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Ministry of Higher Education and Scientific Research
Abderrahmane Mira University of Bejaia
Faculty of Natural and Life Sciences
Department of Food Sciences

Course handout

SOURCE AND TYPOLOGY OF FATS

Speciality :

M1 SCG

Presented by:

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Course Description Sheet

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Purview : Natural and Life Sciences

Sector : Food Sciences

Target audience: M1 Science of fats

Semester: 1

Title of Teaching Unit: Biosynthesis and source of fats

Course title: Source and typology of fats (half-yearly hourly volume: 22h30; course: 1h30)

Credits: 2

Coefficient: 1

Teaching objectives

- To understand the characteristics and applications of plant-based fats, including fluid vegetable oils and solid vegetable fats.
- To analyze the different types of animal fats, including oils and fats from marine and terrestrial sources.
- To compare the composition and nutritional properties of various plant and animal fats.
- To classify the fatty substances based on their origin, texture, and functionality in food and industrial applications.

- To evaluate the health implications of consuming different types of fats from both plant and animal sources.
- To explore the role of fats in culinary practices, food preservation, and their contributions to flavor and texture.

Recommended prior knowledge

Students must have knowledge in particular of biochemistry and physical chemistry of fatty substances

Assessment method: Course exam control: 100%

Foreword

Fats play a fundamental role in our diet and health, representing an essential source of energy and nutrients. This course on the sources and types of fats aims to explore the diversity of these substances, whether of plant or animal origin (marine or terrestrial). By understanding the different categories of fats, we can better appreciate their impact on our nutrition and their use in various fields, such as the food industry, cosmetics, and pharmacology.

From fluid vegetable oils to animal fats, each type of fat has unique characteristics that influence not only their behavior in formulations but also their effects on human health. This course will highlight the different types of fats, their composition, and the physicochemical properties of these fats, as well as their practical applications, allowing students to develop a thorough and critical understanding of this subject.

This document is designed to provide students with a solid foundation regarding fats. By prioritizing clear explanations and concrete examples, it aims to make the concepts accessible and relevant for all academic levels.

Objective of this document:

The main objective of this document is to provide students with the knowledge and skills necessary to understand the different sources and types of fats. It aims to:

• Present the fundamental principles of fats of plant and animal origin (marine and terrestrial) in an accessible and engaging manner for students;

• Highlight the specific characteristics of oils and fats, illustrating each type with concrete and relevant examples;

• Provide practical information on the applications of fats in various fields, such as food, cosmetics, and pharmacology, while explaining their role in nutrition and health;

• Compare and contrast the differentsources of fats, highlighting their advantages, disadvantages, and ideal applications in various contexts.

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I. Generalities

Plant-based fats refer to lipids of vegetal origin, extracted from a wide range of plant sources such as seeds, nuts, fruits, and vegetables. In contrast to animal-derived fats, which are typically rich in saturated fatty acids, plant-based fats are often abundant in unsaturated fatty acids—particularly monounsaturated and polyunsaturated types. This compositional difference confers them notable health benefits, especially in promoting cardiovascular health and overall metabolic well-being.

These fats are extracted from various plant sources, including:

- **Seeds** (such as flaxseeds, chia seeds and sunflower seeds), which are high in essential fatty acids;
- **Nuts** (such as almonds, walnuts and cashews), which provide healthy fats, protein, and fiber;
- **Fruits** (such as avocados and olives), which are unique for their high fat content, primarily in the form of healthy monounsaturated fats;
- **Vegetables** , often derived from seeds (such as canola and soybean), which are widely used in cooking and food preparation.

These dietary lipids exist in several forms, each characterized by specific nutritional properties and functional applications. They are broadly categorized into monounsaturated, polyunsaturated, and saturated fatty acids. Monounsaturated fats, abundant in oils such as olive and avocado, are well-documented for their capacity to reduce low-density lipoprotein (LDL) cholesterol and promote cardiovascular health. Polyunsaturated fats, which encompass essential fatty acids like omega-3 and omega-6, are found in significant amounts in flaxseeds, walnuts, and chia seeds. These compounds contribute to cognitive function, support cell membrane integrity, and exhibit anti-inflammatory effects.

In contrast, saturated fats, though often subject to dietary caution, are present in specific plant oils such as coconut and palm oil. When consumed in moderation, they can be part of a balanced diet without adverse health outcomes.

Collectively, these lipid classes not only offer physiological benefits but also contribute to the organoleptic qualities of food—enhancing flavor, texture, and overall culinary appeal. A nuanced understanding of their roles enables informed dietary choices that align with both health promotion and gastronomic enjoyment.

Beyond their nutritional composition, fats of plant origin contribute meaningfully to both physiological processes and culinary innovation. Their role extends beyond cardiovascular protection, as they also facilitate the absorption and transport of fat-soluble vitamins, playing a crucial part in maintaining systemic homeostasis. From a gastronomic perspective, these lipids offer a broad palette of textures, aromas, and functional properties, allowing for diversified and health-conscious culinary formulations.

Importantly, the incorporation of plant-based fats in place of animal-derived fats not only enhances dietary quality but also resonates with ecological sustainability goals. Given their generally lower carbon footprint and reduced resource demands, they represent a strategic choice in the context of sustainable food systems. Thus, integrating these fats into daily consumption patterns supports a holistic approach to health, encompassing nutritional adequacy, environmental stewardship, and sensory satisfaction.

II. Fluid Vegetable Oils

Fluid vegetable oils represent a diverse and essential group of lipid-based substances extracted from various plant sources, including seeds, nuts, and fruits. Distinguished by their liquid state at room temperature, these oils are characterized by a high proportion of unsaturated fatty acids, which confer both nutritional and functional advantages. In the context of human health, fluid vegetable oils—such as olive, sunflower, canola, and soybean oils—have been widely recognized for their cardioprotective effects, due in large part to their content of monounsaturated and polyunsaturated fats, including omega-3 and omega-6 fatty acids.

Beyond their physiological relevance, these oils play a critical role in food formulation, acting as carriers of flavor, contributors to texture and mouthfeel, and agents in heat transfer during cooking. Moreover, their physicochemical properties—such as oxidative stability, smoke point, and fatty acid composition—make them central to both domestic culinary practices and industrial food processing. With growing interest in plant-based diets and sustainable food systems, fluid vegetable oils are increasingly valued not only for their health benefits but also for their lower environmental footprint compared to animal-derived fats.

This chapter explores the origins, composition, functional properties, and health implications of fluid vegetable oils, highlighting their significance in both nutritional science and food technology.

II.1. Oil seeds

II.1. 1. Sunflower

1.1.1.Botanical description

The sunflower(*Helianthus annuus L*), is an annual herbaceous plant with an erect, coarse, and usually unbranched stem that can reach 1 to 3 meters in height (See Figure.1). It develops a strong taproot with a fibrous root system. The leaves are rough, ovate to heart-shaped, and arranged alternately along the stem after the first pair. The plant produces a large, solitary flower head (capitulum), composed of bright yellow sterile ray florets surrounding a central disk of fertile florets. The fruit is an achene, commonly known as a sunflower seed. Young plants exhibit heliotropism, turning their heads to follow the sun, but mature flower heads typically face east. Sunflower thrives in well-drained, fertile soils and full sunlight.

Figure 1: Sunflower (*Helianthus annuus L.*) plant

1.1.2. Oil Composition

Sunflower oil is a non-volatile oil extracted from the seeds of *Helianthus annuus*. It is widely used in cooking, food processing, and cosmetics due to its light flavor, high smoke point, and nutritional profile. The oil's composition can vary depending on the sunflower variety and breeding, but it is generally characterized by a high content of unsaturated fatty acids and vitamin E.

Sunflower oil consists predominantly of triglycerides, which account for about 98% to 99% of its total composition. These triglycerides are primarily made up of fatty acids such as linoleic acid, oleic acid, palmitic acid, and stearic acid.

Tables I and II present the composition of sunflower oil, with Table I detailing its triglyceride profile analyzed by HPLC and Table II showing its fatty acid composition analysed by CPG.

Table I: Composition of sunflower oil triglycerides analysed by HPLC

Type of TG	Content of Total TG (%)
LLL	36.3
OLL	29.1
PLL	11.3
OOL	6.5
SLL	7.5
POL	4.0
PPL	0.5
OOO	0.6
SOL	2.1
POO	0.4
PPO	0.7

Table II: Composition of Sunflower Oil Fatty Acids (by CPG)

Type of fatty acid	Pourcentage of Total Fatty Acids (%)
C16:0	5-7
C16:1	≤0.4
C17:0	≤0.1
C18:0	4-6
C18:1	15-25
C18:2	62-70
C18:3	≤0.2
C20:0	<1
C20:1	<0.5
C22:0	<1

Sunflower oil is valued not only for its high triglyceride content but also for its minor, unsaponifiable components. These constituents, though present in small amounts, contribute significantly to the oil's nutritional and functional properties.

Unsaponifiable Matter:

The remaining 1% to 2% of sunflower oil is composed of unsaponifiable matter. This fraction includes biologically active compounds that do not form soap during saponification. Includes compounds that do not form soap during saponification, such as sterols, hydrocarbons, tocopherols, and aliphatic alcohols.

Sterol Content

- Total sterols: 325 to 515 mg per 100g of fat
- Sterol profile:
    - Cholesterol: <0.4%
    - Campesterol: 8–11%
    - Stigmasterol: 7–10%
    - β-sitosterol: 58–64%
    - Δ-5 Stigmasterol: 2–7%
    - Δ-7 Stigmasterol: 9–14%
    - Δ-7 Avenasterol: 4–6%
    - Isofucosterol: 0.4–1%
    - Fucosterol: 2–3%

Hydrocarbons

- Squalene: 15–20 mg per 100g of fat (Acts as an antioxidant and is a valuable minor component).

Tocopherol (Vitamin E) Content

- Total tocopherols: 44–120 mg per 100g of fat
- Distribution:
    - α-tocopherols: 91–97%
    - β-tocopherols: 3–6%
    - γ-tocopherols: ≤2%

1.1.3.Oleic Sunflower

The discovery of sunflower mutants rich in oleic acid (a monounsaturated fatty acid) was first reported in the USSR during the 1970s. Subsequent breeding programs led to the development of sunflower hybrids—now known as high-oleic or "oleisol" types—whose seeds contain over 50% oleic acid. These oils are richer in vitamin E and offer a more balanced profile of polyunsaturated fatty acids compared to standard sunflower oil, which is naturally high in linoleic acid (a polyunsaturated fatty acid).

The main differences between the two types of sunflower are shown in the table below:

Table III: Fatty acid composition of the two types of sunflower oil (by CPG)

Type of fatty acid	Standard Sunflower (%)	Oleic Sunflower (%)
C16:0	7	3
C18:0	4	5
C18:2	70	9
C18:1	16	83
C18:3	Traces	Traces

Table III: Comparative Table: Standard vs. Oleic Sunflower Oil

Characteristic	Standard Sunflower Oil (Linoleic-rich)	Oleic Sunflower Oil (Oleisol)
Fatty Acid Profile	High in linoleic acid (polyunsaturated)	High in oleic acid (monounsaturated)
Oleic Acid Content	~16–30%	75–91%
Linoleic Acid Content	~60–74%	5–15%
Vitamin E Content	Moderate	Higher, especially α-tocopherol
Oxidative Stability	Lower	Higher, ideal for frying
Health Benefits	Good source of omega-6	Heart-healthy, improves cholesterol
Typical Uses	Cooking, salads, food processing	Frying, industrial, health foods
Breeding Origin	Traditional varieties	Developed from USSR mutants (1970s)
Availability	Widely available	Increasing global availability

The most striking feature is the reversal in linoleic and oleic acid content between the two types of sunflower.

Dry conditions and high temperatures lead to a decrease in overall oil content. Likewise, the fatty acid composition is subject to variation. In oleic sunflower, the main causes of these fluctuations are:

- **Genetic factors**: Any contamination of an oleic sunflower field by pollen from conventional (standard) sunflower varieties results in a reduction of oleic acid content in the harvested seeds.
- **Environmental factors**: Low temperatures during the seed maturation phase reduce the oleic acid content in favor of linoleic acid. Therefore, oleic sunflower should preferably be cultivated in regions with warm autumns.

II.1. 2.Soybeans

1.2.1. Botanical description

Soybean (Glycine max) is an erect, bushy, annual legume in the family Fabaceae, typically growing between 0.3 and 2 meters tall, depending on the variety. The plant is usually much-branched and covered with fine hairs. Leaves are compound and trifoliate (each leaf is made up of three leaflets), (Figure2), arranged alternately along the stem. The leaflets are oval to lance-shaped, with entire margins (no teeth or lobes), and the surface is often hairy (Fegure.2). Flowers are small, white to purple-pink, and borne in clusters (racemes) in the leaf axils. Each flower is bilaterally symmetrical, about 0.5–1 cm long, and has five petals and ten stamens (nine fused, one free). Flowering generally occurs from mid to late summer.

The fruit is a hairy pod, 3–7 cm long, usually containing 2 to 4 seeds (soybeans). Pods are clustered in groups of 3–5, and split open when ripe to release the seeds. Seeds vary in color—yellow, green, brown, black, or bicolored—depending on the cultivar.

Root system is well-developed and taprooted, often with nodules housing nitrogen-fixing bacteria, which enrich the soil.

Figure 2: Soybean (Glycine max)

1.2.2. Soybean composition

The soybean seed contains about 40% high-quality plant protein, providing all essential amino acids in substantial amounts and with a digestibility close to that of animal proteins. In terms of fat content, soybeans contain approximately 20% lipids, mainly polyunsaturated fatty acids (about 63%), including both omega-6 and omega-3, with a low proportion of saturated fats (around 15%) and no cholesterol. Soybeans are also rich in dietary fiber (13 g per 100 g), complex carbohydrates, and important micronutrients such as iron, zinc, calcium, magnesium, potassium, and folic acid. Additionally, soybeans contain isoflavones—antioxidant compounds that have been studied for their potential benefits on cardiovascular and hormonal health. Thanks to this balanced composition, soybeans are considered a functional food, especially valuable for those seeking to diversify their protein sources or reduce their intake of animal-based products.

The seed also contains non-structural carbohydrates (see Table IV), which make up about 10% of its weight, consisting mainly of soluble sugars and a small amount of starch.

Table IV: Composition of Whole Soybean Seeds and Soybean Embryo

Component	Whole Seeds (% or mg/100g)	Embryo (% or mg/100g)
Protein (%)	40	45
Lipids/Oil (%)	18	5
Carbohydrates (%)	30	10
Fiber (%)	5	–
Ash (%)	5	–
Nitrogen (%)	6.6	7.5
Phosphorus (mg/100g)	700	500
Potassium (mg/100g)	1800	1500
Calcium (mg/100g)	300	200
Magnesium (mg/100g)	250	220

The triglyceride and fatty acid composition of soybean oil is summarized in the table V.

Table V: Soybean Oil Composition in Triglycerides

Triglyceride Type	Pourcentage of Total TGs (%)	PourcentageTriglyceride Type (%)	Pourcentage of Total TGs (%)
LLnLn	0.8	OOL	7.6
LLLn	7.5	SLL	4.2
OLnLn	0.3	POL	7.8
LLL	19.3	PPL	1.5
OLLn	5.0	OOO	1.9
PLLn	2.8	SOL	3.0
OLL	20.4	PDO	1.3
OOLn	0.8	PPO	1.0
PLL	13.1	PSO	0.7
POLn	0.7		

The distribution of fatty acids across the three positions (sn-1, sn-2, and sn-3) of the triglyceride molecules in soybean oil is characterized by a distinct pattern. Polyunsaturated fatty acids, particularly linoleic acid (C18:2), are predominantly located at the sn-2 position, enhancing the nutritional value of the oil. In contrast, saturated fatty acids such as palmitic acid (C16:0) and stearic acid (C18:0) are more commonly found at the sn-1 and sn-3 positions. Oleic acid (C18:1), a monounsaturated fatty acid, tends to be more evenly distributed among all three positions. This specific arrangement influences both the metabolic fate and the functional properties of soybean oil, as fatty acids at the sn-2 position are absorbed differently and may have greater nutritional significance.

The following table presents the distribution of the main fatty acids at the sn-1, sn-2, and sn-3 positions of triglycerides in soybean oil, highlighting the specific localization of each fatty acid within the triglyceride structure.

Table VI: Distribution of Fatty Acids on Positions 1, 2, and 3 of the Triglycerides in Soybean Oil

Fatty Acid	Pourcentage of Total FA in Position 2 (%)	Pourcentage of Total FA in Position 1 (%)
C16:0	1	14
C18:0	<1	6
C18:1	21	23
C18:2	70	48
C18:3	7	8

The composition of soybean oil varies depending on the variety and growing conditions. However, it typically contains a mixture of saturated and unsaturated fatty acids, with a predominance of polyunsaturated fatty acids. The table below presents the average fatty acid composition of soybean oil, highlighting the main components that determine its nutritional and functional properties.

Table VII: Soybean Oil Fatty Acid Composition

Fatty Acid	Pourcentage of Total Fatty Acids (%)	Fatty Acid	Pourcentage of Total Fatty Acids (%)
C14:0	<0.2	C20:0	<1.2
C16:0	8-13	C20:1	<0.4
C16:1	<0.2	C22:0	<0.5
C18:0	2-5		
C18:1	17-26		
C18:2	50-62		
C18:3	4-10		

II.1. 3. Canola

1.3.1. Botanical description

Canola is an oilseed plant belonging to the botanical genus Brassica of the crucifer family (*Brassica napus*), widely cultivated in Europe, Canada, China, and India.
After fertilization, the plant forms siliques (fruits) made of two separated carpels. The siliques typically contain between 10 and 30 seeds, depending on the species, varieties, and the position of the siliques on the plant. The physiological maturity of the seed occurs when it has around 35% moisture content. At this stage, it has accumulated all its fats; the final phase of its formation is simple drying.

Canola is a plant resulting from a cross between cabbage and rapeseed. The origin of this hybrid is not yet clear; the cross may have occurred in the wild around the Mediterranean basin in gardens where cabbages for human consumption and rapeseed for oil production were cultivated side by side.

1.3.2 Oil composition

Canola oil (also known as rapeseed oil in Europe) is a vegetable oil extracted from the seeds of the canola plant. Its fatty acid composition is especially valued for nutritional balance and health benefits. The oil is primarily composed of:

- **Monounsaturated fatty acids**: About 60–63%, mainly oleic acid (omega-9), which supports cardiovascular health.
- **Polyunsaturated fatty acids**: Around 28–32%, including linoleic acid (omega-6) at 19–23% and alpha-linolenic acid (omega-3) at 8–11%. This provides a favorable omega-6/omega-3 ratio, typically between 1.9 and 2.1, which is considered beneficial for a balanced diet.
- **Saturated fatty acids**: Low levels, about 6–8%, mainly palmitic and stearic acids.

Canola oil also contains small amounts of other fatty acids such as palmitoleic, arachidic, and behenic acids, as well as vitamins E and K, phytosterols, and other bioactive compounds. Modern canola varieties are bred to have very low levels of erucic acid (less than 5%), making the oil safe and suitable for human consumption. This composition makes canola oil one of the healthiest edible oils, with a low saturated fat content and a high proportion of essential fatty acids, supporting both heart health and general nutrition

1.3.3. Genetic Improvements

The goal was to eliminate erucic acid (C22:1) (E.A.), considered undesirable following experiments on rats and pigs due to pathological effects on cardiac muscle. Varieties producing oil with virtually no erucic acid were first obtained in Canada (CANBRA variety) and then in Europe. In France, the PRIMOR and JET NEUF varieties were developed (without E.A.).

Canola meal is characterized by the presence of sulfur-containing compounds, glucosinolates, which have undesirable physiological effects, especially in monogastric animals like pigs and poultry. These effects are particularly evident on the thyroid, which hypertrophies and whose hormonal function is altered.

The double qualitative improvement of oil and meal resulted in the adoption of standards characterizing the new varietal types. Canadians defined a standard called "Canola" for the seed (the oil and the canola meal): a maximum of 2% erucic acid and a maximum of 3 micromoles/g of glucosinolates in the de-oiled meal. The EEC has set for the so-called "double zero" canola varieties: a maximum of 2% E.A. and 35 micromoles/g of glucosinolates (in France, 10 to 18 micromoles/g).

The oil content of canola seeds (expressed as % dry matter) varies as follows:

- Winter canola (*Brassica napus*): 42–50%
- Spring canola (*Brassica napus*): 35–45%

The fat, protein, and cellulose composition of both winter and spring canola seeds is presented in table VIII.

Table VIII: Composition of both winter and spring canola seeds

Components	Spring Canola	Winter Canola
Oil (% DM)		
Whole Seed	41.5	45.7
Hull	16.0	12.0
Embryo	47.1	55.3
Protein (% DM, de-oiled)		
Whole Seed	44.7	40
Hull	18.7	18.1
Embryo	53.6	49.4
Cellulose (% DM, de-oiled)		
Whole Seed	11.8	11.5
Hull	34.3	20.5
Embryo	3.0	4.9

The table below presents the fatty acid composition of canola oil, detailing the proportions of each major fatty acid present in this oil and highlighting its unique nutritional profile.

Table IX: Fatty Acid Composition of Canola Oil

Fatty Acids	Pourcentage of total Fatty Acids (%)
C16:0	3-4
C16:1	-
C18:0	1-2
C18:1	9-16
C18:2	11-16
C18:3	7-12
C20:0	-
C20:1	7-13
C22:1	41-52

Erucic acid (C22:1) and eicosenoic acid (C20:1) have been eliminated from canola oil by geneticists, favoring oleic acid.

Table X: Fatty Acid Composition of major, stellar, westar, and primor Varieties:

Fatty Acids	MAJOR (% FA)	STELLAR (% FA)	WESTAR (% FA)	PRIMOR (% FA)
C16:0	3.5	4.2	3.9	4.5
C16:1	0.4	0.2	0.2	0.6
C18:0	1.2	2.1	1.6	1.5
C18:1	14.2	59.1	59.1	60.5
C18:2	13.8	26.3	18.8	21.5
C18:3	9.1	2.4	8.8	10.3
C20:1	10.9	1.3	1.4	0.9
C22:1	46.9	0.4	0.5	0.2

II.2. Germ seed

II.2.1.Wheat Germ

2.1.1 Botanical Description of Wheat Germ

Botanically known as *Triticum aestivum* L., (Figure.3), is the embryo of the wheat kernel and represents approximately 2–3% of the grain's total weight. It is the reproductive part of the seed, responsible for giving rise to a new plant during germination. The wheat kernel, or caryopsis, is composed of three main parts: the bran (outer protective layers), the endosperm (a starch-rich tissue that provides energy during germination), and the germ (the embryo), which is situated at the base of the grain beneath the scutellum. Wheat germ is particularly rich in nutrients, including proteins, lipids—especially unsaturated fatty acids—vitamins (notably vitamin E), minerals, and various bioactive compounds such as phytosterols and polyphenols. Due to its relatively high lipid content (about 10%), wheat germ is also considered a valuable raw material for vegetable oil extraction.

a) **b)**

Figure 3: a) Wheat germ; b) Wheat plant *(Triticum aestivum L)*

2.1.2 Oil composition

Wheat germ oil is notable for its high content of unsaturated fatty acids, making up over 80% of its total fatty acids. The dominant fatty acid is linoleic acid (omega-6), which typically ranges from 42% to 59% of the oil. Other major components include palmitic acid (about 16–19%), oleic acid (omega-9) (13–24%), and alpha-linolenic acid (omega-3) (around 4–8%). Stearic acid is present in much smaller amounts, usually less than 2%. In addition to its fatty acid profile, wheat germ oil is exceptionally rich in vitamin E (tocopherols), with levels often exceeding 100 mg per 100 g, and also contains phytosterols, policosanols, and other bioactive compounds that contribute to its antioxidant properties and health benefits. The oil is extracted from the germ of the wheat kernel, which comprises about 2–3% of the whole grain and yields 8–14% oil by weight.

Wheat germ oil's unique composition makes it highly valued for both nutritional and cosmetic applications, but it is also sensitive to oxidation and should be stored carefully to preserve its quality

The table below summarizes the typical fatty acid composition of wheat germ oil, highlighting the main fatty acids and their respective percentage ranges. This composition reflects the nutritional richness and health-promoting qualities of wheat germ oil.

Table XI: Fatty acid composition of Wheat Germ

Fatty Acid	Percentage Range (%)
Linoleic acid (C18:2)	42–59
Palmitic acid (C16:0)	16–19
Oleic acid (C18:1)	13–24
Alpha linolenic acid (C18 :3)	4–8
Stearic acid (C18:0)	<2

This profile shows that wheat germ oil is particularly rich in linoleic acid (an omega-6 fatty acid), with significant amounts of palmitic and oleic acids, and smaller quantities of alpha-linolenic (omega-3) and stearic acids.

II.2.2 Corn Germ

2.2.1 Botanical Description of Corn Germ

Corn germ, botanically referred to as *Zea mays* L., (Figure.4), is the embryo of the maize kernel and accounts for approximately 10–14% of the total kernel weight. It plays a vital role in plant reproduction, as it develops into a new plant upon germination. The botanical structure of the maize caryopsis includes three primary components: the pericarp (the outer protective covering), the endosperm (a starch-rich storage tissue), and the germ (the embryo), which is located at the lower end of the kernel and closely attached to the endosperm. Corn germ contains the majority of the oil present in the kernel, ranging from 30 to 40% of its dry weight, primarily composed of unsaturated fatty acids such as linoleic and oleic acids. In addition to lipids, corn germ is rich in enzymes, proteins, vitamins (notably vitamin E and B-complex), minerals, and phytosterols, making it a valuable ingredient in vegetable oil production and a source of nutritional compounds in food and feed applications.

a) **b)**

Figure 4: a) Corn germ; b) Corn plant (*Zea mays* L) plant

2.2.2 Oil composition

Corn germ oil is valued for its high content of unsaturated fatty acids and bioactive compounds, making it a popular choice for both nutritional and industrial uses. Key Features

- **High in Polyunsaturated Fatty Acids:** The dominant fatty acid is linoleic acid (omega-6), which constitutes the majority of the oil.
- **Rich in Monounsaturated Fatty Acids:** Oleic acid (omega-9) is present in significant amounts, contributing to heart health.
- **Contains Saturated Fatty Acids:** Palmitic and stearic acids are present in smaller quantities.
- **Bioactive Components:** Corn germ oil contains tocopherols (vitamin E), phytosterols, and other unsaponifiable matter, which provide antioxidant benefits.

The fatty acid composition of corn germ oil is predominantly made up of unsaturated fatty acids, which contribute to its nutritional and functional qualities. Linoleic acid (C18:2, omega-6) is the major component, typically representing 50–62% of the total fatty acids. It is followed by oleic acid (C18:1, omega-9), which accounts for approximately 25–30%**.** Saturated fatty acids are present in lower proportions, mainly palmitic acid (C16:0) at around 10–13%**,** and stearic acid (C18:0) at about 2–4% (Table XII). This composition makes corn germ oil highly suitable for both nutritional and industrial uses, particularly in the production of heart-healthy food products and cooking oils. The high content of polyunsaturated fatty acids, especially linoleic acid, enhances its value as a functional oil with potential health benefits.

Table XII: The fatty acid composition of corn germ oil

Fatty Acid	Percentage Range (%)
Linoleic acid (C18:2)	50–62
Oleic acid (C18:1)	25–30
Palmitic acid (C16:0)	10–13
Stearic acid (C18:0)	2–4
Minor fatty acids (others)	<2

This composition makes corn germ oil a healthy edible oil, widely used in cooking, food processing, and as a source of essential nutrients.

Oil is a by-product of the cereal industry. Corn oil is primarily used for frying and seasoning; it is also used in margarine production and is rich in linoleic acid, making it of interest in dietetics. The unsaponifiable components are used by the pharmaceutical and cosmetic industries. Corn germ meal is used in animal feed (dairy cows). Wheat germ oil is mainly used in dietetics and cosmetics.

II. 3. Oil fruits

II. 3. 1. Olive oil

3.1.1. Botanical description

Olive oil is extracted from the fruits of the olive tree (*Olea europaea*), a member of the *Oleaceae* family. This evergreen tree can grow up to 15 meters in height and is characterized by narrow, lanceolate, silver-green leaves. Its fruits are drupes, commonly referred to as olives, which are oval-shaped and range in color from green to black depending on their ripeness.

The oil is typically obtained by cold pressing the olives, a process that preserves natural aromas, flavors, and nutrients. Among the different quality grades, extra virgin olive oil stands out as the purest, with low acidity and a high content of antioxidants.

Rich in monounsaturated fatty acids, especially oleic acid, this oil also contains polyphenols, known for their antioxidant and health-promoting properties.

Valued not only for its culinary uses, it is also renowned for its health benefits, including cardiovascular protection and anti-inflammatory effects.

Figure 5: Olive fruits (*Olea europaea*)

2.1.2. Oil composition

Olive oil is a fascinating product, especially regarding its composition. About 70 to 80% of olive oil consists of fatty acids, the majority of which are monounsaturated fatty acids (55-83%), primarily oleic acid. These fatty acids are known for their beneficial effects on cardiovascular health, as they can help reduce bad cholesterol while increasing good cholesterol.

In addition to monounsaturated fatty acids, olive oil also contains polyunsaturated (3.5-21%) and saturated fatty acids (7.5-14%) but in much smaller amounts. This contributes to its balanced nutritional profile.

Another important aspect of olive oil is its richness in antioxidants. It is particularly high in vitamin E and polyphenols, which are natural compounds with anti-inflammatory and antioxidant properties. These antioxidants play a key role in protecting cells from damage caused by free radicals, which can help reduce the risk of chronic diseases.

Finally, olive oil is low in trans fats, making it a healthy choice for both cooking and seasoning. Beyond its pleasant flavor, it offers numerous health benefits thanks to its unique chemical composition. It is primarily composed of monounsaturated fatty acids, with oleic acid (C18:1) representing approximately 55 to 83% of the total fatty acid content. It also contains linoleic acid (C18:2) in amounts ranging from 3.5 to 21%, palmitic acid (C16:0) between 7.5 and 20%, and stearic acid (C18:0) from 0.5 to 5%. The presence of arachidonic acid (C20:4) is minimal, typically below 1%. These proportions can vary depending on the olive cultivar, the geographical origin, and the processing methods.

In addition to its lipid profile, olive oil contains a fraction of unsaponifiable compounds that contribute to its nutritional and functional value. Among these, phytosterols (such as β-sitosterol and campesterol) are present in concentrations of approximately 0.5 to 1.5%, while tocopherols (notably α-tocopherol and γ-tocopherol, forms of vitamin E) range from 0.5 to 1.0%. The oil also contains squalene, a natural antioxidant, in similar proportions (0.5 to 1.0%), and polyphenols such as hydroxytyrosol and oleuropein, typically found in amounts between 0.1 and 0.5%. These levels are influenced by the olive variety, the degree of fruit ripeness, environmental factors, and the extraction process used.

III. Fats in Solid Form

III.1. Copra

III. 1.1. Botanical description

Coconuts (*Cocos nucifera Linn.*) belonging to the family Arecaceae are cultivated mainly in the tropical areas of high humidity, regular rainfall, and sandy soil. Countries such as India, Sri Lanka, Indonesia, and Philippines have major share in the global production of coconuts. India is the largest producer of coconuts in the world (annual production of 16,943 million nuts in 2010-2011), and the West coast tall variety is one of the major varieties cultivated there. Copra is the dried coconut albumen with low moisture content (6–8%) and is used to obtain coconut oil by expellers and organic solvents. Coconut oil is rich in medium chain fatty acids and exhibits good digestibility.

In Indian traditional medicine, the coconut has been used as a medicinal plant for centuries.

The coconut palm, scientifically known as *Cocos nucifera* Linn., is a tall tropical palm belonging to the family Arecaceae. It is the only species in the genus Cocos and is easily recognized by its single, unbranched, grey-brown trunk, which is marked with ring-like scars left by fallen leaves. The trunk is typically straight or sometimes slightly curved, reaching heights of 20 to 30 meters and a diameter of 30 to 45 centimeters (Figure.6). At the top, the palm bears a dense crown of large, arching, pinnate leaves that are 4 to 7 meters long, each composed of numerous narrow, linear leaflets arranged on either side of the central rachis. The coconut palm is monoecious, meaning it produces both male and female flowers on the same plant. These flowers are grouped in large, branched inflorescences (spadices) that emerge from woody spathes among the leaves. The small, yellowish male flowers are found mostly at the upper part of the inflorescence, while the larger, globular female flowers are located at the base.

Figure 6: Coconut palm (*Cocos nucifera* L) plant

III.1.2 Oil composition

The oil composition of Coconut palm (*Cocos nucifera L.)* is characterized by a high content of saturated fatty acids, particularly medium-chain fatty acids, with the most abundant being lauric acid.

Coconut oil is characterized by a high content of saturated fatty acids, which make up over 80–90% of its total fatty acid composition (Table XII). Among these, lauric acid (C12:0) is the most abundant, accounting for 45–53% of the oil. Significant amounts of myristic acid (C14:0) are also present (15–19%), as well as palmitic acid (C16:0) (8–9%), caprylic acid (C8:0) (5–7%), capric acid (C10:0) (5–6%), stearic acid (C18:0) (2–3%), and caproic acid (C6:0) (~0.3–0.4%). Unsaturated fatty acids are found in smaller quantities, primarily as oleic acid (C18:1, monounsaturated) at 5–8% and linoleic acid (C18:2, polyunsaturated) at 1–2%. This unique composition gives coconut oil excellent oxidative stability and a long shelf life.

Table XIII: Summary Table of Typical Fatty Acid Composition (% by weight).

Fatty Acid	Percentage Range (%)
Lauric acid (C12:0)	45–53
Myristic acid (C14:0)	15–19
Palmitic acid (C16:0)	8–9
Caprylic acid (C8:0)	5–7
Capric acid (C10:0)	5–6
Stearic acid (C18:0)	2–3
Oleic acid (C18:1)	5–8
Linoleic acid (C18:2)	1–2
Caproic acid (C6:0)	~0.3–0.4
Myristic acid (C14:0)	15–19

Coconut oil generally contains a low content of unsaponifiable fraction, which represents about 0.5 to 1% of its total weight. However, here are general estimates of the concentrations of the main components of the unsaponifiable fraction:

- Sterols: Beta-Sitosterol: Approximately 0.1 to 0.5% of the oil. Other sterols may be present in smaller amounts.

- Tocopherols: Alpha-Tocopherol (Vitamin E): Approximately 0.1 to 0.5% of the oil.

Other forms of tocopherols (such as gamma-tocopherol) may also be present, but in lower quantities.

- Phytosterols: Phytosterols, in general, represent a small fraction of the unsaponifiable fraction, often less than 0.1% of the oil.

III. 1.3 Therapeutic interest

The coconut palm is renowned for its wide range of therapeutic and medicinal properties, with nearly every part of the plant—kernel, oil, water, roots, flowers, and husk—offering potential health benefits.

Coconut milk helps solve urinary problems, gallstones, and hematemesis. Coconut oil has been used as a burn wound remedy. Coconut oil or Copra oil is an edible oil extracted from the kernel of mature coconuts of the coconut palm.Coconut oil also appears to promote the immune system response. Feeding coconut oil completely abolishes the expected immune factor responses to endotoxin and diminishes the production of proinflammatory cytokines in vivo. Recently, the biological properties of virgin coconut oil (VCO) have been widely investigated. It has been found that lauric acid is an effective compound in VCO. Lauric acid is the precursor of monolaurin, which has been shown to modulate immune cell proliferation and possess antimicrobial activity. Inflammation involves many other processes of the immune system; for example, during both acute and chronic inflammatory response, the immunological component cells are activated in response to foreign organisms or antigenic substances. Recent studies point to the important role of inflammation in a wide variety of human diseases that are not primarily disorders of the immune system. These include cancer, atherosclerosis, ischemic heart disease, and some neurodegenerative diseases such as Alzheimer's disease . All parts of the coconut palm are useful, with significant economic value.

III.2. Palm and Palm Kernel

III. 2.1. Botanical description

The oil palm, scientifically known as *Elaeis guineensis*, is an emblematic plant of the Arecaceae family, native to West Africa. This palm can reach heights of up to 20 meters, with a straight, smooth trunk and a crown of pinnate leaves measuring between 4 and 6 meters long, displaying a glossy green color. The flowers, small and grouped in inflorescences, are cream-colored and appear on the same individual, making it a monoecious plant. The fruits, oval-shaped and measuring about 3 to 5 cm, have a reddish outer skin and contain a pulp rich in oil, which produces palm oil, as well as a hard kernel, the source of palm kernel oil. Cultivated in many tropical regions around the world, particularly in Southeast Asia and South America, the oil palm is of great economic importance, being widely used in the food, cosmetic, and even biodiesel industries. In addition to its economic role, it also contributes to the biodiversity of tropical ecosystems.

The oil palm is monoecious, producing both male and female inflorescences on the same plant, though they are borne separately. The inflorescences are axillary, dense, and enclosed in two large, fibrous bracts when in bud. Male flowers are small, numerous, and arranged in cylindrical spikes, while female flowers are larger, subglobose, and occur in clusters. Pollination is primarily cross-pollinated, often facilitated by insects such as weevils.

The fruit is an ovoid-oblong drupe, 2–5 cm long, tightly packed in large bunches that can contain 1,000 to 3,000 fruits. Each fruit has a thin exocarp (skin), a fleshy, oil-rich mesocarp, and a hard, lignified endocarp (shell) that encloses the kernel. The color of the fruit varies from yellow to orange or nearly black when ripe. The root system is adventitious, forming a dense mat in the upper layers of soil, with some roots penetrating deeper.
This species is native to West Africa but is now widely cultivated in tropical regions for its high-yielding oil-rich fruits

Figure 7: Palm *Elaeis guineensis* plant

III. 2.2. Composition

Palm oil PO is derived from the mesocarp of oil palm fruits, and has a balance unsaturated (mainly oleic) and saturated (mainly palmitic) fatty acids. PO is an economically important and versatile vegetable oil used as a raw material for both food and non-food products, and is the most widely used vegetable oil in the world. It has been used in a myriad of food applications and preparation for thousands of years. About 80% of palm oil products are used for edible application.

PO has an excellent oxidative stability as it is high in monounsaturated fatty acid (oleic acid) and vitamin E, and low in polyunsaturated fatty acid.This is particularly important to food industry following the requirement of trans fatty acids labelling by the United States Food and Drug Administration in 2003. There is an increasing concern on the presence of trans fatty acids in hydrogenated products, due to its bad adverse effect on cardiovascular health. Furthermore, palm oil is similar to animal fats such as tallow and lards in terms of physical properties palm oil and palm kernel oil have different physical and chemical properties depending on their intended applications.

The oil palm produces fruits from which palm oil is extracted from the pulp, while the palm kernel corresponds to the nut, from which palm kernel oil is extracted. Palm oil varies in color from light yellow-orange to dark orange-red, due to the presence of carotene in the unsaponifiable fraction. Palm kernel oil is pale yellow when liquid. When solidified, it appears as a fat that is nearly pure white or slightly yellow. It has a characteristic nutty flavor and aroma. Its properties are very similar to coconut oil. Fatty acid composition: While palm oil is characterized by a high content of palmitic acid, palm kernel oil, like coconut oil, is particularly rich in lauric acid C12:0, myristic acid C14:0, and oleic acid C18:1. The fatty acid content of palm oil and palm kernel are shown in the following table:

Table XIV: Fatty acid composition of palm oil and palm kernel oil.

Fatty Acids	Palm Oil (% of total FA)	Palm Kernel Oil (% of total FA)
C6:0	-	0.2
C8:0	-	3.3
C10:0	-	3.5
C12:0	0.2	47.8
C14:0	1.1	16.3
C16:0	44	8.5
C18:0	4.5	2.4
C18:1	39.2	15.4
C18:2	10.1	2.4
C18:3	0.4	-
C20:0	0.1	0.1
Total SFAs	49.9	82.1
Total MUFAs	39.2	15.4
Total PUFAs	10.5	2.4

Hence, palm oil and its fractions, which are free of trans fatty acids, represent the best alternative for replacing partially hydrogenated fats in food formulation and processing. Advances in fractionation technology have made it possible to produce a wide range of hard palm fractions (such as palm stearin and other hard palm oils) with iodine values (IV) as low as 10 or even less. These hard fats are particularly useful in margarine and shortening formulations, as they can serve as texturizing agents that completely replace trans fats. The fatty acid composition of palm oil and its liquid (olein) and solid (stearin) fractions is shown in the following table:

Table XV : The fatty acid content of palm oil and its liquid and solid fractions

Nature	Palm	Olein	Stearin
C16:0	43 - 46	39 – 41	46 - 69
C18:0	4 – 6	4 – 5	4 - 6
C18:1	37 - 41	43 – 44	20 - 38
C18:2	9 - 12	10 – 12	4 - 10

The unsaponifiable fractioncontent of palm oil and palm kernel are shown in the following table:

Table XVI: Unsaponifiable fraction composition of palm oil and palm kernel oil.

Compounds	Palm Oil (mg/kg)	Palm Kernel Oil (mg/kg)
Carotenoids	500 to 700	N/A
Tocopherols (Vitamin E)	1000 to 2000	500 to 1000
Tocotrienols	100 to 300	50 to 150
Phytosterols	1000 to 2000	1000 to 1500

III.3. Cocoa Beans

III.3.1. Botanical description

The cocoa bean is the seed of the cacao tree (Figure.8), *Theobroma cacao*, a small evergreen tree native to the tropical regions of Central and South America. The tree typically grows between 6 and 12 meters in height and features a single, slender trunk with a dense canopy of shiny, leathery, oblong leaves that can reach up to 30 cm in length. Young leaves are often reddish and droop to deter herbivores, turning green as they mature.

Theobroma cacao is cauliflorous, meaning its small, pale pink to yellowish-white flowers grow directly from the trunk and older branches in dense clusters. These flowers are pollinated primarily by tiny midges. After pollination, the tree produces large, ovoid pods—measuring 15 to 30 cm long and 8 to 10 cm wide—that ripen from green or deep purple to yellow or orange. Each pod has a thick, leathery rind and contains 20 to 60 seeds (cocoa beans) embedded in a sweet, mucilaginous white pulp.

The seeds themselves are oval, about 2.5 cm long, and are initially pale lavender to dark brownish-purple in color. After fermentation, they turn mostly brown and develop the characteristic flavors associated with chocolate. The seeds are rich in fat (cocoa butter) and the stimulant theobromine. The tree thrives in humid, tropical climates with consistent rainfall and well-drained, fertile soils, typically at low elevations.

In summary, the cocoa bean is the fermented and dried seed of the Theobroma cacao tree, which is distinguished by its cauliflorous flowering habit, large leathery leaves, and colorful, ridged pods containing the valuable seeds used to produce cocoa and chocolate

Figure 8: Cocoa bean *Theobroma cacao* plant

III.3.2 Cocoa beans composition

Cocoa beans are composed of several key components that contribute to their nutritional and functional properties. The primary constituents are lipids, which make up about 50-57% of the dry weight, with cocoa butter being the main lipid. This fat consists largely of triglycerides, particularly oleic, stearic, and palmitic acids.

Proteins account for approximately 10-15% of the dry weight, and they play a significant role in the flavor development during cocoa fermentation. Carbohydrates, including starch, soluble sugars, and fiber, make up around 20-30%. Of this, dietary fiber (both soluble and insoluble) is a major fraction.

Cocoa beans also contain polyphenols, particularly flavonoids like catechins, epicatechins, and procyanidins, which contribute to their antioxidant properties. The polyphenol content is around 6-8% of the dry weight, varying depending on the variety and processing.

Additionally, minor constituents include alkaloids such as theobromine and caffeine, which are responsible for the stimulant effects of cocoa, and minerals such as magnesium, calcium, and potassium, which are present in smaller quantities.

III.3.3Cocoa butter composition

Cocoa butter is composed primarily of fats, specifically triglycerides, which make up the majority of its composition. These fats consist of three main types of fatty acids: oleic acid, stearic acid, and palmitic acid.

1. Oleic acid is a monounsaturated fat and constitutes about 35-40% of the total fatty acid content in cocoa butter. It is known for being heart-healthy and is also found in olive oil.
2. Stearic acid is a saturated fat and accounts for approximately 30-37% of the total fat content. Despite being a saturated fat, stearic acid is unique in that it has a neutral effect on blood cholesterol levels, unlike other saturated fats.
3. Palmitic acid is another saturated fat, making up around 24-30% of the cocoa butter composition. Like other saturated fats, it can impact cholesterol levels, but it also contributes to the solid texture and stability of cocoa butter at room temperature.

Cocoa butter also contains trace amounts of other fatty acids such as linoleic acid, a polyunsaturated fat that plays a minor role in its composition, typically under 5%.
In addition to fatty acids, cocoa butter contains small amounts of unsaponifiable matter (around 0.5-1%). This includes bioactive compounds like tocopherols (vitamin E), which have antioxidant properties, and phytosterols, which can contribute to health benefits such as lowering cholesterol.

Cocoa butter is valued for its stable fat composition, giving it a smooth, creamy texture and making it a key ingredient in chocolate production. Its composition allows it to melt at body temperature, making it ideal for confectionery use.

III.4 Shea

III.4.1 Botanical description

The shea tree (*Vitellaria paradoxa*, formerly *Butyrospermum parkii*) (Figure 9) is a medium to large deciduous tree native to the dry savannah regions of sub-Saharan Africa.

Typically reaching heights of 7 to 15 meters, but occasionally growing up to 25 meters, the shea tree features a stout trunk that can reach up to 2 meters in diameter. Its bark is thick, cork-like, and provides protection against wildfires common in its native habitat.

The tree forms a broad, rounded crown with dense branching. The leaves are oblong, leathery, and have wavy edges, growing in clusters at the tips of branches. The shea tree produces clusters of small, creamy-white flowers, which bloom for one to two months and are followed by the development of fruits.

The fruit of the shea tree is a fleshy, plum-like berry, 4 to 8 centimeters long, with a thin, edible pulp surrounding a large, shiny brown seed known as the shea nut. Each fruit contains one seed, which is the source of shea butter. The tree begins to bear fruit at 10 to 15 years of age, reaching peak production around 20 to 30 years, and can continue to produce nuts for up to 200 years. The shea tree thrives in poor, well-drained soils and is highly adapted to the arid, savannah climate, where it grows wild and is rarely cultivated in plantations.

This species is ecologically and economically significant across its native range, providing food, cosmetic ingredients, and traditional medicines to local communities.

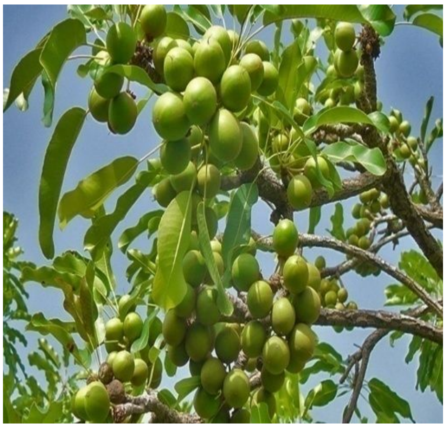

Figure 9: Shea tree (*Vitellaria paradoxa)* plant

III.4.2 Composition

Shea butter's rich composition of fatty acids, vitamins, and bioactive compounds make it an exceptional natural product for skin and hair care. Its unique blend of oleic and stearic acids provides deep moisturizing and protection, while vitamins A and E offer regenerative and antioxidant benefits. The unsaponifiables like triterpenes and phytosterols enhance shea butter's ability to soothe, repair, and protect the skin from various environmental and inflammatory stresses.

Shea butter's composition is what makes it such a potent skincare ingredient. Here's a more detailed breakdown of its components:

4.2.1. Fatty Acids

Fatty acids are the primary constituents of shea butter, responsible for its emollient and moisturizing properties. These fats contribute to the butter's texture, absorption rate, and overall effects on the skin.

- Oleic Acid (40-60%);
- Stearic Acid (20-50%);
- Linoleic Acid (3-11%);
- Palmitic Acid (2-9%);
- Arachidic Acid (Less than 1%).

4.2.2.Unsaponifiable Matter (Up to 10%)

Unsaponifiables are the fraction of fats that do not turn into soap during the saponification process. These components of shea butter are highly beneficial for skin health:

- Triterpenes:
- Phytosterols (Sterols):
- Vitamins:Shea butter is naturally rich in skin-benefiting vitamins that provide antioxidant and regenerative benefits:Vitamin A (Retinol); and Vitamin E (Tocopherol).
- Phenolic Compounds: Shea butter contains a range of phenolic compounds, which act as antioxidants. These compounds protect the skin from environmental oxidative stress and damage.
- Allantoin: is a compound known for its ability to promote wound healing, cell regeneration, and skin soothing. Though present in small amounts, it enhances the anti-inflammatory and soothing properties of shea butter, making it an excellent choice for irritated or sensitive skin.
- Lupeol is another compound found in shea butter
- Minerals: Shea butter contains trace minerals such as calcium, magnesium, and iron, which support overall skin health and function, although their concentrations are typically very low.

III.5. Illipe from Borneo

III. 5. 1. Botanical description

The Borneo illipe, scientifically known as *Shorea stenoptera* (Figure 10), is a large, evergreen tree native to the lowland tropical rainforests of Borneo. This impressive tree can reach heights of 25 to 50 meters, with a straight, stout trunk that may attain a diameter of up to 70 centimeters. Its crown is dense and conical to narrowly hemispherical, composed of somewhat pendulous branches that provide a lush canopy.

The leaves of Shorea stenoptera are large, elliptic to oblong, and leathery, with prominent, well-spaced veins and a hairy midrib on the upper surface. They are arranged alternately along the branches. The bark is smooth to shallowly scaly, starting as brownish-green in young trees and developing cracks and flakes as the tree matures.

The tree produces distinctive egg-shaped fruits, each about 5 centimeters long and 3 centimeters wide, covered with a brown-black husk (epicarp) and equipped with "wings" that aid in dispersal. These fruits, known as illipe nuts, are rich in vegetable fat (45–70%) and are collected from the forest floor after falling, as they germinate rapidly upon absorbing moisture. The nuts are traditionally harvested by local communities and are the source of illipe butter, valued for its use in cosmetics and food.

Shorea stenoptera thrives in humus-rich, sandy alluvial soils in wet lowland forests, but can also grow in heath forests with acidic, nutrient-poor soils. It is an important species for both ecological and economic reasons, supporting local livelihoods and forest conservation efforts. The species is considered endangered due to habitat loss and is protected in parts of its native range.

In summary, the Borneo illipe is a towering rainforest tree with large, leathery leaves, a dense canopy, and distinctive winged fruits that yield valuable illipe butter, making it ecologically significant and culturally important in Borneo.

Figure 10: Borneo illipe *Shorea stenoptera* plant

III.5.2 Composition

Borneo illipe butter, extracted from the nuts of the Shorea stenoptera tree, is notable for its high fat content and unique fatty acid profile. The butter is solid at room temperature, with a creamy, non-greasy texture and a melting point of 34–38°C, slightly higher than that of cocoa butter. Its composition is dominated by stearic acid (40–48%) and oleic acid (31–38%), with palmitic acid (15–20%) also present in significant amounts(see Table VI) . Linoleic acid and other minor fatty acids are found in much smaller quantities.

Borneo illipe butter contains a modest amount of unsaponifiable matter, typically not exceeding 2.5% by weight. This fraction consists of bioactive compounds that do not form soap during the saponification process, such as sterols (including β-sitosterol, campesterol, and stigmasterol), triterpene alcohols, hydrocarbons, and minor components like tocopherols (vitamin E) and squalene.

This high proportion of stearic and oleic acids gives Borneo illipe butter its firmness and excellent emollient properties, making it highly valued in both the cosmetic and food industries. The butter contains about 50% fat in the raw nut and is rich in SOS-type triglycerides (stearic-oleic-stearic), which are important for its functionality as a cocoa butter alternative. Additionally, Borneo illipe butter contains vitamins A and E, contributing to its nourishing and protective effects on the skin. Its low iodine value indicates a low level of unsaturation, which enhances its oxidative stability and shelf life. Overall, the unique composition of Borneo illipe butter makes it a prized ingredient for moisturizing products, soaps, and confectionery applications.

Although present in small quantities, these unsaponifiables play a significant role in enhancing the butter's antioxidant properties, stability, and skin-conditioning effects. As a result, the unsaponifiable matter contributes to the nourishing and protective qualities of Borneo illipe butter, making it especially valuable in cosmetic formulations for skin and hair care. It also helps improve the oxidative stability and shelf life of the butter, further increasing its desirability as a natural ingredient in both food and personal care products.

III. 5. 2. Fat composition

The seeds of Illipe from Borneo contain 50% solid fat.The composition of illipe butter is rich in fatty acids and other bioactive compounds that contribute to its benefits for skin and hair.

1. Fatty Acids (% of total fatty acids)

Fatty acids are the primary building blocks of illipe butter, responsible for its texture, emollient properties, and skin benefits. The most prominent fatty acids found in illipe butter include:

- Stearic Acid (35-45%);
- Oleic Acid (30-50%);
- Palmitic Acid (10-16%);
- Linoleic Acid (5-8%);
- Arachidic Acid (Less than 2%).

2. Unsaponifiable Matter (1-4%)

Unsaponifiables are the components of fats that do not turn into soap during the saponification process. They provide added therapeutic benefits in skincare.

- Triterpenes:

    - These compounds are known for their anti-inflammatory, antioxidant, and skin-soothing properties;
    - Triterpenes in illipe butter help improve skin elasticity and reduce signs of aging.

- Phytosterols:

    - Illipe butter contains plant sterols like beta-sitosterol, campesterol, and stigmasterol;
    - These compounds help to reduce skin inflammation, improve skin hydration, and promote skin healing;
    - Phytosterols can also assist in the regeneration of skin cells, improving overall skin texture and tone.

- Tocopherols (Vitamin E): Though present in smaller quantities, illipe butter contains natural tocopherols (forms of Vitamin E).

- Cinnamic Acid Esters: These compounds provide mild UV protection and contribute to the healing properties of illipe butter. However, like shea butter, this UV protection is not strong enough for standalone use as a sunscreen.

Comparison of cocoa butter, shea butter and illipe butter.

Shea butter, cocoa butter, and illipe butter have notable differences in terms of hardness, melting point, and fatty acid profile. Shea butter is generally semi-solid at room temperature, with a melting point of about 24 to 38 °C, and it is rich in unsaturated fatty acids, particularly oleic acid and stearic acid. In contrast, cocoa butter is harder and has a firmer texture, with a melting point between 30 and 35 °C, and it contains a higher proportion of saturated fatty acids, such as stearic acid and palmitic acid. Illipe butter, on the other hand, is also semi-solid, with a melting point of about 33 to 36 °C, and has a fatty acid profile similar to that of cocoa butter, with a good proportion of both saturated and unsaturated fatty acids. Thus, these three butters are distinguished by their physical characteristics and lipid composition, which influences their use in various fields, including cosmetics and food.

Table XVII: Comparison of the fatty acid composition of cocoa butter, shea butter and illipe butter.

Nature	Cocoa Butter (%)	Illipe Butter (%)	Shea Butter (%)
C16:0	24-29	10-23	3-5
C18:0	32-37	39-50	28-45
C18:1	31-37	31-40	42-59
C18:2	2-5	1-2	3-9
C18:3	<0.3	<0.8	<1

I. Generalities

Animal-derived fats, also known as lipids, are naturally occurring substances found in various tissues of animals. These fats are essential for numerous biological functions and serve as a major energy source for bothanimals and humans. They can be categorized based on their origin, whether terrestrial or marine, and their composition, which includes saturated, monounsaturated, and polyunsaturated fatty acids.

There are two main types of animal-derivedfats: terrestrial and marine. Terrestrial animal fats come from land animals such as cattle, pigs, sheep, and poultry. Examples of these fats include lard, which is extracted from pigs and has a high concentration of saturated fats with some unsaturated fatty acids, tallow derived from cattle and sheep, which is highly saturated and used in various food and industrial products, and poultry fat, which comes from chickens or ducks and is relatively high in monounsaturated fats, giving it a softer texture compared to lard or tallow. Marine animal fats are derived from sources like fish and marine mammals. The most common marine-derived fats include fish oil, extracted from species like cod, salmon, and sardines. Fish oil is rich in polyunsaturated fatty acids, particularly omega-3s such as eicosapentaenoicacid (EPA) and docosahexaenoicacid (DHA). Additionally, historically significant but less commonly used today are seal and whale oils, which also contain long-chain omega-3 fattyacids.

The extraction of animal fats depends on the source and desired product quality. The most common method is rendering, where animal tissues, mainly fat but also bones and connective tissues, are heated to separate the fat fromother components. The rendering process can be either "dry," without adding water, or "wet," which involves using water or steam. The fat is then filtered and purified. For marine oils, pressing is a common method where fish or marine animals are cooked and pressed to extract the oil. After pressing, further purification, often by centrifugation, separates the oilfrom water and impurities. Centrifugation is also used to obtain high-purity oils, especially in fish oil production.

The composition of animal fats can vary depending on factors like the species of the animal, its diet, and the part of the body from which the fat is extracted. Animal fats are primarily composed of triglycerides, which consist of a glycerol molecule bonded to three fatty acids. These fatty acids may include saturated fatty acids, which are found in high concentrations in fats like beef tallow and pork lard. These fats are solid at room temperature and have been associated within creasing levels of LDL (bad) cholesterol. Monounsaturated fatty acids, found in fats like poultry fat and certain marine oils, are considered heart-healthy and may help reduce LDL cholesterol. Marine oils, in particular, are rich in polyunsaturated fatty acids, which include omega-3 fatty acids such as EPA and DHA. These polyunsaturated fats are known for their anti-inflammatory and cardiovascular benefits.

Animal fats also contain cholesterol, which is necessary for cellular structure but has been the subject of health debates due to its potential impact on heart disease. Additionally, animal fats, particularly fish oils, contain fat-soluble vitamins such as vitamin A, vitamin D, and vitamin E, making them valuable from a nutritional standpoint.

In terms of nutritional importance, animal fats are a dense source of energy, providing 9 kcal per gram. They also supply essential fatty acids like linoleic acid (omega-6) and alpha-linolenic acid (omega-3), which the body can not produce on its own. Marine-derived fats, particularly fish oils, are especially noted for their role in promoting heart health, brain function, and reducing inflammation due to their high levels of EPA and DHA. However, there are concerns about the high concentration of saturated fats in terrestrial animal fats, which have been linked to cardiovascular disease. Therefore, nutritionists often recommend balancing the intake of animal fats with plant-based oils that are rich in unsaturated fats.

Beyond their role in nutrition, animal fats are also used in a variety of industrial applications. In the food industry, fats like lard and tallow are valued for their stability and flavor-enhancing properties and are often used in cooking, baking, and frying. They are also ingredients in margarine and shortening. In the cosmetics and pharmaceutical industries, animal fats are used for their moisturizing properties in products like soaps, lotions, and creams. Lanolin, derived from sheep wool, is a commoning redient in skincare products.

Additionally, animal fats are increasingly used in the production of biodiesel as a renewable energy source. Their high energy content makes them an attractive alternative to traditional fossil fuels. Historically, animal fats have also been used in soap and detergent production due to their ability to form lather and remove dirt, although synthetic alternatives have become more popular.

In conclusion, animal-derived fats are versatile substances thatplay significant roles in both nutrition and industry. Although they provide essential nutrients and have numerous applications, there are on going debates regarding their health effects, sustainability, and ethical implication

II. Types of animal-derived fats

II. 1. Marine-derived fats

Fish oils are generally by-products during the preparation of fish meal. The fat content varies depending on the species, the season, and the age of the fish. Extraction is done by steaming the fish, separating the solid mass, and thenseparating the lipid layer from the water through centrifugation. The oil can be sold either as crude oil or refined, just like vegetable oils.

II. 1. 1. Composition

The composition of marine-derived fats is distinct from that of terrestrial animal fats due to their high content of polyunsaturated fatty acids (PUFAs), particularly omega-3 fatty acids. Here's a detailed break down of the composition of marine-derived fats, focusing on the primary components, their functions, and their health implications:

1. 1.1. Triglycerides (Main Component)

Like most fats, marine-derived fats are primarily made up of triglycerides, which are molecules consisting of one glycerol backbone attached to three fatty acids. Triglycerides serve as the main form of energy storage in the body and provide essential fattyacids.

1. 1. 2. FattyAcids

Marine fats are unique because of their high levels of long-chain polyunsaturated fatty acids (PUFAs), especially omega-3 fattyacids. The main types of fatty acids in marine oils include:

a. Omega-3 Polyunsaturated Fatty Acids (PUFAs)

These fatty acids are known for their health benefits, particularly in reducing inflammation and supporting cardiovascular and brain health.

- **Eicosapentaenoic Acid(EPA)**

Chemical Structure: C20:5 (20 carbon atoms and 5 double bonds) see Fig. 1;

***Concentration**:* EPA isfound in significantquantities in marine oils, particularlyfromfattyfish like mackerel, sardines, and salmon ;

Function and Benefits: EPA is crucial for reducing inflammation, lowering blood triglyceride levels, and supporting heart health. It is also involved in producing eicosanoids, which are signaling molecules that regulate inflammation and immunity.

Figure 11 : Chemical structure of Eicosapentaenoic Acid (EPA)

- **Docosahexaenoic Acid (DHA)**

***Chemical Structure**:* C22:6 (22 carbon atoms and 6 double bonds)seeFig.2 ;

Concentration: DHA is another major omega-3 fatty acid found abundantly in marine oils, especially in fish such as salmon, herring, and tuna ;

Function and Benefits: DHA is essential for brain and eye health, as itis a primary structural component of the brain and retina. It plays a role in cognitive function, vision, and neural development. DHA is also important for cardiovascular health.

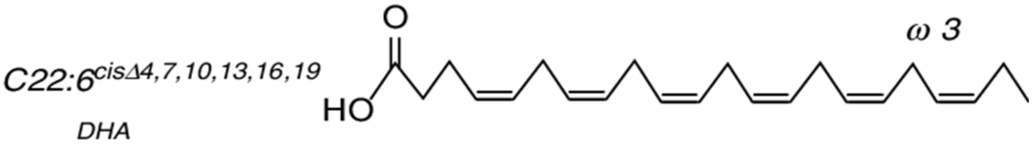

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Figure 12 : Chemical structure of Docosahexaenoic Acid (DHA)

- **Alpha-Linolenic Acid (ALA)**

Chemical Structure: C18:3 (18 carbon atoms and 3 double bonds) see Fig.3 ;

Concentration:Although ALA is more common in plant-based sources like flaxseed, small amounts can befound in marine oils ;

Function and Benefits: ALA is a precursor to EPA and DHA, meaning it can be converted into these two important fatty acids in the body, although the conversion rate is relatively low. ALA is beneficial for cardiovascular health.

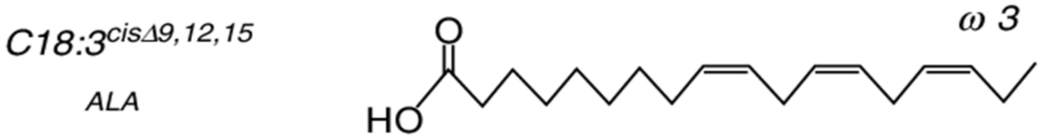

Figure 13 : Chemical structure of Alpha-Linolenic Acid (ALA)

b. Omega-6 PolyunsaturatedFattyAcids

Omega-6 fatty acids are also found in marine-derived fats, though in lower amounts compared to omega-3s. These include:

- **Arachidonic Acid (AA)**

Chemical Structure: C20:4 (20 carbon atoms and 4 double bonds)

Concentration:Present in trace amounts in marine oils.

Function and Benefits:Arachidonic acid is involved in the inflammatory response and is a precursor to eicosanoids, similar to EPA.

c. SaturatedFattyAcids (SFAs)

Although marine oils are primarily known for their omega-3 content, they also contain smaller amounts of saturated fatty acids.

- **Palmitic Acid**

Chemical Structure: C16:0 (16 carbon atoms, no double bonds)

Concentration:Found in moderate amounts in marine oils.

Function:Palmitic acid provides structure to cell membranes and serves as an energy source. However, high levels of palmitic acid are associated with increased LDL cholesterol levels.

- **Stearic Acid**
  - **Chemical Structure**: C18:0 (18 carbon atoms, no double bonds)

- o **Concentration**:Found in smaller amounts in marine oils.
- o **Function**:Stearic acid has a neutral effect on cholesterol levels and is used by the body for energy.

d. Monounsaturated Fatty Acids (MUFAs)

Monounsaturated fatty acids are present in marine oils in moderate amounts.

- **Oleic Acid**

Chemical Structure: C18:1 (18 carbon atoms and 1 double bond)

Concentration: Marine oils contain small to moderate amounts of oleic acid.

Function:Oleic acid is known for its heart health benefits, as it helps to lower LDL cholesterol while maintaining HDL (good) cholesterol.

Hereis a detailed table showing the fatty acid composition of oils from various fish species, broken down by specific fatty acids:

TableXVIII: Detailed Fatty Acid Composition of Oils fromVarious Fish Species

Fatty Acid Composition (%)	Cod Liver Oil	Salmon Oil	Mackerel Oil	Sardine Oil	Herring Oil	Tuna Oil	Anchovy Oil	Krill Oil
Myristic Acid (C14:0)	4-8%	4-7%	5-10%	6-9%	4-6%	3-5%	5-7%	3-4%
Palmitic Acid (C16:0)	10-15%	14-17%	12-15%	12-14%	10-14%	11-15%	12-14%	8-10%
Stearic Acid (C18:0)	1-3%	3-5%	2-4%	2-3%	2-4%	1-2%	2-4%	1-3%
Palmitoleic Acid (C16:1)	6-8%	6-9%	7-12%	6-8%	5-8%	5-7%	8-12%	10-12%
Oleic Acid (C18:1)	15-22%	18-23%	20-25%	19-24%	20-22%	15-20%	18-22%	10-15%
Linoleic Acid (C18:2, omega-6)	0.5-2%	1-3%	1-2%	1-2%	0.5-1%	0.5-1.5%	1-2%	1-2%
Alpha-linolenic Acid (C18:3, omega-3)	0.5-1.5%	1-3%	1-2%	0.5-1%	0.5-1%	0.5-1%	0.5-1%	0.5-1%
Eicosapentaenoic Acid (EPA, C20:5, omega-3)	8-15%	10-15%	7-10%	10-12%	8-10%	8-12%	9-14%	15-20%
Docosahexaenoic Acid (DHA, C22:6, omega-3)	7-15%	12-20%	10-15%	11-16%	12-16%	10-15%	11-17%	20-25%

1. 1. 3. Phospholipids

Marine-derived fats contain phospholipids, especially in krill oil, which is a common marine oil. Phospholipids are a type of lipid that contains a phosphate group and play a critical role in cell membrane structure.

- **Benefits**:Phospholipids are more bioavailable than triglycerides, meaning the body can absorb and utilize them more effectively. They contribute to cell membrane health and are also involved in brain function.

1. 1. 4. Sterols (IncludingCholesterol)

Marine fats contain sterols, including cholesterol. Sterols are important for the structure of cell membranes and the production of hormones.

- **Cholesterol**:
  - Found in small quantities in marine oils. While cholesterol is often viewed negatively due to its association with heart disease, itis essential for the formation of cell membranes and the synthesis of steroid hormones like cortisol, testosterone, and estrogen.

1. 1. 5. Fat-Soluble Vitamins

Marine-derived fats are a rich source of fat-soluble vitamins, which are essential for various biological processes.

VitaminA : Marine oils, especially fish liver oils (e.g., cod liver oil), are rich in vitamin A. Vitamin A is crucial for vision, immune function, and skin health.

Vitamin D : Marine oils are one of the few natural sources of vitamin D, particularly fish liver oils. Vitamin D is vital for calcium absorption, bone health, and immune function.

Vitamin E : Marine-derived fats contain vitamin E, which acts as an antioxidant and protects cells from oxidative damage.

1. 1. 6. Other Bioactive Compounds

Marine oils contain various bioactive compounds that provide additional health benefits.

- **Astaxanthin**: Found in certain marine oils, particularly krill oil, astaxanthin is a powerful antioxidant that protects against oxidative stress and inflammation. It also gives krill oil itsred color (Guerin *et al*., 2003 ; Fassett et Coombes, 2011).
- **Squalene**:Squalene, found in small amounts in marine oils, is a natural antioxidant and has been linked to skin health and immune function (Kelly, 1999 ; Popa *et al*., 2015).

Here's a table detailing the typical composition of oils from various types of fish, focusing on key fatty acids and nutrients:

TableXIX: Nutritional Composition of Oils fromVarious Fish Species

Fish Species	Saturated Fatty Acids (SFAs)	Monounsaturate dFatty Acids (MUFAs)	Polyunsaturated Fatty Acids (PUFAs)	Omega-3 Fatty Acids (EPA + DHA)	Omega-6 Fatty Acids	Vitamin A (IU/100g)	Vitamin D (IU/100g)
Cod Liver Oil	23%	47%	30%	20-25%	2-3%	30,000-100,000	10,000-12,000
Salmon Oil	20%	25%	55%	25-30%	1-3%	600-1,000	300-400
Mackerel Oil	25%	35%	40%	20-25%	2-4%	500-1,200	300-600
Sardine Oil	22%	28%	50%	25-30%	2-4%	300-500	300-500
Herring Oil	18%	35%	47%	22-28%	2-3%	400-1,000	300-500
Tuna Oil	22%	28%	50%	20-25%	1-3%	400-1,200	500-700
Anchovy Oil	23%	25%	52%	25-30%	2-4%	300-800	300-600
Krill Oil	20%	15%	65%	30-35%	1-2%	100-400	200-400

II. 2. Fats of Terrestrial Origin

Fats of terrestrial origin, commonly known as animal fats, are vital biological lipids found in the tissues of land-dwelling animals. These fats serve as a primary energy reserve, provide insulation to maintain body temperature, and offer mechanical protection for internal organs. Beyond these physiological roles, they are key structural components of cell membranes, influencing fluidity, permeability, and signal transduction pathways. In animals, lipids are predominantly stored in adipose tissues, which are widely distributed in various regions of the body, including beneath the skin (subcutaneous fat), between and within muscle fibers (intermuscular and intramuscular fat), and in bone marrow, where lipid content can reach exceptionally high levels, often exceeding 90%.

The chemical composition of animal fats sets them apart from plant-derived oils. They are primarily composed of triacylglycerols (TAGs), which consist of a glycerol back bone esterified with three fatty acids. These fatty acids can be saturated (SFAs), monounsaturated (MUFAs), or polyunsaturated (PUFAs), though animal fats are notably rich in saturated fatty acids. This high saturation level contributes to their solid or semi-solid state at room temperature. Additionally, animal fats are characterized by the presence of unique fatty acids that are less common in plant oils. Odd-chain fatty acids (e.g., pentadecanoic and heptadecanoicacids) and branched-chain fatty acids (e.g., iso- and ante-iso fatty acids) are distinctive features of animal fats. These branched and odd-chain fatty acids, which include methyl groups attached at specific positions (e.g., iso on the (n-1) carbon or ante-iso on the (n-2) carbon), have lower melting points compared to their linear counterparts, imparting distinct physical properties to the fat.

The lipid profile of animal fats also influences their nutritional and sensory properties. Saturated fatty acids are associated with oxidative stability, making these fats less prone to rancidity compared to polyunsaturated fats. Monounsaturated fatty acids, particularly oleic acid, provide a degree of fluidity and are valued for their potential health benefits, such as improving lipid profiles in human diets. However, animal fats are generally lower in polyunsaturated fatty acids compared to plant oils, which may impact their role in balancing omega-6 and omega-3 fatty acid ratios in dietary contexts.

From a culinary perspective, animal fats play a criticalrole in the flavor, texture, and aroma of food products. They are responsible for the rich, savory characteristics of meats and dairy products, contributing to their palatability and consumer appeal. Beyond their nutritional and sensory aspects, animal fats are widely used in the food industry for their functional properties, such as enhancing texture, acting as a cooking medium, and improving the stability of processed foods.

Research into animal fats has also highlighted their complex biochemistry and potential implications for health. While excessive consumption of saturated fats has been linked to cardiovascular risks, emerging studies suggest that specific components of animal fats, such as odd-chain and branched-chain fatty acids, may have unique metabolic benefits. These findings emphasize the need for a nuanced understanding of the role of animal fats in human health and nutrition.

In summary, terrestrial animal fats are not only essential for the biological functioning of animals but also hold significant importance in human nutrition, culinary applications, and industrial uses. Their unique fatty acid composition and physical properties make them a valuable and versatile resource, warranting continued exploration in food science and lipidresearch.

II. 2. 1. Distribution of Lipids in Animal Tissues

- **Location**: In animals, lipids are distributed across various tissues. They are mainly stored in adipocytes, which are specialized cells in subcutaneous connective tissue (under the skin). These fats also accumulate between muscle fibers in the form of well-differentiated clusters and within the bone marrow, where they can constitute up to 96% of the marrow's content.
- **Role of Adipocytes**: Adipocytes serve as the primary storage unit for fat in animals. They play a vital role in energy storage, insulation, and protection of internal organs.
- **Intramuscular Fat**: The fat located between and within muscle fibers is known as intramuscular fat, which contributes to the marbling of meat. The amount of intramuscular fat significantly influences the texture, tenderness, and flavor of meat products.

II. 2. 2.Types of tissues

2. 2.1.Panne (pork kidney fat)

Panne, or pork kidney fat, is a specific type of fat extracted from around the kidneys of the animal. This fatty tissue is particularly appreciated in some cuisines for its fine texture and mild flavor. It is often used in traditional charcuterie recipes, especially in the preparation of stuffing and pâtés, as it helps make the dishes more flavorful and adds a smooth, melt-in-your-mouth texture. Its high fat content also enhances aromas and provides a pleasant consistency when cooked.

2. 2.2. Lard (rind, bacon):subcutaneous tissue frompigs (belly, chest, and back)

Lard consists of fatty tissue from the subcutaneous layer of pigs, especially from the belly, chest, and back. It differs from bacon in the method of preservation (salting and sometimes smoking). Lard, when not processed into bacon, is usually used for its richness in fat and strong flavor. When cooked, it can renderits fat, which is particularly useful for sautéing vegetables or meats. Bacon, on the other hand, is a form of lard that has been smoked, givingit a stronger taste and a crispy texture when cooked. Both products are key in many recipes, especially in European and American cooking.

2. 2. 3. Foie gras (migratorybirds, e.g., geese and ducks)

Foie gras is the liver of a bird, particularly from a duck or goose, that has been specially fattened through a controlled feeding process (gavage). It isconsidered a luxury food, especially associated with French cuisine, renowned for itscreamy texture and refined, almost sweet flavor. Due to its unique production method, foie gras is often seen as a delicacy in festive meals or special occasions. Its texture and taste are highly prized, particularly in pâtés, terrines, or cooked dishes, which are sometimes paired with fruits or sweet sauces to balance the richness of the product.

II. 2. 3. Composition of some tissues (fabrics)

2. 3. 1. Panne composition in fat content

Panne, also known as leaf lard, is a high-quality fat derived from the area surrounding the kidneys and loin of pigs. It is primarily composed of lipids and has a distinct composition that makes it particularly valued in culinary and industrial applications. Its fat composition typically includes the following:

A) **Triglycerides (90–98%)**
   - Panne consists mostly of triglycerides, which are molecules made up of glycerol bound to three fatty acids. These are the primary energy storage molecules in the tissue.

B) **Fatty Acid Composition**

   The fatty acid profile of panne is generally balanced, offering a mix of saturated and unsaturated fats:

- **Saturated fats (40–45%)**:Includes palmitic acid (C16:0) and stearic acid (C18:0). These contribute to its solid structure at room temperature.
- **Monounsaturated fats (45–50%)**:Predominantly oleic acid (C18:1), which provides pliability and makes it ideal for baking.
- **Polyunsaturated fats (5–10%)**:Contains smaller amounts of linoleic acid (C18:2) and linolenic acid (C18:3).
-

C) **Moisture Content (1–5%)**

While panne is primarily fat, it retains a minimal amount of water, which may influence its meltingbehavior and shelf stability.

D) **Impurities and Minor Components (<1%)**

- Small amounts of proteins, phospholipids, and fat-soluble vitamins (such as vitamin A and E) may also be present, along with trace minerals.

Applications Based on Composition:

The high monounsaturated fat content and low moisture make panne ideal for rendering into lard, particularly leaf lard, which is prized for its neutral flavor and high smoking point. This composition makes it suitable for baking (e.g., pie crusts), frying, and as an ingredient in traditional cooking.

2. 3. 2. Lard composition in fat content:

Lard, derivedfrom the subcutaneous tissue of pigs (belly, chest, and back), is primarily composed of fat but also contains connective tissue, skin (rind), and trace amounts of protein. Its fat composition is characterized by a mix of saturated and unsaturated fatty acids, making it versatile for culinary and industrial uses. Belowis a detailed breakdown of its composition:

A) Fat Content (80–90%)

Lard is predominantly composed of lipids, primarily in the form of triglycerides. The fattyacid profile is as follows:

a. Saturated Fats (30–40%)

- **Palmitic Acid (C16:0):** A major contributor to the solid consistency and structural integrity of the fat.
- **Stearic Acid (C18:0):**Provides firmness and stability at room temperature.

b. Monounsaturated Fats (45–55%)

- **Oleic Acid (C18:1):** The most abundant fatty acid in lard, contributing to its smooth texture, mild flavor, and relatively high smoke point. It also provides oxidative stability compared to polyunsaturated fats.

c. Polyunsaturated Fats (5–15%)

- **Linoleic Acid (C18:2):**Improves the pliability of the fat but makes it more prone to oxidation, reducing its shelf life.
- **Alpha-Linolenic Acid (C18:3):**Present in smaller amounts, it contributes to the nutritional value of the fat.

B)Moisture Content (5–15%)

Raw lard contains water, which is reduced during rendering. The moisture content in unrendered lard influences its texture and perishability.

C) Protein and Collagen (5–10%)

- The rind and connective tissue contain collagen and other proteins that are integral to the structure of the subcutaneous tissue. These components are often removed or reduced during rendering but are present in raw lard.

D) Trace Components (<1%)

- **Applications Based on Composition: Vitamins:** Fat-soluble vitamins such as vitamin D and vitamin E, derived from the pig's diet and metabolism.
- **Phospholipids:**These contribute to the emulsifying properties of raw fat.

- **Cholesterol:**Present in small amounts, contributing to the nutritional profile.

- **Belly fat** is richer in unsaturated fats, making it softer and suitable for bacon production.
- **Back fat** has a higher saturated fat content, giving it a firmer texture ideal for rendering into lard for frying or baking.
- **Chest fat**offers an intermediate texture, useful for various processed meat products like sausages or pâtés.

The fatty acid composition, combined with its moderate melting point and neutral flavor, makes lard a preferred choice in cooking, baking, and even in the production of soaps and candles.

2. 3. 3. Complete Fat Composition of Foie Gras (MigratoryBirds, e.g., Geese and Ducks)

Foie gras is a highly lipidic food product, with 50%–60% of its weight composed of fats. Its lipid profile includes:

A)FattyAcids

- **MonounsaturatedFattyAcids (MUFA)**: ~50%–55%
  - Primarily oleic acid (C18:1),which contributes to the creamy texture and rich taste.
- **SaturatedFattyAcids (SFA)**: ~30%
  - Dominated by palmiticacid (C16:0) and stearicacid (C18:0).
- **PolyunsaturatedFattyAcids (PUFA)**: ~10%–15%
  - Includes linoleic acid (C18:2, omega-6) and α-linolenic acid (C18:3, omega-3).

B)Phospholipids

Phospholipids, which play a criticalrole in cell membranes and emulsification, make up ~5%–10% of the total lipids. The major phospholipidsinclude:

- Phosphatidylcholine (lecithin)
- Phosphatidylethanolamine
- Phosphatidylinositol

C)Cholesterol

Foie gras isrelatively high in cholesterol, containing approximately 300–500 mg per 100 g,depending on preparation methods and species (duck vs. goose).

D) Liposoluble Vitamins

Foie gras is a good source of fat-soluble vitamins:

- **Vitamin A (retinol)**:Significant levels, contributing to eye health and skin regeneration.
- **Vitamin E (tocopherol)**:Acts as an antioxidant, protecting fatty acids from oxidation.
- **VitaminD**:Present in smaller amounts, supporting calcium metabolism.
- **VitaminK**: Trace amounts, playing a role in bloodclotting.

E) Minor Lipid Components

- **Sterols**: In addition to cholesterol, trace amounts of other sterols are present.
- **Triglycerides**:Form the bulk of the fat, accounting for ~85%–90% of total lipids.
- **Free Fatty Acids (FFA)**: Low levels, usually resulting from enzymatic activity during liver preparation.

Oxidative Stability

The fat profile of foie gras, rich in oleic acid and tocopherols, provides moderate oxidative stability. However, the polyunsaturated fat content makes it susceptible to rancidity if improperly stored.

II. 2. 4.Odd-Chain and Branched-Chain FattyAcids

- **Odd-Chain FattyAcids**: While most fatty acids found in nature have an even number of carbon atoms, animal fats uniquely contain small amounts of odd-chain fatty acids. These fatty acids are often derived from bacterial fermentation in the rumen of ruminants or can be produced through other biological processes in the animal.These fatty acids have an odd number of carbons, such as pentadecanoicacid (C15:0) and heptadecanoicacid (C17:0). Isovalericacid (C5:0) and valericacid (C5:0) are the most common, and they are primarily found in the fats of ruminants (such as cattle and sheep) through fermentation in the rumen. Otheracids, like Enanthic (C7:0) or nonanoic (C9:0), are muchrarer.Odd-chain fatty acids have been linked to certain health benefits, such as improved insulin sensitivity and a reduced risk of type 2 diabetes.

- **Branched-Chain FattyAcids**: In addition to odd-chain fatty acids, animal fats also contain branched-chain fatty acids (BCFAs). These have a branched molecular structure, which arises due to a methyl group attached to either the (n-1) carbon (iso) or the (n-2) carbon (ante-iso) of the fatty acid chain. These BCFAs are particularly found in ruminant fats (e.g., beef, lamb) and are known to have lower melting points compared to linear fatty acids of the same chain length. This branching helps reduce the rigidity of the fat, contributing to different physical and nutritional properties.

  Though found in small quantities, branched-chain fatty acids have potential biological roles. Some studies suggest they may have anti-inflammatory effects and could influence guthealth by acting as a prebiotic in certain contexts.

II. 2. 5. Extraction: (after rendering)

2. 5. 1. Extraction of lard (pork fats)

Lard is primarily obtained from pig fat, especially subcutaneous fat found around the abdomen and kidneys. The extraction process involves rendering, meaning the fat is slowly heated to melt it, separating the liquid fat from the solid impurities.

Lard extraction method

-Selection of fattytissue: The fat is mainly taken from the subcutaneous layers of the pig, such as the belly fat or the fat surrounding the kidneys (similar to the "panne" mentioned earlier).

-Cutting the fat: The fat is cut into small pieces to ensure even melting.

-Gentleheating: The fat is then heated in a pot or boiler at a low temperature, typically between 70°C and 90°C (158°F and 194°F). This process, called rendering, melts the fat and separates it from solid impurities.

-Filtration: Once the fat is melted, it is filtered to remove any leftover meat, tissue, or other solid matter.

-Cooling and storage: After filtering, the lard is cooled and solidifies at room temperature. It can be stored either as a solid or liquid, depending on the temperature at which it is kept.

The resulting lard is a white, relatively hard fat at room temperature, commonly used for cooking, baking, or in traditional charcuterie recipes.

2. 5. 2. Extraction of tallow(fat from sheep and cattle)

Tallow is obtained from the fat of sheep (ovine) and cattle, specificallyfrom the fat surrounding the kidneys and tail. Like lard, tallow is typically extracted by **rendering**. It differs from lard due to its animal origin and fatty acid composition.

Tallow extraction method

-Selection of fatty tissue: Tallow is taken from the fat surrounding the kidneys and tail of sheep or cattle. This fat is usually firmer and more crumbly than pork fat.

-Cutting and pre-treatment: The fat is cut into uniform pieces to ensure even melting.

-Rendering: As with lard, the fat is slowly heated to a low temperature to melt the fat and separate it from solid impurities. The temperature for tallow can sometimes be slightly higher, ranging from 80°C to 100°C (176°F to 212°F).

-Filtration: Once melted, the fat is filtered to remove any solid chunks.

-Cooling: The tallow is then cooled and solidifies into a hard, white fat at room temperature. It is sometimes refined to improve it sappearance and flavor.

Tallow ismainly used in the production of food products like pastries or in the manufacturing of soap and candles due to its hardening properties and relatively low melting point.

Differences between tallow and lard

Origin: Lard comes from pigs, while tallow comes from sheep (ovine) or cattle.

Texture and use: Lard is softer and is often used for cooking or baking. Tallow, on the other hand, is harder and is mainly used in soap and candle-making, thoughit can also be used in cooking, particularly in traditional recipes or charcuterie.

Chemical properties: Tallow has a higher content of saturated fatty acids compared to lard, giving it a firmer texture.

Belowis a detailed table showing the fatty acid composition of Lard (pork fat) and Tallow (beef or sheep fat), includingodd-chain and branched-chainfattyacids:

TableXX: Fatty acid composition of Lard and Tallow

Fatty Acid	Lard (%)	Tallow (%)	Type	Notes
SaturatedFattyAcids (SFA)				
Palmiticacid (C16:0)	24–26	24–32	Straight-chain	Major contributor to firmness of the fat.
Stearicacid (C18:0)	10–14	20–25	Straight-chain	Higher in tallowthan in lard.
Myristicacid (C14:0)	1–2	3–5	Straight-chain	Impacts meltingproperties.
Odd-Chain SaturatedFattyAcids				
Pentadecanoicacid (C15:0)	~0.5	~1.0	Odd-chain	Found in lower concentrations, linked to dairydiets.
Heptadecanoicacid (C17:0)	~0.3	~0.5	Odd-chain	Biologicallyderivedfrommicrobial action.
Branched-Chain SaturatedFattyAcids				
Iso-palmiticacid (iso-C16:0)	Trace	~0.5	Branched-chain	Found in ruminant fats (tallow).
Iso-stearicacid (iso-C18:0)	Trace	~0.5	Branched-chain	Ruminant-derived; affects fat texture.
MonounsaturatedFattyAcids (MUFA)				
Oleicacid (C18:1, n-9)	44–47	40–45	Straight-chain	Givessoftness and flavor; dominant in both fats.
Palmitoleicacid (C16:1, n-7)	2–3	2–3	Straight-chain	Slightlyhigher in lard thantallow.
Odd-Chain MonounsaturatedFattyAcids				
Heptadecenoicacid (C17:1, n-7)	~0.1	~0.2	Odd-chain	Minor fattyacid in both fats.
PolyunsaturatedFattyAcids (PUFA)				
Linoleicacid (C18:2, n-6)	6–10	2–4	Straight-chain	Higher in lard due to pigdiet.
α-Linolenicacid (C18:3, n-3)	~1	~0.5	Straight-chain	Low levels, more in lard thantallow.
OtherBranched/Odd-Chain Components				
Pristanicacid (C19:0)	Trace	~0.1	Branched-chain	Fromphytanicacidoxidation;common in tallow.

Fatty Acid	Lard (%)	Tallow (%)	Type	Notes
Phytanicacid (C20:0-branched)	Trace	~0.1	Branched-chain	Found in ruminant-derived fats.

II.3. Dairy fat

Dairy fat, also known as milk fat, is primarily extracted through the method of centrifugation or churning. The process begins with the collection of milk, which typically comes from cows, goats, or sheep. Once the milk is collected, it is pasteurized to eliminate bacteria and extend its shelf life. After this step, the milk is centrifuged to separate the cream from the liquid part, which is skim milk. The cream, which contains the majority of the fat, is then churned. This process involves agitating the cream until the fat globules clump together and form a solid mass, ultimately resulting in butter.

Regarding the composition of dairy fat, it consists of various fatty acids, and its composition can vary depending on the animals' diet and other factors. Generally, dairy fat contains about 60 to 70% saturated fatty acids. Among the main saturated fatty acids are palmitic acid (C16:0), stearic acid (C18:0), and myristic acid (C14:0). Additionally, about 30 to 40% of dairy fat is made up of unsaturated fatty acids, such as oleic acid (C18:1), which is a monounsaturated fatty acid, and linoleic acid (C18:2), which is a polyunsaturated fatty acid.

Finally, dairy fat also contains fat-soluble vitamins, such as vitamins A, D, E, and K, as well as phospholipids, which play an important role in nutrition. In summary, dairy fat is an essential source of nutrients and is widely used in human food, whether in the form of butter, cream, or other dairy products. Its composition of fatty acids and nutrients makes it a key element in many diets.

Tables XXI and XXII present the composition of dairy fat, with Table XIX detailing its fatty acid profile analyzed by CPG and Table XX showing the main unsaponifiable compounds composition analysed by HPLC.

Table XXI: Detailed Fatty Acid Composition of dairy fat

Fatty Acid	Chemical Formula	Approx. Percentage
Butyric Acid	C4:0	3-4%

Caproic Acid	C6:0	1-2%
Caprylic Acid	C8:0	2-4%
Capric Acid	C10:0	4-6%
Lauric Acid	C12:0	2-4%
Myristic Acid	C14:0	8-12%
Palmitic Acid	C16:0	25-30%
Stearic Acid	C18:0	2-5%
Oleic Acid	C18:1	25-30%
Linoleic Acid	C18:2	2-5%
Alpha-Linolenic Acid	C18:3	0.5-1%

Table XXII: Unsaponifiable compounds composition of dairy fat

Component	Quantity (per 100g of dairy fat)
Vitamin A	800 - 900 µg
Vitamin D	0.5 - 1.0 µg
Vitamin E	0.5 - 1.0 mg
Vitamin K	0.5 - 1.0 µg
Phospholipids	1.0 - 2.0 g
Cholesterol	100 - 120 mg
Phytosterols	< 1 mg
Beta-carotene	< 0.1 mg

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