Gula

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Introduction

- Most sugars occur naturally in fruits and vegetables
- Sugar is produced in 121 Countries and global production now exceeds 120 Million tons a year.
- Approximately 70% is produced from sugar cane, a very tall grass with big stems which is largely grown in the tropical countries. The remaining 30% is produced from sugar beet, a root crop resembling a large parsnip grown mostly in the temperate zones of the north.

Sugar chemistry

sugar, compound of carbon, hydrogen, and oxygen belonging to a class of substances called **carbohydrates**.

Sugars fall into three groups: the monosaccharides, disaccharides, and trisaccharides. The monosaccharides are the simple sugars; they include **fructose** and **glucose**. The disaccharides are formed by the union of two monosaccharides with the loss of one molecule of water. Disaccharides include **lactose**, **maltose**, and **sucrose**

Jenis Gula berdasarkan proses pembuatannya :

- *Raw Sugar* (Gula Kristal Mentah)
- *Refined Sugar* (Gula Kristal Rafinasi)
- *Plantation White Sugar* (Gula Kristal Putih)

Raw Sugar **(Gula Kristal Mentah)**

- **Bahan baku** gula rafinasi
- **gula setengah jadi** yang dibuat dari tebu atau bit melalui proses *defikasi*
- **Proses** *:* ekstraksi - penguapan – *raw sugar*
- masih mengandung lapisan *molasses* yang menyelimuti kristal gula.

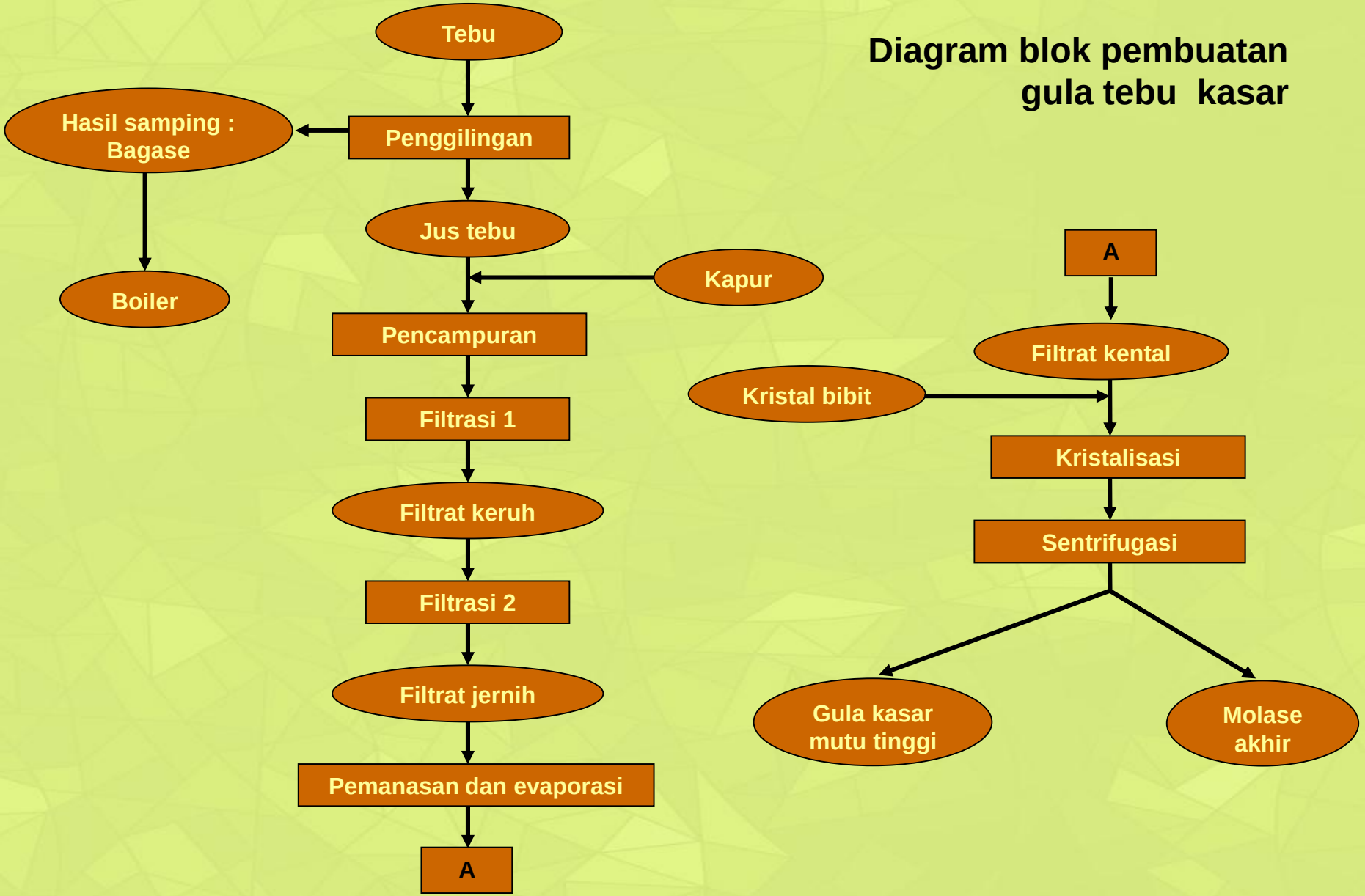
Refined Sugar **(Gula Kristal Rafinasi)**

- merupakan gula sukrosa yang diproduksi melalui tahapan pengolahan gula kristal mentah
- **Proses** : afinasi – pelarutan kembali (*remelting*) - klarifikasi – dekolorisasi – kristalisasi– pengeringan – pengemasan.
- bahan baku industri makanan dan minuman

***Plantation White Sugar* (Gula Kristal Putih)**

- dapat dikonsumsi langsung oleh masyarakat yang dihasilkan dari pengolahan tebu
- **Proses** : ekstraksi – pemurnian – evaporasi – kristalisasi – penyaringan dengan sentrifugasi – pengeringan – pengemasan

Diagram blok pembuatan gula tebu kasar



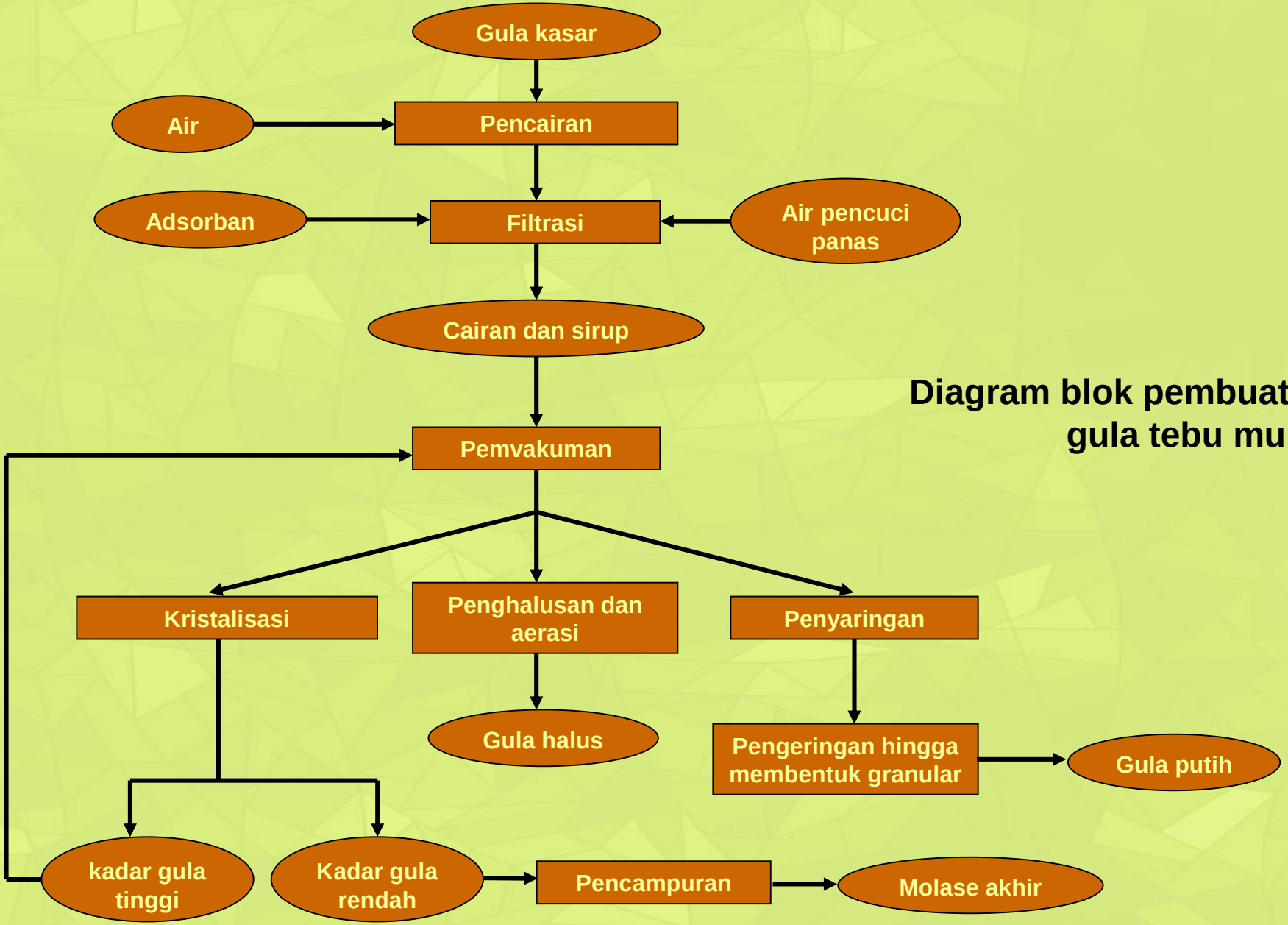
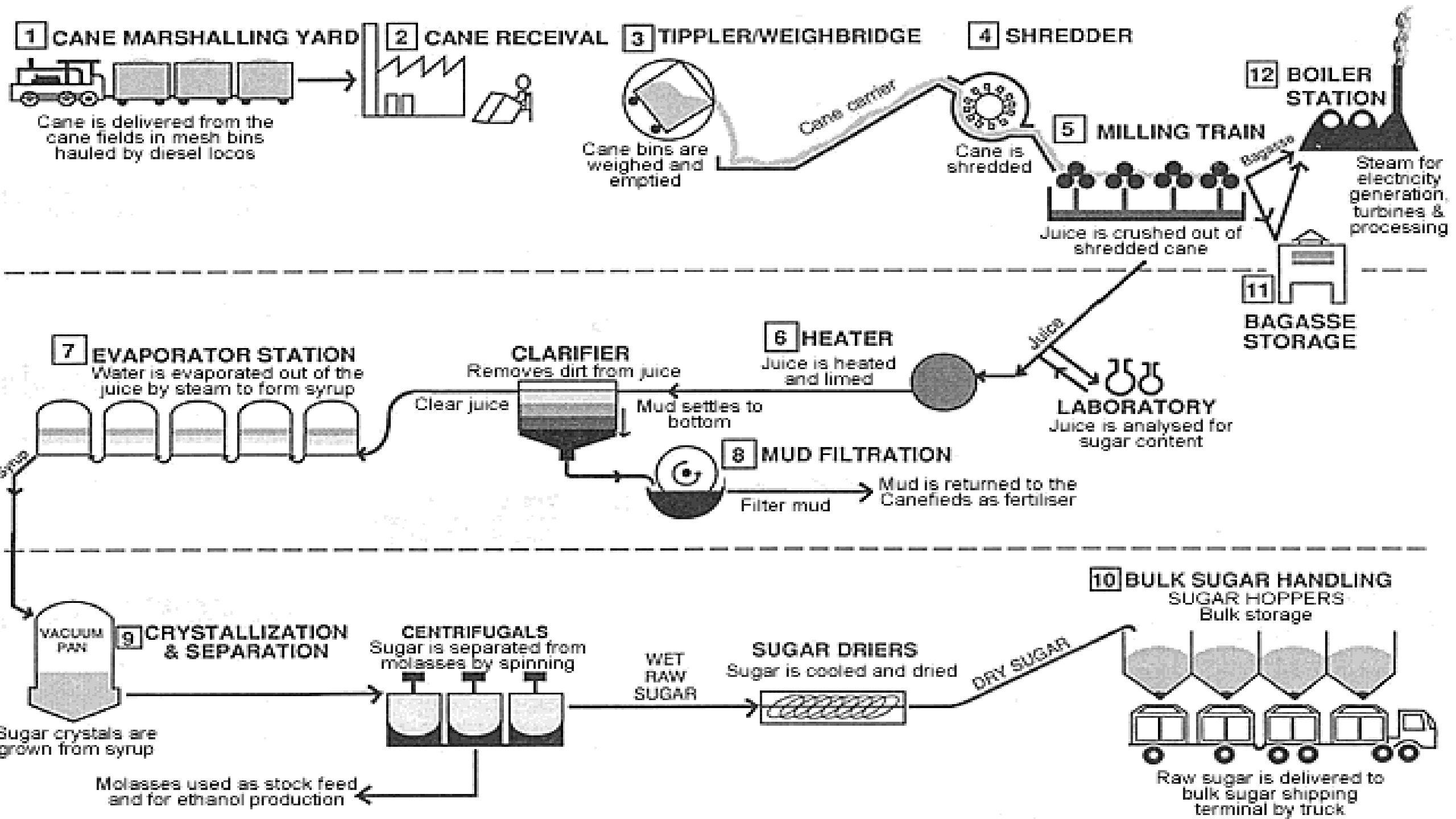
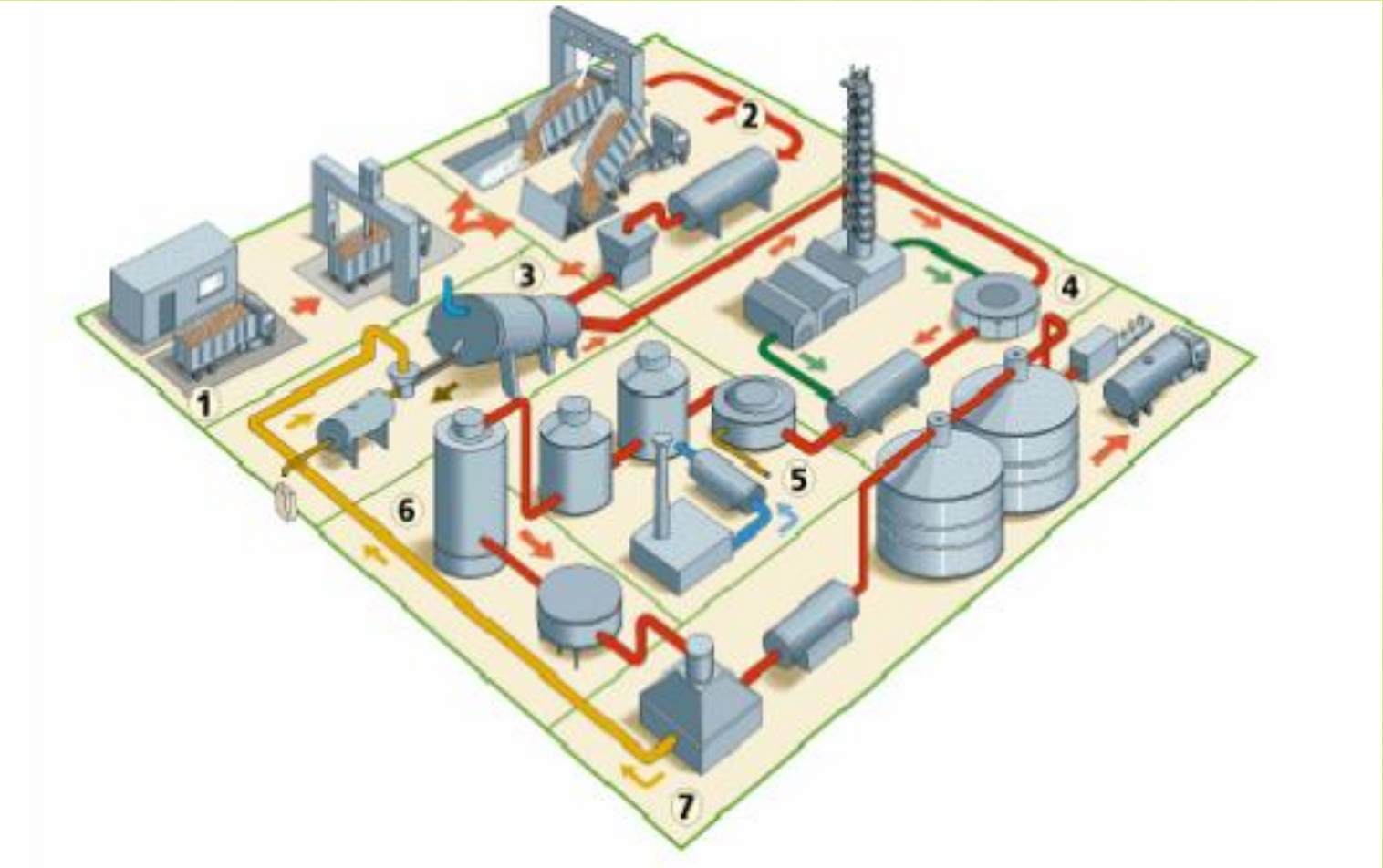


Diagram blok pembuatan gula tebu murni

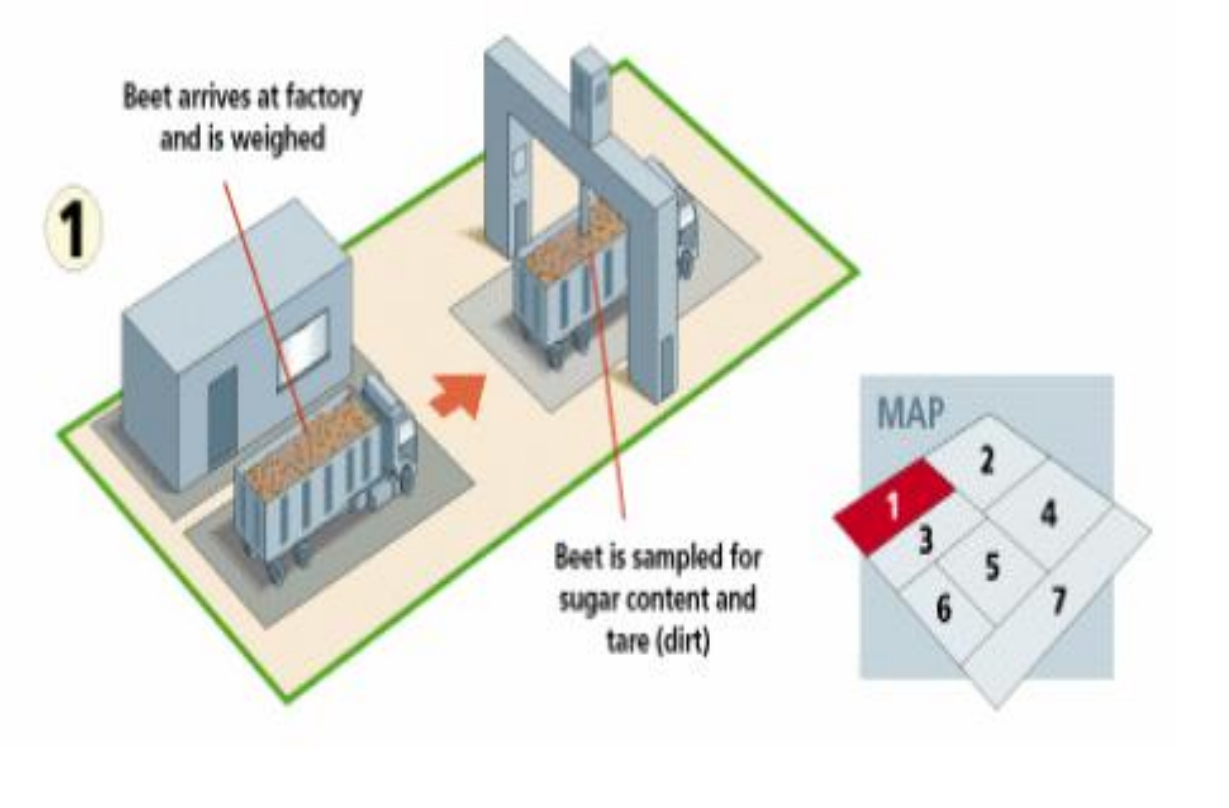

1 CANE MARSHALLING YARD
Cane is delivered from the cane fields in mesh bins hauled by diesel locos
2 CANE RECEIVAL
3 TIPPLER/WEIGHBRIDGE
Cane bins are weighed and emptied
Cane carrier
4 SHREDDER
Cane is shredded
5 MILLING TRAIN
Juice is crushed out of shredded cane
Bagasse
12 BOILER STATION
Steam for electricity generation, turbines & processing
11 BAGASSE STORAGE
Juice
LABORATORY
Juice is analysed for sugar content
6 HEATER
Juice is heated and limed
CLARIFIER
Removes dirt from juice
Clear juice
Mud settles to bottom
7 EVAPORATOR STATION
Water is evaporated out of the juice by steam to form syrup
Syrup
8 MUD FILTRATION
Filter mud
Mud is returned to the Canefields as fertiliser
VACUUM PAN
9 CRYSTALLIZATION & SEPARATION
Sugar crystals are grown from syrup
CENTRIFUGALS
Sugar is separated from molasses by spinning
Molasses used as stock feed and for ethanol production
WET RAW SUGAR
SUGAR DRIERS
Sugar is cooled and dried
DRY SUGAR
10 BULK SUGAR HANDLING
SUGAR HOPPERS
Bulk storage
Raw sugar is delivered to bulk sugar shipping terminal by truck



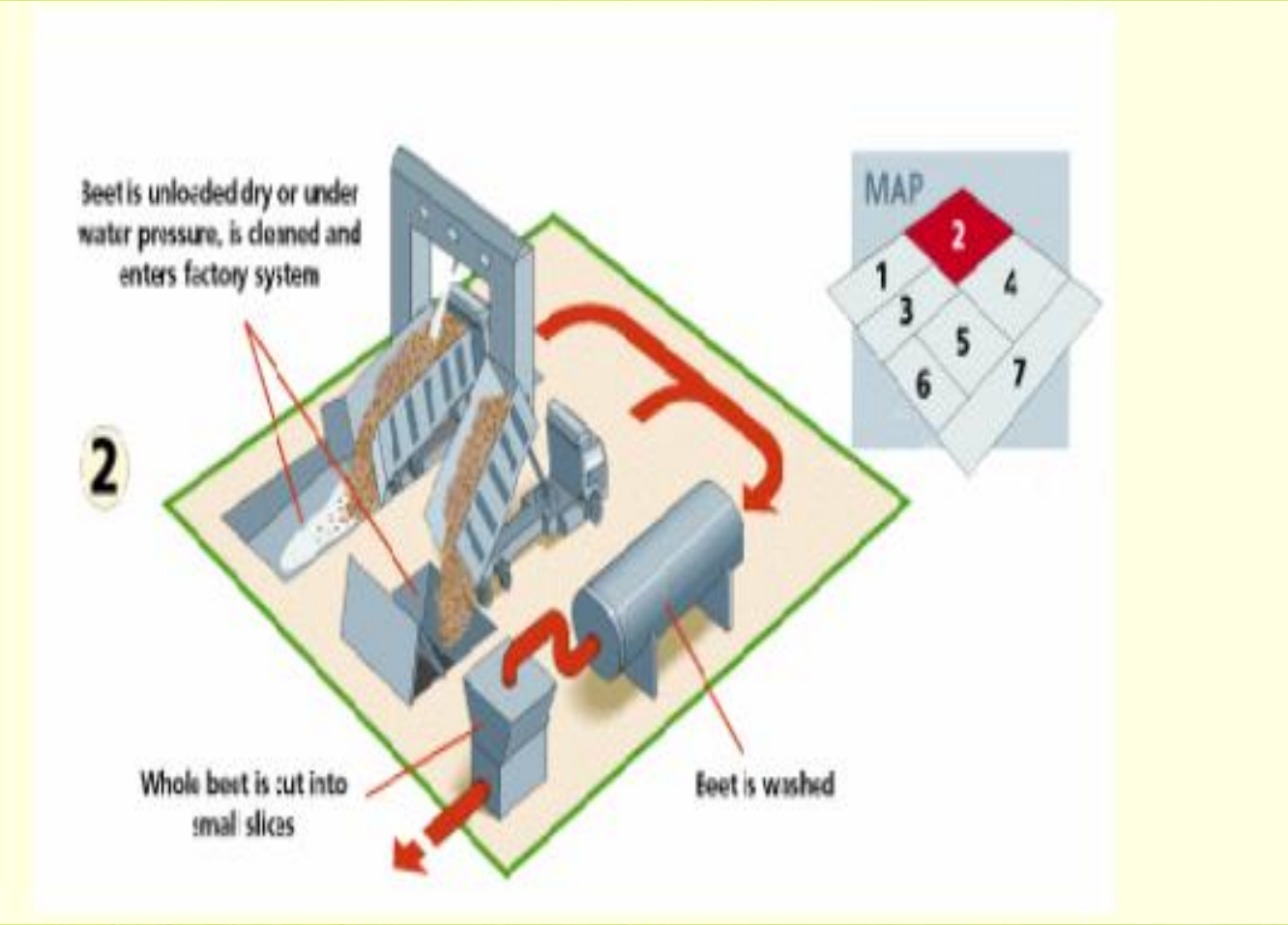
The steps in the manufacture of beet sugar consist of

1. Planting,Growing and Harvesting
2. Washing
3. Slicing
4. Diffusion or Extraction
5. Juice Purification
    a) Carbonation
    b) Sulfitation
6. Evaporation
7. Crystallization

1. Pengumpulan bahan baku



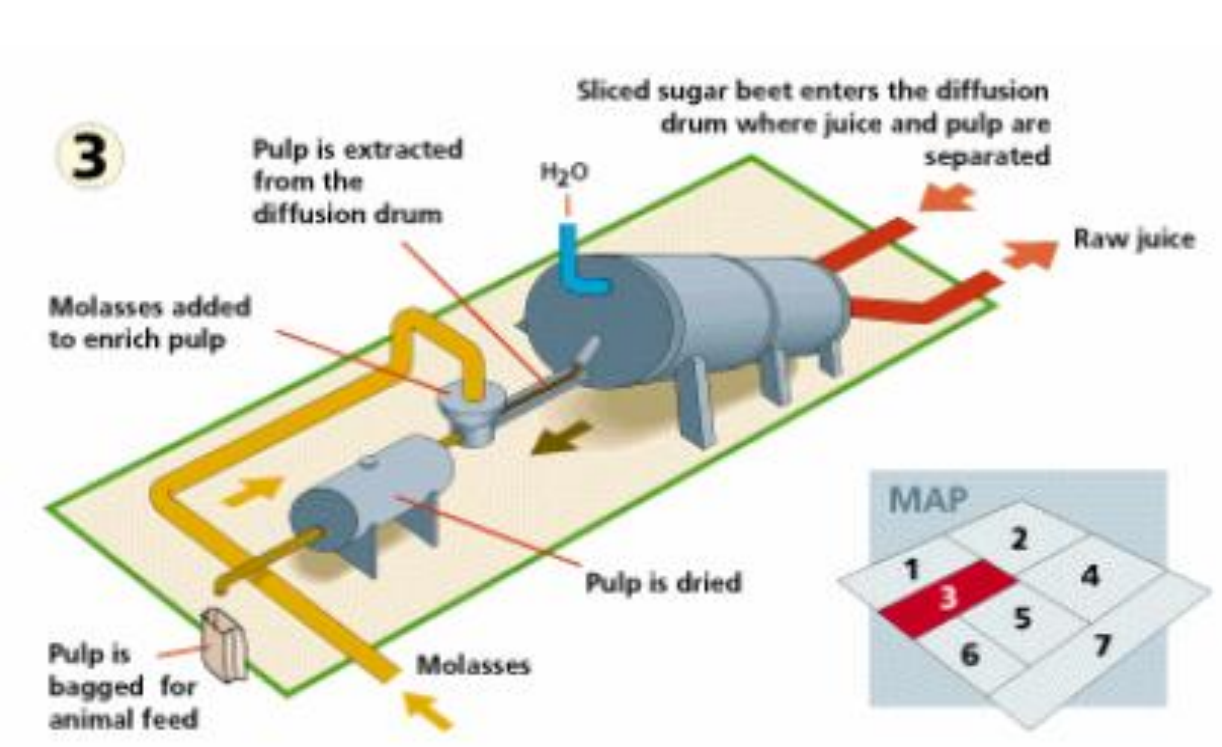
2. Sortasi dan penggilingan



3. Ekstraksi

- Tahap pertama pengolahan adalah ekstraksi jus atau sari tebu. Pada proses ini, tebu dihancurkan dalam sebuah serial penggiling putar yang berukuran besar. Cairan tebu manis dikeluarkan dan serat tebu dipisahkan, untuk selanjutnya digunakan di mesin pemanas (*boiler*).

- The cossettes go through a large tank called a diffuser where raw sugar juice is extracted. The cossettes are gently lifted from the bottom to the top of the diffuser as hot water washes over them absorbing the sugar. After the sugar-laden raw juice is drawn off, the beet pulp is left behind. And the pulp serves animal feeds.



4. EVAPORASI

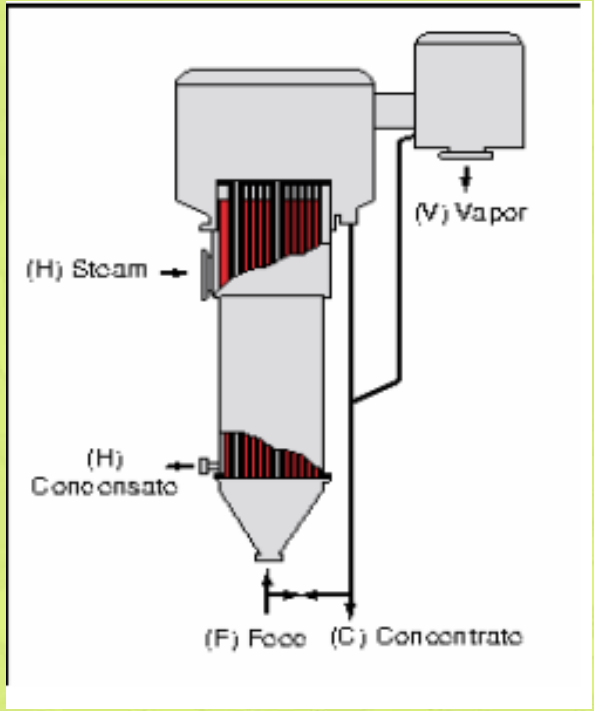
Evaporators are used to separate the materials based on differences in their boiling temperature.

There are ten types evaporator:

1. SHORT & LONG TUBE VERTICAL
2. RISING & FALLING FILM
3. AGITATED THIN FILM
4. FORCED CIRCULATION
5. HORIZONTAL TUBE
6. SINGLE & MULTIPLE EFFECT

LONG TUBE VERTICAL

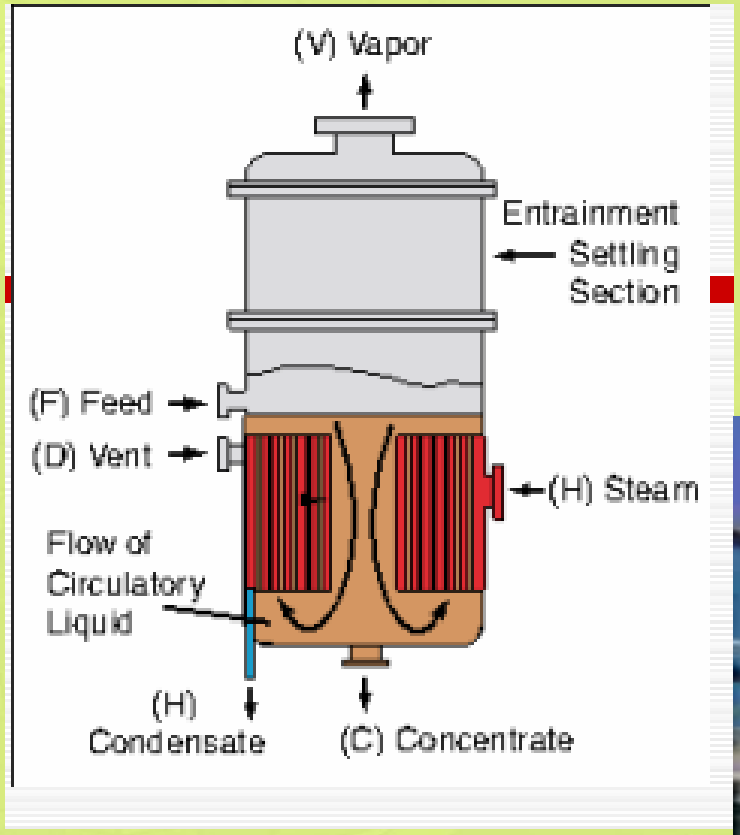
- The long tube vertical, evaporator is one of the most widely used tubular evaporators. It can be built as a large single unit, partially due to the high heat-transfer performance exhibited under most conditions, and partially because of the simplicity and low cost of construction.



Feed flows upward through the tubes and heating medium flows downward on the shellside of a long-tube vertical evaporator.

SHORT TUBE VERTICAL EVAPORATOR

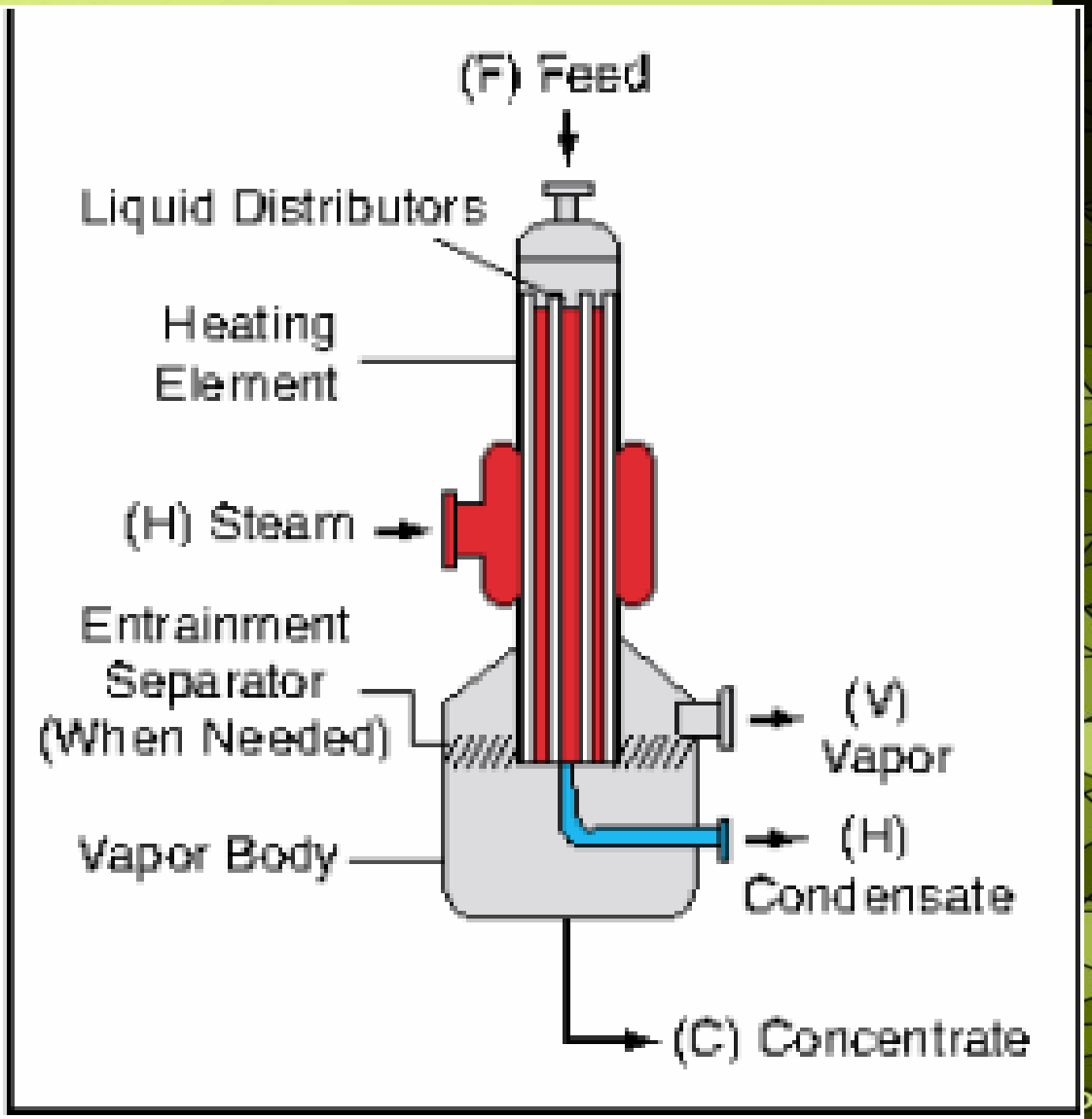
- The short-tube, or calandria, vertical evaporator is one of the earliest types still in widespread commercial use.
- Circulation and heat transfer in this type of evaporator are strongly affected by the **liquid level**.
- However, heat transfer depends greatly on the effect of viscosity and temperature, it is not for use with temperature- sensetive materials, and it is unsuitable for crystalline products unless agitation is provided.



FALLING FILM EVAPORATOR

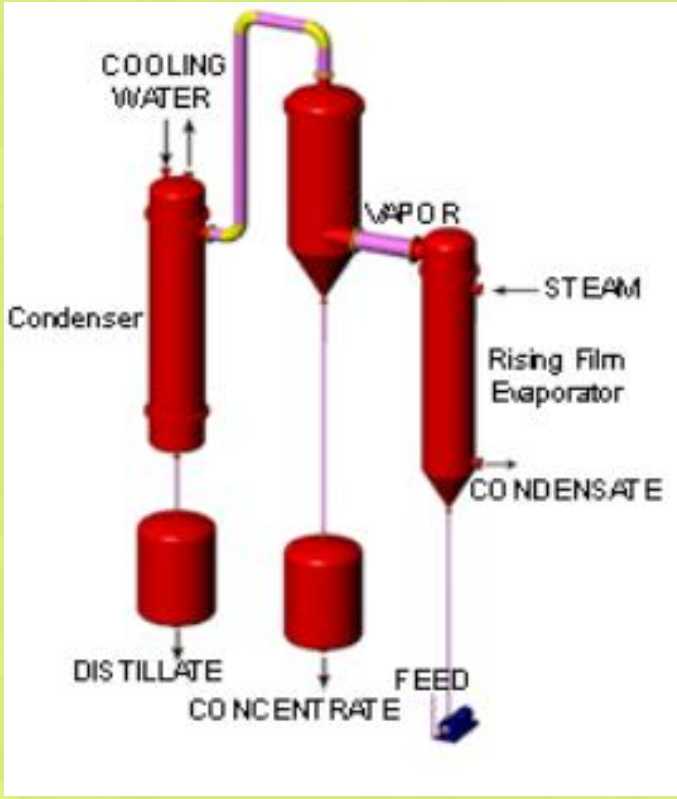
- The long-tube falling-film evaporator is a variation of the long-tube vertical evaporator, in which the equipment is turned upside down so the tubular heat exchanger is on the top of the vapor/liquid separator section.

- The falling-film evaporator is particularly useful in applications where the temperature driving force between the heating medium and the liquid is small (less than 15 F).



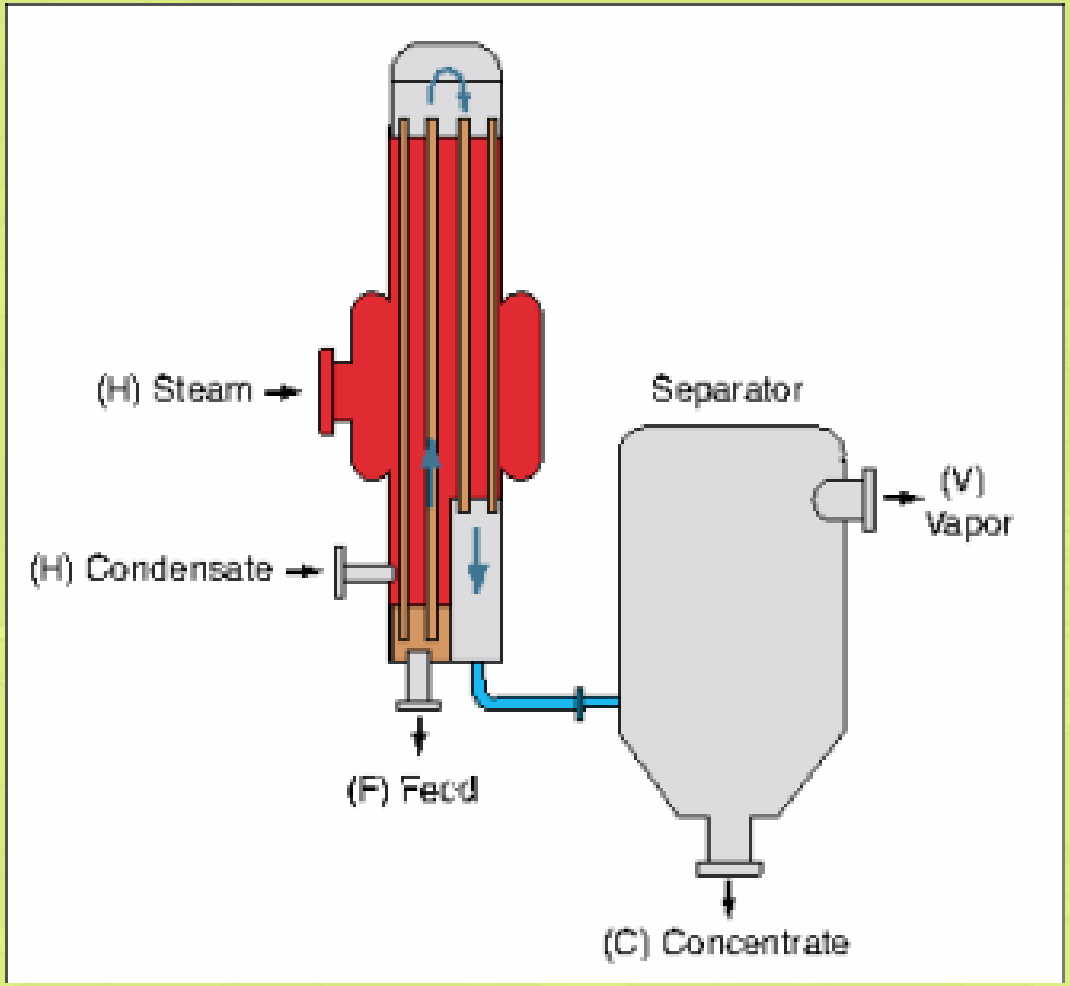
RISING FILM EVAPORATOR

- Rising Film Evaporators
- The rising film evaporator provides a simple solution for concentration, volume reduction of liquids that have moderately heat sensitive products.
- Boiling in vertical tubes promotes vigorous circulation of remaining liquid.
- The liquid and vapor are separated in the cyclone separator.
- Multiple effect arrangement provides the steam economy.



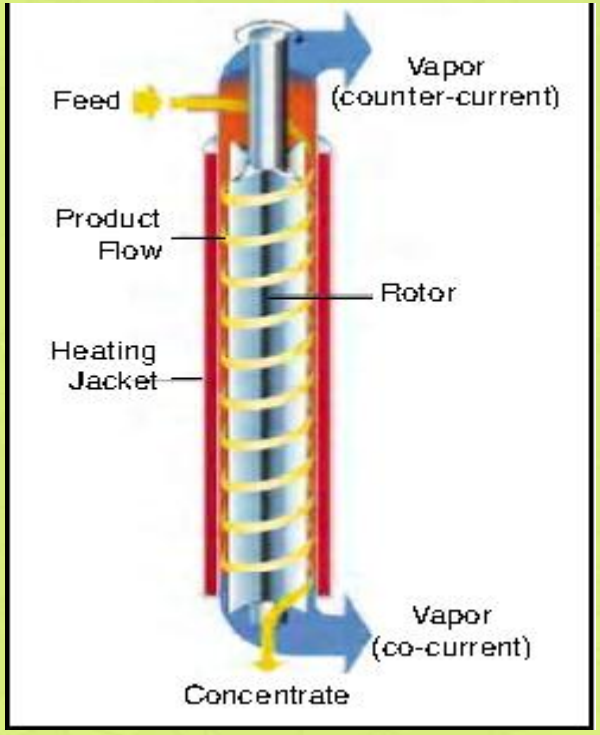
RISING/FALLING FILM EVAPORATOR

- The rising-film and the falling-film evaporators are sometimes combined into a rising/falling-film evaporator to incorporate the advantages of both. When a high ratio of evaporation to feed is required and the concentrate may be viscous, a tube bundle can be divided into two sections, with the first functioning as a rising- film evaporator and the second as a falling-film evaporator.



AGITATED THIN FILM EVAPORATOR

- One of the more useful types of evaporators for difficult to-handle materials is the agitated thin-film evaporator.

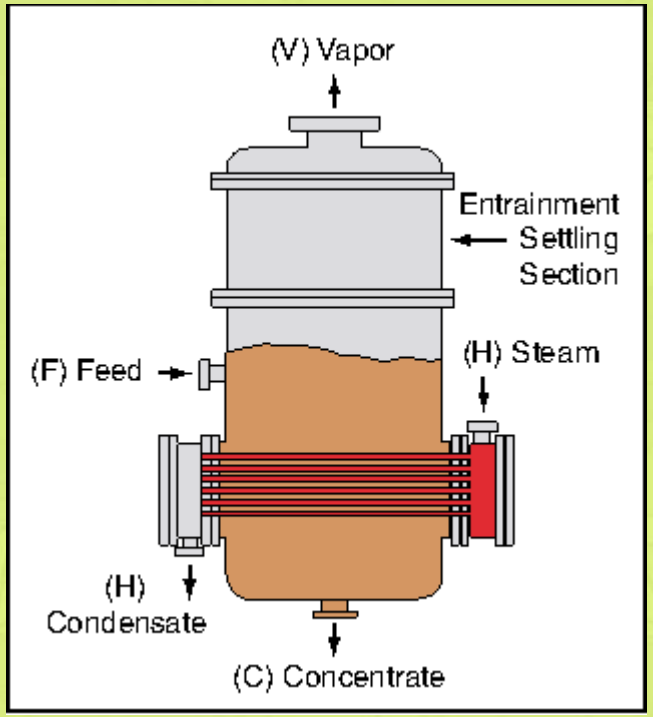


Agitated thin-film evaporators have a wide processing flexibility, and a single system can often be designed to process different products under varied operating conditions. Normally, a thin-film evaporator is operated under reduced pressures in the range of 2—250 mmHg abs.

HORIZONTAL EVAPORATOR

- The horizontal tube evaporator is the oldest type of chemical evaporator.

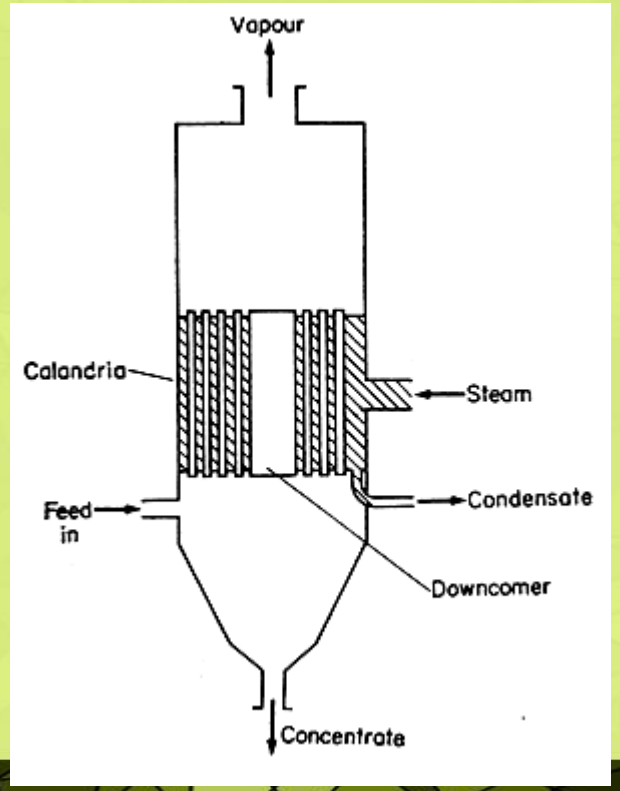
The horizontal tube evaporator is the only type of chemical evaporator in which the heating medium is inside the tubes.



The horizontal evaporator is least satisfactory for fluids that form scale or deposit salt (which would build up on the outside of the tube). it is well suited for processes where the final product is a liquid instead of a solid, such as sugar syrups where the large volume of liquid stored in the evaporator allows a close adjustment of the final density by changing the hold-up in the evaporator.

SINGLE EFFECT EVAPORATOR

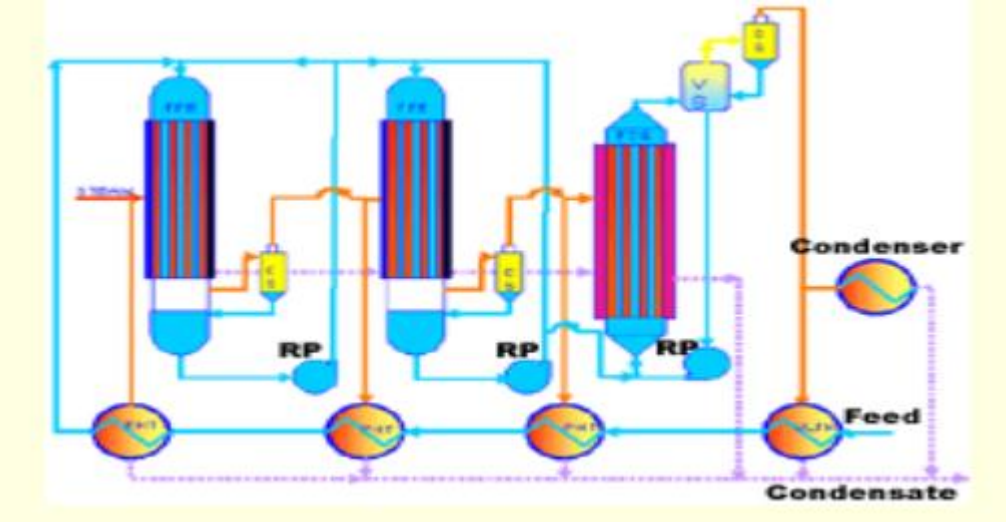
- Single-effect evaporators: A single-effect unit usually uses steam or high-temperature hot water to heat the process liquid to its boiling point. The steam is passed through a coil or jacket and the vapors produced by the boiling liquid are drawn off and condensed. The concentrated liquid then is pumped from the bottom of the vessel.



In particular, single-effect evaporators are utilized for small evaporation rates, or for liquids that boil at high temperatures (high boiling-point elevation liquors).

MULTIPLE-EFFECT EVAPORATOR

- Multiple-effect evaporators: A multiple-effect unit consists of a series of single-effect evaporators. Vapor from the first evaporator is used as the heat source to boil liquid in the second evaporator. Boiling is accomplished by operating the second evaporator at a lower temperature than the first. The process can continue through evaporators (effects).



5. Pendidihan/ Kristalisasi

- Pada tahap akhir pengolahan, sirup ditempatkan ke dalam panci yang sangat besar untuk dididihkan. Di dalam panci ini sejumlah air diuapkan sehingga kondisi untuk pertumbuhan kristal gula tercapai.

6. Penyimpanan Gula Mentah

- Gula kasar yang dihasilkan akan membentuk gunungan coklat lengket selama penyimpanan dan terlihat lebih menyerupai gula coklat lunak yang sering dijumpai di dapur-dapur rumah tangga. Gula ini sebenarnya sudah dapat digunakan, tetapi karena kotor dalam penyimpanan dan memiliki rasa yang berbeda maka gula ini biasanya tidak diinginkan orang. Oleh karena itu gula ini dimurnikan lebih lanjut.

7. Afinasi

- adalah pelunakan dan pembersihan lapisan cairan molasses yang melapisi permukaan kristal
- *Raw sugar* dicampurkan dengan sirup bersuhu 70^{o}C dengan kemurnian sedikit lebih tinggi sehingga tidak melarutkan kristal
- Penurunan intensitas warna yang dicapai pada stasiun ini berkisar 30-50 %.
- Menghasilkan larutan gula dengan *brix* sekitar 65^{o}

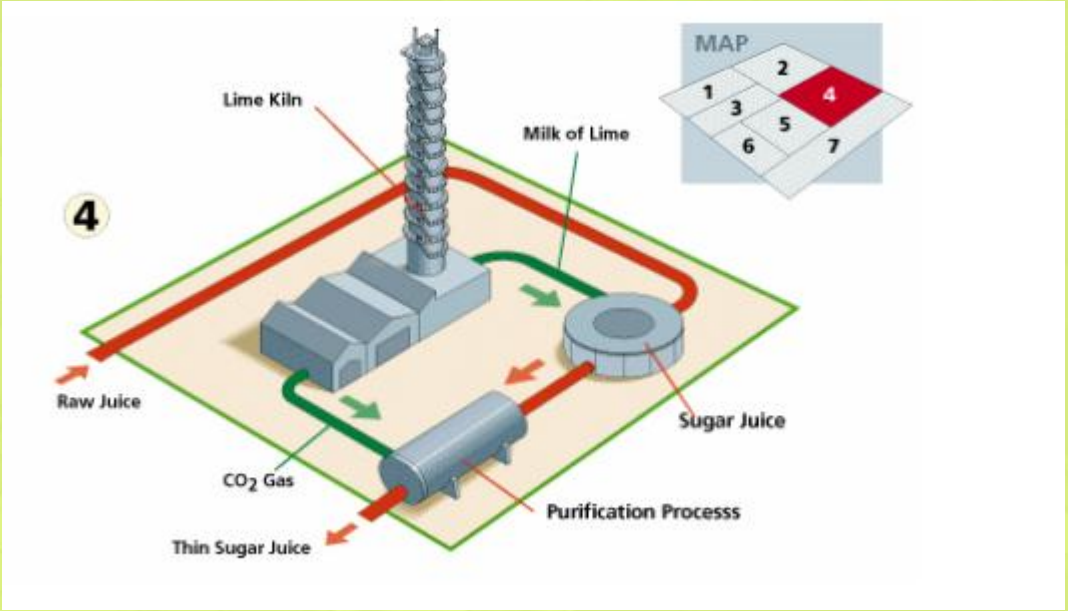
8. Pengendapan (Liming)

- Liming adalah proses pembersihan jus hasil ekstraksi dengan menggunakan semacam kapur ($CaCO_3$) yang akan mengendapkan sebanyak mungkin kotoran untuk kemudian kotoran ini dapat dikirim kembali ke lahan.

Pengendapan – Metode Karbonatasi

- Tahap ini bertujuan untuk membersihkan cairan dari berbagai padatan yang menyebabkan cairan gula keruh. Pada tahap ini beberapa komponen warna juga akan ikut hilang. Karbonatasi dapat diperoleh dengan menambahkan bahan pengendap [kalsium oksida, CaO] dan CO_2

- Before crystallization it is necessary to remove impurities in raw juice. This is accomplished via **carbonation**. The main raw materials used in purification are lime and carbon dioxide gas.



Proses karbonatasi dilakukan dua tahap :

1. pembubuhan kapur sebanyak 0,5% *brix* bersamaan dengan pengaliran CO_2 *ekivalen* dengan jumlah kapur yang ditambahkan
2. menyempurnakan reaksi dengan aliran CO_2 sampai pH berubah di sekitar 8,3. Selanjutnya *liquor* ditapis pada penapis bertekanan *(leaf filter)* menghasilkan *filter liquor* dan *mud*

Carbonation

Chemical reaction one

When the lime is slaked by adding water, the temperature of the mixture rises significantly. This can be described as an *exothermic* reaction.

calcium oxide + water → calcium hydroxide

$CaO + H_2O \rightarrow Ca(OH)_2$

Carbonation

Chemical reaction two

carbon dioxide + calcium oxide → calcium carbonate

CO_2 + CaO → $CaCO_3$

This can be a *reversible* reaction. When the rate of the forward reaction is equal to the rate of the backward reaction, it is said to be at *equilibrium*.

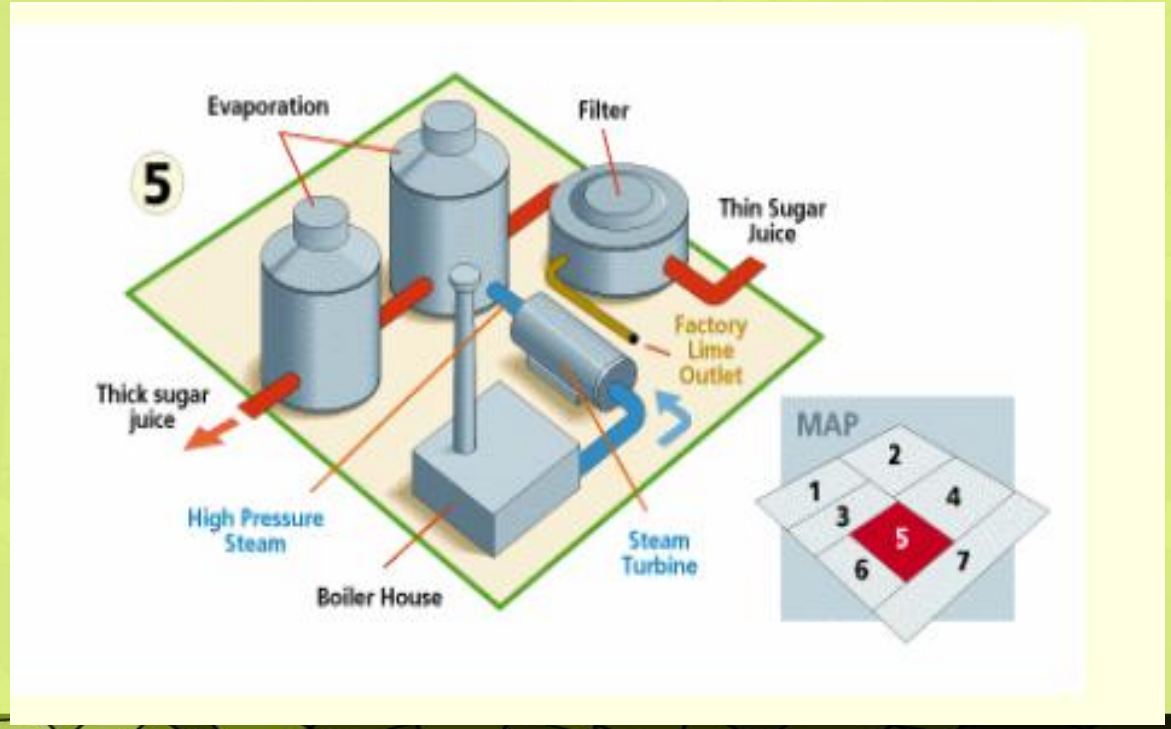
calcium oxide + carbon dioxide → calcium carbonate

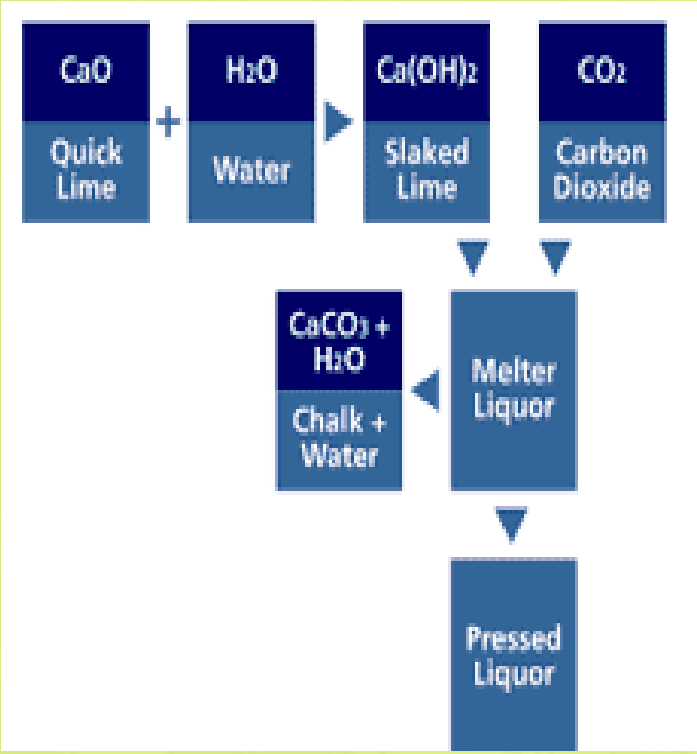
calcium carbonate → calcium oxide + carbon dioxide

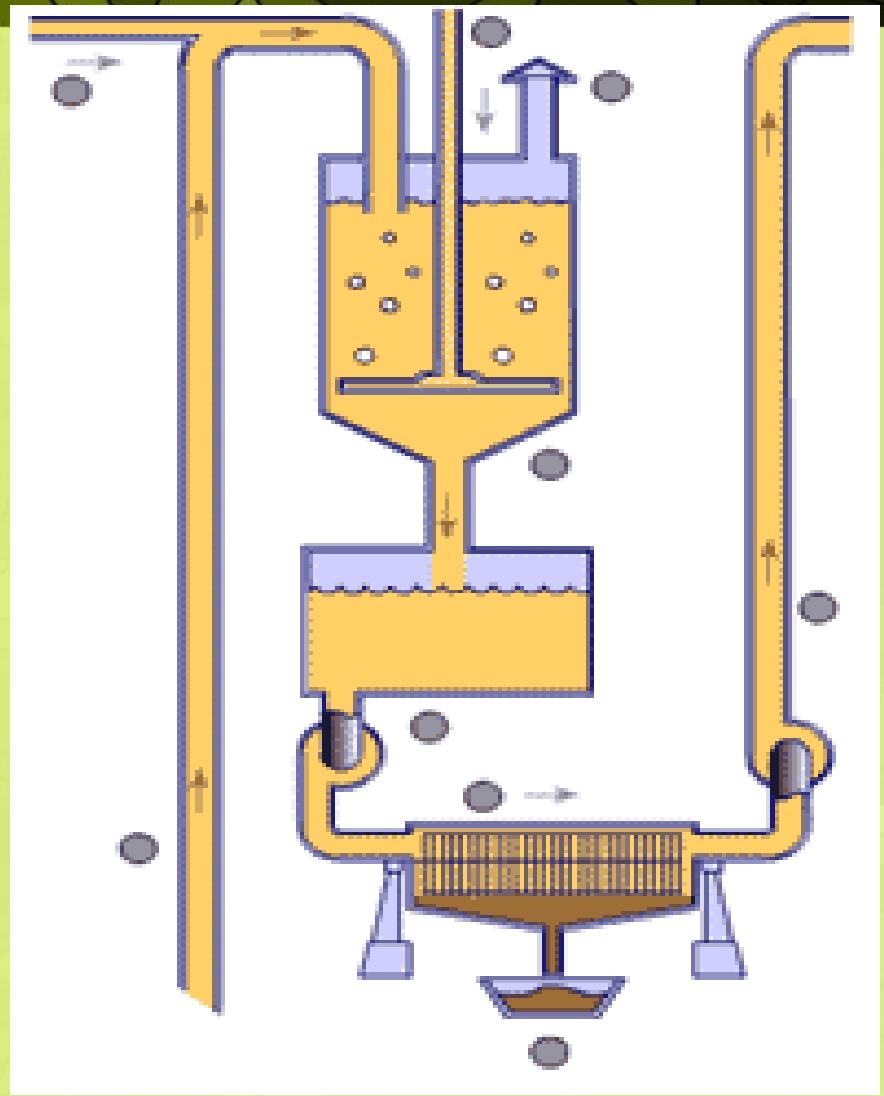
The first reaction combining calcium oxide and carbon dioxide can occur at room temperature. In the factory very high temperatures and a reducing atmosphere are created in a Lime kiln to drive the reaction to produce calcium oxide and carbon dioxide.

9. Penguapan/ Evaporasi

- Setelah mengalami proses *liming*, jus dikentalkan menjadi sirup dengan cara menguapkan air menggunakan uap panas dalam suatu proses yang dinamakan evaporasi.




CaO
Quick Lime
+
H2O
Water
Ca(OH)2
Slaked Lime
CO2
Carbon Dioxide
CaCO3 + H2O
Chalk + Water
Melter Liquor
Pressed Liquor

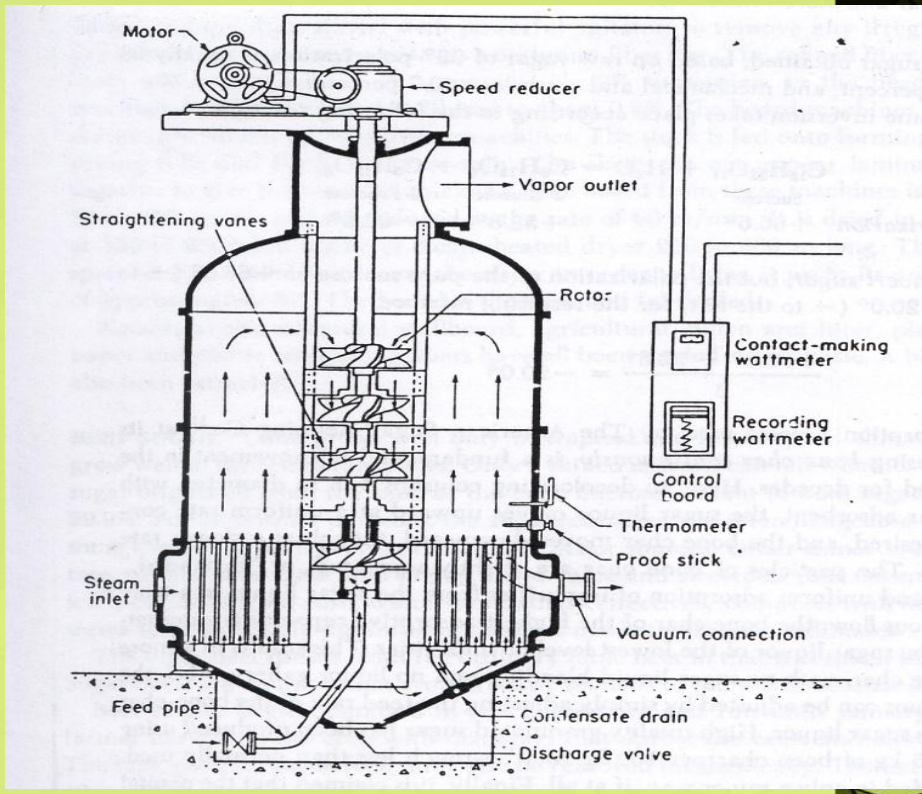


10. Decolorization

- Titik kritis dalam produksi gula rafinasi
- dilakukan dengan pertukaran ion
- Dapat menurunkan warna sekitar 75-85 %
- Metode pemucatann warna ada 2 :

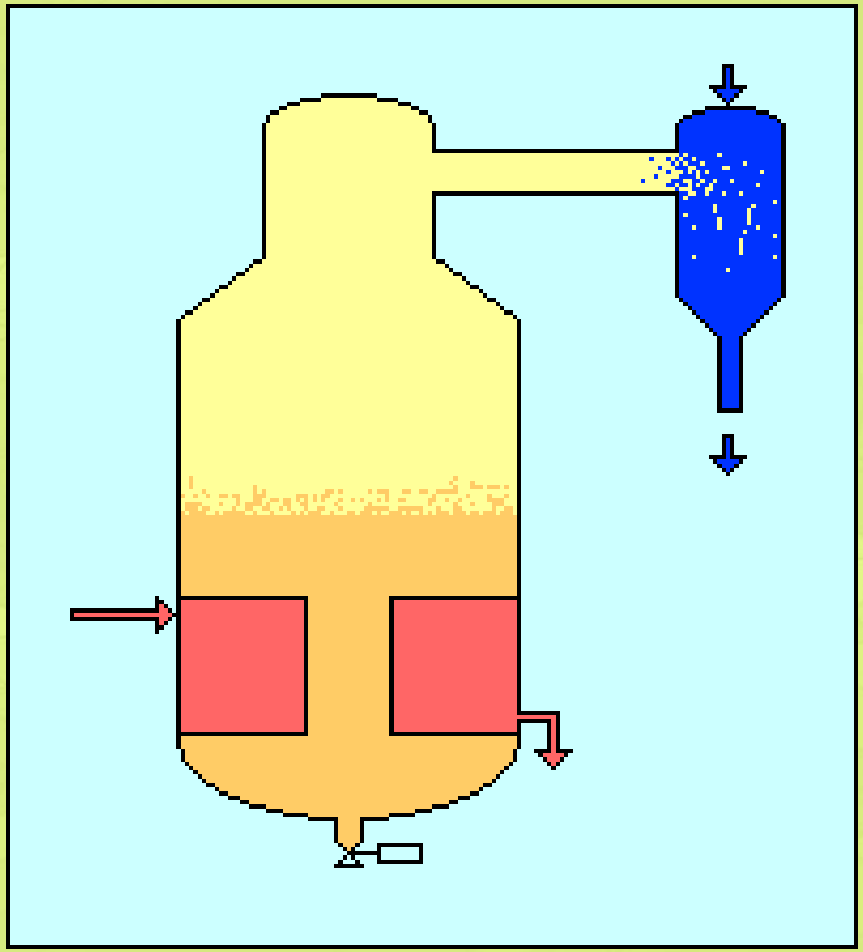
1. **menggunakan karbon aktif** - mereduksi zat warna sangat tinggi, namun bahan ini tidak mampu menghilangkan zat anorganik yang terlarut

2. **Resin penukar ion (Ion- Exchange Resin)** – Resin anion berfungsi mereduksi warna dan resin kation untuk menghilangkan senyawaan anorganik



11. Pendidihan & Kristalisasi

- bertujuan untuk merubah molekul-molekul sukrosa dalam *fine liquor* menjadi kristal gula dengan kehilangan minimum (de Mann, 1997)
- Kristalisasi dilakukan di bejana vakum (65 cm Hg) dengan penguapan *liquor* pada suhu sekitar 70-80^{0}C sampai mencapai supersaturasi tertentu.
- Kemudian bibit kristal dimasukkan secara hati-hati sehingga inti kristal akan tumbuh mencapai ukuran yang dikehendaki tanpa menumbuhkan kristal baru.



12. Sentrifugasi

- bertujuan untuk memisahkan kristal gula dengan *molasses*
- Pemisahan kristal dilakukan dengan cara memutar campuran dalam mesin sentrifugal menghasilkan kristal (gula A) dan sirup A. Selanjutnya sirop A dimasak seperti yang dilakukan sebelumnya menghasilkan gula B dan sirop B.

13. Pengeringan

- bertujuan untuk menurunkan kadar air yang tersisa pada gula sampai dengan kadar 0,05%.


THANK
YOU