Cane Juice Fermentation

The Alcohol School Concise

Renegade Rum Distillery Experience

WIRSPA
West Indies Rum & Spirits Producers' Association Inc.

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Place: Caribbean Distilling Seminar, St Lucia

Date: April 16th -19th , 2024

Alcoholic Fermentation

- Alcoholic fermentation involves the use of bacteria or yeast to convert sugar into alcohol.
- The use of yeast in alcoholic fermentation has been established for centuries and it is used in the process at Renegade Rum Distillery.
- Sugarcane juice is the feedstock used.

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Fermentation Types

- **Spontaneous fermentation**: involves the use of yeasts that exist naturally in the local environment to sow fresh sugar cane juice. There is a higher risk involved in this method since yeast can be overpowered by other yeast strains and bacterium which may affect the batch. Therefore, greater production control is necessary to prevent contamination when employing this method (François, 1999).
- **Pitching (Batch Fermentation):** yeast strains that are industrially bred are pitched directly into the fresh batches of sugar cane juice (François, 1999).
- **Master Batch**: also requires the use of industrially bred yeast strains. It is done by pitching and heating of a sample of fresh sugar cane juice for fermentation, that batch is then used to pitch other tanks (François, 1999).

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Fermentation Types – Renegade Rum Distillery

- The fermentation type employed at Renegade Rum Distillery is Batch Fermentation (the Pitching Method).

- Rapid growth/multiplication of yeast cells and better control of process is favoured.

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Feedstock Production & Quality Management

Renegade Rum production philosophy is based on 3 Ts – Terroir, Transparency & Traceability.

The sugarcane grown for feedstock production is managed by Renegade Rum (CaneCo).

- Farms: 14
- Acreage under cultivation: 300 acres
- Smallest farm: 4 acres
- Largest farm: 40 acres
- Fields: 167
- Terroirs: 52 (natural environment including factors such as soil, topography, climate)
- Sugarcane varieties: 6 (All originated from breeding station in Barbados)

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Feedstock Production & Quality Management

Sugarcane quality is affected by:

- Growth/maturation time – preferred age is 12-18 months old (challenge)
- Harvest time – harvest in dry season or wet season
- Harvest method – manual of mechanical

Main parameters measured:

- Fibre in cane
- Brix in juice
- Total Sugars in juice

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Feedstock Production & Quality Management

The quality of the juice/feedstock is maintained and managed by:

i. Method/practices of harvesting the cane (manual is preferred to mechanization)

ii. Processing of sugarcane in cane yard before and during milling

iii. Filtration of juice using a rotary screen during milling

iv. 3 Step sanitation/CIP of:
   - Juice lines
   - Juice tank
   - Yeast tank
   - Washback/Fermenters

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Process of Obtaining Juice for Fermentation

Milling philosophy:

- Single Farm
- Single Field
- Single Terroir
- Fresh sugarcane
- Field to mill concept
- Milling rate 7-10 ton/hr

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Process of Obtaining Juice for Fermentation

In the milling process of the cane – wet milling is done; imbibition water is added while the cane is being crushed. The addition of water helps:

- In the hydrolysis of sucrose to fructose and glucose.
- In the extraction efficiency (very important for biomass boiler).

Imbibition temperature is maintained around 40-42^{o}C. The flow and volume of imbibition water is adjusted based on brix in juice.

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Preparation of Juice for Fermentation

- Filtration – Juice is filtered through rotary screen to remove solids and bagacillo
- Juice is transferred to juice tank (25,000L)
- Yeast makeup (rehydration of yeast)
- Nutrient makeup – unlike molasses, juice is deficient in minerals, vitamins and amino acids so a nutrient cocktail is used.

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Preparation of Juice for Fermentation Cont.

Yeast

- Type – DistilaMax® RM (dry yeast)
- Supplier – Lallemand Biofuels & Distilled Spirits
- Dosage – 400-600 ppm recommended (RR optimal dosage is based on our process)

Nutrient

- Type – DistilaVite® GN
- Supplier – Lallemand Biofuels & Distilled Spirits
- Dosage – 250-350 ppm recommended (RR optimal dosage is based on our process)

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Fermentation – Renegade Rum Experience

Infrastructure

- Brew House – 90 ft x 60 ft
- 12 horizontal stainless steel washbacks (6 pairs)
- Closed washbacks
- Capacity 40,000 litres each
- Fermentation skid – 6 heat exchangers, pumps and sample points

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Fermentation – Renegade Rum Experience

Rationale for Infrastructure:

- Milling throughput: 75Tc/day. The projection is to fill 2 washbacks per day @ 5 days per week
- Horizontal washback – Washbacks are 40ft long and cannot be fitted vertically (aesthetics).
- Horizontal tanks reduces the hydrostatic pressure exerted on the yeast. This pressure stresses the yeast.
- Horizontal tanks offer a larger surface to volume ratio compared to vertical tank. This increased surface area allows for more even temperature distribution in the tank. This consistent temperature distribution is important in achieving desired flavoured profile and preventing unwanted flavours.
- Horizontal tanks also promotes the settling of solids and sediments at the bottom of the tank. The yeast and solids don't have to travel as far to settle on bottom of tank. The result is a cleaner wash to stills.

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Fermentation Monitoring– Renegade Rum Experience

- Key to fermentation is bacteria control
- pH recorded in juice is 4.5-5.0
- Washback lifecycle monitoring (after 10 hrs., record brix and pH every 4 hrs. until WB fall)
- Yeast cell count
- Temperature control (set point for recirculation and cooling)
- Fermentation skid for cooling

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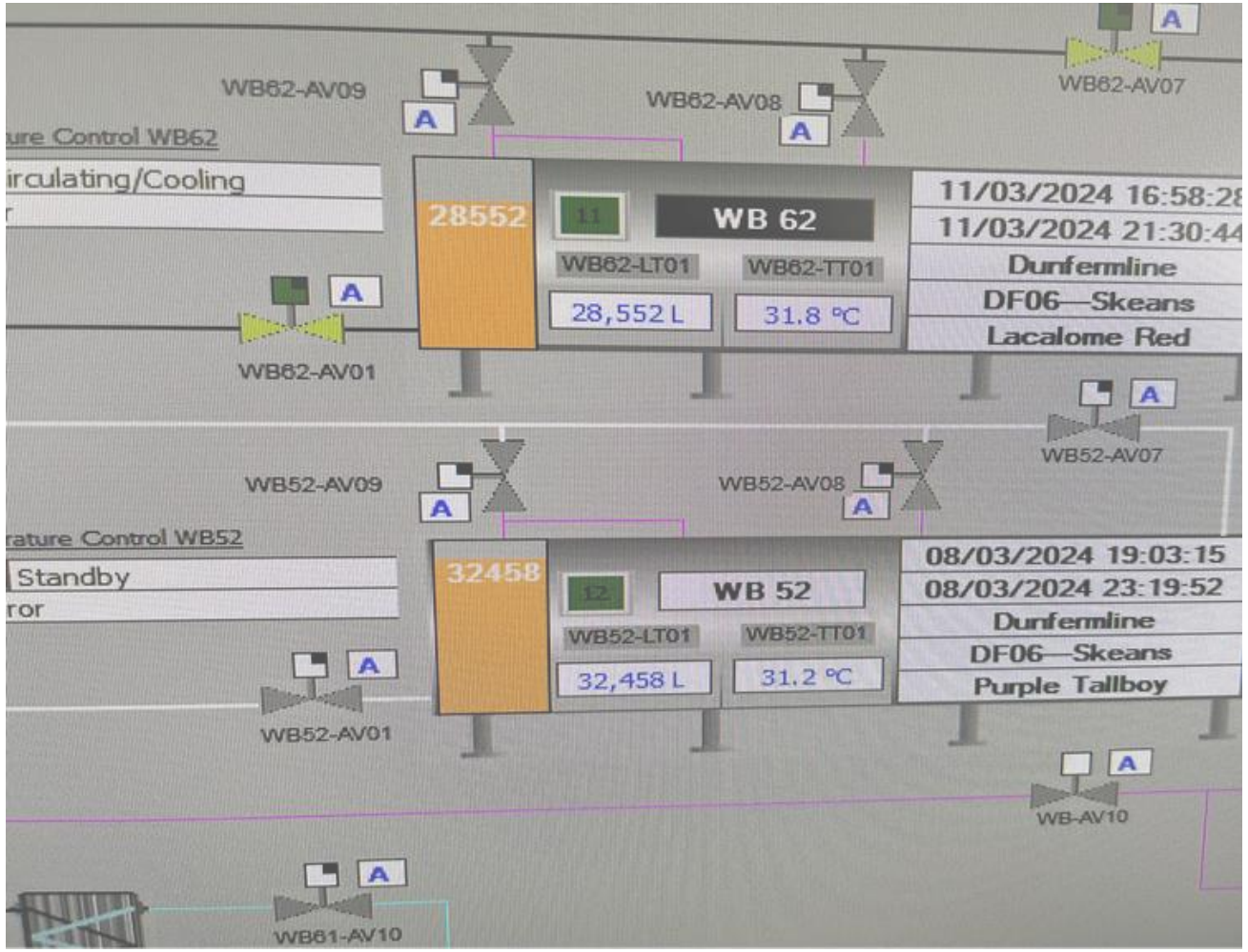
Fermentation Monitoring – Renegade Rum Experience

Washback usage:

- Farm
- Field
- Variety
- Pitching time

Fermentation time: 36-96 hrs.



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Factors Affecting Fermentation

Efficient fermentation is highly dependent on the following physiochemical parameters:

- Temperature
- pH
- Nutrient availability

These parameters facilitate and maintain yeast growth and their viable populations throughout the sugar consumption period.

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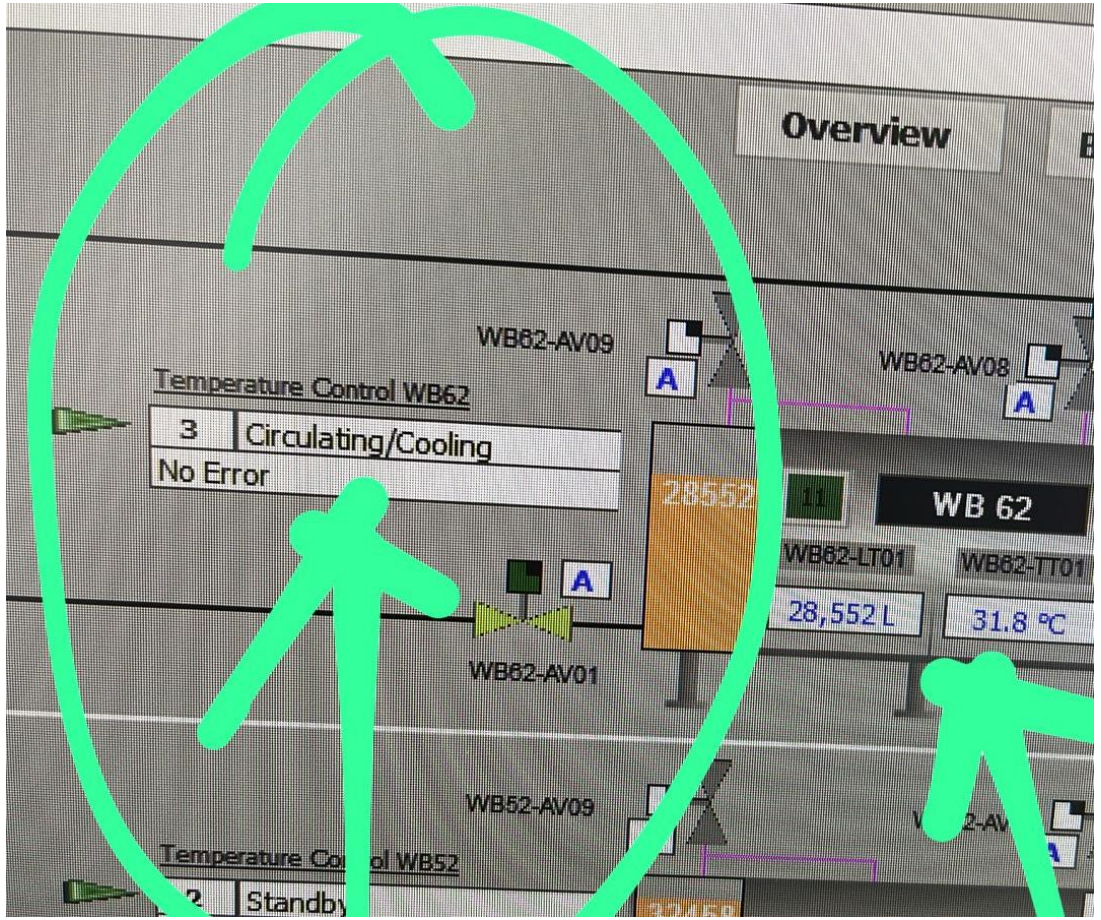
Temperature

- Fermentation is an exothermic – Heat is produced
- Yeasts may either die or stop activity when temperatures exceed 35°C
- Temperature range for DistilaMax RM is 25-35°C
- Set point for Renegade Rum Distillery is 32°C
- Recirculation begins once temperature reaches 32°C to cool washbacks



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Temperature Cont.

1

Temperatures usually above 35°C promote yeast autolysis, which is the rapid growth of heat loving bacteria such as acetic and lactic bacteria that favour lactic fermentation as opposed to alcoholic fermentation (Fahrasmane & Ganou-Parfait, 1997).

2

Low temperatures result in slower fermentation. This is so because it reduces the growth rate of yeast cells as it affects the membrane fluidity and temperature-dependent enzyme activity. (François,1999).

3

At Renegade Rum, the use of horizontal fermenters allow more consistent temperatures during fermentation

4

Cooling system maintains an average temperature of 32°C. (Chiller & Fermentation skid)

5

The ability to cool fermenters and slow down fermentation is an advantage for Renegade Rum.

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pH

- The pH affects the enzymes performance. The optimal pH range for yeast growth can vary from pH 4 to 6.
- Yeast has an optimal pH (4.7) for ethanol production and for growth; and both a minimum and maximum pH that can tolerated.
- If the pH deviates from the optimal level it can be difficult for the cell to balance off both the intracellular and extracellular pH. The cell would have to pump hydrogen ions into the cell or out of the cell to maintain the pH and a lot of energy can be invested into this action. However, the enzymatic function can be affected leading to deactivation or denaturation of the yeast cell. If the enzymes are affected the yeast cell will not be able to grow and produce ethanol efficiently.
- Also, maintaining the proper pH within the fermenter is also very important to reduce stress level.
- The pH of the juice (4.5-5.0) is extremely important and must be close to the optimum pH of the enzyme used.

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Nutrient Availability

- Unlike molasses, cane juice is deficient in minerals, vitamins and amino acids.
- Yeast growth requires FAN (Free Amino Nitrogen)
- DAP is widely used in molasses fermentation as a source nitrogen
- At Renegade Rum Distillery, a nutrient cocktail is used for the source of nitrogen and minerals

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Contamination

- Bacterial contamination during fermentation can result in reduction in ethanol yield and off notes.
- Contaminant bacteria compete with yeast for sugar substrates and micronutrients and produce end products such as lactic acid and acetic acids that inhibit yeast growth and metabolism.
- Contaminants can arise from tanks, transfer lines, heat exchangers, raw materials, yeast preparation and storage.
- At Renegade Rum, a robust 3 step CIP is the standard procedure to mitigate contamination along with daily cleaning of sugar cane mills.

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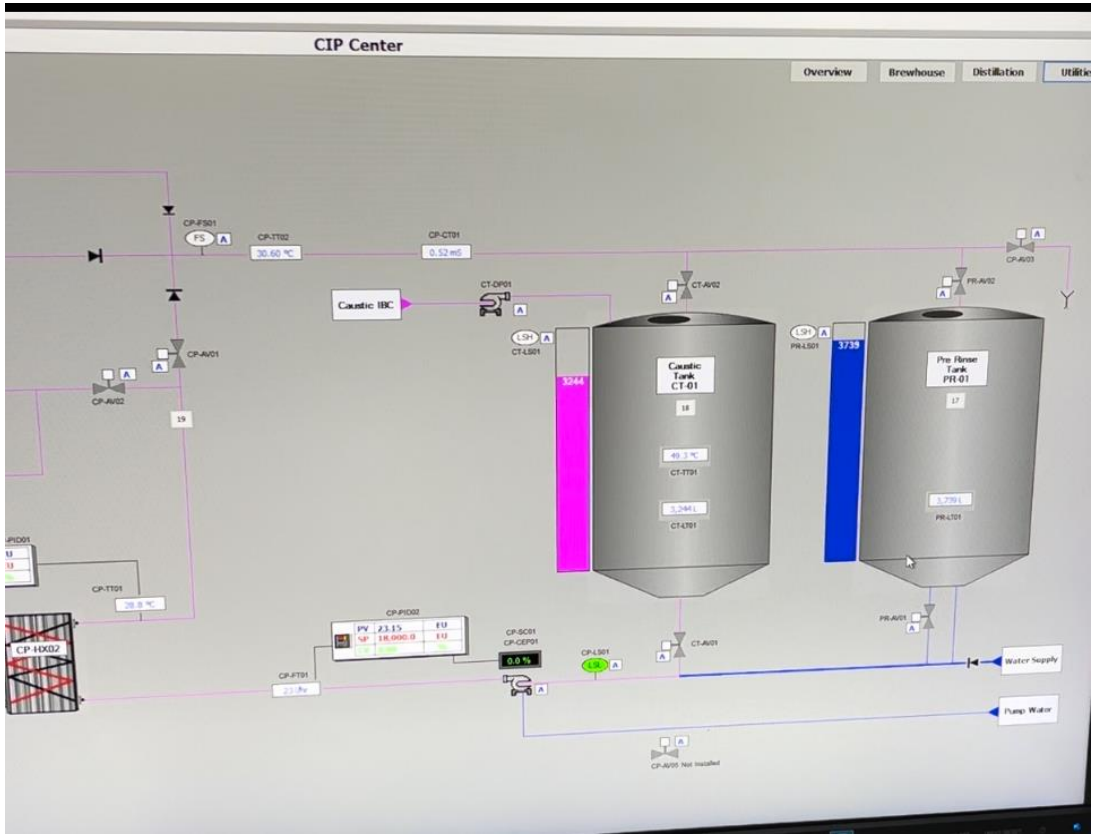
Sanitation

- At Renegade Rum sanitation is key in fermentation
- A 3-step CIP is the SOP implemented to mitigate contamination (Pre-rinse, Caustic, Final rinse)
- Daily cleaning of mills
- Weekly physical review of washbacks and juice tanks to test spray balls and review shadow areas



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Fermentation Monitoring

The life cycle of each fermenter is monitored from pitching to transfer to distillation. Every 4 hrs. operators will:

- Circulate washback
- Collect sample
- Test brix and pH
- Test % ABV

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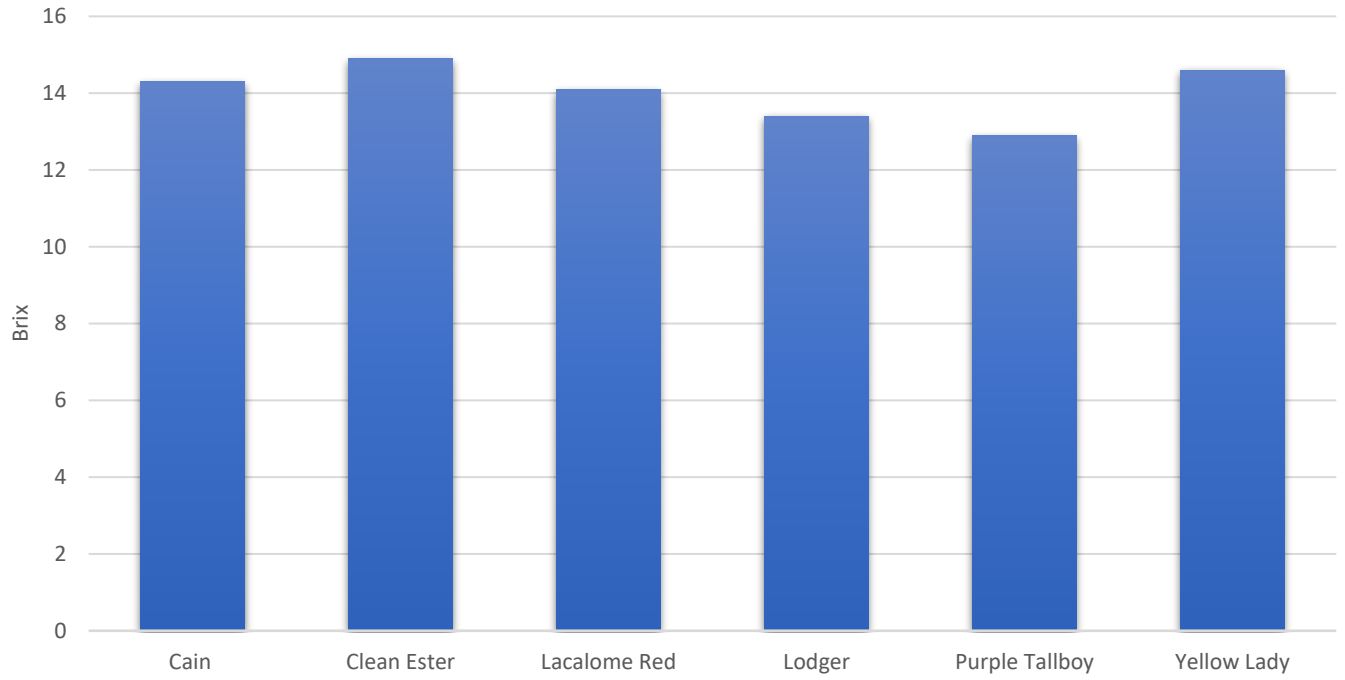
Analysis of Feedstock – Variety vs Brix

Brix in cane varies with cane variety (Similar age cane – 12 months)



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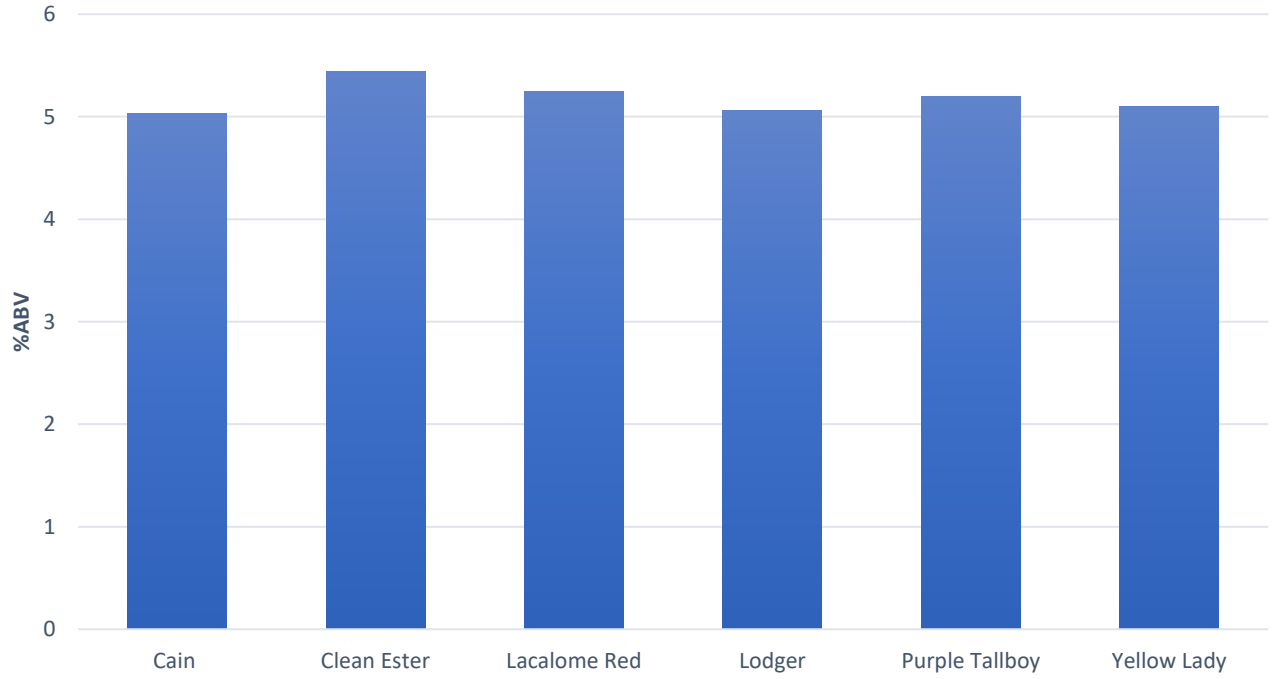
Analysis of Feedstock – Variety vs % ABV in Fermenter



% abv in fermenter varies with cane variety (Consistent pitching conditions)

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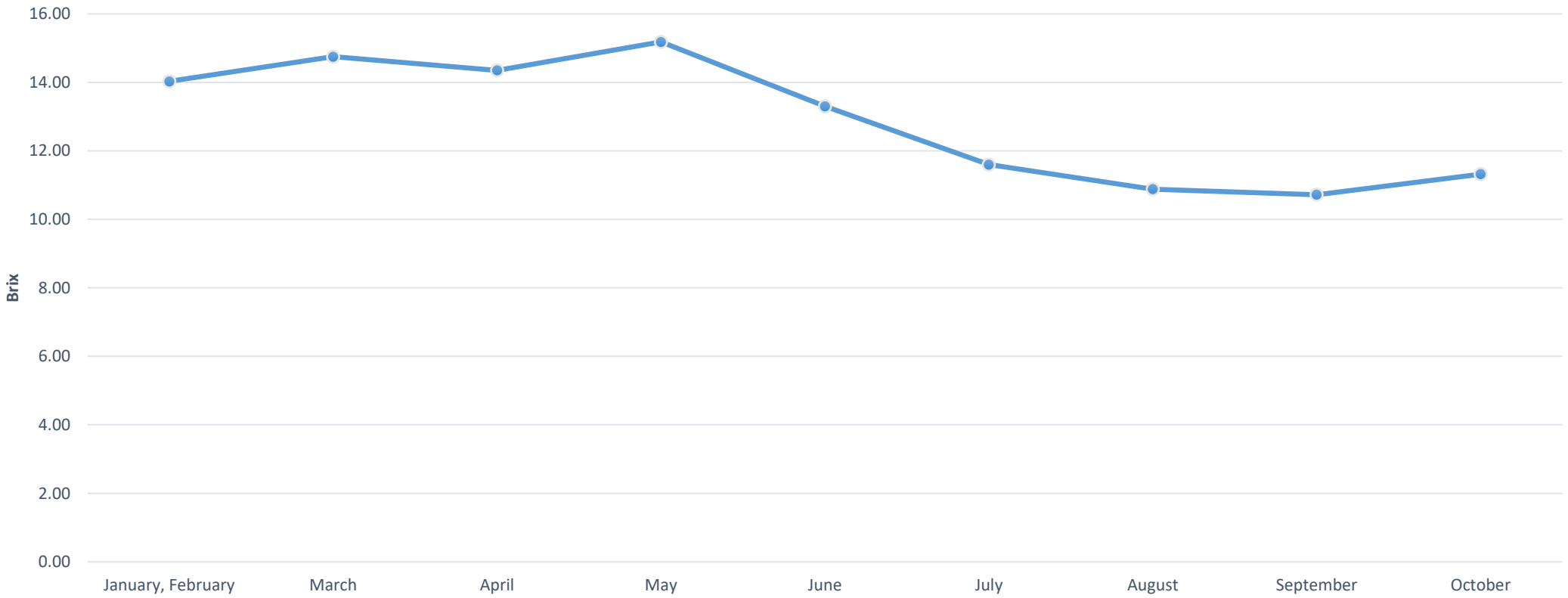
Effect of Time of Harvesting Feedstock

Brix in juice varies with month of harvest- best period to harvest is January to June



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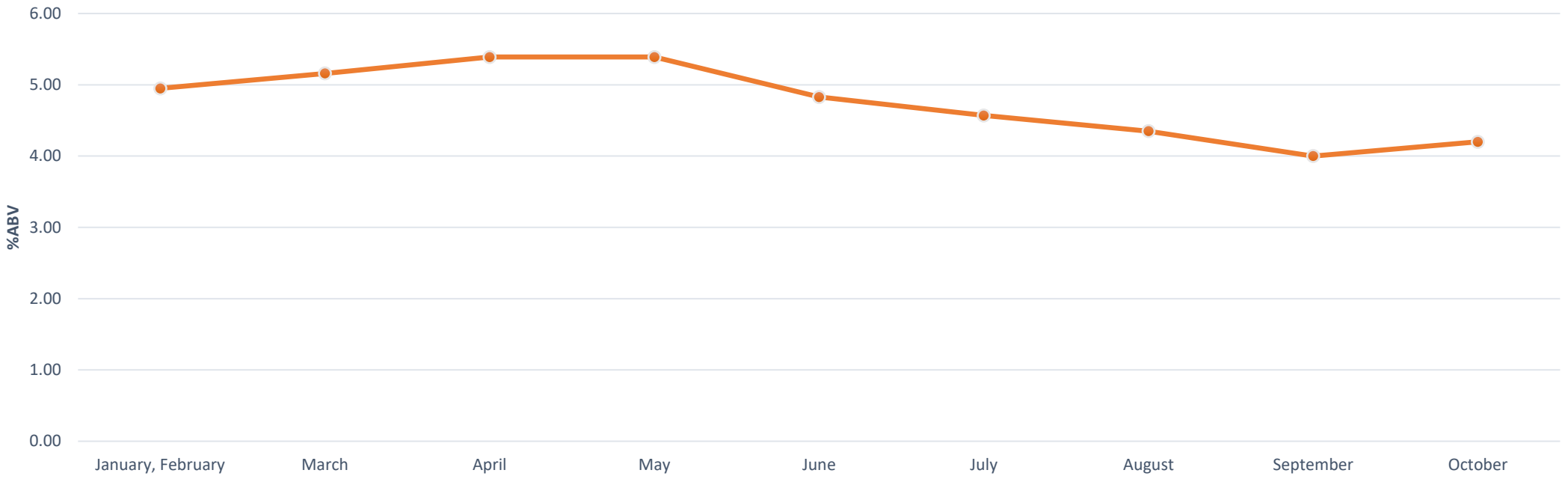
Effect of Time of Harvesting Feedstock

% Abv in fermenter varies with month of harvest



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Fact Sheet

- Targeted % abv in fermented wash – 5.8%
- Average % abv in fermented wash – 5.01%
- Targeted start brix in fermentation – 14.5
- Average start brix in fermenter – 13.4
- Calculated % FE – 84%

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Questions & Answers

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