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ABSTRACT

Juice extracted from lowbush blueberries was used to prepare a low-calorie jelly. Extraction methods included cold-extraction, hot-extraction, and enzyme-extraction. Enzyme-extraction produced the highest yield and least viscous juice with lighter and redder color than other extraction methods whereas hot-extracted juice had an intermediate yield, greatest viscosity and darkest color. Cold-extracted juice made the hardest jelly. Jellies prepared from cold-extracted and enzyme-extracted juices were darker and had a more intense purple color than the corresponding juices, whereas jelly prepared from hot-extracted juice was lighter and redder in color than its corresponding juice.

INTRODUCTION

Maine is the leading state in the production of lowbush blueberries (Vaccinium angustifolium Alt.) with an annual production of 10,000 to 12,500 tons. Favorable growing conditions in 1983 resulted in a record 22,500 tons of blueberries. Approximately 80% of the total Maine blueberry crop is frozen and the remaining 20% is canned for pie and muffin mixes but only a negligible amount is sold fresh annually(9). Wild blueberry flavor is well liked, the blueberries are a good supplement of vitamin C, niacin, and manganese, and are relatively low in sodium (2). Research on the development of new
lowbush blueberry products has been meager despite a large potential for this natively grown fruit. The market for low-calorie foods has grown rapidly in recent years. By using artificial sweeteners or less sugar and/or oil a wide variety of low-calorie food products, such as soft drinks, salad dressing, confectionery, cookies, puddings, and gelatin desserts, have been developed and marketed.

In order to obtain a jelly product of uniform and desirable color, flavor, texture, and clarity, a suitable juice extraction method and the proper amount of essential ingredients, such as pectin, sugar, and acid, are necessary (7, 10). Blueberry juice is not easily extracted because of the gelatinous nature of the fruit (8). Heat and enzyme treatments (3, 6, 14) have been used to increase juice yields. However, these treatments alter the color and consistency of the juice which in turn will affect the quality of the jellies that are made from such juice.

The purpose of this study was to investigate several juice extraction methods, such as cold-extraction, hot-extraction, and enzyme-extraction, and to determine the effects of these methods on the consistency and color of low-calorie blueberry jellies.

**MATERIALS AND METHODS**

**Raw Materials:**

Frozen lowbush blueberries were obtained from Jasper Wyman & Son, Milbridge, Maine and stored at -28.9°C. A low-methoxyl type of pectin (LM-15A8), designed for low soluble solids jellies to be used without addition of calcium salt, was obtained from Hercules Co., Wilmington, Delaware.
**Juice Extraction:**

Blueberries were thawed overnight at 3.5°C, macerated in a Waring Blender and extracted as follows:

1. **Cold-extraction:** berries were pressed using a Carver hydraulic press (Menomonee Falls, WI) at 351.6 kg/cm² for 10 sec.

2. **Hot-extraction:** berries were heated to 77°C for 5 min in a steam-jacketed kettle with stirring and water was added after heating to make up for the vapor loss. Berries were then pressed at 351.6 kg/cm² for 10 sec.

3. **Enzyme-extraction:** berries were treated with 0.1% (w/w) pectin 80SB (Genencor Co., Corning, N.Y.) overnight at 15.6°C, followed by heating to 77°C for 5 min to inactivate the enzyme. Water was added to adjust for the vapor loss and the berries were subsequently pressed at 351.6 Kg/cm² for 10 sec.

**Jelly Preparation:**

Jellies were prepared by premixing 0.2g pectin and 2g sugar in a 30-mi screwcap test tube. Ten ml of juice were then added and mixed well. The tubes were loosely capped and heated in a boiling water bath for 10 min. A 0.3 ml quantity of 1M food grade citric acid was then added and mixed for 2-3 sec before cooling in an ice bath for 30 min. The jellies were stored at 3.3°C.

**Evaluations:** all tests were carried out at room temperature (20 ±1°C) in triplicate, except yield data which are represented by a single determination.

A. Juice. The yield was determined based on a starting quantity of 500g of thawed berries. The pH and total acidity (%)
anhydrous citric acid) were measured according to the AOAC method (1). Soluble solids were determined using an Abbe Refractometer. Viscosity was determined using a Brookfield Viscometer with a RV-1 spindle at 100 rpm. Color was measured with a Hunter Digital Color Difference Meter (Model D25D3A) using values of \( L \) (lightness), \( a \) (redness-greeness), and \( b \) (yellowness-blueness).

B. Jelly. An Instron Universal Testing machine (Model 1000) was used to measure the gel strength. A plunger with a diameter of 8mm was attached to the moving crosshead. The speed of the crosshead was set at 10mm/min and the recording chart speed was set at 50mm/min. The penetration depth was set at 4mm. A full-scale load range of 500g was used and the peak of the force-distance curve was recorded as gel strength. Color of the Jellies was also measured by the Hunter Color Difference Meter.

**Statistical Analysis:**

The data were analyzed by the variance method (13) and Duncan's Multiple Range Test (5) was used to identify significant differences (P<0.05) among the treatment means.

**RESULTS AND DISCUSSION**

Effects of extraction methods on juice characteristics

The yield, pH, total acidity, viscosity, soluble solids, and color of juices extracted by different methods are listed in Table 1. The enzyme-extraction method produced a higher juice yield than either the cold-extraction or the hot-extraction method. This agrees with the reports of Chandler and Highlands (3) and Fuleki and Hope (6) who observed that pectinolytic enzyme facilitated juice extraction by breaking down pectins. Heat treatment had little effect on improving the yield of juice as
Table 1. Effect of different extraction methods on yield, pH, total acidity, viscosity, soluble solids, and color of lowbush blueberry juices.1, 2

<table>
<thead>
<tr>
<th>Method of Extraction</th>
<th>Yield (%)</th>
<th>pH</th>
<th>Total Acidity (%)</th>
<th>Viscosity (cp)</th>
<th>Soluble Solids (%)</th>
<th>Hunter Color</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>±0.01</td>
<td>±0.01</td>
<td>±0.08</td>
<td>±0.19</td>
<td>±0.45 ±0.75 ±0.33 ±0.08</td>
</tr>
<tr>
<td>Cold-Extract.</td>
<td>58.4</td>
<td>3.13</td>
<td>0.48c</td>
<td>17.00b</td>
<td>9.53b</td>
<td>28.70b 42.92b 9.61a 4.47b</td>
</tr>
<tr>
<td>Hot-Extract.</td>
<td>60.8</td>
<td>3.10a</td>
<td>0.52b</td>
<td>18.23a</td>
<td>9.75a</td>
<td>11.21c 22.67c 4.55c 4.99a</td>
</tr>
<tr>
<td>Enzyme-Extract.</td>
<td>70.9</td>
<td>3.02b</td>
<td>0.66a</td>
<td>12.33c</td>
<td>9.90a</td>
<td>30.36a 44.76b 8.63b 5.19b</td>
</tr>
</tbody>
</table>

1. Expressed as means ± S.D. of three determinations (yield values represented by one determination)
2. Values in a column followed by a common letter are not significantly different at P < 0.05 by Duncan's Multiple Range Test.
3. Expressed as % anhydrous citric acid.
observed by Tresslor and Joslyn (14) who stated that heat would partially rupture the berries and reduce the mucilaginous character, facilitating juice extraction. A slight decrease in pH and a significant increase in total acidity were found for both hot-extracted and enzyme-extracted juices as compared to cold-extracted juice, revealing the effects of heat and enzyme action on the conversion of pectins into pectic acids as described by Kertesz (10). The total acidity of the three juices (0.48 to 0.66%) was much higher than that reported by Chatfield and McLaughlin (4) for fresh blueberries, but agreed well with values reported by Chandler and Highlands (3) for juice produced from Maine blueberries. Hot-extracted juice was slightly more viscous than cold-extracted juice, whereas the much lower viscosity of the enzyme-extracted juice may have been due to the pectin hydrolysis in the latter procedure. No significant differences in soluble solids were found among juices extracted by the three different methods.

The enzyme-extracted juice was lighter in color (higher $L$ value) and redder (higher $a$ and $a/b$ values) than the cold-extracted juice, whereas Hunter $L$, $a$ and $b$ values were much lower in the hot-extracted juice than in the other two preparations (Table 1). The sharp decrease in Hunter values of the hot-extracted juice may be due to one of the following reasons:

1. reddish anthocyanin is converted to colorless carbinol base due to the thermal destruction and the remaining bluish-brown "co-pigments" (a high molecular weight complex) starts to dominate the color (15).

2. according to Fulekl'and Hope (6) heating has a more pronounced effect on the cells of the skin than pectic
enzymes, liberating a greater amount of the pigments which results in a juice with a lower Hunter L value.

(3) the reaction between colorless tanning compounds and metal ions to form red, brown, gray, and other colored complex (11, 12) is promoted by the heat treatment.

**Effects of extraction methods of juice on jelly characteristics**

The gel strength, pH, soluble solids, and Hunter color values of jellies prepared from the three juices are listed in Table 2. Viscosity of juice was thought to be an index of its jellying power as stated by Woodroof and Luh (16), i.e. more viscous juice tended to produce a harder gel. In this study the hardest gel was produced using cold-extracted juice, which had an intermediate viscosity (Table 1). A closer look at the three essentials in the jellies (pectin, sugar, and acids) reveals no apparent differences in pH and soluble solids (Table 2). It is therefore speculated that the weaker gels obtained from hot-extracted and enzyme-extracted juices are due to the thermal and enzymatic destruction of berry pectins. In the case of cold-extracted juice, more berry pectins were retained and consequently the hardest gel was obtained. The low sugar content, as indicated by low soluble solids readings, is well below that of a commercial jelly product (i.e. 65%) which makes this product an ideal low-calorie food; furthermore, the product tastes mildly sweet and has a smooth mouthfeel. When color of the juice and its corresponding jelly product were compared (Tables 1 & 2), a darker (lower Hunter L values) and bluish (lower a and a/b values and a higher b value) jelly was obtained from cold-extracted and enzyme-extracted juices. In contrast, hot-extracted juice was found to produce a jelly with Hunter
Table 2. Effect of juices extracted by different methods on the characteristics of low-calorie jellies.  

<table>
<thead>
<tr>
<th>Method of Juice Extraction</th>
<th>Gel Strength (g)</th>
<th>pH</th>
<th>Soluble Solids (%)</th>
<th>Hunter Color</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>L</td>
<td>a</td>
<td>b</td>
<td>a/b</td>
</tr>
<tr>
<td>Cold-Extract.</td>
<td>74.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>26.87&lt;sup&gt;a&lt;/sup&gt;</td>
<td>25.80&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>±1.63 ±0.04 ±0.05</td>
<td>±0.07</td>
<td>±0.08</td>
<td>±0.09</td>
</tr>
<tr>
<td>Hot-Extract.</td>
<td>58.33&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.98&lt;sup&gt;g&lt;/sup&gt;</td>
<td>26.73&lt;sup&gt;g&lt;/sup&gt;</td>
<td>13.62&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>±0.47 ±0.02 ±0.05</td>
<td>±0.72</td>
<td>±0.49</td>
<td>±0.01</td>
</tr>
<tr>
<td>Enzyme-Extr.</td>
<td>57.67&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.95&lt;sup&gt;g&lt;/sup&gt;</td>
<td>26.73&lt;sup&gt;g&lt;/sup&gt;</td>
<td>22.50&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>±0.94 ±0.04 ±0.13</td>
<td>±0.38</td>
<td>±0.65</td>
<td>±0.13</td>
</tr>
</tbody>
</table>

1. Expressed as means ± S.O. of three determinations.
2. Values in a column followed by a common letter are not significantly different at P < 0.05 by Duncan's Multiple Range Test.
values (L, a and b) higher than its corresponding juice. This observation indicates that by using cold-extracted and enzyme-extracted juices to prepare low-calorie jelly, the product would suffer a loss in lightness and redness, whereas jelly prepared from hot-extracted juice would tend to be lighter and redder.

In conclusion, this study showed the feasibility of preparing a rigid, low-calorie jelly product from 100% lowbush blueberry juice with a total acidity close to the range of 0.6-0.7%, which is preferred by most consumers (14). Unlike other commercial blueberry jellies, which contain apple juice or lemon juice, this product is made solely from lowbush blueberries with a strong unique flavor at a sugar content of only about 27%. Further studies on large-scale production of juice and jelly as well as shelf stability are planned.


9. Ismail, A.A. 1984. Personal communication. Former Professor of Plant and Soil Science Department, U. of Maine at Orono, Maine.


