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Serviceberry, a berry fruit with growing interest of industry: Physicochemical and quali-quantitative health-related compound characterisation

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ABSTRACT

Amelanchier canadensis (L.) Medik., commonly called serviceberry, is a potential functional food that is also used for its medicinal purposes. This work evaluated the potential of a cultivated serviceberry species as a functional food by characterising its physicochemical characteristics, antioxidant capacity, vitamin C, phenolics and other phytochemicals selected as health-promoting biomarkers, using high-performance liquid chromatography. The most important compound class identified was polyphenols (62.10%), followed by organic acids (22.63%), monoterpenes (7.95%), and vitamins (7.32%). Results showed that serviceberry fruits could be good sources of phenolic constituents, as catechins (343.46 ± 29.46 mg/100 g_{FW}), anthocyanins (220.66 ± 17.43 mg/100 g_{FW}), and tannins (209.29 ± 7.81 mg/100 g_{FW}) (FW = fresh weight). These results highlight the potential role of *A. canadensis* fruits as a functional food. Further studies are needed to identify several genotypes for breeding to get suitable cultivars for fresh consumption and processing.

1. Introduction

New demands are constantly directed to food producers by consumers. Rising consumer incomes, changes in lifestyle and demographics, and shifting preferences due to advanced knowledge about the relationship between food and health contribute to new demands for foods (Dolgopolova, Teuber, & Bruschi, 2015). Today, foods are intended to not only satisfy hunger and provide necessary nutrients, but also to prevent nutrition-related diseases and improve physical and mental well-being (Annunziata & Vecchio, 2011): functional foods could play an important role in human health. Underutilised fruits, as serviceberry, could be an important source of health promoting phytonutrients with medicinal properties. Furthermore, these fruits have often high pigment contents, which could represent an alternative to synthetic dyes (Rymbai et al., 2016).

The genus *Amelanchier* (family *Rosaceae*) is represented by approximately 25 species widespread in North America and in parts of Eurasia (Michalczyk & Macura, 2010). Serviceberry is native to North America from Alaska, across western Canada, and in the western and north-central USA (Lim, 2012). It is less known and rarely grown in Europe (except Scandinavian countries) in spite of its high frost resistance, decorative value as a shrub, and edible fruits (Bakowska-Barczak, Marianchuk, & Kolodziejczyk, 2007). In its native environment, serviceberry is found in thickets, woodland margins, banks of streams, canyons, and hillsides, from sea level to 3000 m altitude. It prefers a rich,

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well-drained loamy soil but it can also grow in any sandy or clayey soil that is not waterlogged or too dry. It is relatively drought and salt tolerant and thrives in a sunny or semi-shade position (Lim, 2012).

A. alnifolia, *A. arborea* and *A. canadensis* are the best known species. *A. alnifolia* (Saskatoon serviceberry or Alder-leaved serviceberry) is a western North American species. It has a variable habitus but it is usually found as a multi-stemmed shrub ranging from 2–3 m in height: some genotypes are cultivated for commercial fruit production in western USA and Canada. Its fruits are approximately 1 cm in diameter, blue-purple and ripen in July (Hu, Kwok, & Kitts, 2005). *A. arborea* (Downy serviceberry) is an eastern North American large shrub or small tree 8–10 m high and is crossed with *A. laevis* to produce cultivars for the landscape industry in the USA. The fruits of *A. arborea* are purple-black, slightly sweet and ripen in late June (Adhikari, Francis, Schutzki, Chandra, & Nair, 2005). *A. canadensis* (Shadblow serviceberry) is another eastern North American species. It ripens in early June and it is used in the landscape trade. It is a stoloniferous shrub or small tree reaching 8 m in height with a fastigiate crown and smooth ash-grey bark. Twigs are slender, reddish-brown becoming glabrous during flowering, while leaves are alternate, simple, oval-obovate to nearly round. The maroon-purple fruits are similar to *A. arborea* ones (pome, 7–15 mm across, glabrous, wax-coated) (Lim, 2012).

North American indigenous people uses different parts of the serviceberry plant for several medicinal purposes: in Canada, the fruits are used as juice for treating stomach ailments and as a laxative. Eye- and ear-drops are also prepared from ripe serviceberries (Kershaw, 2000). The boiled bark is used as a disinfectant, while the root infusion is used to prevent miscarriage after an injury (Lim, 2012). Native American communities prepare a tea from the twigs and stem and administer it to women just after childbirth. Moreover, a tonic from the bark is given to women after delivery to hasten discharge of the placenta (Turner, 1997).

Amelanchier spp. can also be used as a windbreak plant. The wood can be used for tool handles, canes, canoe crossbars, and small implements, because it is hard, strong, and fine-grained, while the young stems are used to make basket rims, handles, arrows, combs, digging sticks, salmon spreaders, and pipes. Fruits provide a purple dye (Lim, 2012).

The ripe fruit of *Amelanchier* spp. is sweet with a hint of apple, and there is growing interest in using it in the food industry (fresh, pies, pastries, preserves, jams, jellies, spreads cereals, and snack food). The fruits are also been added into cider, wine, beer, or tea (Adhikari et al., 2005; Bakowska-Barczak & Kolodziejczyk, 2008). The native people and early settlers of the North American prairies used serviceberry as one of their main food sources, but its use was limited because of its natural distribution area in the wild. In the last two decades, however, there has been growing interest in the industrial cultivation and utilisation of this fruit in Canada and USA (Michigan) (Adhikari et al., 2005; Kershaw, 2000). Fruit processing has an important role in exploiting the raw material because serviceberry has a relatively short harvest period (Michalczyk & Macura, 2010). Innovative methods of processing, freezing, and packaging have greatly increased the uses of this fruit. Moreover, growers are promoting it as a potential functional food (Jamin, 2009), alongside other fruit species, as *Ribes nigrum* (Donno et al., 2013b), *Morus nigra* (Donno, Cerutti, Prgomet, Mellano, & Beccaro, 2015c) and *Lycium* spp. (Donno, Beccaro, Mellano, Cerutti, & Bounous, 2015a).

The composition of fruits considerably varies depending on genotype, ripening stage at harvest and growing conditions (Michalczyk & Macura, 2010). There are few reports concerning the chemical composition of *Amelanchier* spp.: phytochemical studies on *A. canadensis* are rarely found in the literature. However, the available literature usually emphasises its important health benefits: serviceberry appears to be an excellent source of manganese, magnesium, and iron, and a relatively good source of calcium, potassium, copper, and carotenoids (e.g. lutein). Moreover, the fruit is rich in nutraceuticals, particularly phenolic compounds, as anthocyanins, chlorogenic acid, catechins and rutin (Bakowska-Barczak & Kolodziejczyk, 2008; Bakowska-Barczak et al., 2007). In addition, *Amelanchier* spp. seed oil may serve as a potential dietary source of tocopherols, sterols, and unsaturated fatty acids (Lim, 2012).

Several cultivars of *Amelanchier* spp. were found to possess free radical scavenging activity in a concentration-dependent manner related to their relatively high anthocyanin content (Hu et al., 2005), and antiviral activity against enteric coronavirus. Moreover, serviceberry fruits show antidiabetic properties (as aldose reductase inhibitor activity), and exhibit the ability to regulate lipid metabolism and energy expenditure in a manner consistent with improving metabolic syndrome (Burns Kraft et al., 2008).

The identification and quantification of bioactive compounds in fruits and the evaluation of their biological activities are important to gauge their efficacy as dietary interventions (Donno et al., 2012; Fu et al., 2011). Chromatographic fingerprinting could be considered an easy and reliable technique to characterise and differentiate *Amelanchier* spp. checking the fruit quality and safety (Donno et al., 2015c). The technique shows a relatively complete picture of fruit extracts and provides insight into the synergistic and additive biological effects of the bioactive constituents to total phytocomplex (Donno, Beccaro, Mellano, Cerutti, & Bounous, 2014).

This work aimed to evaluate the potential of a cultivated serviceberry species (*A. canadensis* (L.) Medik.) as a functional food by characterising its physicochemical characteristics, and antioxidant capacity. Furthermore, the characterisation and quantification of several phytochemicals, selected as health-promoting biomarkers, was performed, using high-performance liquid chromatography-diode array detection (HPLC-DAD).

2. Materials and methods

2.1. Plant material, field description, and climate data

Fully ripened fruits (0.5 kg for each replication) were collected from a cultivated genotype of *A. canadensis* (L.) Medik in the middle of June 2015, in Chieri (45°1'0"N, 7°49'0"E, at 305 m A.S.L.), Piedmont (north-western Italy), in the fruit tree germplasm collection of the Department of Agricultural, Forest and Food Sciences, University of Turin. The climate of the area is temperate, with rains in spring and autumn, and a rainfall of approximately 810 mm/year; the soil is loam–clay.