RQF LEVEL 5

FOPSP503

FOOD PROCESSING

Sugarcane Processing

TRAINEE'S MANUAL

October, 2024

SUGARCANE PROCESSING

KOICA Korea International Cooperation Agency

TQUM TVET Quality Management Project

2024

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Original published version: October 2024

ACKNOWLEDGEMENTS

The publisher would like to thank the following for their assistance in the elaboration of this training manual:

Rwanda TVET Board (RTB) extends its appreciation to all parties who contributed to the development of the trainer's and trainee's manuals for the TVET Certificate V in Food Processing, specifically for the module **"FOPSP503: Sugarcane Processing."**

We extend our gratitude to KOICA Rwanda for its contribution to the development of these training manuals and for its ongoing support of the TVET system in Rwanda.

We extend our gratitude to the TQUM Project for its financial and technical support in the development of these training manuals.

We would also like to acknowledge the valuable contributions of all TVET trainers and industry practitioners in the development of this training manual.

The management of Rwanda TVET Board extends its appreciation to both its staff and the staff of the TQUM Project for their efforts in coordinating these activities.

This training manual was developed:

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ACRONYMS

°Bx: Brix

°F: Degree Fahrenheit

^{0}C: Degree Celsius

CBT/A: Competency-Based Training/Assessment

DCH: Direct Contact Heater

GMO: Genetically Modified Organism

HPLC: High-performance liquid chromatography

IER: Ion exchange resins

KOICA: Korea International Cooperation Agency

MCS: Melt Clarification System

PAC: Powdered activated carbon

PE: Polyethylene

pH: Hydrogen Potential

PP: Polypropylene

PPE: Personal protective equipment

RTB: Rwanda TVET Board

SCS: Syrup Clarification System

TLC: Thin-layer chromatography

TQUM: TVET Quality Management

TVET: Technical and Vocational Education and Training

INTRODUCTION

This trainee's manual includes all the knowledge and skills required in food processing specifically for the module of **"Sugarcane Processing".** Trainees enrolled in this module will engage in practical activities designed to develop and enhance their competencies.

The development of this training manual followed the Competency-Based Training and Assessment (CBT/A) approach, offering ample practical opportunities that mirror real-life situations.

The trainee's manual is organized into Learning Outcomes, which is broken down into indicative content that includes both theoretical and practical activities. It provides detailed information on the key competencies required for each learning outcome, along with the objectives to be achieved.

As a trainee, you will start by addressing questions related to the activities, which are designed to foster critical thinking and guide you towards practical applications in the labour market. The manual also provides essential information, including learning hours, required materials, and key tasks to complete throughout the learning process.

All activities included in this training manual are designed to facilitate both individual and group work. After completing the activities, you will conduct a formative assessment, referred to as the end learning outcome assessment. Ensure that you thoroughly review the key readings and the 'Points to Remember' section.

MODULE CODE AND TITLE: FOPSP503 SUGARCANE PROCESSING

Learning Outcome 1: Prepare workplace and sugarcane
Learning Outcome 2: Make syrup
Learning Outcome 3: Crystallize syrup
Learning Outcome 4: Refine brown sugar

Indicative contents
1.1. Selecting materials, tools and equipment used in sugar processing
1.2. Arranging the workplace
1.3 Receiving the sugarcane

Key Competencies for Learning Outcome 1: Prepare workplace and sugarcane.

Knowledge	Skills	Attitudes
• Identification of tools and equipment used in sugarcane processing • Explanation of the sugar processing flow diagram • Identification of quality parameters of sugarcane used in sugar processing	• Selecting tools and equipment • Adjusting tools and equipment • Cleaning workplace, tools and equipment • Arranging the workplace • Preparing sugar packaging materials • Receiving sugarcane	• Paying attention while adjusting tools and equipment • Being responsible when using tools and equipment • Being honest while receiving sugarcane

Duration: 10 hrs

Learning outcome 1 objectives:

By the end of the learning outcome, the trainees will be able to:

1. Identify properly tools and equipment used in sugarcane processing
2. Select properly materials, tools and equipment for sugarcane processing
3. Adjust correctly tools and equipment for sugarcane processing
4. Clean effectively workplace, tools and equipment for sugarcane processing
5. Prepare correctly sugar packaging materials for sugar packaging
6. Explain correctly the sugar processing flow diagram used in sugarcane processing
7. Arrange appropriately the workplace for sugarcane processing
8. Receive properly materials used in sugarcane processing

Resources

Equipment	Tools	Materials
• Weighbridge, • Balance, • Air blower, • Unloader machine, • Conveyor belt, • Air condenser, • Boiler, • Water tanks, • Turbine, • Cutters, • Fibrizor, • Mills,	• Polarimeter or saccharimeter • refractometer, • Squeegee, • Mop, • White towel, • Wooden brush, • Thermometer, • pH meter, • analytic balance, • metallic brushes	• Sugarcane, • Disinfectant, • Single use gloves, • Detergents, • Magadi soda • Packaging materials • Lime • Biocide • Flocculants • Caustic soda • Sulphurous acid

• Evaporation bodies, • Heaters, • Clarifier tank, • Vacuum filter, • Pumps, • PPEs, • Vacuum pump, • Crystallizer, • Vacuum pans, • Centrifugal machine • Hopper, • Bins, • Weighing scale		

Indicative content 1.1: Selecting materials, tools and equipment used in sugarcane processing

Duration: 3hrs

Theoretical Activity 1.1.1: Identification of tools and equipment used in sugarcane processing

Tasks:

1: Answer the following questions related to the identification of tools, and equipment for sugarcane processing:

i. What could be the tools and equipment used in sugarcane processing?
ii. What can be the uses of those tools and equipment?
iii. What could be the safety precautions when using those tools and equipment?

2: Provide the answers to questions by writing them on paper, flip chart, blackboard, or whiteboard.
3: Present the findings/answers to the whole class.
4: For more clarification, read the key readings 1.1.1. in trainee manual

Key readings 1.1.1.: Description of tools and equipment used in sugarcane processing

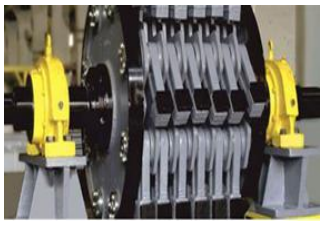
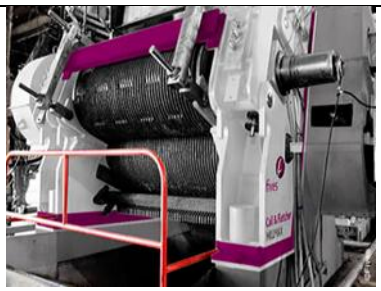
- Tools used in sugarcane processing

Types Of Tools	Picture	Use
Ph meter		It is used to measure the acidity of a sugarcane juice. It provides a precise measurement of the pH level, which is a scale ranging from 0 to 14.

Refractometer		It is used to measure the sugar content as (^{0}Brix) of the sugarcane juice and syrup.
A saccharimeter		It is used to determine sugar purity.

- Equipment used in sugarcane processing

Equipment	Description	Use
Weighbridge		It is a specialized piece of equipment used to accurately measure the weight of sugarcane loads.
Unloader machine		It is used to unload sugarcane from the truck.

Boiler		It used to produce steam for heating and sterilization.
Sugarcane cutter		It is used to cut sugarcane
Fibrizor		A fibrizor is a specialized machine used in sugarcane processing to break down the fibrous material of sugarcane into smaller, more manageable particles.
Sugarcane mill		It is used to crush sugarcane and release the juice

Heater		It is used to heat sugarcane juice
Sugar crystallizer		It is used in the sugar refining process to convert concentrated sugar syrup into sugar crystals.
Vacuum pans		It used to concentrate the sugar solution by evaporating water

- **Safety precautions while using tools and equipment for sugarcane processing**

Sugarcane processing involves working with heavy machinery and sharp tools. It's essential to prioritize safety to prevent accidents and injuries. Here are some key precautions:

✓ **General safety measures for tools and equipment:**

- Wear appropriate PPE, including safety glasses, gloves, safety boots, and hard hats.
- Ensure all workers are properly trained on the safe operation of machinery and equipment.
- Have clear emergency procedures in place and ensure all workers are familiar with them.
- Handle chemicals safely and according to manufacturer's instructions
- Store chemicals in a secure location.

- Use ergonomic equipment and practices to prevent injuries from repetitive tasks.

Practical Activity 1.1.2: Selecting and adjusting tools and equipment for sugarcane processing

Task:

You are asked to go in sugarcane processing workshop to select and adjust tools and equipment for sugarcane processing.

1: Apply safety precautions

2: Referring to the selection criteria and adjustment procedures, select and adjust tools and equipment for sugarcane processing.

3: Present your work to the trainer and the whole class.

4: Read key reading 1.1.2 and ask for clarification where necessary

5: Perform the task provided in the application of learning 1.1.

Key readings 1.1.2: Selecting of tools and equipment

- Selection criteria of tools and equipment for sugarcane processing

  The selection of tools and equipment for sugarcane processing is crucial to ensure efficient and effective sugar extraction. Here are some key criteria to consider:

✓ The tools and equipment should be made from high-quality materials that can withstand the harsh conditions of sugarcane processing.
✓ The equipment should be reliable and have a low failure rate to minimize downtime and maintenance costs.
✓ For tasks that require precise measurements or control, the equipment should be accurate and precise.
✓ The equipment should be able to handle the desired volume of sugarcane efficiently.
✓ The equipment should be energy-efficient to reduce operating costs.

- ✓ The equipment should be easy to maintain and have readily available spare parts.
- ✓ The equipment should be designed with safety features to protect operators from injuries.
- ✓ The equipment should comply with food safety regulations and be easy to clean and sanitize.
- ✓ The equipment should be affordable, considering the budget constraints of the processing facility.
- ✓ The equipment should be compatible with other components of the sugarcane processing plant, ensuring smooth operation and integration.
- ✓ The equipment should comply with relevant industry standards and regulations.

Adjusting tools and equipment

- Functionality of tools and equipment.

✓ **Refractometer**

Analog/hand refractometer:

To use an analogy /handheld refractometer follow the steps below:

- Open the cover and aim the refractometer with the prism toward a bright light or a light source. If necessary, turn the focus ring until the scale is sharp.
- Open the cover and wipe the prism with a soft cloth.
- Apply a few drops of fluid to be measured to the prism. Close the cover and press lightly so that the liquid spreads over the prism without forming bubbles.
- Hold the device horizontally and wait 30 seconds for temperature compensation to work.
- Read the value on the dividing line between white and blue.
- Clean and dry the prism.

Digital refractometer:

To use a digital refractometer, follow the steps below:

- Switch ON button of device.
- Clean the test area and prism with a clean and soft textile or paper towel before applying the test liquid.
- Place the device on a flat, horizontal surface.
- Apply a few drops of the test liquid to the test area. Then press the Read button.
- After a few seconds the reading will be displayed on the screen.
- Clean the test area immediately after use.

- **pH-meter:**

  To use a pH meter, follow the steps below:

✓ Remove the protective cap of the pH meter
✓ First rinse the electrode with distilled water and suck it with filter paper.
✓ Turn the pH meter on by pressing the “ON/OFF” button.
✓ Immerse the pH meter electrode in the solution to be tested (should not be ove r the immersion line).
✓ Stir gently and wait around 30 seconds till the reading stabilizes.
✓ After finishing, clear the electrode with pure water, and turn the pH meter off by pressing the “ON/OFF” button.
✓ Always replace the protective cap after use.

- **Balance:**

  Weighing balances are used to measure the weight of objects with a high degree of accuracy. However, over time, balances can become inaccurate due to wear and tear, environmental factors, or improper use. It is important to adjust your weighing balance regularly to ensure that it is providing accurate readings.

- **Steps to adjust a weighing balance**

✓ **Make sure the balance is levelled.**

Use a spirit level to check the level of the balance platform. If the balance is not levelled, adjust the feet until it is levelled.

✓ **Zero the balance.**

Place a tared weight on the balance platform and press the zero button. The balance should now read zero.

✓ **Adjust the sensitivity.**

The sensitivity of the balance controls how much the balance needle moves in response to a change in weight. Adjust the sensitivity so that the needle moves smoothly and evenly.

✓ **Calibrate the balance.**

Calibration is the process of comparing the readings of the balance to a known standard weight. To calibrate the balance, use a calibration weight that is certified by a recognized laboratory.

- **Adjustment procedure:**
  - Place the calibration weight on the balance platform.
  - Read the weight displayed on the balance.
  - Adjust the balance so that the displayed weight matches the known weight of the calibration weight.
  - Repeat steps 2 and 3 for each adjustment weight that you are using.
- **calibrating a weighbridge:**

A weighbridge, also known as a truck scale, is a precision instrument that requires regular calibration to ensure accurate weight measurements. Here are the general steps involved in calibrating a weighbridge:

- **Preparation:**

  - Ensure that the weighing platform is clear of any obstructions or debris.
  - Inspect the weighbridge for any visible damage to the platform, load cells, or other components.
  - Have the required tools on hand, such as calibration weights, screwdrivers, and wrenches.

- **Calibration:**

  - Place known calibration weights onto the weighing platform.
  - Compare the displayed weight reading with the known weight of the calibration weights.
  - If there is a discrepancy between the displayed weight and the actual weight, make adjustments to the weighbridge's calibration settings. This may involve adjusting screws or using calibration software.
  - Repeat the calibration process with different calibration weights to ensure accuracy across the entire weighing range.

- **Verification:**

  - After making adjustments, re-check the weight readings with the calibration weights to verify that the calibration is accurate.
  - Test the weighbridge with various loads to ensure consistent and accurate measurements.

Documentation:

- Document the calibration process, including the calibration weights used, adjustments made, and the final weight readings.
- Keep a record of all calibration activities for future reference and regulatory compliance.

Practical Activity 1.1.3: Selecting materials and preparing packaging materials used in sugarcane processing

Task:

You are asked to go to the sugarcane processing workshop to select materials and prepare sugar packaging material to be in sugarcane processing.

1: Apply safety precautions

2: Referring to the selection criteria, select materials and prepare packaging materials for sugarcane processing.

3: Present your work to the trainer and the whole class.

4: Read key reading 1.1.3. and ask for clarification where necessary

5: Perform the task provided in the application of learning 1.1.

Key readings 1.1.3: Selecting materials used in sugarcane processing

- Selection criteria of materials used sugarcane processing.

The selection of products used in sugarcane processing is crucial to ensure efficient and effective sugar extraction. The following are key criteria to consider:

✓ **Quality:**

The products should be of high quality and free from impurities that could contaminate the sugar. The products should be compatible with the sugarcane processing machinery and methods.

✓ **Efficiency:**

The products should be efficient in their intended use, ensuring optimal performance and minimal waste.

✓ **Safety:**

The products should be safe for use in food processing, ensuring that they do not pose any health risks to consumers.

✓ **Cost-effectiveness:**

The products should be cost-effective, considering factors such as initial cost, performance, and durability.

✓ **Sustainability:**

Where possible, consider products that are sourced sustainably and have a minimal environmental impact.

Specific product categories and selection criteria:

✓ **Chemicals:**

- **Clarifying agents:** Should be effective at removing impurities from the sugar juice without affecting its quality.
- **Bleaching agents:** Should be safe and effective for whitening the sugar.

- **Preparation of packaging materials:**

✓ **Selection criteria of sugar packaging material**

- The packaging materials should be approved for use with food products.
- The packaging should be strong enough to protect the sugar during transportation and storage.
- Consider using sustainable packaging materials that are environmentally friendly

✓ **Labelling the sugar packaging material**

Labelling sugar packaging material is essential for providing consumers with essential information about the product and ensuring regulatory compliance. Here are the key elements that should be included on a sugar packaging label:

✓ **Mandatory information:**

- **Net weight:** The total weight of the sugar contained in the package.

- **Nutrition facts:** A nutritional label providing information about calories, fat, carbohydrates, protein, sodium, and other nutrients.
- **Best before:** The date by which the sugar is recommended to be consumed.
- **Storage instructions:** Guidelines on how to store the sugar properly to maintain its quality.
- **Country of origin:** The country where the sugar was produced or processed.
- **Manufacturer or distributor information:** The name and contact details of the manufacturer or distributor.

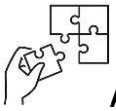
✓ **Additional information:**

- **Brand name:** The name of the sugar brand.
- **Product type:** The specific type of sugar, such as granulated, powdered, or organic.
- **Claims or certifications:** Any claims made about the product, such as "organic," "fair trade," or "non-GMO," should be supported by appropriate certifications.
- **Barcode:** A barcode that can be scanned at the point of sale.

Points to Remember

- Each tool or equipment plays a vital role in ensuring that sugarcane is processed efficiently from reception to the final products.
- It is strictly recommended to adhere to safety precautions while processing sugarcane to avoid accidents and injuries.
- While selecting tools and equipment for sugarcane processing bear in mind the selection criteria.
- Selecting the right tools and equipment helps optimizing their operations while ensuring product quality meets consumer demands
- Wear all necessary PPE before selecting tools and equipment for sugarcane processing
- Unplug electrical equipment when not in use.
- Beware to follow the manufacturer's instructions when using or adjusting tools or equipment.
- For safety issues, always wear PPE before selecting chemicals for sugarcane processing.

- Good packaging material for sugar must fulfil the requirements including inert to the product, moisture and gas barrier and provided with tamper-proof seals and closures**.**



Application of learning 1.1.

There is an exhibition in your district and your school will showcase brown and white sugar.

You are asked to go to the sugarcane processing workshop to:

- Select materials, tools and equipment to be used in sugarcane processing
- Adjust tools and equipment to be used in sugarcane processing

Indicative content 1.2: Arranging workplace

Duration: 3 hrs

Practical Activity 1.2.1: Cleaning and arranging workplace, tools and equipment used in sugarcane processing

Task:

You are asked to go to the sugarcane processing workshop to clean and arrange tools and equipment for sugarcane processing.

1: Apply safety precautions

2: Referring to the cleaning techniques, clean the workplace, tools and equipment for sugarcane processing.

3: Present your work to the trainer and the whole class.

4: Read key reading 1.2.1 and ask for clarification where necessary

5: Perform the task provided in the application of learning 1.2.

Key readings 1.2.1: Cleaning and arranging tools and equipment used in sugar processing

- **Cleaning methods used in sugarcane processing workplace**

Effective cleaning is essential in sugarcane processing to maintain product safety, quality, and prevent contamination. Here are some common cleaning methods:

✓ **High-pressure water washing:**
- **Method:** Using high-pressure water jets to remove dirt, debris, and contaminants from surfaces.
- **Applications:** Cleaning machinery, equipment, floors, and walls.

✓ **Chemical cleaning:**
- **Method:** Using specialized cleaning chemicals to remove specific types of contaminants.
- **Applications:** Cleaning equipment, filters, and storage tanks.
- **Common chemicals:** Detergents, sanitizers, degreasers, and descalers.

✓ **Steam cleaning:**

- **Method:** Using high-pressure steam to clean and sanitize surfaces.
- **Applications:** Cleaning machinery, floors, and walls.

✓ **Ultrasonic cleaning:**

- **Method:** Using high-frequency sound waves to create cavitation, which dislodges dirt and contaminants.
- **Applications:** Cleaning small parts and delicate equipment.

✓ **Mechanical cleaning:**

- **Method:** Using brushes, scrapers, or other mechanical tools to remove dirt and debris.
- **Applications:** Cleaning floors, walls, and equipment.

✓ **Specialized cleaning techniques:**

- **CIP (Clean-In-Place):** For closed systems, CIP involves circulating cleaning solutions through the system to clean it without disassembly.
- **COP (Clean-Out-of-Place):** For equipment that cannot be easily cleaned in place, COP involves disassembling the equipment and cleaning it manually or using specialized cleaning techniques.

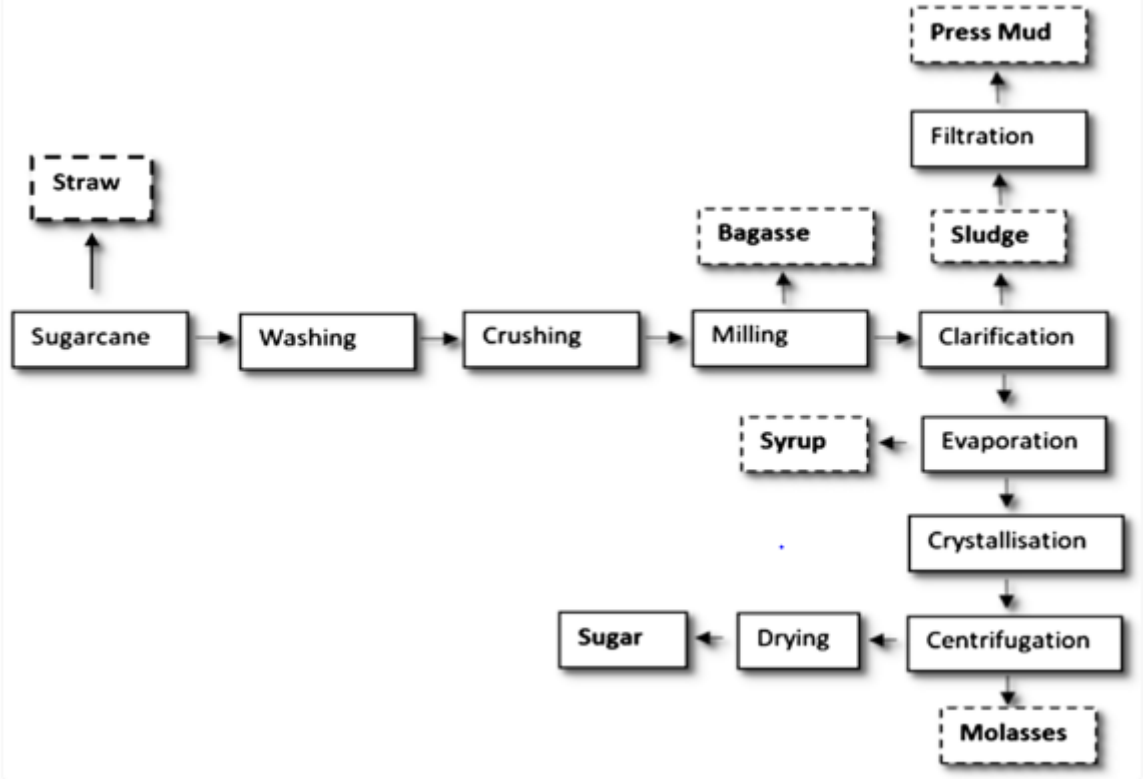
- **Factors to consider when cleaning workplace, tools and equipment:**

✓ **Type of contaminant:** Different cleaning methods are more effective for removing specific types of contaminants.

✓ **Surface material:** The material of the surface to be cleaned will influence the choice of cleaning method.

✓ **Food safety regulations:** Cleaning procedures must comply with food safety regulations and standards.

✓ **Equipment sensitivity:** Some equipment may require specific cleaning methods to avoid damage.



Process flow chart of sugarcane processing

Points to Remember

- For safety issues, clean thoroughly the workplace, tools and equipment for sugarcane processing
- While arranging the workplace, follow the sugarcane processing flow chart to avoid cross contamination, accidents and injuries.

Application of learning 1.2.

There is an open day at your school, trainees will showcase brown and white sugar. You are asked to go to the sugarcane processing workshop to:

- Clean workplace, tools and equipment for sugarcane processing
- Arrange the workplace, tools and equipment for sugarcane processing.

Indicative content 1.3: Receiving the sugarcane

Duration: 4 hrs

Practical Activity 1.3.1: Receiving sugarcane used in sugarcane processing

Task:

You are asked to go to the sugarcane processing workshop to receive sugarcane used in sugarcane processing

1: Apply safety precautions

2: Referring to the sugarcane quality parameters, receive and weigh sugarcanes.

3: Present your work to the trainer and the whole class.

4: Read key reading 1.3.1 and Ask for clarification where necessary

5: Perform the task provided in the application of learning 1.3.

Key readings 1.3.1: Receiving sugarcane used in sugarcane processing

- **The acceptance criteria of sugarcane**

Assessing sugarcane quality before harvesting is crucial for optimizing yields and ensuring the production of high-quality sugar. Here are the key quality parameters of sugarcane, which are crucial for determining the overall quality of the sugar produced:

✓ **Age:**

- Mature sugarcane tends to have higher sugar content and better quality.
- With adequate rain and sunshine, a sugar cane crop typically takes between 16-24 months to mature
- Over-ripe sugarcane may have lower sugar content due to inversion (conversion of sucrose to reducing sugars).

✓ **Brix:**

- A measure of the total soluble solids content in the sugarcane juice.
- Higher Brix levels indicate higher sugar content.
- Ideal Brix levels vary depending on the sugarcane variety and region.

- Brix content should range from 17% - 22%

✓ **Polarity:**
- Also known as sucrose content or purity.
- Measures the percentage of sucrose in the total soluble solids.
- Higher polarity indicates a higher proportion of sucrose, which is desirable for sugar production.

✓ **Purity:**
- The ratio of sucrose to non-sugar solids in the juice.
- Higher purity means less impurities, leading to a higher-quality sugar product.
- Purity should range from 85% - 92%

✓ **Trash analysis:**
- Measures the amount of impurities (trash) in the sugarcane, such as dirt, leaves, and other foreign matter.
- Lower trash content is desirable for efficient processing and higher sugar yield.

✓ **Weight of notes:**
- Measures the weight of individual sugarcane stalks.
- Heavier stalks generally indicate higher sugar content.

✓ **Fiber percent:**
- The percentage of fiber in the sugarcane is 10% -15%.
- Lower fiber content is desirable for efficient juice extraction.

✓ **pH of Juice:**
- The pH of the sugarcane juice can affect the processing and quality of the sugar.
- A slightly acidic pH is generally preferred for optimal sugar extraction.
- Sugar cane juice is naturally acidic with pH range from 4.5 – 5.5

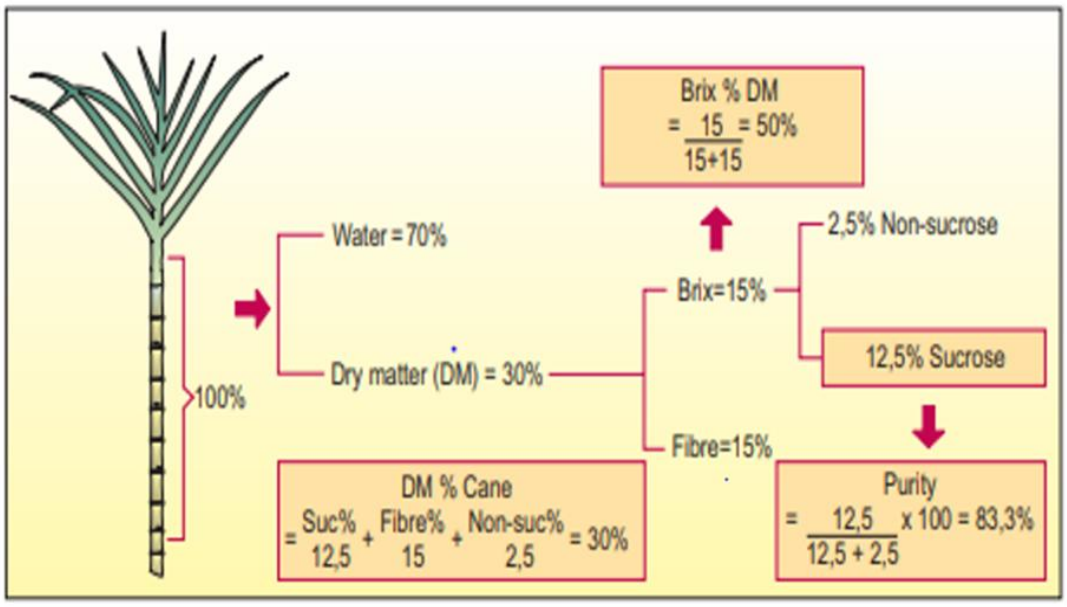


Diagram of a clean stalk of a sugarcane its quality components and their relationship

- **Weighing sugarcane**

Weighing sugarcane before processing is crucial for several reasons:

- ✓ **Accurate payment**

It ensures that farmers are paid fairly for the sugarcane they deliver based on the actual weight.

- ✓ **Production planning**

Knowing the amount of sugarcane received helps in planning the processing capacity and resource allocation.

- ✓ **Inventory management**

Accurate weight records help in tracking the inventory of sugarcane and managing stock levels.

- ✓ **Quality control**

By measuring the weight of sugarcane, it's possible to calculate the yield and quality of the juice extracted, helping to identify any issues in the processing.

- ✓ **Data analysis:**

Weighing data can be used for analysis to improve efficiency and optimize the processing operations

Sugarcane is typically weighed at sugar processing units using a weighbridge**.** This is a large, specialized scale designed to measure the weight of heavy loads, such as trucks or trailers filled with sugarcane.

- Weighing bridge working principles:

✓ **Truck entry:** The sugarcane-laden truck or trailer drives onto the weighing platform of the weighbridge.

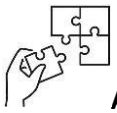
✓ **Weight measurement:** The platform contains sensors that measure the weight of the vehicle and its cargo.

✓ **Display:** The weight reading is displayed on a digital screen or other readout device.

✓ **Data recording:** The weight data is often recorded electronically for tracking and accounting purposes.

Points to Remember

- For high-quality sugar production, only receive sugarcanes with acceptable quality parameters.
- Weighing accurately sugarcane helps to calculate the yield and quality of the juice extracted, helping to identify any issues in the processing.



Application of learning 1.3.

The school 'supplier brought sugarcane for sugar making. You are asked to go in the sugarcane processing workshop to:

- Receive sugarcanes for sugarcane processing
- Weigh sugarcane

Learning Outcome 1 end Assessment

Theoretical assessment

1. Match each tool/equipment with its use by writing the letter corresponding to the correct answer in the column named **"Answer".**

Answer	Tool/Equipment	Use
1……	1. Crystallizer	a) It is used to measure the sugar content as (Brix) in sugarcane juice.
2……	2. Boiler	b) It used to produce steam for heating and sterilization.
3……	3. pH meter	c) It is a piece of equipment used in the sugar refining process to convert concentrated sugar syrup into sugar crystals
4……..	4. Vacuum pan	d) It is used to measure the acidity of a sugarcane juice.
5……..	5. . Saccharimeter	e) It is used to concentrate sugarcane juices by removing water through evaporation.
	6. Weighbridge	

2. Read carefully the following statements and choose by encircling the letter corresponding to the right answer.

I. The following are the safety precautions of using tools and equipment except;

a) Handle chemicals safely and according to manufacturer's instructions

b) Have clear emergency procedures in place and ensure all workers are familiar with them.

c) Mill sugarcanes finely to extract juice

II. The following are the selection criteria of tools and equipment for sugarcane processing except;

a) The tools and equipment should be made from high-quality materials that can withstand the harsh conditions of sugarcane processing
b) The tools and equipment should have a short lifespan so as to be replaced every month
c) The equipment should be easy to maintain and have readily available spare parts.

3.Read carefully the following statements related to selection criteria of materials used in sugarcane processing and answer by "**True"** if it correct or" **False"** if it is incorrect.

a) The chemical products should be of high quality and contain some impurities that could contaminate the sugar……

b) The products should be efficient in their intended use, ensuring optimal performance and minimal waste……

c) The products should be safe for use in food processing, ensuring that they do not pose any health risks to consumers……

d) The products should be expensive to be of high quality, considering factors such as initial cost, performance, and durability……

e) Sugarcane should be overripe to contain high quantity of sugar……

Practical assessment

The school is organizing an open day. In that event, tea and coffee will be served and guests will use sugar made by trainees. You are asked to go in the sugarcane processing workshop to perform the following tasks:

1. To select materials, tools and equipment for sugarcane processing
2. To clean the workplace, tools, and equipment for sugarcane processing
3. To arrange the workplace, tools and equipment for sugarcane processing
4. To receive sugarcanes for sugar production

The task should be completed within 3 hours.

END

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CLEAR
JUICE

Indicative contents
2.1 Extracting raw juice from sugarcane
2.2 Heating raw juice
2.3 Clarifying treated juice for sugar processing
2.4 Evaporating clear juice

Key Competencies for Learning Outcome 2: Make syrup

Knowledge	Skills	Attitudes
• Description of bagasse and raw juice • Identification of raw juices heating stages. • Description of the types of raw juice and quality parameters of clear juice	• Cutting sugarcane into small piece • Milling sugarcane • Analysing the bagasse and raw juice • Mixing and filtration of mixed juice • Liming of heated juice • Clarifying treated juice • Measuring the quality of clear juice • Evaporating clear juice • Checking the effectiveness of evaporation process	• Paying attention while operating machines • Being accurate when analysing the bagasse and raw juice • Being patient when clarifying treated juice • Being precise when measuring quantities

Duration: 25hrs

Learning outcome 2 objectives:

By the end of the learning outcome, the trainees will be able to:

1. Describe properly the quality parameters of bagasse and raw juice for sugarcane processing
2. Cut precisely sugarcane into small pieces according to the size of hooper.
3. Mill properly sugarcane for juice extraction
4. Analyse effectively the bagasse and raw juice referring to quality specifications
5. Filter perfectly mixed juice according to filtration methods
6. Lime adequately heated juice referring to juice quality specifications
7. Clarify properly treated juice according to clarification techniques
8. Measure the quality of clear juice in accordance with clear juice quality specifications
9. Evaporate properly clear juice for sugar syrup making
10. Check correctly the effectiveness of evaporation process as used in sugar syrup making

Resources

Equipment	Tools	Materials
● Cutters ● Fibrizor ● Mills ● Evaporation bodies ● Heaters ● Clarifier tank ● Vacuum filter ● Pumps ● Condenser ● Boiler ● Water tanks ● Turbine ● PPE ● Vacuum pump	● pH meter ● Thermometer ● Refractometer ● Spectrophotometer ● Measuring cylinder ● Polarimeter ● Sample ● Conductometer	● Biocide, ● Lime, ● Flocculent, ● Water, ● Caustic soda, ● Sulphurous acid

Indicative content 2.1: Extracting raw juice from sugarcane

Duration: 7 hrs

Theoretical Activity 2.1.1: Identification of types of raw juices

Tasks:

1: You are requested to answer the following question related to the identification of types of raw juices.

i. What do you think could be the types of raw juices extracted from sugarcanes?
ii. What could be the characteristics of those types of juices?
iii. How do you think sugarcane raw juice is treated?

2: Provide the answers to questions by writing them on paper, flip chart, blackboards, or whiteboards.

3: Present the findings/answers to the whole class.

4: For more clarification, read the key readings 2.1.1

Key readings 2.1.1: Identification of types of raw juices

- **Properties of A, B, and C Grade sugarcane juice as types of raw juice**

The grading of sugarcane juice is based on its quality and sugar content. Here's a breakdown of the typical properties associated with A, B, and C grades:

✓ **A-Grade Juice:**

- **Highest quality:** Considered the best quality juice, with high sugar content and minimal impurities.
- **Colour:** Light in colour, often with a golden hue.
- **Taste:** Sweet and clean with minimal off-flavours.
- **Purity:** High purity level, indicating a high proportion of sucrose.

✓ **B-Grade Juice:**

- **Good quality:** Still considered good quality but with slightly lower sugar content or more impurities compared to A-grade juice.

- **Colour:** May have a slightly darker colour than A-grade juice.
- **Taste:** Slightly less sweet or may have some off-flavours.
- **Purity:** Lower purity level than A-grade juice.

✓ **C-Grade Juice:**

- **Lower quality:** Considered lower quality due to lower sugar content, higher impurity levels, or other defects.
- **Colour:** May have a darker colour and may be cloudy.
- **Taste:** May have a bitter or off-flavour.
- **Purity:** Significantly lower purity level compared to A and B grades.

- **Quality of bagasse and raw juice**

Bagasse and raw juice are two key products of sugarcane processing. Their quality is essential for efficient production and the quality of the final sugar product.

✓ **Bagasse quality analysis**

Bagasse, the fibrous residue left after juice extraction, can be used as a fuel source or for other purposes. Key quality parameters include:

- **Moisture content:** Lower moisture content is desirable for efficient combustion and higher energy output.
- **Ash content:** Higher ash content can reduce the calorific value of bagasse.
- **Fiber content:** The fiber content can impact its suitability for different applications, such as fuel or pulp.
- **Particle size:** Smaller particle sizes are generally preferred for efficient burning in boilers.
- **Contaminants:** The presence of foreign materials, such as dirt or stones, can affect the quality of bagasse as a fuel.

✓ **Chemical composition of bagasse:**

- Cellulose: 45–55%
- Hemicellulose: 20–25%
- Lignin: 18–24%
- Ash: 1–4%
- Waxes: <1%

✓ **Raw juice quality analysis**

Raw juice, extracted directly from sugarcane, is the starting material for sugar production. The juice is an opaque liquid varying in colour from greenish-grey to dark green, and it carries suspended matter such as fine bagasse (bagacillo),

gums, albumin, wax, coloring matter, particles of soil, sand, clay. The quality parameters to analyse in raw juice are:

- **Brix:** A measure of the total soluble solids content, indicating the sugar concentration.
- **Purity:** The ratio of sucrose to non-sugar solids, indicating the quality of the juice.
- **Colour:** The colour of the juice can provide clues about its quality and potential impurities.
- **Acidity:** The pH level of the juice can affect processing and sugar quality.
- **Impurities:** The presence of impurities, such as dirt, wax, and proteins, can impact the clarity and quality of the final sugar product.

- **Mixing and filtration of mixed juice**

Mixing different types of sugarcane juice, such as A, B, and C grades, can be a valuable strategy in sugarcane processing. This can help to:

- ✓ **Balance sugar content:** Different types of sugarcane may have varying sugar content. By blending them, you can achieve a more consistent and desired sugar level in the final product.
- ✓ **Improve overall quality:** Combining juices from different sources can enhance the overall quality and flavor profile of the final product.
- ✓ **Optimize processing:** Mixing can help to optimize the processing efficiency and reduce variability in the downstream operations.

- **Factors to consider when mixing:**
  - ✓ **Sugar content:** Analyze the sugar content of each juice type to determine the optimal mixing ratios.
  - ✓ **Purity:** Consider the purity levels of the different juices to ensure a balanced final product.
  - ✓ **Color:** If color is a concern, ensure that mixing does not result in an undesirable color change.
  - ✓ **Flavor:** Evaluate the flavor profiles of the different juices to determine if they complement each other.

- **Mixing techniques:**
  - ✓ **Batch mixing:** Involves combining specific volumes of each juice type in a mixing tank.
  - ✓ **Continuous mixing:** Uses a continuous flow system to blend the juices as they are being processed.

- **Filtration of mixed juices**

Filtration is a critical step in sugarcane processing to remove impurities from the mixed juice and ensure the quality of the final sugar product.

- ✓ **Types of filters used:**
  - **Sand filters:**
    - Used for removing larger particles such as dirt and sand.
    - Typically consist of a bed of sand through which the juice is passed.
  - **Carbon filters:**
    - Used to remove color, odor, and certain impurities from the juice.
    - Often made of activated carbon, which has a high surface area for adsorption.
  - **Membrane filters:**
    - Use porous membranes to separate impurities from the juice based on size or charge.
    - Types include microfiltration, ultrafiltration, and Nano filtration.
  - **Clarifiers:**
    - Specialized equipment that combines filtration and sedimentation to remove impurities.
    - Often used in large-scale sugarcane processing plants.
- ✓ **Factors affecting filtration efficiency:**
  - **Juice properties:** The viscosity, pH, and temperature of the juice can affect filtration efficiency.
  - **Filter type:** The choice of filter depends on the specific impurities to be removed.
  - **Operating conditions:** Factors like flow rate, pressure, and filter bed depth can influence filtration performance.
- ✓ **Filtration process:**
  - **Pre-treatment:** The juice may be pre-treated to remove larger particles or adjust its properties before filtration.
  - **Filtration:** The juice is passed through the selected filter.
  - **Filtrate collection:** The filtered juice is collected for further processing.
  - **Filter cleaning:** The filter must be cleaned or replaced periodically to maintain its effectiveness.

Efficient filtration is essential for producing high-quality sugar.

Practical Activity 2.1.2: Extracting raw juice from sugarcane

Task:

You are asked to go to the sugarcane processing workshop to extract juice from sugarcane.

1: Apply safety precautions

2: Referring to the sugarcane juice extraction techniques, extract raw juice from sugarcane.

3: Present your work to the trainer and the whole class.

4: Read key reading 2.1.2 and ask for clarification where necessary

5: Perform the task provided in the application of learning 2.1.

Key readings 2.1.2.: Extracting raw juice from sugarcane

- **Sugarcane cutting**

Sugarcane cutting is the initial step in the sugarcane processing process. It involves harvesting the mature sugarcane stalks and cutting them into smaller, manageable pieces.

The primary purpose of sugarcane cutting is to prepare the sugarcane for subsequent processing steps, such as milling and juice extraction. By cutting the sugarcane into smaller pieces, it is easier to handle and process, and it increases the surface area available for juice extraction.

- **Milling sugarcane**

Milling is one of the most critical stages in sugarcane processing. It involves breaking down the sugarcane stalks and extracting the juice, which will later be processed into sugar.

Milling process:

- ✓ **Shredding:** The sugarcane stalks are shredded into smaller pieces to increase the surface area for efficient juice extraction.

- ✓ **Pressing:** The shredded sugarcane is pressed between rollers to extract the juice. This process can involve multiple stages of pressing to maximize juice yield.
- ✓ **Juice separation:** The extracted juice is separated from the fibrous residue (bagasse).

- **Factors affecting milling efficiency:**
  - ✓ **Sugarcane quality:** The quality of the sugarcane, including maturity, fiber content, and Brix level, affects juice extraction efficiency.
  - ✓ **Milling equipment:** The type and condition of the milling machines are crucial for optimal performance.
  - ✓ **Operating parameters:** Factors like roller pressure, speed, and temperature can influence juice yield.

- **Imbibition process in milling sugarcane**

Imbibition is a vital step in sugarcane processing, as it plays a crucial role in optimizing juice extraction and overall sugar yield. It is a critical process in sugarcane processing that involves the absorption of water by the sugarcane fibers.

The purpose of imbibition is to dilute the juice that is retained in the fibrous structure of bagasse. This ensures that this residual juice, which represents approximately half the weight of bagasse has a lower sucrose composition. The amount of imbibition water applied is generally defined as a percentage of the cane fiber weight (imbibition rate), which is an important extraction parameter.

- ✓ **Imbibition procedure:**
  - **Water application:** Warm (70-75^{o}C) water is applied to the shredded sugarcane.
  - **Absorption:** The sugarcane fibers absorb the water, causing them to swell.
  - **Increased porosity:** This swelling increases the porosity of the sugarcane fibers, making it easier for the juice to be extracted during the milling process.
- ✓ **Benefits of imbibition:**
  - Imbibition helps to increase the amount of juice that can be extracted from the sugarcane.
  - By improving juice extraction efficiency, imbibition can help reduce energy consumption during the milling process.
  - Imbibition can help to improve the quality of the extracted juice, leading to higher-quality sugar.

Points to Remember

- It is recommended to filter the raw juice from the sugarcane in order to remove impurities such as bagasse and mud.
- Mix different grades of sugarcane raw juice to effectively make a high-quality sugar.
- Milling is one of the most critical stage in sugarcane processing, monitor closely this stage while processing sugarcane.
- For effective sugarcane juice extraction, imbibition is recommended.

Application of learning 2.1.

There are bunches of sugarcane in the school's sugarcane processing workshop, you are asked to go to that workshop to extract the raw juice in those sugarcane.

Indicative content 2.2: Heating raw juice

Duration: 6 hrs

Practical Activity 2.2.1: Heating of raw juice

Task:

You are asked to go to the sugarcane processing workshop to heat raw juice from sugarcanes.

1: Apply safety precautions

2: Referring to the heating procedures of the raw juices, heat the raw juices from sugarcane.

3: Present your work to the trainer and the whole class. Ask for clarification where necessary

4: Read key reading 2.2.1 and ask for clarification where necessary

5: Perform the task provided in the application of learning 2.2.

Key readings 2.2.1: Heating of raw juice

- **Heating the sugarcane raw juice**

Heating raw juice in sugarcane production serves several purposes:

✓ **Clarification:**

Heating can cause impurities in the juice, such as proteins and gums, to coagulate. This makes it easier to remove these impurities through filtration or sedimentation, resulting in a clearer and more refined juice.

✓ **Sterilization:**

Heating can kill harmful microorganisms, such as bacteria and fungi, that may be present in the raw juice. This helps to prevent spoilage and ensure the safety of the final sugar product.

✓ **Evaporation:**

Heating can be used to evaporate water from the raw juice, concentrating it and preparing it for crystallization. This reduces the volume of the juice and makes it easier to handle and process.

✓ **Color adjustment:**

In some cases, heating can be used to adjust the color of the juice. For example, mild heating can help to caramelize the sugars in the juice, giving it a slightly darker and richer color.

✓ **Stages of heating raw juice before liming**

Heating the raw sugarcane juice before liming is a crucial step in the sugarcane processing industry. This process helps to improve the clarity and quality of the juice by denaturing proteins and other impurities, making them easier to remove through subsequent clarification steps.

- **Heating methods:**
  - **Direct heating:** Using steam or hot water to directly heat the juice.
  - **Indirect heating:** Using a heat exchanger to transfer heat from a hot fluid to the juice.

✓ **Factors to consider:**

- **Temperature:** The optimal temperature for heating can vary depending on the specific properties of the juice and the desired level of clarification.
- **Holding time:** The juice may need to be held at a specific temperature for a certain period to achieve the desired effects.
- **pH adjustment:** Lime may still need to be added after heating to fine-tune the pH to the desired level.

✓ **Stages of heating raw juice after liming**

The heating of limed juice in sugarcane processing typically involves the following stages:

- **Pre-heating:** The limed juice is initially heated to a temperature of around 60-70°C (140-158°F). This pre-heating step helps to denature proteins and other impurities, making them easier to remove through subsequent clarification processes.
- **Flash heating:** The pre-heated juice is then subjected to a rapid temperature increase, often using flash heaters. This step further denatures proteins and improves the coagulation process.
- **Holding:** The heated juice is held at a specific temperature for a period of time to allow for complete coagulation and sedimentation of impurities. The holding time and temperature can vary depending on the specific process conditions and the desired level of clarification.

- **Cooling:** After the holding period, the juice is cooled to a temperature suitable for filtration or other downstream processes.

Practical Activity 2.2.2: Liming of heated juice

Task:

You are asked to go to the sugarcane processing workshop to lime heated juice for sugar production.

1: Apply safety precautions

2: Referring to the liming procedures of heated juice, lime the heated juice for sugar production.

3: Present your work to the trainer and the whole class.

4: Read key reading 2.2.2 and ask for clarification where necessary

5: Perform the task provided in the application of learning 2.2.

Key readings 2.2.2: Liming of heated juice

- **Definition:**

Milk of lime is a suspension of calcium hydroxide (lime) in water. It is a crucial reagent used in the sugarcane processing industry for various purposes, including juice clarification, pH adjustment, and precipitation of impurities.

- **Purpose of liming raw juice for sugarcane processing**

Liming is a crucial step in sugarcane processing that serves several important purposes:

- ✓ **Clarification:** Lime (calcium hydroxide) reacts with impurities in the raw juice, forming calcium salts that can be more easily removed through filtration or sedimentation. This helps to clarify the juice and improve its appearance.
- ✓ **pH adjustment:** The pH of the juice needs to be adjusted to a specific range for efficient sugar crystallization. Liming is used to increase the pH of the

juice, making it more alkaline.

- ✓ **Precipitation of impurities:** Lime can precipitate certain impurities, such as organic acids and colorants, from the juice.
- ✓ **Preventing scale formation:** Liming can help to prevent the formation of scale (calcium carbonate) in heat exchangers and other equipment, which can reduce efficiency and increase maintenance costs.

- **Preparation process:**

  - ✓ **Lime slaking:**

    - **Hydration:** Quicklime (calcium oxide) is mixed with water in a lime slacker to form calcium hydroxide.
    - **Exothermic reaction:** This reaction is highly exothermic, releasing a significant amount of heat.
    - **Equation:** $CaO + H_2O \rightarrow Ca(OH)_2$ + heat

  - ✓ **Dilution:** The slaked lime is diluted with water to form milk of lime. The desired concentration of milk of lime depends on the specific application in the sugarcane process.
  - ✓ **Aging:** The milk of lime is often allowed to age for a period of time to improve its settling properties and reduce its alkalinity.

- **Factors affecting milk of lime quality:**

  - ✓ **Lime purity:** The quality of the lime used can affect the properties of the milk of lime. High-purity lime is preferred for sugarcane processing.
  - ✓ **Water quality:** The quality of the water used for slaking and dilution can impact the milk of lime.
  - ✓ **Aging time:** The aging period can influence the settling properties and reactivity of the milk of lime.

- **Storage and handling:**

  - ✓ **Storage:** Milk of lime should be stored in a cool, dry place to prevent sedimentation and hardening.
  - ✓ **Handling:** It should be handled with care, as it can be corrosive. Protective equipment, such as gloves and eye protection, should be worn when handling milk of lime.

- **Monitoring effectiveness of liming in sugar processing**

Monitoring the effectiveness of liming in sugarcane processing is crucial to ensure optimal juice clarification, pH adjustment, and overall sugar quality. The Following are the methods and parameters to consider:

- ✓ **pH measurement:**

Use a pH meter to measure the pH of the juice before and after liming. The desired pH range for liming can vary depending on the specific process and equipment used. If the pH is not within the desired range, adjust the amount of lime added.

- ✓ **Clarity measurement:**

Use a turbidimeter to measure the turbidity or cloudiness of the juice. Effective liming should result in a decrease in turbidity, indicating improved clarification.

- ✓ **Sedimentation:**

Monitor the sedimentation of impurities after liming. A well-limed juice should have clear, settled sediments.

- ✓ **Calcium ion concentration:**

Use titration methods to measure the concentration of calcium ions in the juice. Excess calcium ions can lead to scaling and other problems.

- ✓ **Sugar yield:**

Compare the sugar yield before and after liming. Effective liming should result in higher sugar yields due to improved juice quality and extraction efficiency.

- ✓ **Equipment performance:**

Monitor for signs of scale formation in heat exchangers and other equipment. Effective liming can help prevent scale formation, reducing the need for frequent cleaning and maintenance.

- ✓ **Process efficiency:**

Evaluate the overall efficiency of the sugarcane processing process, including juice extraction, clarification, and crystallization. Make adjustments to the liming process based on the monitoring results to optimize efficiency and product quality.

Points to Remember

- Heating raw juice before liming has several benefits including enhanced clarification, reduced lime consumption, improved juice quality and reduced scale formation.
- Make sure to use milk of lime in sugarcane processing for the purpose of clarifying juice, adjusting pH, and precipitating impurities.
- Closely monitor the liming process to obtain a good sugar yield.

Application of learning 2.2.

In sugarcane processing workshop there is extracted raw juice of sugarcane. You are asked to go in the sugarcane processing workshop to:

- Heat sugarcane raw juice
- Lime the heated juice

Indicative content 2.3: Clarifying treated juice for sugar processing

Duration: 6hrs

Practical Activity 2.3.1: Clarifying treated juice

Task:

You are asked to go to the sugarcane processing workshop to clarifying treated juice.

1: Apply safety precautions

2: Referring to the clarification method of heated juice, clarify the heated juice for sugar production.

3: Present your work to the trainer and the whole class.

4: Read key reading 2.3.1and ask for clarification where necessary

5: Perform the task provided in the application of learning 2.3.

Key readings 2.3.1: Clarifying of treated juice

- **Purpose of clarifying treated juice**

Clarification is a critical step in sugarcane processing that involves removing impurities from the treated juice to improve its quality and prepare it for subsequent steps like evaporation and crystallization.

- **Methods of sugarcane juice clarification:**
  - ✓ **Sedimentation:**
    - **Gravity separation:** This is a simple method where the juice is allowed to settle, allowing impurities to settle at the bottom.
    - **Factors affecting sedimentation:** Temperature, pH, and the nature of impurities can influence sedimentation efficiency.
  - ✓ **Filtration:**
    - **Sand filters:** Remove larger particles like dirt and sand.
    - **Carbon filters:** Remove colour and odour.
    - **Membrane filters:** Remove smaller particles and microorganisms.

- ✓ **Centrifugation:**
  - **High-Speed separation:** Centrifuges use centrifugal force to separate solid particles from the liquid.
  - **Types of centrifuges:** Clarifiers and separators are commonly used in sugarcane processing.
- ✓ **Flotation:**
  - **Air injection:** Air is introduced into the juice to create bubbles that carry impurities to the surface.
  - **Removal:** The impurities are skimmed off the surface.

- **Factors affecting clarification efficiency:**
  - ✓ **Juice properties:** The viscosity, pH, and temperature of the juice can affect clarification efficiency.
  - ✓ **Impurity type:** The nature and size of impurities can influence the choice of clarification method.
  - ✓ **Equipment selection:** The type and condition of the clarification equipment can impact the effectiveness of the process.
  - ✓ **Operating parameters:** Factors like flow rate, temperature, and pressure can affect clarification results.

- **Importance of clarification:**
  - ✓ Clarification removes impurities that can affect the taste, colour, and overall quality of the final sugar product.
  - ✓ A clearer juice can lead to higher sugar yields during the crystallization process.
  - ✓ Clarification helps prevent equipment clogging and improves processing efficiency.

- **Types of juices in sugarcane processing: Mud Juice and clear Juice**

In sugarcane processing, the juice extracted from the sugarcane is typically classified into two main types:

- ✓ **Mud juice:**

Mud juice is a cloudy or turbid liquid that contains a significant amount of suspended solids, such as fiber, wax, and other impurities. It is often the initial juice extracted from the sugarcane using milling or diffusion processes. Mud juice is typically subjected to clarification processes, such as sedimentation or filtration, to remove impurities and produce clear juice.

✓ **Clear juice:**

Clear juice is a translucent or transparent liquid that has undergone clarification processes to remove impurities. It is typically produced by subjecting mud juice to filtration, centrifugation, or other clarification techniques. Clear juice is usually further processed through evaporation and crystallization to produce sugar.

- **Clarification of treated juice in sugarcane processing**

✓ **Sedimentation methods:**

Sulphitation

Sulphur dioxide (SO_2) is added to the treated juice to lower the pH and promote the precipitation of impurities. The lowered pH causes proteins and other impurities to coagulate and settle. Sulphitation can improve juice clarity, reduce colour, and help prevent microbial growth.

Flocculation

Chemicals known as flocculants are added to the juice to form larger particles (flocs) that can be more easily removed through sedimentation. Common flocculants include lime (calcium hydroxide), alum (aluminum sulfate), and polyelectrolytes.

✓ **Filtration of clear juice**

The purpose is to further remove any remaining impurities from the clarified juice.

Filtration techniques: Vacuum filtration, pressure filtration, and cross-flow filtration are commonly used.

✓ **Treatment of mud juice:**

The purpose of treating mud juice is to recover additional sugar from the mud juice and reduce waste.

Methods of treating mud juice:

- **Repassing:** The mud juice can be repassed through the milling process to extract more juice.
- **Fermentation:** In some cases, the mud juice can be fermented to produce ethanol or other products.
- **Composting:** The residual solids from mud juice can be composted for use as a soil amendment.

- **Measuring the quality of clear juice in sugarcane processing**

The quality of clear juice in sugarcane processing is crucial for determining the final quality of the sugar product. Several key parameters are used to measure the quality of clear juice:

- ✓ **pH**

The pH of the juice affects its stability, colour, and the efficiency of subsequent processing steps. A slightly acidic pH is generally preferred for sugar production.

- ✓ **Brix**

Brix indicates the total soluble solids content in the juice, which is directly related to the sugar content. Higher Brix levels generally indicate higher sugar quality.

- ✓ **Polarity**

It is calculated from the Brix and sucrose content. Polarity measures the purity of the juice, with higher polarity indicating a higher proportion of sucrose.

- ✓ **Purity**

It is calculated from the Brix and sucrose content. Purity is a key indicator of juice quality. Higher purity levels lead to higher-quality sugar.

- ✓ **Turbidity**

It is measured using a turbidimeter. Turbidity indicates the presence of suspended particles in the juice. Lower turbidity indicates a clearer and purer juice.

Points to Remember

- It is strictly recommended to clarify limed sugarcane juice to remove impurities and thus improve the quality of the final sugar.
- Sugarcane juice clarification helps to effectively evaporate water in the treated juice and crystallize sugar.

Application of learning 2.3.

During the peer to peer coaching, trainees from BDC school want to learn from your school how to process sugarcane. You are asked to go in the sugarcane processing workshop to:

- Clarify sugarcane treated juice.

Indicative content 2.4: Evaporating clear juice

Duration: 6hrs

Practical Activity 2.4.1: Evaporating clear juice

Task:

You are asked to go to the sugarcane processing workshop to evaporate clear juice.

1: Apply safety precautions

2: Referring to the evaporation methods of clear juice, evaporate clear juice for sugar production.

3: Present your work to the trainer and the whole class. Ask for clarification where necessary

4: Read key reading 2.4.1

5: Perform the task provided in the application of learning 2.4.

Key readings 2.4.1: Evaporating clear juice

- **Evaporation of clear juice in sugarcane processing**

Evaporation is a critical step in sugarcane processing, where water is removed from the clarified juice to concentrate the sugar content. This concentrated solution is then further processed to crystallize sugar.

✓ **Evaporation methods:**

Multiple effect evaporators: These are the most commonly used evaporators in sugarcane processing. They consist of a series of evaporators connected in a cascade, with the vapour from one evaporator being used to heat the juice in the next. This allows for efficient heat transfer and energy conservation.

Falling film evaporators: The juice flows down the inside of heated tubes, promoting efficient heat transfer and evaporation.

Forced circulation evaporators: The juice is circulated through the evaporator using a pump, enhancing heat transfer and preventing fouling.

✓ **Factors affecting evaporation efficiency:**

- **Temperature:** Higher temperatures generally lead to faster evaporation rates. However, excessive temperatures can cause sugar degradation or caramelization.
- **Pressure:** Reducing pressure in the evaporator can lower the boiling point of the juice, allowing for evaporation at lower temperatures.
- **Juice properties:** The viscosity, sugar concentration, and other properties of the juice can affect evaporation rates.
- **Equipment design:** The design and condition of the evaporator can influence its efficiency.

✓ **Importance of evaporation:**

- **Sugar concentration:** Evaporation is essential for increasing the sugar concentration in the juice, preparing it for crystallization.
- **Energy efficiency:** Multiple effect evaporators can be highly energy efficient, reducing the overall energy consumption of the process.
- **Product quality:** Proper evaporation can help to preserve the quality of the sugar and prevent degradation.

Points to Remember

- Closely monitor evaporation process to effectively remove water in clear juice thus preserving the quality of sugar.
- Use the evaporators that will effectively remove water while using less energy.
- It is recommended to test the juice properties such as viscosity and sugar concentration before evaporating the juice

Application of learning 2.4.

In sugarcane processing workshop, there is 100 litres of clear juice from sugarcane. You are asked to go in the sugarcane processing workshop to:

- Evaporate the clear juice so as to make sugar syrup

Learning outcome 2 end assessment

Theoretical assessment

1. Read carefully the following statements and choose by encircling the letter corresponding to the right answer

   I. The following are the factors affecting sugarcane milling efficiency except:
      a) The quality of the sugarcane, including maturity, fiber content, and Brix level.
      b) The type and condition of the milling machines.
      c) The cleaning products used before sugarcane milling

   II. The quality parameters to analyse in the sugarcane raw juice are the following except:
      a) Acidity
      b) Purity
      c) Porosity
      d) Brix

2. Match the grades of sugarcane juice with their properties by writting the letter and the corresponding number in the provided space.

Answer	**Properties of sugarcane raw juice**	**Grade of sugarcane raw juice**
1)…….	1. It is considered good quality but with slightly lower sugar content. It may have a slightly darker colour and is slightly less sweet or may have some off-flavours	A
2)…….	2. It is considered lower quality due to lower sugar content, higher impurity levels, or other defects. It is may have a darker colour and may be cloudy. It may have a bitter or off-flavour	B
3)…….	3. It is considered the best quality juice, with high sugar content and minimal impurities. It is light in colour, often with a golden hue and is sweet and clean with minimal off-flavours	C

3. Read carefully the following statement related to sugarcane processing and fill in the provided space with the appropriate missing words in blacket **(coagulation, clarification, evaporation, sterilization, centrifugation, pasteurization)**

a) …….. refers to the process of removing impurities from the extracted juice to improve its quality and prepare it for subsequent steps like evaporation and crystallization.

b) ……. separates solid particles from the liquid juice. It involves spinning the juice at high speeds, which causes the denser solid particles to settle to the bottom while the lighter liquid remains on top.

c) ……is the process of removing water from the clarified juice to concentrate the sugar content. This concentrated solution is then further processed to crystallize sugar.

d) …….. refers to the process of killing all microorganisms, including bacteria, viruses, and spores, present in the raw juice.

4. Read the following statements related to sugarcane processing and answer by **True** if it right or **False** if it is wrong

a) Sulphur dioxide (SO_2) is added to the treated juice to increase the pH and promote the precipitation of impurities……

b) Polarity measures the purity of the juice, with higher polarity indicating a lower proportion of sucrose……

c) Flocculants are added to the juice to form larger particles (flocs) that can be more easily removed through sedimentation…….

c) Brix indicates the total soluble solids content in the juice, which is directly related to the sugar content. Higher Brix levels generally indicate higher sugar quality…….

d) Turbidity indicates the presence of dissolved particles in the juice. Higher turbidity indicates a clearer and purer juice……

Practical assessment

PRIME cooperative located in Rutsiro district has a sugarcane plantation, recently they established a sugarcane processing unit. However, the cooperative lacks a qualified technician to process sugarcane. You are asked by the production manager to perform the following tasks:

1. To extract raw juice from sugarcane
2. To heat the sugarcane raw juice
3. To clarify treated juice for sugar processing
4. To evaporate clear juice

The task should be completed in 4 hours

All materials, tools and equipment are available at PRIME cooperative

END

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SUGAR
SUGAR

Indicative contents
3.1 Boiling syrup **3.2 Centrifuging the massecuite** **3.3 Drying brown sugar crystals**

Key Competencies for Learning Outcome 3: Crystallize Syrup

Knowledge	Skills	Attitudes
• Description of types of massecuite • Description of centrifugation of Massecuite	• Boiling the syrup to form crystals in sugarcane processing • Centrifuging the Massecuite • Re-boiling of A-heavy and B-heavy molasses • Applying drying techniques • Screening of brown sugar crystals • Analysing of quality of brown sugar	• Being careful while forming crystals and checking the quality of massecuite and centrifuging • Paying attention while checking final molasses and analysing quality of brown sugar • Being responsible while re-boiling of a-heavy and b-heavy molasses

Duration: 25 hrs

Learning outcome 3 objectives:

By the end of the learning outcome, the trainees will be able to:

1. Describe clearly types of massecuite in sugarcane processing
2. Boil effectively the syrup to form crystals according to boiling conditions
3. Centrifuge effectively the massecuite according to centrifugation methods
4. Check correctly final molasses (by product) according to molasses specification
5. Dry correctly brown sugar crystals process as required for sugar production
6. Describe properly drying techniques used in sugar production
7. Screen properly brown sugar crystals as required for sugar production
8. Analyse effectively quality of brown sugar according to product specification

Resources

Equipment	Tools	Materials
● Crystallizer ● Vacuum pans ● Pipes, pumps, centrifugal machine ● Oven ● Hopper ● Bins ● Weighing scale (balance) ● Stitching machine	● Pressure gauge ● Vacuum gauge ● Thermometer ● Refractometer ● Spectrophotometer ● Polarimeter ● Bins ● Beaker ● Analytical balance ● Conductivity meter	● Water ● Steam ● Heat resistant gloves

Indicative content 3.1: Boiling of syrup

Duration: 7 hrs

Theoretical Activity 3.1.1: Description of types of massecuite in sugarcane processing

Tasks:

1: Answer the following questions related to boiling of sugar syrup.

i. What do you understand by:
   a. Evaporation
   b. Syrup
   c. Crystals
   d. Crystallization process
   e. Massecuite

ii. What could be the purpose of boiling syrup?

iii. What could be the boiling conditions of syrup?

2: Provide the answers to the asked questions by writing them on papers, flip chart, Blackboard or white board.

3: Present the findings/answers to the whole class.

4: For more clarification, read the key reading 3.1.1

Key readings 3.1.1.: Description of types of massecuite in sugarcane processing

●Definitions of terms

✓ **Evaporation** refers to the process of removing water from sugar cane juice to concentrate the sugar content before crystallization occurs. This is a critical step in the overall sugar manufacturing process, as it allows for the transformation of thin juice, which contains approximately 15-16% sugar, into thick syrup with a sugar concentration of about 67-72**%.**

✓ **Syrup** is the concentrated sugarcane juice with a solid content between 72% and 75%, Cane syrups are usually made from sugarcane juice, concentrated by evaporation, after clarification.

✓ **Crystals**

Refer to the solid forms of sucrose that are produced during the crystallization phase of sugar manufacturing. The syrup is further boiled under vacuum in

multiple pans, which causes sugar crystals to develop and grow, forming a mixture called massecuite.

✓ **Crystallization process** is the process of making crystals. It takes place in a vacuum boiling pan. Thick juice or syrup is fed to the vacuum pans and evaporated until saturated. Seed crystals are added during a strike to grow sugar crystals. The process is continued until a specified crystal size has been reached.

Or **crystallization process in sugar processing** involves evaporating syrup under vacuum conditions until super saturation is reached, seeding with fine crystals for growth, separating those crystals from mother liquor using centrifugation, and finally washing and drying them to produce high-purity raw sugar ready for storage or refining.

✓ **Massecuite:** refers to a mixture of crystals suspended in a liquid known as mother liquor, which is produced during the crystallization phase of sugar manufacturing.

● Purpose of boiling syrup

✓ **Concentration of sugars:** The boiling process serves to evaporate a significant amount of water from the sap, which typically contains about 2% sugar. Through boiling, the sugar concentration increases until it reaches approximately 66% sugar content, which is necessary for the liquid to be classified as syrup.

✓ **Caramelization:** During boiling, not only is water removed, but the heat also causes chemical changes in the sugars. The sucrose (a disaccharide) present in sap breaks down into glucose and fructose (monosaccharides) when heated. This transformation leads to caramelization, which contributes to the flavour and colour profile of maple syrup. The Maillard reaction may also occur during this process, further enhancing flavour development through non-enzymatic browning.

✓ **Sterilization:** Boiling also helps to eliminate any potential pathogens or microorganisms present in the raw sap. This step is crucial for ensuring that the final product is safe for consumption and has an extended shelf life.

✓ **Removal of impurities:** As sap is boiled down, impurities such as sugar sand (also known as niter) can precipitate out. This allows for easier filtration and results in a clearer final product.

✓ **Flavour development:** During boiling, complex chemical reactions occur, including the Maillard reaction and caramelization. These reactions contribute to the development of unique flavours and aromas that characterize high-quality

maple syrup. The heat applied during boiling transforms the raw sap into rich syrup with distinct taste profiles.

✓ **Achieving proper density:** Boiling allows producers to monitor and achieve the correct density for syrup before bottling it. The ideal density is measured using tools like hydrometers or refractometers, ensuring that the final product has a consistent quality that meets industry standards.

●Boiling Conditions

✓ **Temperature:** Syrup boiling generally occurs at temperatures ranging from 100°C to 115°C (212°F to 239°F), depending on atmospheric pressure and desired syrup density.

✓ **Pressure:** Vacuum boiling techniques are often employed to lower the boiling point of the syrup, allowing for evaporation at lower temperatures which helps prevent caramelization of sugars and degradation of flavour compounds.

✓ **Time:** The duration of boiling can vary but typically lasts between 30 minutes to several hours based on factors such as syrup composition and desired crystal size.

✓ **Brix level:** The Brix level (a measure of sugar concentration) during boiling should be monitored closely; optimal levels range from 60° Brix to 80° Brix before cooling for crystallization.

●Description of types of massecuite

✓ **Massecuite** is a mixture of sugar crystals and molasses, a byproduct of sugar refining. It's classified based on its purity and the stage of the crystallization process. Types of massecuite:

- **A-Massecuite**

○**Purity:** Highest purity (around 83-88%)

○**Crystallization:** Initial stage of crystallization

○**Purpose:** Produces the highest quality sugar, often suitable for export or direct consumption

- **B-Massecuite**

○ **Purity:** Lower purity than A-massecuite (around 69%)

○ **Crystallization:** Second stage of crystallization

○ **Purpose:** Produces a lower-grade sugar, often used for industrial purposes or as a sweetener.

- **C-Massecuite**

- **Purity:** Lowest purity (around 47%)
- **Crystallization:** Final stage of crystallization
- **Purpose:** Produces a very low-grade sugar or molasses, often used as a feed additive or for industrial applications.

Practical Activity 3.1.2: Boiling of syrup

Task:

Referring to the previous theoretical activities (3.1.1), you are requested to go to the sugarcane processing workshop to boil syrup for formation of crystals

1: Apply safety precautions.

2: Present out the procedure of performing boiling of syrup for formation of crystals

3: Referring to the procedure provided perform boiling of syrup for formation of crystals

4: Present your work to the trainer and whole class.

5: Read key reading 3.1.2 and ask clarification where necessary

6: Perform the task provided in application of learning 3.1

Key readings 3.1.2: Boiling of syrup for formation of crystals

- **Steps of boiling syrup for forming crystals**

  - ✓ **Boiling: feeding syrup into vacuum pan** (a large closed kettle with steam heated pipes) to **form massecuite** (The mixture of crystals and mother liquor from a boiling) The boiling occurs under reduced pressure (vacuum), allowing the syrup to boil at lower temperatures, which helps prevent caramelization and preserves the quality of the sugar.
  - ✓ **Crystallization: Dropping massecuite** into a receiving tank called a crystallizer where it is cooled down and the crystals continue to grow. During crystallization, careful monitoring of temperature and density is critical. Fine seed crystals may be added to facilitate this process. The mixture of crystals and remaining syrup, known as "massecuite," is created during this stage.

- **Checking the quality of massecuite**

✓ **The quality of good massecuite can be assessed based on several factors:**

- **Crystal size:**
  - **Uniformity:** The crystals should be of a uniform size for efficient separation from molasses.
  - **Large crystals:** Larger crystals are generally preferred as they are easier to handle and have better appearance.
- **Crystal purity:**

- **Impurities:** The crystals should be free from impurities such as colorants, foreign matter, and other non-sugar substances.
- **Sucrose content:** A high sucrose content in the crystals is essential for producing high-quality sugar.

Molasses content:

- **Minimization:** The goal is to have a low molasses content in the massecuite, as molasses reduces the purity of the sugar.
- **Separation efficiency:** The crystallization process should be efficient in separating sugar crystals from molasses.

Color:

- **Whiteness:** The massecuite should have a white or light-coloured appearance.
- **Impurities:** Darker colors may indicate the presence of impurities.

Texture:

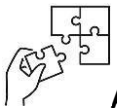
- **Grainy Texture:** The massecuite should have a grainy texture, indicating the presence of well-formed sugar crystals.
- **Viscosity:** The viscosity of the massecuite can affect the efficiency of the crystallization process.

pH:

- **Neutral pH:** A slightly acidic or neutral pH is generally preferred for optimal crystallization.

Points to Remember

- The quality of good massecuite in sugar manufacturing hinges on high purity levels, controlled colour content, optimal crystal yield, consistency in composition, effective temperature control, and efficient mechanical circulation during processing.
- Syrup boiling conditions in sugar manufacturing are vital for ensuring high-quality sugar production from sugarcane processing plants.
- Controlling temperature, pressure, time, and Brix levels during this phase, manufacturers can optimize both yield and quality of crystalline sugar.



Application of learning 3.1.

In your school after getting clarified juice from sugarcane, You are asked to go in sugarcane processing workshop boil syrup and check quality of massecuite.

Indicative content 3.2: Centrifuging the Massecuite

Duration: 10hrs

Theoretical Activity 3.2.1: Description of centrifugation and molasses in sugarcane processing

Tasks:

1: Answer the following questions related to the description of molasses

i. How do you understand by the following terms:
   a. Centrifugation
   b. Molasses
   c. Brix
   d. Polarity
   e. Purity

ii. What could be the criteria of selecting suitable centrifugal machine?

iii. What could be the quality parameters of molasses in sugarcane processing?

2: Provide the answers to the asked questions by writing them on papers, flip chart, Blackboard or white board.

3: Present the findings/answers to the whole class.

4: For more clarification, read the key reading 3.2.1

Key readings 3.2.1.: Description of centrifugation and molasses in sugarcane processing

- **Definition of some terms**

✓ **Centrifugation:** is defined as the method used to separate sugar crystals from the surrounding molasses or syrup. Once crystallization is complete, the massecuite is fed into centrifuges that spin rapidly to separate the solid sugar crystals from the liquid syrup (mother liquor). The centrifugal force effectively removes most of the syrup coating from each crystal.

✓ **Molasses:** is a thick, dark to light brown syrup that is primarily produced as a by-product during the refining of sugarcane or sugar beet juice into sugar. It can also refer to a syrup made from boiling down sweet vegetable or fruit juice.

Types of molasses

- **First molasses (light molasses):** This type has the highest sugar content and is the sweetest. It results from the first boiling of sugar cane or beet juice.
- **Second molasses (dark molasses):** This type is produced from a second boiling and has a slightly bitter taste compared to first molasses.

- **Blackstrap molasses:** This is the darkest and most robust in flavour, resulting from a third boiling where most of the sucrose has been crystallized out, leaving behind a viscous syrup with a strong bitterness.

- **Purpose of centrifugation of massecuite**

✓ **Separation of sugar crystals from molasses**: Effectively separate sugar crystals from the liquid molasses. The centrifuge utilizes centrifugal force generated by high-speed rotation to drive this separation process, allowing for the efficient extraction of sugar crystals while leaving behind the unwanted molasses.

✓ **Achieving desired purity and quality**: Centrifugation plays a vital role in ensuring that the final sugar product has the desired purity, colour, and granulation. This purification process enhances the taste, texture, and appearance of the final product.

✓ **Maximizing yield and reducing losses:** Effective separation reduces the amount of valuable sugar content lost through evaporation or other means during processing.

✓ **Enhancing operational efficiency:** Centrifuges are designed for high throughput rates, enabling continuous processing of large volumes of massecuite without compromising quality.

✓ **Cost-effectiveness**: centrifugation contributes to cost savings in sugar production operations. The robust design and reliability of modern centrifuges also lead to lower maintenance costs and extended equipment lifespan, further enhancing overall cost-effectiveness.

- **Methods of centrifugation of massecuite**

✓ **Batch centrifugation**

- In this method, a specific quantity of massecuite is loaded into a centrifuge bowl, which is then spun at high speeds. The centrifugal force generated causes the denser sugar crystals to move outward against the bowl wall, while the lighter syrup (molasses) remains closer to the center. After a predetermined time, the syrup is drained off, leaving behind a cake of sugar crystals that can be further processed or dried.

  Advantages: This method allows for precise control over processing conditions and is suitable for small to medium-scale operations.

- **Disadvantages:** It can be time-consuming and may not be as efficient for large volumes compared to continuous methods

✓ **Continuous centrifugation**

- **Continuous centrifugation systems** are designed to operate continuously rather than in discrete batches.

In this setup, massecuite flows into the centrifuge at a constant rate while separated syrup and crystal outputs are also removed continuously. This method utilizes either horizontal or vertical centrifuge designs.

- **Advantages:** Continuous systems generally offer higher throughput and efficiency, making them ideal for large-scale sugar production facilities.
- **Disadvantages:** They may require more complex machinery and control systems compared to batch processes.

- **Criteria of selection of suitable centrifugal machine**
  - ✓ **Processing requirements:** Evaluate the processing capacity and throughput required for your application. This includes understanding the batch size, production volume, and desired processing speed. The centrifuge should be capable of handling the specific requirements of your sugar production process.
  - ✓ **Separation efficiency:** Assess the centrifuge's ability to achieve the desired level of separation efficiency. This involves considering factors such as centrifugal force, rotational speed, and separation mechanisms that will effectively separate solids from liquids or classify particles based on density.
  - ✓ **Product quality** Prioritize centrifuges that can maintain or enhance the quality of your end product. Features such as gentle handling, minimal shear forces during processing, and customizable settings are essential to preserve product integrity and characteristics.
  - ✓ **Maintenance requirements** Evaluate the maintenance needs of the centrifuge, including cleaning protocols, lubrication schedules, and component replacement frequency. Opt for machines with user-friendly designs that allow easy access to components to minimize downtime and maintenance costs.
  - ✓ **Compatibility:** Ensure that the selected centrifuge is compatible with existing process equipment and infrastructure within your facility. Considerations include physical footprint, power requirements, and integration capabilities with current systems.
  - ✓ **Regulatory compliance:** Verify that the centrifuge meets relevant regulatory standards and certifications applicable to your industry and application. This includes sanitation requirements, material compatibility, safety features, and adherence to industry regulations.
  - ✓ **Cost considerations:** Analyze the total cost of ownership associated with the centrifuge selection process. This encompasses initial purchase price, installation costs, operating expenses (including energy consumption), and long-term maintenance expenses. Evaluate energy efficiency as it can significantly impact operational costs over time.

- ✓ **Customization options:** Consider whether customization options are available for specific applications or unique operational needs. Tailored solutions can enhance performance in specialized processes.

- Q**uality parameters molasses (Brix, polarity and purity)**
  - ✓ **Brix** is a scale used to measure the sugar content in an aqueous solution. It is defined as the percentage by weight of sucrose in a solution at a specific temperature (usually 20°C). In the context of molasses, Brix indicates how concentrated the sugar content is within the liquid
  - ✓ **Polarity** refers to the ability of a substance to rotate plane-polarized light due to its optical activity. In sugar manufacturing, measuring polarity helps determine the amount of sucrose present in relation to other components like glucose and fructose.
  - ✓ **Purity** in molasses reflects how much of its composition consists of fermentable sugars versus non-sugar components such as ash, organic acids, and other impurities.

Practical Activity 3.2.2: Centrifuging the massecuite

Task:

Referring to the previous theoretical activity (3.2.1), you are requested to go in sugarcane processing workshop and perform centrifugation of massecuite and check the quality molasses

1: Apply safety precautions.

2: Present out the procedure of performing centrifugation of massecuite and checking the quality molasses

3: Referring to the procedure provided on step 2, perform centrifugation of massecuite and checking the quality molasses

4: Present your work to the trainer and whole class.

5: Read key reading 3.2.2 and ask clarification where necessary

6: Perform the task provided in application of learning 3.2

Key readings 3.2.2: Centrifuging the massecuite

- **Steps involved in this process are as follows**

  - ✓ **Feeding the Massecuite:** The massecuite, which contains both sugar crystals and molasses, is fed into a perforated basket within the centrifuge.
  - ✓ **Spinning Phase:** Once the basket is filled, it spins at speeds that can reach up to 1200 revolutions per minute (rpm). This rapid spinning creates a centrifugal force that effectively separates the denser sugar crystals from the less dense liquid molasses.
  - ✓ **Washing:** After separation, the sugar crystals are often washed with water or steam to remove any residual molasses coating them. This step enhances the purity of the final product.
  - ✓ **Discharge Cycle:** Following washing, the centrifuge undergoes a braking phase where it slows down, allowing for the discharge of separated sugar through an outlet while retaining most of the molasses within.
  - ✓ **Final Product:** The result of this process is raw sugar that consists of 97-99 percent sucrose, characterized by its golden color due to a thin film of molasses on its surface.

- **Checking the quality molasses (brix, polarity and purity)**

✓ **Brix Measurement**

- **Testing Method:** To measure Brix, a refractometer or hydrometer can be used. A refractometer measures the degree to which light bends as it passes through the molasses sample. The higher the Brix value, the more sugar present.
- **Interpretation:** Typical Brix values for molasses range from 60 to 80 degrees. Higher values indicate better quality molasses with more fermentable sugars.

✓ **Polarity Measurement**

- **Testing Method:** Polarimetry is employed for this measurement. A polarimeter shines polarized light through a sample of molasses and measures the angle of rotation caused by dissolved sugars.
- **Interpretation:** The polarity reading gives insight into not just sucrose concentration but also indicates potential impurities or degradation products that may affect fermentation processes

✓ **Purity Assessment**

- **Testing Method:** Purity can be calculated using both Brix and polarization measurements with the formula:

  Purity=(Polarity÷Brix)×100

This calculation provides a percentage that indicates how pure (i.e., how much sucrose relative to total solids) the molasses is.

- **Interpretation:** A purity level above 70% generally indicates good quality molasses suitable for fermentation or further processing. Lower purity levels suggest higher concentrations of impurities that could hinder fermentation efficiency.

Practical Activity 3.2.3: Re-boiling of A-heavy and B-heavy molasses

Task:

Referring to the previous theoretical activities (3.2.1), you are requested to go in sugarcane processing workshop and re-boil A-heavy and B-heavy molasses.

1: Apply safety precautions.

2: Present out the procedure of re-boiling of A-heavy and B-heavy molasses

3: Referring to the procedure provided on step 2, re-boil A-heavy and B-heavy molasses.

4: Present your work to the trainer and whole class.

5 Read key reading 3.2.3 and ask clarification where necessary.

6: Perform the task provided in application of learning 3.2

Key readings 3.2.3: Re-boiling of A-heavy and B-heavy molasses and checking of final molasses (by product)

- **Definitions**
  - ✓ **Molasses** is a by-product of sugar extraction from sugarcane or sugar beet. The classification into A-heavy and B-heavy molasses is based on their sugar content, viscosity, and mineral composition:
  - ✓ **A-heavy molasses** typically has a higher sugar content (around 50% total sugars) and lower impurities compared to B-heavy.
  - ✓ **B-heavy molasses** contains more non-sugar components (around 45% total sugars) and is often used for fermentation processes.

- **Re-boiling Process**

- ✓ **Re-boiling** definition involves heating the molasses again to concentrate the sugars further and reduce moisture content. This process can enhance the syrup's flavor profile and improve its usability in various applications such as animal feed or fermentation.
- ✓ **Steps involved in re-boiling:**
  - **Preparation:** The molasses is first filtered to remove any solid impurities.
  - **Heating:** The filtered molasses is then heated in a controlled environment. The temperature must be carefully monitored to prevent caramelization, which can alter flavour negatively.
  - **Concentration:** As water evaporates, the concentration of sugars increases. This step may involve multiple boiling cycles to achieve desired consistency.
  - **Cooling:** After reaching the desired concentration, the syrup is cooled rapidly to prevent further changes in composition.

- **Quality check of final molasses**

After re-boiling, it's essential to check the quality of the final product through various tests:

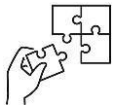
- ✓ **Parameters for quality assessment:**
  - **Sugar content analysis:** Using methods like polarimetry or high-performance liquid chromatography (HPLC) to determine the total sugar content.
  - Viscosity Measurement: This helps assess how thick or fluid the final product is, which can affect its application.
  - **pH level testing:** Ensuring that pH levels are within acceptable ranges (typically between 5.0 - 7.0) for food-grade products.
  - **Microbial testing:** To ensure that no harmful bacteria or yeast have proliferated during processing.
- ✓ **By-products evaluation**

During re-boiling, some by-products may form due to thermal degradation of sugars or other compounds present in molasses. These by-products can include caramels or other complex sugars that may not be desirable depending on the intended use of the final product.

- It's crucial to evaluate these by-products as they can affect both flavour and nutritional value.

Points to Remember

- Centrifugation plays a vital role in achieving high efficiency and productivity in sugar production by ensuring that maximum amounts of sugar are extracted from each batch of massecuite while minimizing crystal breakage and maintaining product quality.
- The accuracy and reliability of the measurements (Brix, polarity, and purity) are critical for optimizing production processes and ensuring product quality in sugar manufacturing.
- The re-boiling process of A-heavy and B-heavy molasses significantly impacts their final quality and usability as a product. Careful monitor throughout this process ensures that undesirable characteristics are minimized while maximizing beneficial properties.



Application of learning 3.2.

In your workshop there is molasses obtained after centrifuging the massecuite. You are asked go in sugarcane processing workshop re-boil A-heavy and B-heavy molasses to check final molasses (by product).

Indicative content 3.3: Drying of brown sugar crystals

Duration: 8hrs

Theoretical Activity 3.3.1: Description of drying brown sugar crystals process

Tasks:

1: Answer the following questions related to drying brown sugar crystals.

- **i.** What do you understand by the following terms:
  - a. Brown sugar crystals
  - b. Screening
- **ii.** What could be the purpose of drying brown sugar crystals?
- **iii.** What could be the drying techniques of brown sugar crystals?
- **iv.** How can you analyse the quality of brown sugar?
- **v.** What could be the good quality brown sugar specifications?

2: Provide the answers to the asked questions by writing them on papers, flip chart, Blackboard or white board.

3: Present the findings/answers to the whole class.

4: For more clarification, read the key reading 3.3.1

Key readings 3.3.1.: Description of drying brown sugar crystals process

- **Definition of some terms**

✓ **Brown sugar crystals:** are sugar crystals that contain a certain percentage of molasses, which gives them their distinctive brown colour and flavour. These crystals can be classified into different types based on the amount of molasses they retain.

✓ **Screening** refers to the process of separating solid particles from liquids or other solids based on size.

✓ **Bagasse**: the fibrous residue left after juice extraction

- **Purpose of drying sugar crystals**

✓ **Moisture reduction:**

One of the primary reasons for drying sugar is to reduce its moisture content. Sugar discharged from centrifugal machines typically contains between 0.1% to 0.4% moisture, which is not suitable for storage or packaging.

Excess moisture can lead to clumping and lump formation, making it difficult to handle and process further.

- ✓ **Prevention of microbial growth:**

Higher moisture levels in sugar can promote the growth of microbial organisms, which can lead to spoilage and deterioration of the product. By reducing the moisture content to a safe limit (ideally below 0.04%), the risk of microbial contamination is minimized, ensuring that the sugar remains stable during storage.

- ✓ **Improved handling properties:**

Drying enhances the handling properties of sugar by preventing it from forming lumps due to moisture retention. This is particularly important during transportation and storage, as lumpy sugar can be challenging to work with in both industrial and retail settings.

- ✓ **Preservation of quality:**

Maintaining low moisture levels helps preserve the quality and purity of sugar crystals, preventing changes in colour or flavour that can occur when sugars are exposed to higher humidity environments over time.

- ✓ **Avoidance of melanoidin reaction:**

Hot sugar is hygroscopic, meaning it tends to absorb moisture from the atmosphere as it cools down after processing. If hot sugar is bagged directly without adequate cooling and drying, it can absorb ambient moisture, leading to undesirable reactions such as melanoidin formation, which alters its colour and quality.

Practical Activity 3.3.2: Drying brown sugar crystals

Task:

Referring to the previous theoretical activities (3.3.1), you are requested to go in Sugarcane processing workshop and dry brown sugar crystals.

1: Apply safety precautions.

2: Present out the procedure of drying of brown sugar crystals

3: Referring to the procedure provided on step 2, dry brown sugar crystals

4: Present your work to the trainer and whole class.

5: Read key reading 3.3.2 and ask clarification where necessary

6: Perform the task provided in application of learning 3.3

Key readings 3.3.2: Drying of brown sugar crystals

- **Drying techniques (rotary drum drying, solar drying, heat exchanger drying)**

✓ **Rotary drum drying**

Rotary drum drying is a continuous process that involves the use of a rotating cylindrical drum to dry materials. The brown sugar syrup is fed into the drum where it is subjected to hot air or gas flow.

- **The key steps involved in this method include:**
  - **Feed preparation:** The brown sugar syrup is concentrated to a certain degree before entering the rotary dryer.
  - **Heat transfer:** Hot air or gas enters the drum at one end while the syrup is introduced at the opposite end. As the drum rotates, the syrup coats the inner surface and is exposed to hot air.
  - **Evaporation:** The moisture evaporates from the syrup due to heat transfer from the hot air.
  - **Crystallization:** As moisture content decreases, sugar crystals begin to form.
  - **Collection:** Dried sugar crystals exit through an outlet at the other end of the drum.
- **Advantages of rotary drum drying include:**

High efficiency and continuous operation, making it suitable for large-scale production. However, it requires significant energy input and can lead to uneven drying if not properly controlled.

✓ **Solar drying**

Solar drying utilizes sunlight as a natural heat source to evaporate moisture from brown sugar crystals. This method can be implemented using solar dryers or open-air drying techniques.

- **The process typically involves:**
  - **Preparation of sugar syrup**: Similar to other methods, brown sugar syrup must be concentrated before drying.
  - **Placement in solar dryers**: The syrup or partially dried crystals are spread out in trays within a solar dryer that captures sunlight.
  - **Heat absorption:** The solar dryer absorbs sunlight and converts it into heat energy which warms up the trays containing sugar.
  - **Moisture evaporation:** As temperatures rise inside the dryer, moisture evaporates naturally.
- **The advantages of solar drying include**

Low operational costs and minimal energy consumption since it relies on renewable energy sources. However, its effectiveness is highly dependent on weather conditions and may not be suitable for regions with limited sunlight.

✓ **Heat exchanger drying**

Heat exchanger drying involves transferring heat from one medium (usually air) to another (the brown sugar syrup) without direct contact between them. This method can be more controlled compared to rotary drum dryers

- **The process typically involves:**
  - **System setup:** A heat exchanger system consists of two separate chambers—one for heating air and another for introducing moist sugar syrup.
  - **Heating process:** Air is heated using various methods (electricity, steam) before being directed into contact with moist sugar syrup in a separate chamber.
  - **Moisture removal:** As warm air passes over or through the syrup, moisture evaporates efficiently due to temperature differences.
- **Advantages:**
  - **Controlled environment:** Heat exchangers allow precise control over temperature and humidity levels during drying.
  - **Energy efficiency:** They can be designed to recover waste heat, improving overall energy efficiency.

- **Screening of brown sugar crystals**

✓ **Screening process**

After sufficient crystallization has occurred

- Carefully remove any excess liquid from the jar without disturbing the crystals.
- Use a sieve or fine mesh strainer to separate any smaller, unwanted particles from your larger brown sugar crystals.

- **Analysing quality of brown sugar**

✓ **Polarity**

Polarity in brown sugar is an important factor that affects its solubility and interaction with other substances. Brown sugar contains both sucrose and various impurities, including molasses, which contribute to its overall polarity. The presence of hydroxyl groups in the sugar molecules makes them polar, allowing for hydrogen bonding with water. To analyse the polarity, one can use techniques such as:

- Thin-layer chromatography (TLC) or

- High-performance liquid chromatography (HPLC), can be employed to analyse the composition of sugars and determine their polarity.

✓ **Moisture Content:** Is a critical quality parameter for brown sugar as it influences texture, shelf life, and susceptibility to microbial growth. The moisture content can be determined using methods such as:

- **Oven drying methods**: This involves heating a sample of brown sugar at a specific temperature until all moisture evaporates, followed by weighing the sample before and after drying.
- **Karl Fischer titration:** A more precise method for measuring moisture content that uses a chemical reaction with iodine.

✓ **Suspended and insoluble matters:** Refer to any particulate matter present in brown sugar that does not dissolve when mixed with water. The presence of suspended and insoluble matter in brown sugar can indicate impurities or poor processing practices. These impurities can include dirt, minerals, or other organic materials that may affect both the appearance and taste of the sugar.

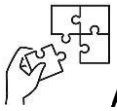
To analyse suspended and insoluble matter:

- **Filtration method:** A known weight of brown sugar is dissolved in distilled water, then filtered through a pre-weighed filter paper. The residue collected on the filter paper is dried and weighed again to determine the amount of insoluble matter.

✓ **Sugar colour:** The colour of brown sugar is an important quality parameter that reflects its degree of refinement and molasses content. Colour can be measured using spectrophotometry or visual comparison against standardized colour charts (such as those provided by the American Society of Testing Materials).

Points to Remember

- If hot sugar is bagged directly without adequate cooling and drying, it can absorb ambient moisture, leading to undesirable reactions such as melanoidin formation, which alters its color and quality.
- The choice among the rotary drum drying, solar drying, and heat exchanger drying will depend on factors such as production scale, available resources, environmental considerations, and economic viability.
- Brown sugar typically ranges from light tan to dark brown; darker sugars generally contain more molasses, which contributes additional flavors but may also indicate higher impurity levels if not processed correctly.
- The acceptable moisture content for brown sugar typically ranges from 0.5% to 2%. Higher moisture levels can lead to clumping and spoilage.



Application of learning 3.3.

Your school prepares an open day for presenting different products made in the school. You are asked to go in sugarcane processing workshop and dry of brown sugar crystals.

Learning outcome 3 end assessment

Theoretical assessment

1.Read carefully the statements in table below and match the definitions with its appropriate term and write your answer in provided space

Answers	Definitions	Terms
1.....	1. refers to a mixture of crystals suspended in a liquid known as mother liquor, which is produced during the crystallization phase of sugar manufacturing.	A. Crystallization process
2.....	**2.** is the process of making crystals	B. Crystals
3.....	3. refers to the process of removing water from sugar cane juice to concentrate the sugar content before crystallization occurs.	C. Syrup
4.....	4. The fibrous residue left after juice extraction	D. Molasses
5.....	5. refer to the solid forms of sucrose that are produced during the crystallization phase of sugar manufacturing.	E. Evaporation
6.....	6. Is the concentrated sugarcane juice with a solid content between 72-75% cane syrup usually concentrated by evaporation after clarification	F. Massecuite
7.....	7. Is a by-product of sugar obtained after sugar centrifugation	G. Bagasse

2.Read carefully the following statements and choose by encircling the letter corresponding to the right answer

i. A-Massecuite contains about:
   a. 30-40% solids
   b. 40-50% solids
   c. 50-60% solids

d. 60-70% solids

ii. B-Massecuite contains around
   a. 30.40% solids
   b. 40-50% solids
   c. 50-60% solids
   d. 60-70% solids

iii. C-Massecuite contains around
   a. 30.40% solids
   b. 40-50% solids
   c. 50-60% solids
   d. 60-70% solids

iv. Bagasse, molasses, press mud are the types of:
   a. Refined sugar
   b. By product of sugar
   c. Raw sugar
   d. None of the above

3. Read the following statements in sugarcane processing and write True if the statement is correct or False if the statement is wrong

a. In refined sugar production, the purity of the final product is often targeted at around 99.9%.....

b. Centrifugation is defined as the method used to separate sugar crystals from the surrounding molasses or syrup……..

C. Batch centrifugation in this method, a specific quantity of massecuite is loaded into a centrifuge bowl, which is then spun at high speeds. The centrifugal force generated causes the denser sugar crystals to move outward against the bowl wall, while the lighter syrup (molasses) remains closer to the center……

Practical assessment

KUNDWA company located in Nyanza district has a sugarcane plantation, recently they established a sugarcane processing unit. However, the cooperative lacks a qualified technician to process sugarcane. The production manager asks you to perform the following tasks:

1. To boil syrup and check quality of massecuite
2. To re-boil A-heavy and B-heavy molasses to check final molasses (by product)
3. To dry brown sugar crystals

The task should be completed in 4 hours

All materials, tools and equipment are available at KUNDWA company.

END

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Learning Outcome 4: Refine Brown Sugar

Indicative contents
4.1 Melting brown sugar
4.2 Clarifying melt sugar
4.3 Crystallizing refined syrup
4.4 Decolorizing clarified sugar melt

Key Competencies for Learning Outcome 4: Refine Brown Sugar

Knowledge	Skills	Attitudes
• Explanation of affination of brown sugar • Explanation of white sugar quality requirements • Description of decolourization reagents and their working principle	• Melting brown sugar • Clarifying melt sugar • Decolourizing melt sugar • Crystallizing refined syrup	• Being careful while melting affinized sugar • Paying attention while applying clarification of melt sugar • Being responsible while applying sugar melt decolourization steps • Being responsible while crystallizing refined syrup

Duration: 10 hrs

Learning outcome 4 objectives:

By the end of the learning outcome, the trainees will be able to:

1. Explain correctly white sugar quality requirements in sugar manufacturing
2. Describe clearly decolourization reagents and their working principle
3. Melt effectively affined sugar according to the melting condition
4. Clarify properly melt sugar to make white sugar
5. Decolourize effectively sugar melt in sugar manufacturing
6. Crystallize correctly refined syrup in sugar manufacturing

Resources

Equipment	Tools	Materials
● Crystallizer ● Vacuum pans ● Pipes ● Pumps ● Centrifugal machine ● Oven ● Hopper ● Weighing scale (balance) ● Stitching machine	● Pressure gauge ● Vacuum gauge ● Thermometer ● Refractometer ● Spectrophotometer ● Polarimeter ● Beaker ● Bins ● Analytical balance ● Conductivity meter.	● Water ● Steam ● Brown sugar

Indicative content 4.1: Melting of brown sugar

Duration: 2 hrs

Practical Activity 4.1.1: Melting of affinized sugar

Task:

You are requested to go to the sugarcane processing workshop and melt affinized sugar

1: Apply safety precautions.

2: Present out the procedures of melting affinized sugar

3: Referring to the procedure provided on step 2, melt of affinized sugar

4: Present your work to the trainer and whole class.

5: Read key reading 4.1.1 and ask clarification where necessary

6: Perform the task provided in application of learning 4.1

Key readings 4.1.1: Melting of affinized sugar

- **Definitions**

✓ **Affination** is a process used in sugar refining that involves treating raw sugar crystals with warm heavy syrup to remove the molasses coating from the sugar crystals.

✓ **Affined sugar:** Sugar is produced after centrifugation in affination process

- **Purpose of affination process is**

✓ To obtain affinated sugar
✓ Containing minimum colour and ash. In this process above 50 to 60% colour is removed mechanically depending on input colour of raw sugar.
✓ Remove the film of adhering molasses from the sugar crystals.
✓ Preparation for further Processing
✓ Obtain affinated sugar over 99% purity
✓ Improving quality of the final sugar product

- **Melting of affinized sugar**

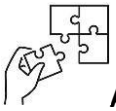
The melting of affinized sugar is a process that involves the transformation of solid sugar into a liquid state.

✓ **Factors influencing melting process, including:**

- **The crystalline structure of the sugar:** The melting point for pure sucrose is approximately 186 degrees Celsius (367 degrees Fahrenheit). When heated to this temperature, the bonds holding the sugar molecules together begin to break down, allowing them to transition from a solid state to a liquid state.
- **Heating Process**
  - **Heating Method:** The most common method for melting sugar is through direct heat on a stove or using an oven. Care must be taken to avoid burning the sugar.
  - **Temperature Control:** It is crucial to monitor the temperature closely. Heating should be gradual; sudden high temperatures can lead to caramelization or burning rather than melting.
  - **Use of Equipment:** A saucepan or double boiler can be used for even heating. Stirring may be necessary to ensure uniform melting and prevent hot spots that could cause burning.
- **Interaction with moisture:** When affinized sugar is added to water (especially hot water), it dissolves rather than melts in the traditional sense. The individual sugar molecules bond with water molecules instead of each other, leading to a solution rather than a melted solid. For melting of sugar maintained the concentration of melt liquor of 64 to 65 °Brix. Some times we add enzymes of dextron and starch in this sugar melter. A screen is usually installed at the exit of melter.

Points to Remember

- For melting of sugar use hot water or sweet water and maintain the concentration of melt liquor of 64 to 65° Brix.



Application of learning 4.1.

The production unit in your school receive a demand to supplying a white sugar to the neighbouring primary school. You're asked to go in sugarcane processing workshop and melt affined sugar.

Indicative content 4.2: Clarifying melted sugar

Duration: 2 hrs

Practical Activity 4.2.1: Clarification of melted sugar

Task:

You are requested to go to the sugarcane processing workshop and apply clarification of melt sugar

1: Apply safety precautions (wear PPE).

2: Referring to the procedure provided on step 2, apply clarification of melt sugar

3: Present your work to the trainer and whole class.

4: Read key reading 4.2.1. Ask clarification where necessary

5: Perform the task provided in application of learning 4.2.

Key readings 4.2.1: Clarification of melted sugar

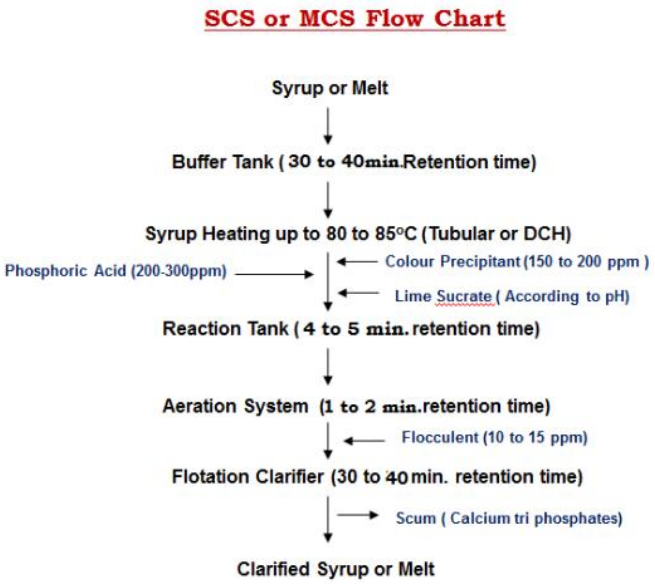
- **White sugar quality requirements**
  - ✓ **Polarity**
    - **Definition:** Polarity measures the amount of sucrose present in the sugar. It's expressed as a percentage.
    - **Requirement:** High polarity is desirable, typically above 99.8%. This indicates a high concentration of sucrose and minimal impurities.
  - ✓ **Brix**
    - **Definition:** Brix measures the soluble solids content in a solution, including sugars. It's often used to determine the concentration of sugar in a liquid or syrup.
    - **Requirement:** For white sugar, the Brix value should be very high, typically around 99.5%, indicating a low water content and high sugar concentration.
  - ✓ **pH**
    - **Definition:** pH measures the acidity or alkalinity of a solution. A pH of 7 is neutral, while values below 7 are acidic and above 7 are alkaline.
    - **Requirement:** White sugar should have a slightly acidic pH, typically around

6.5-7.0. This helps prevent microbial growth and maintains the sugar's stability.

- ✓ **Purity**
  - **Definition:** Purity refers to the absence of impurities or foreign substances in the sugar. It's a measure of the overall quality and safety of the product.
  - **Requirement:** White sugar should have a very high purity, with minimal amounts of impurities such as ash, colorants, and other contaminants. This ensures that the sugar meets food safety standards and is suitable for consumption.

- **Clarification process** helps to removing impurities and eliminates maximum colour of melt. Generally, refineries are following two types of clarification processes. They are:

  - ✓ **Melt phosfloatation:** The phosphoflotation process works on the principle of forming low density aggregates of particles and bubbles, and lower the density, more quickly they float. The process of **phosphotation** consists of screening the liquor to separate the coarse suspended solids and then dosing the liquor with **phosphoric acid and lime sucrate.** The resultant precipitate, after occlusion and absorption of the fine suspended solids, colloids and coloring matter, is floated with the aid of **air bubbles** enmeshed in the floccules.

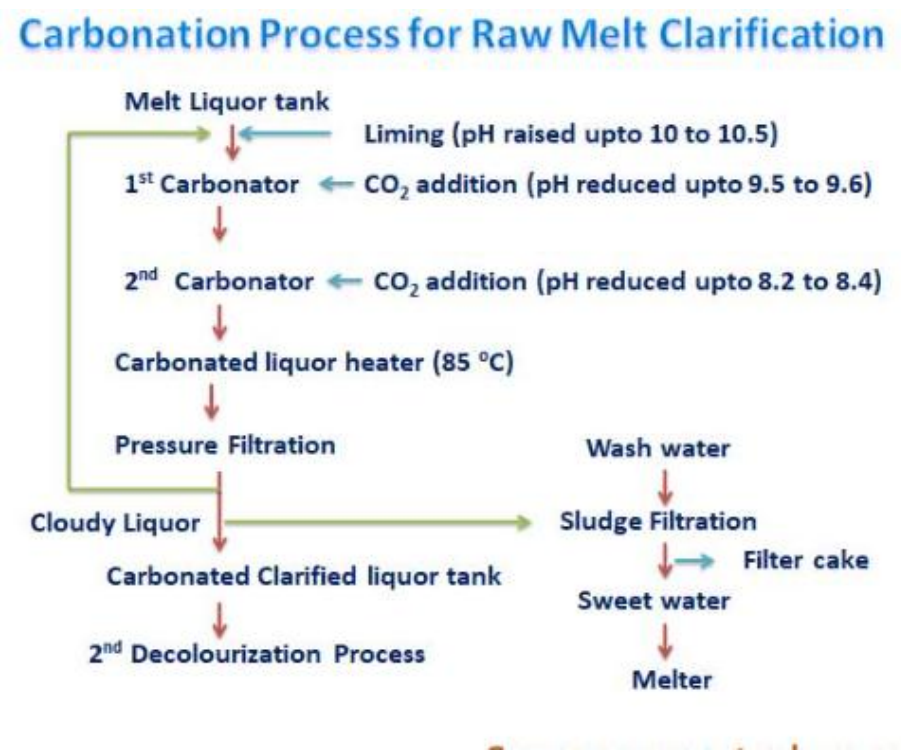


MCS: Melt Clarification System, **SCS:** Syrup Clarification System

- ✓ **Melt carbonation**: This carbonation process of melt mainly having two distinct steps:

- The first step is the formation of a voluminous and gelatinous precipitate by reaction of calcium and CO_2 and
- Second step involves the conditioning of the precipitate in order to improve its filter-ability.

$Ca(OH)_2 + CO_2 = CaCO_3 + H_2O$

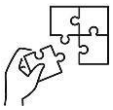


✓ **Pressure clarification method**

Pressure clarification is an advanced technique used in the sugar industry to enhance the efficiency of juice purification. This method involves applying pressure to the juice extracted from sugarcane or sugar beets, which accelerates the settling of suspended solids and facilitates the removal of impurities.

Points to Remember

- For clarifying melted sugar, white sugar quality requirement should be considered.
- In clarification of raw melt process, colour reduction will be depended on type of process. It will be around in the range of 30% to 50%.



Application of learning 4.2.

The production unit in your school receives a demand for supplying white sugar to the neighbouring primary school. You are asked to go in sugarcane processing workshop and clarify melted sugar.

Indicative content 4.3: Decolorizing clarified sugar

Duration: 3hrs

Theoretical Activity 4.3.1: Description of decolourization reagents and their working principle

Tasks:

1: Answer the following questions related to the centrifugation of massecuite

i. What do you understand by ion Exchanger Resin?
ii. What do you understand by Powdered Activated Carbon?

2: Provide the answers to the asked questions by writing them on papers, flip chart, Blackboard or white board.

3: Present the findings/answers to the whole class.

4: For more clarification, read the key reading 4.3.1

Key readings 4.3.1.: Description of decolourization reagents and their working principle.

- **Types of sugar decolourization reagents and their working principle**

✓ **Ion exchanger resin**

- Ion exchange resins are synthetic materials that can exchange ions with the surrounding solution. They are typically composed of a polymer matrix with functional groups that can either attract cations (positively charged ions) or anions (negatively charged ions).
- **Working principle:**
  - **Cation exchange resins:** These resins contain functional groups that attract cations, such as sodium, potassium, and calcium ions. When a sugar solution is passed through a cation exchange resin bed, the cations in the solution are exchanged for hydrogen ions from the resin. This process neutralizes the solution and removes mineral salts that contribute to color.
  - **Anion exchange resins:** These resins contain functional groups that attract anions, such as chloride, sulfate, and phosphate ions. By removing these anions, anion exchange resins can help to reduce the overall acidity of the solution and remove additional color-causing impurities.
- **Advantages of ion exchange resins:**

- Highly efficient in removing mineral salts and reducing color.
- Can be regenerated and reused multiple times.
- Can be used in continuous processes, improving productivity.

✓ **Powdered activated carbon**

Powdered activated carbon (PAC) is another common reagent used for decolorizing sugar solutions. It is produced by carbonizing organic materials at high temperatures, which creates a porous structure with a large surface area.

Working principle:

- **Adsorption:** When a sugar solution is passed through a bed of powdered activated carbon, the carbon particles adsorb the color-causing impurities onto their surface. This process is based on the physical attraction between the impurities and the carbon surface.
- **Microporosity:** The high porosity of activated carbon allows it to capture a wide range of impurities, including organic compounds, pigments, and trace metals.

Advantages of Powdered Activated Carbon:

- Highly effective in removing organic impurities and reducing color.
- Can be used for a wide range of sugar types and qualities.
- Relatively easy to handle and apply.

Practical Activity 4.3.2: Decolorizing clarified sugar

Task:

Referring to the previous theoretical activities (4.3.1), you are requested to go to sugarcane processing workshop and decolorize clarified sugar melt.

1: Apply safety precautions (wear PPE).

2: Referring to the procedure provided , Apply sugar melt decolourization steps.

3: Present your work to the trainer and whole class.

4: Read key reading 4.3.2. Ask clarification where necessary.

5: Perform the task provided in application of learning 4.3

Key readings 4.3.2: Applying sugar melt decolorization steps

- **Sugar melt decolorization Steps**

✓ **Sweetening On:** In this initial phase, the sugar melt is introduced into the decolorization system. This typically involves mixing the sugar solution with activated carbon or other adsorbents that have a high affinity for colorants and impurities. The sweetening on phase ensures that the adsorbent material effectively interacts with the sugar melt, allowing for optimal adsorption of colored compounds.

✓ **Service Run:** During the service run, the mixture is allowed to flow through the decolorization unit where it remains in contact with the adsorbent for a specified duration. This time frame is crucial as it determines how effectively colorants are removed from the sugar melt. Parameters such as temperature, pressure, and flow rate are carefully controlled to maximize efficiency.

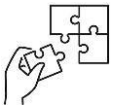
✓ **Sweetening Off:** Once the service run is complete, the sweetening off phase begins. This involves stopping the flow of sugar melt into the decolorization unit while allowing any residual liquid to drain out. This step helps ensure that no additional impurities are introduced into the system after treatment.

✓ **Back Wash:** After sweetening off, a back wash procedure may be implemented to clean out any accumulated impurities from within the decolorization unit. In this step, water or another suitable cleaning solution is passed through in reverse direction to dislodge and remove trapped particles and contaminants from the adsorbent material.

- ✓ **Re-generation:** Re-generation refers to restoring the effectiveness of the adsorbent material used during decolorization. This can involve heating or chemically treating activated carbon or other materials to remove absorbed colorants and impurities so they can be reused in subsequent cycles without significant loss of performance.
- ✓ **Displacement** Finally, displacement involves replacing any remaining spent adsorbent with fresh material before reinitiating another cycle of sweetening on. This ensures that each batch of sugar melt processed will have optimal clarity and quality by starting with an effective adsorbent medium.

Points to Remember

- Ion Exchanger resin and powdered activated carbon reagents are very important as decolorizing clarified sugar melt.
- Decolourization process colour reduction will be depended on type of process. It will be around in the range of 60% to 70% on input of the melt.
- A combination of ion exchange resins and powdered activated carbon is used to achieve the desired level of decolorization.
- The quality requirements ensure that decolorized sugar products are safe for consumption and meet industry standards for taste, appearance, and overall quality.



Application of learning 4.3.

The staff members of the sector where your school is located make a demand of 10kg white sugar per day. Ask trainees to go in the sugarcane processing workshop and decolorize clarified sugar melt.

Indicative content 4.4: Crystallizing refined syrup

Duration: 3 hrs

Practical Activity 4.4.1: Crystallizing refined syrup

Task:

You are requested to go to the sugarcane processing workshop and crystallize refined syrup
1: Apply safety precautions (wear PPE).

2: Present out the procedure of crystallizing of refined syrup.

3: Referring to the procedure provided on step 2, crystallize of refined syrup.

4: Present your work to the trainer and whole class.

5: Read key reading 4.4.1. Ask clarification where necessary

6: Perform the task provided in application of learning 4.4

Key readings 4.4.1: Crystallizing refined syrup

- **Boiling of Refined Syrup**

✓ The boiling process serves to evaporate excess water, increasing the concentration of sugar in the syrup. Typically, this is done in large evaporators where heat is applied to facilitate evaporation while maintaining a controlled temperature to prevent caramelization.

✓ **Purpose of boiling refined syrup**

Crystallization:

- **Supersaturation:** Boiling increases the concentration of sugar in the syrup, creating a supersaturated solution. This means that the solution contains more sugar than it can normally hold at a given temperature.
- **Nucleation:** This supersaturation promotes the formation of tiny sugar crystals, acting as seeds for further growth.
- **Crystal growth:** As the boiling continues, more sugar molecules join these existing crystals, causing them to grow larger.

Moisture removal:

- **Concentration:** Boiling removes excess water from the syrup, increasing its sugar content. This concentration is essential for efficient crystallization.
- **Purity:** By reducing the water content, impurities that may interfere with crystallization are also minimized.

Color and flavor development:

- **Maillard reaction:** During the boiling process, a chemical reaction called the Maillard reaction can occur, contributing to the development of the characteristic color and flavor of brown sugar.

✓ **Boiling conditions**

Temperature:

- **Optimal range:** 70-80°C (158-176°F)
- **Higher temperatures:** Can increase crystallization rate but also lead to increased color formation and potential sugar degradation.
- **Lower temperatures:** Can reduce crystallization rate and may result in inefficient boiling.

Pressure:

- **Vacuum conditions:** Typically used to reduce the boiling point of the syrup, allowing for lower temperatures and improved crystal formation.
- **Pressure control:** Careful control of pressure is essential to maintain the desired boiling temperature and prevent excessive foaming.

Boiling time:

- **Optimal duration:** The boiling time depends on the desired degree of crystallization and the specific properties of the syrup.
- **Careful monitoring:** The boiling process must be carefully monitored to ensure that the desired end point is reached without overcooking.

- **Centrifugation of refined massecuite**

✓ **The purpose of centrifuging refined massecuite** :

To separate the sugar crystals from the remaining molasses.

✓ **Principle**

By spinning the massecuite at high speeds in a centrifugal machine, the sugar crystals are forced to the outer edge of the machine, while the molasses remains in the center. This allows for the efficient recovery of the sugar crystals, which can then be further processed or packaged for sale.

✓ **Benefits of centrifuging refined massecuite:**

Increased sugar yield: Centrifugation allows for a higher recovery of sugar crystals from the massecuite, which can lead to a higher overall sugar yield.

- **Improved sugar quality**: The centrifugal process can help to remove impurities from the sugar crystals, resulting in a higher quality product.
- **Reduced molasses content**: By efficiently separating the sugar crystals from the molasses, centrifugation can help to reduce the amount of molasses that remains in the final product.
- **Increased productivity:** Centrifugal machines are highly efficient and can process large volumes of massecuite in a short amount of time, which can help to increase productivity in sugar refining operations.

- **Drying of white sugar**

✓ **Purpose of drying white sugar**

- **Preventing caking and clumping:** Excess moisture in sugar can cause it to clump or cake together, making it difficult to handle and use. Drying removes this moisture, ensuring a free-flowing product.
- **Maintaining quality and appearance:** Dry sugar retains its desired texture, color, and sweetness. Moisture can lead to discoloration, loss of flavor, and other quality issues.
- **Improving storage stability:** Dried sugar is less susceptible to spoilage and microbial growth during storage. This extends its shelf life and maintains its freshness.
- **Facilitating packaging and transportation:** Dry sugar is easier to package and transport without the risk of damage or spoilage caused by moisture.
- **Meeting consumer expectations:** Consumers expect sugar to be dry and free-flowing. Drying ensures that the product meets these expectations and maintains its appeal.

✓ **White sugar drying conditions**

- **Temperature**
  - **Range:** Typically, between 25°C (77°F) and 40°C (104°F).
  - **Factors:** The specific temperature depends on the desired final moisture content, the type of dryer used, and the ambient conditions.
- **Humidity**
  - **Target:** Low humidity levels are essential to facilitate efficient drying and prevent moisture reabsorption.
  - **Methods:** Dehumidifiers or air conditioners are often used to maintain a dry environment.
- **Airflow**
  - **Importance:** Adequate airflow is necessary to carry away moisture from the sugar crystals.
  - **Factors:** The rate and direction of airflow can influence drying time and energy consumption.
- **Drying time**

- **Factors:** The drying time varies depending on the initial moisture content, temperature, humidity, and airflow conditions.
- **Target:** The goal is to reduce the moisture content to a level that prevents lumping and ensures product stability.

✓ **Drying methods**

- **Fluidized bed dryers:** These dryers use a bed of hot air to suspend and dry the sugar crystals.
- **Conveyor dryers:** Sugar is conveyed through a heated chamber, allowing for controlled drying.
- **Rotary dryers:** These dryers use a rotating drum to tumble the sugar while exposing it to hot air

● **Packaging of white sugar**

This final step involves transferring the dry sugar into bags or containers suitable for distribution and sale.

✓ **Types of sugar packaging material**

- **Plastic bags:** These are the most common type of sugar packaging, providing a balance of durability and cost-effectiveness. They can be made from various plastics like polyethylene (PE) or polypropylene (PP).
- **Paper bags:** While less common for granulated sugar, paper bags are often used for specialty sugars like brown sugar or organic sugar. They are biodegradable and offer a more natural look.

✓ **Sugar storage conditions**

- **Cool, dry location:** Avoid storing sugar in areas with high humidity or near heat sources.
- **Airtight containers:** Transfer sugar from its original packaging into airtight containers like glass jars or food-grade plastic bins. This helps prevent moisture absorption and clumping.
- **Away from strong odors:** Sugar can absorb odors from nearby items. Store it away from spices, coffee, or other strongly scented substances.

Points to Remember

- The boiling of refined syrup, involves several critical conditions that must be met to ensure the desired quality and consistency of the final product.

Application of learning 4.4.

The food plant neighbouring your school that produce bakery products make a demand of white sugar to your school. You are asked to go to the sugarcane processing workshop and crystallize refined syrup.

Learning outcome 4 end assessment

Theoretical assessment

1. Read carefully the statements in table below and match each definition with its appropriate term. Write your answer in the column named **"Answer".**

Answer	Term	Definition
1.....	**1.**Affined sugar	A. is a process used in sugar refining that involves treating raw sugar crystals with warm heavy syrup to remove the molasses coating from the sugar crystals
2.....	**2.**Affination	B. sugar is a process that involves the transformation of solid sugar into a liquid state.
3.....	**3.**The melting of affinized	C. Sugar is produced after centrifugation/purging in affination process

2. Read the following statements carefully and select the best answer for each by encircling the letter corresponding to it.

I. The following are the sugar melt decolourization steps except:
   a) Displacement
   b) Service run
   c) Boiling
   d) sweetening off
   e) Sweetening on

II. The following are the white sugar quality requirements except:
   a) Polarity
   b) Brix
   c) Age
   d) pH
   e) Purity

3.Read carefully the following statements related to the benefits centrifuging refined massecuite and answer by True if the statement is correct or False if it is wrong.

a) Centrifugation allows for a lower recovery of sugar crystals from the massecuite, which can lead to a higher overall sugar yield……

b) The centrifugal process can help to remove impurities from the sugar crystals, resulting in a higher quality product. ……

c) By efficiently separating the sugar crystals from the molasses, centrifugation can help to reduce the amount of molasses that remains in the final product

Practical assessment

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Imberecyane cooperative located in Nyagatare district has a sugarcane plantation, recently they established a sugarcane processing unit. However, the cooperative lacks a qualified technician to process sugarcane. The production manager asks you to perform the following tasks:

1. To melt affinized sugar
2. To clarify melt sugar
3. To decolorize clarified sugar melt
4. To crystallize refined syrup

The task should be completed in 4 hours

All materials, tools and equipment are available at Imberecyane cooperative

END

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October 2024