and microbial attacks (Hickel et al. 1996). While the toxicity of *S. nigra* has been reported to be rare and low (Brunneton 2001), Vigneaux (1985) indicated that their fruits can cause bloody diarrhea and mydriasis.

Hanlka (1977) mentioned that new growth can be fatal to cattle and sheep. Lectins found in the bark of various *Sambucus* species are thought to be responsible for its toxicity (Van Damme et al. 1997; Lehmann et al. 2006). The gene encoding for the type-2 inactivating protein of European elderberry has been expressed in transgenic tobacco where it produced an enhanced resistance to some insect species, emphasizing the protective role of such protein (Rapisarda et al. 2000). Similar toxicity of the aphid *Aulacorthum magnoliae* Essig et Kuwana feeding on *S. sieboldiana* to the predator *Harmonia axyridis* Pallas has been reported (Fukunaga and Akimoto 2007). Lectins and ribosome inactivating protein composition of the bark and fruits of elderberries is complex and their role is not well understood (Atkinson and Atkinson 2002).

The allergological potential of elderberry pollen has not been determined, although its presence in the air was not considered a health problem in Vienna three decades ago (Horak et al. 1976). Because *Sambucus* pollen concentration has been constantly on the rise between 1976 and 1989 (Jäger 1989) and may have increased even further since, its impact on allergies must probably be reevaluated.

The toxicity of some chemicals found in European elderberry has been put to good use in the field of micropropagation. Kuhn et al. (2007) successfully demonstrated the antifungal property of elderberries and leaf extracts on the fungus *Microdochium nivale*.

D. Traditional Medicine

Amerindian and European peoples made use of the American and European elderberry, respectively. In both cases the leaves, flowers, and fruit have long been used to alleviate or cure various ills. American elderberry is prominent in traditional medicine. A poultice made from the leaves reportedly relieves pain and promotes the healing of contusions and sprains, and can be used as a disinfectant to wash sores to prevent infection. The dried leaves are combined with mint leaves and used to treat dyspepsia. An infusion from dried branches was used to cure severe headaches. An infusion made from the flowers is said to have soothing and laxative properties or was used to "sweat out fever". A fruit decoction is still used in Croatia to reduce fever (Pieroni et al. 2003). The juice of the fruit with some added honey is reportedly a highly effective cough syrup. The same mixture with the addition of some extract of sumac (the fruit of *Rhus glabra* L.) can be gargled to treat a sore throat. Infusions of the fruit were consumed as an antirheumatic. The inner bark is used to prepare ointments. Bark scrapings were used as an emetic and laxative. The pith was infused by the Iroquois to treat heart disease and venereal disease. Meskwaki women used elderberry to assist childbirth. The Choctaw decocted seeds and roots for liver troubles. Dried flowers were used to treat colic in infants by the Mohegan. Elderberry has been considered to possess calming, carminative, cathartic, cooling, cyanogenic, depurative, diuretic, emetic, exciting, laxative, stimulant, sudorific and toxic properties, and it has been used in folk medicine to treat abrasions, asthma, bronchitis (Kültür 2007), bruises, burns, cancer, chapping, chills, dropsy, epilepsy, fever (Kaileh et al. 2007), gout, headache (Passalacqua et al. 2007), neuralgia, psoriasis, rheumatism, rashes, sores, sore throat, swelling, syphilis, and toothache.

Other elderberry species have been popular in folk medicine wherever they grow, as in Brazil where *S. australis* (de Barros et al. 2007), in Mexico where *S. mexicana* (Adame and Adame 2000), and in Iran and Turkey where *S. ebulus* are still in use (Ebrahimzadeh et al. 2007; Kültür 2007). The antioxidant activity of this last species has been shown to be high (Hosseinimehr et al. 2007). A number of studies have been conducted with a view to identifying molecules that might account for the fruit's medicinal properties. To date, however, most research on elderberries has focused on the European species *nigra*.

Unfortunately, few of the claims made about the medicinal properties of elderberries are supported by scientific research or clinical studies (Schapowal 2007) and they must be regarded as the stuff of popular tradition, not solid fact based on rigorous experimentation. The elderberry, in fact, is so firmly rooted in folk medicine and popular traditions that some scientists have attempted to determine whether these claims have any basis. Yesilada (1997; Yesilada et al. 1997), for example, investigated the anti-inflammatory and anti-arthritic properties of elderberry (*S. ebulus*). They conducted *in vitro* studies on the inhibitory effects of extracts from a number of plants frequently used in Turkish folk medicine, including European elderberry. Their findings reportedly validated some of the latter's traditional uses.

E. Modern Medicine

Formatted: Bullets and Numbering

The American Botanical Association (2004) provided a good historical review about elderberry uses as a medicinal plant with references going as far back as the 14th century. Despite a few reported cases of poisoning in animals and humans, the European and American elderberries have acquired an impressive reputation as a medicinal plant and their medicinal value has been recently reviewed by Charlebois (2007). A number of studies have been conducted with a view to identifying molecules that might account for the fruit's medicinal properties.

1. Leaf. The leaves are ground up and applied to wounds or contusions to relieve pain. Even today, *S. canadensis* or *S. mexicana* leaves are utilized in Central America to treat measles (Folliard 2008).

2. Flower. The flowers of European and American elderberries are used, mainly in infusions, to relieve the symptoms of rashes of allergic origin and intestinal problems. They are reported to be effective as a diuretic and laxative as well (Beaux et al. 1998; Uncini Manganelli et al. 2005) and are even recommended by the German Commission and the European Medicines Agency for upper respiratory tract infections (Blumenthal et al. 1998; European Medicines Agency 2008). They can also show some anti-inflammatory properties (Mascolo et al. 1987).

3. Fruit. However, the fruit of the elderberries has always been most widely used. Not only are these berries an effective diuretic and laxative but, like the flowers, they are also used to treat various disorders, including colic, sinus congestion, constipation, diarrhea, sore throat, colds (Schapowal 2007) and rheumatism ((Novelli 2003; Uncini Manganelli et al. 2005). They are known to show anti-inflammatory (Barak et al. 2002; Gorchakova et al. 2007), antiviral (Zakay-Rones et al. 1995; Zakay-Rones et al. 2004), antioxidative (Pool-Zobel et al. 1999), and antibacterial (Chatterjee et al. 2004) actions. However, juice concentrate had no effect on kidney stone-inducing ions solubility (Walz and Chrubasik 2008). Antibacterial activity on two strains of *Streptococcus pneumoniae* was also reported for *S. mexicana* by Molina-Salina et al. (2007).

Research has shown that elderberries contain a number of active substances (Bermúdez-Soto and Tomás-Barberán 2004). We now know that they are rich in tannins, which relieve diarrhea and nasal congestion. They also contain valeric acid, which eases breathing, and hence their usefulness in the treatment of asthma (Novelli 2003)). In addition, soluble compounds that can stimulate insulin secretion and enhance glucose absorption, are found in elderberries suggesting that they may be a potentially valuable weapon in treating the symptoms of diabetes (Gray et al. 2000; Goetz 2007).

4. Antiviral and Antimicrobial Properties. European elderberry flower extract can inhibit prokaryotic neuraminidase *in vitro* (Schwerdtfeger and Melzig 2008). Other interesting curative properties are attributed to Sambucol®, a commercial product containing a standardized extract from the European elderberry (Zakay-Rones et al. 1995). These authors found that the compound possessed the property of deactivating hemagglutinin, a protein found on the surface of some viruses that enables the virus to attach itself to a host cell. Viruses with hemagglutinin include those in the group known as the myxoviruses, which cause influenza, among other disorders (Anonymous, 2005).

In light of this observation, Sambucol® was tested as a treatment for influenza. The results are suggestive: 93% of the patients who were given Sambucol® experienced relief of their symptoms after two days, whereas 92% of those who received a placebo took up to six days to recover. The authors reported that Sambucol® possessed the property of inhibiting the replication of 11 strains of the influenza virus, and hence expedited recovery (Barak et al. 2001; 2002). In addition, Sambucol® appears to possess the capacity to activate the immune system by increasing cytokine production. The investigators suspect that it may act as an immunoprotector or immunostimulant, and that it may be advantageous to give it in conjunction with chemotherapy in treating immunodepressive cancers or AIDS (Barak et al. 2001). This latter hypothesis was formulated after two cases had been observed in which patients with HIV used an elderberry-based decoction in conjunction with chondroitin and glucosamine sulfate (Konlee 1998). In both cases, the number of cancer cells declined substantially. One of the patients also reported that his general state of health had improved in various ways: less swollen ganglia, less inflammation of the colon, and the return of restorative sleep. However, the rather small number of cases studied does not fully warrant these results.

Uncini Manganelli et al. (2005) conducted an *in vitro* study on the antiviral activity of three plants, including the European elderberry, on the feline immunodeficiency virus (FIV). FIV and HIV share many characteristics, making FIV a useful animal model for AIDS research. Their findings suggest the elderberry may potentially be highly useful in treating HIV. However, further research will be required in order to identify the specific substance that possesses the antiviral activity (Uncini Manganelli et al. 2005).

Another study has confirmed that elderberry bark contains a non-toxic ribosome protein deactivator. The use of these proteins in conjunction with monoclonal antibodies appears to be a promising tool in the field of cancer therapy (Girbes et al. 2003). Rutin and chlorogenic acid are found in the fruit (Lee and Finn 2007) and plant parts (Thomas et al. 2008). These two compounds have anti-oxidant and antimicrobial activities (Basile et al. 2000; Grace and Logan 2000; van der Watt and Pretorius 2001; Zhu et al. 2004). Additionally, chlorogenic acid has antiviral activity (Chiang et al. 2002) and may have some cancer preventative activities in rodents (Conney et al. 1991; Mori et al. 2000). Thomas et al. (2008) quantified rutin and chlorogenic acid levels in flowers, green stems, woody stems and green leaves of *S. canadensis*.

The levels of both compounds varied among the various parts, among cultivars, among harvest times, and depended on where the plants were grown. They felt that these plant parts could be viably harvested to provide these compounds as phytochemicals.

5. Anthocyanins and Antioxidant Capacity. Elderberries contain abundant quantities of anthocyanins, the pigments that give them their purple color (Fossen et al. 1998). This abundance of anthocyanins and other polyphenolics is especially valued in today's markets for their potential health benefits (Strack and Wray 1994; Wang et al. 1996; Hollman 2001; Lee 2004). The antioxidant capacity of the anthocyanins in elderberries has been reported to exceed that of vitamins C and E (Anonymous, 2005). *Sambucus nigra* extract has been shown to protect low-density lipoprotein against oxidation (Abuja et al. 1998). Most of the anthocyanins contained in the berries are metabolized before entering the blood stream (Frank et al. 2005).

Lee and Finn (2007) examined the anthocyanins and phenolic composition of elderberry genotypes that represented *S. nigra* and *S. canadensis* backgrounds. While they found that the levels of the various compounds varied among genotypes and years, the most striking differences were between the two species. *Sambucus nigra* has no acylated anthocyanins whereas *S. canadensis* contained the more stable acylated anthocyanins (Brønnum-Hansen and Hansen 1983; Inami et al. 1996; Malien-Aubert et al. 2001; Turker et al. 2004). Lee and Finn (2007) found that the same 11 anthocyanins were present in each of the *S. canadensis* genotypes that they tested: cyanidin 3-sambubioside-5-glucoside (second major pigment present), cyanidin 3,5-diglucoside, cyanidin 3-sambubioside, cyanidin 3-glucoside, cyanidin 3-rutinoside, delphinidin 3-rutinoside (trace levels present), cyanidin 3-(*Z*)-*p*-coumaroyl-sambubioside-5-glucoside, cyanidin 3-*p*-coumaroyl-glucoside, petunidin 3-rutinoside (trace levels present), cyanidin 3-(*E*)-

p-coumaroylsambubioside- 5-glucoside (major pigment present), and cyanidin 3-*p*-coumaroyl-sambubioside. This was the first time delphinidin 3-rutinoside and petunidin 3-rutinoside had been reported in *S. canadensis*.

Cyanidin-based anthocyanins were the major anthocyanins present in *S. canadensis* and all of these samples had more acylated anthocyanins (>60% of the total pigment present) than non-acylated anthocyanins(Lee and Finn 2007). The *S. nigra* genotypes, 'Korsør' and 'Haschberg' had five and seven individual anthocyanins, respectively. These genotypes contained cyanidin 3-sambubioside-5-glucoside, cyanidin 3,5-diglucoside, cyanidin 3-sambubioside, cyanidin 3-glucoside, and pelargonidin 3-glucoside (present in trace levels). 'Haschberg' had two additional peaks (trace levels of cyanidin 3-rutinoside and delphinidin 3-rutinoside). This was the first report to identify delphinidin 3- rutinoside present in *S. nigra* (only detected in 'Haschberg'). 'Korsør' examined by Kaack and Austed (1998) also had cyanidin 3-glucoside as the major pigment. The *S. nigra* samples examined by Watanabe et al. (1998) and Inami et al. (1996) were found to have slightly more cyanidin 3-sambubioside than cyanidin 3-glucoside.

Bridle and García-Viguera (1997) reported cyanidin 3-sambubioside-5-glucoside as the major anthocyanin in the *S. nigra* sample they tested, but Brønnum-Hansen and Hansen (1983) reported cyanidin 3-glucoside as the major pigment of *S. nigra*. As in previous research with *S. nigra*, Lee and Finn (2007) found there were no acylated pigments in 'Korsør' and 'Haschberg'. Both species contained 3-sambubioside-5-glucoside, 3,5-diglucoside, 3-sambubioside (second major pigment present), and 3-glucoside (major pigment present) of cyanidin. *Sambucus nigra* also had cyanidin-based anthocyanins as the major anthocyanins. Wu et al. (2004) identified three additional minor anthocyanins in *S. nigra* (cyanidin 3-rutinoside, pelargonidin 3-glucoside, and pelargonidin 3-sambubioside) – the first time a non-cyanidin-based anthocyanin was reported in elderberries. ‘Korsør’ and ‘Haschberg’ contained trace levels of pelargonidin 3-glucoside, but pelargonidin 3-sambubioside was not detected. In conclusion, *S. canadensis* would be a better choice to use when processing fruit as the acylated anthocyanins will have greater color stability and maintain a better antioxidant capacity compared to *S. nigra*.

Further in Lee and Finn (2007), they found that both species had three cinnamic acids and five flavonol glycosides but that the proportion of the individual polyphenolics differed between them. Neochlorogenic acid (3-caffeoylquinic acid), chlorogenic acid (5-caffeoylquinic acid), quercetin 3-rutinoside, and isorhamnetin 3-rutinoside were the major polyphenolics present in *S. canadensis*. Chlorogenic acid and quercetin 3-rutinoside were the major polyphenolics in *S. nigra*. Isorhamnetin 3-glucoside was present at low levels in *S. nigra*. Neochlorogenic acid, cryptochlorogenic acid, kaempferol 3-rutinoside, isorhamnetin 3-rutinoside, and isorhamnetin 3-glucoside were identified for the first time in *S. canadensis* and *S. nigra* berries.

In an evaluation of the antioxidant potential of European elderberries to inactivate free iron radicals in human plasma, Halvorsen et al. (2002) surveyed a wide variety of fruits, berries, vegetables, and grains in a typical Norwegian diet for their total antioxidant levels. While the study did not allow for statistical differences to be assessed between the fruit crops, they found that antioxidant capacity of ‘Samdal’ elderberry (3.37 mmol/100 g) was comparable to wild *Rubus idaeus* L. (3.97 mmol/100 g), cultivated ‘Veten’ raspberry (3.06 mmol/100 g), ‘Hardyblue’ (syn. 1613A) blueberry (*Vaccinium corymbosum* L.; 3.96 mmol/100 g), and ‘Corona’ strawberry (*Fragaria* × *ananassa* Duch ex Rozier.; 2.34 mmol/100 g). However ‘Samdal’ tended to have lower levels than those for wild strawberries (*F. vesca* L.; 6.88 mmol/100 g), wild blackberry (*Rubus nemoralis* Müll; 6.13 mmol/100 g), genotypes of black currant (*Ribes nigrum* L.; 7.35 mmol/100 g), and bilberry (*V. myrtillus* L.; 8.23 mmol/100 g). Frank et al. (2005) concluded that the anthocyanins contained in European elderberries have a low bioavailability. More studies are needed to fully understand the relationship between elderberry chemical composition and the various effects reported.

F. Ecological Value and Ornamental Potential

Formatted: Bullets and Numbering

The American and European elderberries continue to have value in ecosystem management and restoration. The shallow, aggressive root system and hardiness of the wild species make elderberry ideal for river bank stabilization or shelterbelt establishment. They are also praised for their qualities as suitable plant materials for wildlife and habitat management programs providing shelter and food to countless species of animals, birds, and insects (Hankla 1961; Worley and Nixon 1974; Coastal Zone Resources Division 1978; DeGraaf and Witman 1979; Elias 1980; Martin and Mott 1997; Rajchard et al. 2007). Of the various elderberry species found in North America, *S. canadensis* and *S. cerulea* (Raf.) probably possess the greatest value for wildlife (Coastal Zone Resources Division 1978). Some mammals will also feed on twigs and leaves. Their tendency to form dense thickets makes them good candidates as windbreaks along roadsides and farm fields (Paquet and Jutras 1996).

The attractive appearance, flowers and fruits of the European and American elderberries, their ease of cultivation, and their numerous cultivars have earned them a good reputation as an ornamental. Consumers appreciate the color and shape of the foliage, and various cultivars are commercially available. Their hardiness makes them suitable as ornamentals well outside their natural distribution range.

G. Markets and Production Costs

Formatted: Bullets and Numbering

Very little information has been published on the market potential and the production volumes and costs of elderberries and only general information is available (Charlebois and Richer 2005). Fruit and flower production are known in Canada and the U.S. (*S. canadensis*), in the Russian Federation, Poland, Hungary, Portugal, Bulgaria (Brinckmann and Lindenmaier 1994), Chile (Finn, person. commun.), Denmark, Germany, Italy and Switzerland (*S. nigra*). Milliken and Bridgewater (2001) reported *Sambucus* as having a potential for cultivation in Scotland. These authors also reported that *Sambucus* fruits, flowers and leaves were commercially available in Scotland with 7 known traders and a trade price varying between 3.25 and 10.10 £/kg with an estimated harvest for elderberry flowers of 100 tons (Milliken and Bridgewater 2001). Elderberry flowers are one of the most important wild plant resources commercially exploited in England (Sanderson and Prendergast 2002). According to Murray and Simcox (2003), a growing number of companies in the United Kingdom are harvesting elderberries. Moreover, Prendergast and Dennis (1997) believe that future development in the elderberry flower industry might head for cultivation rather than collecting from wild stands with an emphasis on organic product lines. In 2004, about 11 ha were dedicated to elderberry production in Switzerland (P. Rusterholz, person. commun.) while between 150 and 180 ha were in production in Hungary (Tökei and Dunkel 2003). Ferencz (2005) studied the costs associated with elderberry production in Hungary. He concluded that producers underestimated their production costs.

As pointed out by Way (1965), the North American elderberry market has an interesting potential with an estimated 2000 tons processed annually in the Lake Erie area at that time (Way 1967). McKay (2001) forecasted that the demand for elderberry was expected to grow. In comparison with many fruit crops, the market for elderberry is still in development. It is recommended that a prearranged market be located to insure profitability (Way 1965; Skirvin and Otterbacher 1977). Numerous products derived from the elderberry fruit and flowers are currently available in various parts of the world. However, these few examples are not adequate to enable us to estimate the actual quantities of flowers and fruits that the market might be able to absorb. Accordingly, an economic study will be required in order to obtain a clearer picture of the quantities of elderberries processed worldwide. The nutrient value and the medicinal potential of elderberries can advantageously be compared to those of better known fruits such as strawberries, blueberries and cranberries. Moreover, elderberry production is not as demanding as any of the above. As pointed out by Tőkei et al. (2005), the market should be able to absorb an increase in elderberry production. With the introduction of new cultivars and the publication of production guides it is to be expected that new products will be introduced in the years to come.

H. Processing

Formatted: Bullets and Numbering

Few studies addressed the potential effects of processing on elderberry derived product quality and much of them deal with the European species. Nakatami et al. (1995) and Inami et al. (1996) have demonstrated that acylation confers a better light and heat stability to anthocyanins extracted from American elderberry compared to those extracted from European elderberry. Juice processing from European elderberry was judged unsatisfactory (Kaack 1989b) and improvements to increase juice yield and lower turbidity were proposed (Landbo et al. 2007). Repeated pigments extraction from elderberry pomace with 0.1 M aqueous HCl gave good results (Brønnum-Hansen et al. 1985). Freezing the berries prior to pressing resulted in less pomace with only a marginal reduction in its anthocyanin content (Brønnum-Hansen et al. 1985). Pigment extraction can be optimized by adding citric acid to the extraction solvent, which increases the efficiency of the extraction process and helps stabilize the pigments (Kaack 1990b). Selection of cultivars with high vitamin C content along with reduced air exposure of the juice extracted should be considered as a means to maintain pigment integrity during processing (Kaack and Austed 1998). As a rule, processing can impact negatively on phytonutrients such as anthocyanins and polyphenolics (Lee et al. 2002). This further emphasizes the need to select cultivars with high phytochemical content and fruits that are ripe since variety and maturity can affect anthocyanin concentration (Brønnum-Hansen et al. 1985). According to Brønnum-Hansen and Flink (1985) minimum anthocyanin degradation and maximum product stability occur with undiluted extract at pH 3 with 2.5% of maltodextrin added as a structure stabilizer freeze dried at a temperature of 75°C and 60°C for the tray and the product, respectively.

In a detailed study on aroma composition and sensory quality of fruit juices processed from European elderberry cultivar, Kaack (2008a) and Kaack et al. (2005) showed the complex chemical composition and transformation of such juices. Similarly, chemical analysis of aqueous extracts from *S. nigra* flowers revealed their complex chemical composition and the importance of cultivar selection (Jørgensen et al. 2000; Kaack et al. 2006; Christensen et al. 2008). Kaack (2008b) also investigated the effect of temperature, liquid phase composition, and extraction time on the extraction of various chemicals from European elderberry flowers. From the results obtained with his analytical technique, Kaack (2008a, b) proposed cultivar selections better suited for specific market segments.

The effect of packing materials and storage time on volatile compounds in tea processed from flowers of European elderberry was also investigated. Kaack and Christensen (2008) demonstrated that the aroma of elderberry flowers is complex and that its chemical composition is affected by the packing material used and storage time.

VI. CONCLUDING REMARKS

From pre-history to Dioscorides to Shakespeare to Harry Potter, elderberries have been intimately linked to human culture for millennia. Either as the source of numerous superstitions, as an important part of the medicine chest or as a multi-purpose food source, elderberries have become integrated into the matrix of numerous civilizations. Long the only source available, natural populations are now being supplemented by well-managed orchards of selected cultivars. Despite the conservation of traditional harvest from wild populations, plant breeding, horticulture, and modern chemistry are guiding the development of elderberry into a viable multi-purpose crop with customized cultivars better suited for specific market segments.

The production and processing of elderberry fruit and flowers are well established in Europe. The publication of a growing number of studies on the chemical characterization of various plant parts from different elderberry species is likely to increase elderberry production and consumption in North America. Such studies are necessary to orient clinical and epidemiological research needed to defend the numerous health claims made about elderberries.

Elderberries are easy to grow and offer a wide range of applications. They are among the most polyvalent group of plants ever used by man. With the release of new cultivars, as well as additional basic horticultural research, they offer a huge potential to horticulture and food industry alike. As pointed out by Luther Burbank close to a century ago "The elderberry has qualities of its own that will commend it strongly" (Whitson et al. 1914).

LITERATURE CITED

Abuja, P.M., M. Murkovic, and W. Pfannhausser. 1998. Antioxidant and prooxidant activities of elderberry (*Sambucus nigra*) extract in low-density lipoprotein oxidation. J. Agr. Food Chem. 46:4091-4096.

Adame, J., and H. Adame. 2000. Plantas curativas del Noreste Mexicano. Ediciones Castillo. Nuevo Léon, México. p. 386.

Adams, J. 1927. The germination of seeds of some plants with fleshy fruits. Am. J. Bot. 14:415-428.

Adams, W. 1915. Adam's improved ever bearing elderberry no. 2. http://www.freepages.genealogy.rootsweb.com/~springport/pictures_13/00001370.jpg. Accessed on October 3, 2006.

Agustí, M. 1617. Llibre dels secrets de agricultura casa rustica y pastoril. (Facsimile edition: Alta Fulla, Barcelona 1988). Esteve Liberós. Barcelona.

Allen, G.M., M.D. Bond, and M.B. Main. 2002. 50 Common native plants important in Florida's ethnobotanical history. Circ. 1439, University of Florida IFAS Extension.

Amett, R.E., Jr. 2000. American insects: a handbook of the insects of America north of Mexico. 2nd edition. CRC Press. Boca Raton, FL. p. 1003.

Anonymous. 2005. *Sambucus nigra* (Elderberry). Altern. Med. Rev. 10:51-54.

Atkinson, M.D., and E. Atkinson. 2002. *Sambucus* nigra L. J. Ecol. 90:895-923.

Backlund, A., and B. Bremer. 1997. Phylogeny of the *Asteridae* s. str. based on *rbc*L sequences, with particular reference to the *Dipsacales*. Plant Syst. Evol. 207:225-254.

Bailey, L.H. 1930. p. 3067-3072. In, The standard cyclopedia of horticulture. III - P-Z. Macmillan, New York.

Bailey, L.H., and E.Z. Bailey. 1976. Hortus third: a concise dictionary of plants cultivated in the United States and Canada. MacMillan. New York. p. 1312.

Barak, V., T. Halperin, and I. Kalickman. 2001. The effect of Sambucol, a black elderberry-based, natural product, on the production of human cytokines: I. Inflammatory cytokines. Eur. Cytokine Netw. 12:290-296.

Barak, V., S. Birkenfeld, T. Halperin, and I. Kalickman. 2002. The effect of herbal remedies on the production of human inflammatory and anti-inflammatory cytokines. Israel Med. Assoc. J. 4:919-922.

Barnola, P. 1972. Étude expérimentale de la ramification basitone sur le sureau noir (*Sambucus nigra* L.). Ann. Sci. Nat. Bot. Biol. Vég. 13:369-400.

Basile, A., S. Sorbo, S. Giordano, L. Ricciardi, S. Ferrara, D. Montesano, R.C. Cobianci, M.L. Vuotto, and L. Ferrara. 2000. Antibacterial and allelopathic activity of extract from *Castanea sativa* leaves. Fitoterapia 71:S110-S116.

Beaudry, F., H. Bernard, A. Bouchard, P. Bourque, J. Landry, and J.-P. Roy. 1982. Arbres et arbustes ornementaux pour le Québec - L'inventaire. Gouvernement du Québec Ministère de l'agriculture, pêcheries et de l'alimentation. Québec.

Beaux, D., J. Fleurentin, and F. Mortier. 1998. Effect of extracts of *Orthosiphon stamineus* Benth., *Hieracium pilosella* L., *Sambucus nigra* L. and *Arctostaphylos uva-urs*i (L.) Spreng. in rats. Phytother. Res. 12:498-501.

Bermúdez-Soto, M.J., and F.A. Tomás-Barberán. 2004. Evaluation of commercial red fruit juice concentrates as ingredients for antioxidant functional juices. Eur. Food Res. Technol. 219:133-141.

Bir, R.E. 1992. Growing and propagating showy native woody plants. The University of North Carolina Press. Chapel Hill, NC. p. 192.

Blum, O., A. Bytnerowicz, W. Manning, and L. Popovicheva. 1988. Ozone air pollution in the Ukrainian Carpathian Mountains and Kiev region. p. 45-50, Proc. Int. Symp. on Air Pollution and Climate Changes Effects on Forest Ecosystems. Gen. Tech. Rep. PSW-GTR-166. Albany, CA.

Blumenthal, M., W.P. Busse, and S. Klein. 1998. The complete German commission E monographs - therapeutic guide to herbal medicines. The American Botanical Council. Austin, TX.

Böcher, T.W. 1941. Højsommerekskursionen til Brædstrup, Byrup og Vrads. Bot. Tidsskr. 45:433-439.

Bolli, R. 1994. Revision of the genus *Sambucus*. Diss. Bot. 223:1-256.

Bourquelot, E., and E. Danjou. 1905. Sur la sambunigrine, glucoside cyanidrique nouveau, retiré des feuilles de sureau noir. C. R. Hebd. Seances Acad. Sci. Ser. D Sci. Nat. 141:598-600.

Bradberry, S., and A. Vale. 2007. Poisonous substances - plants. Medicine 35:649-651.

Brand-Garnys, E.E., H. Denzer, H. Meijer, and H.M. Brand. 2007. Flavonoids: a review for cosmetic application. Part I. J. Appl. Cosmetol. 25:93-109.

Brassard, N., C. Richer, and D. Charlebois. 2004. Micropropagation of elderberry (*Sambucus nigra* ssp. *canadensis*). IAPTC&B and Annual Workshop of the Atlantic Plant Tissue Culture and Biotechnology Association, Truro, NS.

Bridle, P., and C. García-Viguera. 1997. Analysis of anthocyanins in strawberry and elderberry. A comparison of capillary zone electrophoresis and HPLC. Food Chem. 59:299-304.

Brinckmann, J.A., and M.P. Lindenmaier. 1994. Herbal drugs and phytopharmaceuticals: a handbook for practice on a scientific basis. In. CRC Press, Boca Raton, FL.

Brindza, J., B. Stehlíková, D. Tóth, V. Sedláčková, L. Kolisnik, O. Grygorieva, and Z. Kochanová. 2007. Characteristics of selected ecotypes from prevalently natural populations black elderberry (*Sambucus nigra* L.) in Slovakia. In: Congress Centre of the Slovak University of Agriculture (ed.), 1st International Scientific Conference on Medicinal, Aromatic and Spice Plants. Nitra, Slovak Republic.

Brinkman, K.A. 1974. *Sambucus* L., elder. p. 754-757. In: C.S. Schopmeyer (ed.), Seeds of woody plants in the United States. Agric. Handbk. 450. USDA Forest Service, Washington, D.C.

Brinkman, K.A., and W.G. Johnson. 2008. *Sambucus* L. - elder. p. 1014-1018. In, The woody plant seed manual. Agric. Handbook 727. USDA Forest Service, Washington, D.C.

Broekaert, W.F., M. Nsimba-Lubaki, B. Peeters, and W.J. Peumans. 1984. A lectin from elder (*Sambucus nigra* L.) bark. Biochem. J. 221:163-169.

Brønnum-Hansen, K., and S. Hansen. 1983. High-performance liquid chromatographic separation of anthocyanins of *Sambucus nigra* L. J. Chromatogr. 262:385-392.

Brønnum-Hansen, K., and J.M. Flink. 1985. Anthocyanin colourants from elderberry (*Sambucus nigra* L.). 2. Process considerations for production of a freeze dried product. J. Food Technol. 20:713-723.

Brønnum-Hansen, K., F. Jacobsen, and J.M. Flink. 1985. Anthocyanin colourants from elderberry (*Sambucus nigra* L.). 1. Process considerations for production of the liquid extract. J. Food Technol. 20:703-711.

Brookes, B. 2008. House martins eating elderberries. Br. Birds 101:384.

Brunneton, J. 2001. Plantas tóxicas. Vegetales peligrosos para el hombre y los animales. Zaragoza. Acribia.

Bubenicek, L. 2002. Dictionnaire des plantes comestibles. Paris. p. 328.

Buhrmester, R.A., J.E. Ebinger, and D.S. Seigler. 2000. Sambunigrin and cyanogenic variability in populations of *Sambucus canadensis* L. (Caprifoliaceae). Biochem. Systemat. Ecol. 28:689-695.

Buriff, C.R., and G.W. Still. 1972. Seasonal activity of adult elder shoot borer as indicated by blacklight traps J. Econ. Entomol. 65:1201-1202.

Byers, P., and A. Thomas. 2005. Elderberry research and production in Missouri. New York Berry News 4:14-17.

Caisse, N. 1998. Inventaire et productivité de *Prunus virginiana* L., *Sambucus canadensis* L., *Viburnum trilobum* Marsh., *Vaccinium vitis-idaea* L. et *Rubus chamaemorus* L. dans la péninsule acadienne avec une étude des populations de *R. chamaemorus* L. M. Sc. Thesis, Université de Moncton, Moncton, NB.

Campbell, S.J., R. Wanek, and J.W. Coulston. 2007. Ozone injury in west coast forests: 6 years of monitoring. Gen. Tech. Rep. PNW-GTR-722. U.S. Dept. of Agr., For. Serv. Pacific Northwest Res. Sta.

Cerulean, S., C. Botha, and D. Legare. 1986. Planting a refuge for wildlife: how to create a backyard habitat for Florida's birds and beasts. Florida Game and Freshwater Fish Commission. Tallahassee, FL.

Charlebois, D. 2007. Elderberry as a medicinal plant. p. 284-292. In: J. Janick, and A. Whipkey (eds.), Issues in new crops and new uses. ASHS, Alexandria, VA.

Charlebois, D., and C. Richer. 2005. Le sureau : exigences de la production, cultivars et potentiel de mise en marché. Agri-Réseau 1-8.

Chatterjee, A., T. Yasmin, D. Bagchi, and S.J. Stohs. 2004. Inhibition of *Helicobacter pylori* in-vitro by various berry extracts, with enhanced susceptibility to clarithromycin. Mol. Cell. Biochem. 265:19-26.

Chia, L. 1975. A chromosome and thin-layer chromatographic study of the genus *Sambucus*. Ph.D. Thesis, Cornell University, Ithaca, NY.

Chiang, L.C., W. Chiang, M.Y. Chang, L.T. Ng, and C.C. Lin. 2002. Antiviral activity of *Plantago major* extracts and related compounds in vitro. Antivir. Res. 55:53-62.

Christensen, L.P., K. Kaack, and X.C. Fretté. 2008. Selection of elderberry (*Sambucus nigra* L.) genotypes Best suited for the preparation of elderflower extracts rich in flavonoids and phenolic acids. Eur. Food Res. Technol. 227:293-305.

Chrubasik, C., and S. Chrubasik. 2008. Scientific proof of the traditional use of elderberry as a herbal drug / Schwarzer holunder: Volkstümliche Anwendungen wissenschaftlich belegt. Z. Phytother. 29:71-74.

Clarke, J.B., and K.R. Tobutt. 2006. Development of microsatellite primers and two multiplex polymerase chain reactions for the common elder (*Sambucus nigra*). Mol. Ecol. Notes 6:453-455.

Clergeau, P. 1992. The effects of birds on seed germination of fleshy-fruited plants in temperate farmland. Acta Oecol. 13:679-686.

Coastal Zone Resources Division. 1978. Handbook for terrestrial wildlife habitat development on dredged material. Tech. Rep. D-78-37. U.S. Army Eng. Waterways Experimental Station. Vicksburg, MS.

Conner, W.H., R.T. Huffman, and W.M. Kitchens. 1990. Composition and productivity in bottomland hardwood forest ecosystems: the report of the vegetation workshop. p. 445-480. In: J.G. Gosselink, L.C. Lee, and T.A. Muir (eds.), Ecological processes and cumulative impacts: illustrated by bottomland hardwood wetland ecosystems. Lewis Publishing, Chelsea, MI.

Conney, A.H., T. Lysz, T. Ferraro, T.F. Abidi, P.S. Manchand, J.D. Laskin, and M.T. Huang. 1991. Inhibitory effect of curcumin and some related dietary compounds on tumor promotion and arachidonic acid metabolism in mouse skin. Adv. Enzyme Regul. 31:385-396.

Craig, D.L. 1978. Elderberry culture in eastern Canada. Publication 1280. Information Services, Agriculture Canada.

Cram, W.H. 1982. Seed germination of elder (*Sambucus pubens*) and honeysuckle (*Lonicera tatarica*). HortScience 17:618-619.

Czarnecka, J. 2005. Seed dispersal effectiveness in three adjacent plant communities: xerothermic grassland, brushwood and woodland. Ann. Bot. Fenn. 42:161-171.

D'Abrosca, B., M. DellaGreca, A. Fiorentino, P. Monaco, L. Previtera, A.M. Simonet, and A. Zarrelli. 2001. Potential allelochemicals from *Sambucus nigra*. Phytochem. 58:1073-1081.

Dall'olio, F., V. Malagonini, S. Guerrini, J.T.Y. Lau, and F. Serafini-Cessi. 1996. Differentiation-dependent expression of human ß-galactoside α2,6-sialyltransferase mRNA in colon carcinoma CaCo-2 cells. Glycoconjugate J. 13:115-121.

Dammer, U. 1890. Die extrafloralen nectarien an *Sambucus nigra*. Plant Syst. Evol. 40:261-264.

Darrow, G.M. 1975. Minor temperate fruits. p. 271-273. In: J. Janick, and J.N. Moore (eds.), Advances in Fruit Breeding. Purdue University Press, West Lafayette, IN.

Davis, D.D., D.M. Umbach, and J.B. Coppolino. 1981. Susceptibility of tree and shrub species and response of black cherry foliage to ozone. Plant Dis. 65:904-907.

Davis, O.H. 1927. Germination and early growth of *Cornus florida*, *Sambucus canadensis*, and *Berberis thunbergii*. Bot. Gaz. 84:225-263.

de Barros, F.M.C., K.N. Pereira, G.D. Zanetti, and B.M. Heinzmann. 2007. Medicinal plants used by people from São Luiz Gonzaga, RS, Brazil / Plantas de uso medicinal no Município de São Luiz Gonzaga, RS, Brasil. Lat. Am. J. Pharm. 26:652-662.

Deam, C.C. 1924. Shrubs of Indiana. Publ. No. 44. The Department of Conservation, State of Indiana. Indianapolis, IN.

DeGraaf, R.M., and G.M. Witman. 1979. Trees, shrubs, and vines for attracting birds - a manual for the Northeast. University of Massachusetts Press. Amherst, PA. p. 194.

DellaGreca, M., A. Fiorentino, P. Monaco, L. Previtera, and A.M. Simonet. 2000a. Cyanogenic glucosides from *Sambucus nigra*. Nat. Prod. Res. 14:175-182.

DellaGreca, M., A. Fiorentino, P. Monaco, L. Previtera, and A.M. Simonet. 2000b. Degraded cyanogenic glucosides from *Sambucus nigra*. Tetrahedron Lett. 41:6507-6510.

Dirr, M.A., and C.J. Heuser. 1987. The reference manual of woody plant propagation: from seed to tissue culture. Varsity Press. Athens, GA. p. 239.

Donoghue, M.J., C.D. Bell, and R.C. Winkworth. 2003. The evolution of reproductive characters in Dipsacales. Int. J. Plant Sci. 164:453-464.

Donoghue, M.J., T. Eriksson, P.A. Reeves, and R.G. Olmstead. 2001. Phylogeny and phylogenetic taxonomy od Dipsacales with special reference to *Sinodoxa* and *Tetradoxa* (Adoxaceae). Harv. Pap. Bot. 6:459-479.

Duke, J.A. 1985. CRC handbook of medicinal herbs. CRC Press. Boca Raton, FL. p. 677.

Durand, L., F. Morissette, and G. Lamoureux. 1981. Plantes sauvages comestibles. Le Groupe Fleurbec. Saint-Cuthbert, QC. p. 167.

Dzhangaliev, A.D., T.N. Salova, and P.M. Turekhanova. 2003. The wild fruit and nut plants of Kazakhstan. Hortic. Rev. 29:305-371.

Eaton, E.R., and K. Kaufman. 2007. Kaufman field guide to insects of North America. HMCop Field Guides.

Ebrahimzadeh, M.A., M. Mahmoudi, M. Karami, S. Saeedi, A.H. Ahmadi, and E. Salimi. 2007. Separation of active and toxic portions in *Sambucus ebulus*. Pak. J. Biol. Sci. 10:4171-4173.

Elias, T.S. 1980. The complete trees of North America - field guide and natural history. Van Nostrand Reinhold. New York. p. 948.

Environnement Canada. 2002. Portrait de la biodiversité du Saint-Laurent - *Sambucus canadensis*. www.qc.ec.ca/faune/biodiv/fr/recherche/especes/map.asp?T=PV&id=1382. Accessed on December 2, 2002.

European and Mediterranean Plant Protection Organization. 2008. Certification scheme for *Sambucus*. Bull. OEPP/EPPO Bull. 38:19-24.

European Medicines Agency. 2008. Community herbal monograph on *Sambucus nigra* L., flos. Doc. Ref. EMEA/HMPC/283166/2007.

Fahn, A. 1987. The extrafloral nectaries of *Sambucus nigra*. Annals of Botany 60:299-308.

Ferencz, À. 2005. Work organization and economic evaluation of elderberry growing / A bodzatermestés munkaszervezési és ökonómiai értékelése. Horticulture / Kertgazdaság 37:90-95.

Fernald, M.L. 1970. Gray's manual of botany. 8^{th} edition. D. Van Nostrand Company. Toronto, ON. p. 1632.

Filippin, L., E. Angelini, and M. Borgo. 2008. First identification of a phytoplasma infecting *Cornus sanguinea* and *Sambucus nigra*. Plant Pathology 57:1175.

Finn, C.E., A.L. Thomas, P.L. Byers, and S. Serçe. 2008. Evaluation of American (*Sambucus canadensis*) and European (*S. nigra*) elderberry genotypes grown in Missouri and Oregon and impact on cultivar development. HortScience 43:1385-1391.

Folliard, T. 2008. Phytothérapie externe en Amérique du Sud et en Amérique Centrale - Mexique et Guatemala (partie 1). Phytothérapie 6:175-183.

Foote, L.E., and S.B. Joes. 1989. Native shrubs and woody vines of the Southeast: landscaping uses and identification. Timber Press. Portland, OR. p. 199.

Fossen, T., L. Cabrita, and O.M. Andersen. 1998. Colour and stability of pure anthocyanins influenced by pH including the alkaline region. Food Chem. 63:435-440.

Frank, T., S. Sonntag, G. Strass, R. Bitsch, R. Bitsch, and M. Netzel. 2005. Urinary pharmacokinetics of cyanidin glycosides in healthy young men following consumption of elderberry juice. Int. J. Clin. Pharm. Res. 25:47-56.

Fukunaga, Y., and S.I. Akimoto. 2007. Toxicity of the aphid *Aulacorthum magnoliae* to the predator *Harmonia axyridis* (Coleoptera: Coccinellidae) and genetic variance in the assimilation of the toxic aphids in *H. axyridis* larvae. Entomol. Sci. 10:45-53.

Galletta, G.J., and D.G. Himelrick. 1990. The small fruit crops. p. 1-13. In: G.J. Galletta, and D.G. Himelrick (eds.), Small fruit crop management. Prentice Hall, Englewood Cliffs, NJ.

Gasson, P. 1979. The identification of eight woody genera of the Caprifoliaceae by selected features of their root anatomy. Bot. J. Linn. Soc. 78:267-284.

Ghirardini, M.P., M. Carli, N. del Vecchio, A. Rovati, O. Cova, F. Valigi, G. Agnetti, M. Macconi, D. Adamo, M. Traina, F. Laudini, I. Marcheselli, N. Caruso, T. Gedda, F. Donati,

A. Marzadro, P. Russi, C. Spaggiary, M. Bianco, R. Binda, E. Barattieri, A. Tognacci, M. Girardo, L. Vaschetti, P. Caprino, E. Sesti, G. Andreozzi, E. Coletto, G. Belzer, and A. Pieroni. 2007. The importance of a taste. a comparative study on wild food plant consumption in twenty-one local communities in Italy. J. Ethnobiol. Ethnomed. 3:1-22.

Gigienova, E.-I., A.-U. Umarov, and A.-L. Markman. 1969. Oils of the seeds of *Sambucus nigra*. Chem. Nat. Comp. 5:100.

Girbes, T., J.M. Ferreras, F.J. Arias, R. Muñoz, R. Iglesias, P. Jimenez, M.A. Rojo, Y. Arias, Y. Perez, J. Benitez, D. Sanchez, and M.J. Gayoso. 2003. Non-toxic type 2 ribosome-inactivating proteins (RIPs) from *Sambucus*: Occurrence, cellular and molecular activities and potential uses. Cell. Mol. Biol. 49:537-545.

Godzik, S. 1998. Ozone in the Upper Silesia Region - concentration and effects on plants. p. 59-64. In: A. Bytnerowicz, M. Arbaugh, J. Michael, and S.L. Schilling (eds.), Proc. Int. Symp. on Air Pollution and Climate Changes Effects on Forest Ecosystems. Gen. Tech. Rep. PW-GTR-166. Albany, CA.

Goetz, P. 2007. Phytothérapie du diabète. Phytothérapie 5:212-217.

Gorchakova, T.V., I.V. Suprun, I.A. Sobenin, and A.N. Orekhov. 2007. Use of natural products in anticytokine therapy. Bull. Exp. Biol. Med. 143:316-319.

Grace, S.C., and B.A. Logan. 2000. Energy dissipation and radical scavenging by the plant phenylpropanoid pathway. Philos. Trans. R. Soc. London, Ser. B 355:1499-1510.

Grauer, J. 1990. Elderberries on Long Island. Pomona 23:68.

Gray, A.M., Y.H.A. Abdel-Wahab, and P.R. Flatt. 2000. The traditional plant treatment, *Sambucus nigra* (Elder), exhibits insulin-like and insulin-releasing actions *in-vitro*. J. Nutr. 130:15-20.

Greenwood, J.S., H.M. Stinissen, W.J. Peumans, and M.J. Chrispeels. 1986. *Sambucus nigra* agglutinin is located in protein bodies in the phloem parenchyma of the bark. Planta 167:275-278.

Grieve, M. 1931. A modern herbal. Jonathan Cape. London. p. 919.

Griffiths, M. 1994. Index of garden plants. Timber Press. Portland , OR. p. 1234.

Griffiths, M.E. 2006. Salt spray and edaphic factors maintain dwarf stature and community composition in coastal sandplain heathlands. Plant Ecol. 186:69-86.

Grime, J.P., J.G. Hodgson, and R. Hunt. 1988. Comparative plant ecology: a functional approach to common British species. Unwin-Hyman. London, UK. p. 742.

Groven, I. 1975. Cutting and fertilization of elders / Beskæring og gødskning af hyld. Meddelelse Nr. 1181, Statens Planteavlsforsøg.

Guangwan, H., L. Chunlin, G. Murrell, and L. Keming. 2008. Lectotypification of *Sambucus chinensis* (Caprifoliaceae) and a new variety from Hunan, China. Novon 18:61-66.

Guédon, D., M. Brum, O. Saperas, L.G. Quintelas, D. Bizet, S. Bizot, E. Bourny, P.A. Compagnon, H. Kergosien, J. Respaud, J.M. Seigneuret, K. Taoubi, and P. Urizzi. 2008. Impurities in herbal substances, herbal preparations and herbal medicinal products, III. Pesticide residues / Impuretés des drogues végétales, préparations à base de drogues végétales et médicaments à base de plantes III. Résidus de pesticides. S.T.P. Pharma Pratiques 18:111-136.

Guilmette, M. 2006. Impact d'une pollinisation assistée sur la production fruitière du *Sambucus nigra* ssp. *canadensis* (L.) R. Bolli. M. Sc. Thesis, Université Laval, Québec, QC.

Guilmette, M., C. Richer, J.A. Rioux, and C. Charlebois. 2007. Impact d'un apport supplémentaire de pollen sur la mise à fruit de *Sambucus nigra* subsp. *canadensis* (L.) R. Bolli. Can. J. Plant Sci. 87:531-536.

Gunther, E. 1945. Ethnobotany of Western Washington: the knowledge and use of indigenous plants by Native Americans. Publications in Anthropology. Univ. of Washington. Seattle, WA. p. 67.

Gustafsson, M.H.G. 1995. Petal venation in the Asterales and related orders. Bot. J. Linn. Soc. 118:1-18.

Halliday, G. 1997. A flora of Cumbria. Centre for North-Wesr Regional Studies, University of Lancaster. Lancaster, UK. p. 612.

Halvorsen, B.L., K. Holte, M.C.W. Myhrstad, I. Barikmo, E. Hvattum, S.F. Remberg, A.-B. Wold, K. Haffner, H. Baugerod, L.F. Andersen, J.Ø. Moskaug, D.R. Jacobs, Jr., and R. Blomhoff. 2002. A systematic screening of total antioxidants in dietary plants. J. Nutr. 132:461-471.

Hankla, D.J. 1961. American Elder. p. 58-59. In: L.K. Halls, and T.H. Ripley (eds.), Deer browse plants of southern forests. USDA For. Serv., South For. Exp. Sta., New Orleans, LA, and Southeast For. Exp. Sta., Asheville, N.C., Ashville, N.C.

Hankla, D.J. 1977. American elder/*Sambucus canadensis* L. p. 89-90. In: L.K. Halls (ed.), Southern fruit producing woody plants used by wildlife. Gen. Tech. Rep. SO-16. U.S. Department of Agriculture, Forest Service, Southern Forest Experimental Station, New Orleans, LA.

Hao, C.Y., C.G. Cheng, and P. Liu. 2007. The applications of Fourier transform infrared spectroscopy in resolving some taxonomic doubts of Caprifoliaceae. Spectrosc. Spect. Anal. 27:38-42.

Hardin, J.W., and J.M. Arena. 1974. Human poisoning from native and cultivated plants. Duke University Press. Durham, NC.

Harley, J.L., and E.L. Harley. 1987. A check-list of mycorrhiza in the British flora. New Phytol. 105:1-102.

Harlow, W.M. 1954. Twig key to the deciduous woody plants of eastern North America. Dover Publications. New York. p. 56.

Hayes, B. 1984. Culture of the Elderberry. Pomona 20:33.

Hayes, B. 1987. Report on Elderberries. Pomona 17:252.

Heinrich, W., and G. Schaller. 1987. Veränderungen von Ökosystemstrukturen im Einflussbereicheines Dungemittelwerkes. Hercynia 24:328-334.

Heit, C.E. 1967. Propagation from seed. Part 6. Hardiness - a critical factor. Am. Nurs. 125:10-12, 88-96.

Helbig, D., V. Böhm, A. Wagner, R. Schubert, and G. Jahreis. 2008. Berry seed press residues and their valuable ingredients with special regard to black currant seed press residues. Food Chem. 111:1043-1049.

Hensel, A., A.M. Deters, C. Müller, T. Stark, N. Wittschier, and T. Hofmann. 2007. Occurrence of N-phenylpropenoyl-L-amino acid amides in different herbal drugs and their influence on human keratinocytes, on human liver cells and on adhesion of *Helicobacter pylori* to the human stomach. Planta Med. 73:142-150.

Hibler, J. 2004. The Berry bible: with 175 recipes using cultivated and wild, fresh and frozen berries. William Morrow Cookbooks. New York. p. 352.

Hickel, A., M. Hasslacher, and H. Griengl. 1996. Hydroxynitrile lyases: functions and properties. Physiol. Plant. 98:891-898.

Hickey, M., and C.J. King. 1981. 100 Families of flowering plants. Cambridge University Press. Cambridge, UK. p. 567.

Hidayati, S.N., C.C. Baskin, and J.M. Baskin. 2000. Dormancy-breaking and germination requirements of seeds of four *Lonicera* species (Caprifoliaceae) with underdeveloped spatulate embryos. Seed Sci. Res. 10:459-469.

Hightshoe, G.L. 1988. Native trees, shrubs, and vines for urban and rural America: a planting design manual for environmental designers. Van Nostrand Reinhold. New York. p. 849.

Hill, L. 1983. Vintage elderberries. Horticulture 61:44-47.

Hillier, J., and A.J. Coomes. 2002. The Hillier manual of trees & shrubs (Hillier gardener's guide). David & Charles PLC. UK. p. 511.

Himelrick, D.G., and G.J. Galletta. 1990. Factors that influence small fruit production. p. 14-823. In: G.J. Galetta, and D.G. Himelrick (eds.), Small fruit crop management. Prentice Hall, Englewood Cliffs, NJ.

Hollman, P.C. 2001. Evidence for health benefits of plant phenol: local or systemic effects? J. Sci. Food Agric. 81:842-852.

Horak, F., M. Hussarek, and S. Jäger. 1976. Antigenspektrum der allergishen rhinitis. Wien. Klin. Wochenschr. 88:653-657.

Hosie, R. 1979. Native trees of Canada. 8th edition. Canadian Forestry Service, Dept. Environment. Ottawa, ON. p. 389.

Hosseinimehr, S.J., F. Pourmorad, N. Shahabimajd, K. Shahrbandy, and R. Hosseinzadeh. 2007. In vitro antioxidant activity of *Polygonium hyrcanicum*, *Centaurea depressa*, *Sambucus ebulus*, *Mentha spicata* and *Phytolacca americana*. Pak. J. Biol. Sci. 10:637-640.

Hu, Y., Q. Zhang, G. Rao, and Sodmergen. 2008. Occurrence of plastids in the sperm cells of Caprifoliaceae: biparental plastid inheritance in Angiosperms is unilaterally derived from maternal inheritance. Plant Cell Physiol. 49:958-968.

Hultén, E., and M. Fries. 1986. Atlas of North European vascular plants north of the Tropic of Cancer. Koeltz Scientific Books. Köningstein, Germany. p. 868.

Inami, O., I. Tamura, H. Kikuzaki, and N. Nakatani. 1996. Stability of anthocyanins of *Sambucus canadensis* and *Sambucus nigra*. J. Agr. Food Chem. 44:3090-3096.

Jäger, S. 1989. Trends in the frequency of different pollen types in Vienna from 1976 to 1989. Aerobiologia 5:9-16.

Jensen, S.R., and B.J. Nielsen. 1973. Cyanogenic glucosides in *Sambucus nigra* L. Acta Chem. Scand. Ser. B 27:2661-2662.

Johansson, A., P. Laako, and H. Kallio. 1997. Characterization of seed oils of wild, edible Finnish berries. Z. Lebensm. Unters. For. 204:300-307.

Jones, A.T. 1972. Purification and properties of elderberry latent virus, one of four sap-transmissible viruses obtained from American elder (*Sambucus canadensis* L.). Ann. Appl. Biol. 70:49-58.

Jones, A.T., and A.F. Murant. 1971. Serological relationship between cherry leaf roll, elm mosaic and golden elderberry viruses. Ann. Appl. Biol. 69:11-15.

Jørgensen, U., M. Hansen, L.P. Christensen, K. Jensen, and K. Kaack. 2000. Olfactory and quantitative analysis of aroma compounds in elder flower (*Sambucus nigra* L.) drink processed from five cultivars. J. Agr. Food Chem. 48:2376-2383.

Kaack, K. 1988. Effect of nitrogen, planting distance and time of harvest on yield and fruit quality of elderberry (*Sambucus nigra* L.). Tidsskr. Planteavl / Dan. J. Plant Soil Sci. 92:79-82.

Kaack, K. 1989a. New varieties of elderberry (*Sambucus nigra* L.). Tidsskr. Planteavl / Dan. J. Plant Soil Sci. 93:59-65.

Kaack, K. 1989b. Juice processing from elderberry (*Sambucus nigra* L.). Tidsskr. Planteavl / Dan. J. Plant Soil Sci. 93:365-368.

Kaack, K. 1990a. Ripening of elderberry (*Sambucus nigra* L.). Tidsskr. Planteavl / Dan. J. Plant Soil Sci. 94:127-129.

Kaack, K. 1990b. Processing of anthocyanin colourant from elderberry (*Sambucus nigra* L.) pomace. Tidsskr. Planteavl / Dan. J. Plant Soil Sci. 94:423-429.

Kaack, K. 2008a. Aroma composition and sensory quality of fruit juices processed from cultivars of elderberry Eur. Food Res. Technol. 227:45-56.

Kaack, K. 2008b. Processing of aroma extracts from elder flower (*Sambucus nigra* L.). Eur. Food Res. Technol. 227:375-390.

Kaack, K., and T. Austed. 1998. Interaction of vitamin C and flavonoids in elderberry (*Sambucus nigra* L.) during juice processing. Plant Food Hum. Nutr. 52:187-198.

Kaack, K., and L.P. Christensen. 2008. Effect of packing materials and storage time on volatile compounds in tea processed from flowers of black elder (*Sambucus nigra* L.). Eur. Food Res. Technol. 227:1259-1273.

Kaack, K., L.P. Christensen, M. Hughes, and R. Eder. 2005. The relationship between sensory quality and volatile compounds in raw juice processed from elderberries (*Sambucus nigra* L.). Eur. Food Res. Technol. 221:244-254.

Kaack, K., L.P. Christensen, M. Hughes, and R. Eder. 2006. Relationship between sensory quality and volatile compounds of elderflower (*Sambucus nigra* L.) extracts. Eur. Food Res. Technol. 223:57-70.

Kaack, K., X.C. Fretté, L.P. Christensen, A.-K. Landbo, and A.S. Meyer. 2008. Selection of elderberry (*Sambucus nigra* L.) genotypes best suited for the preparation of juice. Eur. Food Res. Technol. 226:843-855.

Kabuce, N. 2007. NOBANIS - Invasive alien species fact sheet - *Sambucus nigra*. http://www.nobanis.org/files/factsheets/Sambucus_nigra.pdf. Accessed on September 20, 2008.

Kaileh, M., W.V. Berghe, E. Boone, T. Essawi, and G. Haegeman. 2007. Screening of indigenous Palestinian medicinal plants for potential anti-inflammatory and cytotoxic activity. J. Ethnopharmacol. 113:510-516.

Kammerer, D.R., S. Schillmöller, O. Maier, A. Schieber, and R. Carle. 2007. Colour stability of canned strawberries using black carrot and elderberry juice concentrates as natural colourants. Eur. Food Res. Technol. 224:667-679.

Kellerman, W.A. 1904. Index to uredineous culture experiments with list of species and hosts for North America. J. Mycol. 10:64-76.

Kislichenko, V.S., and V.V. Vel'ma. 2006. Amino-acid composition of flowers, leaves, and extract of *Sambucus* nigra flowers. Chem. Nat. Comp. 42:125-126.

Kline, L.J., D.D. Davis, J.M. Skelly, J.E. Savage, and J.E. Ferdinand. 2008. Ozone sensitivity of 28 plant selections exposed to ozone under controlled conditions. Northeast. Nat. 15:57-66.

Kneller, M., and D. Peteet. 1999. Late-glacial to early Holocene climate changes from a Central Appalachian pollen and macrofossil record. Quarternary Res. 51:113-147.

Kollànyi, I., G. Kollànyi, and B. Hajdù. 2005. Varieties and candidate varieties for enlarging the assortment of elderberry / A fekete bodza fajtavlasztékának bővitésére alkalmas fajtk és fajtaljelötek. Horticulture / Kertgazdaság Special edition:83-88.

Kollmann, J., and S.A. Reiner. 1996. Light demands of shrubs seedlings and their establishment within scrublands. Flora 191:191-202.

Konlee, M. 1998. An extract from elder berries, used in combination whit a common treatment for arthritis (glucosamine and chondroitin sulfate), inhibits HIV and other lipid envelope viruses. Positive Health News Fall:1-29.

Krusmann, G. 1986. Manual of cultivated broad-leaved trees and shrubs: E-Pro. III. Timber Press. Portland, OR. p. 445.

Kuhn, K., and K. Förster. 2007. Black elder (*Sambucus nigra* L.) extract: effects of plant organ, cultivar and sampling date on in vitro growth of *Microdochium nivale* (Fr.) Samuels & Hallet / Schwarzer holunder (*Sambucus nigra* L.) - Extrakt: Einfluss von pflanzenorgan, sorte und probenahmetermin auf das in vitro wachstum von Microdochium nivale (Fr.) Samuels & Hallet. Pflanzenbauwissenschaften 11:32-38.

Kültür, Ş. 2007. Medicinal plants used in Kirklareli province (Turkey). J. Ethnopharmacol. 111:341-364.

Künsch, U., and A. Temperli. 1978a. Changes in free and protein-bound amino acids in elderberry fruit (*Sambucus nigra*) during maturation. J. Sci. Food Agric. 29:1037-1040.

Künsch, U., and A. Temperli. 1978b. Influence of maturity and nitrogen fertilizer on the free and protein-bound amino acids content of black elderberries / Einfluss von Reife und Stickstoffdungung auf die Gehälte von freien- und Proteingebundenen Aminosäuren von schwarzen Holunderbeeren. Plant Food Hum. Nutr. 3:233-240.

Landbo, A.K., K. Kaack, and A.S. Meyer. 2007. Statistically designed two step response surface optimization of enzymatic prepress treatment to increase juice yield and lower turbidity of elderberry juice. Innov. Food Sci. Emerg. Technol. 8:135-142.

Lau, C.S., D.J. Carrier, L.R. Howard, J.O. Lay, Jr., J.A. Archambault, and E.C. Clausen. 2004. Extraction of antioxidant compounds for energy crops. Appl. Biochem. Biotech. 114:569-583.

Laurie, A., and L.C. Chadwick. 1931. The modern nursery. A guide to plant propagation, culture and handling. Macmillan. New York. p. 494.

Lawrence, G.H.M. 1951. Taxonomy of vascular plants. Macmillan Publishing. New York. p. 823.

Lee, J. 2004. The blueberry: composition, anthocyanins, and polyphenolics. Ph.D. Thesis, Oregon State University, Corvallis, OR.

Lee, J., and C.E. Finn. 2007. Anthocyanins and other polyphenolics in American elderberry (*Sambucus canadensis*) and European elderberry (*S. nigra*) cultivars. J. Sci. Food Agric. 87:2665-2675.

Lee, J., R.W. Durst, and R.E. Wrolstad. 2002. Impact of juice processing on blueberry anthocyanins and polyphenolics: comparison of two pretreatments. J. Food Sci. 67:1660-1667.

Lehmann, F., E. Tiralongo, and J. Tiralongo. 2006. Sialic acid-specific lectins: occurrence, specificity and function. Cell. Mol. Life. Sci. 63:1331-1354.

Lekka, M., P. Laidler, M. Łabędź, A.J. Kulik, J. Lekki, W. Zając, and Z. Stachura. 2006. Specific detection of glycans on a plasma membrane of living cells with atomic force microscopy. Chem. Biol. 13:505-512.

Li, T.S.C. 2000. Medicinal plants - culture, utilization and phytopharmacology. CRC Press. New York. p. 517.

Lid, J. 1979. Norsk og Svensk Flora. Det Norske Samgalet. Oslo, Norway. p. 800.

Lightfoot, J. 1777. Flora Scotica: or, a systematic arrangement, in the Linnaean method, of the native plants of Scotland and the Hebrides. I. B. White. London.

Lin, L.-Z., and J.M. Harnly. 2007. A screening method for the identification of glycosylated flavonoids and other phenolic compounds using a standard analytical approach for all plant materials. J. Agr. Food Chem. 55:1084-1096.

Little, E.L. 1980. The Audubon field guide to North American trees - Eastern Region. Alfred A. Knopf. New York. p. 714.

Łuczaj, Ł., and W.M. Szymański. 2007. Wild vascular plants gathered for consumption in the Polish countryside: a review. J. Ethnobiol. Ethnomed. 3:17.

Mabey, R. 1996. Flora Britannica - The definitive new guide to Britain's wild flowers, plants and trees. Sinclair-Stevenson. London. p. 480.

Mahlstede, J.P., and E.S. Haber. 1957. Plant propagation. Wiley. New York. p. 412.

Maisenhelder, L.C. 1958. Understory plants of bottomland forests. USDA Forest Service, Occasional Paper 165. Southern For. Expt. Stn. New Orleans, LA.

Malien-Aubert, C., O. Dangles, and M.J. Amiot. 2001. Color stability of commercial anthocyanin-based extracts in relation to the phenolic composition. Protective effects by intra- and intermolecular copigmentation J. Agr. Food Chem. 49:170-176.

Mamula, D., and D. Miličić. 1975. Cherry leaf roll virus in *Sambucus ebulus* L. Acta Hort. 44:33-37.

Marie-Victorin, F. 1935. Flore Laurentienne. 2nd edition. Les Presses de l'Université de Montréal. Montréal, QC. p. 925.

Marshall, E.J.P. 1989. Susceptibility of four hedgerow shrubs to a range of herbicides and plant growth regulators. Ann. Appl. Biol. 115:469-479.

Martin, A.C., H.S. Zim, and A.L. Nelson. 1951. American wildlife and plants. McGraw-Hill. New York. p. 500.

Martin, C.O., and S.P. Mott. 1997. American elder (*Sambucus canadensis*); Section 7.5.7. In: U.S. Army Corps of Engineers Wildlife Resources Management Manual. Tech. Rep. EL-97-14. U.S. Army Engineer Waterways Experiment Station. Vicksburg, MS.

Mascolo, N., G. Autore, F. Capasso, A. Menghini, and M. Palmira Fasulo. 1987. Biological screening of Italian medicinal plants for anti-inflammatory activity. Phytother. Res. 1:28-31.

Mathieu, F., D. Charlebois, and N. Chevrier. 2007. Étude de la maturation des fruits du sureau du Canada. p. 40. In: U. Laval (ed.), Proc. of Conférence sur la Recherche et l'Innovation Québécoises en Agriculture et en Agroalimentaire Québec, QC.

Mathieu, F., N. Chevrier, and D. Charlebois. 2008a. Biochemical characterisation of American elder berries for a product oriented cultivar selection. p. 81, Plants & Soils: Montreal'08 Ecological Intensification, Biofuels and Bioproducts. Montréal, QC.

Mathieu, F., N. Chevrier, and D. Charlebois. 2008b. Fruit phenology of American elder: picking the right fruits? p. 81, Plants & Soils: Montreal'08 Ecological Intensification, Biofuels and Bioproducts. Montréal, QC.

McKay, S.A. 2001. Demand increasing for aronia and elderberry in North America. NY Fruit Q. 9:2-3.

McLaughlin, J., L. Vasquez, and J. Haynes. 2008. Native landscape plants for South Florida. ENH 875, University of Florida IFAS Extension.

Mehra, P.N., and K.S. Bawa. 1968. B-chromosomes in some Himalaya hardwoods. Chromosoma 25:90-95.

Merica, E., M. Lungu, I. Balan, and M. Matei. 2006. Study on the chemical composition of *Sambucus* nigra L. essential oil and extracts. NutraCos January/February:25-27.

Metcalfe, C.R. 1948. The elder tree (*Sambucus nigra* L.) as a source of pith, pegwood and charcoal with some notes on the structure of the wood. Kew Bull. 1:163-169.

Milliken, W., and S. Bridgewater. 2001. Flora Celtica: sustainable development of Scottish plants. Edinburg, UK.

Moerman, D.E. 1998. Native American ethnobotany. Timber Press. Portland, OR. p. 927.

Molina-Salinas, G.M., A. Pérez-López, P. Becerril-Montes, R. Salazar-Aranda, S. Said-Fernández, and N.W. Torres. 2007. Evaluation of the flora of northern Mexico for in vitro antimicrobial and antituberculosis activity. J. Ethnopharmacol. 109:435-441.

Mori, H., K. Kawabata, K. Matsunaga, J. Ushida, K. Fujii, A. Hara, T. Tanaka, and H. Murai. 2000. Chemopreventive effects of coffee bean and rice constituents on colorectal carcinogenesis. Biofactors 12:101-105.

Morrow, E.B., G.M. Darrow, and D.H. Scott. 1954. A quick method of cleaning berry seed for breeders. Proc. Am. Soc. Hortic. Sci. 63:265.

Murray, M., and H. Simcox. 2003. Use of wild living resources in the United Kingdom - A review. UK Committee for IUCN.

Nakatani, N., H. Kikuzaki, J. Hikida, M. Ohba, O. Inami, and I. Tamura. 1995. Acylated anthocyanins from fruits of *Sambucus canadensis*. Phytochem. 38:755-757.

Nilsson, A. 1987. Hybriden mellan fläder och druvfläder funnen i Skåne. Sven. Bot. Tidskr. 81:174-175.

Novelli, S. 2003. Developments in berry production and use. Agriculture and Agri-Food Canada Bi-Weekly Bulletin 16:5-6.

Novikova, O.V., and N.E. Kosheleva. 2007. Environmental-geochemical assessment of tree vegetation in the city of Quito. Vestn. Mosk. Univ. Ser. V Geogr.:43-48.

OEPP/EPPO. 1996. Tobacco ringspot nepovirus, CAB International, Wallingford, UK.

Osbaldeston, T.A., and R.P.A. Wood. 2000. Dioscorides de materia medica. Ibidis Press. Johannesburg, SA. p. 78.

Ourecky, D.K. 1970. Chromosome morphology in the genus *Sambucus*. Am. J. Bot. 57:239-244.

Paquet, G., and J. Jutras. 1996. Aménagement de boisés et terres privés pour la faune. 7-Plantation de haies brise-vent pour la faune. Ministère des ressources naturelles du Québec. Québec, QC. p. 6.

Pascarella, J.B., K.D. Waddington, and P.R. Neal. 2001. Non-apoid flower-visiting fauna of Everglades National Park, Florida. Biodivers. Conserv. 10:551-566.

Passalacqua, N.G., P.M. Guarrera, and G. De Fine. 2007. Contribution to the knowledge of the folk plant medicine in Calabria Region (southern Italy). Fitoterapia 78:52-68.

Philipson, B.A. 1946. Some observations on the apical meristems of leafy and flowering shoots. Bot. J. Linn. Soc. 53:187-193.

Pieroni, A., M.E. Giusti, H. Münz, C. Lenzarini, G. Turković, and A. Turković. 2003. Ethnobotanical knowledge of the Istro-Romanians of Zejane in Croatia. Filoterapia 74:710-719.

Pirone, P.P., B.O. Dodge, and H.W. Rickett. 1960. The New York Botanical Garden - diseases and pests of ornamental plants. 1960 edition. The Ronald Press Company. New York. p. 776.

Plant Gene Resources of Canada Agriculture and Agri-Food Canada. 2007. *Sambucus*. http://pgrc3.agr.gc.ca/cgi-bin/npgs/html/taxon.pl?32983. Accessed on September 3, 2008.

Plummer, A.P., D.R. Christensen, and S.B. Monsen. 1968. Restoring big-game range in Utah. Publication no. 68-3. Utah Division of Fish and Game. Salt Lake City, UT.

Pogorzelski, E. 1982. Formation of cyanide as a product of decomposition of cyanogenic glucosides in the treatment of elderberry fruit (*Sambucus nigra*). J. Sci. Food Agric. 33:496-498.

Poincelot, R.P. 1980. Horticulture: principles and practical applications. Prentice-Hall. Englewood Cliffs, NJ. p. 592.

Pool-Zobel, B.L., A. Bub, N. Schröder, and G. Rechkemmer. 1999. Anthocyanins are potent antioxidants in model systems but do not reduce endogenous oxidative DNA damage in human colon cells. Eur. J. Nutr. 38:227-234.

Prendergast, H.D.V., and F. Dennis. 1997. Superior merits of a troublesome weed - elder in the 1990s. British Wildlife 8:281-286.

Prior, R.L. 2003. Fruits and vegetables in the prevention of cellular oxidative damage. Am. J. Clin. Nutr. 78:570-578.

Rachwal, L. 1983. Tolerance variability of trees and shrubs to high concentrations of SO_2 and heavy metals. Aquilo Ser. Bot. 19:342-353.

Radford, A.E., H.E. Ahles, and D.R. Bell. 1968. Manual of the vascular flora of the Carolinas. University of North Carolina. Chapel Hill, NC. p. 1183.

Rajchard, J., Z. Balounová, R. Novák, and P. Kindlmann. 2007. Indirect effect of extreme flooding: disappearance of wading birds roost caused by vegetation turn. Ekologia Bratislava 26:64-67.

Rapisarda, P., F. Fanella, and E. Maccarone. 2000. Reliability of analytical methods for determining anthocyanins in blood orange juices. J. Agr. Food Chem. 48:2249-2252.

Rich, A. 1859. Dictionnaire des Antiquités Romaines et Grecques. 1883 edition. Firmin-Didot. Paris.

Rimpapa, Z., J. Toromanović, I. Tahirović, A. Sapcanin, and E. Sofić. 2007. Total content of phenols and anthocyanins in edible fruits from Bosnia. Bosnian Journal of Basic Medical Sciences 7:117-120.

Ritter, C.M., and G.W. McKee. 1964. The elderberry: history, classification and culture. Bull. 709. Pennsylvania State University, College of Agriculture, Agricultural Experimental Station. University Park, PA.

Robertson, C. 1892. Flowers and insects. IX. Bot. Gaz. 17:269-276.

Roper, T.R., D.L. Mahr, and P.S. McManus. 1998. Growing currants, gooseberries & elderberries in Wisconsin. University of Wisconsin-Extension, Cooperative Extension Publishing. p. 9.

Rossell, C.R., and I.M. Rossell. 1999. Microhabitat selection by small mammals in a southern Appalachian fen in the USA. Wetlands Ecology and Management 7:219-224.

Sánchez-Monge y Parellada, E. 1980. Diccionario de plantas agricolas. Servicio Publicaciones Agrarias, Minesterio de Agricultura. Madrid. p. 466.

Sanderson, H., and D.V. Prendergast. 2002. Commercial uses of wild and traditionally managed plants in England and Scotland. Centre for Economic Botany and Royal Botanical Gardens, Kew. Richmond, UK.

Sansdrap, A. 2000. La culture des sureaux. Le Fruit Belge 68:486:130-132.

Savolainen, V., M.W. Chase, S.B. Hoot, C.M. Morton, D.E. Soltis, C. Bayer, M.F. Fay, A.Y. de Bruijn, S. Sullivan, and Y.-L. Qiu. 2000. Phylogenetics of flowering plants based on combined analysis of plastid *atpB* and *rbcL* gene sequences. Syst. Biol. 49:306-362.

Scalbert, A., C. Manach, C. Morand, and C. Rémésy. 2005. Dietary polyphenols and the prevention of diseases. Crit. Rev. Food. Sci. Nutr. 45:287-306.

Schaefer, H.M., and V. Schmidt. 2002. Feeding strategies and food intake of blackcaps (*Sylvia atricapilla*) consuming ripe or unripe fruits and insects. J. Ornithol. 143:341-350.

Schapowal, A. 2007. Herbals for respiratory tract infection in pediatrics / Phytopharmaka bei Atemwegsinfekten in der Pädiatrie. Z. Phytother. 28:174-180.

Schneck, J. 1880. Red calyx in *Sambucus canadensis*. Bot. Gaz. 5:40.

Schnitzler, A. 1997. River dynamics as a forest process: interaction between fluvial systems and alluvial forest in large European river plains. Bot. Rev. 63:40-64.

Schooley, K. 1995. Elderberries for home gardens. In: Factsheet Agdex # 238/10. Ontario Ministry of Agriculture, Food and Rural Affairs. Ontario.

Schuette, H.A., and J.W. Brooks. 1936. Elderberry seed oil (*Sambucus canadensis* L.): preliminary communication. J. Am. Oil Chem . Soc. 13:314-316.

Schwerdtfeger, S.M., and M.F. Melzig. 2008. Effects of plant extracts on neuraminidase activity / Wirkung von Pflanzenextrakten auf die Neuraminidase-Aktivität. Z. Phytother. 29:65-70.

Seabra, I.J., M.E.M. Braga, M.T.P. Batista, and H.C. de Sousa. 2008. Fractioned high pressure extraction of anthocyanins from elderberry (*Sambucus nigra* L.) pomace. Food Bioprocess Technol. 1:324-333.

Seeram, N.P. 2008. Berry fruits for cancer prevention: current status and future prospects. J. Agr. Food Chem. 56:630-635.

Seigler, D.S. 1976. Plants of the Northeastern United States that produce cyanogenic compounds. Econ. Bot. 30:395-407.

Shahidi-Noghabi, S., E.J.M. Van Damme, and G. Smagghe. 2008. Carbohydrate-binding activity of the type-2 ribosome-inactivating protein SNA-I from elderberry (*Sambucus nigra*) is a determining factor for its insecticidal activity. Phytochem. 69:2972-2978.

Short, H.L., and E.A. Epps, Jr. 1976. Nutrient quality and digestibility of seeds and fruits from forests. J. Wildl. Manage. 40:283-289.

Silver, J.C. 1933. Biology and morphology of the spindle worm, or elder borer. USDA Technical BulletinTB345. USDA Dept. of Agriculture. Washington, DC.

Simonovik, B., A. Ivančič, J. Jakše, and B. Bohanek. 2007. Production and genetic evaluation of interspecific hybrids within the genus *Sambucus*. Plant Breeding 126:628-633.

Šišák, L. 2006. Importance of non-wood forest product collection and use for inhabitants in the Czech Republic. J. For. Sci. 52:417-426.

Skirvin, R.M., and A. Otterbacher. 1977. Elderberry cultivar performance in Illinois. Fruit Var. J. 31:7-10.

Small, E., P.M. Catling, and C. Richer. 2004. Poorly known economic plants of Canada - 41. American elder (*Sambucus nigra* subsp. *canadensis* (L.) R. Bolli) and blue elderberry (*S. nigra* subsp. *cerulea* (Raf.) R. Bolli. Can. Bot. Assoc. Bull. 37:20-28.

Smith, A.E., and D.M. Secoy. 1981. Plants used for agricultural pest control in Western Europe before 1850. Chem. Ind.:12-17.

Smith, E. 1993. Natural dyes from Florida native plants. The Palmetto 13:12-15.

Stang, E.J. 1990. Elderberry, highbush cranberry, and Juneberry management. p. 363-382. In: G.J. Galletta, and D.G. Himelrick (eds.), Small fruit crop management. Prentice Hall, Englewood Cliffs, NJ.

Stiebel, H., and F. Bairlein. 2008. Frugivory in central European birds I: diet selection and foraging / Frugivorie mitteleuropäischer Vögel I: Nahrung und Nahrungserwerb. Vogelwarte 46:1-23.

Stiles, E.W. 1980. Patterns of fruit presentation and seed dispersal in bird-disseminated woody plants in the eastern deciduous forest. Am. Nat. 116:670-688.

Stokes, D.W. 1981. The natural history of wild shrubs and vines - eastern and central North America. Harper & Row. New York, NY. p. 246.

Strack, D., and V. Wray. 1994. The anthocyanins. p. 1-22. In: J.B. Harborne (ed.), The flavonoids. Chapman & Hall, London.

Strauss, E., and R. Novak. 1971. Cultivation attempts of elderberry (*Sambucus nigra* L.) / Anbauversuche mit Holunder (*Sambucus nigra* L). Mitt. Klostern. 21:16-26.

Struempf, H.M., J.E. Schondube, and C.M. Del Rio. 1999. The cyanogenic glycoside amygdalin does not deter consumption of ripe fruit by cedar waxwings. Auk 116:749-758.

The American Botanical Council. 2004. The ABC clinical guide to elder berry. 63.

The National Land and Water Information Service Agriculture and Agri-Food Canada. 2000. Plant hardiness zones of Canada 2000. http://nlwis-snite1.agr.gc.ca/plant00/index.phtml?lang=en-CA. Accessed on October 6, 2008.

Thomas, A.L., P.L. Byers, C.E. Finn, Y.-C. Chen, G.E. Rottinghaus, and W.L. Applequist. 2008. Occurrence of rutin and chlorogenic acid in elderberry leaf, flower, and stem in response to genotype, environment, and season. Acta Hort. 765:197-206.

Thompson, F. 1969. Harris tweed - The story of a Hebridean industry. David & Charles. Newton Abbot, UK. p. 191.

Thompson, J.N. 1981. Elaiosomes and fleshy fruits: phenology and selection pressures for ant-dispersed seeds. Am. Nat. 117:104-108.

Tingle, F.C., and E.R. Mitchell. 1986. Behavior of *Heliothis virescens* (F.) in presence of oviposition deterrents from elderberry. J. Chem. Ecol. 12:1523-1531.

Tökei, L., and Z. Dunkel. 2003. A new method for determining water uptake in elder-berry. Geophysical Research Abstracts, Nice, France.

Tőkei, L., Z. Dunkel, and A. Jung. 2005. A New method for determining water uptake in elderberry plantation Phys. Chem. Earth 30:245-248.

Toulemonde, B., and H.M.J. Richard. 1983. Volatile constituents of dry elder (*Sambucus nigra* L.) flowers. J. Agr. Food Chem. 31:365-370.

Tull, D., and G.O. Miller. 1991. A field guide to wildflowers, trees and shrubs of Texas. Gulf Publishing, Co. Houston, TX. p. 315.

Turek, S., and W. Cisowski. 2007. Free and chemically bonded phenolic acids in barks of *Viburnum opulus* L. and *Sambucus nigra* L. Acta Pol. Pharm. 64:377-383.

Turker, N., S. Aksay, and H.I. Ekiz. 2004. Effect of storage temperature on the stability of anthocyanins of a fermented black carrot (*Daucus carota var.* L.) beverage: Shalgam. J. Agr. Food Chem. 52:3807-3813.

Uncini Manganelli, R.E., L. Zaccaro, and P.E. Tomei. 2005. Antiviral activity in-vitro of *Urtica dioica* L., *Parietaria diffusa* M. et K. and *Sambucus nigra* L. J. Ethnopharmacol. 98:323-327.

USDA, ARS. 2008a. GRIN species records of *Sambucus*. http://www.ars-grin.gov/cgi-bin/npgs/html/exsplist.pl. Accessed on November 26, 2008.

USDA, ARS, National Genetic Resources Program. 2008b. Germplasm Resources Information Network - (GRIN) [Online Database]. http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?32983. Accessed on November 4, 2008.

USDA ARS. 2008. USDA National Nutrient Database for Standard Reference, Release 21. Nutrient Data Laboratory Homepage http://www.ars.usda.gov/ba/bhnrc/ndl. Accessed on October 8, 2008.

Uyemoto, J.K., R.M. Gilmer, and E. Williams. 1971. Sap-transmissible viruses of elderberry in New York Plant Dis. Rep. 55:913-916.

Vaissière, B. 2005. Mesure de l'importance agronomique et économique des insectes pollinisateurs. INRA Press Info 275:2.

Vallès, J., M.À. Bonet, and A. Agelet. 2004. Ethnobotany of *Sambucus nigra* L. in Catalonia (Iberian Peninsula): The integral exploitation of a natural resource in mountain regions. Econ. Bot. 58:456-469.

Van Damme, E.J.M., S. Roy, A. Barre, P. Rougé, F. Van Leuven, and W.J. Peumans. 1997. The major elderberry (*Sambucus nigra*) fruit protein is a lectin derived from a truncated type 2 ribosome-inactivating protein. Plant J. 12:1251-1260.

van der Watt, E., and J.C. Pretorius. 2001. Purification and identification of active antibacterial components in *Carpobrotus edulis* L. J. Ethnopharmacol. 76:87-91.

Van Dersal, W.R. 1938. Native woody plants of the United States. Their erosion control and wildlife values. Misc. Publ. #323. United States Government Printing Office. Washington, DC. p. 326.

Van Lent, J.W.M., A.J. Wit, and J. Dijkstra. 1980. Charactirization of a carlavirus in elderberry (*Sambucus spp.*). Neth. J. Plant Pathol 86:117-134.

Vaněčková-Skuhravá, I. 1996. Life cycles of five eriophyid mites species (Eriophyoidea, Acari) developing on trees and shrubs. J. Appl. Entomol. 120:513-517.

Vickery, R. 1995. A dictionary of plant lore. Oxford University Press. Oxford. p. 437.

Vigneaux, C. 1985. Plantes médicinales. Thérapeutique, toxicité. Masson. Paris.

Vines, R.A. 1960. Honeysuckle family (Caprifoliaceae). p. 941-946. In, Trees, shrubs, and vines of the Southwest. University of Texas Press, Austin, TX.

Vogt, U.K. 2001. Hydrolic vulnerability, vessel refilling, and seasonal courses of stem water potential of *Sorbus aucuparia* L. and *Sambucus nigra*. J. Exp. Biol. 52:1527-1536.

Wainio, W.W., and E.B. Forbes. 1941. The chemical composition of forest fruits and nuts from Pennsylvania. J. Agric. Res. 62:627-635.

Waksmundzka-Hajnos, M., A. Oniszczuk, K. Szewczyk, and D. Wianowska. 2007. Effect of sample-preparation methods on the HPLC quantitation of some phenolic acids in plant materials. Acta Chromatogr. 19:227-237.

Walker, M., J. Nunez, M. Walkingstick, and S.A. Banack. 2004. Ethnobotanical investigation of the Acjachemen clapperstick from blue elderberry, *Sambucus mexicana* (Caprifoliaceae). Econ. Bot. 58:21-24.

Walker, M.K., D.F. Farkas, V. Loveridge, and L. Meunier-Goddik. 2006. Fruit yogurt processed with high pressure. Int. J. Food Sci. Technol. 41:464-467.

Walz, B., and S. Chrubasik. 2008. Impact of a proprietary concentrate of *Sambucus nigra* L. on urinary pH. Phytother. Res. 22:977-978.

Wang, H., G. Cao, and R.L. Prior. 1996. Total antioxidant capacity of fruits. J. Agr. Food Chem. 44:701-705.

Watanabe, T., A. Yamamoto, S. Nagai, and S. Terabe. 1998. Analysis of elderberry pigments in commercial food samples by micellar electrokinetic chromatography. Anal. Sci. 14:839-844.

Way, R. 1965. Elderberry varieties and cultural practices. p. 233-236. In: New York State Horticultural Society (ed.), 1965 Annual Meeting.

Way, R.D. 1967. Elderberry growing in New York State. Cornell Extension Bulletin 1177, New York State College of Agriculture.

Way, R.D. 1981. Elderberry culture in New York State. New York's Food and Life Sciences Bulletin 91:1-4. New York State Agr. Expt. Sta., Geneva, NY.

Waźbińska, J., U. Puczel, and J. Senderowska. 2004. Yield in elderberry cultivars grown on two different soils in 1997-2003. J. Fruit Ornament. Plant Res. 12:175-181.

White, F.B. 1876. The edible wild fruits of Scotland. Scott. Nat. 3:22-28.

Whitson, J., R. John, and H. Smith Williams. 1914. Luther Burbank: his methods and discoveries and their practical application. VI. Luther Burbank Press. New York. p. 304.

Wilczyński, S., and R. Podlaski. 2005. The effect of air temperature and precipitation on the size of annual growth rings in a wild-growing form of the elderberry (*Sambucus nigra* L.) in the Świętokrzyski national park. J. Fruit Ornament. Plant Res. 13:79-89.

Willcox, J.K., S.L. Ash, and G.L. Catignani. 2004. Antioxidants and prevention of chronic disease. Crit. Rev. Food. Sci. Nutr. 44:275-295.

Wilson, P.M.W., and J.W. Wilson. 1977. Experiments on the rate of development of adventitious roots on *Sambucus nigra* cutting. Aust. J. Bot. 25:367-375.

Winge, Ö. 1944. The *Sambucus* hybrid *S. nigra* x *S. racemosa*. C. R. Trav. Lab. Carlsberg Ser Physiol. 24:73-78.

Worley, D.M., and C.M. Nixon. 1974. Elders. p. 180. In: J.D. Gill, and W.M. Healy (eds.), Shrubs and vines for Northeastern wildlife. General Technical Report NE-9 Northeastern Forest Experimental Station. USDA Forest Service, Broomall, PA.

Wu, X., L. Gu, R.L. Prior, and S. McKay. 2004. Characterization of anthocyanins and proanthocyanins in some cultivars of *Ribes*, *Aronia*, and *Sambucus* and their antioxidant capacity. J. Agr. Food Chem. 52:7846-7856.

Wunderlin, R., and B. Hansen. 2008. Atlas of Florida vascular plants. www.plantatlas.usf.edu/maps.asp?plantID=2186. Accessed on September 8, 2008.

Wyman, D. 1969. Shrubs and vines for American gardens. 1969 edition. Macmillan. New York, NY. p. 442.

Yatskievych, G. 2006. Steyermark's flora of Missouri. Revised edition, vol. 2. Missouri Botanical Garden Press. St. Louis, MO.

Yesilada, E. 1997. Evaluation of the anti-inflammatory activity of the Turkish medicinal plant *Sambucus ebulus*. Chem. Nat. Comp. 33:539-540.

Yesilada, E., O. Ustun, E. Sezik, Y. Takaishi, Y. Ono, and G. Honda. 1997. Inhibitory effects of Turkish folk remedies on inflammatory cytokines: interleukin-1alpha, interleukin-1beta and tumor necrosis factor alpha J. Ethnopharmacol. 58:59-73.

Young, J.A., and C.G. Young. 1986. Collecting, processing and germinating seeds of wildland plants. Timber Press. Portland, OR. p. 236.

Young, J.A., and C.G. Young. 1992. *Sambucus* L. - Elder. p. 313-314. In, Seeds of woody plants in North America. Dioscorides Press, Portland, OR.

Zafra-Stone, S., T. Yasmin, M. Bagchi, A. Chatterjee, J.A. Vinson, and D. Bagchi. 2007. Berry anthocyanins as novel antioxidants in human health and diseases prevention. Molecular Nutrition and Food Research 51:675-683.

Zafrilla, P., A. Valero, and C. García-Viguera. 1998. Stabilization of strawberry jam colour with natural colourants. Food Sci. Technol. 4:99-105.

Zakay-Rones, Z., E. Thom, T. Wollan, and J. Wadstein. 2004. Randomized study of the efficacy and safety of oral elderberry extract in the treatment of influenza A and B virus infections. J. Int. Med. Res. 32:132-140.

Zakay-Rones, Z., N. Varsano, M. Zlotnik, O. Manor, L. Regev, M. Schlesinger, and M. Mumcuoglu. 1995. Inhibition of several strains of influenza virus in-vitro and reduction of symptoms by an elderberry extract (*Sambucus nigra* L.) during an outbreak of influenza B in Panama. J. Altern. Complem. Med. 1:361-369.

Zhu, X., H. Zhang, and R. Lo. 2004. Phenolic compounds from the leaf extract of artichoke (*Cynara scolymus* L.) and their antimicrobial activities. J. Agr. Food Chem. 52:7272-7278.

Table 1. Vernacular names of *Sambucus nigra*

Language	*Sambucus nigra*	*Sambucus canadensis*
English	black elderberry, bour tree, bore tree, elder, common elder, European elder	American elder(berry), bourtree, Canada elder, eastern elderberry, elderberry, common elder, sweet elder, pie elder, elder-blow, blackberry elder, Mexican elder

French	arbre de Judas, grand sureau, haut bois, sambequier, sambuquier, sampêchier, seu, seuillet, seuillon, sureau, sureau commun, sureau noir, sus, suseau, susier	sureau blanc, sureau du Canada, sirop blanc
Afrikaans		Kanadese vlier
Danish	almindelig hyld	
German	Flieder, memeine Holunder, Holunder, schwarzer Flieder, schwarzer Holunder	
Hungarian	fekete bodza	
Italian	sambuco, sambuco nero, sambuco nostrale, zambuco, zambuco arboreo	
Polish	bez czarny	
Portuguese	sabugueiro, sabugueiro negro, sabugueiro preto	sabugueiro do Canada
Russian	Черен бъз	
Spanish	saúco, canillero, cañilero, linsusa, sabuco, sabugo, saúco blanco, sauquero, sayugo, yezgo	sauco del Canada

(Sánchez-Monge y Parellada 1980; Wunderlin and Hansen 2008); http://www.tela-botanica.org/eflore/BDNFF/4.02/nn/60241/vernaculaire)

Table 2. Nutritive values for various small fruits (content per 100 g fresh fruit)

Composition	Elderberry	Grape	Raspberry	Blackberry	Strawberry	Cranberry	Blueberry
Water	79.8	80.5	85.8	88.5	91.0	87.1	84.2
Energy (kcal)	73	69	52	43	32	46	57
Amino acids (mg)	0.645	0.574	ND	ND	0.563	0.862	0.497
Calcium (mg)	38	10	25	29	16	8	6
Carbohydrates (g)	18.4	18.1	11.9	9.6	7.7	12.2	14.5
Fat (g)	0.50	0.16	0.65	0.49	0.30	0.13	0,33
Fiber (g)	7.0	0.9	6.5	5.3	2.0	4.6	2.4
Iron (mg)	1.60	0.36	0.69	0.62	0.42	0.25	0.28

Phosphorus (mg)	39	20	29	22	24	13	12
Protein (N x 6.25)	0.66	0.72	1.20	1.39	0.67	0.39	0.74
Sodium (mg)	6	2	1	1	1	2	1
Vitamin A (IU)	600	66	33	214	12	60	54
Vitamin B6 (mg)	0.230	0.086	0.055	0.030	0.047	0.057	0.052
Vitamin C (mg)	36.0	10.8	26.2	21.0	58.8	13.3	9.7

Adapted from the Internet site of the United States Department of Agriculture (USDA)

http://www.nal.usda.gov/fnic/foodcomp/cgi-bin/measure.pl.

Last updated: January 13, 2009

C:\Denis\Articles en préparation\Horticultural Reviews\Charlebois et al - Elderberry revised.doc