The Influence of Freezing on the Content of Ascorbic Acid in Vaccinium Species Berries

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Abstract
There has been an expansion of blueberry culture in Estonia where it is developing into a promising berry crop. For producers the chemical context of berries during storage is important, since the whitish market is more profitable than the fresh market. That is why great interest is being given to berry quality during storage. Moreover, in Estonia there are not enough studies on the biochemical content of locally grown Vaccinium species. Investigations were carried out on the following species: V. myrtillus, V. corymbosum x V. angustifolium and V. angustifolium. The last two are key species currently of interest to berry growers. The analyses were done on fresh and frozen berries, after harvest (fresh berries) and 1, 5, 9, 9 months of frozen storage (frozen berries). The analyses done on fresh berries showed that the content of ascorbic acid ranged between 6.2 - 14.3 mg/100 g FW. There were differences in ascorbic acid content between species. After 15 months of frozen storage, the content of ascorbic acid was 12.3 - 18.1 mg/100 g FW. The next set of analyses at 5 months showed a significant decrease in the content of ascorbic acid; the lowest level was 4.3 mg/100 g FW and the highest 5.7 mg/100 g FW. By 9 months the ascorbic acid content ranged from 6.8 to 8.5 mg/100 g FW. The effect of freezing on the content of ascorbic acid among blueberry species was significant. There was not a significant change in the content of dry matter which ranged from 12.6 - 20.9 % among different Vaccinium species.

INTRODUCTION

The importance of blueberry cultivation has risen in Estonia. The cultivation areas do not exceed the 0.23 % of all cultivated berry cultures, which was 5423 ha. in 2002 (Võrno, unpublished). In 2002 there were 124 ha in blueberry plantations with an average size of about 0.8 ha. By the year 2003 the area increased to 1.7 ha with an average size of 0.34 ha. In the locof market the most popular blueberries are bilberries (Vaccinium myrtillus). In order to sell the cultivated and lesser known blueberry species, their health benefits could be published. The chemical composition of berries is an important quality indicator and therefore is a focus of interest for processors and producers. The V. angustifolium berries are a valuable supplemental source of nutrients as part of everyday diet; also they are reported to have high antioxidative activity and therefore may be associated with health benefits (Kalt et al., 2000, Pris et al., 1998, Wang et al.., 1996). It is known that free radicals in the living organisms may harm biological molecules such as proteins, lipids, nucleic acids, and disturb the function of mitochondria, endosomes and cell membranes. Oxidative processes are thought to be involved in many harmful diseases such as cancer, virus infection and cell aging. It is also found that biochemical oxidative stress could be reduced by natural antioxidants (O’Connell et al., 2001). Ascorbic acid has an important role in the human body as a free radical scavenger.

The purpose of the current paper was to examine ascorbic acid content during frozen storage of blueberries. Additionally, the content of dry matter was evaluated since it may correlate with the soluble solids content. The current study is part of a wider study on different Vaccinium angustifolium phenotypes.

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MATERIALS AND METHODS

The two study areas are located in the Tartu County (58° 22' N, 26° 43' E), in the southern part of Estonia. The soil of the experimental field is situated on the openpcast peat pit belongs, according to the WRB soil classification, to the soils subgroup of Fibr- Dysric Histosol. The mineral soil of the study area was Enti Umbric Albeluvisol. The study species were bilberry (European bilberry, V. myrtillus L.), half-high blueberry (V. coriobuxum L. x V. angustifolium Alton) and lowbush blueberry (V. angustifolium). The bilberries were picked from the native forest that surrounds the openpcast peat pit. The half-high blueberry cultivars 'Northblue' and 'Northcountry', which are suitable for cultivation in Estonian conditions were selected for study. The berries were picked at the commercial maturity and frozen immediately after analyses of fresh berries. The material was from a single season collected in July 2002. The berry analyses were done using fresh and frozen berries and repeated after harvest and 1.5, 2, and 9 months of storage. Berries were frozen stored at -24 °C.

Ascorbic acid (AA) was determined by applying the modified Tihinen's method (Cook and Moston, 1981, Estree et al., 1995, AOAC, 2000). Three percent trichloroacetic acid was used as extractant of AA in preparation of samples for titration.

To the trichloroacetic titration mixture organic solvent (1,2-dichloroethane) was added and titrated with 2,6-dichlorophenolphthol (2,6-DCPIP). The visual end-point of titration detected in the organic layer.

Dry matter of berry samples was determined gravimetrically as the residue remaining after drying at 105°C until samples reached a stable weight.

Based on the data of Tõnismäe meteor station, the winter of 2002 was relatively mild with an average temperature of -1.4 °C. During spring the average temperature (7.3 °C) was higher than the normal average of 4.5 °C. During the summer months the average temperature was 16.5 °C, as compared to the normal average of 14.4 °C. During the spring months the precipitation was 29.2 mm, compared to the normal average of 36.5 mm. In summer months there was 64.5 mm of rainfall compared to an average of 69.5 mm. The accumulated photosynthetically active radiation Qc was 1676.5 MJ m^-2.

Data were analysed by ANOVA and by the two-way analysis of variance (Factors: A - freezing and storage, B - species and cultivars), at significance level of P<0.05. Also the standard deviation was calculated and illustrated on the graphs.

RESULTS

The first analyses done on fresh berries showed that the AA content among the Vaccinium selections ranged between 6.2 - 14.3 mg/100 g FW (Fig. 1). There were significant differences between species as well. After 1.5 months of frozen storage, the AA content was 12.3 - 18.1 mg/100 g FW. The next set of analyses showed significant decrease in the AA content; the lowest level was 4.3 mg/100 g FW and the highest 5.7 mg/100 g FW. There was an effort of freezing on the AA content in the species studied. But in this set of analyses, the differences between varieties were not so obvious. During the last observations at 9 months of frozen storage an increase in AA content was observed. Between the species and cultivars the differences were smooth as it was found during the previous set of analyses.

In June of 2003, dry matter content varied from 13.6 to 19.1% (Fig. 2.). By April of 2004 the dry matter content changed ranging from 12.6 up to 20.9%.

The regression analysis did not show any correlation between the AA and dry matter content.

DISCUSSION

The Vaccinium species contain different components such as AA, sugars and phenolic antioxidants (Kalt et al., 2000). The berries of V. angustifolium are reported as a relatively good source of AA (Bullock et al., 1983), but there are a number of different berry crops which fruits have higher AA content.
The AA is one of the major nutritional quality indicators in horticultural crops. The content of AA is influenced by many different agrotechnical factors including fertilizer, pruning, and thinning (Lee and Kader, 2000). Climatic conditions (precipitation, temperature, and light) are also important. When fruits and vegetables are harvested the most important factors affecting quality are maturity, handling before storage and the postharvest storage (Lee and Kader, 2000). One of the best methods for the preservation of biochemical quality of the berries is frozen storage at -20 ± 2°C (Amos et al., 2000). Freezing and storage can cause changes in berry quality parameters (Kamprue et al., 2002), including a decrease in water-soluble vitamins (Lee and Kader, 2000; Kamprue et al., 2002).

Kamprue et al. (2002) report that AA content in raspberry cultivars before and after frozen storage could reach from 83.1 to 88.1% and in the case of blackberry the losses were 29.3 to 35.5%. The current study with different Vaccinium species and cultivars showed that AA content was from 81.0 ± 6.2%. The lowest AA loss was observed in the berries high cultivar 'Northton' and the greatest losses occurred in the berries of low cultivar 'Northblue'. Barriers of bilberry had a relatively great loss (66.8 ± 4%). Interestingly, the variation in AA content of starting material did not (although the final vitamin content in different species and cultivars.

AA synthesis is found to be correlated with potassium uptake, also the presence of carbohydrates is necessary for AA synthesis. Like other authors (Rodriguez-Burrusco et al., 2000; Mena et al., 2002) we noticed an increase in AA content during storage at temperatures between 2 and 4 °C. Changes in AA content of frozen vegetables storage has been described as a linear decrease (Karan et al., 2010). In our study after 1.5 months of frozen storage the content of AA ranged from 12.3 to 18.1 mg/100 g FW. AA content was on average 31.6% higher in frozen berries. Howard et al. (1999) found that in some cases, frozen vegetables may be better source of AA than their fresh counterparts. Maybe AA monitoring should be accompanied with the parallel sugar determination. Although some authors have found a positive correlation between high quality and AA content (Sahinbashe and Desh, 1989) our study did not.

There are obvious differences between Vaccinium phenotypes. During the freezing storage the differences tend to be reduced, but that phenomena needs further investigation.

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Literature Cited

Fig. 1. Ascorbic acid content (mg/100g fresh weight), 1, Billberry (V. myrtillus), 2, Lowbush blueberry (V. angustifolium), 3, "Northblue" (V. corymbosum x V. angustifolium).
Fig. 2. Dry matter content (%) of Vaccinium species. 1. bilberry (V. myrtillus), 2. crowberry (V. angustifolium), 3. "Shadblue" (V. corymbosum x V. angustifolium), 4. "Nordbocca" (V. corymbosum x V. angustifolium).