# Fermentation Management of Cane Sugar Based Feedstocks

The Alcohol School Concise

Robert Piggot

International Technical Director

LBDS

WIRSPA

West Indies Rum & Spirits Producers' Association Inc.

Ethanol Technology Institute

Place: Caribbean Distilling Seminar, St Lucia

Date: April 2024

# Types Sugar Based Feedstock

- Cane juice
- Blackstrap molasses
- High test molasses
- Thick Juice (Beet)
- Sweet sorghum
- Tree Sap
- Fruits
- White or Raw sugar
- Dextrose syrup

Ethanol Technology Institute

# Juice Fermentations

Ethanol Technology Institute

# Juice

## Advantages

- Rapid fermentation
- Cane can be selected for varietal and terroir.
- Extra nutrients not usually required
- No up-front energy requirement for concentration
- Effluent easy to treat or recycle
- Bagasse source of energy?

## Disadvantages

- Cannot be stored. Ideally crushed on site.
- Low alcohol wash
- Seasonal
- Usually contaminated

Ethanol Technology Institute

# Points to Remember on Cane Juice

- Crush cane withing 24 hours of harvest.
- Counter current wash water should be good quality.
- Get selected yeast into the must as soon as possible.  Do not leave in tanks or pipes. Preferable to crush on site.
- Nutation is generally not needed but may speed up fermentation.
- Clean equipment well at least daily.
- Fermentation will be fast often in open fermenters to help dissipate heat
- Distilled to low strength to retain the flavour of the cane fermentations

Ethanol Technology Institute

# Molasses

Ethanol Technology Institute

# Points to Remember

- No one makes Blackstrap Molasses as a product.  It is a waste product of sugar production.  As such, the alcohol plant receives all the molasses plant upsets, poor storage conditions, added chemicals and efficiency improvements. Even previously used molasses can be added.  YOU ARE IN EFFECT THE SUGAR PLANTS EFFLUENT TREATMENT FACILITY.

- Very high mineral and gum content.  In India they are starting to use more B molasses which is much easier to ferment.

- It is very high fouling; you need to account for this in plant design and operations. Especially in distillation.

- The molasses market is not transparent.

- Preshipment samples not always representative of the delivered shipment.

Ethanol Technology Institute

# It varies a lot!

- Molasses is a very variable product and its overall distilling quality is constantly declining.

Effected by:

- Quality and variety of the cane
- Soil condition and fertilization
- Climatic conditions
- Harvesting methods
- Manufacturing process
- Storage

Ethanol Technology Institute

# They vary a lot!

## 2 Cane Molasses Assays

| | #1 | #2 |
|---|---|---|
| Brix | 84.9 | 88.32 |
| Silica | 0.22 | 0.26 |
| Total Sugar | 51.30 | 58.39 |
| TSAI | 53.30 | 60.3 |
| Reducing Sugars | 18.97 | 23.58 |
| Non fermentable Sugars | 2.96 | 3.5 |
| Ash | 13.40 | 11.08 |
| Calcium | 0.41 | 0.35 |
| Sucrose | 32.36 | 33.31 |

Ethanol Technology Institute

# Types of Molasses

- A Type (EP 1) one crystallization step rare but good feed stock if handled properly.
- B Type (EP 2) two crystallization steps
- C Type (EP 3)three crystallization steps. Most common form of blackstrap
- Refiners From the cleanup of the raw sugar. Lower minerals higher sugar.

Ethanol Technology Institute

# Molasses Storage

Ethanol Technology Institute

# Notes on Molasses Storage

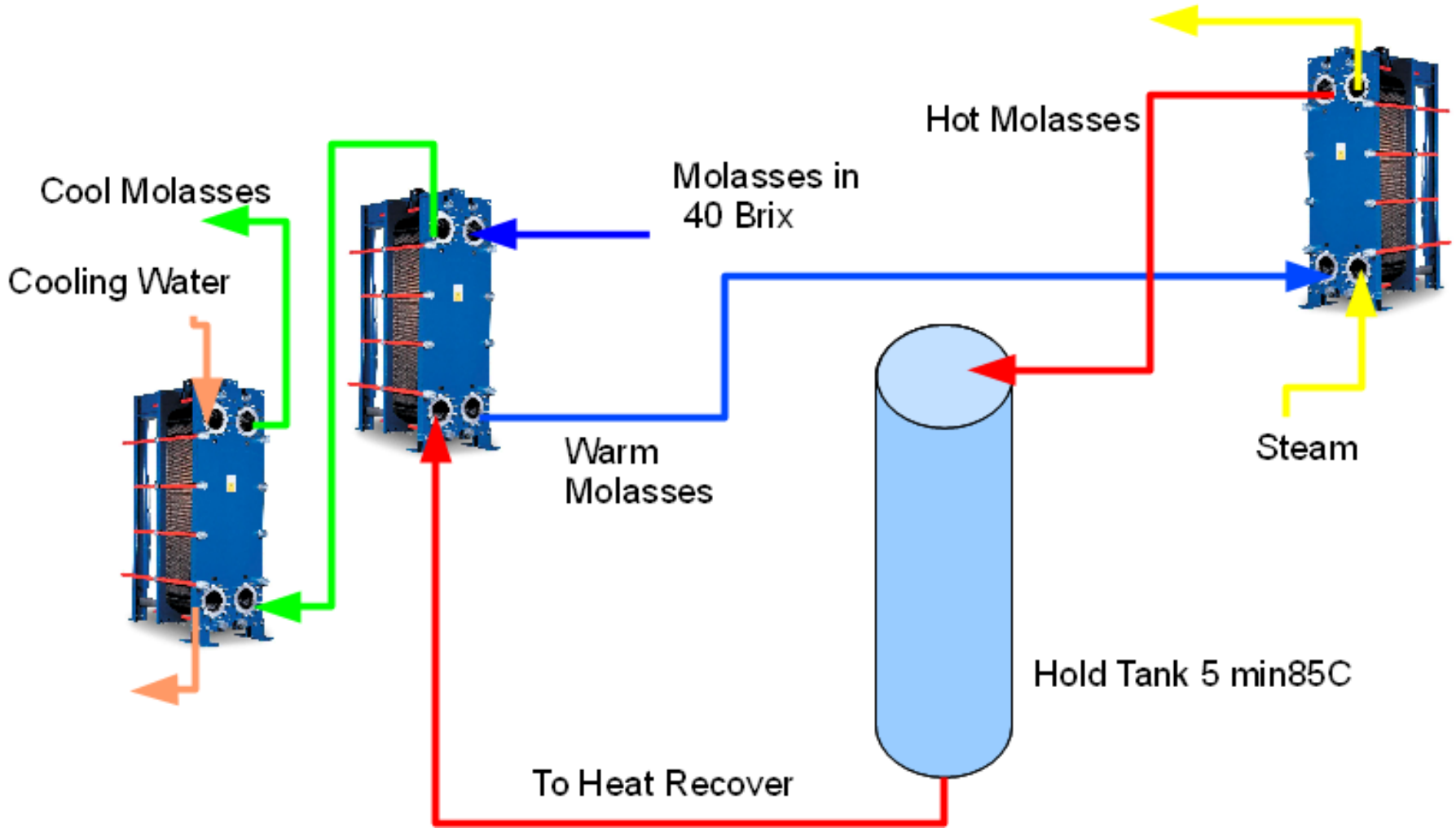
- Millard reactions increase dramatically over 60°C.  Will generate gas and heat.
- If possible be sure sugar mill cools before storage
- Molasses in storage is not homogeneous.
- Osmotic pressure of 80 brix molasses stops most bacteria however some *(Leuconostoc menesteroides)* can still produce unwanted dextrins at this time.
- Do not use tanks designed for water or fermentation

Ethanol Technology Institute

# Molasses Pre-treatment

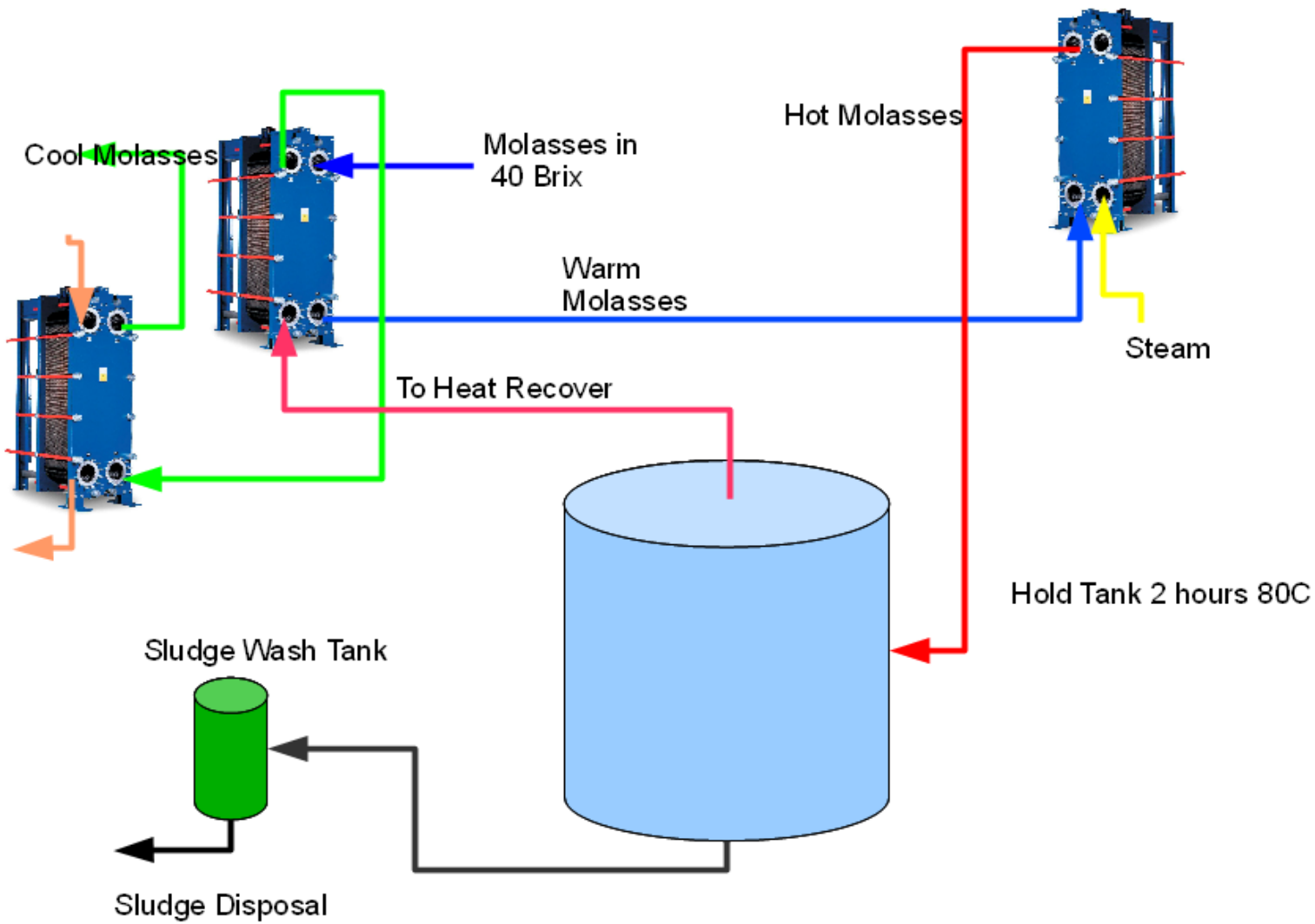
Ethanol Technology Institute

# Pasteurization (Not Sterilization)



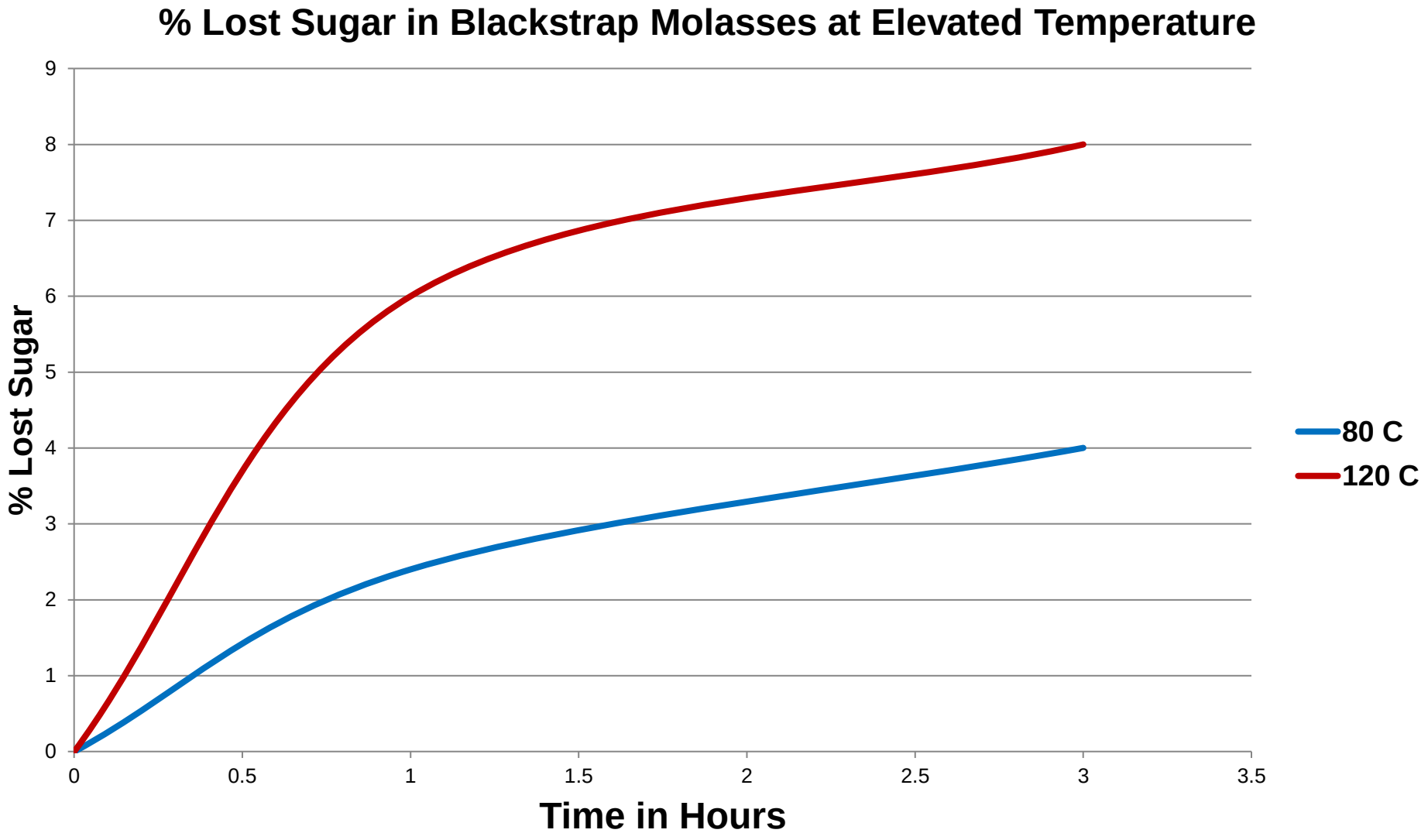

Ethanol Technology Institute

# Sludge Settling




Ethanol Technology Institute

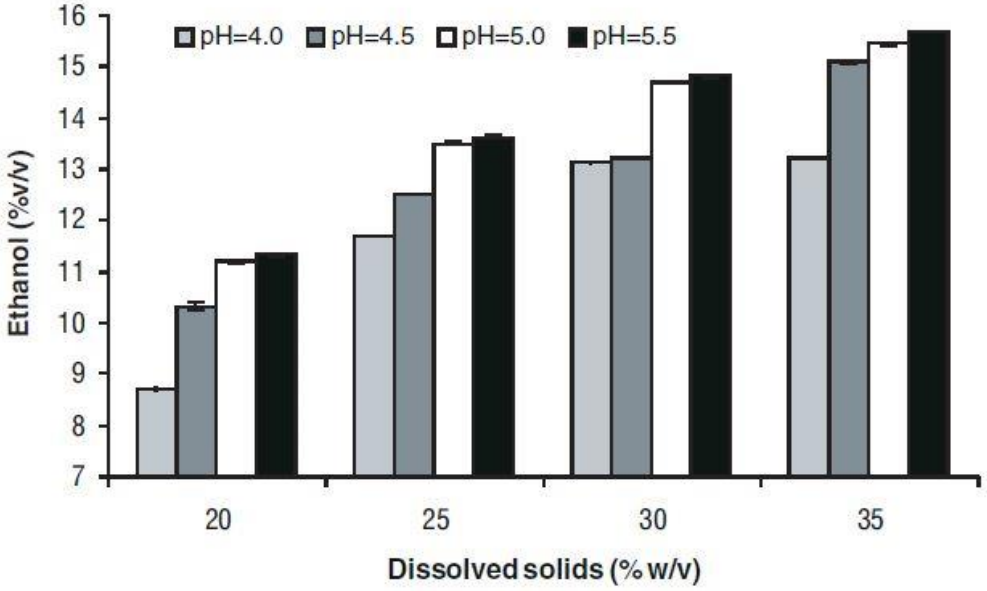
# Sugar Losses in Processing




Ethanol Technology Institute

# Drop pH with Acid

- Reduce the pH with acid addition to slow bacteria growth.
- Better to control bacteria in other ways due to significantly reduced yield at lower start pH




Ethanol Technology Institute

# Fermentation

Ethanol Technology Institute

# Import Steps around Fermentation

| | |
|---|---|
| • Yeast Handling and Conditioning | Chris R |
| • Cleaning and Sanitation | Don B |
| • Nutrition | Maria N |

Ethanol Technology Institute

# Fermentation

**Fermentation is the heart of the distillery!!**

Fermentation is the only place alcohol is made.

Fermentation is the source of most your flavours and pre cursors. (others come from wood extracts)

Ethanol Technology Institute

# Fermention:  Before we Start

Ethanol Technology Institute

# Good Mixing

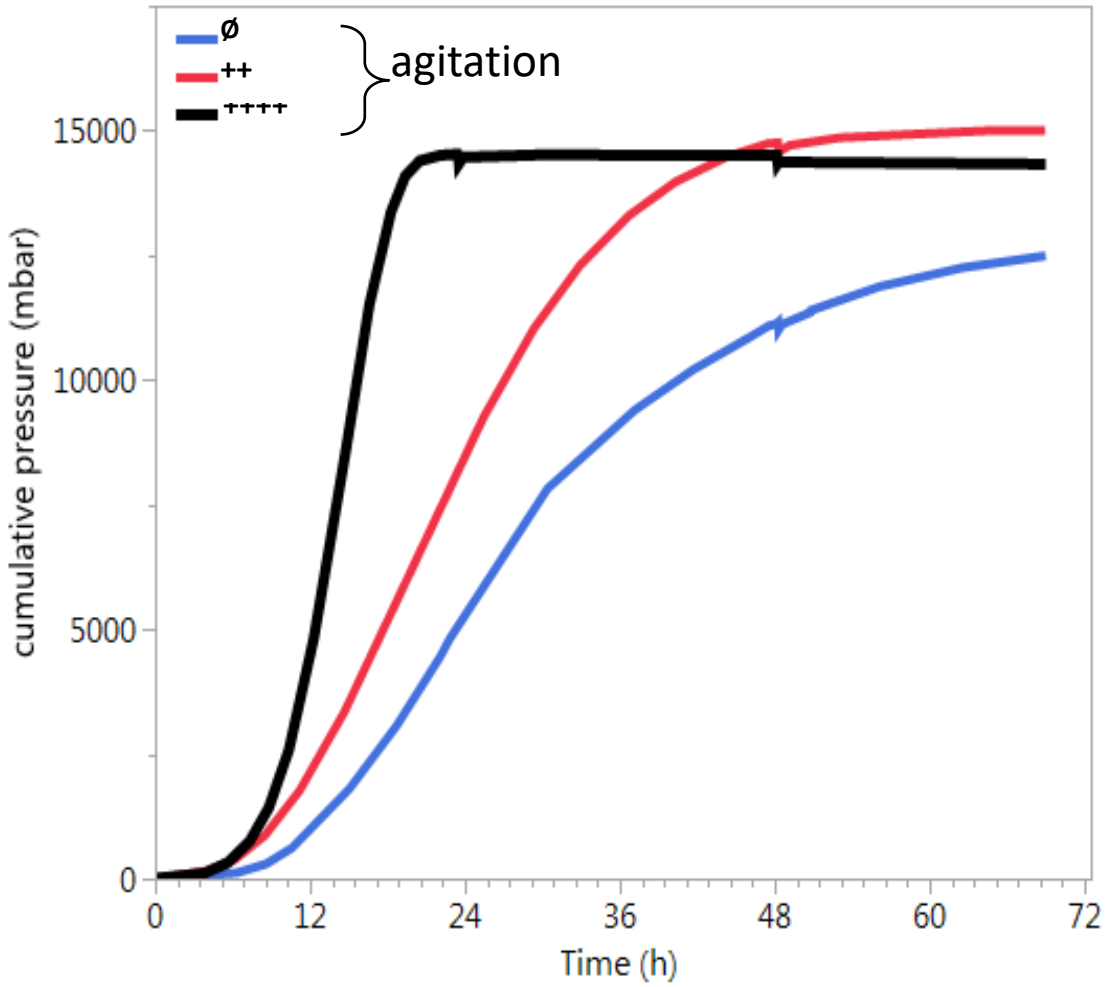
- Good mixing is important for good complete fermentations.
- It keeps fermenter homogeneous
- Ensures good yeast-substrate contact especially at end of fermentation
- Even temperature throughout fermentation

Ethanol Technology Institute

# Impact of Agitation on Kinetics

What happens during agitation?

- Yeast is kept in suspension
- Cells divide and ferment faster
- $CO_2$ during fermentation is not enough

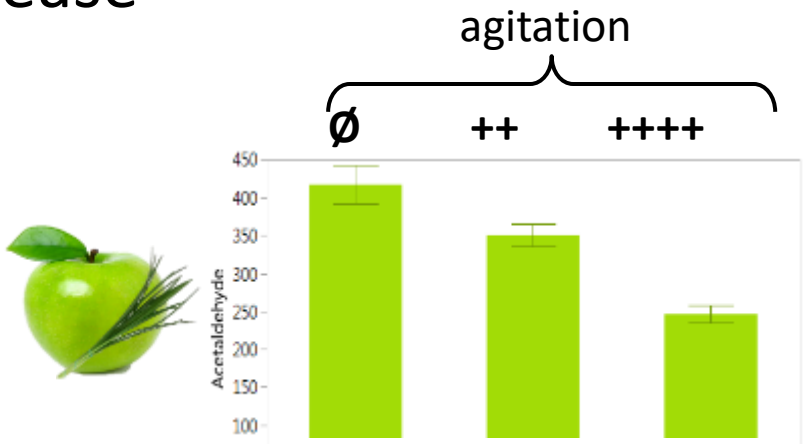


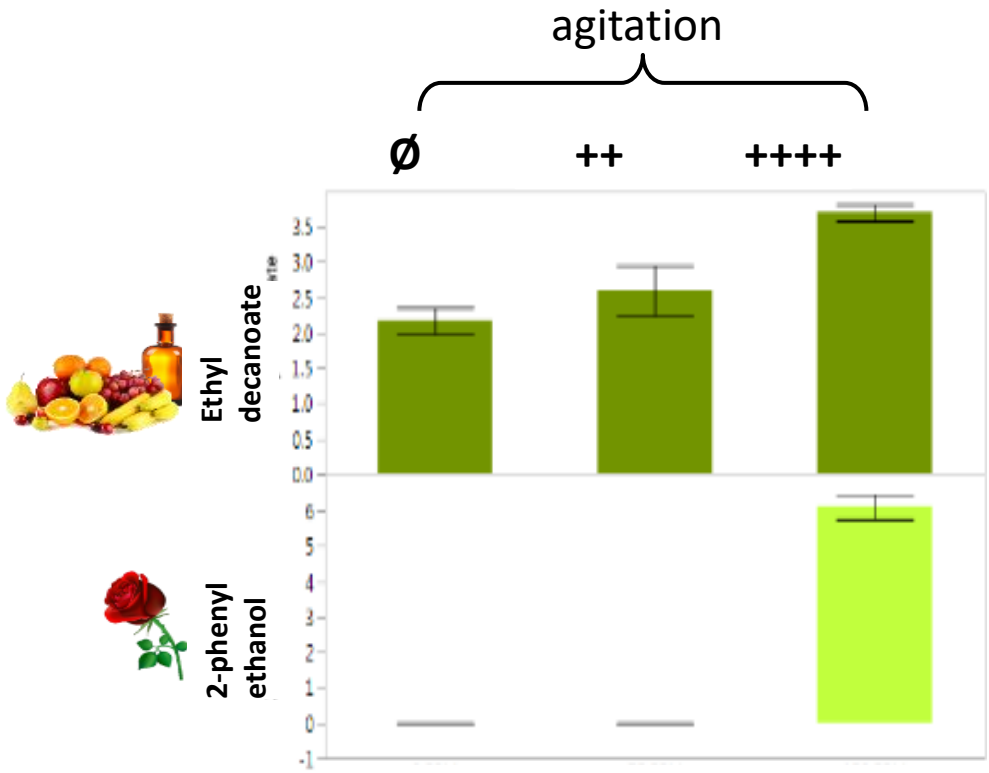

Ethanol Technology Institute

# Impact of Agitation on Aromatic Profile

What about congeners?

- Acetaldehyde will go down
- Production of desirable compounds will increase



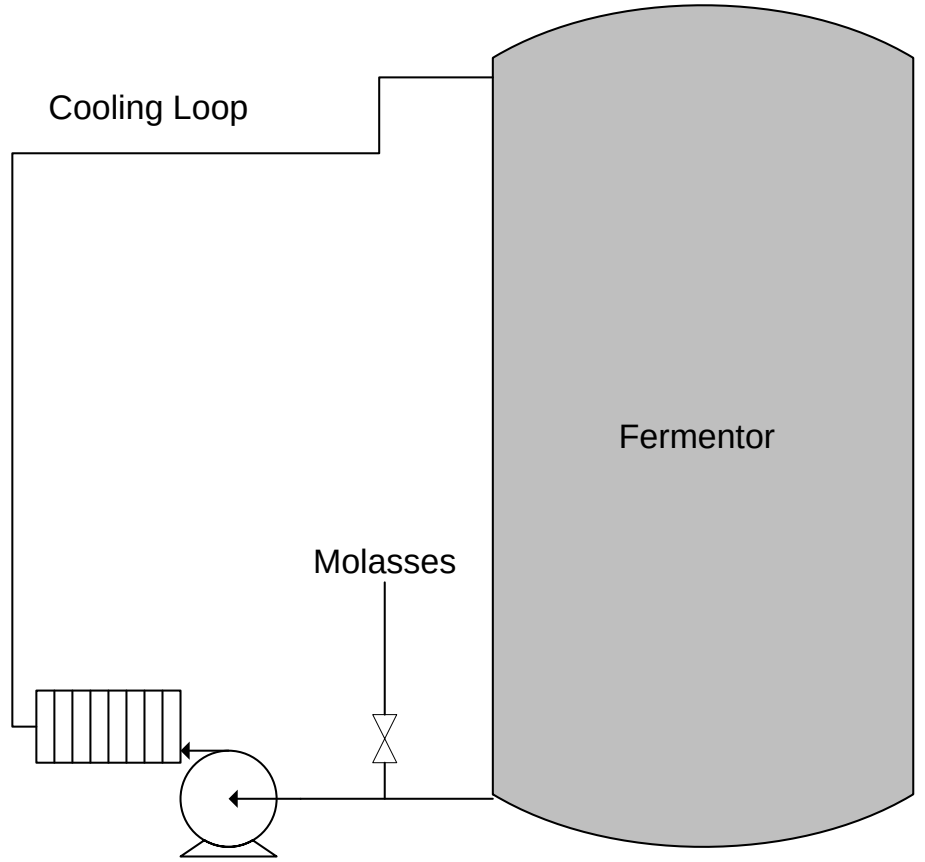




Glucose → 2 pyruvates → (2 $CO_2$) **2 acetaldehyde** → 2 ethanol

Ethanol Technology Institute

# Cooling and Piping

- 304 Stainless is a common construction material
- External cooling loops the most common. Try to stay away from internal cooling coils
- CIP should be easy
- Return cooled wash to top of fermenter
- Most molasses yeast happiest with a fermentation temperature of 33 to 34°C




Ethanol Technology Institute

# Water (and Dunder) Recycle

- It is important in most areas to conserve water. Recycling of clean water steams especially from distilling can be used in fermentation. Be careful of the temperature.
- There are 2 reasons people recycle dunder:
  - To reduce water use and effluent. This generally does not work well and should be avoided. Unless it has been through a pretreatment step. There are better ways to reduce effluent and water use.
  - To add bacteria for flavour production. This is more art than science. There will be some yield loss It can work well or be a total mess. It is an operations decision at each distillery if they want to go along this path.

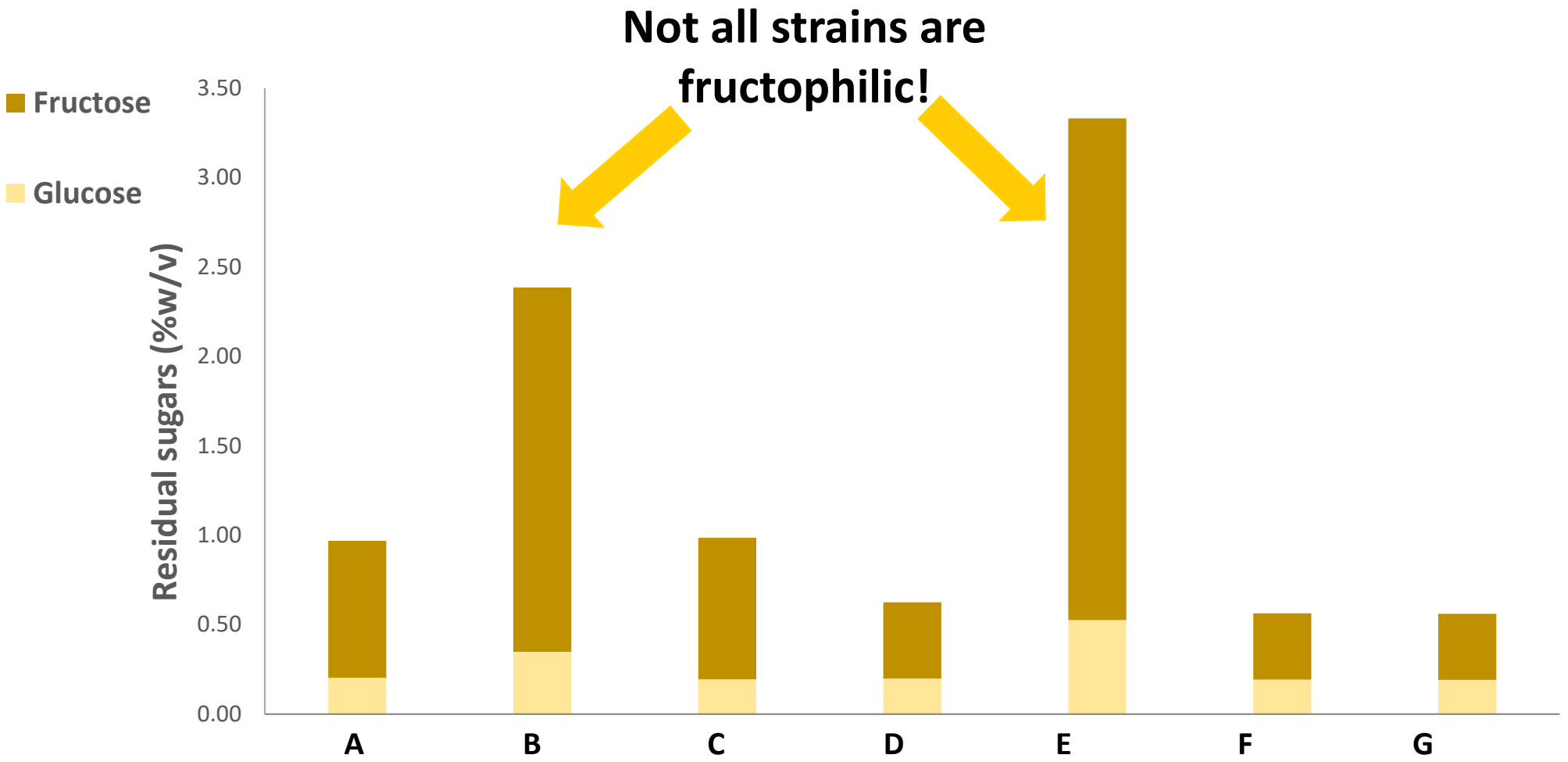
Ethanol Technology Institute

# Strong Healthy Yeast

- Yeast is the heart of the distillery. It produces your alcohol and most of your flavours.
- Yeast is a living organism keep it happy for best results
- Yeast that is not treated well before or at beginning of fermentation will look like it is preforming well, but it will not finish fermentation when stresses are high.
- Choose the right yeast for you:
  - Flavour
  - Temperature tolerance
  - Resistance to high alcohol
  - Consumption of fructose

Ethanol Technology Institute

# Sugar Consumption By Different Strains in Molasses

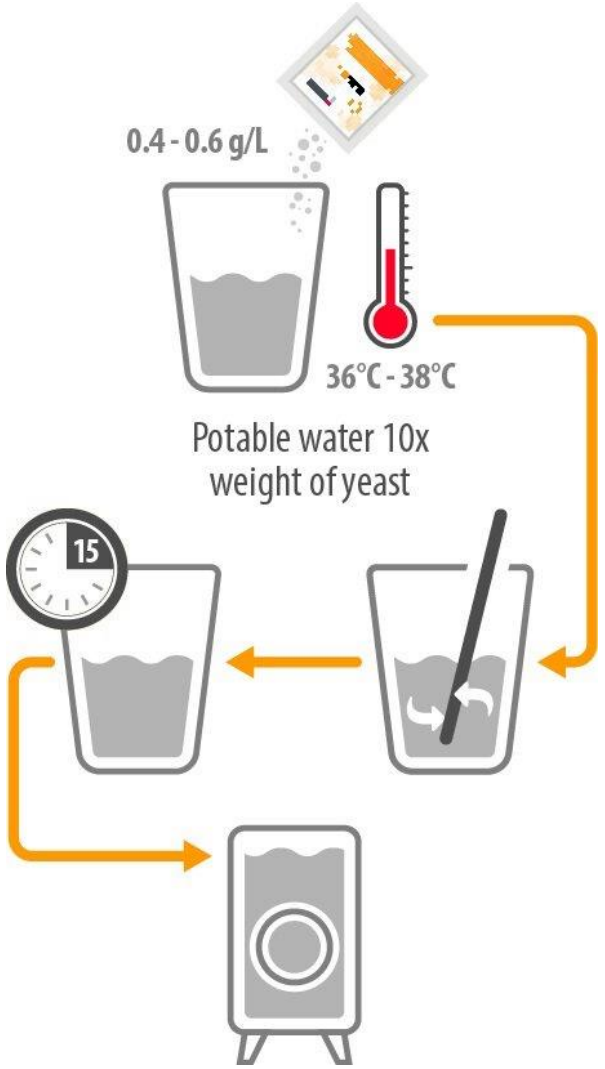



Ethanol Technology Institute

# Rehydration Process.

Important mainly if you want to reach high ethanol content

**1 - Rehydrate Yeast in 10 times its weight of potable water at the temperature between 36– 38°C**




**2 – Suspend carefully by gentle stirring**

**3 – Wait ideally for 15-20 minutes maximum. (minimum time 10 minutes)**

**4 – Add preparation to the wash. If the temperature difference between the wash and the rehydration medium is more than 8°C, slowly add wash into the medium**

Ethanol Technology Institute

# Rehydration Nutrition

| Sample (48hr) | Sucrose | Glucose | Fructose | Total Sugars | EtOH (%v/v) |
|---|---|---|---|---|---|
| Control | 0.293 | 0.117 | 1.527 | 1.937 | 11.4 |
| 300ppm | 0.437 | 0.133 | 1.727 | 2.297 | 12.7 |
| 600ppm | 0.307 | 0.120 | 1.720 | 2.147 | 12.7 |
| 1000ppm | 0.343 | 0.113 | 1.683 | 2.140 | 13.0 |
| 1500ppm | 0.407 | 0.127 | 1.707 | 2.240 | 12.9 |
| 2000ppm | 0.420 | 0.123 | 1.580 | 2.123 | 12.4 |
| 4000ppm | 0.413 | 0.143 | 1.790 | 2.347 | 12.7 |
| 8000ppm | 0.247 | 0.107 | 1.560 | 1.913 | 13.0 |

All data %w/v unless otherwise indicated

- Sometimes nutrition can be added to the rehydration water. Talk with your yeast supplier before you do this as some nutrients can damage the yeast at this stage.

Ethanol Technology Institute

# Propagator Brix

| Propagation drop (8hr) sugar data | | | | | | | |
|---|---|---|---|---|---|---|---|
| Yeast | Brix | Sucrose | Glucose | Fructose | Total Sugars | Live Cell | Viability |
| 1 | 11 | 1.48 | 1.91 | 3.11 | 6.49 | 4.30E+07 | 82.4 |
| 2 | 11 | 1.92 | 1.62 | 2.77 | 6.31 | 2.84E+07 | 84.7 |
| 1 | 8 | 0.29 | 1.33 | 2.41 | 4.02 | 4.45E+07 | 90.1 |
| 2 | 8 | 0.61 | 1.1 | 2.15 | 3.85 | 2.31E+07 | 94.2 |
| 1 | 4 | 0 | 0.55 | 1.15 | 1.7 | 6.46E+07 | 97.6 |
| 2 | 4 | 0 | 0.44 | 1.05 | 1.48 | 2.96E+07 | 96.9 |

| 65hr results 4 Brix Prop | | | | | | |
|---|---|---|---|---|---|---|
| Sample | Sucrose | Glucose | Fructose | Total Sugars | Glycerol | EtOH (%v/v) |
| 1 | 0.88 | 0 | 0 | 0.88 | 0.48 | 13.54 |
| 1 | 0 | 0 | 0 | 0 | 0.44 | 13.52 |
| 1 | 0 | 0 | 0 | 0 | 0.54 | 13.22 |

A lower Brix in the propagation vessel can result in healthier yeast and better yields

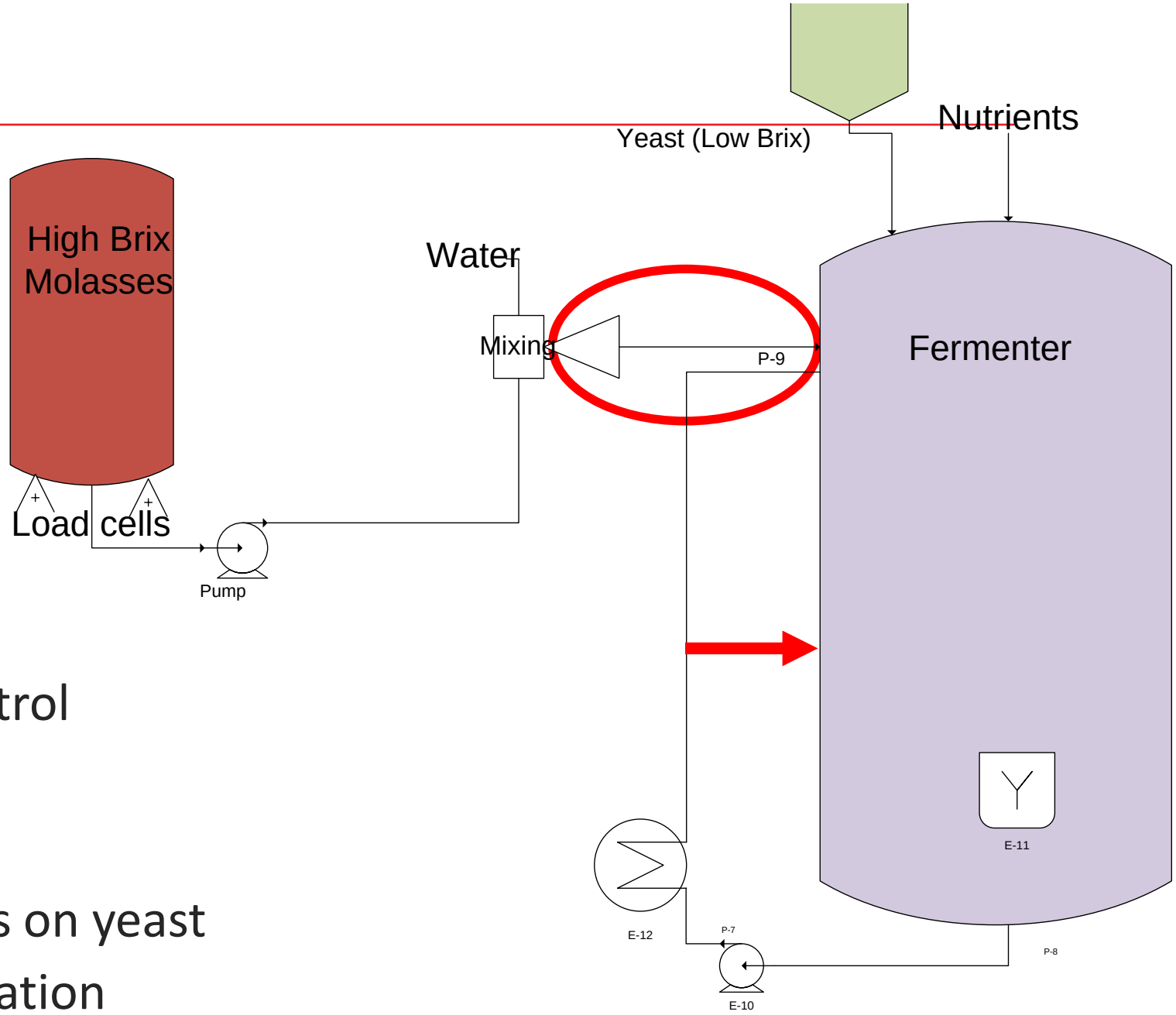
Ethanol Technology Institute

# Types of Fermentation

- Four main fermentation types in general use
  - Batch
  - Fed Batch
  - Incremental Feed
  - Continuous

Ethanol Technology Institute

# Batch




Plus

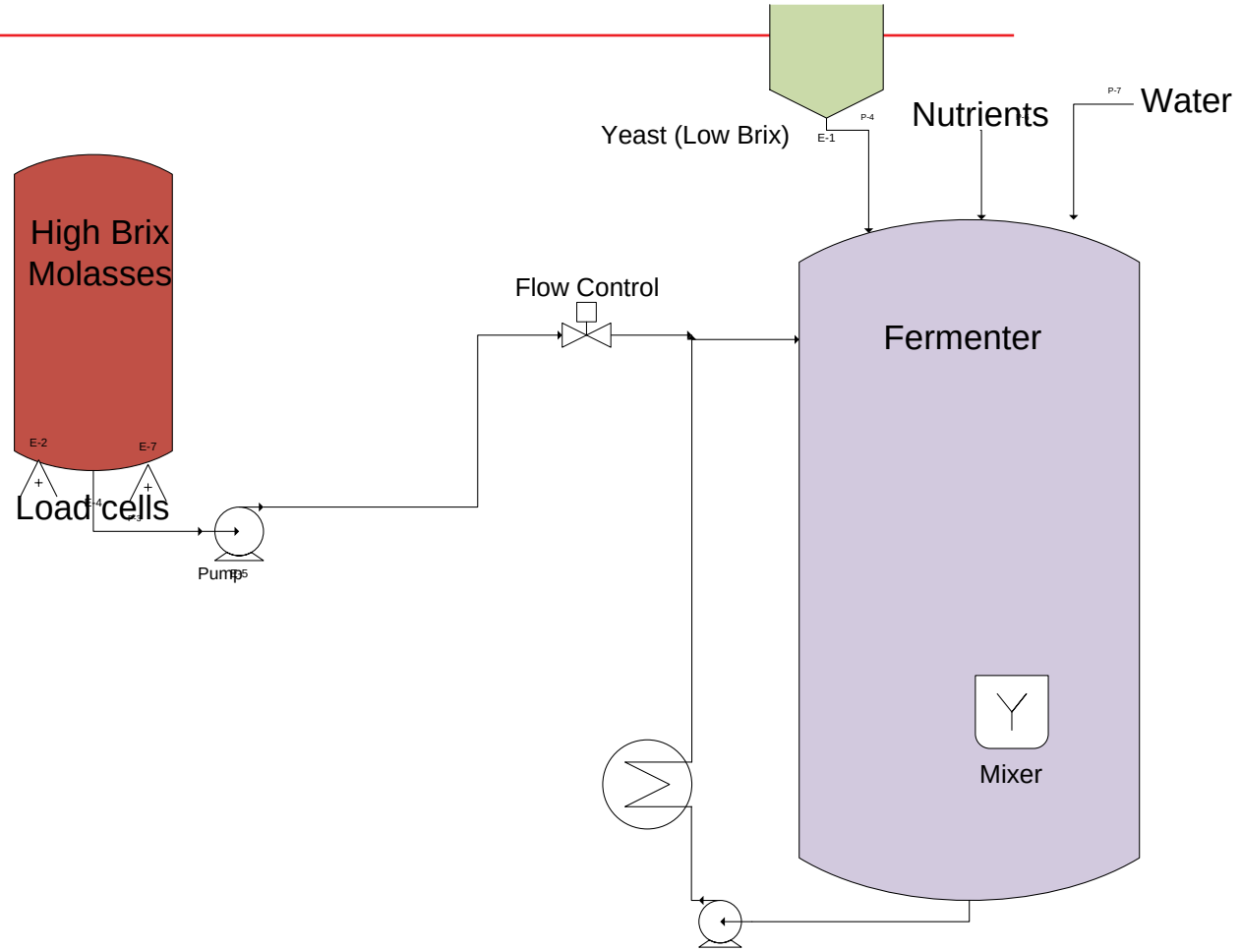
- Simple easy to control

Minus

- High osmotic stress on yeast
- High risk contamination

Ethanol Technology Institute

# Fed Batch




Plus

- Low osmotic stress
- Healthier yeast
- Little sugar for bacteria
- Higher alcohols possible
- Higher Yields
- Faster fermentations

Minus

- More complicated to run

Ethanol Technology Institute

# Running a Fed Batch Process.

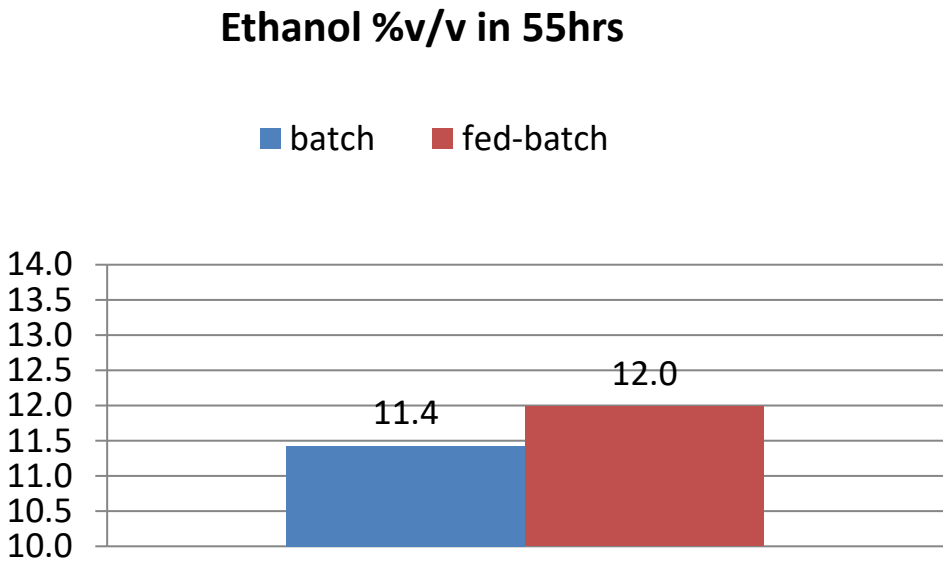
- Fed batch is the SSF of sugar fermentations

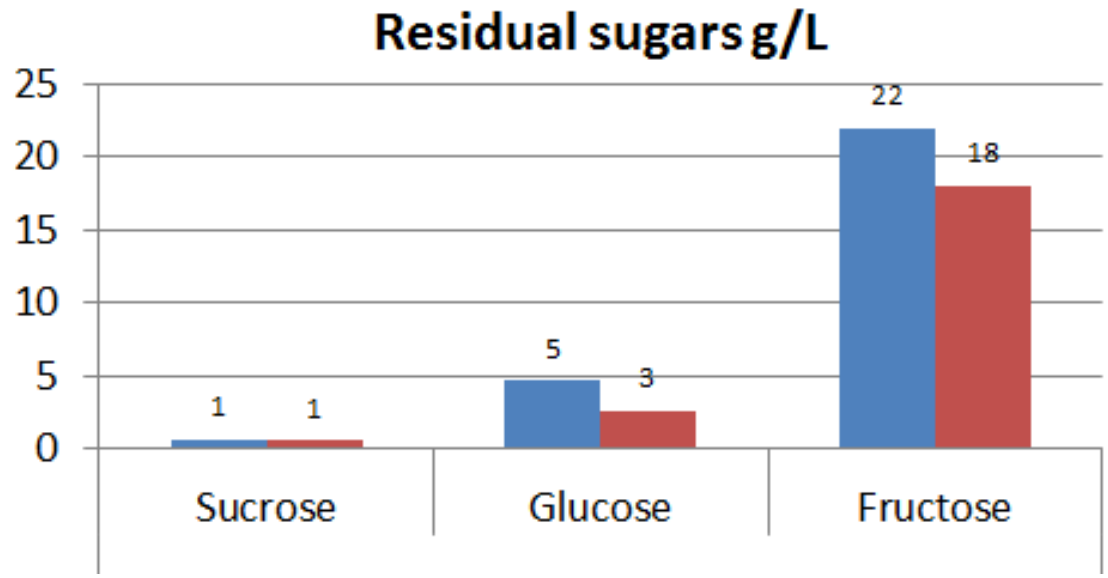
STEPS

1. Add required water to fermenter
2. Add a strongly fermenting propagator to a fermenter (Works well with 5% of fermenter volume.)
3. Weight in molasses to fermenter slowly keeping sugar at about 2% (Mass flow meter will work)
4. Time will depend on final strength of alcohol but about 24 hours to fill and about 8 more hours to finish fermentation.

Ethanol Technology Institute

# Batch vs Fed Batch




Ethanol Technology Institute

# QUESTIONS

Ethanol Technology Institute