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Ropy Maple syrup

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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

Illustrations

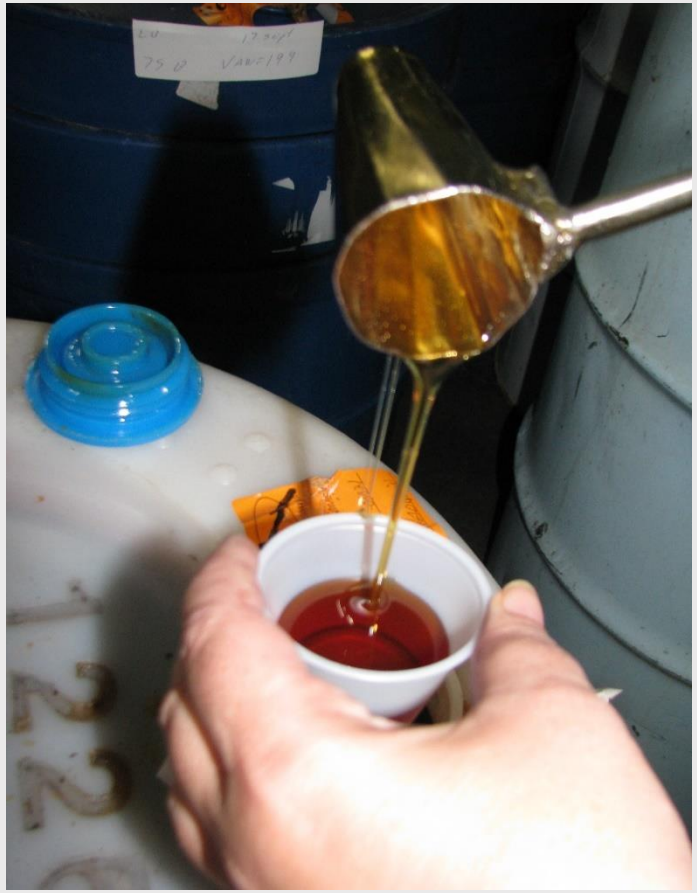
Economic Impact

Causes

Ropy syrup: texture defect, string length > 10 cm

Overview of the Ropy Syrup Issue

- **Illustrations**
- Economic Impact
- Causes



Ropy syrup: texture defect, string length > 10 cm

Overview of the Ropy Syrup Issue

Illustrations

Economic Impact

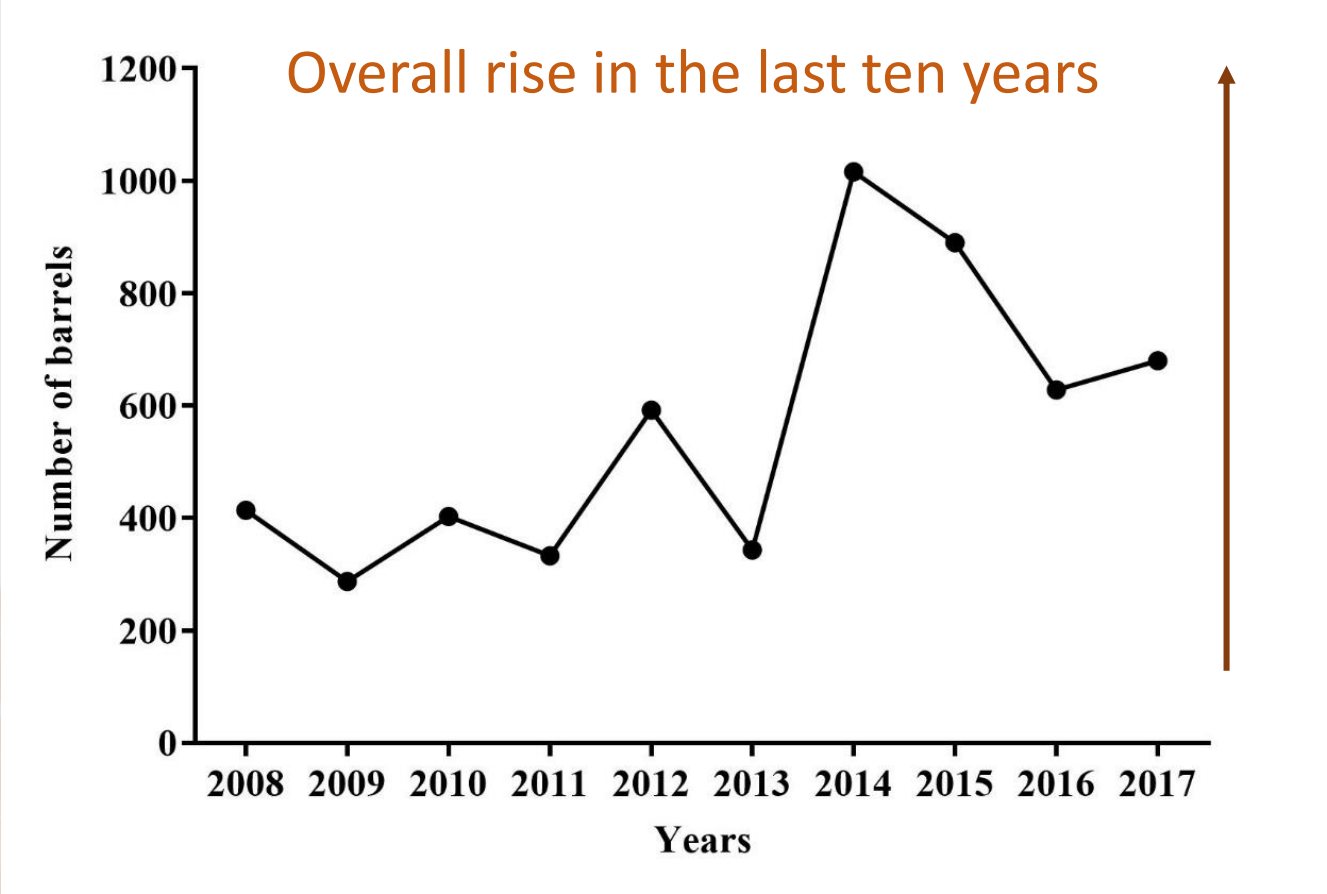
Causes

- 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



Graded unfit for human consumption

Automatically discarded

Overview of the Ropy Syrup Issue

Illustrations

Economic Impact

Causes

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

+ 5,5 M$ lost in ten years

[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.

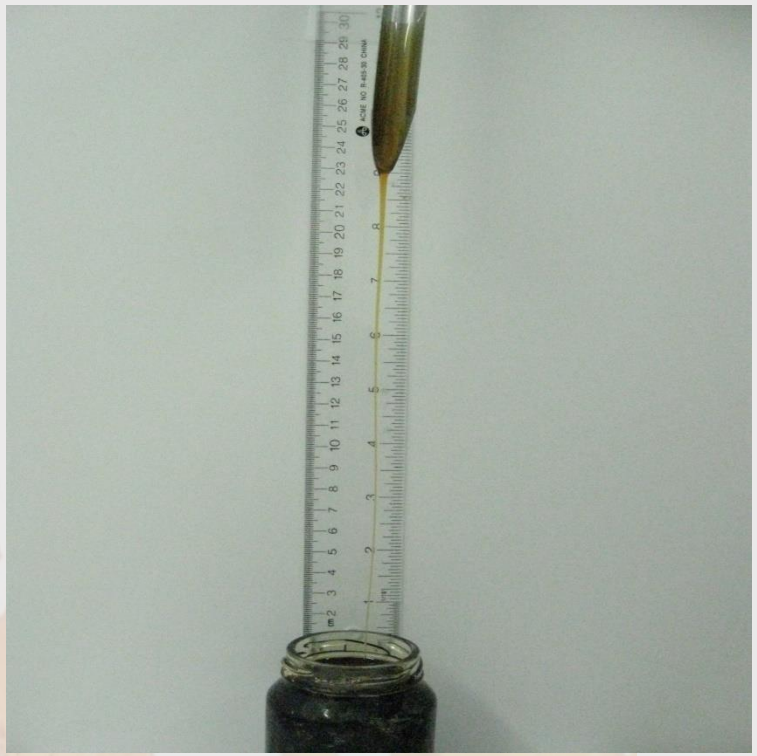
Overview of the Ropy Syrup Issue

Illustrations

Economic Impact

Causes

- Fermentation of exopolysaccharides (EPS) producing bacteria in sap resulting in the production of stringy maple syrup [1]

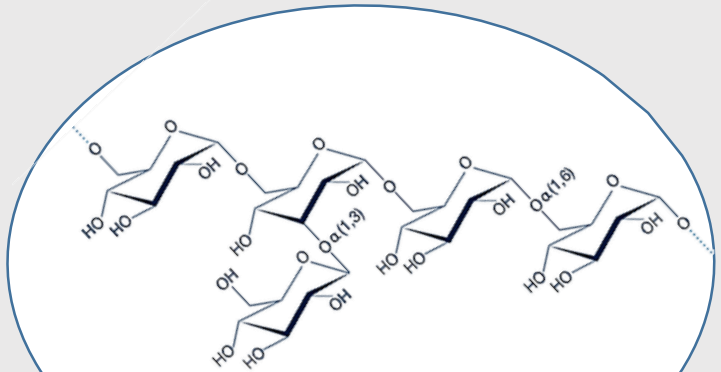


EPS reported in maple syrup [2]:

Dextrans

Arabinogalactans

Rhamnogalacturonans



Dextran molecular structure

[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

Illustrations

Economic Impact

Causes

- 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

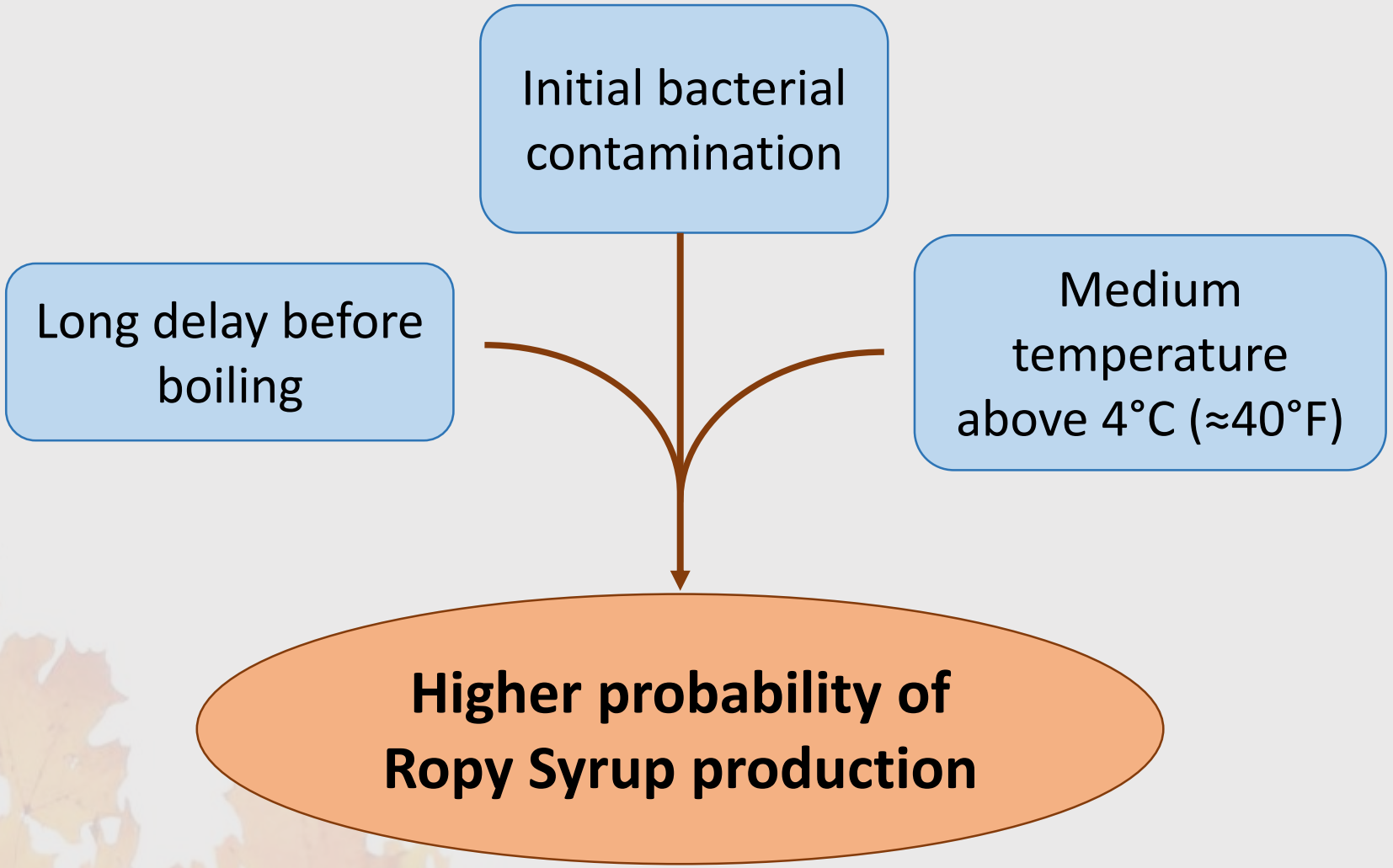
[3] Edson and Jones (1912) ; Britten and Morin (1995)
[4] Morin et al. (1993)

Overview of the Ropy Syrup Issue

Illustrations

Economic Impact

Causes



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

Maple sap

Maple syrup

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

Fermentation in sterile 8°Bx concentrate

Bacteria 1 | Bacteria 2 | Bacteria 3 | Control

4°C | 15°C | 23°C – 8hrs 4°C – 16 hrs

3 Days

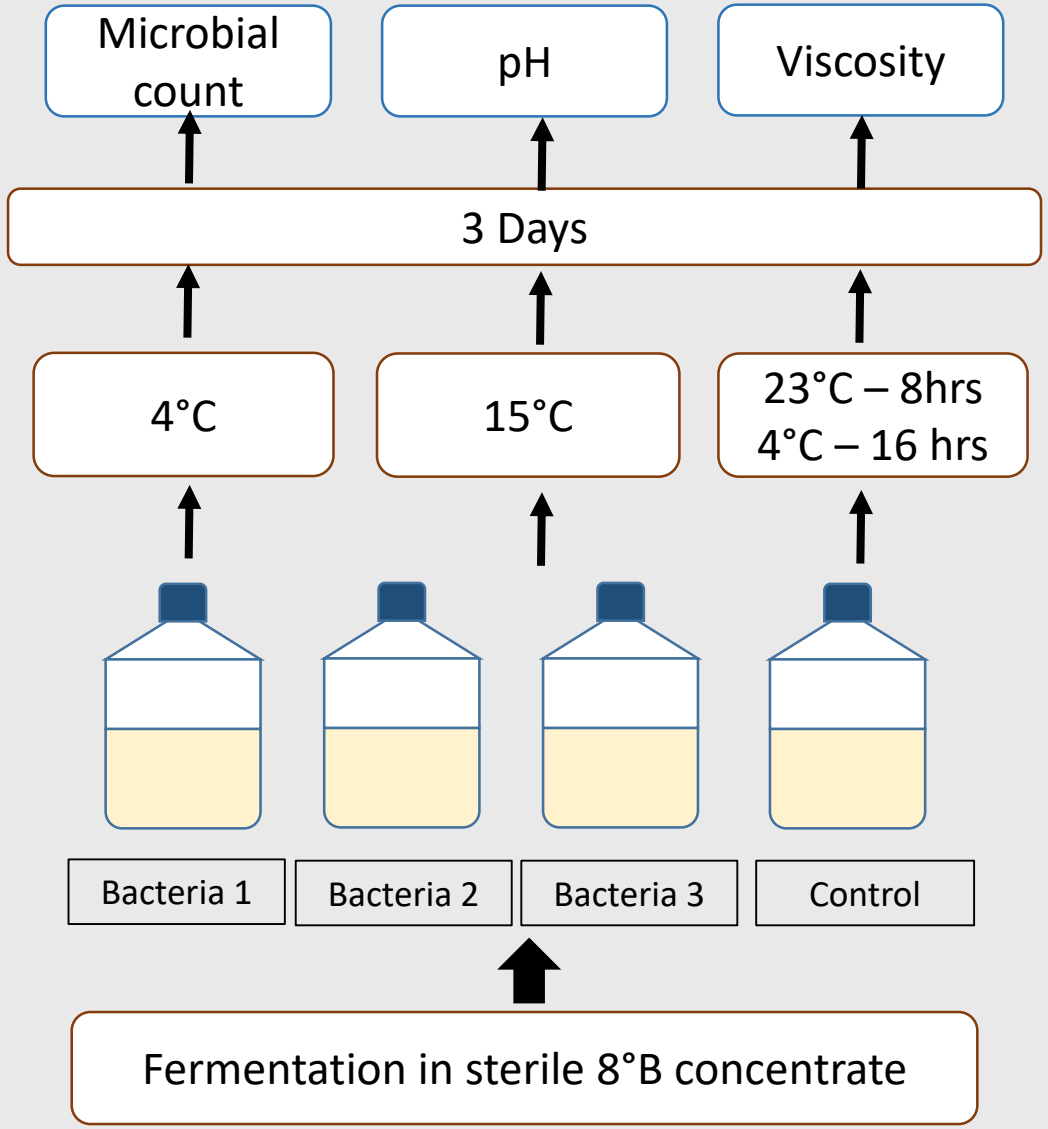
Microbial count | pH | Viscosity

Objective 1

Methodology

Maple sap

Maple syrup

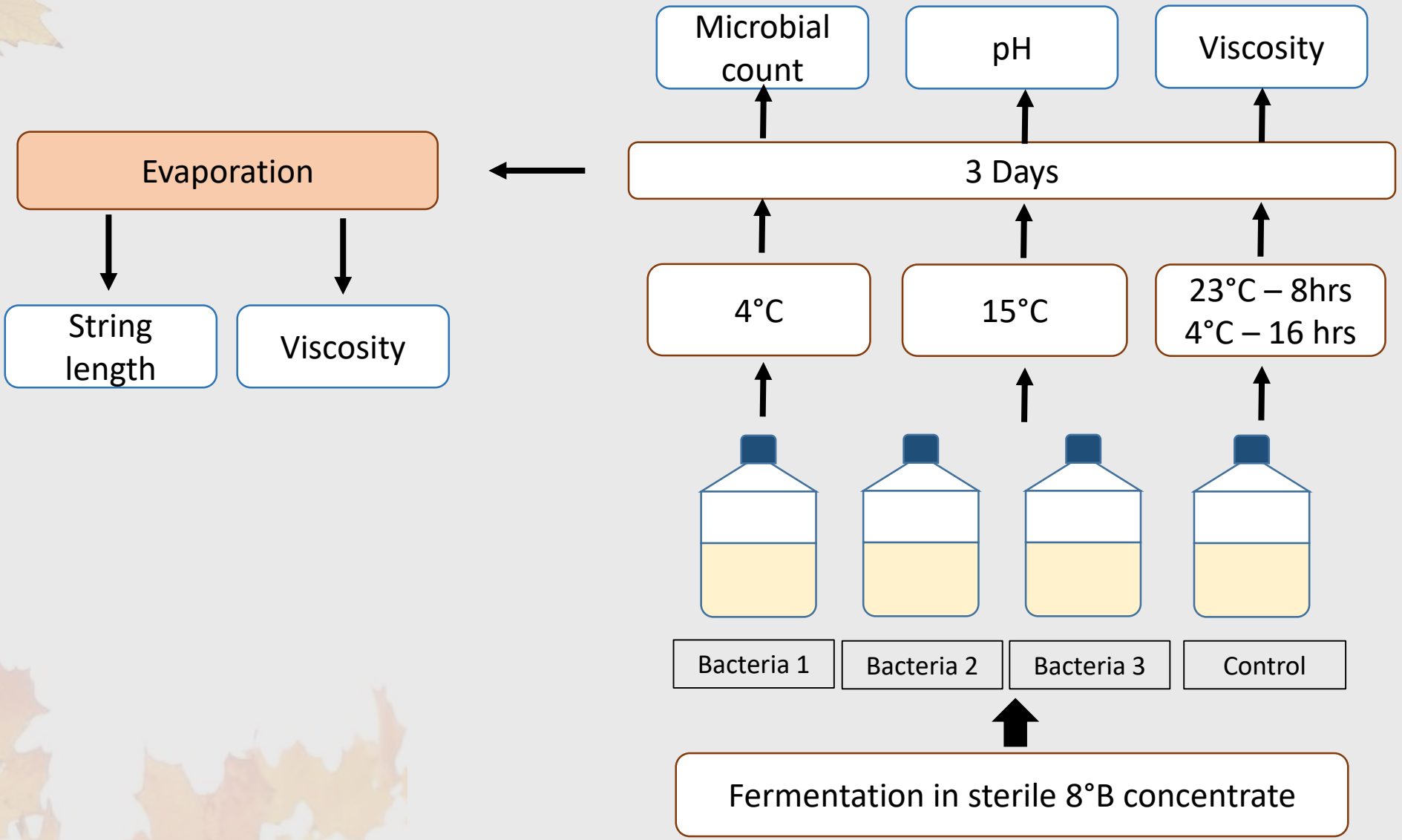


Objective 1

Methodology

Maple sap

Maple syrup



Objective 2

Methodology

Maple sap

Maple syrup

3 ropy syrups from producers

↓

Polysaccharide extraction and purification

↓

Monosaccharide composition characterization

Results and Discussion

Maple sap

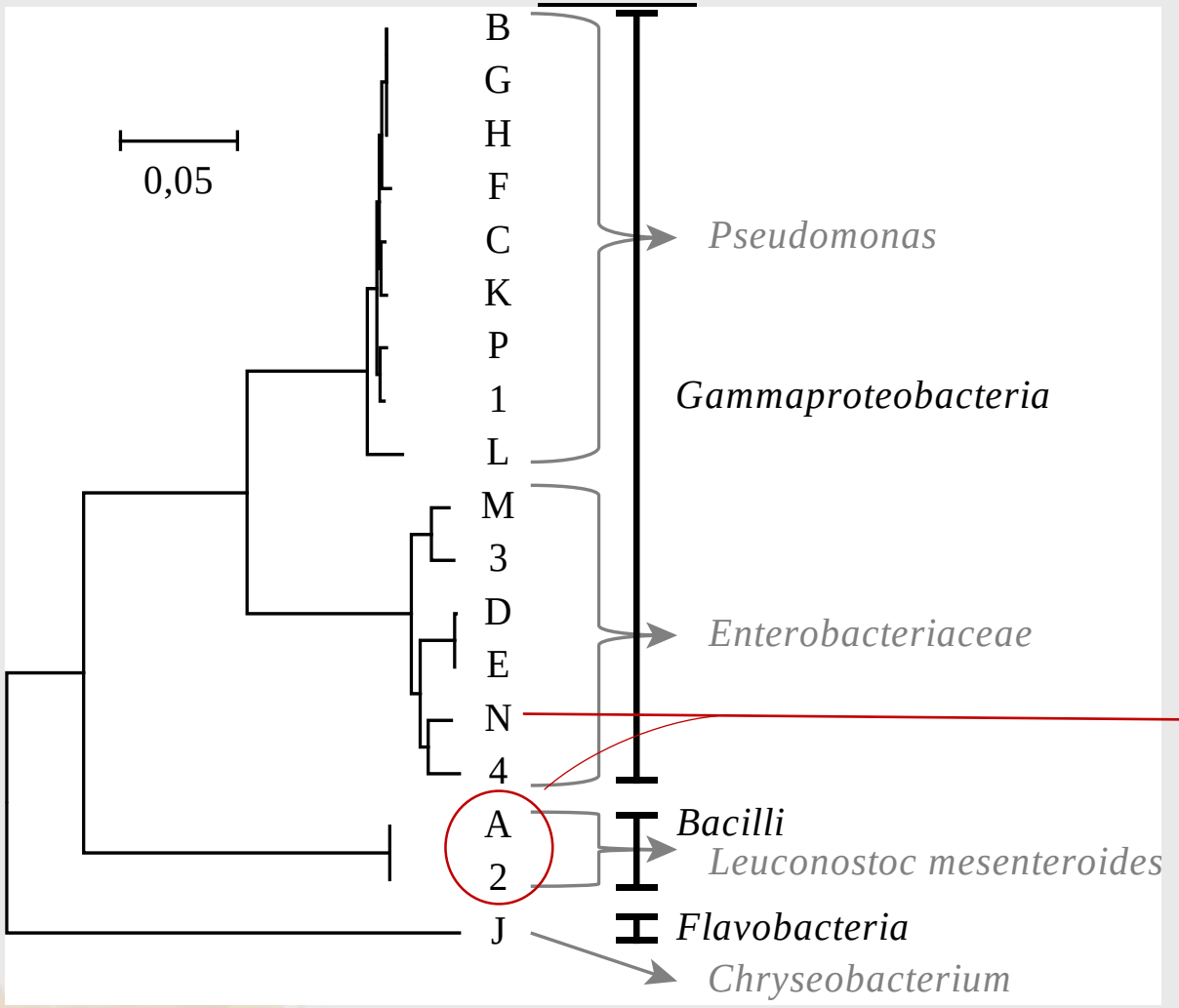
Maple syrup

Results and Discussion

Maple sap

Maple syrup

Phylogenetic tree of the 18 bacterial isolates



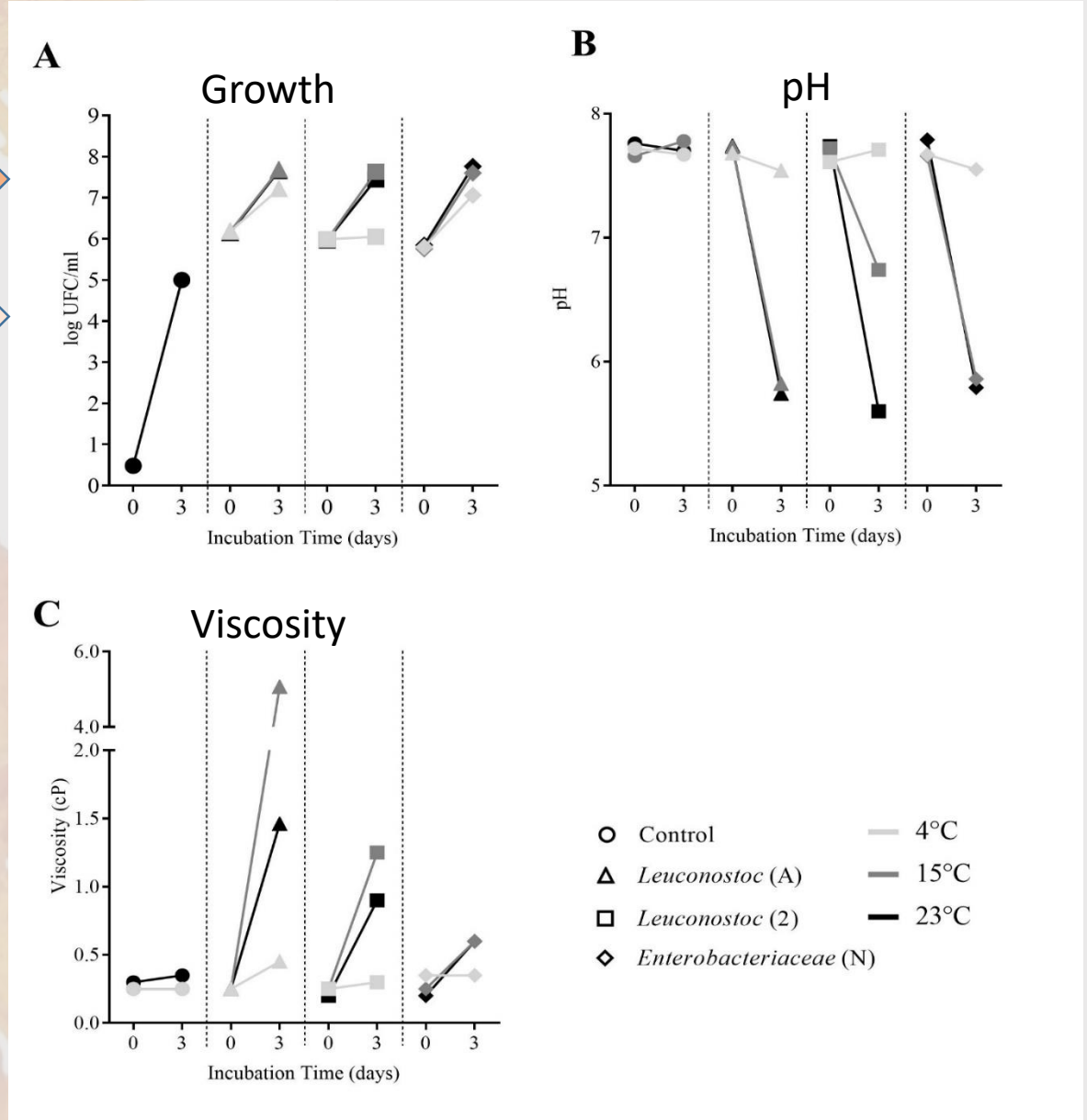
Experiment:
Fermentation of each isolates 2 days at 15°C then 4 days at 4°C in sterile concentrate

3 isolates responsible of viscous maple concentrates

Results and Discussion

Maple sap

Maple syrup



<u>3 isolates inoculated (10^6 CFU/ml) :</u>

Leuconostoc (A)

Leuconostoc (2)

Enterobacteriaceae (N)

<u>3 Incubation temperatures:</u>

4°C (≈ 40°F)

15°C (= 59°F)

23°C (≈ 74°F)

<u>Incubation time:</u>

3 days

<u>Measurements:</u>

A: Aerobic mesophilic bacteria count (CFU/ml)

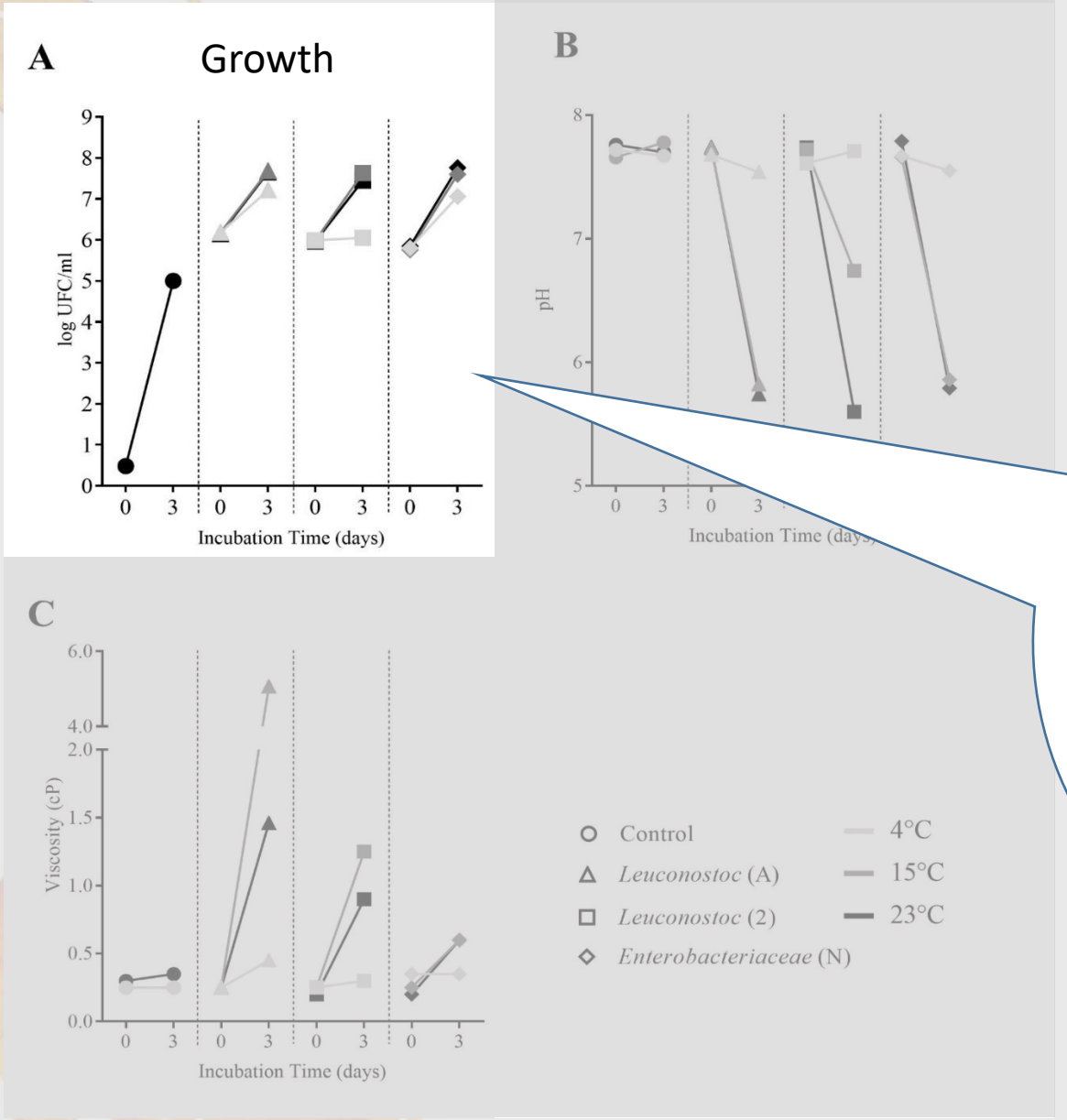
B: pH

C: viscosity

Results and Discussion

Maple sap

Maple syrup



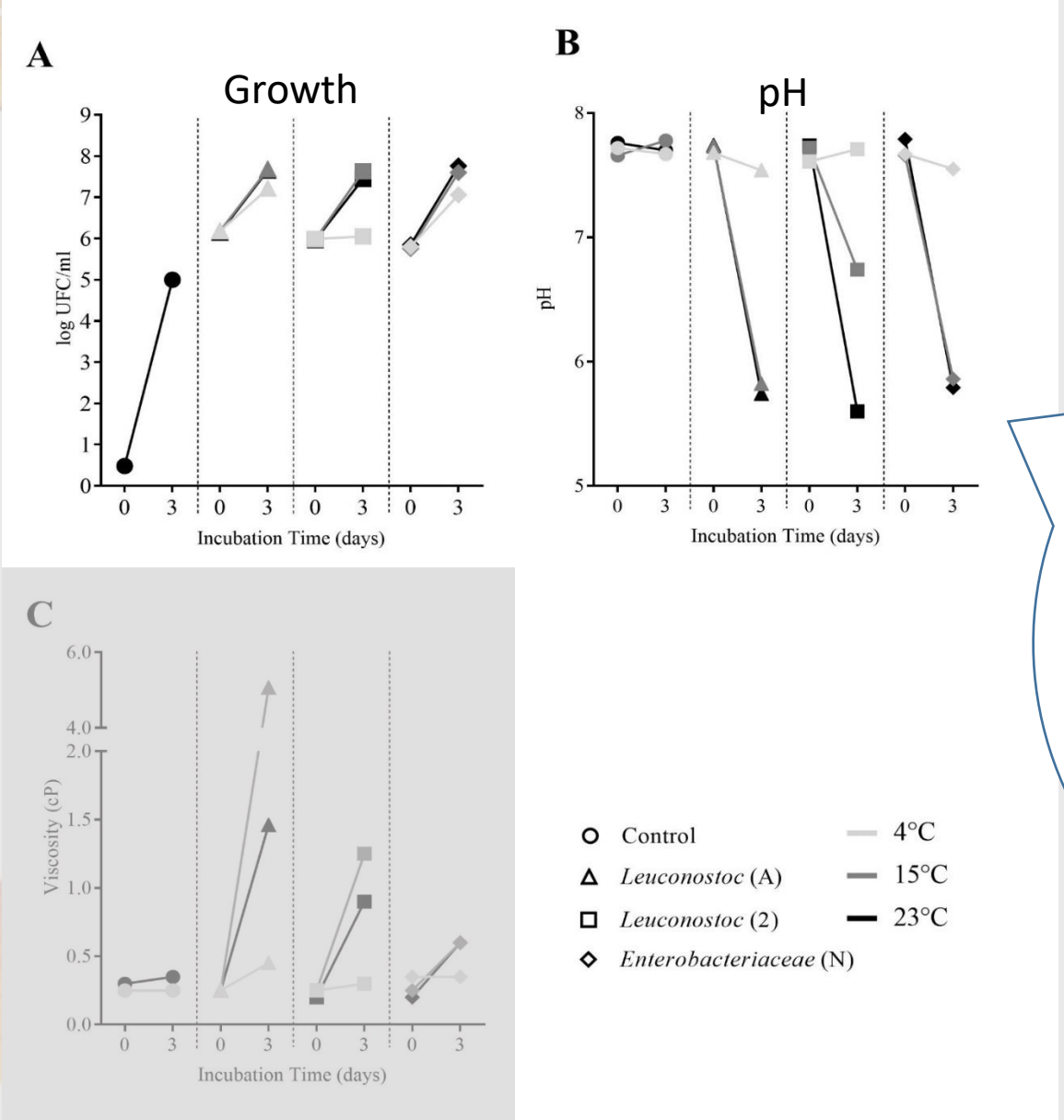
Bacterial growth from 10^6 to 10^8 CFU/ml at 15°C and 23°C.

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

Results and Discussion

Maple sap

Maple syrup



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

Correlated with bacterial growth during fermentation

Results and Discussion

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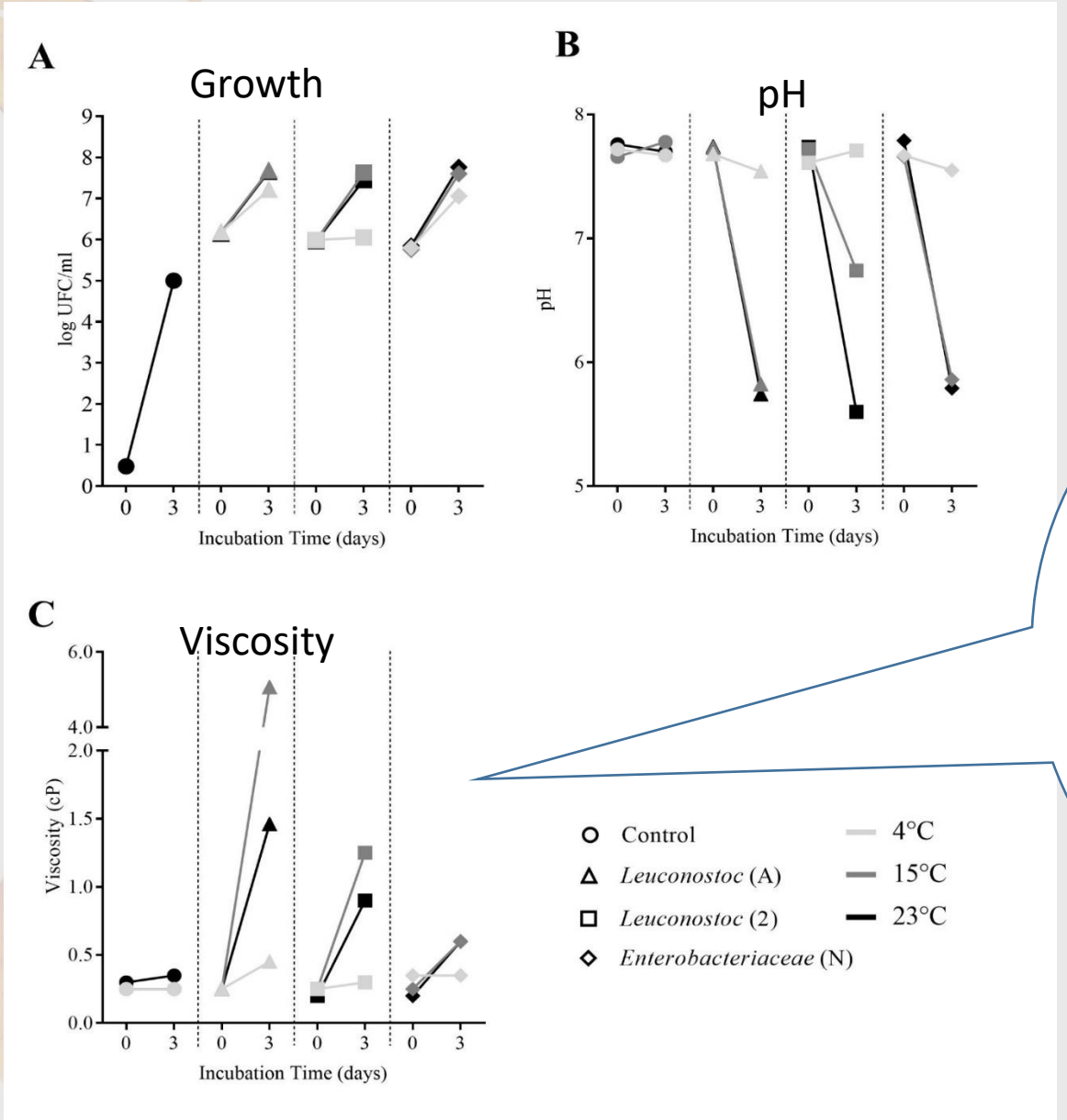
Maple sap

Maple syrup



Higher viscosities are reached at 15°C.

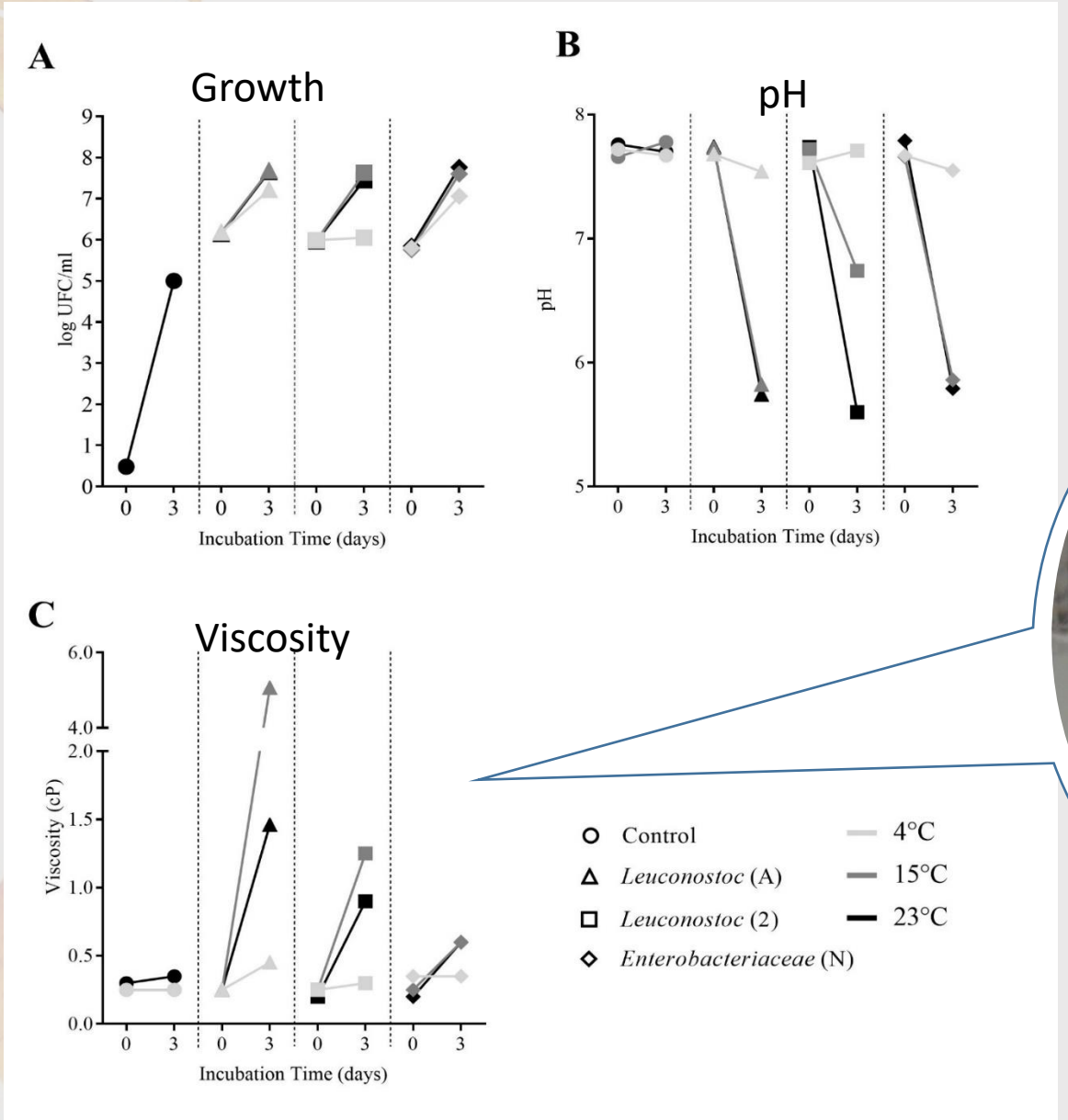
Leuconostoc A gave the highest viscosity at 15°C.

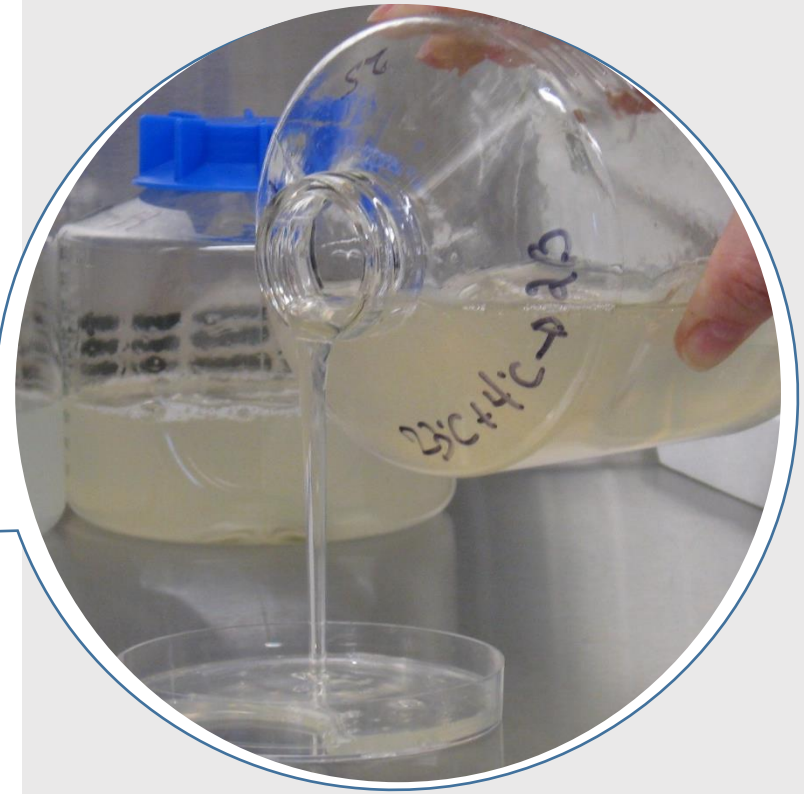
Low or no change of viscosities at 4°C.

Results and Discussion

Maple sap

Maple syrup





Results and Discussion

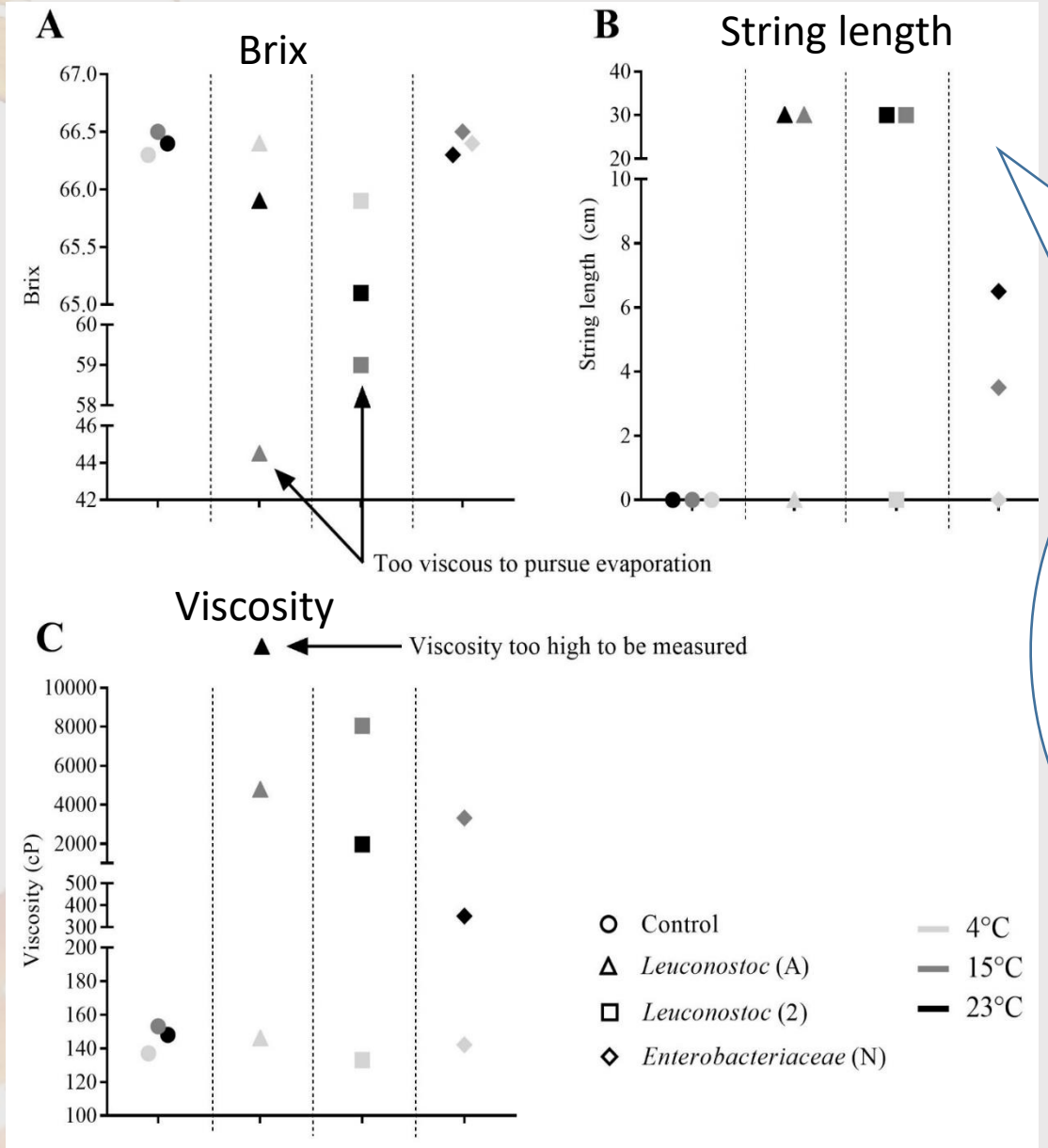
Maple sap

Maple syrup

Results and Discussion

Maple sap

Maple syrup



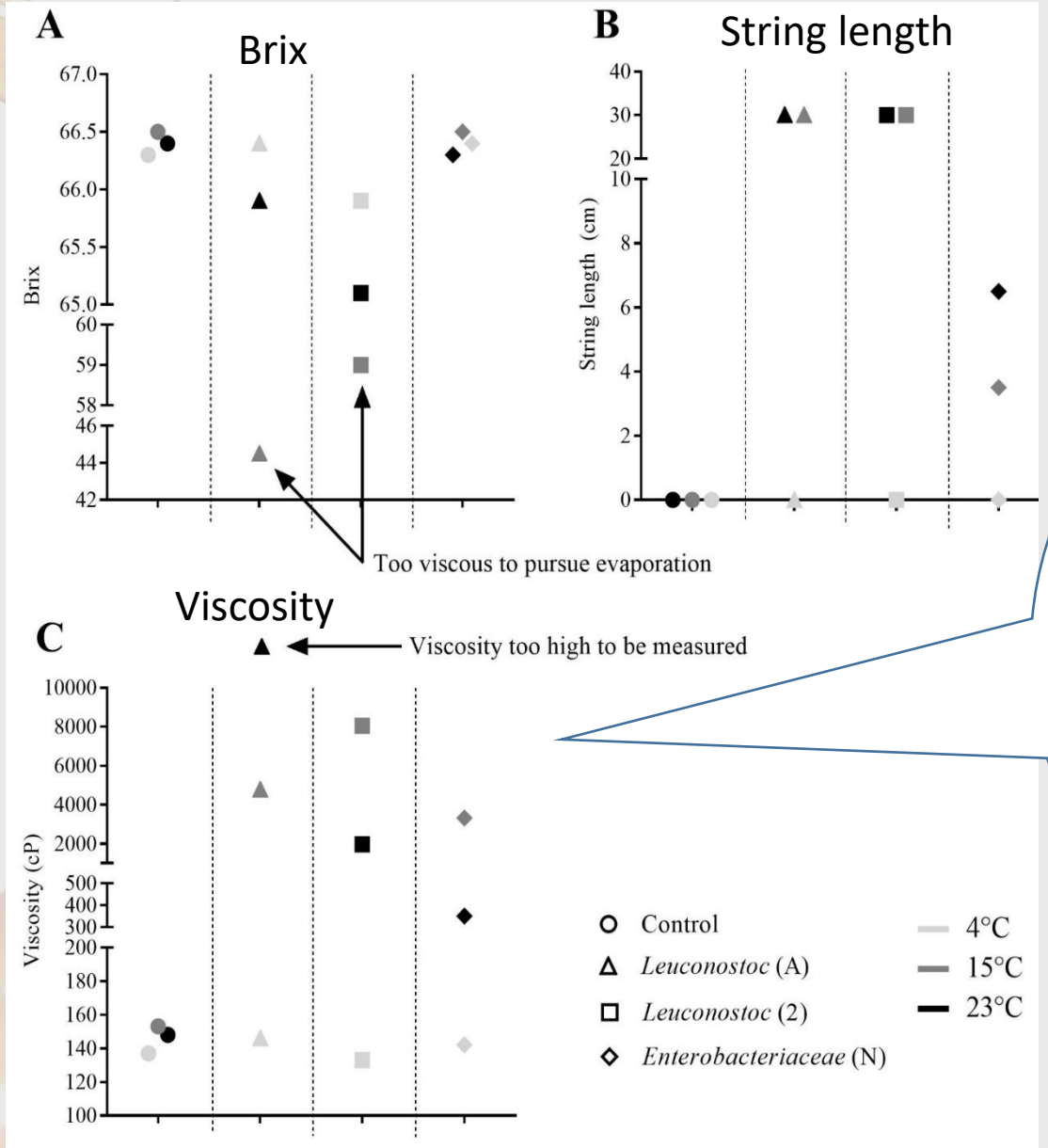
Leuconostoc A and 2 were responsible for syrups with strings up to 30 cm.

No ropy syrups when 4°C was maintained during fermentation

Results and Discussion

Maple sap

Maple syrup



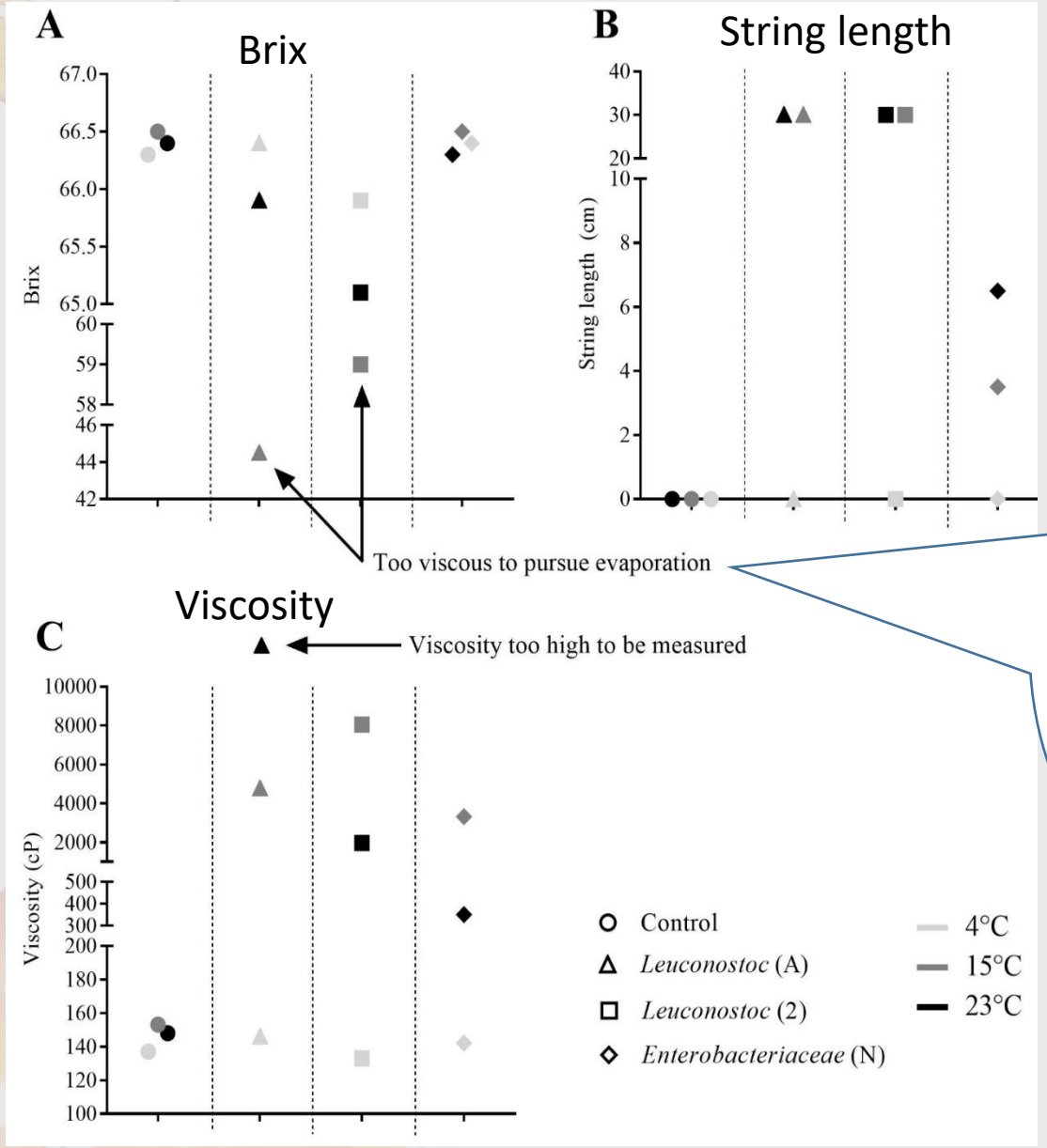
Leuconostoc A incubated at 23 °C was responsible for the highest viscosity.

Followed by *Leuconostoc* 2 and *Enterobacteriaceae* N incubated at 15°C.

Results and Discussion

Maple sap

Maple syrup

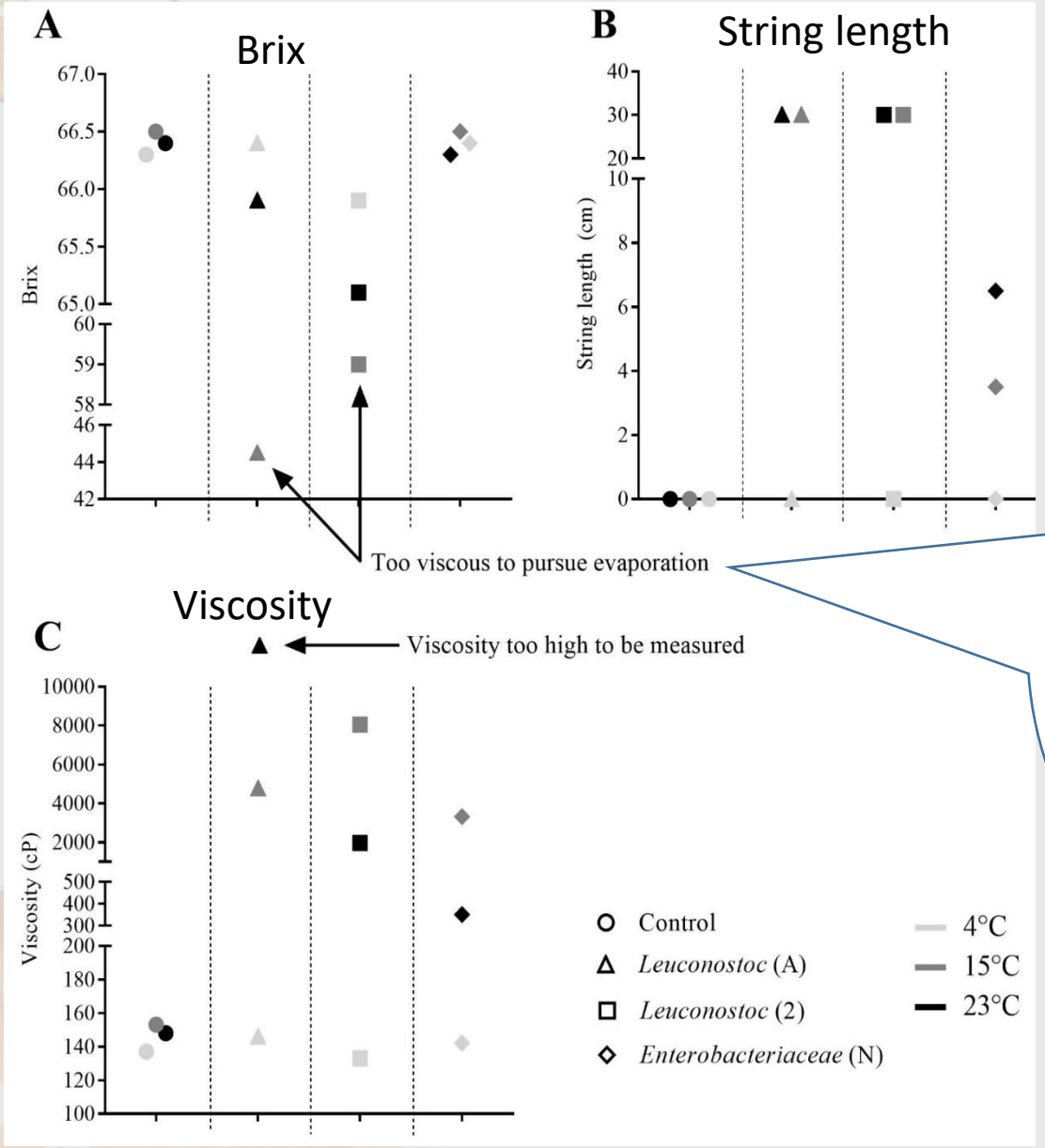


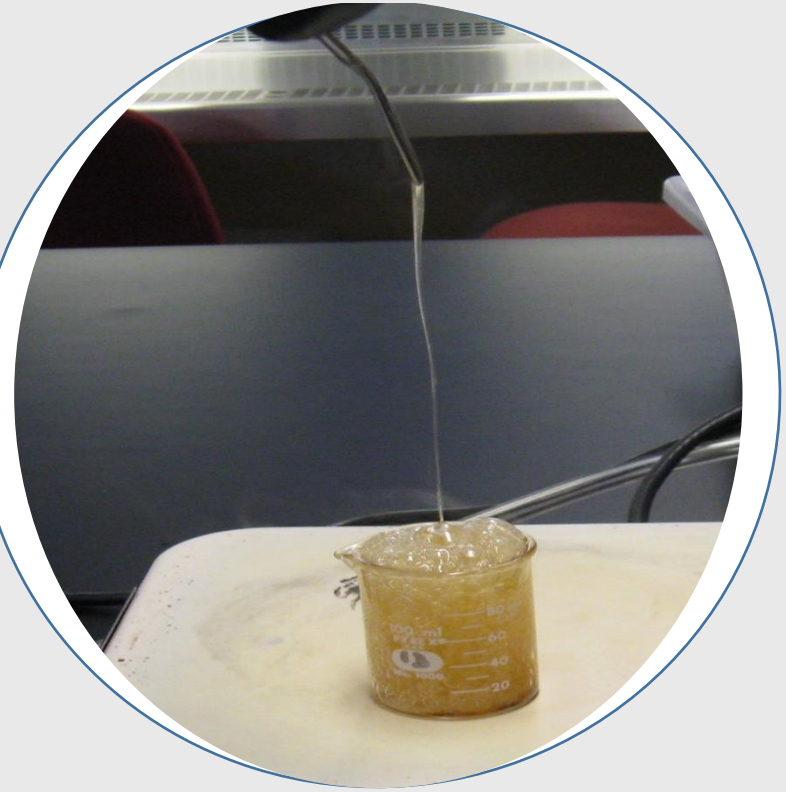
Moreover, *Leuconostoc* fermentations at 15°C led to difficulties during evaporation.

Results and Discussion

Maple sap

Maple syrup

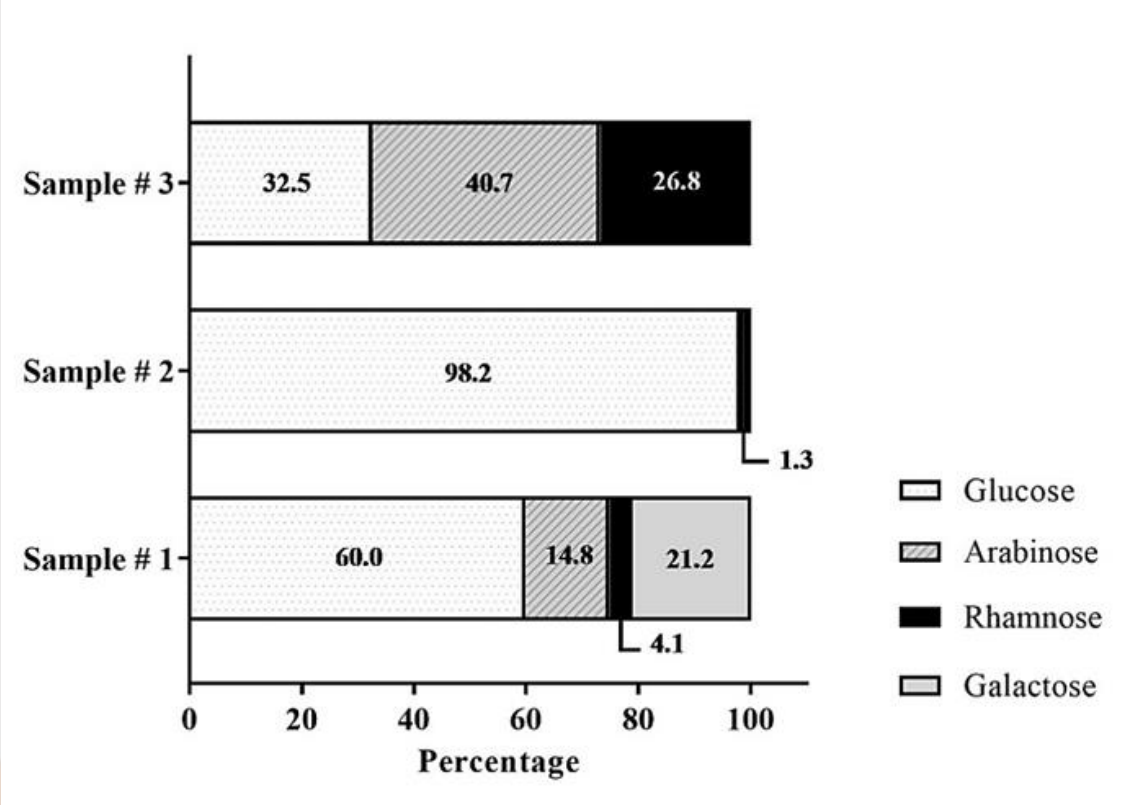




Results and Discussion

Maple sap

Maple syrup



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

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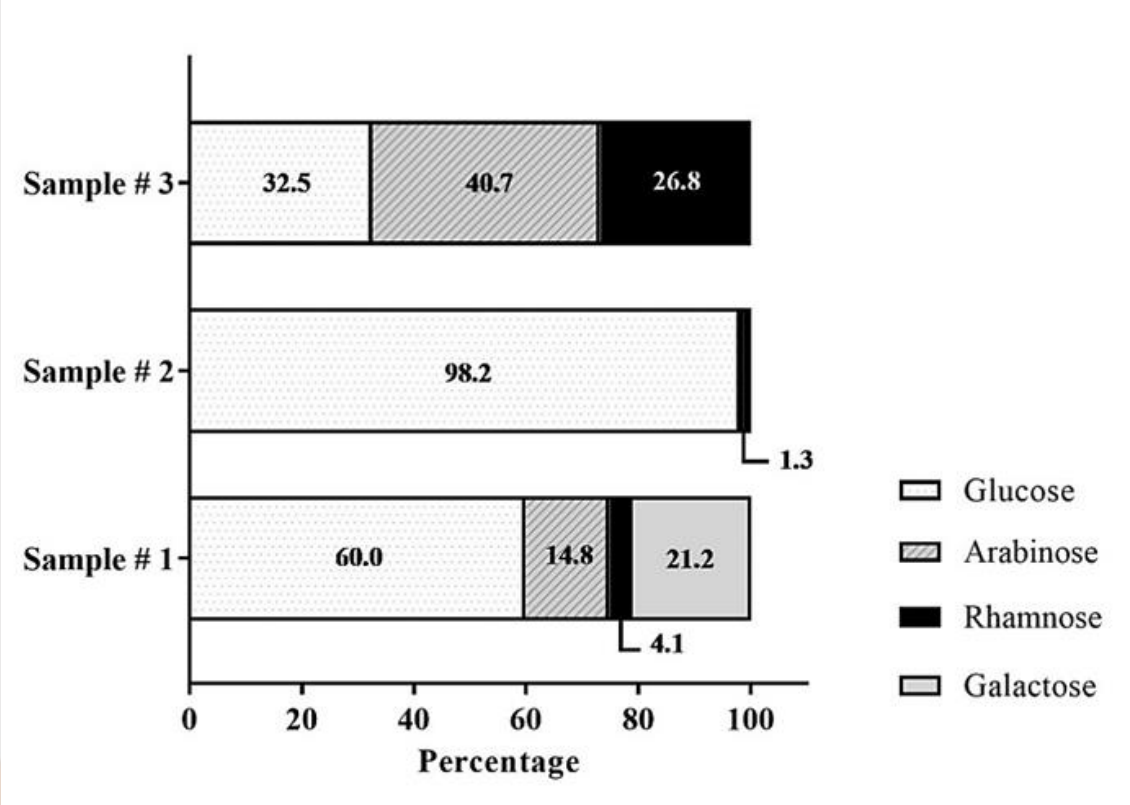
Maple sap

Maple syrup



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.

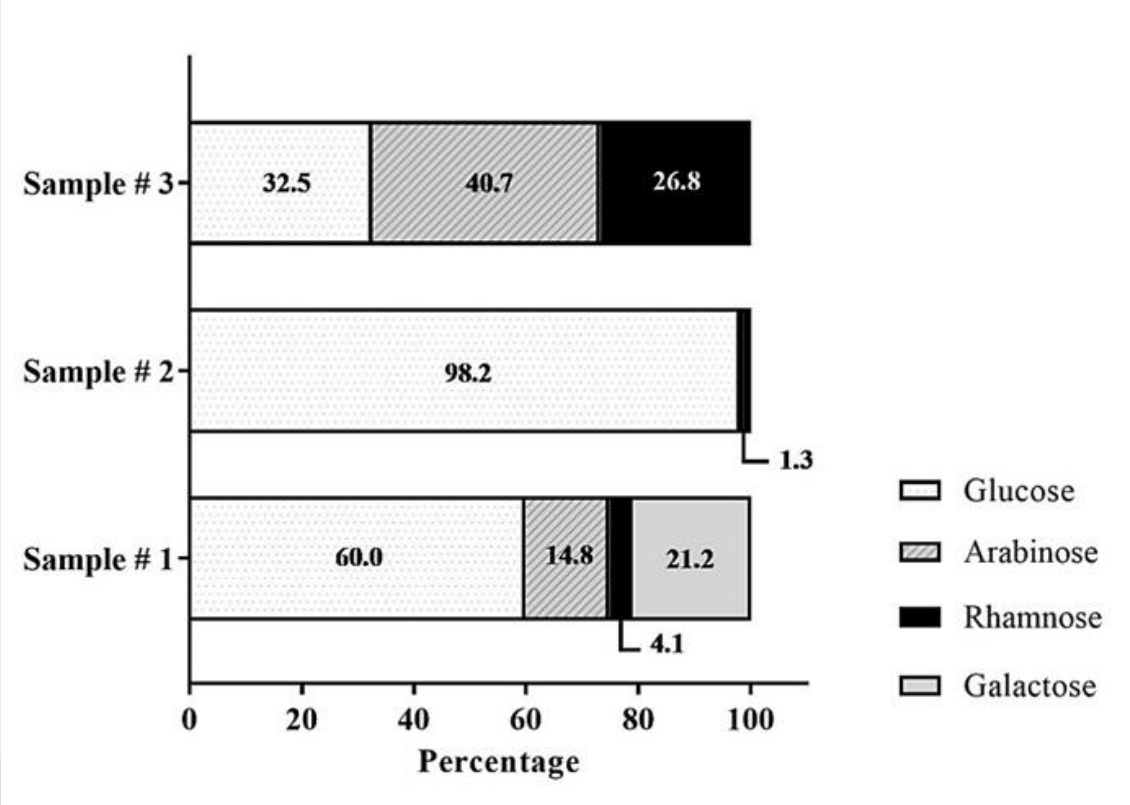
When polymerized, glucose leads to dextrans.

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

Results and Discussion

Maple sap

Maple syrup



Monosaccharide composition of purified polysaccharides from 3 ropy maple syrup samples

Monosaccharides (MS)

Arabinose and rhamose in sample #1 and #3
↓
arabinogalactans and rhamnoglucans

Galactose in sample #1
↓
Galactans or arabinogalactans

How to prevent ropy syrup formation

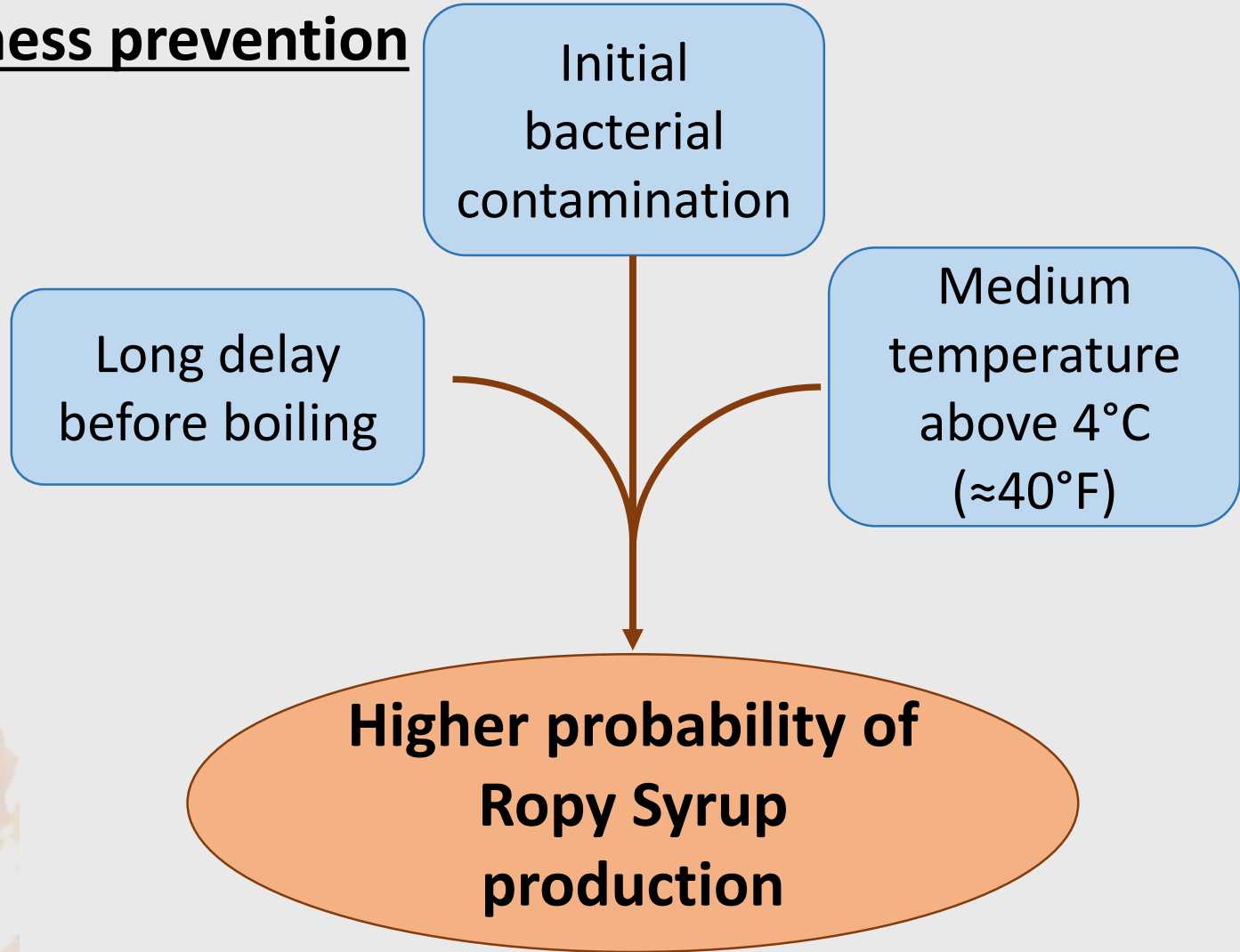
Contributing factor of ropiness

- 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



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

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