Ropy Maple syrup

By Martin Pelletier
An original research from: Luc Lagacé, Mariane Camara, Simon Leclerc, Carmen Charron, Mustapha Sadiki

Annual meeting of the IMSI and NAMSC
Concord, New-Hampshire, USA
October 27th, 2018
Presentation Overview

• Overview of the ropy syrup issue
  • Illustrations
  • Economic impact
  • Causes

• Objectives

• Methodology

• Results and Discussion
  • Characterization of ropy maple sap
  • Characterization of ropy maple syrup

• Ways to prevent development of ropiness
Overview of the Ropy Syrup Issue

Ropy syrup: texture defect, string length > 10 cm
Overview of the Ropy Syrup Issue

Ropy syrup: texture defect, string length > 10 cm
Overview of the Ropy Syrup Issue

- Ropy sap is prone to overflow when boiled and, thus, requires a lot of antifoaming agent

- It is difficult and sometime impossible to filter ropy syrup
Overview of the Ropy Syrup Issue

Illustrations
Economic Impact
Causes

Overall rise in the last ten years

Graded unfit for human consumption
Automatically discarded
## Overview of the Ropy Syrup Issue

<table>
<thead>
<tr>
<th>Year</th>
<th>Total sales of syrups in Quebec (millions lbs)(^a)</th>
<th>Ropy syrups (lbs)(^b)</th>
<th>% of ropy syrup</th>
<th>Weighted price ($/lbs)(^a)</th>
<th>Economic loss ($)(^c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>58.772</td>
<td>146 125</td>
<td>0,25</td>
<td>2,20</td>
<td>321 476</td>
</tr>
<tr>
<td>2009</td>
<td>109.373</td>
<td>101 300</td>
<td>0,09</td>
<td>2,74</td>
<td>277 561</td>
</tr>
<tr>
<td>2010</td>
<td>88.078</td>
<td>142 243</td>
<td>0,16</td>
<td>2,74</td>
<td>389 745</td>
</tr>
<tr>
<td>2011</td>
<td>101.869</td>
<td>117 536</td>
<td>0,12</td>
<td>2,78</td>
<td>326 749</td>
</tr>
<tr>
<td>2012</td>
<td>96.138</td>
<td>208 952</td>
<td>0,22</td>
<td>2,80</td>
<td>585 066</td>
</tr>
<tr>
<td>2013</td>
<td>120.324</td>
<td>121 065</td>
<td>0,10</td>
<td>2,89</td>
<td>349 879</td>
</tr>
<tr>
<td>2014</td>
<td>113.722</td>
<td>358 607</td>
<td>0,32</td>
<td>2,84</td>
<td>1 018 445</td>
</tr>
<tr>
<td>2015</td>
<td>107.168</td>
<td>314 134</td>
<td>0,29</td>
<td>2,86</td>
<td>898 424</td>
</tr>
<tr>
<td>2016</td>
<td>148.177</td>
<td>221 659</td>
<td>0,15</td>
<td>2,94</td>
<td>651 677</td>
</tr>
<tr>
<td>2017</td>
<td>152.250</td>
<td>240 013</td>
<td>0,16</td>
<td>2,92</td>
<td>700 837</td>
</tr>
</tbody>
</table>

\(^a\) Data from economic file, FPAQ (2017)

\(^b\) Estimated by converting the number of ropy maple syrup’s barrels (32 gal.us per barrel) received by the FPAQ to lbs.

\(^c\) Estimation based on ropy syrup (lbs) and weighted price ($/lbs) for each year.
Overview of the Ropy Syrup Issue

• Fermentation of exopolysaccharides (EPS) producing bacteria in sap resulting in the production of stringy maple syrup \(^1\)

**EPS reported in maple syrup \(^2\):**
- Dextrans
- Arabinogalactans
- Rhamnogalacturonans

---
\(^1\) Fabian and Buskirk (1935);
\(^2\) Sun et al. (2016); Storz, Darvill and Albersheim (1986); Adams and Bishop (1960)
Overview of the Ropy Syrup Issue

• Some bacteria previously associated to ropy syrup: *Aerobacter aerogenes*, *Bacillus aceris* or *Enterobacter agglomerans* ³

• Can develop in improperly handled or stored sap/concentrate ⁴

• Bacteria will be destroyed with the high temperature reached during evaporation but their metabolites (EPS) will remain in the syrup

---

³ Edson and Jones (1912) ; Britten and Morin (1995)
⁴ Morin et al. (1993)
Overview of the Ropy Syrup Issue

- Initial bacterial contamination
  - Long delay before boiling
  - Medium temperature above 4°C (≈40°F)

Higher probability of Ropy Syrup production
Objectives

1. Update of the identification and characterization of bacteria responsible of ropiness

2. Study the composition of EPS present in maple syrup (valorization)
Objective 1

Methodology

6 concentrates and 4 saps from producers

Bacterial isolation, purification and genetic sequencing

18 isolates inoculated in 8°Bx sterile concentrates

2 days at 15°C then 4 days at 4°C

Viscosity measured

3 bacteria selected

Microbial count

pH

Viscosity

3 Days

4°C

15°C

23°C – 8hrs
4°C – 16 hrs

Fermentation in sterile 8°Bx concentrate

Bacteria 1

Bacteria 2

Bacteria 3

Control

© Centre ACER
**Methodology**

**Objective 1**

- Maple sap
- Maple syrup

**Microbial count**, **pH**, and **Viscosity**

- 3 Days
- **4°C**
- **15°C**
- **23°C – 8hrs**
- **4°C – 16 hrs**

**Fermentation in sterile 8ºB concentrate**

- Bacteria 1
- Bacteria 2
- Bacteria 3
- Control
**Methodology**

**Objective 1**

- **Maple sap** → **Evaporation**
  - String length
  - Viscosity

- **Evaporation** →
  - **Microbial count**
  - **pH**
  - **Viscosity**

- **Microbial count** → **3 Days**
  - **4°C**
  - **15°C**
  - **23°C – 8hrs**
  - **4°C – 16 hrs**

- **3 Days** →
  - **Bacteria 1**
  - **Bacteria 2**
  - **Bacteria 3**
  - **Control**

- **Fermentation in sterile 8°B concentrate**

© Centre ACER
Objective 2

Methodology

Maple sap

Maple syrup

- 3 ropy syrups from producers
- Polysaccharide extraction and purification
- Monosaccharide composition characterization

© Centre ACER
Results and Discussion

Maple sap

Maple syrup

© Centre ACER
Results and Discussion

Phylogenetic tree of the 18 bacterial isolates

Experiment: Fermentation of each isolates 2 days at 15°C then 4 days at 4°C in sterile concentrate

3 isolates responsible of viscous maple concentrates
Results and Discussion

3 isolates inoculated (10^6 CFU/ml):
- Leuconostoc (A)
- Leuconostoc (2)
- Enterobacteriaceae (N)

3 Incubation temperatures:
- 4°C (≈ 40°F)
- 15°C (= 59°F)
- 23°C (≈ 74°F)

Incubation time:
- 3 days

Measurements:
A: Aerobic mesophilic bacteria count (CFU/ml)
B: pH
C: viscosity
RESULTS AND DISCUSSION

Bacterial growth from $10^6$ to $10^8$ CFU/ml at 15°C and 23°C.

An increase is also observed at 4°C for strain A and N but to a lesser extent.
Results and Discussion

Sharp decrease of pH at 15°C and 23°C.

Correlated with bacterial growth during fermentation.

Maple sap

Maple syrup
Results and Discussion

Higher viscosities are reached at 15°C.

*Leuconostoc A* gave the highest viscosity at 15°C.

Low or no change of viscosities at 4°C.
Results and Discussion

Maple sap

Maple syrup

© Centre ACER
Results and Discussion

Maple sap

Maple syrup
Results and Discussion

Leuconostoc A and 2 were responsible for syrups with strings up to 30 cm.

No ropy syrups when 4°C was maintained during fermentation.
Results and Discussion

Leuconostoc A incubated at 23 °C was responsible for the highest viscosity. Followed by Leuconostoc 2 and Enterobacteriaceae N incubated at 15°C.
Results and Discussion

Moreover, *Leuconostoc* fermentations at 15°C led to difficulties during evaporation.
Results and Discussion

Maple sap

Maple syrup

© Centre ACER
Maple sap

Maple syrup

Results and Discussion

Monosaccharide composition of purified polysaccharides from 3 ropy maple syrup samples

Polysaccharides (PS)

Multiple PS found in each syrup samples:
- 7 in sample #1
- 4 in sample #2
- 8 in sample #3

Each of them can be produced by different microorganisms
Results and Discussion

Monosaccharide composition of purified polysaccharides from 3 ropy maple syrup samples

Monosaccharides (MS)

Glucose was present in each samples, sample #2 had the highest proportion.

When polymerized, glucose leads to dextrans.

Dextrans are synthetized by Lactic acid bacteria (e.g. *Leuconostoc mesenteroides*) and are commonly used as texture modifier in foods.
Results and Discussion

Monosaccharide composition of purified polysaccharides from 3 ropy maple syrup samples

Monosaccharides (MS)
- Arabinose and rhamose in sample #1 and #3
  - arabinogalactans and rhamnoglucons
- Galactose in sample #1
  - Galactans or arabinogalactans

© Centre ACER
How to prevent ropy syrup formation

**Contributing factor of ropiness**

- Uncontrolled temperature of sap and concentrate (<4°C as a target)
- Long cooling time after shutdown of evaporator
- Long downtime between sap run
- Sagging main line
- Poor maintenance and sanitation of sap management plumbing (substation and sugar house)
How to prevent ropy syrup formation

**Sound practices for ropiness prevention**

- Efficient washing and sanitation of equipment in contact with sap and sap concentrates
- Proper handling and storage of concentrates waiting to be boiled (as cold as possible)
- Quick boiling of concentrates especially when the latter temperature is high

**Initial bacterial contamination**

**Long delay before boiling**

**Medium temperature above 4°C (≈40°F)**

**Higher probability of Ropy Syrup production**
How to prevent ropy syrup formation

Troubleshooting

• Ropy syrup production can’t be reversed without proper sanitation

• Once the source of ropiness has been identified, it must be properly sanitized as well as every equipment downstream from that point

• There can be more than one source of ropiness

• Good sanitation begins with a thorough cleaning, only then will the sanitizing agent perform properly
Conclusion

• The current work demonstrated the importance of proper sap and concentrate handling
• A good sanitation of all the equipment is a first step in the prevention of ropiness
• According to the results obtained, the health risks associated with the consumption of ropy syrup are considered low from a microbiological and chemical standpoint
• Valorization of this kind of syrup as a texturizing agent or in other applications should be investigated further
References


