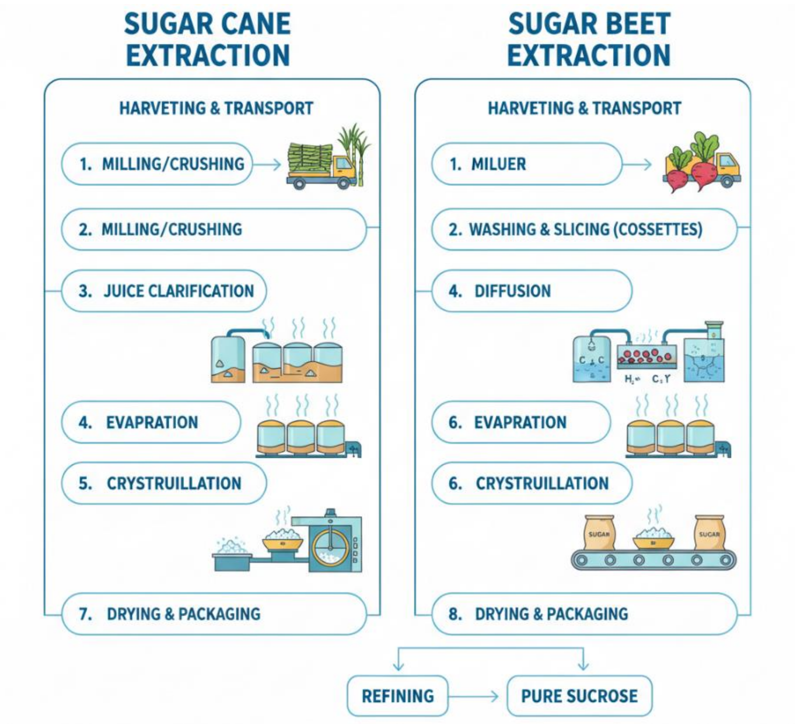
Confectionery 

I. Main types of sugars

1. **Monosaccharides:**
   • Glucose: A reducing sugar obtained from starch hydrolysis.
   • Fructose: Found naturally in fruits and honey, sweeter than sucrose.
   • Galactose: Commonly present in milk sugars (lactose).
2. **Disaccharides:**
   • Sucrose (glucose + fructose): The most widely used sugar in confectionery; extracted from sugar cane or sugar beet.
   • Lactose: Used as a filler or texturizer in chocolate and dairy-based confectionery.
   • Maltose: Formed by starch hydrolysis; used in malt syrups.
3. **Polyols** (Sugar Alcohols): Sorbitol, Mannitol, Xylitol Used in sugar-free confectionery as sweeteners and humectants.

II. Sugar extraction processes

1. Sugar cane and sugar beet (Extraction of sucrose)



1.1 Harvesting

- *Sugar cane: cut as whole stalks; leaves/tops usually removed in field or at mill.*
- *Sugar beet: mechanically uprooted, then freed from soil and leaves before entering the factory.*

1.2 Washing and Preparation

- *Cane or beet: thoroughly washed to remove soil, stones, sand and plant residues.*
- *Cane: mechanically shredded into fine fibers to ease juice extraction.*
- *Beet: sliced into thin strips ("cossettes") to increase surface area for sucrose diffusion.*

1.3 Juice Extraction

- *Cane – Milling: shredded cane passes through roller mills; water (imbibition) helps recover remaining sucrose. Products: raw cane juice (vesou) + bagasse (fibrous fuel).*
- *Beet – Diffusion: cossettes in a diffusion tower contacted with hot counter-current water. Products: raw diffusion juice + exhausted beet pulp (pressed/dried for animal feed).*

1.4 Purification (Clarification)

Raw juice contains many non-sugars; it is purified by:

- *Liming: milk of lime ($Ca(OH)_2$) neutralizes acids and precipitates/coagulates impurities.*
- *Carbonation: CO_2 forms $CaCO_3$ particles that trap impurities; suspension clarified by sedimentation/filtration to give clear juice.*
- Sulphitation (optional): SO_2 may be added (especially in cane) to improve color, stability and pH control.

1.5 Evaporation

- Clear "thin juice" is concentrated in multiple-effect evaporators under vacuum until it becomes a thick syrup (~60–70% solids, mainly sucrose).

1.6 Crystallization

- Syrup is boiled under vacuum in pans; small sucrose crystals (seeds) are added or formed.
- Under controlled cooling and further water removal, crystals grow, forming massecuite (crystals + mother liquor).

1.7 Centrifugation

- Massecuite is spun in centrifuges.
  - Solid: crystalline sugar (raw cane sugar or white/refined beet sugar, depending on process).
  - Liquid: molasses, used for fermentation (ethanol, yeast, etc.) and animal feed.

1.8 Drying and Packaging

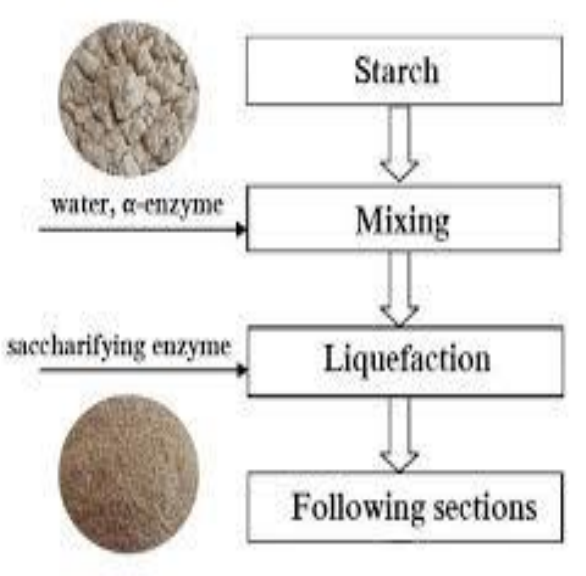
- Sugar crystals are dried with hot air, cooled, screened by size, then stored and packaged as raw, white or refined sugar.

2. Corn starch hydrolysis (Glucose syrups & HFCS)

2.1 Milling: Corn kernels undergo: Cleaning**,** steeping in warm water + SO_2 to soften the kernel. Wet milling to separate: starch, protein (gluten), oil (germ) and fiber

2.2 Liquefaction

- Corn starch is mixed with water.
- α-amylase enzyme breaks down long starch chains into shorter dextrins.
- Performed at high temperature (≈105°C) then cooled.



***2.3 Saccharification* :**

Glucoamylase converts dextrins into glucose molecules.

Result: glucose syrup (30–96% glucose depending on grade).

***2.4 Isomerization* (for HFCS):** To produce high-fructose corn syrup, glucose is passed over glucose isomerase enzyme which converts a portion of glucose → fructose

2.5 Purification*:* Includes: Decolorization (activated carbon), Ion exchange and Filtration

2.6 Concentration & Storage: The final syrup is evaporated to reach desired solids content then stored in heated tanks.

III. Molecular transformations of sugars

1. Caramelization

a non-enzymatic browning reaction: sugars are heated to high temperatures without amino- acids. For sucrose, caramelization begins above 160°C.

1. Dehydration: Heating causes removal of water molecules from sugar and formation of intermediate compounds (dehydro-dimers and furans..)

2. Isomerization: Sugars rearrange structurally, forming new isomers

3. Fragmentation: High heat breaks down sugar molecules into smaller compounds (aldehydes and ketones..), these contribute to the nutty, buttery, and caramel-like aromas.

4. Polymerization: Different molecules combine to form dark brown polymers. These polymers give caramel its characteristic color.

Sensory effects : Color: from pale gold → deep brown • Flavor: buttery, nutty, roasted, sweet-bitter notes

Aroma: complex mix of volatile flavor compounds (furans, esters, lactones)

Applications: Caramel candies, toffee, butterscotch, browning agents for beverages and cotton candy coloration

2. Maillard Reaction

It is a reaction between reducing sugars (glucose, fructose, lactose) and amino acids or proteins. It begins at lower temperatures than caramelization, typically 100–140°C.

1. Initial condensation: A reducing sugar reacts with an amino acid forming a Schiff base.

2. Amadori rearrangement: The Schiff base rearranges to a more stable compound called the Amadori product.

3. Advanced Maillard reactions: Dehydration, fragmentation, cyclization, reaction with sulfur compounds and Formation of melanoidins (brown polymers)

Sensory effects: golden to deep brown, roasted, toasted, nutty, caramel-like Aroma: hundreds of volatile compounds, including pyrazines and furans Industrial

Applications: Nougat and praline, caramel and fudge (color + flavor) , baked confectionery (cookies, biscuits, wafers, roasted nuts ..

3. Crystallization

Occurs when sugar concentration is too high and the solution can no longer hold it dissolved.

• **Fine crystals** → smooth, creamy texture Example: fondant, fudge, milk sweets

• **No crystals** → hard, glassy texture Example: hard candies, lollipops, brittles

Factors influencing crystallization

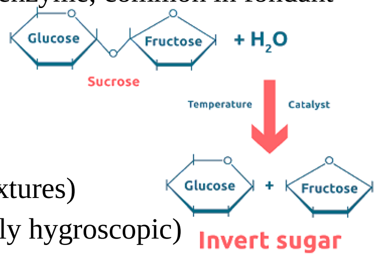
1. Temperature
   - • Slow cooling encourages large crystals (undesirable in many sweets).
   - • Rapid cooling + agitation → small crystals.
2. Cooling Rate
   - • Rapid cooling creates a supersaturated state quickly.
   - • Controlled agitation helps crystal nuclei form evenly.
3. Interfering Agents: Used to prevent unwanted crystallization:
   - • Glucose syrup: reduces sucrose's ability to crystallize
   - • Acids: convert sucrose to invert sugar which crystallizes poorly
   - • Fats: interfere with crystal growth
   - • Proteins: stabilize fine crystals (e.g., in fudge)

Crystalline candy	Non-crystalline candy
Many small sugar crystals dispersed in the product	No crystals (sugar is in a glassy / amorphous state)
Soft, creamy, sometimes slightly grainy	Hard, brittle, chewy or elastic
Encourage controlled crystallization (lots of tiny crystals)	Prevent crystallization (keep sugar dissolved and supercooled)

4. Inversion of sucrose

Inversion is the hydrolysis of sucrose into: Glucose and fructose The mixture is called invert sugar, sweeter and more soluble.

1. ***Acid hydrolysis :*** using lemon juice, cream of tartar, citric acid. Heat accelerates the reaction
2. ***Enzymatic hydrolysis*** : Using invertase enzyme, common in fondant and chocolate fillings



Advantages of invert sugar

- Prevents crystallization (for smooth textures)
- Keeps products moist (fructose is highly hygroscopic)
- Increases sweetness (fructose is sweeter than sucrose)
- Improves shelf life

Applications : Soft caramels, chewy candies, jellies, marshmallows ..

2. Gelation

It is the process by which gelling agents form a 3D-network that traps water, creating elastic or firm textures.

Main Gelling Agents

1. Gelatin: Protein derived from collagen forms elastic, thermo-reversible gels, used in marshmallows, gummies and jelly desserts

2. Pectin: Plant-derived polysaccharide, requires sugar + acid for gelation. Ideal for fruit jellies, jams, and gummy candies

3. Agar-agar: Extracted from red seaweed, forms strong, heat-resistant gels. Used in Asian confectionery and vegan gummies

4. Starch: Forms gels through gelatinization and retrogradation • Used in Turkish delight, licorice, and puddings

Mechanism of Gelation

• Gelling agents hydrate and swell in water.
• Upon cooling or cross-linking, molecules align and form a network structure.
• Water becomes immobilized within this network → solid-like texture.

Example: Industrial production of hard candy (based on non-crystallized sugar)

Formulation: Sucrose for sweetness, glucose syrup to prevent crystallization, water as a solvent and organic acids for partial inversion of sucrose

a. Sugar dissolution

- Mixing water + sucrose + glucose syrup
- Heating until full dissolution

Molecular transformation: Beginning of sucrose inversion in the presence of acids (sucrose → glucose + fructose)

b. Concentration / High-temperature cooking : The syrup is heated to 150–160°C (hard crack stage) to:

- Evaporate water (final moisture ≤ 2%)
- Prevent crystallization

Major molecular transformations:

1. Caramelization ; Dehydration reactions, formation of furans (HMF) and formation of colored polymers (caramelan, caramelen, caramelin)
2. Partial inversion of sucrose : Breakdown into fructose + glucose
3. Formation of an amorphous state ; The melted sugar becomes a viscous, non-crystalline mass. Glass transition → hard, transparent texture

c. Controlled cooling At around 120–130°C:

Addition of flavors, colors, acids

Cooling on a cold table or cooling drum Transformations:

Stabilization of the glassy (amorphous) state, no crystallization occurs due to high viscosity + glucose syrup

d. Shaping and forming: techniques include: • Extrusion • Molding • Rolling and cutting • Forming filled centers (for filled hard candies)

e. Packaging Hard candies are highly moisture-sensitive → require airtight packaging.