Antioxidant levels in frozen and processed lingonberries (Vaccinium vitis-idaea subsp. minus) and bog blueberries (Vaccinium uliginosum)

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Introduction

Bog blueberries (Vaccinium uliginosum L.) and lingonberries (V. vitis-idaea subsp. minus (Lodd. Hult.) are the most important wild-collected berries in Alaska. Both wild sources of antioxidants; frozen bog blueberries have a water soluble ORAC (optical radical absorbance capacity) averaging 79 μmol TE/g, and lingonberries average 224 μmol TE/g from wild harvested Alaska berries (in press). Both wild berries have a tart flavor and are rarely eaten fresh. They are processed into jams, jellies, other frozen, dried and cooked products.

Since the 1950s, the Alaska Cooperative Extension Service has conducted research into Alaska’s wild berries including testing many recipes for private and commercial berry pickers and consumers (Stanek & Butcher 1998). Early work identified mineral nutrient and vitamin C content of these berries (Cooperative Extension Service 1950, Heller & Scott 1961), but because of recent research on antioxidants and other phytochemicals, Alaskans are interested in learning about potential health benefits of processed wild berry products. What happens to antioxidant levels when berries are frozen, cooked or dried? How can berries be preserved to maintain the most phytochemicals? The purpose of this research was to test bog blueberries and lingonberries for antioxidants and demonstrate how antioxidant levels change with recommended processing methods.

Methods

Wild berries were harvested through July and August 2005, and all samples were frozen, 0°C until processing two months later. Berries were randomly divided into three replicate blocks (three processing dates), then randomly sampled to provide sufficient berries for each recipe. Nine recipes were tested for bog blueberry and eight for lingonberry:

<table>
<thead>
<tr>
<th>Processing method</th>
<th>Bog Blueberry</th>
<th>Lingonberry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freezer</td>
<td>157</td>
<td>270</td>
</tr>
<tr>
<td>Jelly</td>
<td>155</td>
<td>268</td>
</tr>
<tr>
<td>Leather</td>
<td>125</td>
<td>226</td>
</tr>
<tr>
<td>Syrup</td>
<td>161</td>
<td>253</td>
</tr>
<tr>
<td>Crush fruit &amp; sugar mixed, 21°C minus</td>
<td>130</td>
<td>225</td>
</tr>
<tr>
<td>Berries, sugar, lemon simmered 5 min</td>
<td>177</td>
<td>300</td>
</tr>
<tr>
<td>(140°C)</td>
<td>165</td>
<td>290</td>
</tr>
</tbody>
</table>

All samples were analyzed at Brunwick Laboratories, Waramah MA. The scavenging capacity of water soluble antioxidants was determined by methods outlined in Huda and Cu (2002). Individual antioxidants were chosen because of their high levels in blueberries and blueberries from previous studies (Hakkinen 2000, Zheng & Wang 2003, Wang et al. 2005). Three, completely randomized replicates were analyzed by ANOVA, and means of processed products were compared to the control (frozen) using Dunnett’s mean separation.

Literature Cited


Conclusion

Changes in antioxidant levels with processing may be due to:

a) Drying that concentrates antioxidants in the skin (Haakinen 2000)
b) Dilution from added sugars and water per gram of product
c) Oxygen degradation of antioxidants i.e. vitamin C (Gill et al. 1999)
d) Biochemical changes in antioxidants to non-reactive substances or new compounds with antioxidant activity (Nicoli et al. 1997)
e) Thermal instability due to high or low temperatures during storage and processing (Dawdy et al. 2000; Galler et al. 2003; Haakinen 2000; Kall et al. 2000; Nicoli 2001; Piga et al. 2003; Zafrilla et al. 2001)
f) Removal of skin, etc. that are high in antioxidants (Rothe 2005)

Researchers have shown that antioxidant levels change with time in processed products and frozen berries (Zafrilla et al. 2001, Haakinen 2000), so we do not know the “shelf life” of our products. Nevertheless, we can conclude that the antioxidants we tested are not totally destroyed with processing; even boiled products have significant levels of antioxidants.

Dried fruit and leather provide the greatest levels of antioxidants in processed products including quercetin, p-coumaric acid, total phenolics and anthocyanins, and vitamin C.

Hydrophilic Oxygen Radical Absorption Capacity (H-ORAC)

In bog blueberry, the total water soluble antioxidant activity (H-ORAC) level in all processed products was significantly lower than the control except for dried fruit and fruit leather in which the antioxidants were concentrated more. Although all processed lingonberry products had lower H-ORAC levels than the control, canned fruit and frozen juice did not differ significantly from frozen berries.

Total Phenolics

Total phenolics increased significantly with drying and processing as fruit leather in both blueberries and lingonberries (Figs. 3 & 4) but were lower than the control with most other methods of processing. Only canned and frozen juice showed no decrease in total phenolics from the frozen berries for both species.

Total Anthocyanins

Total anthocyanins increased significantly with drying and preservation as fruit leather for both blueberries and lingonberries (Figs. 5 & 6), but decreased with most other methods of processing. Only frozen juice showed no decrease in total anthocyanins from the frozen berries.

Quercetin

Quercetin levels in blue berries were significantly higher than frozen berries for all methods of processing except freezer jam and frozen juice (Fig 7). Quercetin levels increased by three or more times the control in all products that were not frozen. A similar trend did not occur in lingonberries where nearly all methods of processing showed decreases in levels of quercetin except fruit leather, dried fruit and frozen juice (Fig 8).

Vitamin C and p-Coumaric Acid

Vitamin C levels were negligible in all samples of lingonberries. Bog blueberry fruit leather had higher vitamin C activity than frozen berries but in nearly all other processing methods, it was lower (Fig 9). Only frozen juice had similar levels of vitamin C to the frozen berries.
p-Coumaric acid levels were negligible in blue berry including frozen berries. Levels in lingonberries were significantly higher in fruit leather and dried fruit and lower in canned fruit and jam (Fig 10). The other methods showed reduced levels but were not significantly different from the frozen berry control.

Figure 1: H-ORAC levels in bog blueberry frozen and processed fruit.

Figure 2: H-ORAC levels in lingonberry frozen and processed fruit.

Figure 3: Total phenolics (mg gallic acid equivalents per g) in bog blueberry frozen and processed fruit.

Figure 4: Total anthocyanins (mg cyanidin-3-glucoside equivalent per g) in bog blueberry frozen and processed fruit.

Figure 5: Total phenolics (mg gallic acid equivalents per g) in lingonberry frozen and processed fruit.

Figure 6: Total anthocyanins (mg cyanidin-3-glucoside equivalent per g) in lingonberry frozen and processed fruit.

Figure 7: Quercetin levels in bog blueberry frozen and processed fruit.

Figure 8: Quercetin levels in lingonberry frozen and processed fruit.

Figure 9: Vitamin C levels in bog blueberry frozen and processed fruit.

Figure 10: p-Coumaric acid levels in lingonberry frozen and processed fruit.