SIDI MOHAMED BEN ABDELLAH UNIVERSITY
POLYDISCIPLINARY FACULTY OF TAZA
PROGRAM: AGRI-FOOD ENGINEERING/ S6

COURSE MODULE:
AGRO-RESOURCE PROCESSING AND VALORIZATION

COURSE HANDOUT








ACADEMIC YEAR: 2025-2026

Pr. RHARRABTI

SIDI MOHAMED BEN ABDELLAH UNIVERSITY
POLYDISCIPLINARY FACULTY OF TAZA
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COURSE: AGRO-RESOURCE PROCESSING AND VALORIZATION

CHAPTER 1: VALORIZATION IN AGRO-INDUSTRY

Oilseed Sector

1. The Olive Tree

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Academic year: 2025-2026

Historical Background

The olive tree (*Olea europaea* L.) belongs to the Oleaceae family. It is a characteristic species of the Mediterranean basin and thrives in warm, dry climates. It is cultivated for its fruit (a drupe), which is used for both table olives and olive oil production.

The olive tree is one of the oldest cultivated trees in human history:

- ✓ First domesticated by the Phoenicians and Syrians around 4000 BC
- ✓ Introduced into the Middle East, Palestine, and Cyprus around 3500 BC
- ✓ Later disseminated throughout the entire Mediterranean basin

It has strong cultural, economic, and symbolic significance in Mediterranean civilizations.

Global Olive Grove Distribution

The olive tree is cultivated across five continents. However, more than 90% of global olive production is concentrated in the Mediterranean basin.

There are approximately 784 million olive trees worldwide, of which:

- ✓ 66% are located in Europe
- ✓ 17% in Mediterranean Asia
- ✓ 14% in the Maghreb region

The main producing countries include: Spain, Tunisia, Italy, Turkey, Greece, Morocco, Syria, and Portugal. Spain remains the world leader in olive oil production.

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Oilseed Sector 1. The Olive Tree

National Context (Morocco)

The olive tree represents the most important fruit crop in Morocco. It plays a major socio-economic role:

- ✓ Contributes approximately 5% of national agricultural GDP
- ✓ Generates around 70,000 permanent jobs
- ✓ Provides nearly 20 million workdays annually

The sector is considered strategic within the framework of national agricultural development plans.

Zone	Area in ha	Address
Mountains	250,000 (37%)	Taounate, Taza, Ouezzane, Chefchaouen, Azilal, Khénifra, Al Hoceima, Amizmiz...
Irrigated (*)	250,000 (37%)	Haouz, Tadla, Oasis...
Favorable soil	180 000 (26 %)	Meknes, Fez, Sefrou, El Hajeb, Gharb, Loukkous...

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Oilseed Sector 1. The Olive Tree

National Context (Morocco)

Different Varieties Cultivated at the National Level

✓ *Picholine Marocaine*	✓ *Haouzia* ✓ *Menara*	✓ *Arbequina* ✓ *Arbosana*
• 96% of the cultivated area • Dual purpose: olive oil and table olives • Density: 80 to 400 trees/ha • Oil yield: 18% • Average olive yield per tree: 50 kg • Sensitive to several diseases and pests • Strong alternate bearing	• Clones of Picholine Marocaine (developed by INRA Morocco) • Dual-purpose fruits • Oil yield: 24% • Olive yield per tree: > 60 kg • Reduced alternate bearing	• Exclusively intended for oil extraction • Hedgerow plantations • Density: 1,800 plants/ha • Olive yield: > 15 tons/ha • Oil yield: 20%

- ✓ Dahbia
- ✓ Meslalla
- ✓ Picual
- ✓ Frontoio
- ✓ Manzanilla
- ✓ Gordal Sevillana
- ✓ Arbequine

…etc.

Situation in the Taza Region

In the Taza province, olive cultivation occupies a significant proportion of agricultural land.

- ✓ Olive-growing area: approximately 74,000 hectares
- ✓ Irrigated area: around 1,500 hectares
- ✓ Represents nearly 30% of the province's Utilized Agricultural Area (UAA)
- ✓ Accounts for about 9% of the national olive-growing area

The olive sector is therefore a major driver of rural economic activity in the region.

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Oilseed Sector 1. The Olive Tree

Situation in the Taza Region

Distribution of Olive-Growing Areas by Circle in Taza Province

Circle	Total Area (ha)	Productive Area (ha)	Average Production (tons)
Taza	18,000	11,250	20,000
Oued Amlil	17,300	11,000	20,000
Aknoul	10,000	7,500	12,000
Tahala	11,000	6,000	10,000
Tainaste	17,700	12,000	18,000
Total	**74,000**	**49,250**	**80,000**

Annual Biological Cycle of the Olive Tree

The olive tree follows a well-defined annual biological cycle:

- ✓ January–February: Floral induction and differentiation
- ✓ March: Development of inflorescences
- ✓ April: Flowering period
- ✓ Late April–May: Pollination, fertilization, and fruit set
- ✓ June: Initial fruit growth
- ✓ September: Veraison (onset of color change)
- ✓ October: Fruit maturation and oil accumulation (lipogenesis)
- ✓ Mid-November to January: Harvest period

This cycle is strongly influenced by climatic conditions.

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Oilseed Sector 1. The Olive Tree

Detailed Phenological Stages

Stage A – Winter Dormancy (January – February)

Vegetative buds remain in a resting state.

Detailed Phenological Stages

<u>Stage B – Bud Swelling (beginning of March)</u>
Resumption of vegetative activity; buds begin to elongate.

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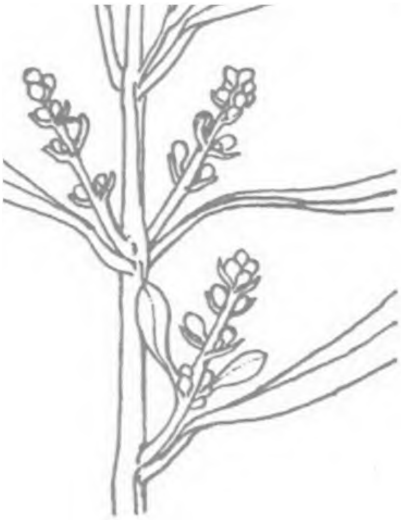
Oilseed Sector 1. The Olive Tree

Detailed Phenological Stages

<u>Stage C – Inflorescence Formation (mid-March)</u> :
Emergence and development of floral clusters.

Detailed Phenological Stages

<u>Stage D – Floral Bud Enlargement (end of March)</u> :
Flower buds become visible and enlarge progressively.



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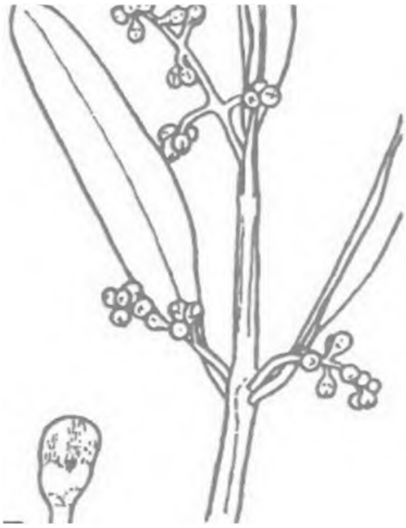
Oilseed Sector 1. The Olive Tree

Detailed Phenological Stages

<u>Stage E – Flower Differentiation (beginning of April)</u> :
The floral organs (calyx and corolla) become clearly distinguishable.



Detailed Phenological Stages

<u>Stage F – Beginning of Flowering (mid-April)</u> :
The first flowers begin to open.

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Oilseed Sector 1. The Olive Tree

Detailed Phenological Stages

<u>Stage F1 – Full Bloom (end of April – Beginning of May)</u> :
The majority of flowers are open; this is the critical stage for pollination.

Detailed Phenological Stages

Stage G – Petal Fall (mid-May) :
Petals dry out and fall, marking the end of flowering.


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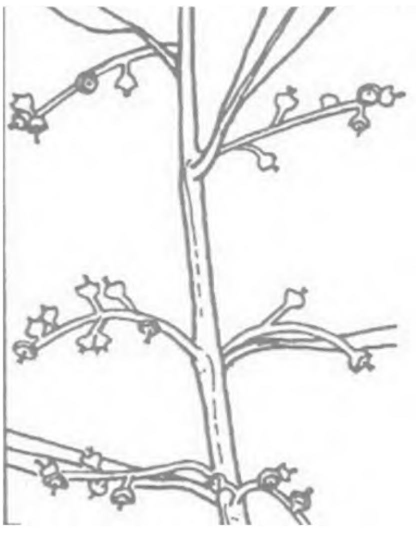
Oilseed Sector 1. The Olive Tree

Detailed Phenological Stages

Stage H – Fruit Set (end of May – Beginning of June) :
Fertilized flowers develop into small fruits.




Detailed Phenological Stages

<u>Stage I – Initial Fruit Growth (June)</u> :
Fruits increase in size and reach approximately the size of a wheat grain.

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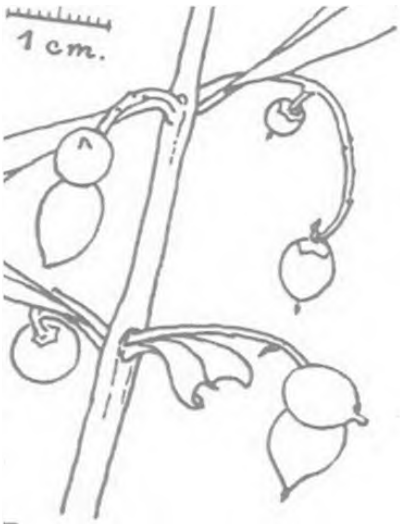
Oilseed Sector 1. The Olive Tree

Detailed Phenological Stages

<u>Stage I1 – Advanced Fruit Growth (July – August)</u> :
Fruit enlargement continues (8-10 mm); the pit begins to harden (lignification phase).



Detailed Phenological Stages

<u>Stage J – Veraison (Color Change, September-October)</u>:
Fruits change color progressively from green to purple and then black.



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Detailed Phenological Stages

<u>Stage K – Maturation and Oil Accumulation (lipogenesis)</u>:
The pulp softens and oil content increases significantly. (end of October – beginning of November).

<u>Stage L – Harvest (mid-November - January)</u> :
Harvest timing depends on the variety and intended use (table olives or oil production).

Agro-Ecological Requirements

Temperature:

- ✓ Resistant to low temperatures (8–10°C) during dormancy
- ✓ Temperatures around 0–1°C may damage flowers
- ✓ Growth slows between 35–38°C
- ✓ Temperatures above 40°C may cause leaf burn and fruit drop

Rainfall:

- ✓ Optimal requirement: around 600 mm/year, well distributed
- ✓ Can tolerate 450–600 mm/year if soil has good water retention capacity

Agro-Ecological Requirements

Climatic Constraints:

- ✓ Hot dry winds can cause dehydration
- ✓ Fog and excessive humidity may favor diseases
- ✓ Hail and spring frost can significantly reduce yield

Light:

- ✓ High sunlight exposure is essential for proper growth and fruiting
- ✓ Tree orientation, planting density, and thinning pruning must be considered

Soil:

- ✓ Prefers deep, well-drained soils
- ✓ Balanced texture: 50% fine particles (clay and silt) and 50% coarse particles (sand)
- ✓ Tolerates alkaline soils up to pH 8–8.5

Agro-Ecological Requirements

<u>Pollination :</u>

In the olive tree, it is the flower that turns into a fruit through the transfer of pollen between the male organs and the female organs.

Olive flowers contain both male organs (stamens) and female organ (pistil), however most olive varieties are self-incompatible. Cross-pollination is required for optimal fruit set. Therefore, orchards should include compatible pollinator varieties whose flowering periods must be synchronized. Pollination is mainly carried out by wind (anemophilous pollination).

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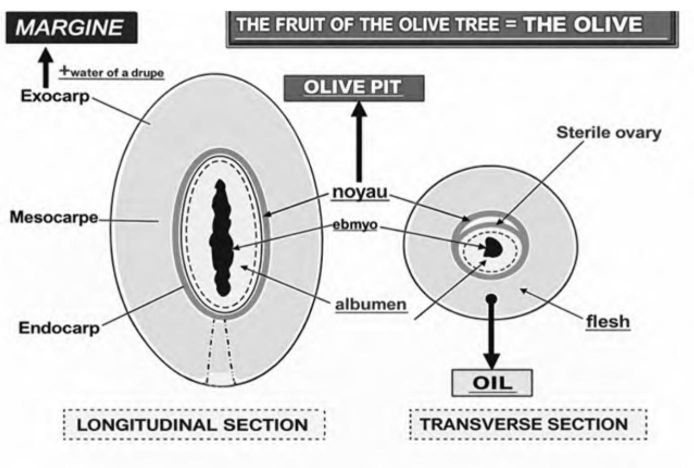
Oilseed Sector 1. The Olive Tree

Olive Oil Processing Technologies

Olive oil extraction remains the main objective of olive cultivation. Methods have evolved, but the core steps are:

- ✓ Leaf removal and washing
- ✓ Crushing
- ✓ Malaxation (kneading)
- ✓ Liquid phase separation



* Olive pit = olive pomace

Olive Oil Processing Technologies

Olive Oil	Acidity (%)	Peroxide Index	Absorbance at 270 nm
Extra Virgin Olive Oil(1 2)	≤ 1,0	≤ 20	≤ 0,25
Virgin Olive Oil(1 2)	≤ 2,0	≤ 20	≤ 0,25
Ordinary Virgin Olive Oil(1	≤ 3,3	≤ 20	≤ 0,30
Lampante Virgin Olive Oil(1 3)	> 3,3	–	–
Refined Olive Oil(4)	≤ 0,3	≤ 5	≤ 1.10
Olive Oil(5)	≤ 1.5	≤ 15	≤ 0,90
Crude Olive Pomace Oil	–	–	–
Refined Olive Pomace Oil	≤ 0,3	≤ 5	≤ 2.00
Olive Pomace Oil	≤ 1.5	≤ 15	≤ 1.70

(1) Virgin olive oil: oil obtained from olives solely by mechanical and physical processes, including thermal conditions, that cause no alteration in the oil, and that has not undergone any treatment other than washing, decantation, centrifugation and filtration.
(2) Fit for direct consumption.
(3) Not fit for direct consumption.
(4) Obtained from virgin olive oils by ry refining techniques not affecting their natural glyceridic structure.
(5) Obtained by cutting refined olive oil with virgin olive oil fit for direct consumption. (Official Gazette No. 4488 of 5-6-97)

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Oilseed Sector 1. The Olive Tree

Olive Oil Processing Technologies

National olive oil production is ensured by traditional units (16000 maâsras) which process about 30% of olive production. The remaining production (70%) is handled by semi-modern and modern discontinuous units using super-presses, as well as industrial units employing a continuous two- or three-phase system with centrifugation.

Extraction systems are essentially of three types:

● **Press-based crushing units**, classified according to the pressure applied: traditional maâsras units with pressures on the order of 100 kg/cm², semi-modern units with pressures around 200 kg/cm², and modern units equipped with super-presses capable of developing pressures up to 400 kg/cm².

Olive Oil Processing Technologies

● **Crushing units equipped with three-phase continuous systems using two centrifugation steps**: the first separates pomace and the mixture of oil and vegetation water, and the second separates the oil from the vegetation water (the three phases are pomace, vegetation water, and oil).

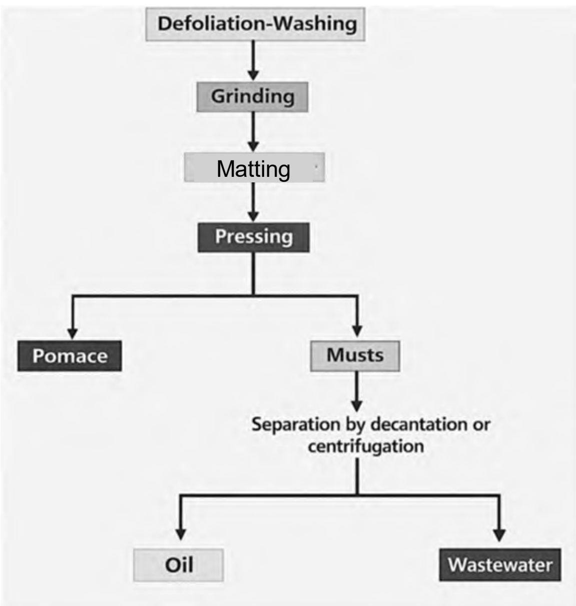
● **Crushing units equipped with two-phase continuous systems using a single centrifugation step** that separates the oil and the pomace moistened by vegetation water from the olives (the two phases are oil and pomace).

Olive Oil Processing Technologies

❑ Discontinuous press extraction system

This extraction process is illustrated in the adjacent figure.

In traditional units (maâsras), the process involves crushing the olives with millstones, placing the resulting paste onto mats, and then extracting the oil by applying pressure using wooden or metal presses, followed by separating the liquid phases (oil and vegetation water) by decantation.



Olive Oil Processing Technologies

❑ Discontinuous press extraction system

Leaf Removal and Washing

The presence of leaves during the crushing of olives results in a greenish coloration of the oil, caused by chlorophyll pigments that promote the photo-oxidation of the oil, leading to poor shelf stability.

The purpose of washing is to prevent the following issues:

- ✓ Interference of soil with the color and other organoleptic properties (aroma, taste) of the oil.
- ✓ Reduction in extraction yield, since soil can absorb up to a quarter (25%) of its weight in oil.

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Oilseed Sector 1. The Olive Tree

Olive Oil Processing Technologies

❑ Discontinuous press extraction system

Crushing = Grinding

The purpose of this operation is to break the cell walls of the olives and allow the release of oil droplets. Granite millstones (2 to 3 stones) are used in the press system. They crush the olives for 20 to 30 minutes.

Given the slow rotation speed of these millstones (10 to 14 revolutions per minute), it is possible not only to crush the olive pulp and pits but also to initiate a preliminary mixing (malaxation) of the entire paste simultaneously.

Olive Oil Processing Technologies

❑ Discontinuous press extraction system

Matting

The paste obtained after crushing is placed into plastic mats (formerly made from doum palm leaves) at a rate of 5 to 10 kg per mat.

According to current international standards, the mats must be washed once a week to prevent an increase in the oil's acidity or the development of an organoleptic defect known as the “mat” defect.

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Oilseed Sector 1. The Olive Tree

Olive Oil Processing Technologies

❑ Discontinuous press extraction system

Pressing

The filled mats are stacked in a traditional press for a residence time of 4 to 6 hours.

This is a relatively slow operation, as the maximum pressure generated by manual tightening is insufficient to extract most of the oil contained in the crushed material.

The liquid phase flows into a collection tank, while the pomace remains on the mats.

Olive Oil Processing Technologies

❑ Discontinuous press extraction system

<u>Decantation</u>

The separation of the oil from the vegetation water is carried out by simple natural decantation in covered basins to prevent photo-oxidation.

This method is used only in traditional maâsras due to its slow pace. Modern vertical centrifuges are used to separate olive oil from the vegetation water more efficiently.


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Oilseed Sector 1. The Olive Tree

Olive Oil Processing Technologies

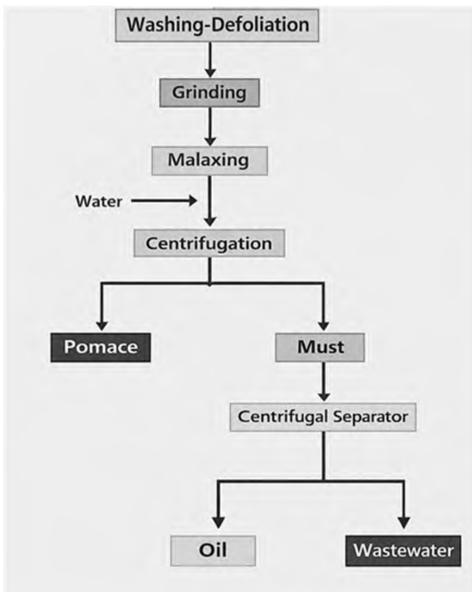
❑ Continuous extraction system with three-phase centrifugation

The continuous system emerged in the 1970s with new extraction technologies.

This modern design replaces traditional pressing. It uses horizontal centrifuges, called “decanters,” which improve both the yield and productivity of olive mills.

There are two systems:

- ✓ **Three-phase**
- ✓ **Two-phase**



Olive Oil Processing Technologies

❑ Continuous extraction system with three-phase centrifugation

<u>Leaf Removal:</u>

This step is necessary to prevent the oil from acquiring an excessively green coloration, which results in excessive bitterness and reduced shelf life.

<u>Washing:</u>

The olives are washed with cold water. Washing prevents soil contamination from affecting the color, aroma, and taste of the oil.

CHAPTER 1: VALORIZATION IN AGRO-INDUSTRY
Oilseed Sector 1. The Olive Tree

Olive Oil Processing Technologies

❑ Système continu d'extraction avec centrifugation à 3 phases

<u>Crushing:</u>

Traditional mills are replaced by metallic hammer or disc crushers, which have the advantage of being fast but do not allow complete release of the oil contained in the olive vacuoles.

Therefore, malaxation after crushing is necessary to extract all the oil remaining in the fruit.

Olive Oil Processing Technologies

❑ Continuous extraction system with three-phase centrifugation

Malaxation:

This operation, which complements the shearing and crushing effects, aims to extract all remaining oil from the vacuoles, aggregate the oil droplets into larger drops, and form pockets of a continuous oil phase.

Malaxation produces a paste containing both solids and fluids. The solid fraction, called pomace, consists of pits, skins, cell walls, etc., while the fluid fraction is composed of oil and vegetation water, also referred to as olive mill wastewater (OMW).

Olive Oil Processing Technologies

❑ Continuous extraction system with three-phase centrifugation

Horizontal Centrifugation:

After crushing and malaxation, the paste is pumped at variable speed into a horizontal centrifuge, with the addition of warm water (20–25°C) to the malaxated paste. This results in the initial separation of pomace, oil, and vegetation water.

The solid phase, called pomace, contains the majority of the solids present in the olive: skin, pulp, pit, and a small portion of oil.

The aqueous phase still contains some oil, which is separated by subjecting the vegetation water to a second centrifugation in a vertical centrifuge.

Olive Oil Processing Technologies

❑ Continuous extraction system with three-phase centrifugation

Vertical Centrifugation:

The liquid oil phase, which contains the vegetation water (OMW), must be purified by more intensive centrifugation in a vertical centrifuge, which separates the oil from OMW.

The major disadvantage of this system is its high water consumption, resulting in greater environmental pollution. In fact, the water usage of the three-phase system is significantly higher than that of the traditional system, reaching approximately 100–130 L per 100 kg of olives.

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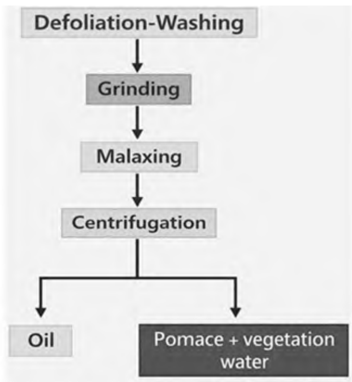
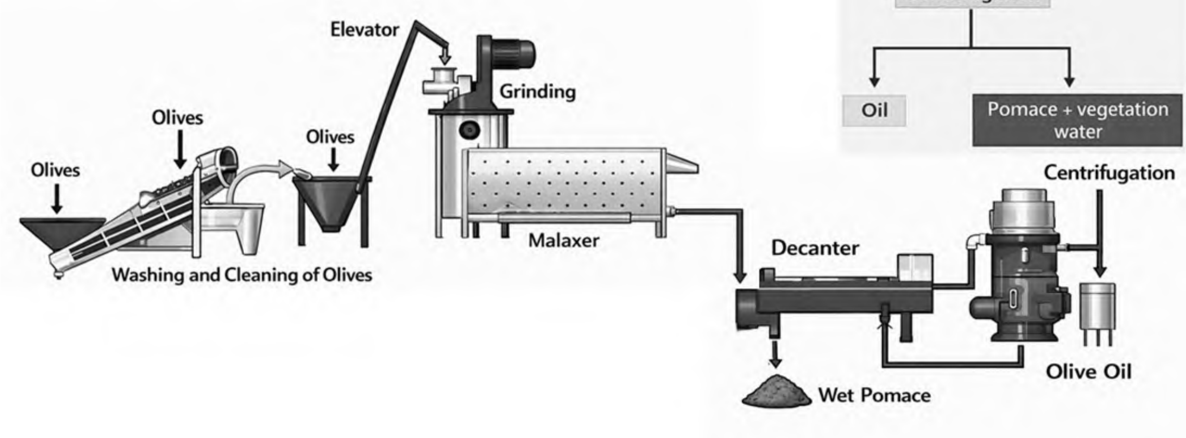
Oilseed Sector 1. The Olive Tree

Olive Oil Processing Technologies

❑ Continuous extraction system with two-phase centrifugation

This extraction process is illustrated in the following figures:





Olive Oil Processing Technologies

❑ Continuous extraction system with two-phase centrifugation

The large amount of residues generated during olive oil extraction using the three-phase method has encouraged the development of new technologies and the continuous two-phase system.

The main innovation of this system is that it enables the production of virgin olive oil without the need to add water to the decanter; consequently, there is virtually no generation of wastwater. This extraction technology offers the advantage of saving substantial amounts of water and energy and reducing environmental impact.

CHAPTER 1: VALORIZATION IN AGRO-INDUSTRY
Oilseed Sector 1. The Olive Tree

Olive Oil Processing Technologies

❑ Continuous extraction system with two-phase centrifugation

During the centrifugation step, two streams are generated: one containing the oil, and the other containing most of the solid material together with nearly all of the intrinsic water, referred to as **wet pomace**.

The moisture content of the pomace obtained from the two-phase decanter is relatively high and may approach 60%. Drying of this pomace to acceptable moisture levels is therefore carried out for use in animal feed.

Olive Oil Processing Technologies

❑ Comparison of the three extraction systems

Input–output analysis for the three olive oil extraction systems

SYSTEM	INPUTS	QUANTITY	OUTPUTS	QUANTITY
Pressing	Olive	1 Tm	Oil	200 Kg
	Washing water	100–120 l	Pomace (40% water, 7% oil)	400–600 Kg
			Margines (88% water)	400–600 l
	Energy	90–60 Kw.h		
3 Phases	Olive	1 Tm	Oil	200 Kg
	Washing water	100–120 l	Pomace (40% water, 4% oil)	500–600 Kg
	Additional water	700–1000 l	Wastwater (94% water, 1% oil)	1,000–1,200 l
	Energy	90–117 Kw.h		
2 Phases	Olive	1 Tm	Oil	200 Kg
	Washing water	100–120 l	Wet pomace (60% water, 3% oil)	800 Kg
			Vegetation water	100–150 l
	Energy	< 90–117 kW.h		

CHAPTER 1: VALORIZATION IN AGRO-INDUSTRY
Oilseed Sector 1. The Olive Tree

Olive Oil Processing Technologies

❑ Comparison of the three extraction systems

Oil yield and characteristics of the by-products obtained with different oil extraction systems

Parameters	2-Phase Decanter	3-Phase Decanter	Super-Press System
Yield (%)	86.1	85.5	84.5
Pomace (Olive cake)			
Quantity (kg/100 kg olives)	75.5	57.5	45.5
Moisture (%)	57.3	55.4	35.5
Oil (%)	3.5	3.6	6.8
Oil (kg/100 kg olives)	2.7	2.0	5.4
Wastewater (Vegetation water)			
Volume (liters/100 kg olives)	3.6	90	75
Oil (kg/100 kg olives)	0.06	1.05	2.4
Total oil in by-products (kg/100 kg olives)	2.8	3.1	7.8

Olive Oil Processing Technologies

❑ Comparison of the three extraction systems

Quality characteristics of the oils obtained using the three different extraction systems

Parameters	2-Phase Decanter	3-Phase Decanter	Super-Press System
Acidity (%)	0.5	0.6	0.8
Peroxide value (meq/kg)	5.3	5.0	8.3
Total polyphenols (mg/L tyrosol)	198	100	183
O-Diphenols (mg/L caffeic acid)	116	79	105
Oxidative stability (days)	269	146	210
Degraded total polyphenols	20.0	39.8	25.5
K270	0.17	0.18	0.25
ΔK	0.01	0.01	0.01

Valorization of Olive By-Products

❑ The main by-products of the olive tree are:

- ✓ Pruning residues.
- ✓ Pomace, composed of pits, pulp, and skin, and in some cases, olive vegetation water.
- ✓ Olive Mill Wastewater (OMW), originating from the liquid fraction of the olives and from any water that may be added during the crushing process.

Valorization of Olive By-Products

- **Valorization of pruning residues:**

Pruning residues have numerous applications:

- ✓ *Direct use in animal feed*: they can substitute for hay or straw.
- ✓ *Composting*: used as a component in organic compost production.
- ✓ *Fuel for industrial or domestic use*: olive tree pruning wood and other woody residues can be crushed, dried, and compressed into wood pellets for heating purposes.
- ✓ *Raw material for industry*: olive wood can be used in paper production, furniture manufacturing, or craft and artisanal works.

Valorization of Olive By-Products

- **Valorization of Pomace :**

- ✓ *Use in animal feed* after supplementation with other components such as cactus, forage, and minerals.
- ✓ *Use as fuel*: olive pomace is a fuel with a moderate calorific value (approximately 2950 Kcal/kg). After separating the pulp from the pits, the pulp can be processed into wood pellets, while the pits can be used directly in boilers.
- ✓ *Use as fertilizer*: olive pomace compost can be applied to agricultural soils to improve soil fertility and crop productivity.

Valorization of Olive By-Products

❑ Agricultural Valorization of OMW:

✓ *Biogas production*: Applying anaerobic digestion to OMW allows the conversion of approximately 80% of the organic matter into biogas, with 65–70% methane content. Anaerobic treatment of OMW can contribute to energy self-sufficiency.

✓ *Composting*: OMW can be used to produce fertilizing compost for soils. An advantage of compost derived from OMW is the absence of pathogenic microorganisms, combined with high concentrations of phosphorus and potassium, unlike urban solid residues.

Valorization of Olive By-Products

❑ Agricultural Valorization of OMW:

✓ *Spreading and Soil Fertilization*

- Use of OMW for soil compaction: This is particularly useful in areas where water availability is a limiting factor.
- Direct use as fertilizer: Controlled application of OMW and pomace compost provides suitable fertilization for olive trees, vineyards, and certain annual crops without posing risks to the environment or the crop.
- Use in irrigation: OMW can be applied in irrigation due to its high water content and nutrient richness.

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CHAPTER 1: VALORIZATION IN AGRO-INDUSTRY

Oilseed Sector

2. Sunflower

Prof. Yahia RHARRABTI
Academic year: 2025-2026

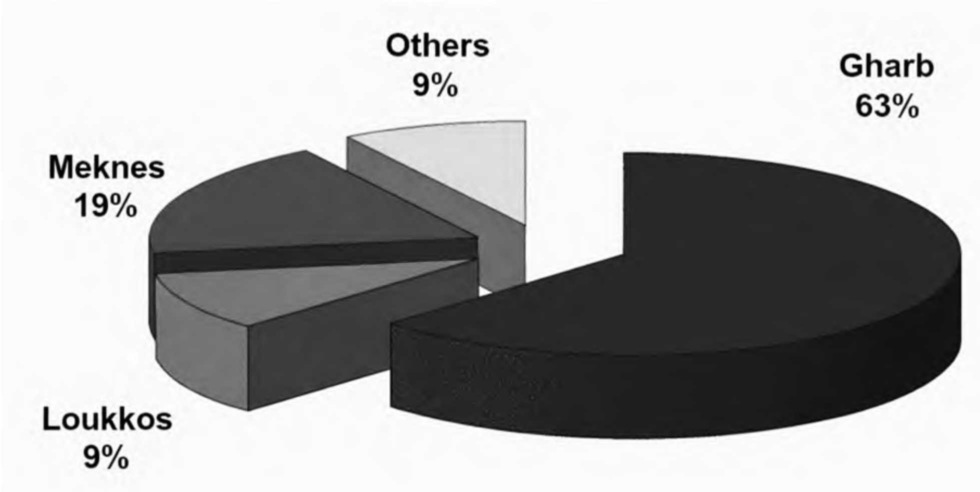
Historical Background

The sunflower belongs to the family *Compositae* (Asteraceae), genus *Helianthus*, species *annuus*. Its name refers to the characteristic form of its composite inflorescence, the *capitulum*. The term derives from the Greek words *Helios* ("sun") and *Anthos* ("flower"). The French name reflects the plant's tendency to orient itself toward the sun during the day.

- ✓ It is endemic to the southern regions of North America.
- ✓ By the 15th century, Native Americans cultivated it for food, medicinal purposes, and ornamentation.
- ✓ In the 16th century, Spanish explorers introduced it to Europe as an ornamental plant.
- ✓ Its diffusion eastward and northward across the continent led to its use in livestock feed, dye production, papermaking, and, most importantly, for its seeds as a source of oil.

Situation in Morocco

Two Moroccan varieties are cultivated: *Karima* (Oro-9) and *Salima* (Record).



Sunflower production by region

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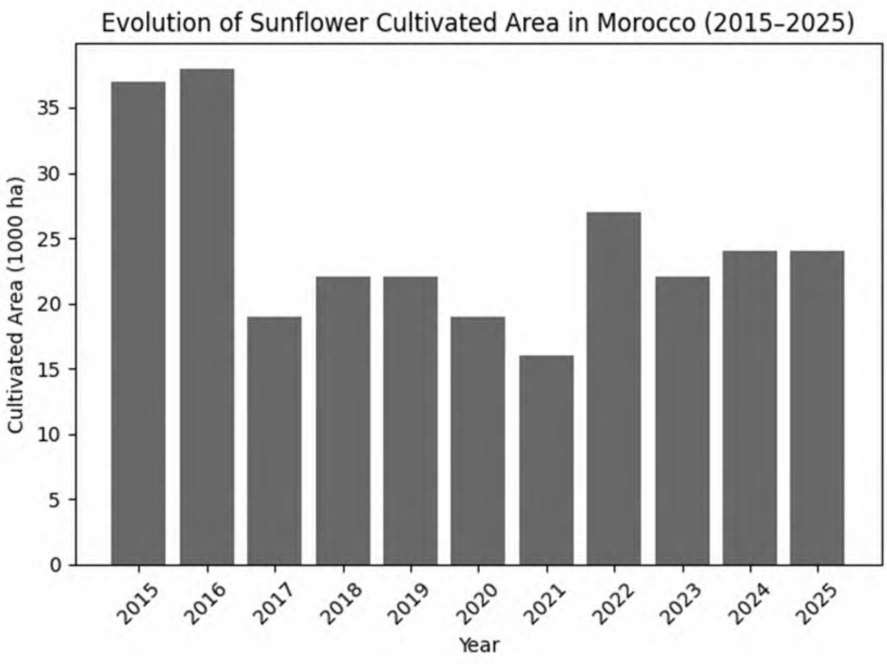
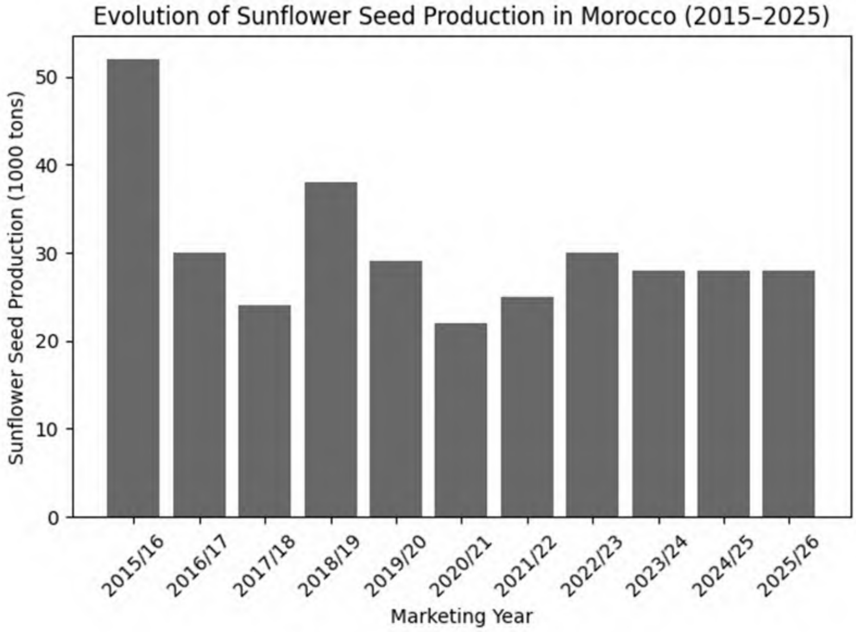
Oilseed Sector 2. Sunflower

Situation in Morocco

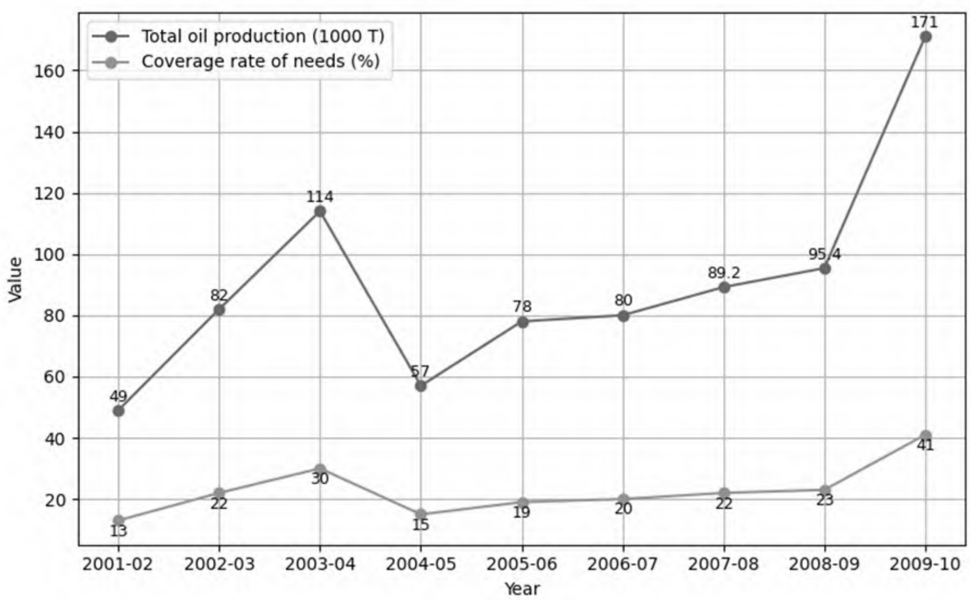


Situation in Morocco



CHAPTER 1: VALORIZATION IN AGRO-INDUSTRY
Oilseed Sector 2. Sunflower

Situation in Morocco



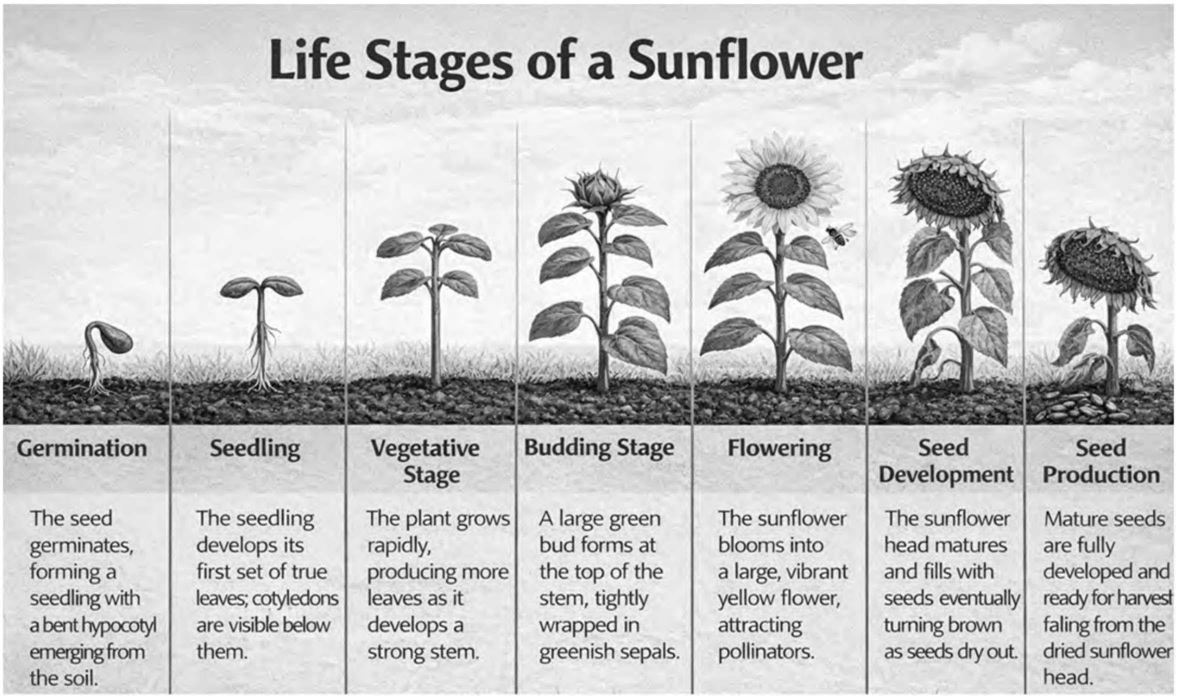
Evolution of local oil production and coverage rate of consumption needs

Life Cycle of the Sunflower

- ✓ The plant reaches a height of 2–4 meters, with large leaves.
- ✓ Its inflorescence is a broad capitulum (15–40 cm) containing up to 1,500 florets.
- ✓ It is entomophilous (pollinated by bees) and allogamous.
- ✓ The fruits are achenes with a pericarp (husk) not fused to the seed (kernel), containing 55–70% oil.

CHAPTER 1: VALORIZATION IN AGRO-INDUSTRY
Oilseed Sector 2. Sunflower

Life Cycle of the Sunflower



Ecological Requirements

❑ **Temperature**
- ✓ Optimal range: 20–25°C
- ✓ Minimum for germination: 8–10°C
- ✓ Sensitive to frost, especially during early growth and flowering
- ✓ Moderately tolerant to heat and drought compared to many crops

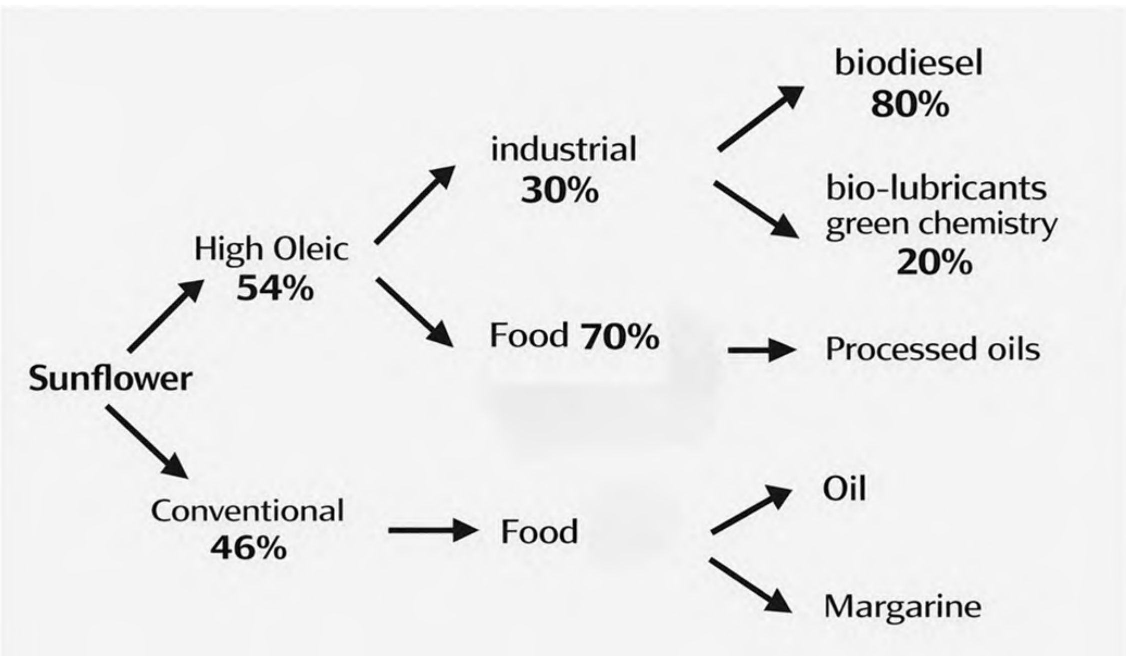
❑ **Light**
- ✓ Sunflower is a highly light-demanding (photophilous) plant
- ✓ Requires full sunlight for maximum photosynthesis and seed production
- ✓ Although often associated with heliotropism (young plants turning toward the sun), mature plants generally face east

❑ **Water**
- ✓ Total water need: 500–700 mm over the growing cycle
- ✓ Critical stages for water: Germination; emergence; flowering and seed filling
- ✓ Severe drought reduces yield and oil content

❑ **Soil**
- ✓ Best suited soils: Deep, well-drained soils with loamy or sandy-loam textures
- ✓ Optimal soil pH: 6.0–7.5
- ✓ Avoid: Waterlogged soils and highly saline soils

CHAPTER 1: VALORIZATION IN AGRO-INDUSTRY
Oilseed Sector 2. Sunflower

Food and Industrial Uses



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CHAPTER 1: VALORIZATION IN AGRO-INDUSTRY

Oilseed Sector

3. Peanut

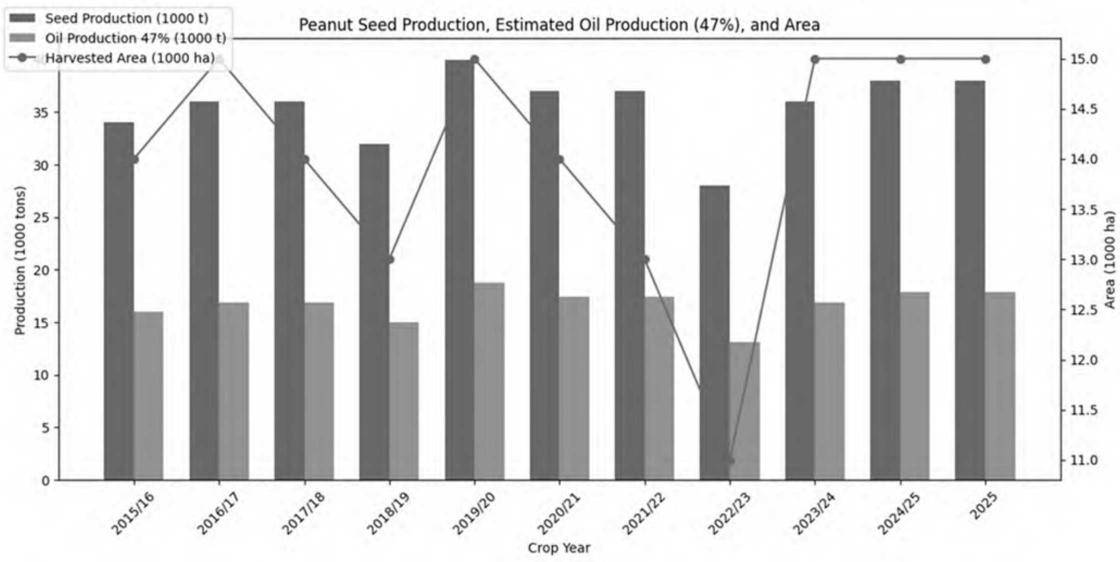
Prof. Yahia RHARRABTI
Academic year: 2025-2026

General Overview

- ✓ The peanut ranks sixth among the world's most important oilseed crops.
- ✓ It contains 48–50% lipids, 26–28% protein, and is rich in fiber, minerals, and vitamins.
- ✓ Globally, it is cultivated on 26.4 million hectares, with a total world production of 37.1 million tons.
- ✓ Cultivated peanut (*Arachis hypogaea* L.) belongs to the genus Arachis within the legume family.
- ✓ It originated in the Amazon basin, where all species of the genus are found.
- ✓ Dissemination began in the 16th century, spreading eastward along the Spanish Peru–Philippines axis and toward Africa along the Portuguese Brazil–West Africa axis.

Situation in Morocco

Approximately 15,000 hectares of peanut are cultivated along the Atlantic coast between Kénitra and Larache, under irrigation on sandy soils.



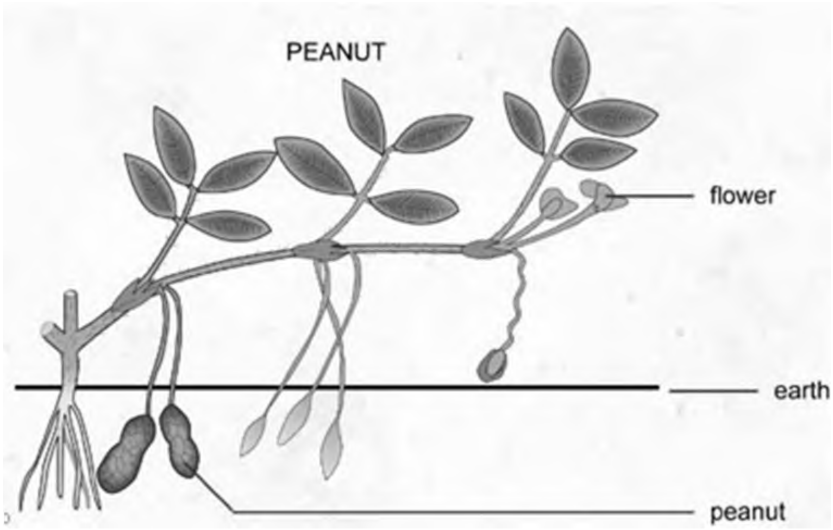
CHAPTER 1: VALORIZATION IN AGRO-INDUSTRY
Oilseed Sector 3. Peanut

Plant Description

- ✓ Peanut is an annual herbaceous legume, 30–70 cm tall, with yellow flowers. It is predominantly autogamous, though cross-pollination rates range from 0.2–5%.
- ✓ It has a taproot system with numerous secondary branches.
- ✓ Leaves are alternate, with two pairs of opposite, elliptic leaflets.
- ✓ Inflorescences consist of 3–5 sessile, papilionaceous yellow flowers.

Fertilization and Development

Flowers arise in leaf axils and wither rapidly. The base of the fertilized ovary elongates into a peduncle called a gynophore, which penetrates the soil where the fruit (pod) develops. The pod is indehiscent and contains 1–4 seeds.



CHAPTER 1: VALORIZATION IN AGRO-INDUSTRY
Oilseed Sector 3. Peanut

Main varieties of cultivated peanut in Morocco

Genus	Arachis		
Species	Hypogaea		
Subspecies	Hypogaea	Fastigiata	
Varieties	Hypogaea	Vulgaris	Fastigiata
Types	Virginia	Spanish	Valencia
Growth habit	Erect/Prostrate	Erect	Erect
Branching	Alternate	Sequential	Sequential
Flowers on main stem	No	Yes	Yes
Leaf color	Dark green	Light green	Light green
Cycle	120–140 days	90 days	90 days
Dormancy	Yes	No	No
Pods (cavities)	2 cavities	2 cavities	3–4 cavities

Ecological Requirements

❑ Soil

Loose, permeable soils (especially sandy loam) are optimal, ensuring gynophore penetration and pod harvest. Well-drained and aerated soils are essential due to high respiratory activity of developing pods.

❑ Temperature and Sunlight

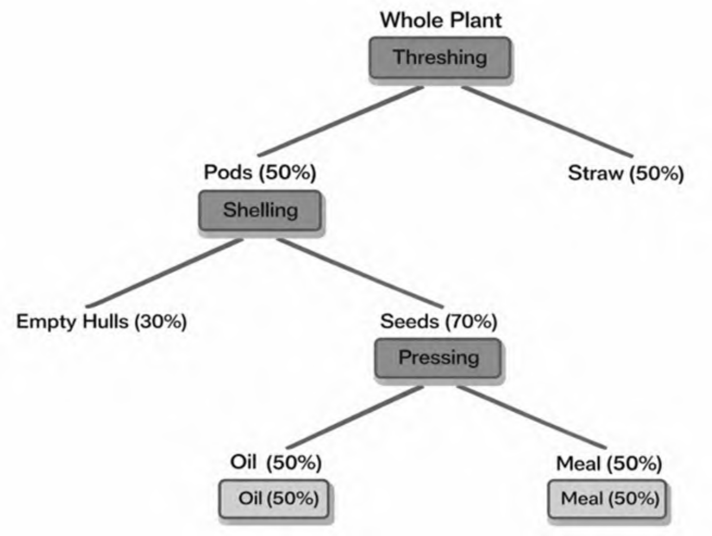
Optimal growth occurs between 25–35°C. Higher temperatures may alter the vegetative cycle but increase oil content. Low temperatures are unsuitable. Long days positively influence productivity.

❑ Water Regime

Peanut is typically rainfed. Rainfall between 500–1000 mm during the growing season ensures good yields. It is drought-tolerant, but supplemental irrigation during stress periods enhances production quality.

Peanut Products

Peanuts are consumed as seeds (after shelling), oil (via industrial or artisanal extraction), or processed forms such as butter, paste, or flour. By-products are used as fodder, fuel, compost, and in human or animal feed (oilcakes = meals).



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CHAPTER 1: VALORIZATION IN AGRO-INDUSTRY

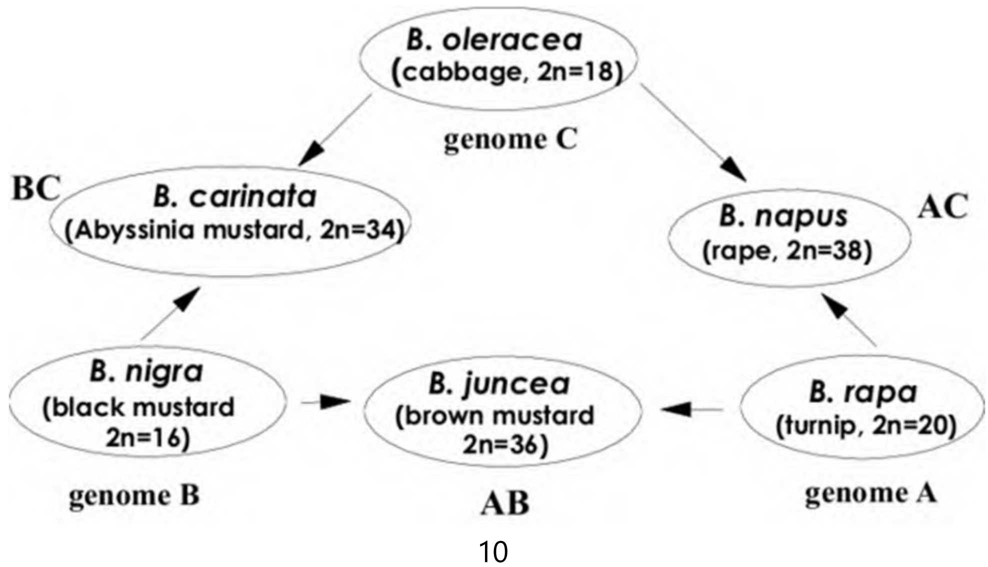
Oilseed Sector

4. Rapeseed

Prof. Yahia RHARRABTI
Academic year: 2025-2026

General Overview

Rapeseed (*Brassica napus* var. *napus*) is a natural hybrid between cabbage (*Brassica oleracea* L.) and turnip (*Brassica rapa* L.). Its diversification center lies at the intersection of the centers of turnip (Europe, Asia) and cabbage (Western Europe, North Africa).



General Overview

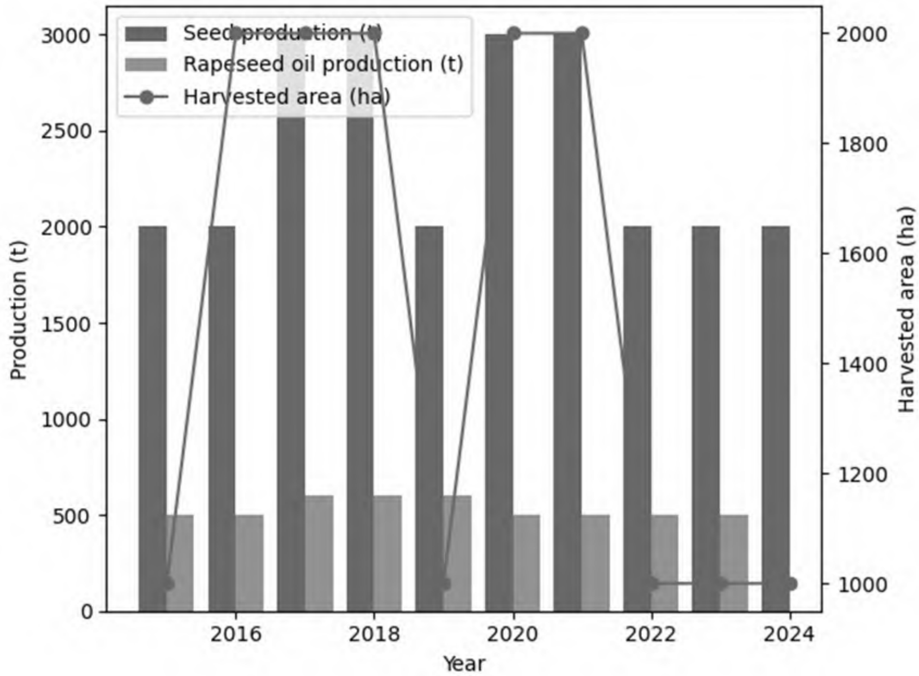
- ✓ Rapeseed is mentioned in Sanskrit texts (2000–1500 BC) and in Greek, Roman, and Chinese writings (500–200 BC).
- ✓ Cultivation and trade expanded in the Netherlands during the 16th century, where rapeseed oil was used as lamp fuel and later as steam engine lubricant.
- ✓ Only after the selection of varieties free from erucic acid (carcinogenic) in 1975 and low in glucosinolates (toxic compounds responsible for bitterness) in 1980 did rapeseed oil gain acceptance for human consumption.

CHAPTER 1: VALORIZATION IN AGRO-INDUSTRY
Oilseed Sector 4. Rapeseed

Situation in Morocco

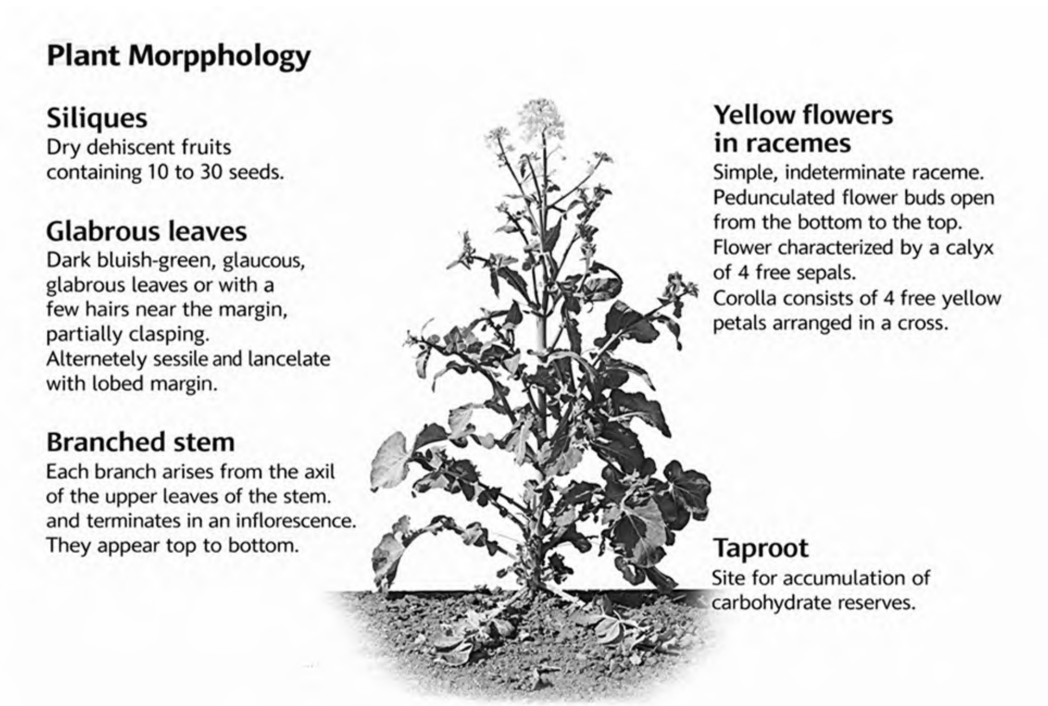
- ✓ Morocco is experiencing a very significant deficit in vegetable oils, and domestic production does not cover the country's overall needs.
- ✓ Rapeseed, alongside sunflower, offers an alternative to diversify and intensify annual oilseed crops.
- ✓ Its agronomic advantage lies in rotation with wheat, replacing faba bean (susceptible to Orobanche).
- ✓ It also serves as a good preceding crop for cereals, leaving behind a clean soil free of weeds and returning large quantities of mineral elements and organic matter to the soil.
- ✓ Two pure-line varieties (Narjisse and Moufida) with 50% oil content were registered in 2008–2009.

Situation in Morocco



CHAPTER 1: VALORIZATION IN AGRO-INDUSTRY
Oilseed Sector 4. Rapeseed

Plant description

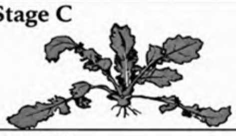


Fécondation

Ovules are generally fertilized by self-pollination, although outcrossing rates of 20 to 30% have been observed. The pollen, which is heavy and sticky, cannot be carried long distances by wind. It is therefore transported by insects, mainly bees. When plants are located close to one another, cross-pollination may also result from direct contact between clusters of flowers.

CHAPTER 1: VALORIZATION IN AGRO-INDUSTRY
Oilseed Sector 4. Rapeseed

Main growth stages of rapeseed development cycle

Stage A 	**Stage A–Cotyledon Stage** • Seedlings mark the row. • Stage A (10): cotyledon stage. No true leaves. Only the two cotyledons are visible.
Stage B 	**B– Rosette Formation** • Stage B : appearance of true leaves. No internodes between the petioles. Absence of true stem. • Stage B1 (11) : 1 true leaf spread out or unfolded. • Stage B2 (12) : 2 true leaf spread out or unfolded. • Stage B3 (13) : 3 true leaves spread out or unfold. • Stage B4 (14) : 4 true leaves spread out or unfold. • Stage Bn (1n) : n true leaves spread out or unfolded.
Stage C 	**C- Stem Elongation** • Stage C1 (31): resumtion of vegetation. Appearance of young leaves. • Stage C2 (32): visible internodes. Slight constriction forms at the base ntwpetioles. The stem.
Stage D 	**D- Clustered Buds** • Stage D1 (51): clustered buds still hidden beneath terminal leaves. • Stage D2 (53): main inflorescence appears. Clustered buds. Secondary inflorescences appear. At this stage, the stem reaches or exceeied a height of 20 cm as measured from the base of rosette to the floral clusters.

Main growth stages of rapeseed development cycle

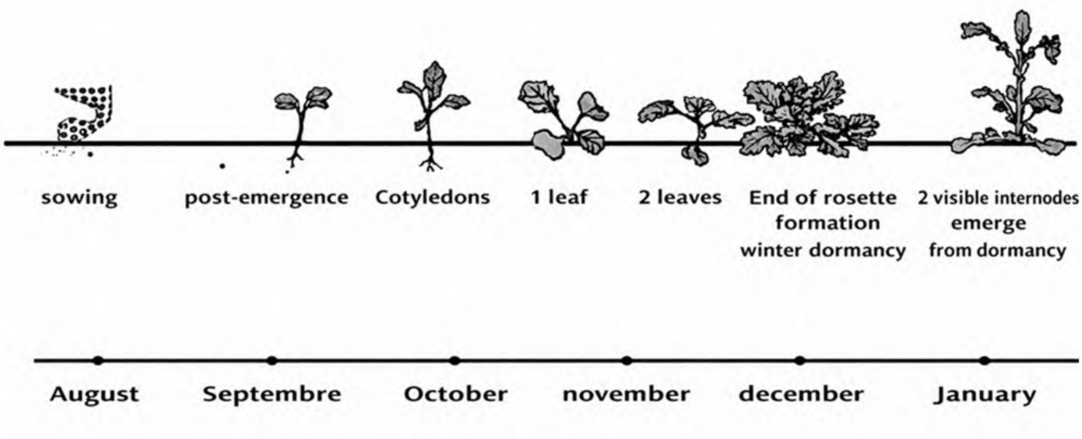
Stage E 	**E– Separated Buds** • **Stage E (59)** : flower pedicels lengthen starting with those on the periphery.
Stage F 	**F– Flowering** • **Stage F1 (60)** : first flowers open. • **Stage F2 (61)** : flowering axis elongates. Numerous flowers open.
Stage G 	**G– Silique Formation** • **Stage G1 (70)**: petal drop. First 10 siliques are less than 2 cm long. Secondary inflorescence flowering begins. • **Stage G2** : first 10 siliques are between 2 and 4 cm long. • **Stage G3** : first 10 siliques are longer than 4 cm. • **Stage G4 (73)**: first 10 siliques become swollen. • **Stage G5 (81)**: colored seeds.

CHAPTER 1: VALORIZATION IN AGRO-INDUSTRY
Oilseed Sector 4. Rapeseed

Growth and Development

❑ Vegetative Phase

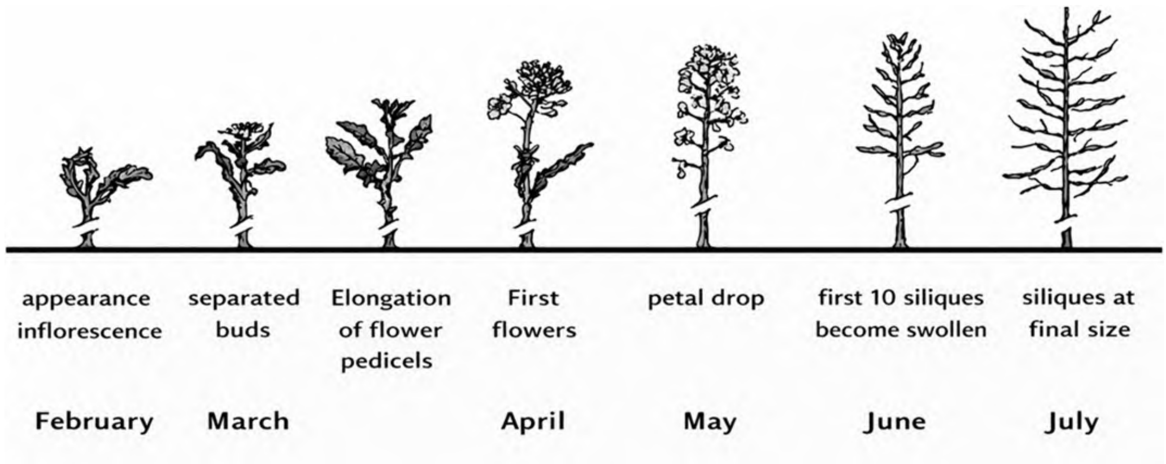
Sown in autumn, winter rapeseed first spreads its two cotyledons above the soil, then develops around twenty leaves forming a rosette before winter. At the beginning of winter, the plant has a stem of 2 to 3 cm. At the same time, the root system develops as a taproot.



Développement et croissance

❑ **Reproductive and maturity Phase**

At the end of winter, stem elongation begins: the inflorescence starts to form at the top of the stem, and at the same time the upper internodes begin to elongate. Flowering lasts 4 to 6 weeks. Fruit formation is relatively rapid. Seed maturity is reached 6 to 7 weeks after fertilization.



Ecological Requirements

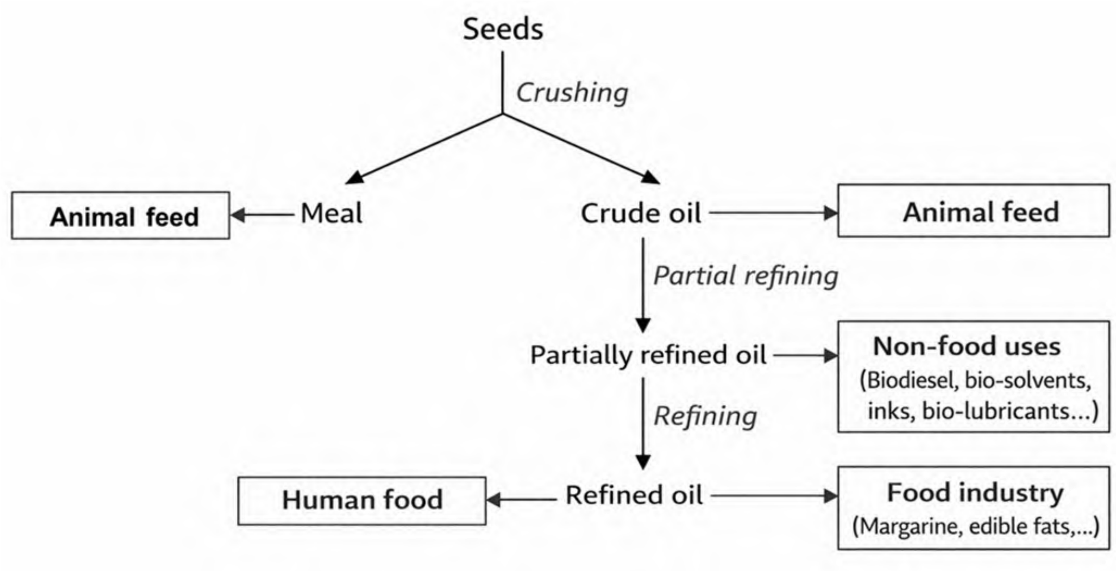
❑ **Temperature**

It is a major factor influencing yield variability due to the risk of winter and spring frosts. The cumulative temperature required from the beginning to the end of flowering is 360 to 380 degree-days. Excessively high temperatures at the end of flowering can lead to the abortion of flower buds.

❑ **Water**

A lack of water can affect the uniformity of emergence. Rapeseed is relatively insensitive to photoperiod, but long days have a positive effect on productivity. The end of flowering and the pod-filling period often occur during significant water deficit, leading to a reduction in thousand-seed weight. Irrigation may therefore be justified.

Food and industrial uses



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Oilseed Sector

5. Soybean

Prof. Yahia RHARRABTI
Academic year: 2025-2026

General Overview

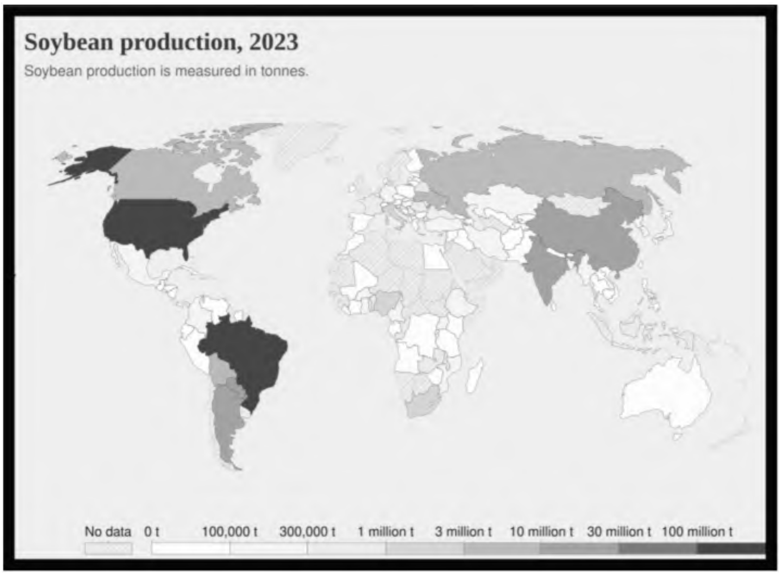
Soybean, also called soya, Chinese pea, or oilseed bean (Glycine max), is an annual plant species belonging to the legume family. This plant, originating from Manchuria in northeastern China, is believed to have been domesticated between 1700 and 1100 BC. Between 1400 and 1700 AD, it spread throughout Asia via historical trade routes. During travels in Asia in the 16th and 17th centuries, European missionaries discovered both its culinary diversity and its agricultural potential, and introduced it first into Europe and later, from the 18th century onward, into North America.

CHAPTER 1: VALORIZATION IN AGRO-INDUSTRY

Oilseed Sector 5. Soybean

Situation Worldwide and in Morocco

- ✓ Soybean cultivation, like that of most oilseed crops, has continuously expanded worldwide between 1990 and 2025. Production reached 353 million tonnes in 2023 over an area of approximately 130 –139 million hectares.
- ✓ In Morocco, soybean was introduced in 1981. It is cultivated exclusively under irrigation, and its cultivated area has never exceeded 12,000 ha, currently remaining below 1,000 ha.



Plant Description

Soybean (*Glycine max* (L.) Merrill) is an annual herbaceous plant, hairy (covered with fine gray or brown hairs), belonging to the order Fabales, family Leguminosae, subfamily Fabaceae.

The vegetative system of soybean includes:

– An erect growth habit with a height ranging from 30 to 150 cm
– Alternate leaves composed of three leaflets

CHAPTER 1: VALORIZATION IN AGRO-INDUSTRY
Oilseed Sector 5. Soybean

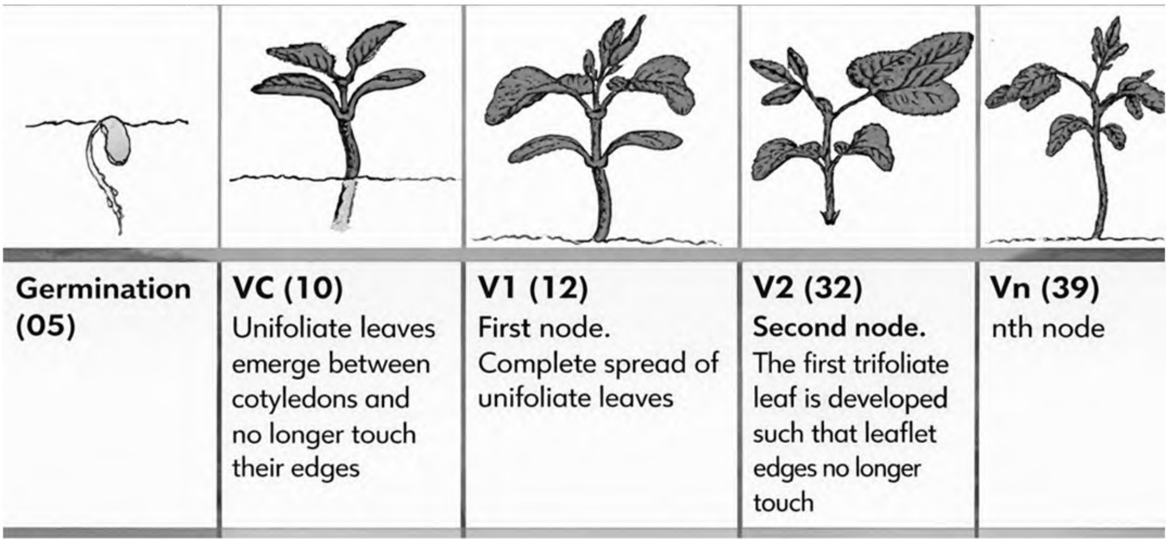
Plant Description

The reproductive system of soybean is characterized by:

– Small, isolated flowers, violet or yellowish in color, hermaphroditic and self-pollinated. Fertilization is cleistogamous (self-fertilization occurring before flower opening),

– Fruits in the form of pods (legumes), rough and hairy, dehiscent, containing two to four seeds rich in protein.

Main reference stages of soybean development



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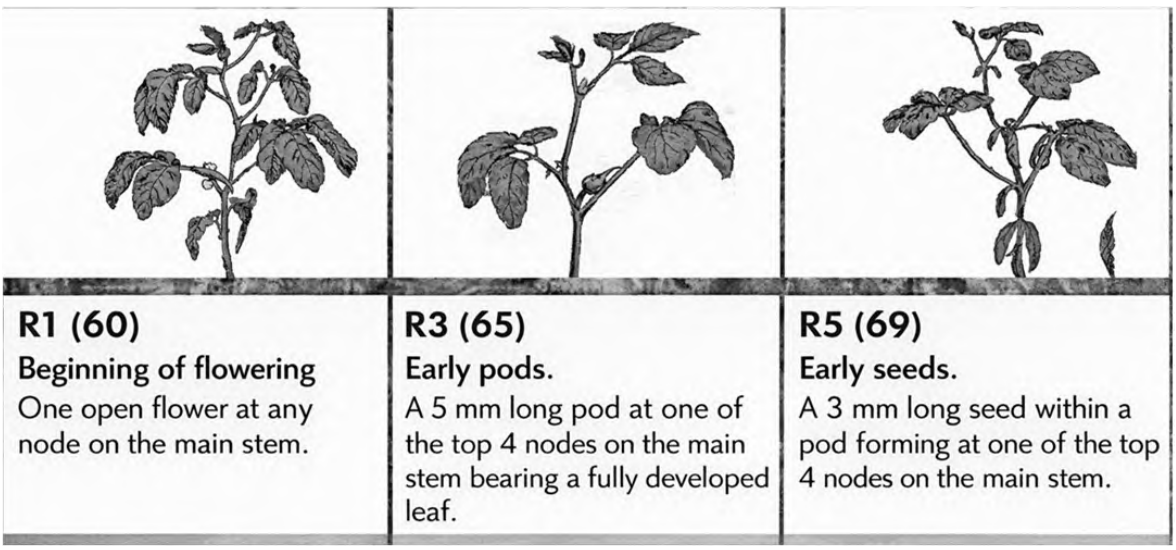
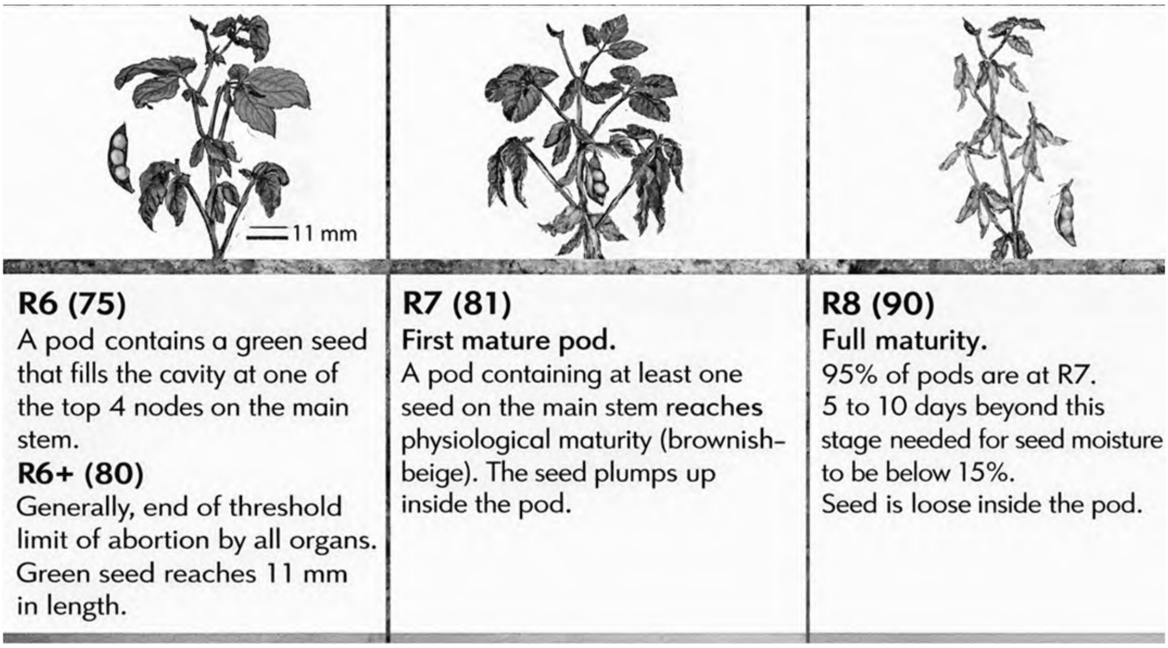
Oilseed Sector 5. Soybean

Main reference stages of soybean development



Main reference stages of soybean development



CHAPTER 1: VALORIZATION IN AGRO-INDUSTRY
Oilseed Sector 5. Soybean

Ecological Requirements

❑ <u>Temperature</u>

Soybean is cultivated in climates with hot summers.Optimal growth requires average temperatures between 20 and 30°C; temperatures below 20°C or above 40°C significantly slow down growth.Soybean does not have high water requirements but is sensitive to excess moisture.

❑ <u>Soil</u>

Soybean can grow in a wide variety of soils, with optimal development in moist alluvial soils rich in organic matter.Like most legumes, soybean fixes atmospheric nitrogen through symbiosis with a bacterium (*Bradyrhizobium japonicum*).

Food and Industrial Uses

❑ Soybean in human nutrition

Soy flour : obtained by grinding roasted soybean seeds into a fine powder. It is rich in high-quality proteins and other nutrients. Two types of soy flour are distinguished: whole (full-fat) flour and defatted flour.

Soy milk : a creamy beverage obtained from whole soybean seeds. Owing to its characteristic nutty flavor and high nutritional value, it can be used in various ways. It is mainly consumed in China and Japan.

Soy oil : refers to the natural oil extracted from whole soybean seeds. It is the most consumed vegetable oil in the United States, accounting for approximately 75% of total edible oil consumption. It is widely used in the industrial production of various products such as mayonnaise, coffee creamers, margarine, and spreads.

Food ingredients : such as soy lecithin (food additive E322 with emulsifying properties, widely used in chocolate); textured soy proteins (which can partially or totally replace meat); and soy concentrates and isolates (used in infant nutrition).

CHAPTER 1: VALORIZATION IN AGRO-INDUSTRY
Oilseed Sector 5. Soybean

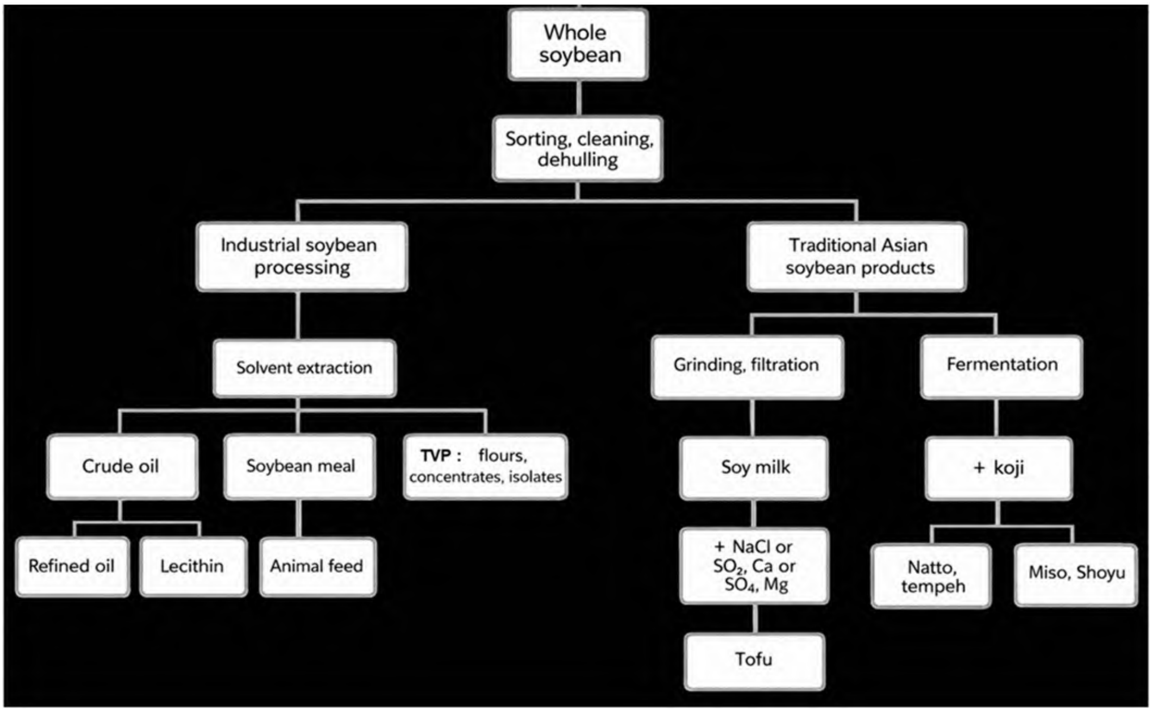
Food and Industrial Uses

❑ Soybean in animal nutrition

Soybean meal : a by-product of seed processing, containing around 45% crude protein. It is widely used in dairy cattle feeding.

Textured soy proteins : derived from soybean meal, widely used in aquaculture feeds and pet food.

Food and Industrial Uses



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Oilseed Sector

6. Vegetable Oil Extraction Processes

Prof. Yahia RHARRABTI
Academic year: 2025-2026

Overview of Vegetable Oil Extraction Processes

The stages of vegetable oil extraction are as follows:

❑ Cleaning

Seeds are sieved and cleaned to remove impurities (leaves, stems, etc.) using air aspiration.

❑ Pretreatment

Before extraction, seeds are generally pretreated to facilitate oil recovery. They are dehulled (peanut, sunflower) or de-skinned (soybean, rapeseed, peanut).

For solvent extraction, seeds are crushed between corrugated rollers to rupture the oil-containing cells.

Seeds may also be heated to increase oil fluidity, thereby improving extraction yield..

Overview of Vegetable Oil Extraction Processes

❑ Oil Extraction

Two extraction methods are used:

Mechanical pressing : This method uses only mechanical presses. It produces a very pure oil containing no foreign substances. However, it does not extract all the oil, leaving 9 to 20% oil in the press cake depending on the seed type. This residual oil cannot be recovered for edible use.

Solvent extraction : This method uses non-polar organic solvents, mainly hexane. Although hexane is supposed to be removed, a small but non-negligible amount remains in the oil. This method is the most widely used because it extracts more oil than mechanical pressing.

Overview of Vegetable Oil Extraction Processes

❑ **Oil Refining**

Refining of crude oils aims to remove undesirable compounds in order to obtain oil of suitable quality for use and storage.

It generally includes degumming, neutralization, bleaching (decolorization), deodorization, and sometimes dewaxing (winterization).

Degumming (or demulsification) : Removes phospholipids (which cause instability, turbidity, and coloration during heating) by acid treatment (citric, phosphoric, or sulfuric acid).

Neutralization : Removes free fatty acids using an alkaline solution (soda), converting them into soaps for separation.

CHAPTER 1: VALORIZATION IN AGRO-INDUSTRY
Oilseed Sector 6. Extraction Processes

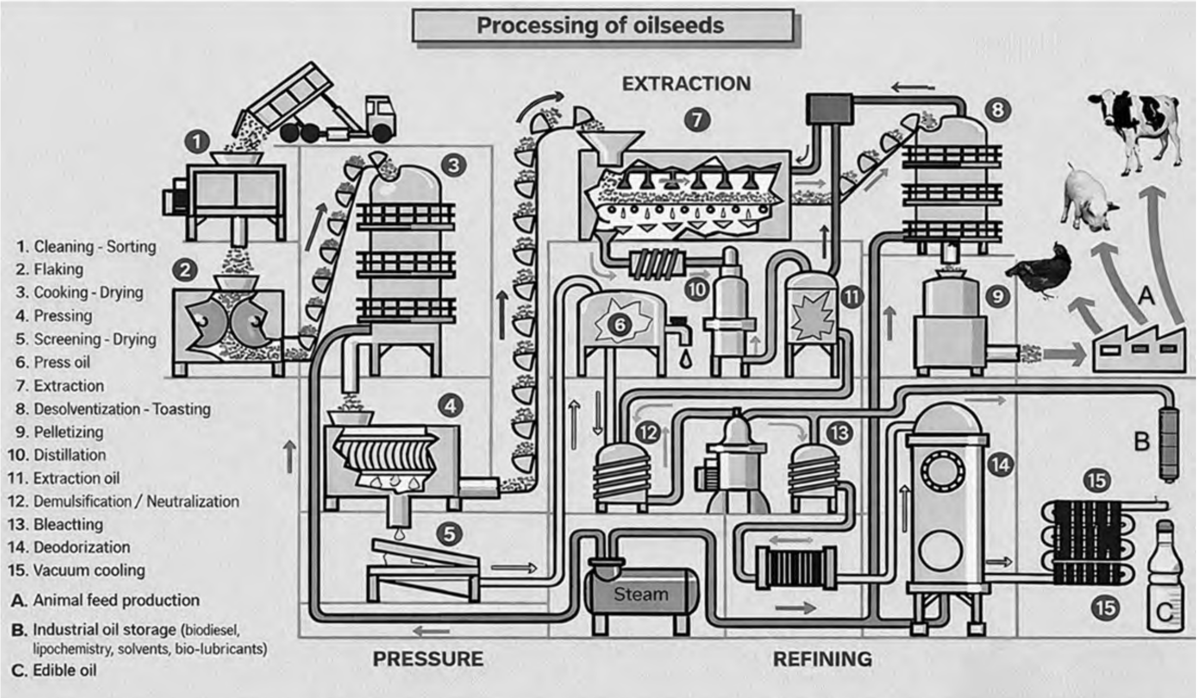
Overview of Vegetable Oil Extraction Processes

Decolorization (or Bleaching) : Decolorization consists of eliminating coloring pigments (chlorophylls, carotenoids), as well as certain impurities such as soaps, trace metals, and oxidation products.This operation is carried out by adsorption using bleaching earths or activated carbon. The oil is heated under vacuum, then mixed with the adsorbent, followed by filtration to remove the used earths.

Deodorization : It is a treatment by distillation under vacuum at high temperature, allowing the removal of volatile compounds responsible for undesirable odors and flavors. These compounds include mainly free fatty acids, aldehydes, ketones, and hydrocarbons. This step improves the organoleptic quality and stability of the oil.

Winterization (or Dewaxing) : aims to remove waxes and high-melting triglycerides that may cause turbidity of the oil at low temperature (sunflower). The oil is progressively cooled to allow crystallization of these compounds, then filtered to eliminate the formed crystals. This operation is particularly important for oils intended for refrigeration.

Vegetable Oil Extraction Process Flow Diagram



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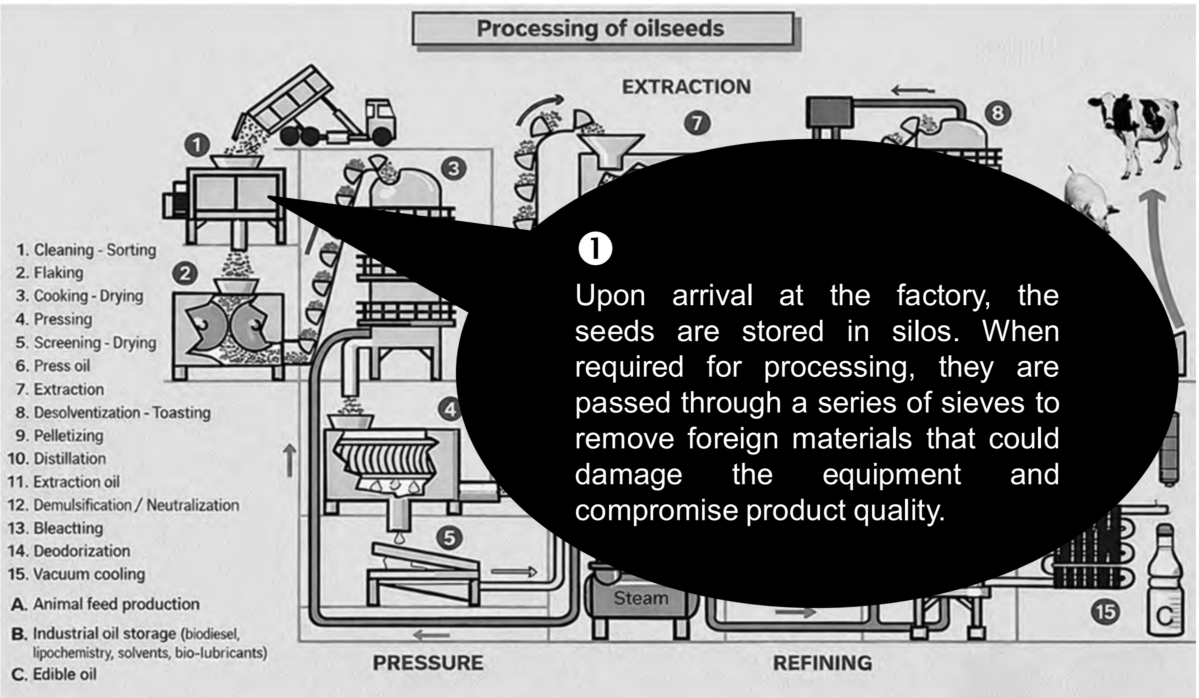
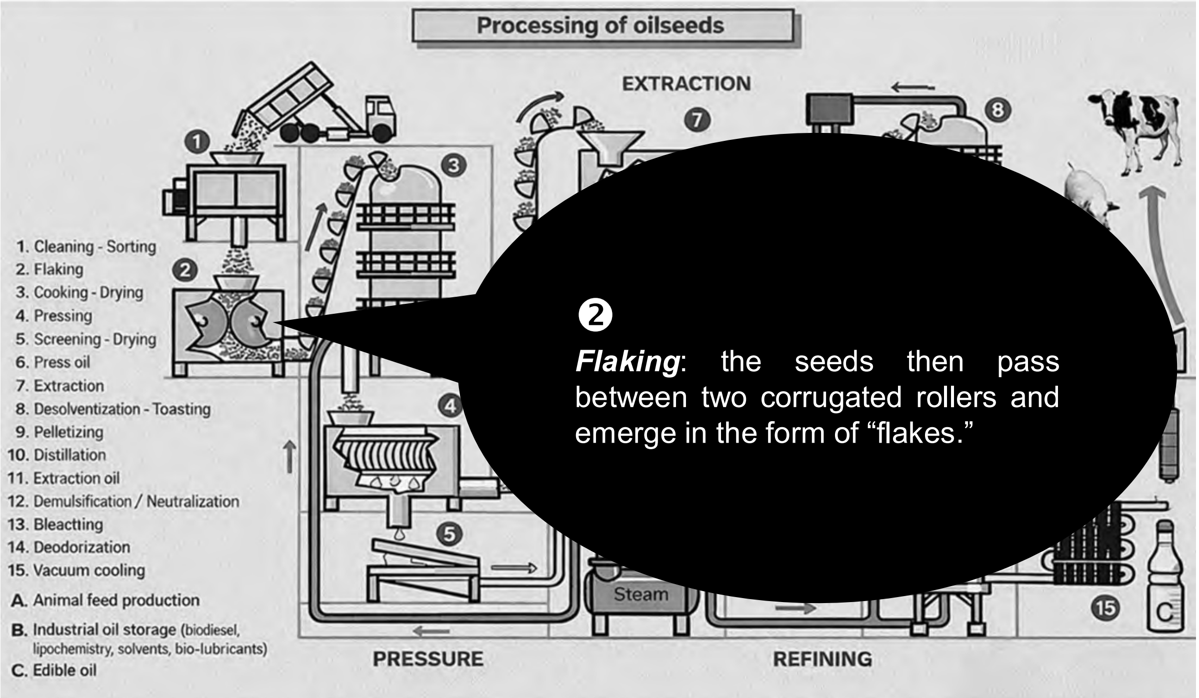
Oilseed Sector 6. Extraction Processes

Vegetable Oil Extraction Process Flow Diagram



Vegetable Oil Extraction Process Flow Diagram



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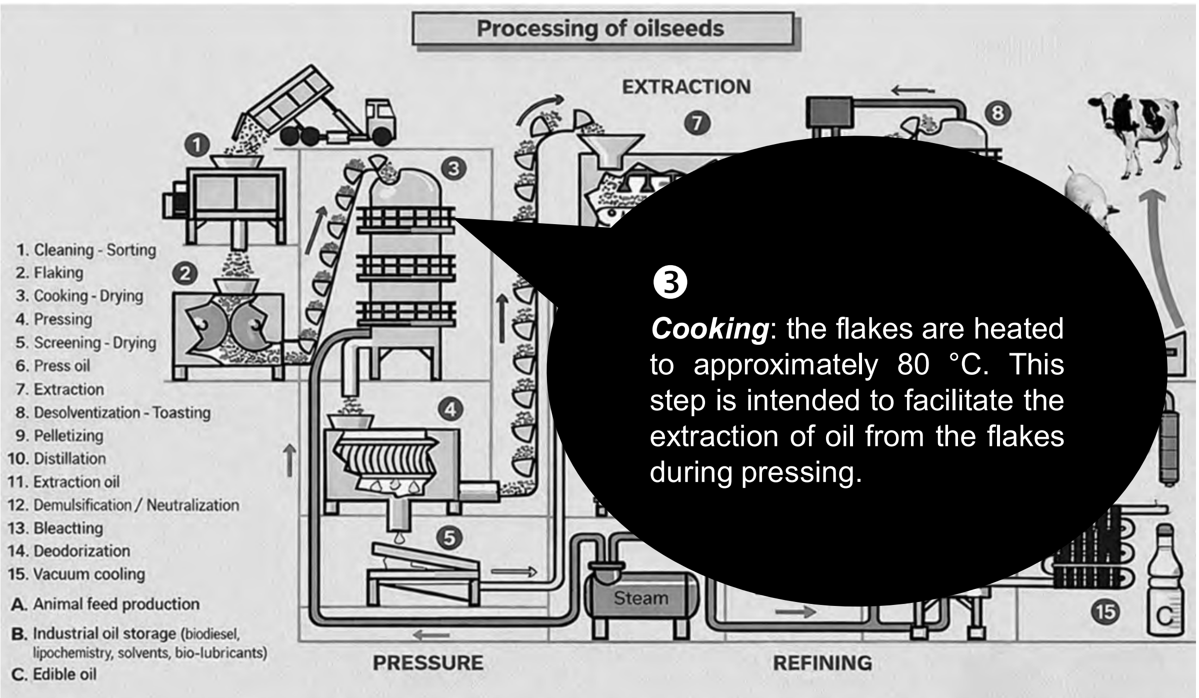
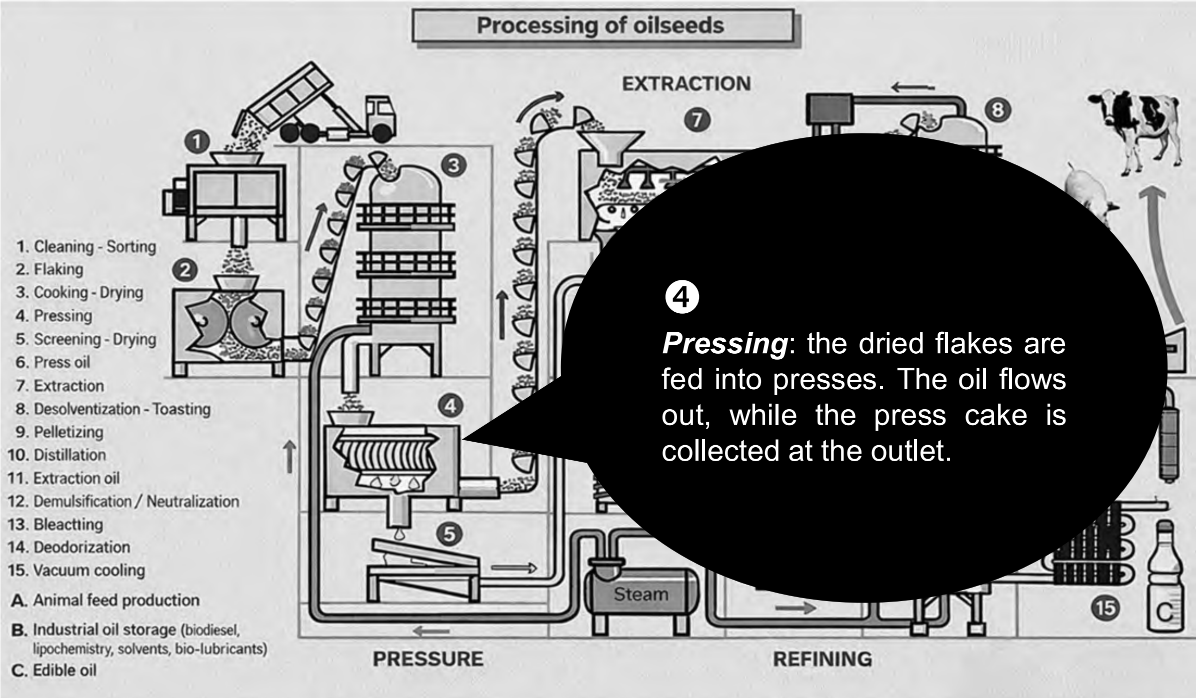
Oilseed Sector 6. Extraction Processes

Vegetable Oil Extraction Process Flow Diagram



Vegetable Oil Extraction Process Flow Diagram



❹

Pressing: the dried flakes are fed into presses. The oil flows out, while the press cake is collected at the outlet.

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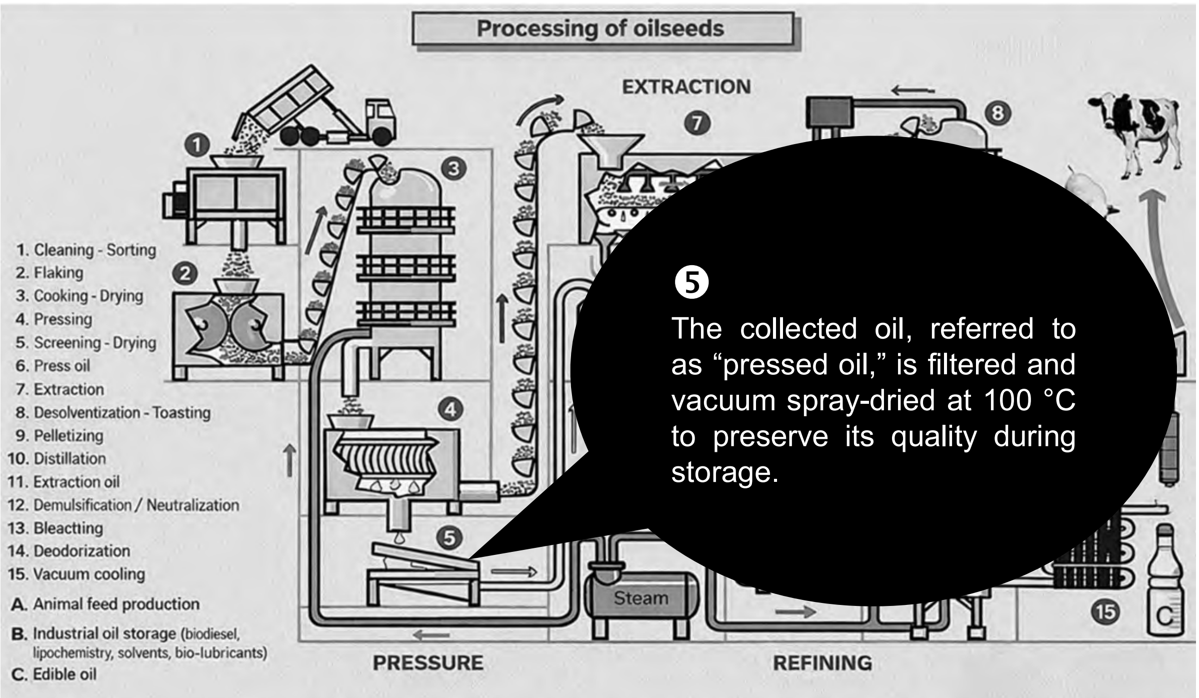
Oilseed Sector 6. Extraction Processes

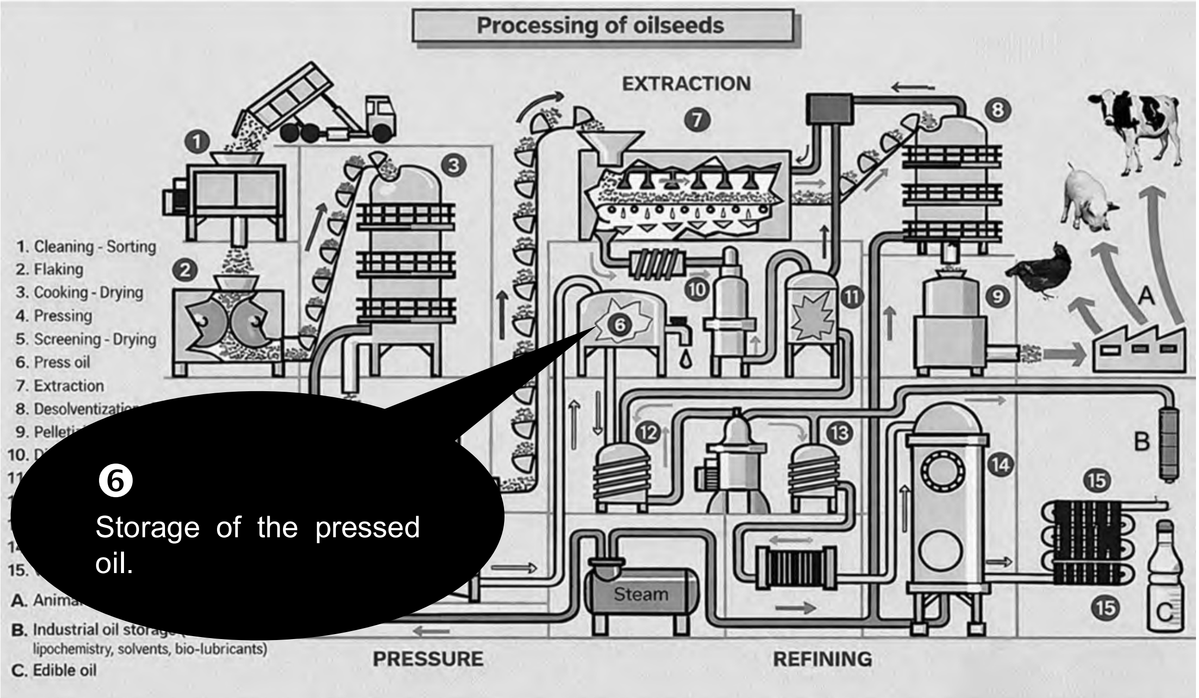
Vegetable Oil Extraction Process Flow Diagram



❺

The collected oil, referred to as "pressed oil," is filtered and vacuum spray-dried at 100 °C to preserve its quality during storage.

Vegetable Oil Extraction Process Flow Diagram



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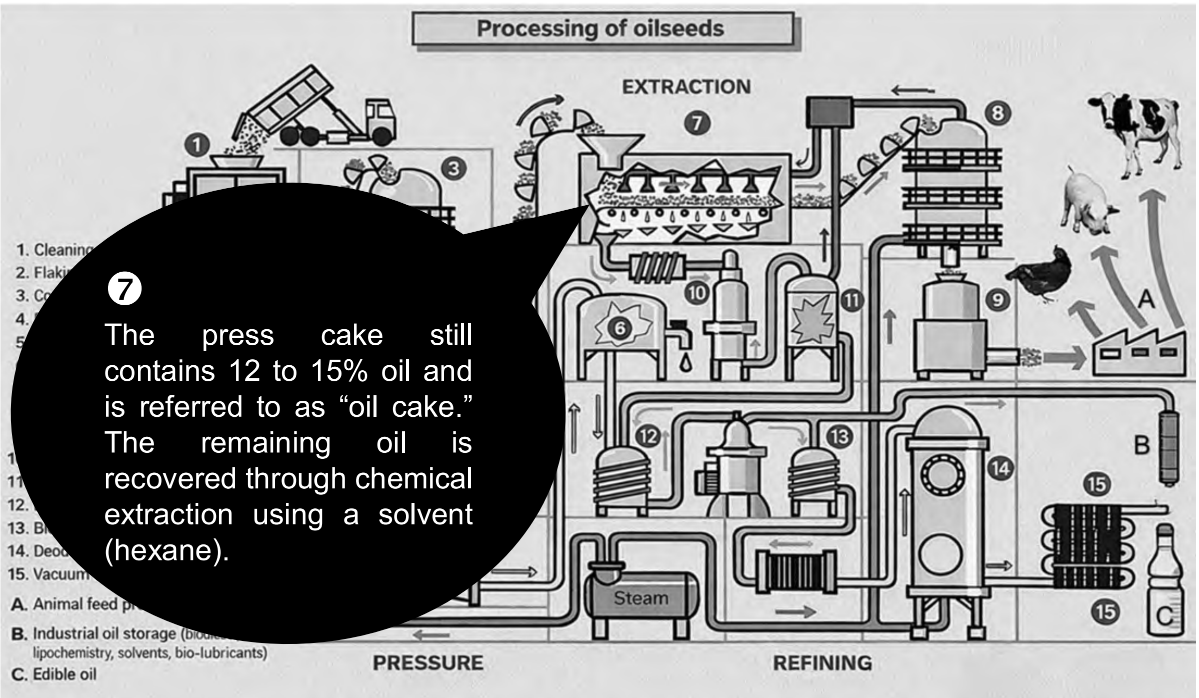

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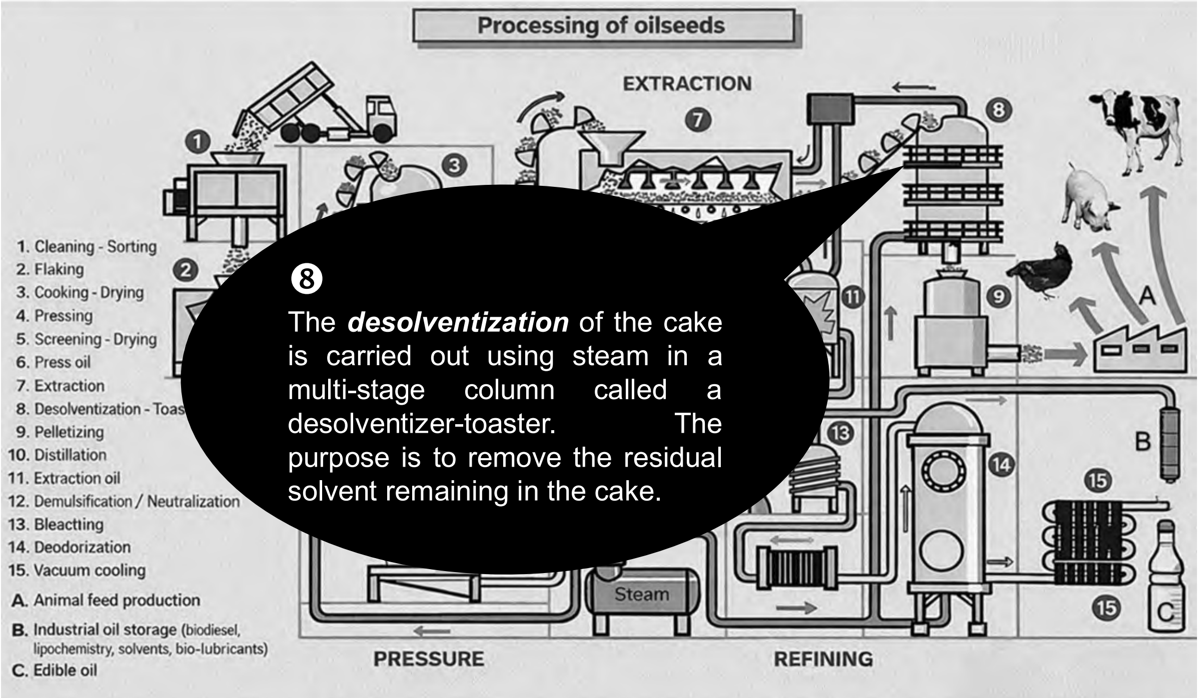
Oilseed Sector 6. Extraction Processes

Vegetable Oil Extraction Process Flow Diagram



❽

The ***desolventization*** of the cake is carried out using steam in a multi-stage column called a desolventizer-toaster. The purpose is to remove the residual solvent remaining in the cake.

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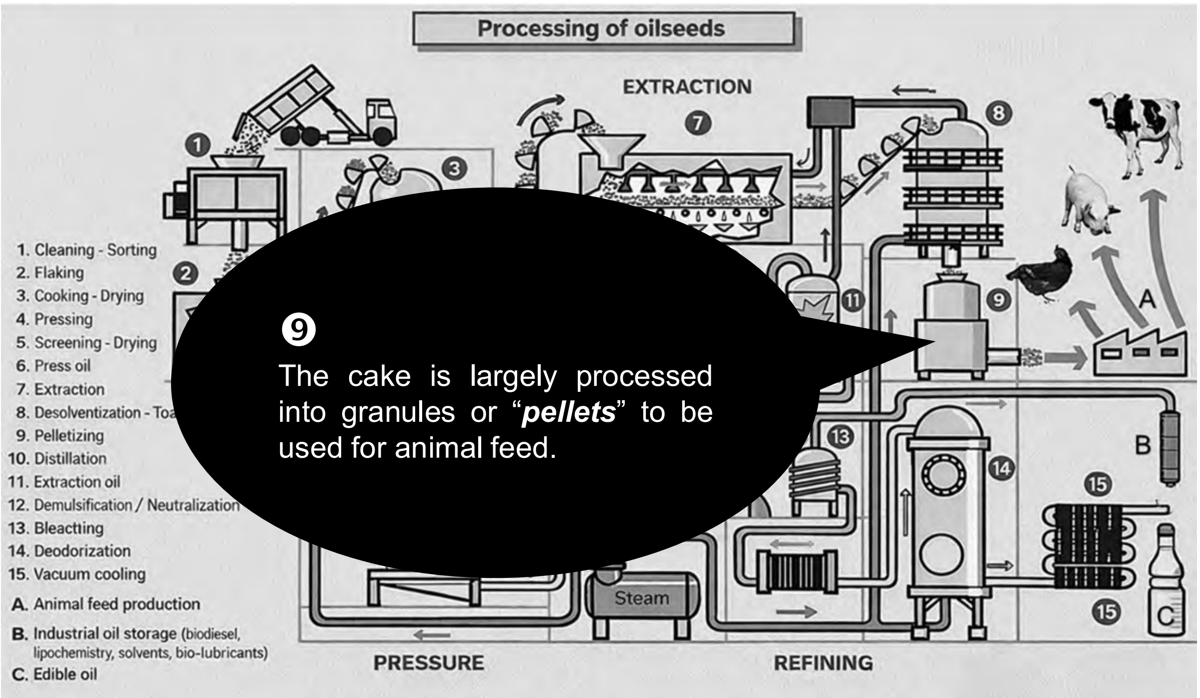
Oilseed Sector 6. Extraction Processes

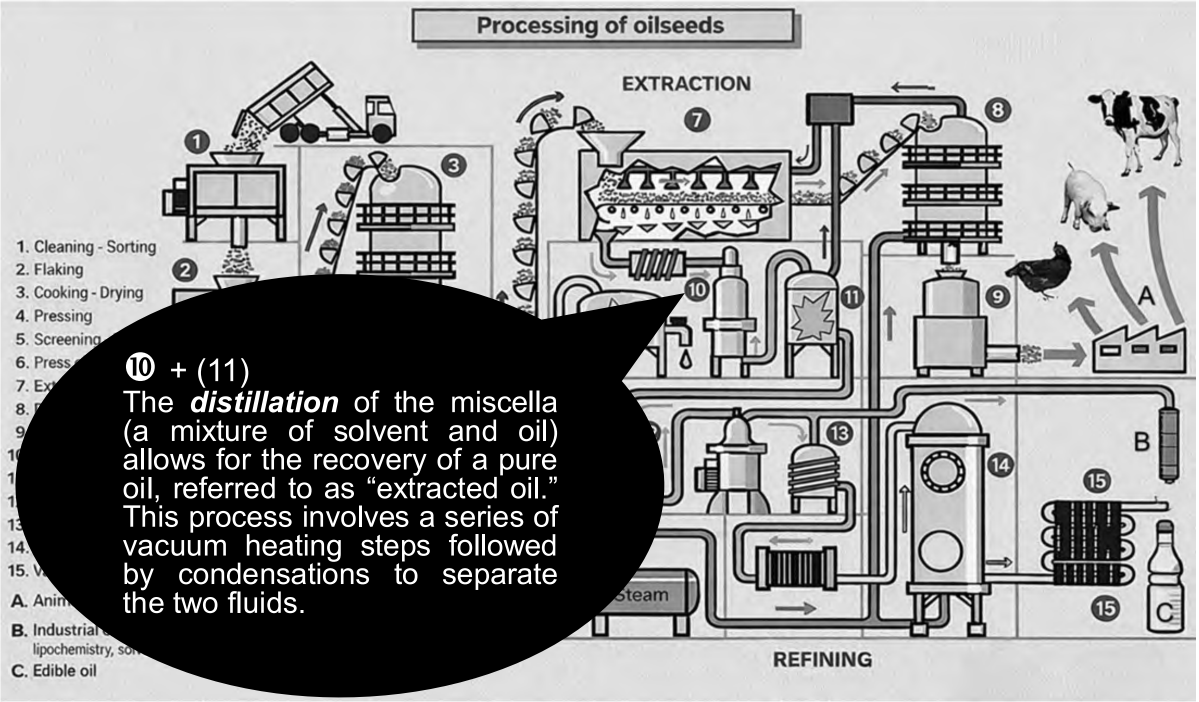
Vegetable Oil Extraction Process Flow Diagram



❾

The cake is largely processed into granules or "***pellets***" to be used for animal feed.

Vegetable Oil Extraction Process Flow Diagram



⓾ + (11)
The ***distillation*** of the miscella (a mixture of solvent and oil) allows for the recovery of a pure oil, referred to as "extracted oil." This process involves a series of vacuum heating steps followed by condensations to separate the two fluids.

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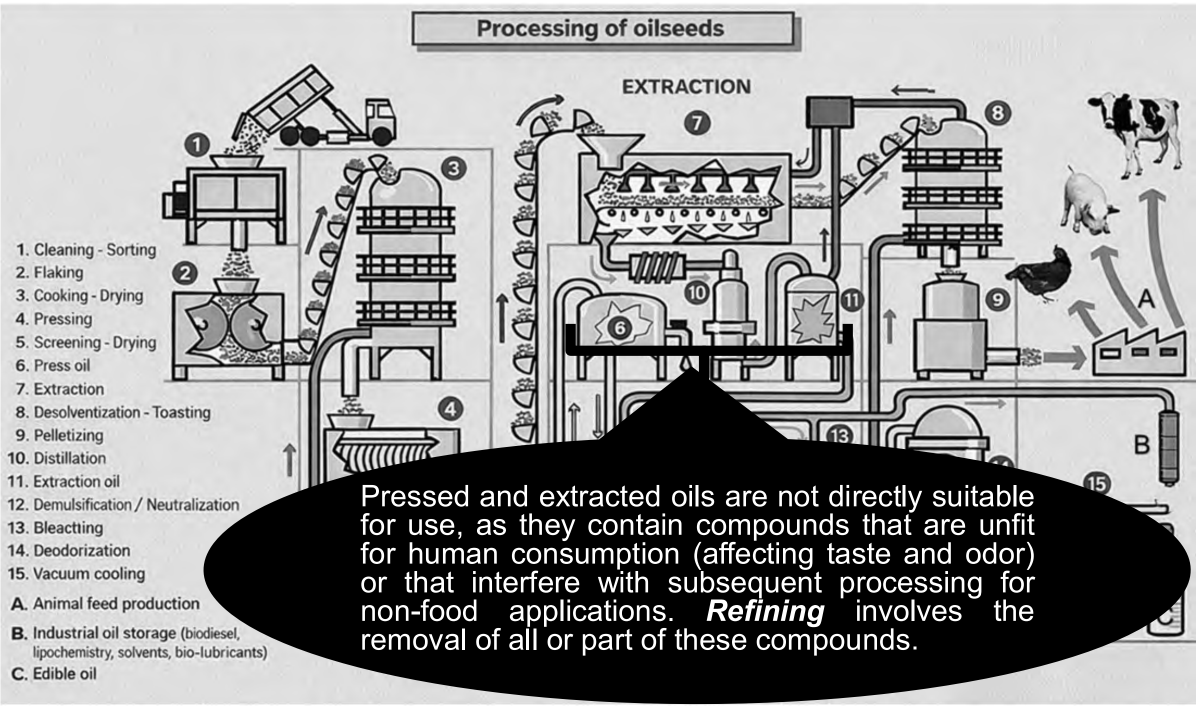
Oilseed Sector 6. Extraction Processes

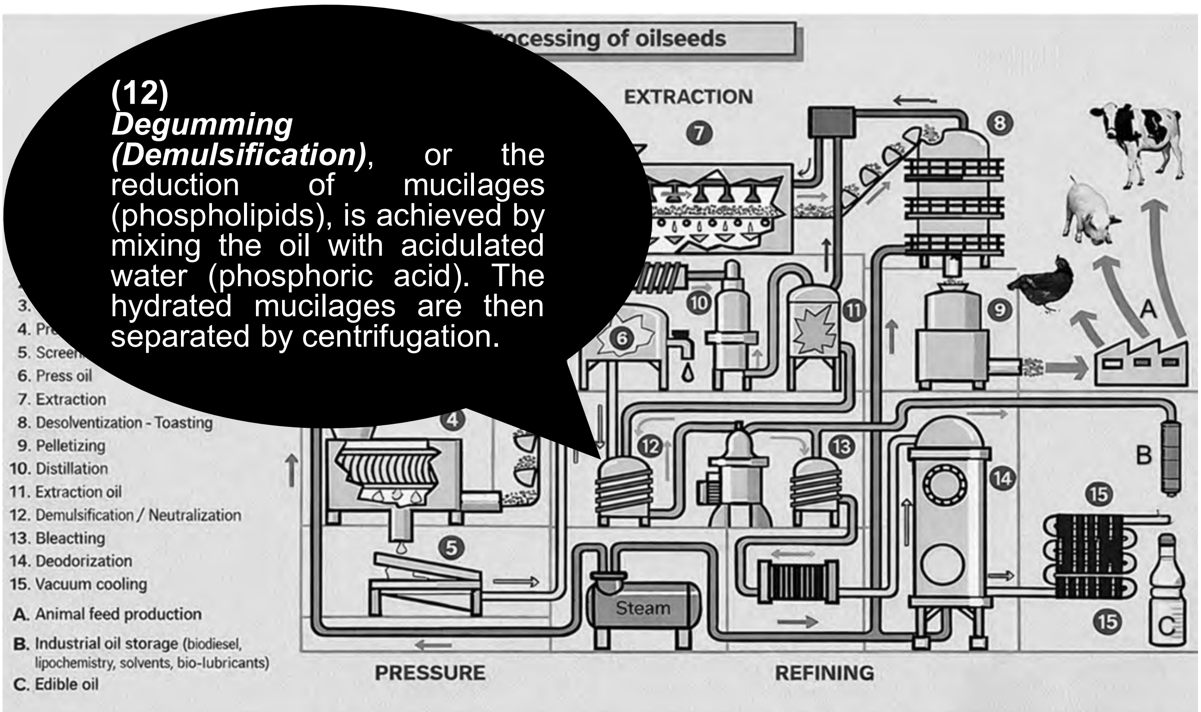
Vegetable Oil Extraction Process Flow Diagram



Pressed and extracted oils are not directly suitable for use, as they contain compounds that are unfit for human consumption (affecting taste and odor) or that interfere with subsequent processing for non-food applications. ***Refining*** involves the removal of all or part of these compounds.

Vegetable Oil Extraction Process Flow Diagram

(12)
Degumming (Demulsification), or the reduction of mucilages (phospholipids), is achieved by mixing the oil with acidulated water (phosphoric acid). The hydrated mucilages are then separated by centrifugation.



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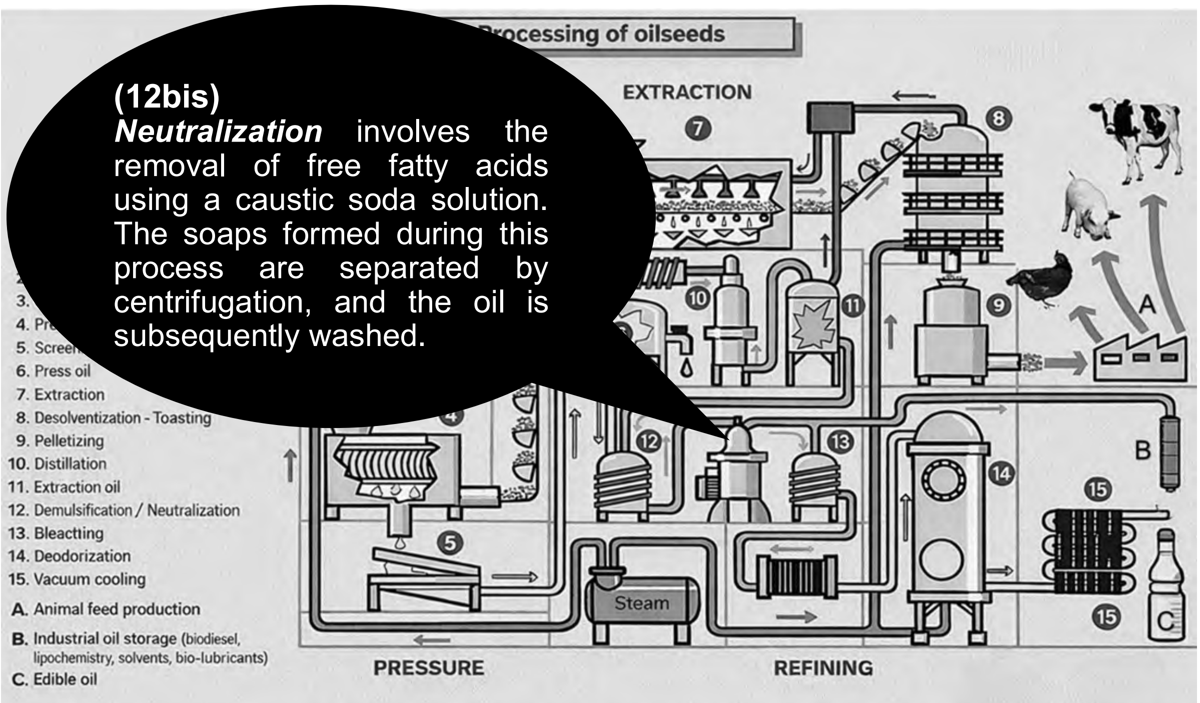
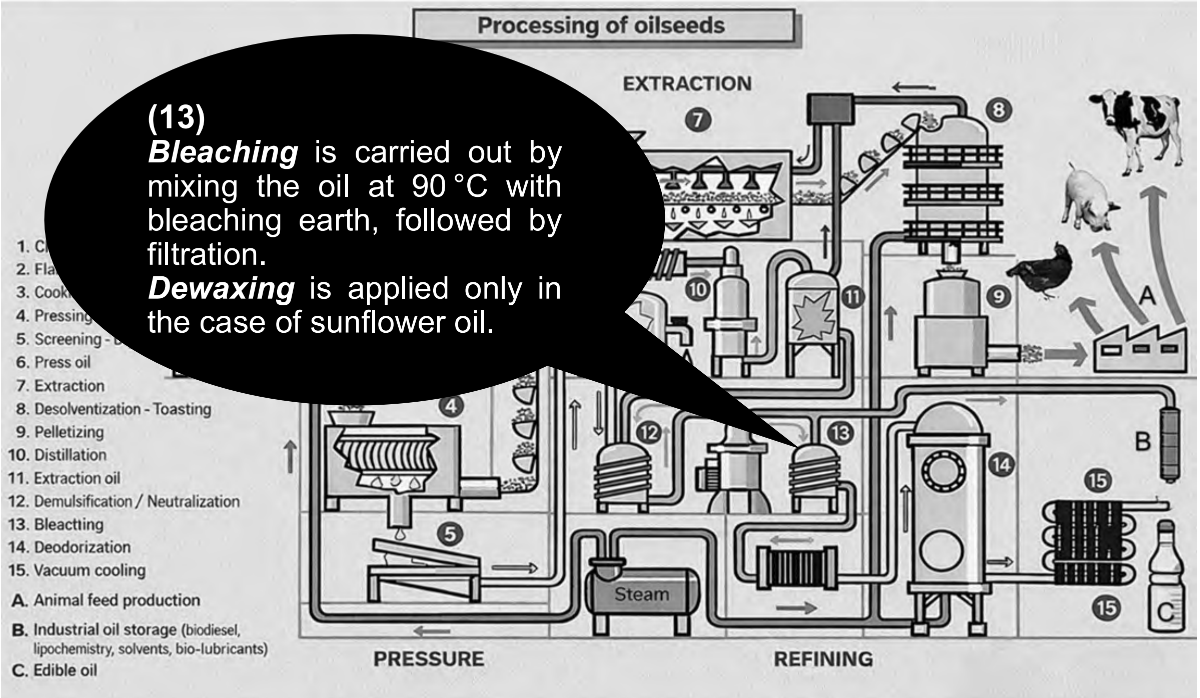
Oilseed Sector 6. Extraction Processes

Vegetable Oil Extraction Process Flow Diagram

(12bis)
Neutralization involves the removal of free fatty acids using a caustic soda solution. The soaps formed during this process are separated by centrifugation, and the oil is subsequently washed.



Vegetable Oil Extraction Process Flow Diagram



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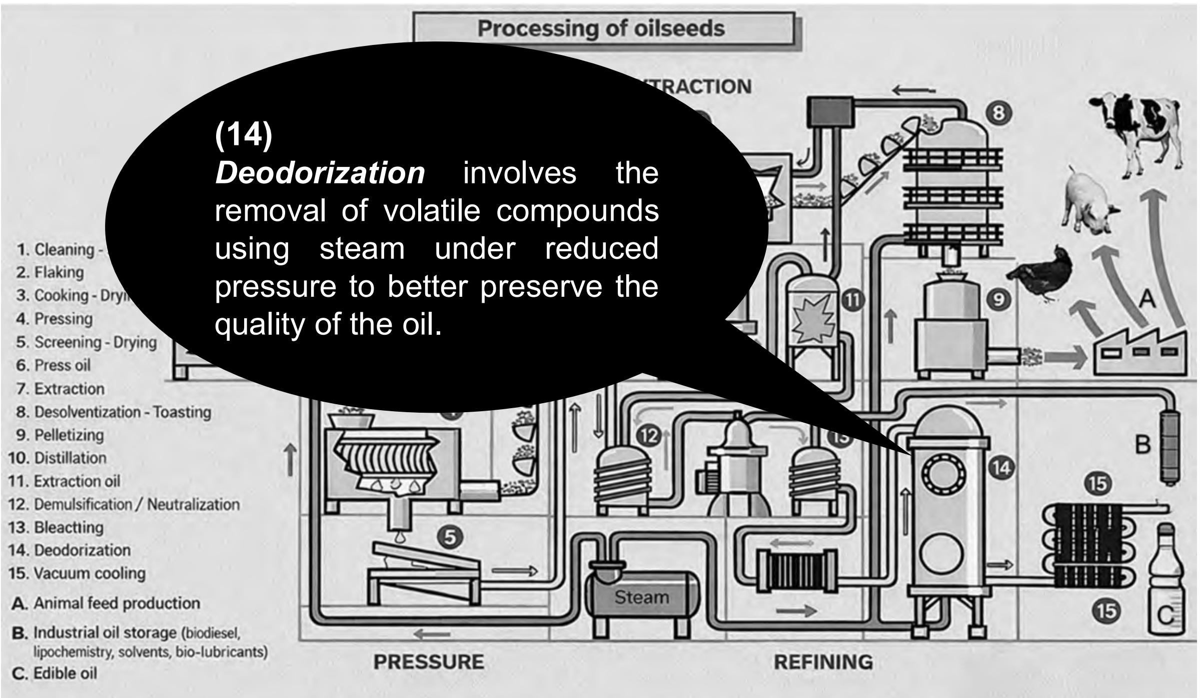
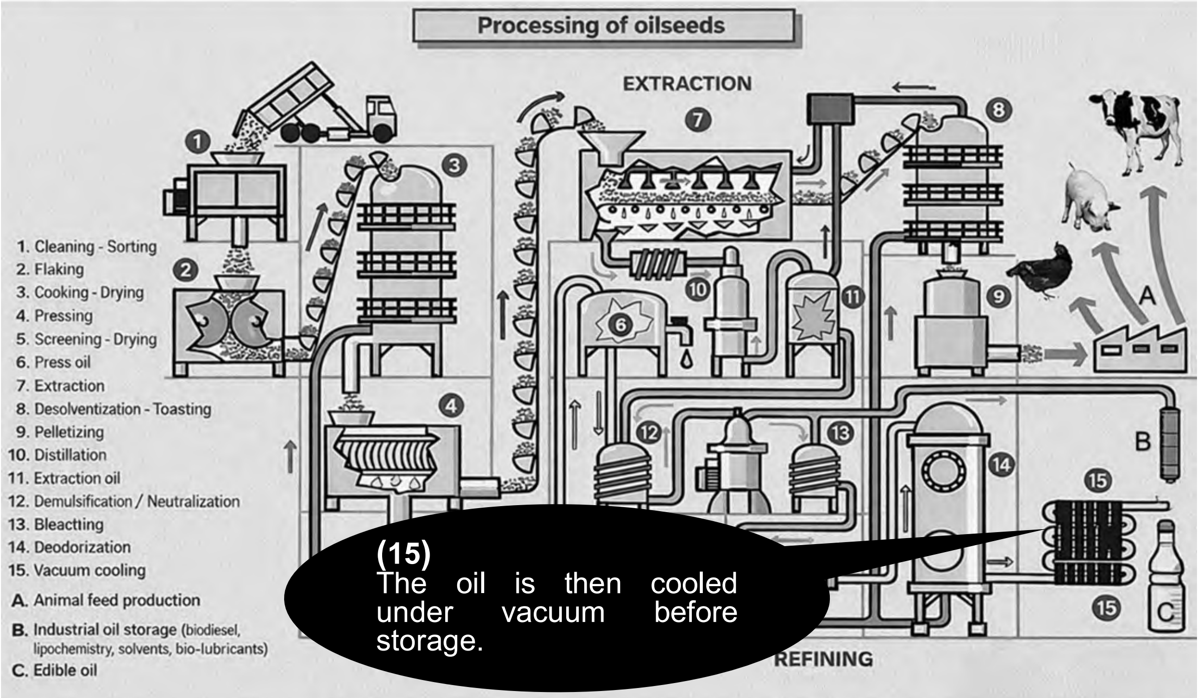
Oilseed Sector 6. Extraction Processes

Vegetable Oil Extraction Process Flow Diagram



Vegetable Oil Extraction Process Flow Diagram



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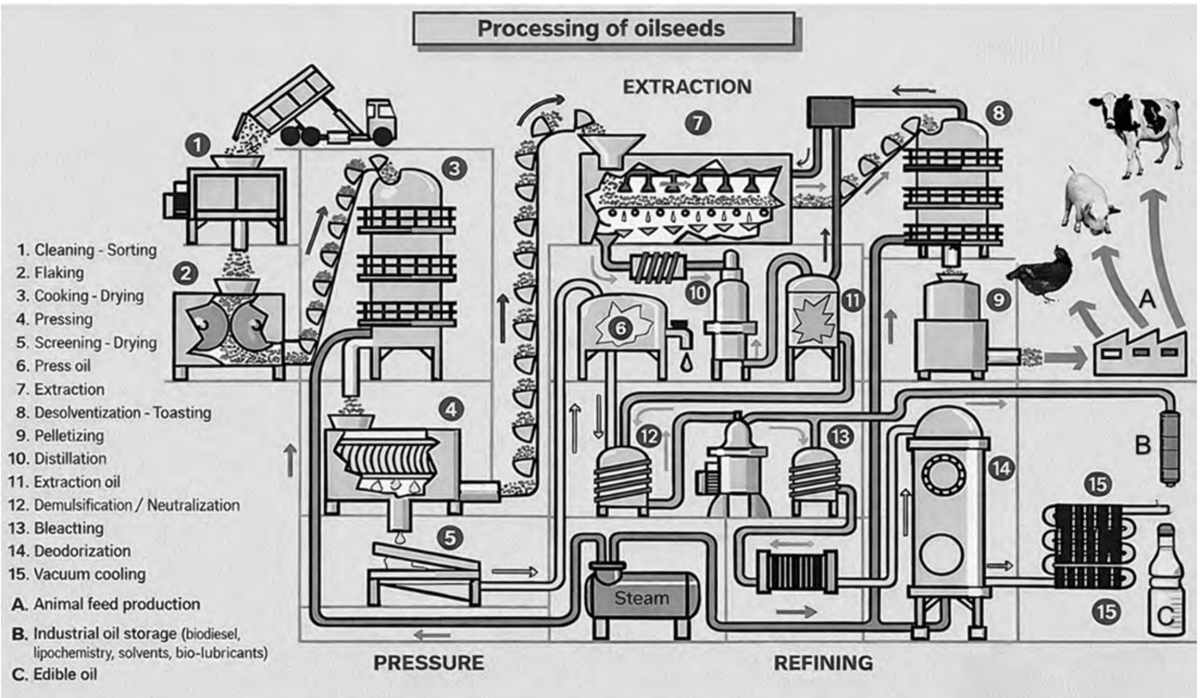
Oilseed Sector 6. Extraction Processes

Vegetable Oil Extraction Process Flow Diagram



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POLYDISCIPLINARY FACULTY OF TAZA
PROGRAM: AGRI-FOOD ENGINEERING/ S6

COURSE: AGRO-RESOURCE PROCESSING AND VALORIZATION

CHAPTER 1: VALORIZATION IN AGRO-INDUSTRY

Sugar Sector

1. Sugar Beet

Prof. Yahia RHARRABTI
Academic year: 2025-2026

CHAPTER 1: VALORIZATION IN AGRO-INDUSTRY

Sugar Sector 1. Sugar Beet

General overview

Sugar beet cultivation, which appeared at the beginning of the 19th century in Central Europe, has since spread worldwide. Today, this plant grows on all continents except Oceania, but it is mainly cultivated in temperate regions (Europe, Asia, North America, and North Africa).

It was introduced from Poland in 1775 by Vilmorin, and sugar extraction techniques were later developed by the chemist Margraff. In 1802, the first sugar production factory was launched in Poland.

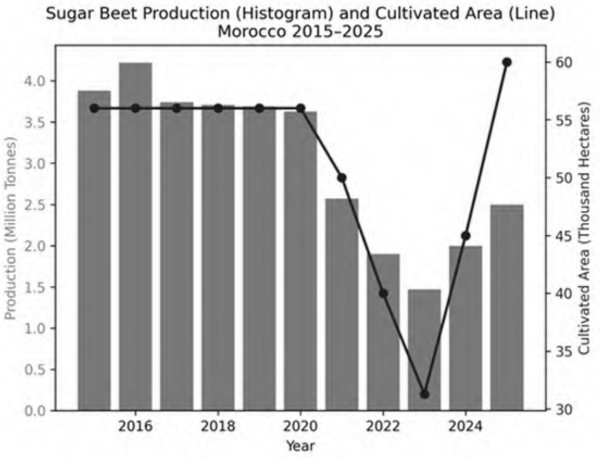
Until the early 19th century, sugarcane was the primary source of sugar. The war between England and France declared in 1792, as well as Napoleon's continental blockade in 1806, led to a sugarcane shortage. Napoleon then promoted large-scale cultivation of sugar beet..

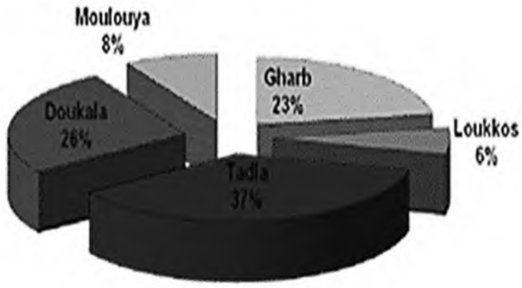
Situation in Morocco

Sugar beet cultivation in Morocco occupies about 55,000 ha annually, producing nearly 3.5 million tons of roots.

Together with sugarcane, it enables the production of nearly 400,000 tons of sugar across 13 sugar factories and refinery-sugar factories, covering around 40% of national sugar consumption.

Sugar beet is grown in the regions of Doukkala, Gharb, Loukkos, Tadla, and Moulouya.





CHAPTER 1: VALORIZATION IN AGRO-INDUSTRY
Sugar Sector 1. Sugar Beet

Plant Description

The sugar beet (*Beta vulgaris* ssp. *vulgaris*) is a dicotyledonous plant belonging to the family *Chenopodiaceae* and the genus *Beta*. The genus includes three species, among which is the species *vulgaris*. Sugar beet is part of the subspecies *vulgaris*, which also includes other cultivated forms such as forage beet and table beet/beetroot. Cultivated beets are derived, after domestication, from the sea beet, *Beta vulgaris* ssp. *maritima*.

Sugar beet

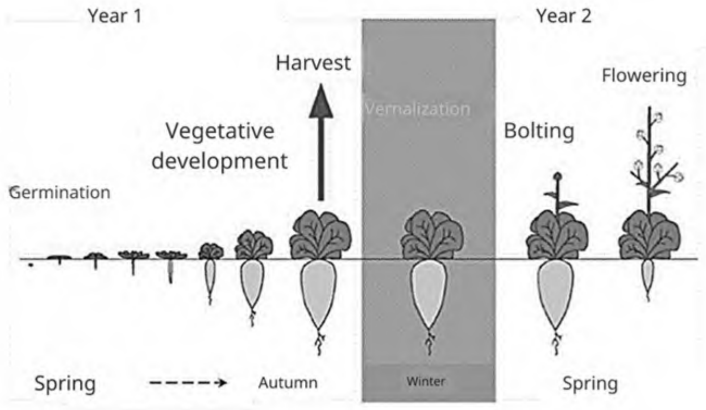
Forage beet

Table beet

Sea beet

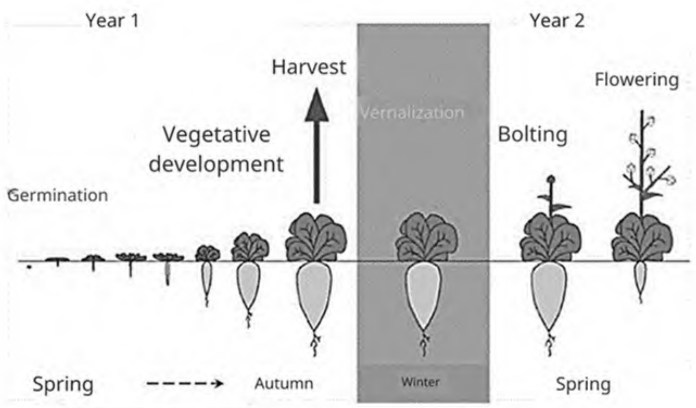
Development Cycle

Sugar beet is a biennial plant of long days. The first year corresponds to the vegetative phase, during which the plant develops only its foliar system and its root system. Leaf production is continuous, while the root enlarges and accumulates reserves in sucrose. The foliar rosette measures nearly 50 cm. The root is conical in shape, measures between 15 and 35 cm in length, and can contain up to 20% of its weight in sugar.



Development Cycle (continued)

The transition to the reproductive phase is initiated after exposure to winter cold. In the spring of the second year of cultivation, when photoperiod and temperature (20 to 25 °C) become optimal, the plant develops a flowering stem (bolting or heading process) followed by inflorescences with bisexual flowers. To achieve this, it must draw on its sugar reserves stored in the root during the first year.



Ecological Requirements

❑ Temperature

Sugar beet requires, from sowing to harvest, approximately 2400 to 2800 degree-days. The seed begins to germinate from 3.5°C and about 150 degree-days are required, i.e., about 10 days at 15°C in the soil, for emergence. Spring frosts below 3°C may cause physiological or mechanical damage. During the active period of root development, the most favorable temperatures are 23–25°C during the day and 12–15°C at night.

❑ Water

Water requirements are 600 to 700 mm. In April, at emergence, the seedbed must be moist, but excess water is harmful. In summer, rainfall must be abundant (80 to 90 mm) in order to obtain maximum yield in weight. Conversely, in September–October, rainfall must remain low to limit dilution of sugar content in the root.

CHAPTER 1: VALORIZATION IN AGRO-INDUSTRY
Sugar Sector 1. Sugar Beet

Ecological Requirements

❑ Light

Light is a driving element of growth and a determining factor throughout the plant cycle. For this reason, it is essential to obtain rapid soil cover and maintain it under optimal sanitary conditions until harvest in order to benefit from maximum solar radiation.

❑ Soil

For sugar beet, the optimal soil contains 2 to 4% organic matter and 15 to 20% clay. However, it is possible to cultivate sugar beet in a wide range of soils. Shallow soils should be avoided. Stones are also problematic because they complicate root development. Suitable pH ranges between 6.5 and 8, with an optimum between 7 and 7.5.

Food and industrial uses

Sugar beet is used for sugar production, and secondarily for alcohol and fuel ethanol. Its by-products include molasses, which still contains about 50% sugar and is used as a palatable feed for animals; beet pulp, a residue from sugar extraction, generally dehydrated for the same use; molasses is also used for the production of baker's yeast; collars and leaves are used for livestock feed or returned to the soil.

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Sugar Sector 1. Sugar Beet

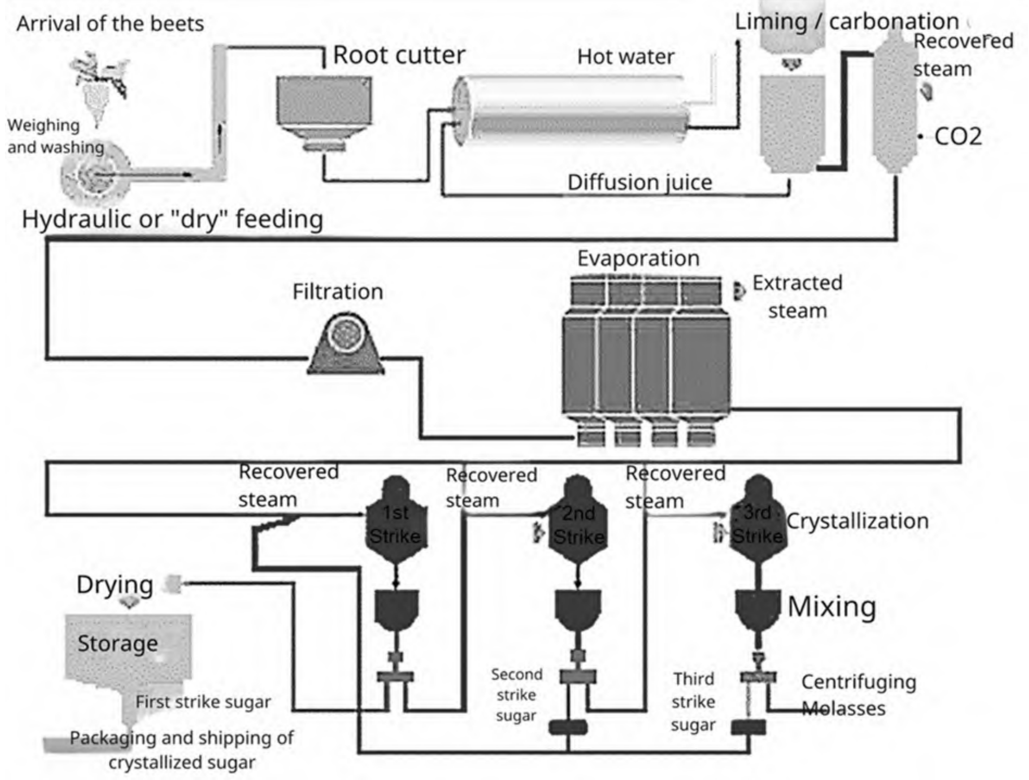
Sugar Production

Sugar beet contains 76% water, 24% dry matter and between 15 and 20% sugar. Sugar is stored in the roots. Before consumption, it must be extracted while preserving sugar content. Processing must be rapid; this is why sugar factories are located near cultivation areas.

Nine steps are necessary for sugar extraction:

Beets are weighed and washed, then cut into thin slices, immersed in a flow of hot water to extract sugar. The juice is purified, then filtered, and concentrated into syrup by evaporation. When the sugar concentration reaches about 65%, it is then heated under vacuum to initiate crystallization. The cooked mass is finally sent into centrifuges which remove the liquid and retain the crystallized white sugar.

Sugar Sector **1. Sugar Beet**



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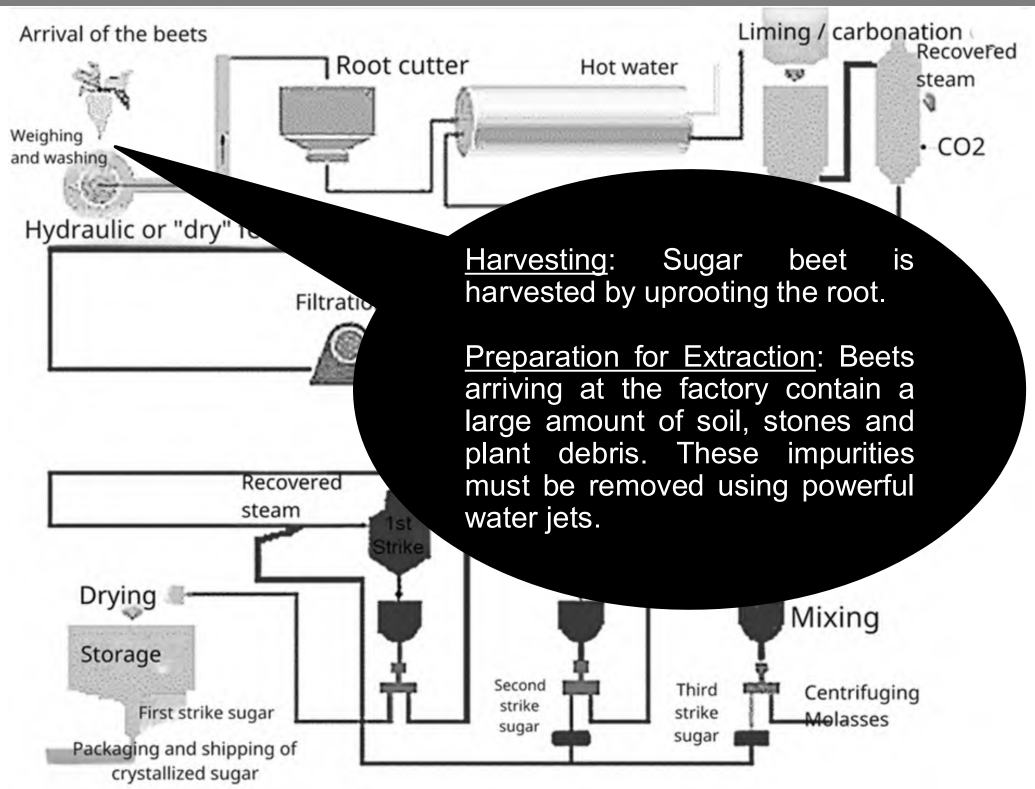
Sugar Sector **1. Sugar Beet**



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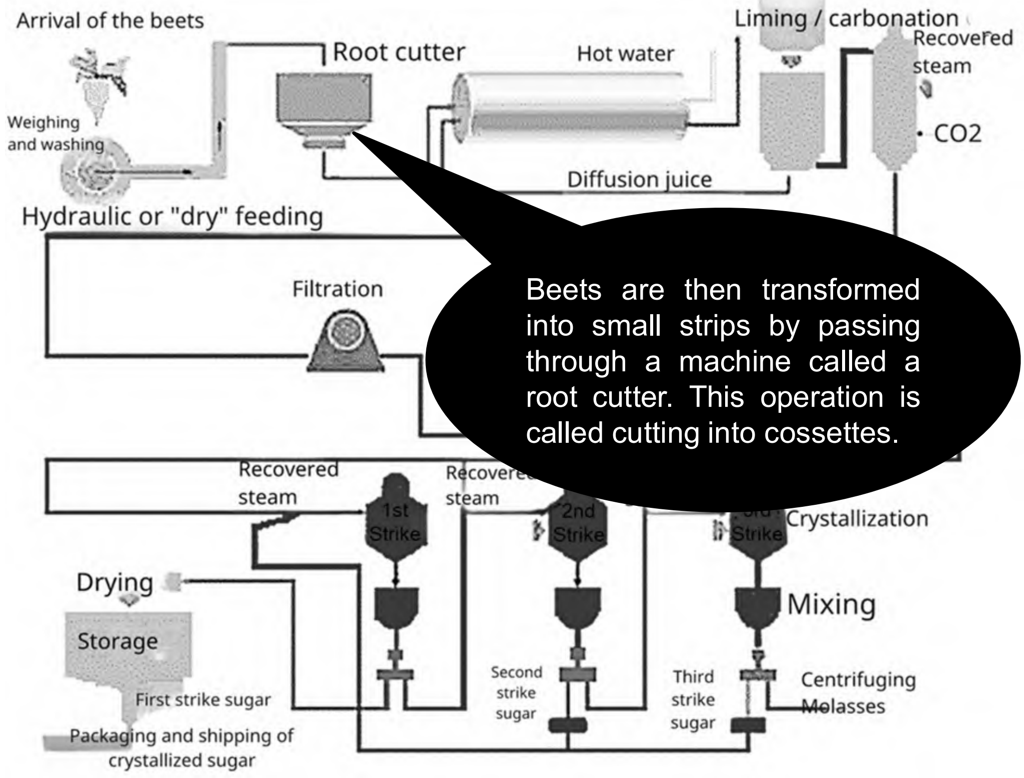
Sugar Sector 1. Sugar Beet



Beets are then transformed into small strips by passing through a machine called a root cutter. This operation is called cutting into cossettes.

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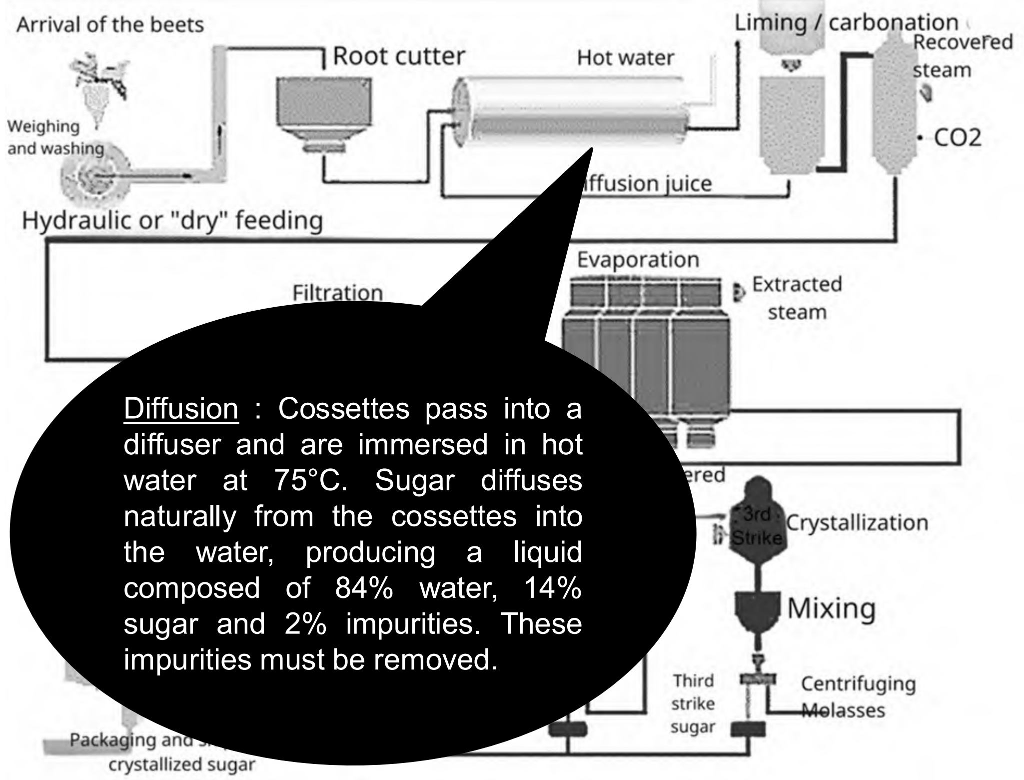
Sugar Sector 1. Sugar Beet



<u>Diffusion</u> : Cossettes pass into a diffuser and are immersed in hot water at 75°C. Sugar diffuses naturally from the cossettes into the water, producing a liquid composed of 84% water, 14% sugar and 2% impurities. These impurities must be removed.

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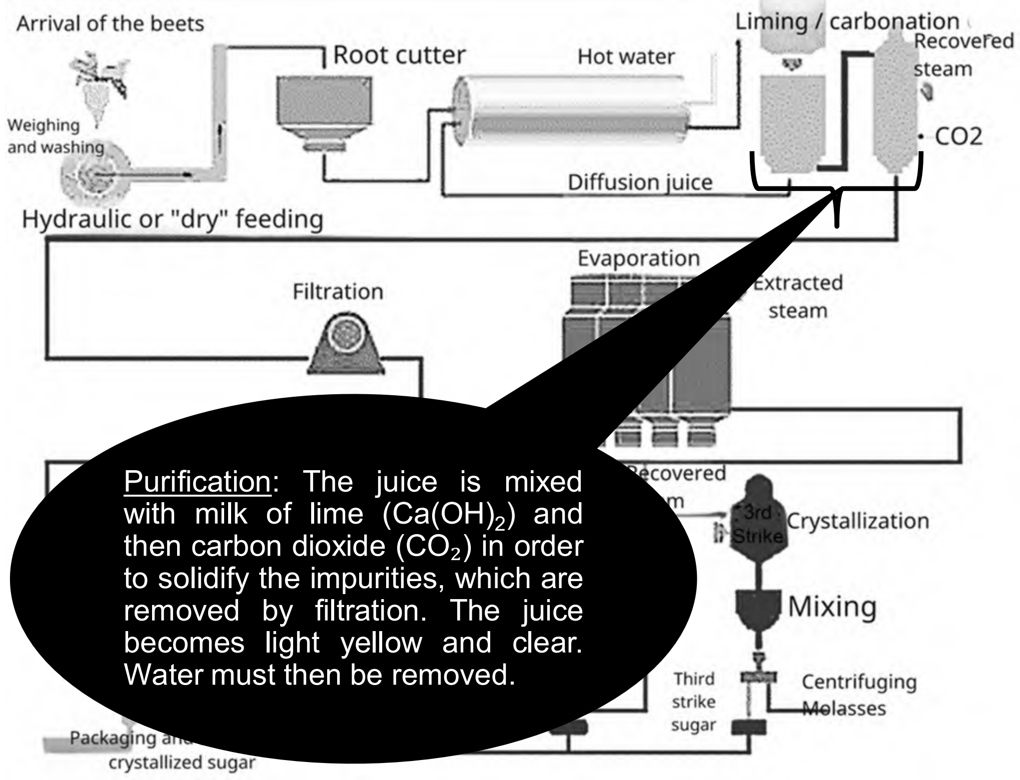

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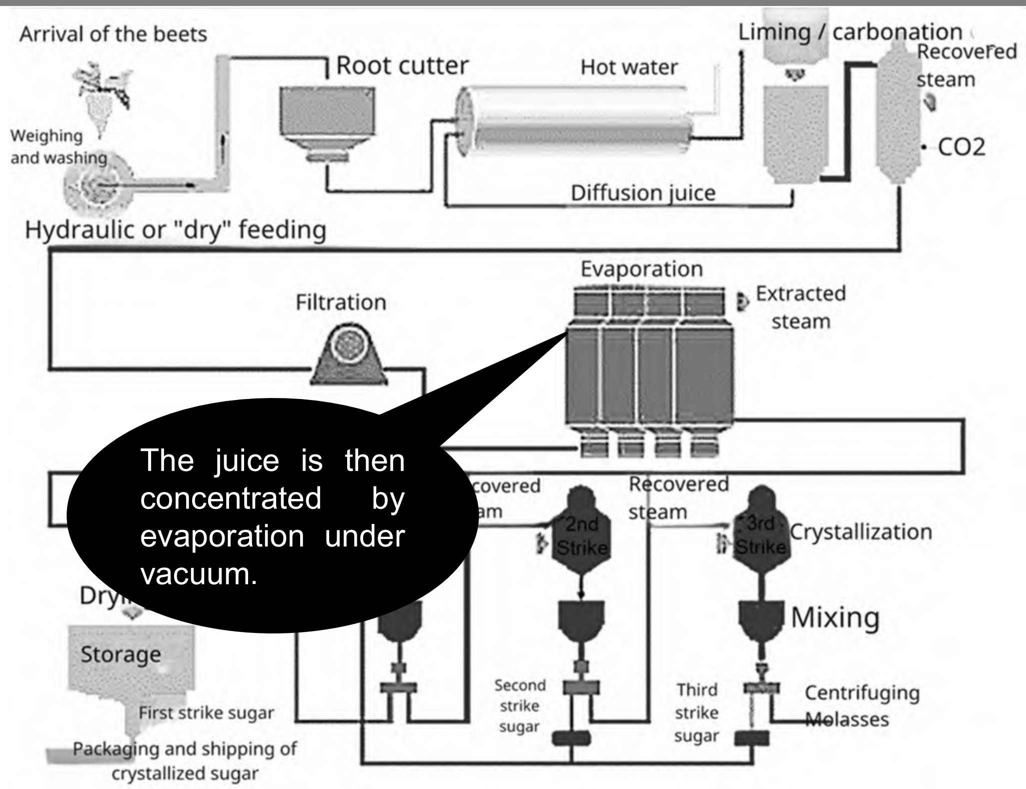
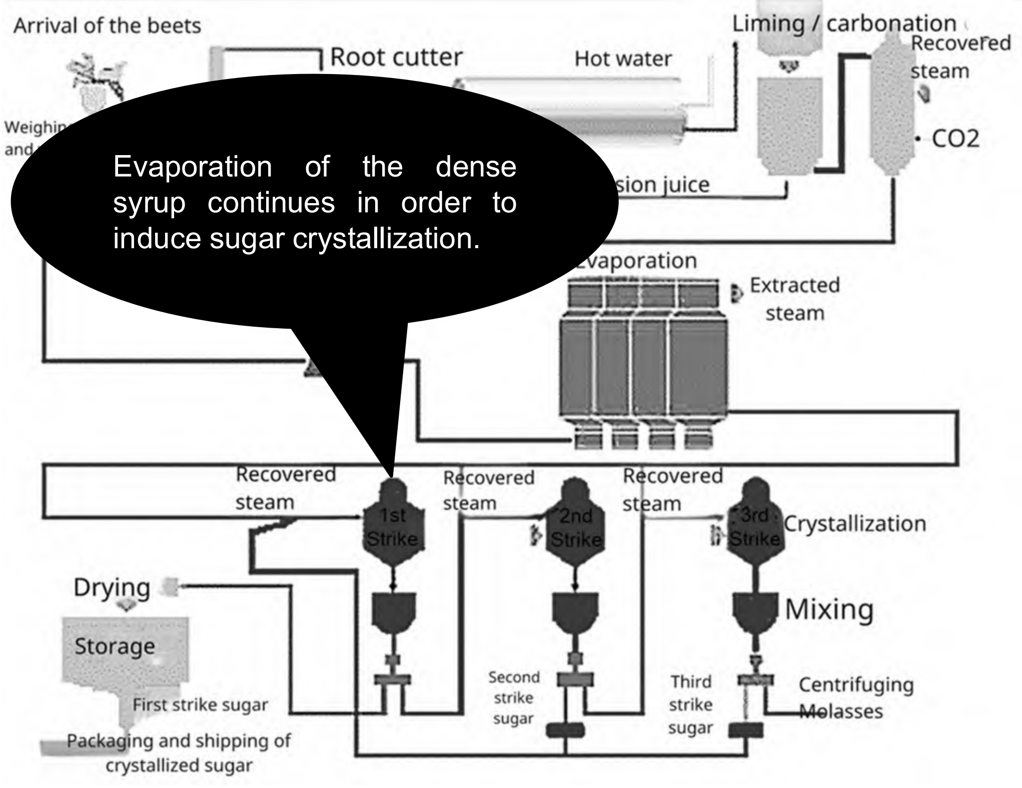
Sugar Sector **1. Sugar Beet**



Evaporation of the dense syrup continues in order to induce sugar crystallization.



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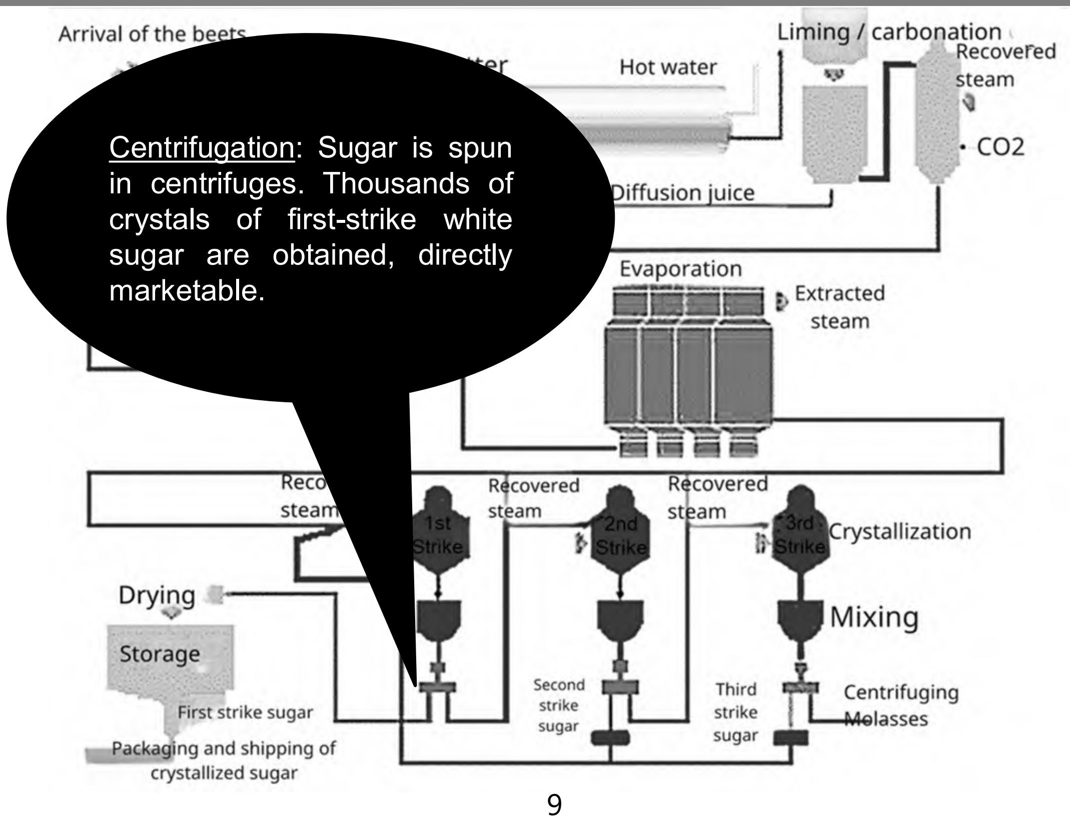
Sugar Sector 1. Sugar Beet

Centrifugation: Sugar is spun in centrifuges. Thousands of crystals of first-strike white sugar are obtained, directly marketable.



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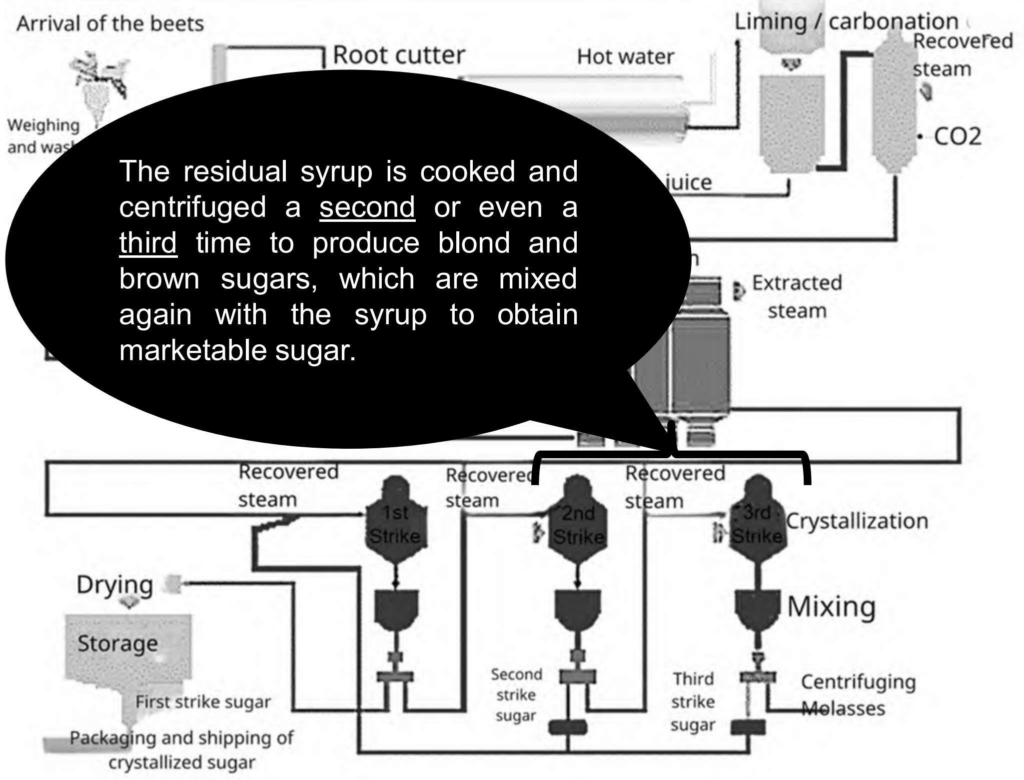
Sugar Sector **1. Sugar Beet**



The residual syrup is cooked and centrifuged a <u>second</u> or even a <u>third</u> time to produce blond and brown sugars, which are mixed again with the syrup to obtain marketable sugar.

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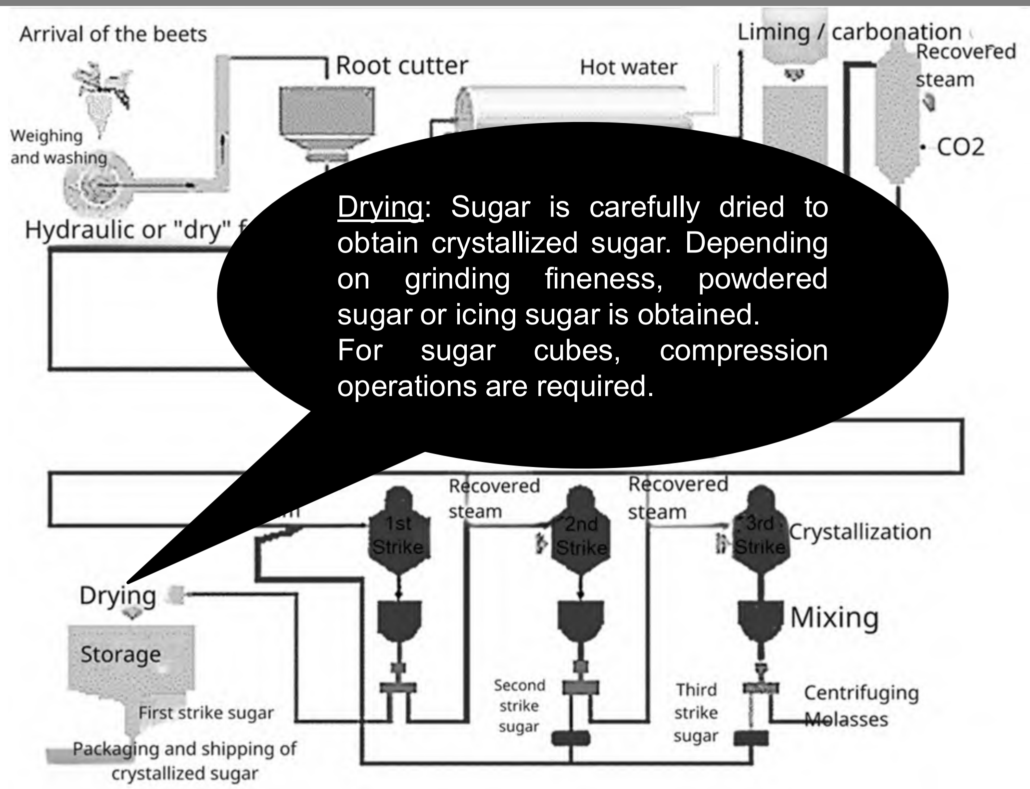

<u>Drying</u>: Sugar is carefully dried to obtain crystallized sugar. Depending on grinding fineness, powdered sugar or icing sugar is obtained.
For sugar cubes, compression operations are required.

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Sugar Sector

2. Sugarcane

Prof. Yahia RHARRABTI
Academic year: 2025-2026

General overview

Sugarcane (*Saccharum officinarum*) is a plant belonging to the family Poaceae and the genus Saccharum. It is primarily cultivated for its stem, from which sugar is extracted. With an annual production volume exceeding 2.2 billion tonnes, sugarcane is the most widely cultivated crop worldwide, accounting for more than 20% of the total agricultural biomass produced globally.

Its center of origin is believed to be the archipelago of New Guinea, from where it was progressively disseminated by humans, initially throughout the islands of the Pacific Ocean and across the Indian Ocean, reaching Malaysia and the Indochinese Peninsula.

The cultivation range of sugarcane extends from 37° north latitude (Mediterranean regions) to 30° south latitude, including countries such as Brazil and South Africa. Of tropical origin, sugarcane is extensively cultivated in South America, particularly in Brazil, the world's leading producer, as well as in Asia, notably in India and China, and also in Australia and North America, especially in Florida.

General overview

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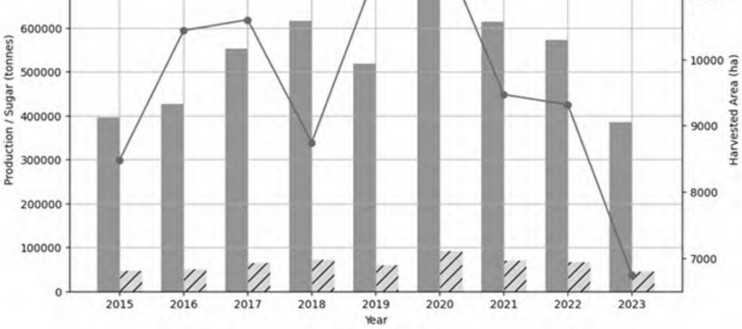
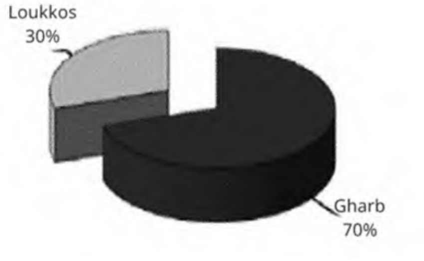
Sugar Sector 2. Sugarcane

Situation in Morocco

Sugarcane production in Morocco currently averages approximately 600,000 tonnes, enabling the production of around 65,000 tonnes and together with sugar beet near 400,000 tonnes of sugar, which covers nearly 40% of domestic consumption requirements.

Sugarcane cultivation in Morocco is concentrated mainly in the Gharb and Loukkos regions.





Plant Description

The sugarcane stem typically reaches 2 to 5 m in height and 2 to 4 cm in diameter. It does not branch above ground; however, underground buds give rise to additional stems. A well-developed sugarcane clump may contain 10 to 15 stems. The stem consists of a succession of more lignified nodes, where buds (eyes) are located, and sugar-rich internodes, which may display yellow, green, red, purple, or brown coloration depending on the variety, often becoming reddish when exposed to sunlight.

The leaves are alternate, arranged in two opposite rows, and possess a blade approximately 1 m in length and 2 to 10 cm in width. The lower part of the stem gradually becomes bare as the basal leaves dry out and senesce.

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Sugar Sector 2. Sugarcane

Development Cycle

a = cuttings

b = bud sprouting and rhizogenesis

c = tillering initiation

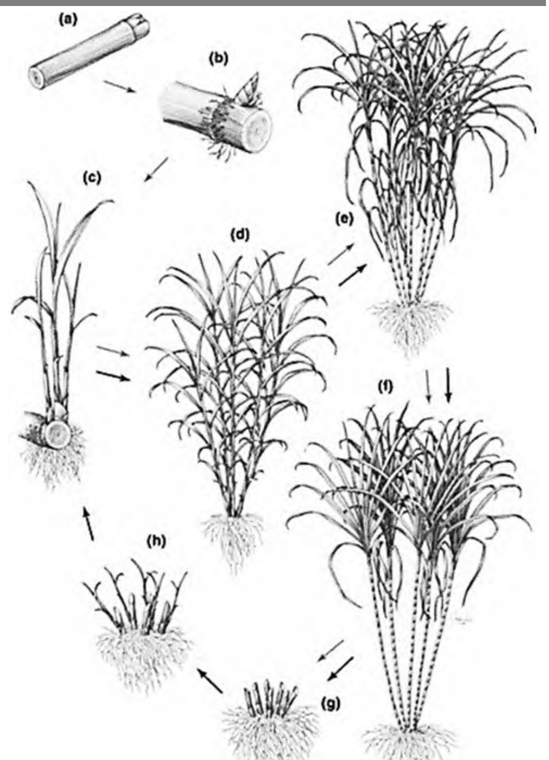
d = intensive tillering

e = onset of maturation

f = optimal sucrose concentration in harvestable stems

g = harvesting

h = ratoon regrowth



Ecological Requirements

The growth cycle, development, and maturation of sugarcane are closely influenced by climatic conditions. Water availability and heat promote vegetative growth, whereas drought and low temperatures, particularly during the night, favor maturation.

❑ **<u>Temperature</u>**

- Optimal daytime temperatures:
  - Germination: 26°C to 33°C
  - Growth: 28°C to 35°C
- Minimum temperature for growth: 15°C to 18°C
- Lethal temperature (frost): 0°C

❑ **<u>Water</u>**

During the vegetative stage, sugarcane requires:

- 100 to 170 mm of water per month, depending on climatic conditions
- 1,000 to 2,000 mm annually, with a well-defined dry season of 4 to 5 months corresponding to the cane maturation period

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Sugar Sector 2. Sugarcane

Ecological Requirements

❑ **<u>Light</u>**

Sugarcane requires abundant light for both vegetative growth and sucrose accumulation. Plants grown under full sunlight develop thicker and taller stems, broader, thicker, and greener leaves, as well as a more extensive root system. Light also promotes cane maturation by facilitating a reduction in the amount of structural water within the plant tissues.

❑ **<u>Altitude</u>**

Sugarcane can be found on high plateaus at elevations of around 1,400 m; however, to achieve satisfactory industrial sugar yields, cultivation is recommended mainly in coastal regions not exceeding 500 m above sea level.

❑ **<u>Soil</u>**

Sugarcane can grow in a wide range of soils, provided they are deep, loose, rich in organic matter and mineral nutrients, and sufficiently moist. The optimal soil pH ranges between 7.0 and 7.5.

Food and Industrial Uses

In addition to sugar, which is the principal high-value product derived from sugarcane, several other by-products can also be valorized for food and industrial applications.

❑ **Bagasse**

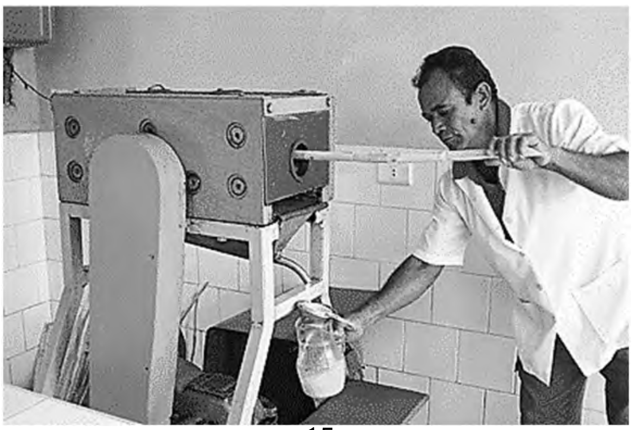
Bagasse consists of the fibrous residue obtained after crushing sugarcane stems. It represents approximately 30% of the weight of harvested cane delivered to the factory and still contains a small amount of residual sugar.

Bagasse is primarily used as fuel in sugar mills to heat furnaces and generate electricity. Surplus bagasse not utilized as fuel can be further processed for paper production, used as animal bedding, incorporated into livestock feed, or valorized as a composting substrate.

Food and Industrial Uses

❑ **Sugarcane juice**

Sugarcane juice is obtained by passing sugarcane stems through a press. This juice, commonly referred to as *vesou*, contains approximately 70% water, 14% sucrose, 14% fibrous matter, and 2% impurities. It is widely consumed as a beverage in many countries, often served with a small amount of Lemon juice and ice.



Food and Industrial Uses

❑ **Molasses**

Molasses is the liquid residue remaining after sugar extraction from sugarcane juice. It is dark-colored, viscous, and still contains a small amount of residual sugar, as well as vitamin B6 and mineral elements.

Molasses can be fermented and distilled to produce ethanol for pharmaceutical purposes or for biofuel production. It is also used in human nutrition and in livestock feeding, often in combination with Bagasse. In addition, molasses serves as a basic substrate for the cultivation of baker's yeast.

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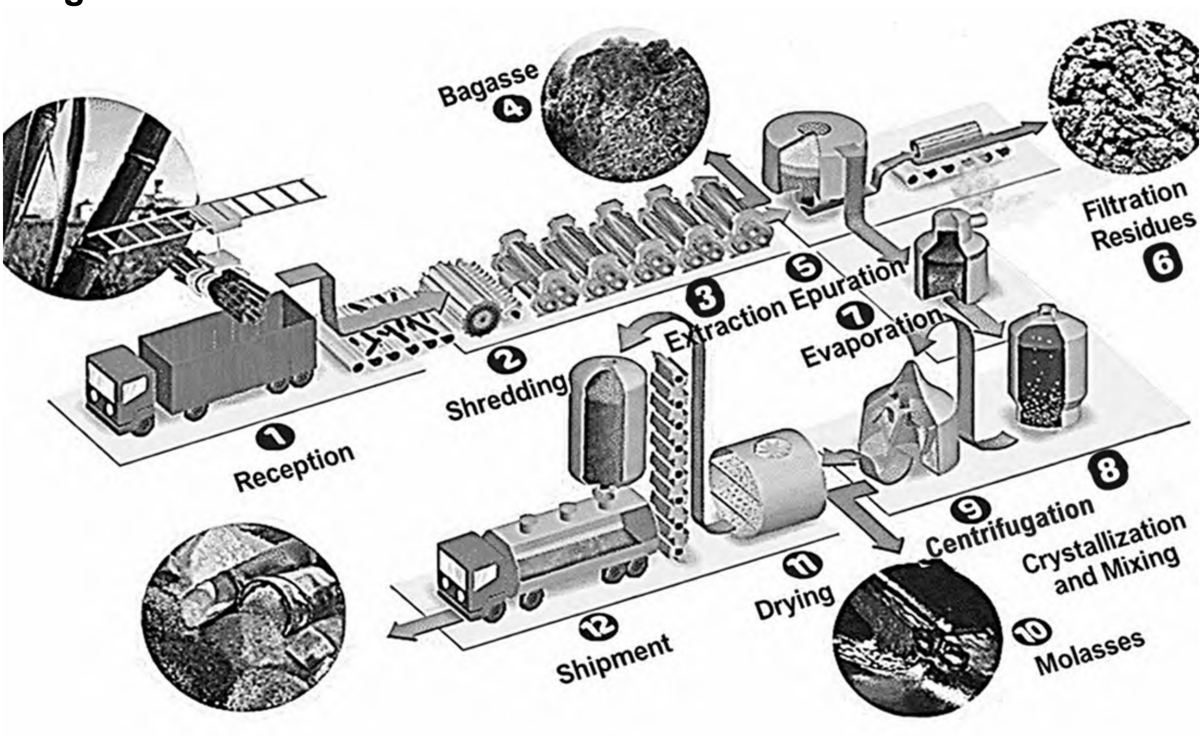
Sugar Sector 2. Sugarcane

Sugar Production Process



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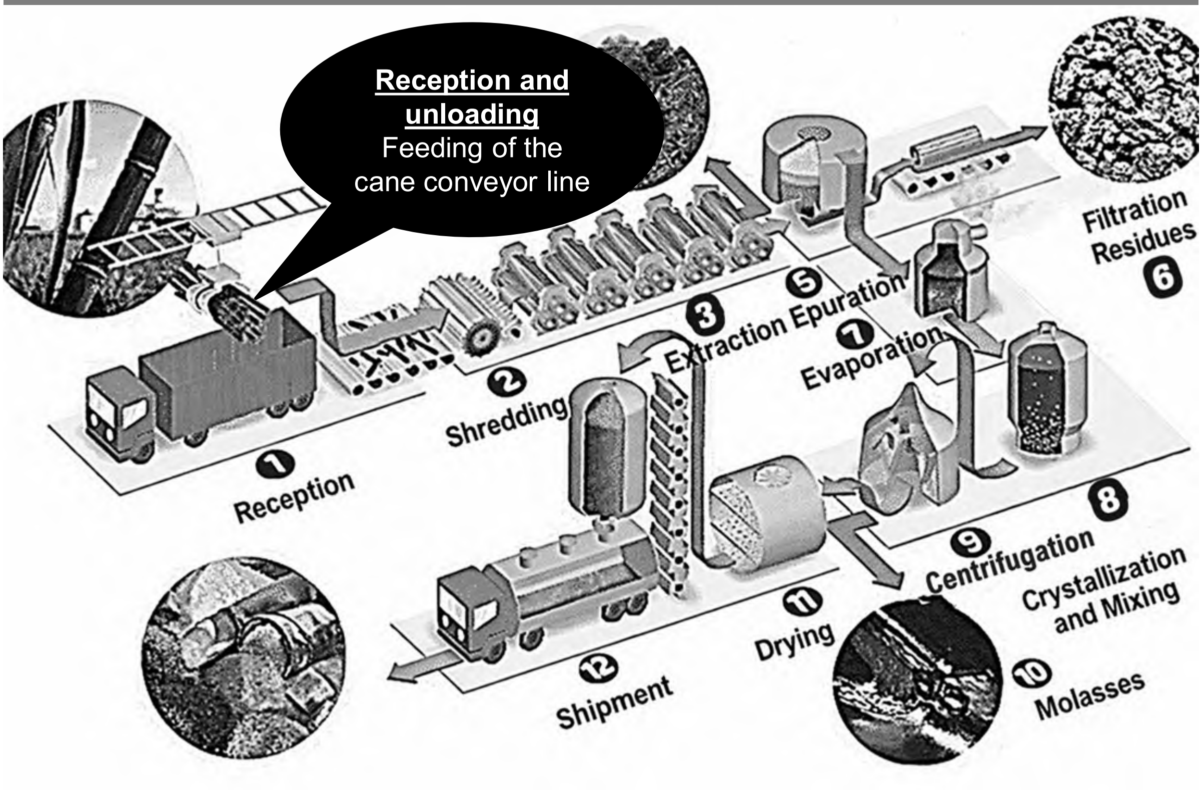
Sugar Sector **2. Sugarcane**



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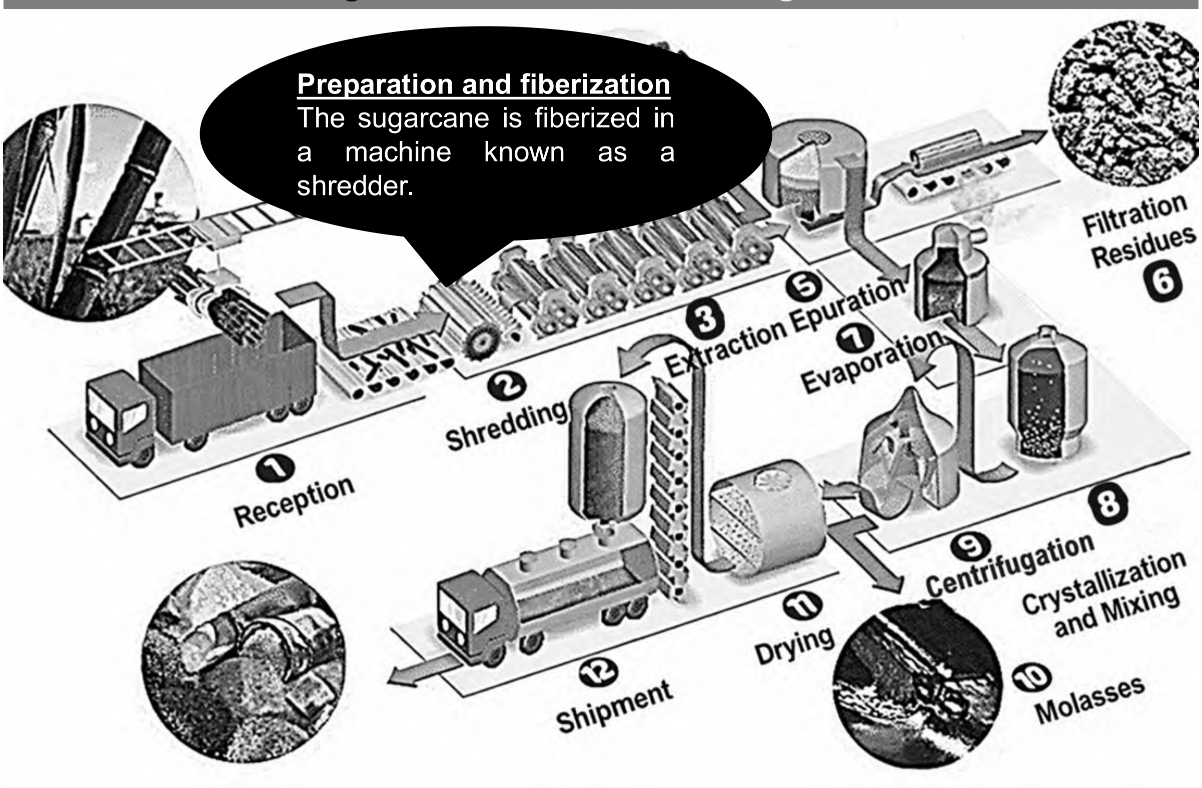
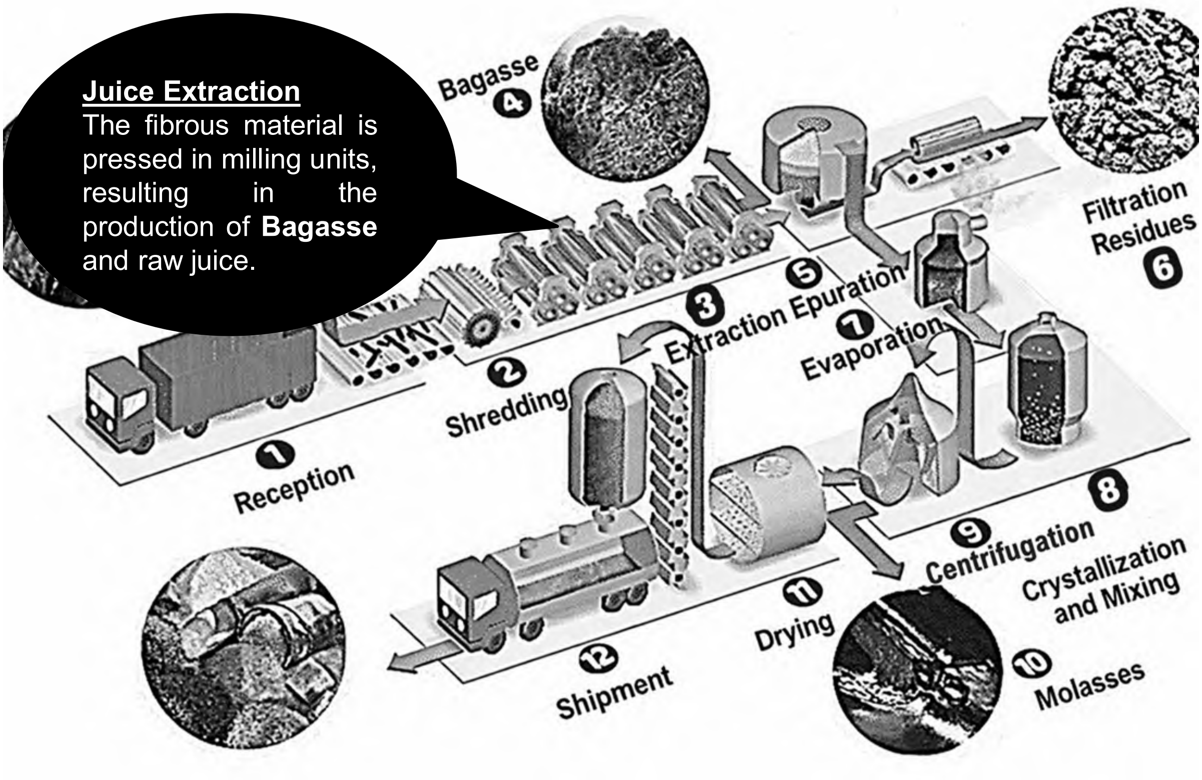
Sugar Sector **2. Sugarcane**



Juice Extraction
The fibrous material is pressed in milling units, resulting in the production of **Bagasse** and raw juice.



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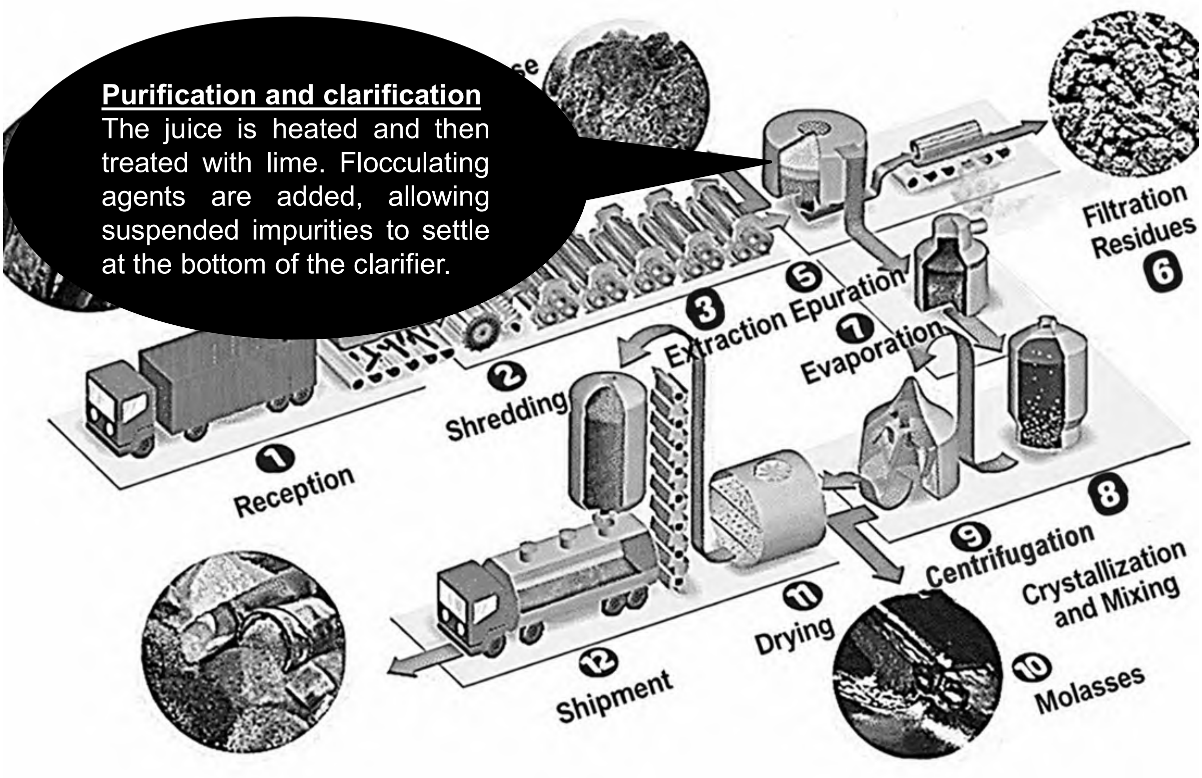
Sugar Sector 2. Sugarcane

Purification and clarification
The juice is heated and then treated with lime. Flocculating agents are added, allowing suspended impurities to settle at the bottom of the clarifier.



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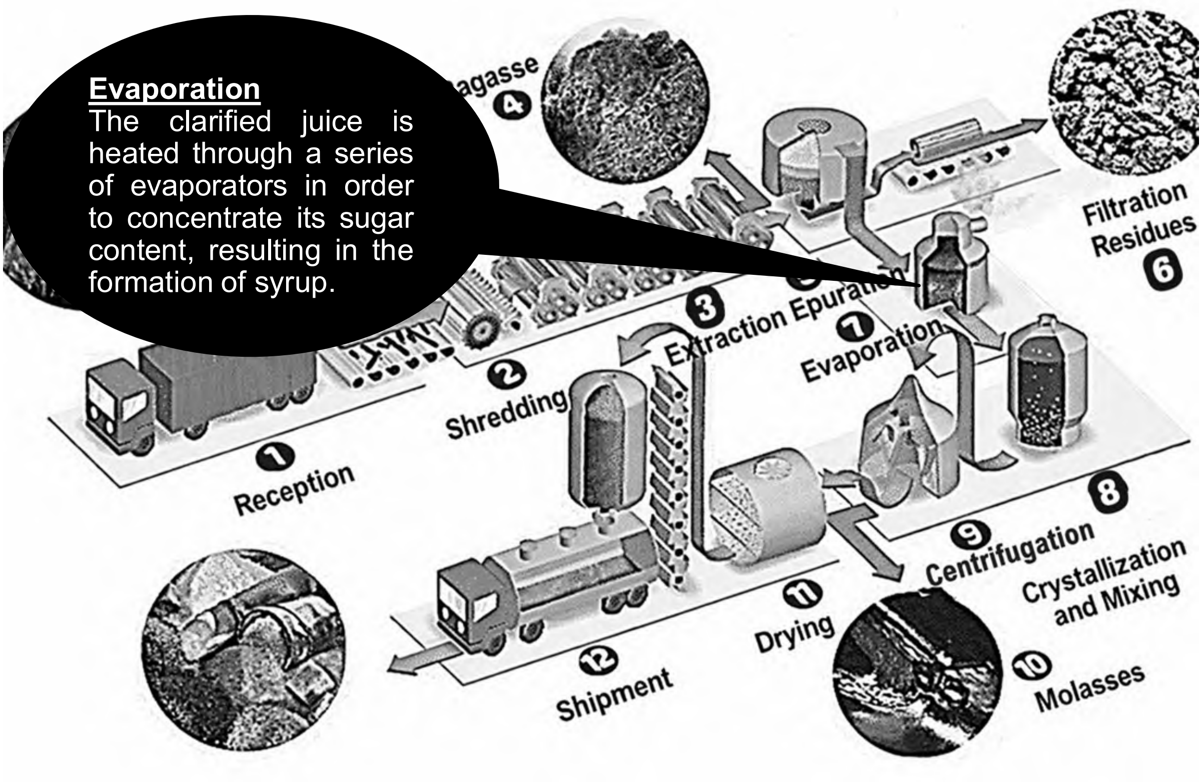
Sugar Sector **2. Sugarcane**



Evaporation
The clarified juice is heated through a series of evaporators in order to concentrate its sugar content, resulting in the formation of syrup.

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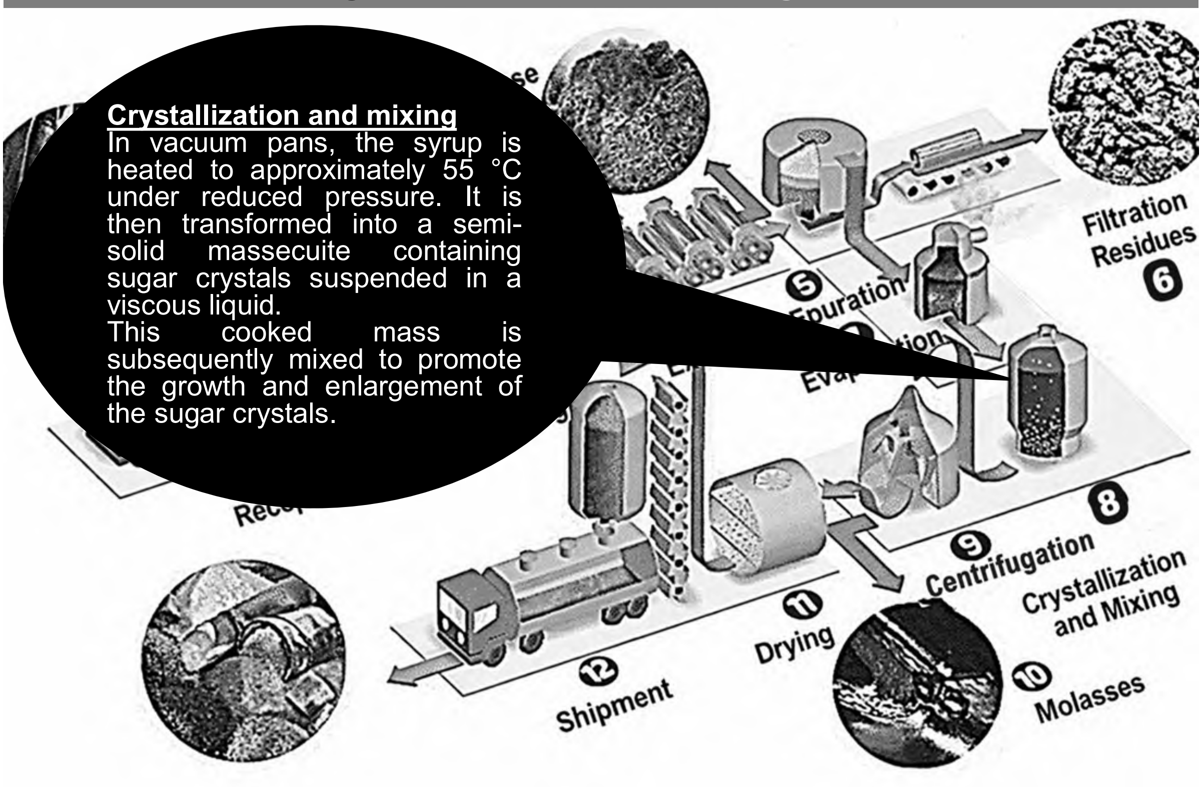
Sugar Sector **2. Sugarcane**



Crystallization and mixing
In vacuum pans, the syrup is heated to approximately 55 °C under reduced pressure. It is then transformed into a semi-solid massecuite containing sugar crystals suspended in a viscous liquid.
This cooked mass is subsequently mixed to promote the growth and enlargement of the sugar crystals.

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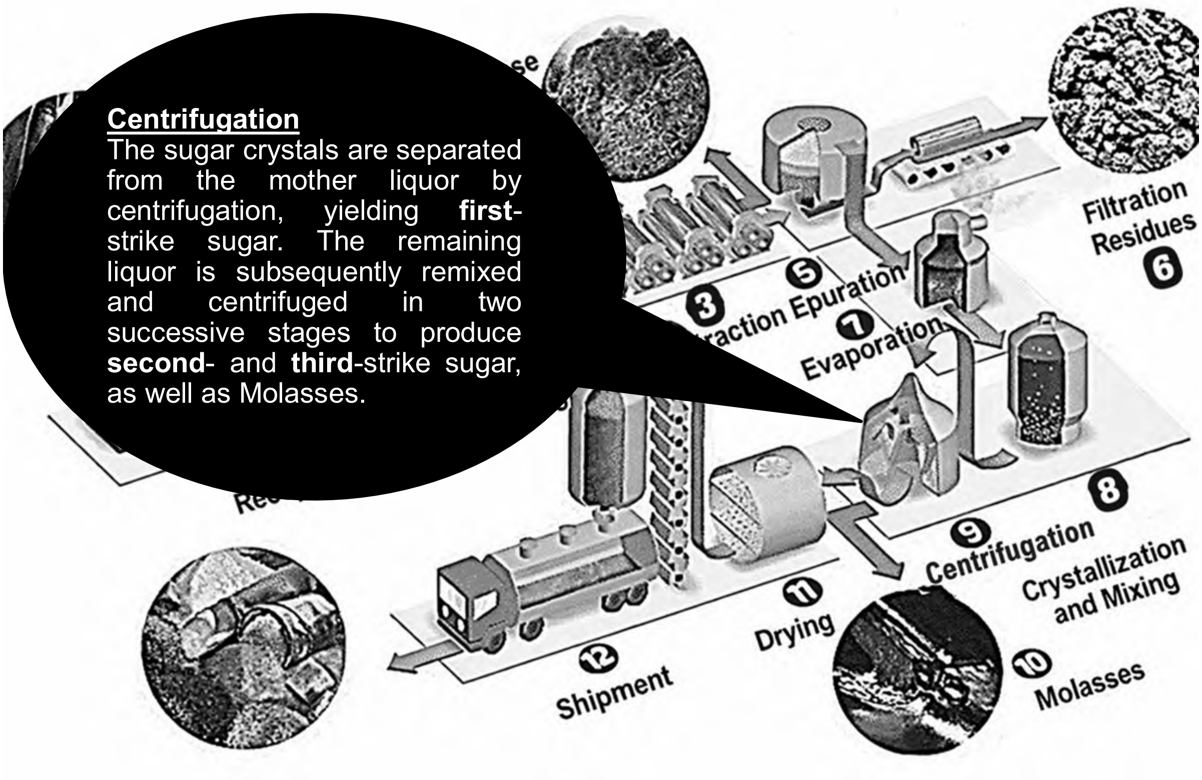
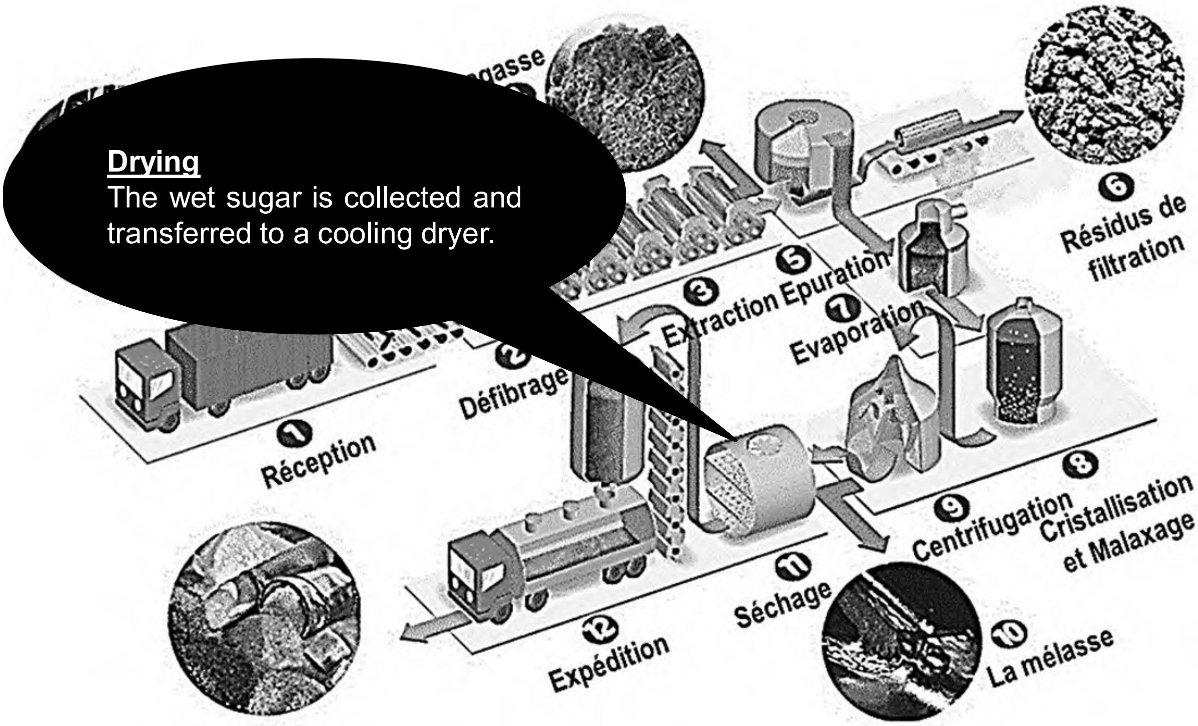
Sugar Sector **2. Sugarcane**



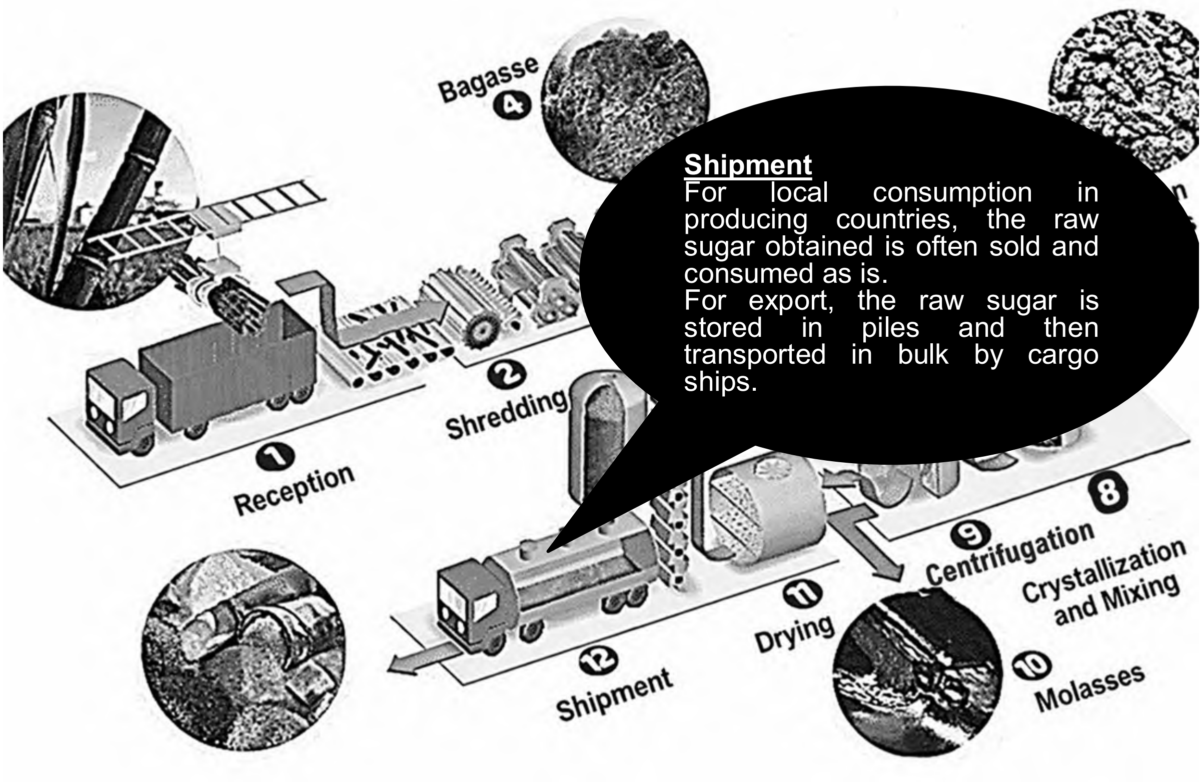
<u>Centrifugation</u>
The sugar crystals are separated from the mother liquor by centrifugation, yielding **first**-strike sugar. The remaining liquor is subsequently remixed and centrifuged in two successive stages to produce **second**- and **third**-strike sugar, as well as Molasses.

CHAPTER 1: VALORIZATION IN AGRO-INDUSTRY

Sugar Sector **2. Sugarcane**



<u>Drying</u>
The wet sugar is collected and transferred to a cooling dryer.


Shipment
For local consumption in producing countries, the raw sugar obtained is often sold and consumed as is.
For export, the raw sugar is stored in piles and then transported in bulk by cargo ships.
Bagasse 4
1 Reception
2 Shredding
8
9 Centrifugation
Crystallization and Mixing
10 Molasses
11 Drying
12 Shipment

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PROGRAM: AGRI-FOOD ENGINEERING/ S6

COURSE: AGRO-RESOURCE PROCESSING AND VALORIZATION

CHAPTER 2: VALORIZATION IN COSMETICS AND PHARMACEUTICALS

1. Argan Tree

Prof. Yahia RHARRABTI
Academic year: 2025-2026

CHAPTER 2: VALORIZATION IN COSMETICS AND PHARMACEUTICALS

1. Argan Tree

General overview

The history of the argan tree is believed to date back several million years in North Africa. During that period, the Moroccan coasts and the Canary Islands were part of a common landmass. The argan tree likely emerged naturally during these climatic transitions.

During the Tertiary era, marked by the uplift of the Atlas Mountains, the argan tree expanded its distribution. The evolution toward a warm and temperate climate favored its development, initially in Morocco and, to a lesser extent, in Algeria and Brazil.

The earliest references to the argan tree in the Maghreb were made by Arab geographers and scholars between the 10th and 12th centuries, including Ali Ibn Rodhoan, El Bechri, and El Idrissi. Later, in 1219, Ibn al-Baytar described the tree and its uses, particularly its oil, in “Treatise on Simple Drugs”.

General overview

In 1515, Leo Africanus (Hassan El Ouazzan) described spiny trees in the Haha region producing a fruit called “argane,” from which an oil with a distinctive odor was extracted for food and lighting.

In 1737, Carl Linnaeus in his work Hortus Cliffortianus, described the species based on dried specimens under the name *Sideroxylon spinosum* L.

In 1819, Roemer and Schultes established the genus Argania, leading to the binomial Argania spinosa (L.) Skeels, officially recognized in 1911, according to the Index Kewensis.

CHAPTER 2: VALORIZATION IN COSMETICS AND PHARMACEUTICALS

1. Argan Tree

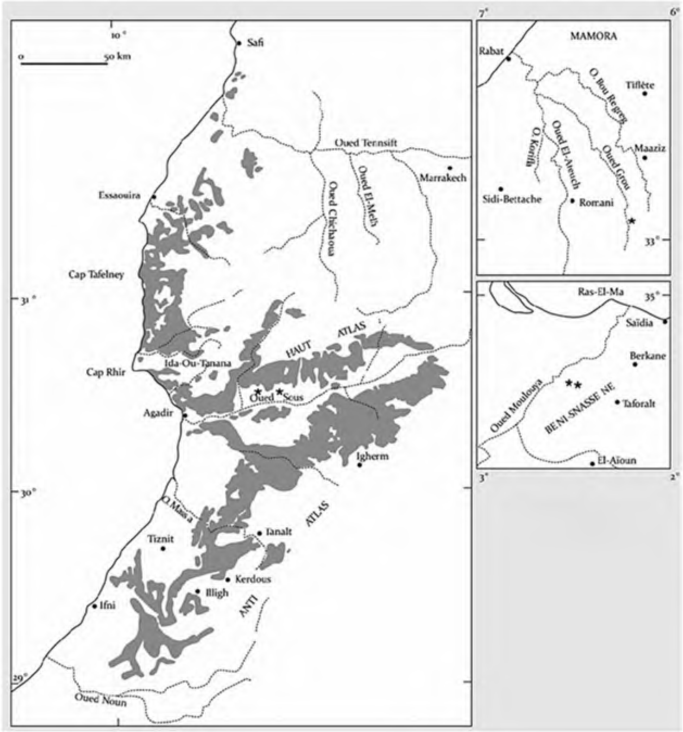
Geographical Distribution in Morocco

The argan tree currently covers approximately 800,000 hectares, mainly in southwestern Morocco along the Atlantic coast, from the Tensift River in the north to the Drâa River in the south.

It also develops in the Souss plain, on the southern slopes of the Western High Atlas, and on both the northern and southern slopes of the Western Anti-Atlas, reaching altitudes of 1,300–1,500 m. Two small populations have been reported in the upper valley of Oued Grou, southeast of Rabat, and in the northwestern foothills of the Beni-Snassen.

The argan forest represents:14.25% of Morocco’s total forest area9.2% of the national forest domain

Geographical Distribution in Morocco



CHAPTER 2: VALORIZATION IN COSMETICS AND PHARMACEUTICALS

1. Argan Tree

Taxonomy

The argan tree is a strictly endemic species to Morocco. It constitutes the only representative within the country of a predominantly tropical family.

The systematic classification is as follows:

- Division ....Phanerogams
- Sub-division ....Angiosperms
- Class ....Dicotyledons
- Sub-class ....Gamopetalae
- Order ....Ebenales
- Family ....Sapotaceae
- Genre ....*Argania*
- Espèce ....*Argania spinosa* (L.) Skeels

CHAPTER 2: VALORIZATION IN COSMETICS AND PHARMACEUTICALS

1. Argan Tree

General Characteristics of the Argan Tree

The argan tree constitutes a remarkable floristic and botanical entity within the Moroccan flora. It is a spiny arboreal species of considerable stature, typically attaining heights of 8 to 10 meters. The crown is broad, spreading, dense, and characteristically rounded. The trunk is short, gnarled, and twisted, often consisting of multiple intertwined stems.

Argan woodlands are generally open and sparsely vegetated. The trees are deliberately spaced apart to allow for intercropping during the rainy season.

CHAPTER 2: VALORIZATION IN COSMETICS AND PHARMACEUTICALS

1. Argan Tree

- **Wood**

The wood of the argan tree is characterized by a dark color and fissures at the base of the trunk. It is hard, dense, heavy, and highly resistant, making it an excellent source of charcoal.

- **Roots**

The roots penetrate deeply into the soil, allowing access to water from deep layers. This enables the tree to adapt to arid and semi-arid climates.

- **Branches**

Branches are highly spiny, which explains the species name “*spinosa*”. The spines, which provide protection, correspond to modified secondary branches.

❑ Leaves

Leaves are small, nearly persistent, leathery, and dark green on the lower surface. They are arranged alternately, often grouped in clusters, and are lanceolate or spatulate in shape.

❑ Flowers

Flowers are hermaphroditic, yellow-green or sometimes white, and grouped in small axillary clusters.

❑ Fruit

The fruit is a sessile berry composed of a fleshy pericarp (pulp) surrounding one or more kernels forming a nut. The pulp represents 55–75% of the fresh weight. It is green to light yellow and turns dark brown upon drying.

CHAPTER 2: VALORIZATION IN COSMETICS AND PHARMACEUTICALS
1. Argan Tree

Ecological Requirements

❑ Climate

The argan tree is a thermophilic and xerophilic species adapted to arid to semi-arid warm and temperate climates. Optimal rainfall is about 500 mm/year; however, 120 mm/year may be sufficient in some regions. The tree is sensitive to prolonged frost and does not tolerate sustained temperatures around 0°C, although it can withstand short periods of negative temperatures. Conversely, it tolerates high temperatures remarkably well, reaching up to 50°C in regions such as Taroudant..

❑ Soil

The argan tree has no strict requirements regarding the physico-chemical nature of the soil. It can grow on various soil types, including saline soils. However, it does not thrive on mobile sandy soils.

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1. Argan Tree

Importance of the Argan Tree

The argan tree is both a forest and fruit tree with multiple uses and is of major importance in the regions where it grows. It serves as:

- A **forest** tree, providing fuelwood and construction wood
- A **forage** tree, with leaves and fruits contributing significantly to animal feed
- A **fruit** tree, producing seeds and pulp

Thus, it plays important economic, social, and environmental roles.

Socio-economic Importance

Despite harsh environmental conditions, the argan tree provides numerous products and services:

- Wood production: 400,000 m^3/year
- Pastoral production: 500 forage units/ha/year
- Oil production: 3,500–4,000 tons/year
- Shell production: 78,000 tons/year

Socio-economic Importance (continued)

Considering the economic value of these products and the current extent of argan woodlands, the total production of these forests may be estimated at approximately 2.8 billion Moroccan dirhams.

The argan forest supports approximately two million rural inhabitants and helps limit rural exodus.

It generates:

- 800,000 workdays/year in forestry
- More than 2 million workdays/year in oil extraction (mainly by women)

CHAPTER 2: VALORIZATION IN COSMETICS AND PHARMACEUTICALS
1. Argan Tree

Socio-economic Importance (continued)

❑ **Wood production**

The argan tree yields a hard, heavy, and highly resistant wood, characterized by high density and excellent combustibility. It is extensively used as fuelwood, particularly for charcoal production, owing to its slow-burning properties. Its use in fine woodworking remains limited due to its hardness; however, it is widely employed as construction timber in rural housing, as well as in the manufacture of traditional agricultural implements and various household items.

❑ **Pastoral production**

Argan tree foliage constitutes a form of “aerial pasture” for camels and goats. The fruit pulp also serves as a valuable feed resource for livestock. Moreover, the press cake resulting from oil extraction is utilized in animal feeding as an energy-rich supplement, particularly for the fattening of cattle.

CHAPTER 2: VALORIZATION IN COSMETICS AND PHARMACEUTICALS
1. Argan Tree

Socio-economic Importance (continued)

❑ **Oil production**

The oil extracted from the kernel of the argan fruit is not only edible and organoleptically appreciated, but also exhibits highly valuable nutritional properties. It is composed of approximately 80% unsaturated fatty acids, including a significant proportion of linoleic acid. These dietary qualities make argan oil a highly sought-after product, often marketed at a price significantly higher than that of olive oil, notably due to its limited availability and the labor-intensive processes involved in its production.

In traditional pharmacopoeia, argan oil is recognized for its antioxidant properties. Its consumption has been associated with the stimulation of enzymatic activities involved in detoxification processes and cellular antioxidant defense. Furthermore, it is widely used for its beneficial effects on skin health, particularly in preventing cutaneous dryness, delaying physiological aging, and the management of certain dermatological conditions, such as juvenile acne and varicella.

Environmental significance

The argan tree plays a crucial role in environmental protection. Argan woodlands constitute an effective barrier against desert encroachment and are often regarded, particularly in the southernmost regions, as a “green belt” mitigating the processes of desertification.

One of its primary ecological functions is the protection of soils through the shade provided by its dense canopy, especially in sub-desert environments where drought and solar desiccation represent major constraints to vegetation. In mountainous areas, argan stands, through the combined effect of trees, understory vegetation, and continuous plant cover, limit surface runoff and soil erosion, while promoting the infiltration of rainwater and the recharge of groundwater reserves.

Furthermore, numerous living organisms, including fauna, flora, and microflora, are closely associated with the presence of the argan ecosystem. The disappearance of the argan tree would inevitably lead to the loss of multiple species, thereby contributing to a significant decline in regional biodiversity.

CHAPTER 2: VALORIZATION IN COSMETICS AND PHARMACEUTICALS

1. Argan Tree

Argan Oil Extraction

Before initiating oil extraction, both the fruit and the kernel undergo a series of processing steps, including: drying, depulping, crushing, roasting, and grinding. Once these steps are completed, oil extraction is carried out using two methods: traditional or mechanical.

❑ Traditional Extraction

The harvesting of argan fruits is exclusively carried out by Berber women and follows an artisanal process comprising five stages:

Depulping : There are two methods for depulping: (i) It may be performed manually by women, who remove the fruit pulp using two stones; the separation of pulp and nut occurs during this operation. (ii) Alternatively, goats may contribute to depulping by consuming the fruit and subsequently rejecting the nut.

Crushing (or Decortication): This operation is carried out using the same stones as for depulping. One stone serves as a support, while the other functions as a hammer applied along a cleavage plane. The nut is cracked by applying strong pressure. Sorting is performed at the end of the process. This is the most **labor-intensive stage**.

Roasting of Kernels: Roasting is performed in earthen containers over a low wood fire. The kernels are continuously stirred to prevent carbonization and to maintain a brown coloration. This operation aims to: (i) evaporate water, (ii) destroy saponins and other non-lipid substances, (iii) release oil previously emulsified within the cellular juice, (iv) dry the kernels and impart a characteristic nutty flavor

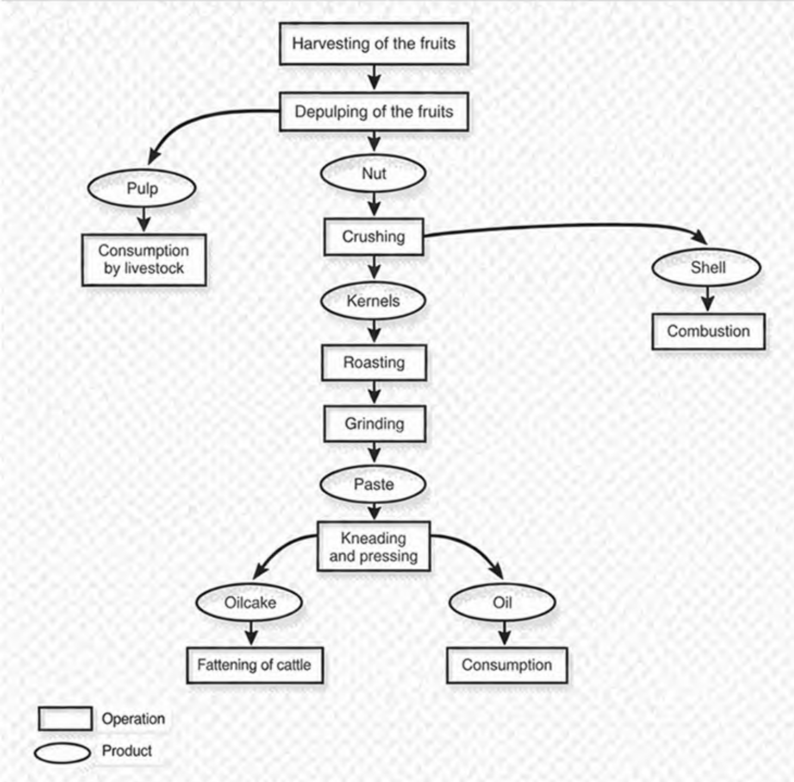
CHAPTER 2: VALORIZATION IN COSMETICS AND PHARMACEUTICALS

1. Argan Tree

Grinding of Kernels: Grinding is carried out using a carved stone mill, producing a brown-colored paste. This paste is collected in a container for the subsequent malaxation step.

Malaxation and Pressing: The resulting paste is manually malaxed in a basin. Small quantities of water are added until a smooth paste is obtained. The paste is then vigorously kneaded until oil begins to appear. Manual pressing yields oil, which is collected and stored, often in recycled containers.

Traditional process of argan oil production



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1. Argan Tree

Characteristics of Traditional Extraction

The oil obtained is left to settle until it becomes clear. It has a brownish color and a characteristic nutty taste. The extraction residue (oil cake) is dark in color, bitter in taste, and still contains a significant proportion of oil (approximately 10%). It is widely used as animal feed, particularly for cattle.

This method is slow because pproximately 8 to 10 hours of work are required to produce one liter of oil. The yield rarely exceeds 30%The oil has limited shelf life due to the addition of water during malaxation. Traditionally, salt is added to improve preservation, and oil is produced progressively as needed.

Recognizing the limitations of this artisanal process, its labor intensity and low efficiency, producers have long sought improvements, particularly in the pressing stage, through mechanization..

❑ Mechanical Extraction

Argan oil can also be extracted using mechanical presses, which eliminates the need for water during malaxation. This method significantly improves oil yield by recovering the approximately 10% of oil remaining in the oil cake during traditional extraction.

The process involves:

- Depulping using a mechanical depulper, which separates pulp from the nut
- Sorting of nuts and pulp
- Crushing, which remains the most demanding stage when performed manually; however, semi-automatic crushers can be used to facilitate the process, save time, and increase productivity
- Roasting using gas-powered roasters
- Oil extraction using mechanical presses

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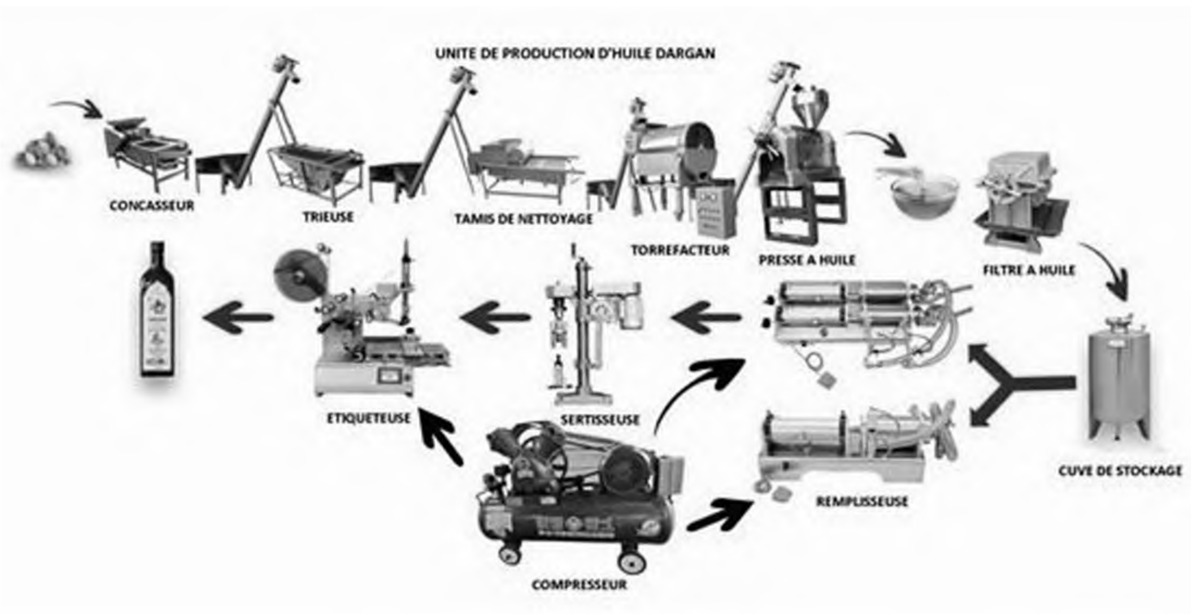
1. Argan Tree



Uses of Argan Oil

Argan oil possesses numerous valuable properties, making it suitable for multiple applications, particularly in food, cosmetics, and medicine.

❑ Food Use

Edible argan oil is produced from roasted kernels. This preparation step gives the oil a flavor reminiscent of sesame and roasted hazelnut. It is highly appreciated in culinary practices due to its ability to enhance the flavor of dishes. It can be:

- Consumed raw as a staple food
- Used as a cooking oil
- Incorporated as a key ingredient in traditional preparations such as "***Amlou***".

CHAPTER 2: VALORIZATION IN COSMETICS AND PHARMACEUTICALS
1. Argan Tree

❑ Cosmetic Use

Argan oil intended for cosmetic applications is produced from unroasted kernels. Its cosmetic activity is mainly attributed to its high content of unsaturated fatty acids and antioxidant compounds.

Regular application of cosmetic-grade argan oil is recommended for:

- Treating skin cracks and dryness
- Managing dehydrated skin
- Treating acne

In the long term, it helps reduce the rate of wrinkle formation. It is also recommended for treating superficial burns and relieving rheumatic pain when used in massage on joints. When applied to hair, argan oil restores shine and luster.

CHAPTER 2: VALORIZATION IN COSMETICS AND PHARMACEUTICALS

1. Argan Tree

CHAPTER 2: VALORIZATION IN COSMETICS AND PHARMACEUTICALS

1. Argan Tree

❑ Medicinal Use

Argan oil possesses natural properties that may contribute to the prevention and treatment of various diseases.

Prevention of Cardiovascular Diseases

From a structural perspective, argan oil is rich in oleic and linoleic acids, as well as vitamin E. This composition distinguishes it from commonly consumed edible oils and confers beneficial effects against cardiovascular diseases.

Prevention of Cancer Proliferation

Argan oil is rich in bioactive compounds, including unsaturated fatty acids, tocopherols, polyphenols, sterols, and carotenoids. These components provide significant biological potential by influencing several mechanisms involved in carcinogenesis.

Influence on the Immune System

The potential immunomodulatory effect of argan oil is based on the synergistic action of its bioactive components. These compounds act through cellular protection, regulation of inflammatory processes, and as a support of natural immune defense mechanisms.

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CHAPTER 2: VALORIZATION IN COSMETICS AND PHARMACEUTICALS

2. Prickly Pear (Barbary Fig)

Prof. Yahia RHARRABTI
Academic year: 2025-2026

General overview

The prickly pear cactus (*Opuntia ficus-indica*) is a plant species belonging to the family Cactaceae, order Caryophyllales. Most species in this family are succulent plants, namely xerophytic species capable of storing water reserves within their tissues to withstand prolonged drought periods.

Opuntia ficus-indica is native to Mexico. It was introduced into Spain by the conquistadors and later, during the 16th century, spread to North and South Africa and throughout the Mediterranean Basin, where it became naturalized to the extent of becoming a characteristic element of the landscape. Its dissemination resulted both from human activity, through the transport of cladodes as an anti-scurvy food source, and from birds, which contributed to seed dispersal after consuming the fruits.

Situation in Morocco

At present, this species is cultivated in numerous countries, notably Mexico, Algeria, Morocco, Tunisia, United States, Chile, South Africa, Greece, Israel, Turkey, Italy, and Portugal. In many of these countries, it is commonly referred to as prickly pear/Barbarian fig or the Indian fig (k'rmous el hindia) in arabic.

In Morocco, prickly pear plantations occur along coastal regions extending from Sidi Ifni to Tangier, as well as in several inland areas. Over the past two decades, cultivated area has expanded considerably due to increasing drought conditions, rising from 50,000 ha in 1998 to more than 120,000 ha currently. The Guelmim-Oued Noun region ranks first, accounting for approximately 50% of the national area, followed by Marrakesh-Safi (Haouz and Kelaa Sraghna), representing nearly 30%.

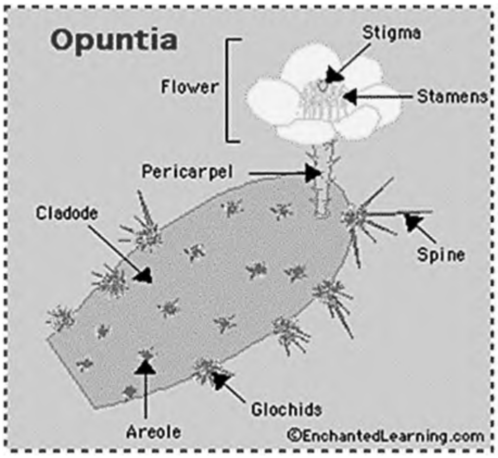
Biology of the Barbary fig

This species is a tree-like plant that may reach 3 to 5 meters in height. Its structural organization into cladodes, commonly called pads, is highly distinctive. Cladodes are flattened modified stems measuring 30–40 cm in length, 15–25 cm in width, and 1.5–3 cm in thickness, characterized by a strong capacity for water storage. Connected together, they progressively form branches.

The basal cladodes become lignified and, after approximately four years of growth, form a true trunk. These cladodes perform the photosynthetic function normally associated with leaves and are covered by a waxy cuticle (cutin), which limits transpiration and provides protection against predators.

Biology of the Barbary fig (continued)

Leaves are conical and only a few millimeters long. They appear on young cladodes and are ephemeral. At the base of the leaves are areoles (approximately 150 per cladode), which are modified axillary buds characteristic of Cactaceae family.



True spines are whitish, sclerenchymatous, firmly attached, and 1–2 cm long. Spineless varieties also exist.

Glochids are fine brownish spines only a few millimeters long. They detach easily but possess minute hook-like scales, allowing firm penetration into the skin and making removal difficult. They remain present even in spineless varieties.

CHAPTER 2 : VALORIZATION IN COSMETICS AND PHARMACEUTICALS
2. Barbary Fig

Varieties of Barbary fig in Morocco

In Morocco, Opuntia exhibits significant genetic diversity, and several species and cultivars have been identified. Some species are spiny, with variable spine coloration, whereas others are spineless.

The cultivar ‘Dellahia’, naturalized in northern regions, particularly around Al Hoceima, possesses strong yellow spines.

In the Tiznit region, three cultivars are distinguished:

- Achfri: late flowering, long spines, approximately three spines per areole, tree height around 1.2 m
- Moussa: spineless, late maturity
- Aissa: spineless, early maturity.

Ecological Requirements

❑ **Temperature** : Barbary fig is widely distributed in arid and semi-arid climates. Its geographical expansion is mainly limited by low winter temperatures. The tolerance threshold is approximately 10°C. In Morocco, optimal plantations occur in coastal regions where annual mean temperature reaches 26°C and winter minima do not fall below 9°C. Maximum temperatures average around 40°C.

❑ **Water** : This species is highly drought tolerant and is commonly found in areas receiving less than 200 mm of annual rainfall.

❑ **Soil** : Preferred soils are light sandy-loamy soils with moderately acidic pH (5.1–6.7), generally poor in organic matter (0.1–1.8%).

CHAPTER 2 : VALORIZATION IN COSMETICS AND PHARMACEUTICALS
2. Barbary Fig

Food Uses and Valorization

❑ **Fruit Production**:

The economic importance of this crop primarily lies in its fruits, whose nutritional value is comparable to juicy fruits such as pears, apples, apricots, and oranges. They are considered a good source of vitamin C and provide substantial energy value. Sugar content in most varieties ranges from 12% to 17%.

In Morocco, Barbary fig fruits are mainly consumed fresh and marketed in production areas and nearby urban centers; to a lesser extent, they are also consumed dried, particularly in southern regions.

Food Uses and Valorization

- **<u>Fodder production</u>**:

Fodder production for livestock represents the second most important economic use of Barbary fig worldwide and also in Morocco. Cactus pads are highly appreciated by livestock because they are rich in water, fiber, proteins, and mineral elements. Their consumption contributes to improving milk flavor and butter coloration.

Before being supplied to animals, the pads are dehydrated for several days in order to prevent diarrhea caused by excessive water intake. Pads from spiny species may also be briefly exposed to fire to eliminate spines before feeding.

CHAPTER 2 : VALORIZATION IN COSMETICS AND PHARMACEUTICALS
2. Barbary Fig

Food Uses and Valorization

- **<u>Vegetable Production</u>**:

Spineless cactus cultivars are used for the production of young cladodes consumed as vegetables. These young pads are known as Nopals or Nopalitos, especially in Mexico and southern United States, where a large Mexican population resides.They are prepared in various forms, including salads, cooked dishes with meat and eggs, and savory pies.

The nutritional value of nopals is comparable to leafy vegetables such as lettuce and spinach. They are considered an important source of vitamins and minerals, particularly calcium and iron.

This horticultural use has not yet been fully developed in Morocco.

Food Uses and Valorization

❑ **<u>Agro-Food Products</u>**:

Young cladodes may be valorized through preservation as small pieces in canned products. Modern processing industries for canned Nopalitos exist in Mexico and the United States.

In Morocco, non-governmental organizations are currently conducting trials on young cladode preservation.

Cactus fruits can also be processed into jam and juice. Similar experimental initiatives for jam production are currently underway in Morocco.

CHAPTER 2 : VALORIZATION IN COSMETICS AND PHARMACEUTICALS

2. Barbary Fig

Food Uses and Valorization

❑ **<u>Cosmetic and Pharmaceutical Products</u>**:

Beyond their use in animal and human nutrition, cladode mucilage is used in the manufacture of shampoos, hair conditioners, dermal creams, and moisturizing lotions.

It has also long been used by rural women in Morocco as a natural hair softener.

This mucilage additionally contributes to lowering blood cholesterol levels.

Food Uses and Valorization

❑ **Cosmetic and Pharmaceutical Products (continued)**:

- Dried cladode powder (nopal powder) contributes to blood glucose and cholesterol regulation.
- It also exhibits slimming and anti-hyperglycemic effects.
- Tea prepared from Opuntia flowers is traditionally used in Italy (especially Sicily) as a remedy for kidney disorders.
- Capsules made from dried flowers are used as diuretic regulators and in managing prostate dysfunction.
- Decoctions of dried flowers are used in Moroccan traditional medicine to relieve gastrointestinal pain, burns, and sunburn.
- Fruit juice, rich in flavonoids and vitamin C, has demonstrated hepatoprotective activity.
- A betacyanin pigment isolated from the fruit has shown antiproliferative activity on human cells.

CHAPTER 2 : VALORIZATION IN COSMETICS AND PHARMACEUTICALS
2. Barbary Fig

Food Uses and Valorization

❑ **Cosmetic and Pharmaceutical Products (continued)**:

Barbary fig seed oil is exceptionally rich in vitamin E, sterols, and omega-6 fatty acids. These compounds confer remarkable antioxidant, anti-aging, healing, and moisturizing properties.

It is currently considered one of the most potent plant oils in the cosmetic sector.

In Morocco, this oil is extracted and marketed by NGOs and small private enterprises, mainly for export.

Its commercial price ranges from 800 to 1000 euros per liter due to very low extraction yields: approximately one tonne of fruits is required to obtain 30 kg of seeds and produce one liter of oil.

Food Uses and Valorization

- **<u>Carmine Production</u>**:

Carmine is a natural red pigment highly sought after by food and cosmetic industries because of its biochemical properties.

It is produced through the cultivation of cochineal insects, particularly *Dactylopius coccus* and *Dactylopius opuntiae*, both hosted by Barbary fig.

The insects are collected from the plant and air-dried to obtain a crude product called grana, from which 10–26% carmine can be extracted.

CHAPTER 2 : VALORIZATION IN COSMETICS AND PHARMACEUTICALS
2. Barbary Fig

Food Uses and Valorization

- **<u>Use in Apiculture</u>**:

Barbary fig is characterized by abundant flowering, with a flowering cycle extending from 3 to 6 months depending on region and cultivar.

Its large yellow flowers, abundant pollen, and nectar strongly attract bees.

Ecosystems rich in melliferous species such as prickly pear provide favorable conditions for apiculture, enabling production of high-quality natural honey with high commercial value.

This contributes to improving farmers' income and enhancing local economic profitability.

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CHAPTER 2: VALORIZATION IN COSMETICS AND PHARMACEUTICALS

3. Aromatic and Medicinal Plants

Prof. Yahia RHARRABTI
Academic year: 2025-2026

CHAPTER 2 : VALORIZATION IN COSMETICS AND PHARMACEUTICALS

3. Aromatic and Medicinal Plants

General overview

Morocco is a major producer of aromatic and medicinal plants (AMPs). It ranks 12th worldwide in exports, generating nearly 25 million USD for cultivated plants and 37 million USD for spontaneous wild species. Morocco still has strong expansion potential within a global market estimated at 15 billion USD, while the broader market reaches 64 billion USD.

More than 35,000 plant species are used worldwide in pharmaceutical, phytotherapeutic, herbal, and hygiene industries.

Because of its geographical diversity, Morocco offers varied Mediterranean bioclimates supporting rich flora of more than 4,200 species, with highly marked endemism. Among these, 500 to 600 species have aromatic and/or medicinal interest.

General overview

Morocco possesses ancestral know-how preserved over centuries in medicinal plant use and aromatic compound extraction for both household and commercial perfumery.

It is a traditional supplier of aromatic and medicinal plants to the international market. This activity involves both spontaneous wild species and dried cultivated plants intended for herbal medicine and food flavoring.

More than twenty species are exploited for essential oil production and aromatic extracts destined mainly for perfume, cosmetics, hygiene products, and flavor industries.

CHAPTER 2 : VALORIZATION IN COSMETICS AND PHARMACEUTICALS
3. Aromatic and Medicinal Plants

Production

The exploitation and cultivation of AMPs have gained considerable importance over the last two decades in both developed and developing countries.

In some countries such as Morocco, production is largely export-oriented, whereas in China, India, and Indonesia, a substantial share is marketed domestically.

Besides spontaneous forest and rangeland species (rosemary, wormwood, thyme, lavender), several cultivated species are grown in different Moroccan regions, including condiments and spices such as vervain, saffron, sage, mint, caraway, coriander, cumin, fenugreek, fennel, and anise.

- **Spontaneous Wild Species**:

Important species include thyme, rosemary, carob, oregano, bay leaves, cedar, wormwood, myrtle, and pennyroyal mint.

- **Cultivated Species**:

Three groups are distinguished:

Plants cultivated for seeds: coriander, cumin, fennel, anise

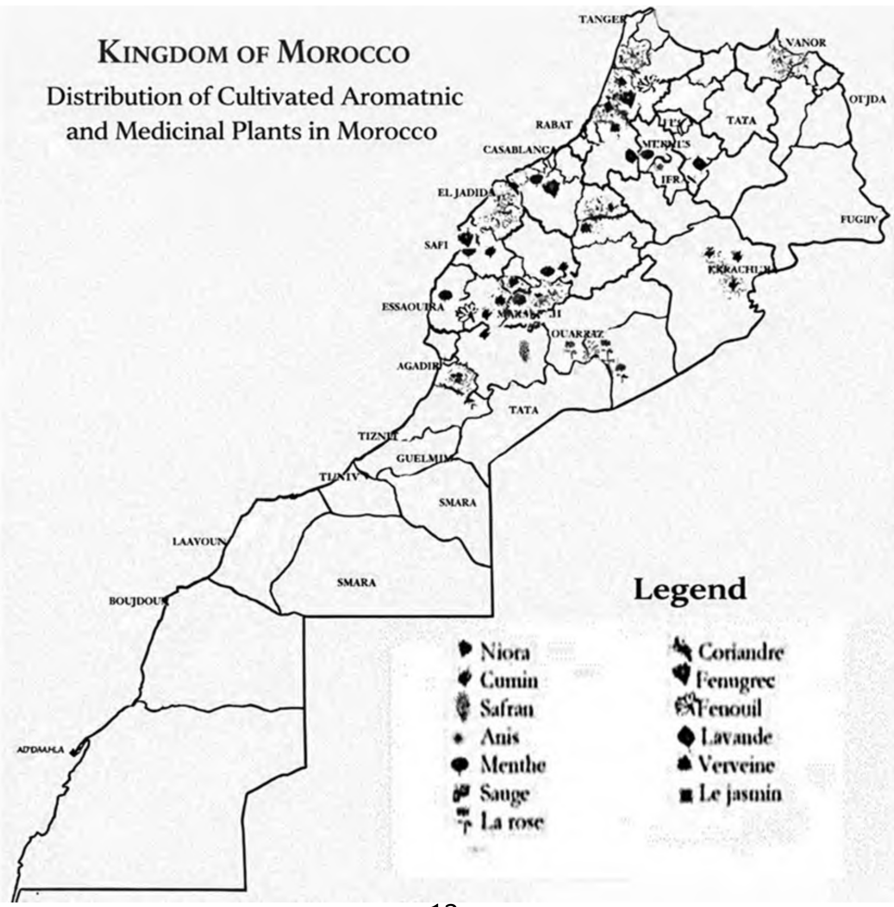
Plants cultivated for leaves: vervain, mint, parsley.

Plants cultivated for other plant parts: saffron, rose, jasmine, paprika (niora).

French → English	Moroccan Dialect
Absinthe → Wormwood	Chiba
Ammi → Bishop's weed	Bechnikha
Aneth → Dill	Chabt
Anis vert → Green anise	Habbet hlawa
Armoise → Wormwood	Chih
Basilic → Basil	Lahbaq
Bigaradier → Bitter orange	Laranj
Camomille bleue → Blue chamomille	Chajrat Mariem
Camomille sauvage → Wild chamomille	Babounj
Cannelle → Cinnamon	Korfa
Câpre → Caper	Kobbar
Cardamome → Cardamom	Kaâkola
Caroubier → Carob tree	Kharroub
Carvi → Caraway	Al karwia
Céleri → Celery	Krafass
Chicorée → Chicory	Hendaba
Clou de girofle → Clove	koranfal
Coriandre → Coriander	Al qazbor
Cresson → Watercress	Hab er'chad
Cumin → Cumin	Al kamoune
Curcuma → Turmeric	Kharkoum
Eau de fleur d'oranger → Orange blossom water	Ma Zhar
Estragon → Tarragon	Tarkhoum
Fenouil → Fennel	Ennafaâ
Fenugrec → Fenugreek	Halba
Jasmine → Jasmine	Yasmine

French → English	Moroccan Dialect
Géranium → Geranium	Lâatarcha
Gingembre → Ginger	Skinjbir
Laurier noble → Bay laurel	Wraq sidna moussa
Lavande → Lavender	Khzama
Marjolaine → Marjoram	Mardadouch
Marrube blanc → White horehound	Marriwa
Mauve → Mallow	Khobbeyza
Mélisse → Lemon balm	Naânaâ sufi
Menthe pouliot → Pennyroyal mint	Fliyou
Menthe verte → Spearmint	Naânaâ
Muscade → Nutmeg	Gouza
Myrte → Myrtle	Rihane
Nigelle → Nigella	Sanouj
Origan → Oregano	Zaatar
Ortie blanche → White nettle	Harrigua
Oseille → Sorrel	Humeyda
Persil → Parsley	Maadnous
Paprika → Paprika	Tahmrira
Réglisse → Licorice	Ark souss
Romarin → Rosemary	Yazir
Rose pale → Damask rose	Al ward al beldi
Safran → Saffron	Zaâfrane
Sauge → Sage	Salmia
Sésame → Sesame	Janjlane
Thym → Thyme	Azziitra
Verveine → Vervain	Al louiza


KINGDOM OF MOROCCO
DISTRIBUTION OF WILD MAPs IN MOROCCO
NADOR
OUJDA
TAZA
RABAT
CASABLANCA
SAFI
AGADIR
TATA
GUELMIM
ASSA
SMARA
LEGEND
Ammi visnaga
camomille bleu
Le myrte
Laurier noble
Le romarin
Le Thym
L'armoise blanche


KINGDOM OF MOROCCO
Distribution of Cultivated Aromatnic and Medicinal Plants in Morocco
OUJDA
TATA
RABAT
CASABLANCA
SAFI
ESSAOUIRA
AGADIR
TATA
GUELMIM
SMARA
SMARA
LAAYOUN
Legend
Niora
Cumin
Safran
Anis
Menthe
Sauge
La rose
Coriandre
Fenugrec
Fenouil
Lavande
Verveine
Le jasmin

Harvesting

Raw material harvesting is generally performed by local populations because of their knowledge of collection sites.

For cultivated AMPs, farmers produce seeds, which are purchased by collectors who also act as intermediaries. These collectors harvest and sell the products to processors/exporters. The latter ensure cleaning and packaging before export, either directly or through export agents.

Drying remains largely traditional, with products spread on the ground in open air.

On the local market, dried AMPs products increasingly face competition from imported products that are more expensive but better presented and packaged, thus offering stronger quality assurance..

CHAPTER 2 : VALORIZATION IN COSMETICS AND PHARMACEUTICALS
3. Aromatic and Medicinal Plants

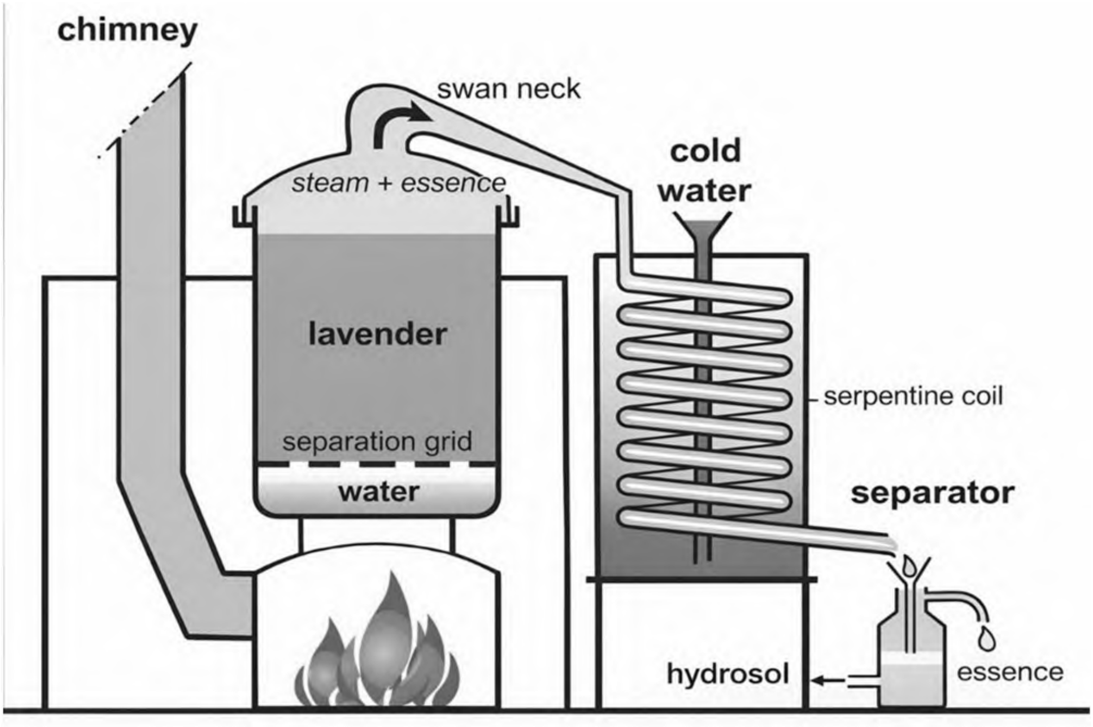
Processing

The majority of AMPs in Morocco, including wormwood and rosemary, are exported either as dried plants or essential oils.

For dried plants, processing remains mostly traditional, involving sun or shade drying and packaging in polypropylene bags of 30–50 kg. Some modern units employ more advanced cleaning lines including pre-cleaners, multi-sieve selectors, and graders.

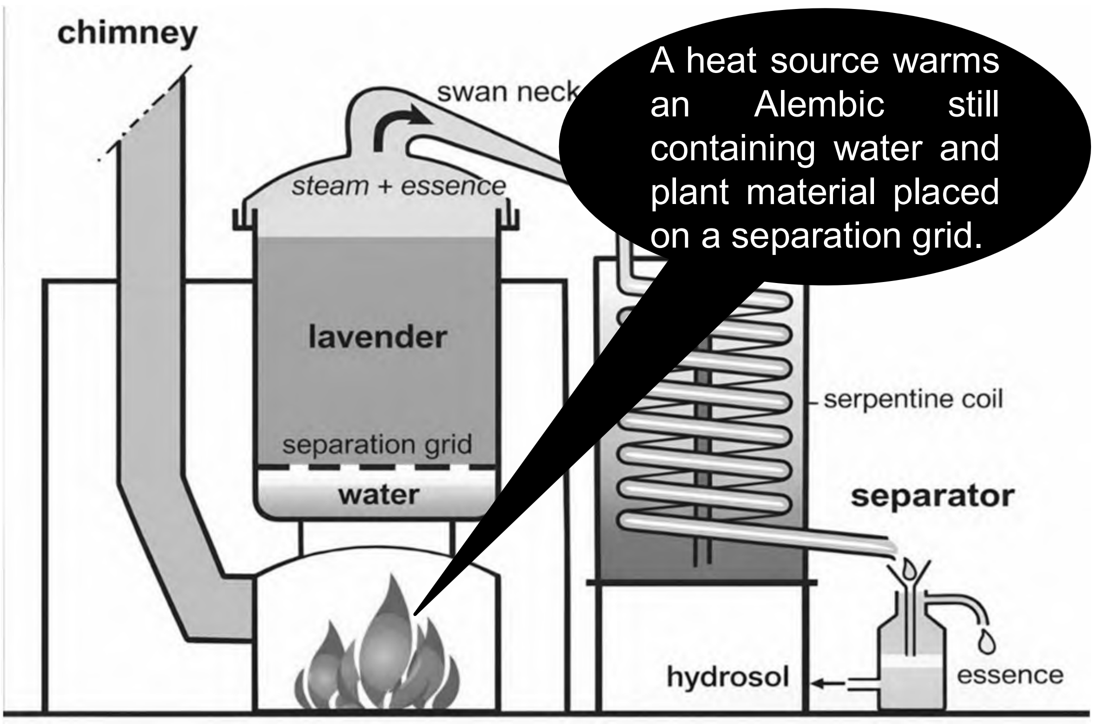
For essential oils, nearly all Moroccan distillers rely on steam-hydrodistillation using mobile alembic stills heated over direct fire. These technologies remain artisanal and distillation management efficiency remains limited.

Distillation Process (Alembic Still Operation)

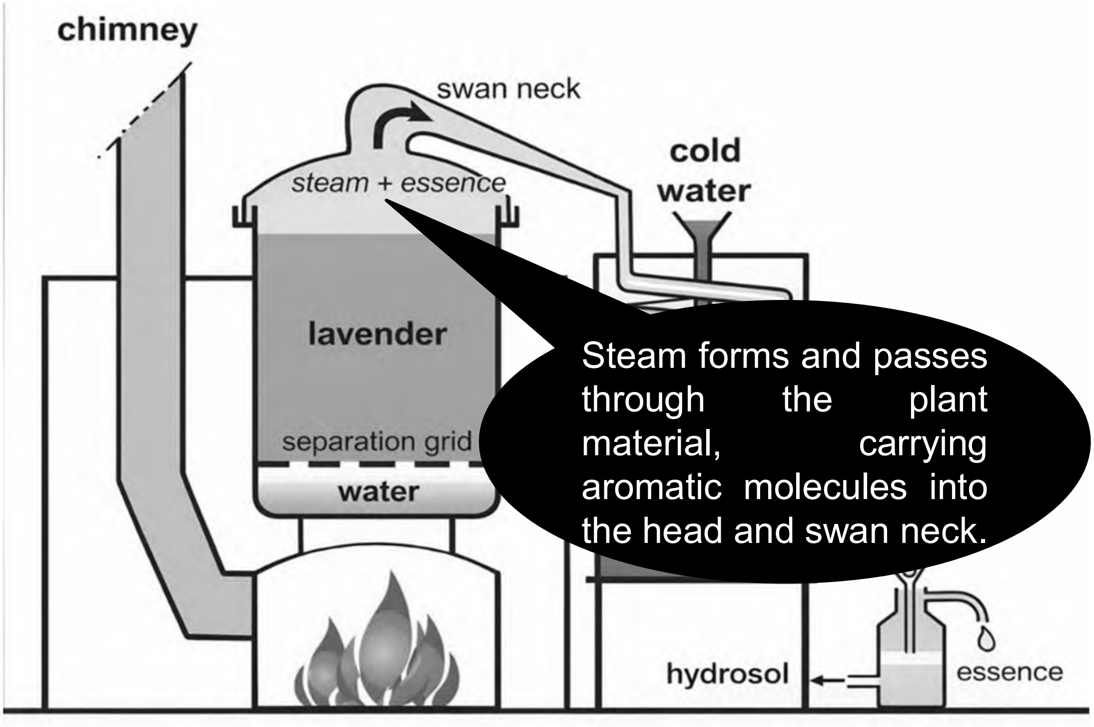


CHAPTER 2 : VALORIZATION IN COSMETICS AND PHARMACEUTICALS
3. Aromatic and Medicinal Plants

Distillation Process (Alembic Still Operation)



Distillation Process (Alembic Still Operation)



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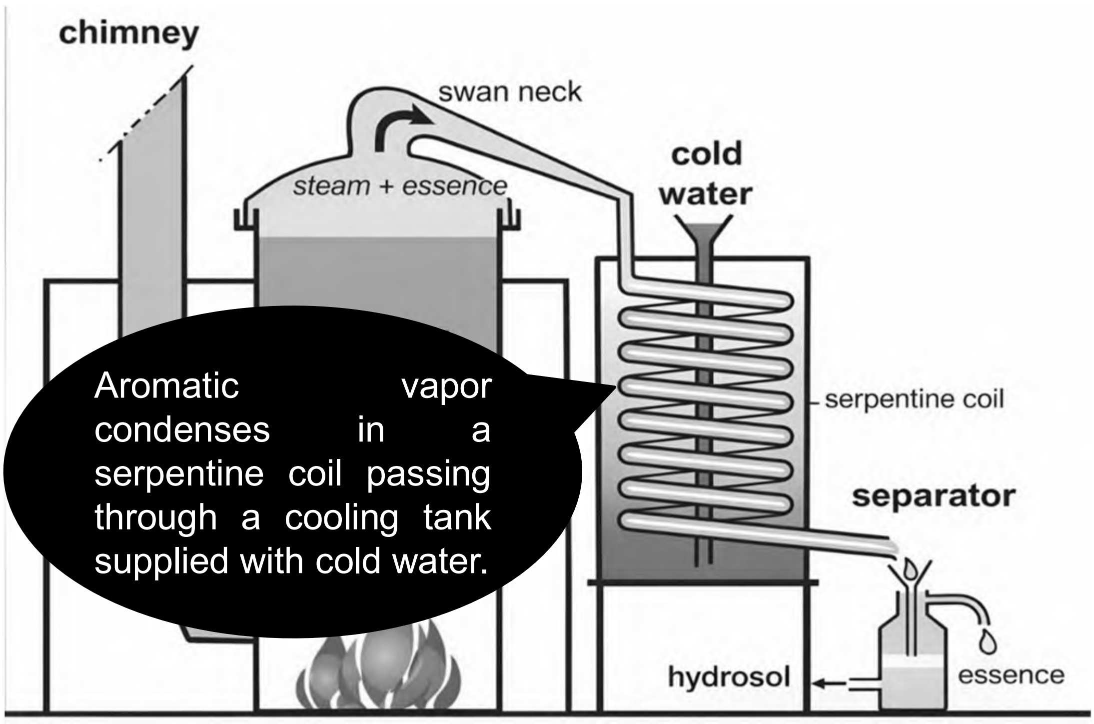
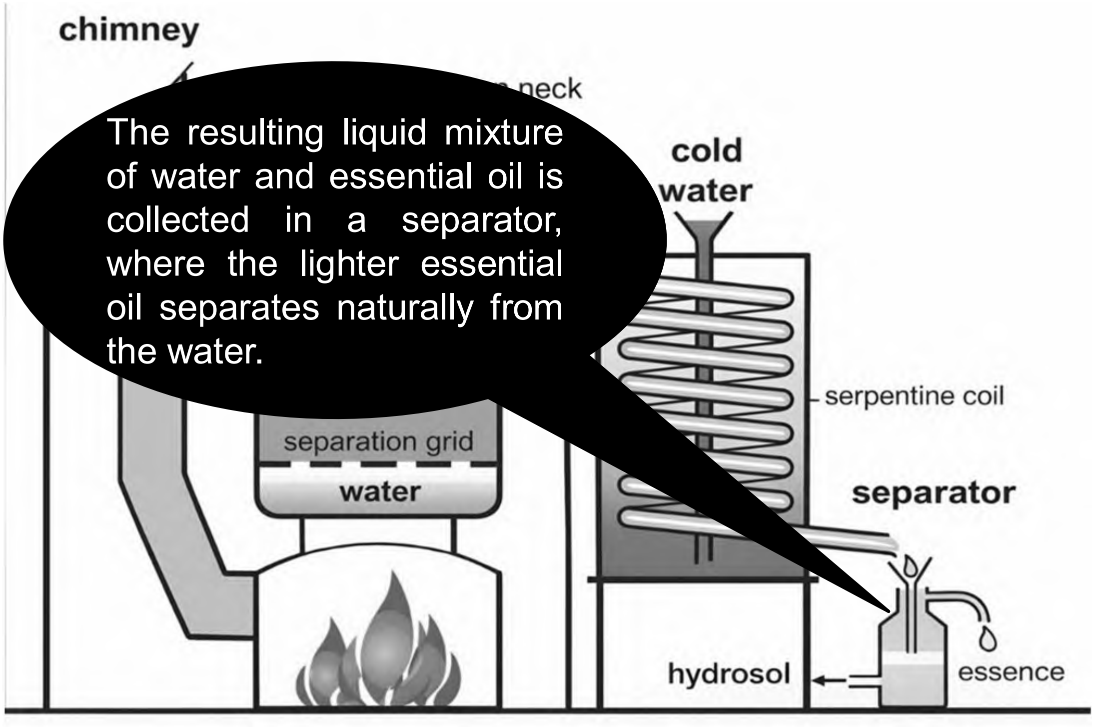
3. Aromatic and Medicinal Plants

Distillation Process (Alembic Still Operation)



Distillation Process (Alembic Still Operation)



CHAPTER 2 : VALORIZATION IN COSMETICS AND PHARMACEUTICALS
3. Aromatic and Medicinal Plants

Value Chain Actors

Economic actors, from upstream to downstream, include:

1) **<u>Collectors</u>**: men and women from harvesting regions.
2) **<u>Intermediaries</u>**: financially capable individuals with strong knowledge of collection zones, often working for industrial units.
3) **<u>AMP Cooperatives</u>**: recently established organizations supported by forest authorities, carrying out primary transformation according to available means.
4) **<u>Herbalists</u>**: generally small enterprises or individual operators engaged in herbal medicine, fine spices, and essential oils. They obtain their supplies either through intermediaries or directly from the market, and subsequently commercialize their products within the local market.

Value Chain Actors (continued)

5) **Industrial operators**: private enterprises owned either by Moroccan investors or by subsidiaries of foreign companies specialized in AMPs. These operators obtain their raw materials either through intermediaries, directly from cooperatives in the case of wild-collected AMPs, or from producers of cultivated aromatic and medicinal plants..
6) **Laboratories**: specialized in the formulation and processing of products supplied by industrial operators in order to manufacture finished products intended for consumers, including cosmetics, pharmaceuticals, perfumery products, and food products. These laboratories are mainly located in developed countries, particularly the United States and Europe.