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FST 503

FATS AND OILS TECHNOLOGY

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- Course title: Fats and Oils Technology
- Course credit load: 3

Series 1: Oils and Fats Industry in Nigeria

Series outline

- **1.1 Historical Development**
    - Early traditional practices
    - Colonial and post-colonial expansion
    - Modern industrial growth
- **1.2 Current Status**
    - Major producers and processors
    - Market demand and consumption trends
    - Government policies and regulations
- **1.3 Economic Importance**
    - Contribution to GDP and employment
    - Export and trade relevance
    - Linkages with other industries
- **1.4 Challenges and Prospects**
    - Quality control and adulteration issues
    - Technological limitations
    - Opportunities for innovation and sustainability

Introduction

Nigeria has long been recognised as one of the leading producers of oils and fats in Africa, with palm oil, groundnut oil, and other vegetable oils forming an integral part of both domestic consumption and industrial use. The industry has evolved from traditional extraction methods to modern processing techniques, and it continues to play a vital role in food security, employment, and economic development. By examining the oils and fats industry in Nigeria, you will gain insights into its historical roots, current dynamics, and future prospects, all of which are essential for understanding the broader field of fats and oils technology.

The aim of this Series is to equip you with the knowledge and analytical skills needed to evaluate the development, current status, economic importance, and challenges of the oils and fats industry in Nigeria.

We shall commence this Series by exploring the historical development of the industry, tracing its growth from traditional practices to modern industrialisation. Next, we will examine the current status of the industry, focusing on producers, processors, and market trends. Following that, we will analyse the economic importance of oils and fats, considering their contribution to national income, employment, and trade. Finally, we will conclude by evaluating the challenges facing the industry and the prospects for innovation and sustainability.

Series Learning Outcomes

Upon completing this Series, you should be able to:

- **SLO 1.1** define the historical development of the oils and fats industry in Nigeria,
- **SLO 1.2** explain the current status of the oils and fats industry in Nigeria,
- **SLO 1.3** analyse the economic importance of oils and fats in Nigeria, and
- **SLO 1.4** evaluate the challenges and prospects of the oils and fats industry in Nigeria.

1.1 Historical Development

1.1.1 Early traditional practices

In Nigeria, the production of oils and fats began with **traditional extraction methods**, which relied on manual labour and simple tools. **Traditional extraction methods** refer to the use of rudimentary techniques such as pounding, boiling, and pressing oil-rich seeds or fruits to release oil. Communities often processed **palm fruits** and **groundnuts** locally, using household-scale equipment. These methods were labour-intensive and produced relatively small quantities of oil, but they were sufficient for domestic consumption and local trade.

local extraction methods Villagers used clay pots, wooden mortars, and hand presses to extract oil. The oil was often cloudy and contained impurities, yet it was valued for cooking and cultural practices.

Fill in the blank: Traditional extraction methods in Nigeria relied heavily on _____ labour and simple tools.

Diagram showing traditional palm oil extraction process Caption: Figure 1.1 Traditional palm oil extraction methods

1.1.2 Colonial and post-colonial expansion

During the colonial period, Nigeria's oils and fats industry expanded significantly due to the introduction of **mechanised processing techniques**. **Mechanised processing techniques** are industrial methods that use machines such as hydraulic presses and expellers to extract oil more efficiently. Colonial administrators encouraged large-scale cultivation of palm and groundnut, which became major export commodities.

regional trade networks Palm oil and groundnut oil were exported to Europe, where they were used in soap-making, margarine production, and other industrial applications. This created regional trade networks that linked Nigerian producers with international markets.

After independence, Nigeria continued to invest in oilseed production, with government-backed initiatives to modernise processing plants and improve yields.

Fill in the blank: Colonial expansion introduced _____ processing techniques that increased oil production efficiency.

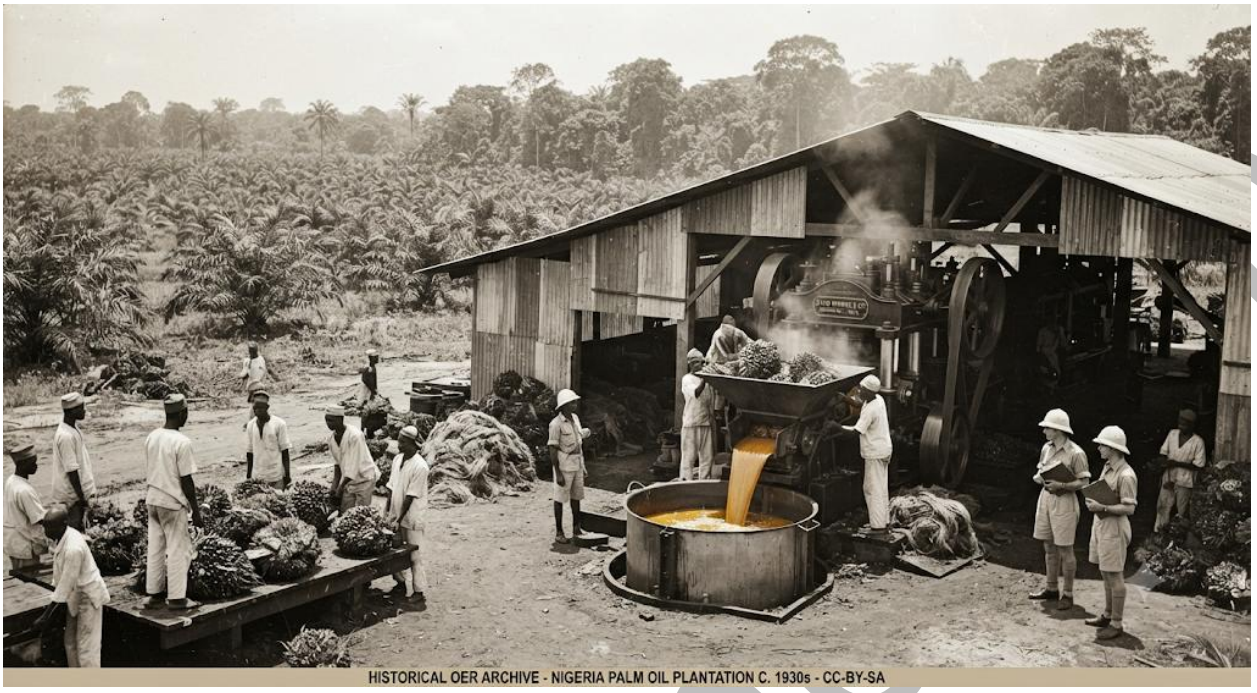


Image of colonial-era palm oil plantation with processing equipment Caption: Plate 1.1 Colonial palm oil plantation in Nigeria

1.1.3 Modern industrial growth

In recent decades, Nigeria has witnessed the growth of **industrial-scale oil processing plants**, which use advanced technologies to refine oils and improve quality. **Industrial-scale oil processing plants** are large facilities equipped with modern machinery for extraction, refining, and packaging of oils. These plants produce oils that meet international standards for clarity, taste, and shelf life.

government interventions Government policies have supported the establishment of vegetable oil refineries, encouraged private investment, and promoted research into improved oilseed varieties. However, challenges such as adulteration, poor infrastructure, and fluctuating global prices continue to affect the industry.

Fill in the blank: Modern industrial growth in Nigeria's oils and fats industry has been supported by _____ interventions and private investment.

TIMELINE OF NIGERIA'S OILS AND FATS INDUSTRY MILESTONES

ERA / PERIOD	KEY MILESTONES & EVENTS	SIGNIFICANCE	TECHNOLOGICAL & MARKET SHIFTS	ILLUSTRATIVE ICONS
Pre-Colonial Era (Before 1885)	Early cultivation of oil palm (*Elaeis guineensis*) and groundnuts. Traditional, manual extraction of palm oil and groundnut oil.		Local consumption, cultural use, and limited regional trade.	Household-scale production; diverse uses for food, medicine, and fuel.
Colonial Era (1885 - 1960)	Establishment of large-scale plantations by European companies (e.g., Lever Brothers). Introduction of small mechanical presses (e.g., Pioneer Oil Mills).		Shift from subsistence to major global export crop. Foundation of the formal industry	Industrial-scale processing; development of transport infrastructure (railways, ports).
Post-Independence & Oil Boom (1960 - 1980)	Indigenization Decree (transfer of foreign assets to Nigerians). Peak of global palm oil export position. Rise of groundnut pyramids in the North.		National control over resources. Significant foreign exchange earner.	Investment in larger processing facilities. Diversification into other oilseeds.
Structural Adjustment & Liberalization (1986 - 2000)	Implementation of Structural Adjustment Program (SAP). Removal of subsidies and devaluation of the Import bans on some oils.		Challenging period for local industries; increased competition from imports. Shift to domestic processing.	Rise of small-scale processors. Increased focus on oilseed alternatives (e.g., soybean).
Modernization & Sustainability (2000 - Present)	Introduction of high-yielding seedling varieties. Adoption of RSPO (Roundtable on Sustainable Palm Oil) principles. Growth of domestic demand.		Efforts to increase yields, improve quality, and meet local and international standards.	Precision agriculture; integrated supply chains; focus on quality quality and food safety.

NIGERIA OILS AND FATS INDUSTRY HISTORY TIMELINE OER

Table 1.1 Key milestones in Nigeria's oils and fats industry

Period	Key development	Impact
Pre-colonial	Traditional extraction	Local consumption
Colonial	Mechanised processing	Export trade
Post-colonial	Expansion of plantations	Industrialisation
Modern era	Advanced refineries	Quality improvement

Pilot questions 1.1

1. Which traditional oilseed was most commonly processed in Nigerian villages?
2. What type of labour characterised traditional extraction methods?
3. Which industrial applications in Europe relied on Nigerian palm oil during colonial times?
4. What technological advancement marked the colonial expansion of oil production?
5. Name one government intervention that has supported modern industrial growth in Nigeria's oils and fats industry.

1.2 Current Status

1.2.1 Major producers and processors

Nigeria remains one of Africa's largest producers of **vegetable oils**, with palm oil, groundnut oil, and soybean oil leading the market. **Vegetable oils** are oils extracted from plant seeds or fruits, commonly used for cooking, industrial applications, and as raw materials in food processing. Large-scale producers operate refineries that supply both domestic and export markets, while small-scale processors continue to serve local communities.

The industry is characterised by a mix of modern refineries and traditional mills, creating a dual system of production. This duality ensures that oils are available across different socio-economic groups, although quality standards vary.

Fill in the blank: Nigeria's oils and fats industry is characterised by a mix of _____ refineries and traditional mills.

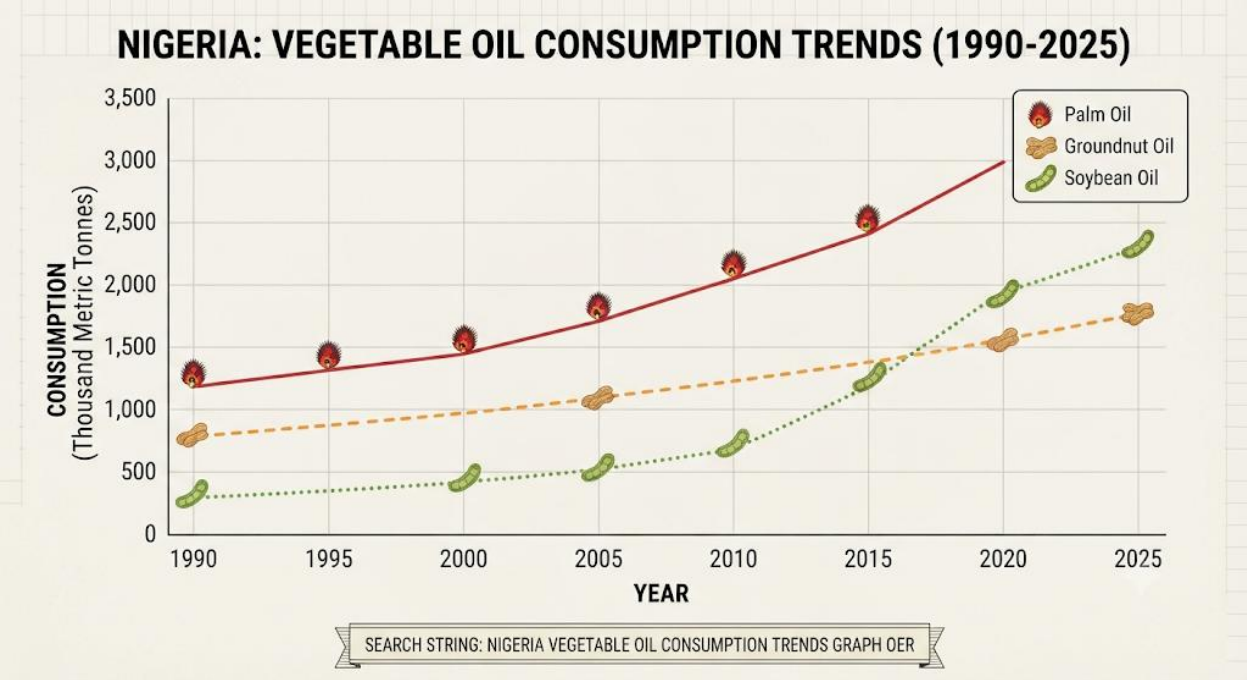
Image of a modern vegetable oil refinery in Nigeria Caption: Plate 1.2 Modern vegetable oil refinery in Nigeria

1.2.2 Market demand and consumption trends

The demand for oils and fats in Nigeria is driven by population growth, urbanisation, and changing dietary habits. **Market demand** refers to the quantity of oils and fats consumers are willing and able to purchase at different prices. Consumption trends show increasing preference for refined oils due to their clarity, taste, and perceived health benefits.

Urban households often purchase packaged oils, while rural communities may continue to rely on locally processed oils. Industrial demand is also rising, particularly in food manufacturing, cosmetics, and pharmaceuticals.

Fill in the blank: Consumption trends in Nigeria show increasing preference for _____ oils due to clarity and taste.



Graph showing consumption trends of vegetable oils in Nigeria over time Caption: Figure 1.2 Consumption trends of vegetable oils in Nigeria

1.2.3 Government policies and regulations

The Nigerian government has introduced policies to regulate the oils and fats industry, focusing on quality control, import restrictions, and support for local production. **Quality control** refers to measures taken to ensure oils meet safety and nutritional standards. Agencies such as NAFDAC and SON enforce regulations to prevent adulteration and promote consumer safety.

Policies also encourage investment in oilseed cultivation and processing, aiming to reduce dependence on imports and strengthen food security. However, enforcement challenges and infrastructural gaps remain significant obstacles.

Fill in the blank: Agencies such as _____ and SON enforce regulations to prevent adulteration in Nigeria's oils and fats industry.

Box 1.1 Key government agencies regulating oils and fats in Nigeria

- NAFDAC: National Agency for Food and Drug Administration and Control
- SON: Standards Organisation of Nigeria
- Federal Ministry of Agriculture and Rural Development

Pilot questions 1.2

1. What are the three leading vegetable oils produced in Nigeria?
2. Which factor has contributed most to rising demand for oils and fats in Nigeria?
3. What type of oils do urban households prefer?
4. Name one industrial sector that relies heavily on oils and fats.
5. Which government agency enforces quality control standards in Nigeria's oils and fats industry?

1.3 Economic Importance

1.3.1 Contribution to GDP and employment

The oils and fats industry in Nigeria contributes significantly to the **Gross Domestic Product (GDP)**, which is the total monetary value of goods and services produced within a country. By

providing raw materials for food processing, cosmetics, and pharmaceuticals, the industry supports economic growth and diversification.

Employment opportunities are created across the value chain, from farming and harvesting oilseeds to processing, packaging, and distribution. This makes the industry a vital source of livelihood for millions of Nigerians, particularly in rural communities.

Fill in the blank: The oils and fats industry contributes to Nigeria's _____ by supporting food processing and other sectors.

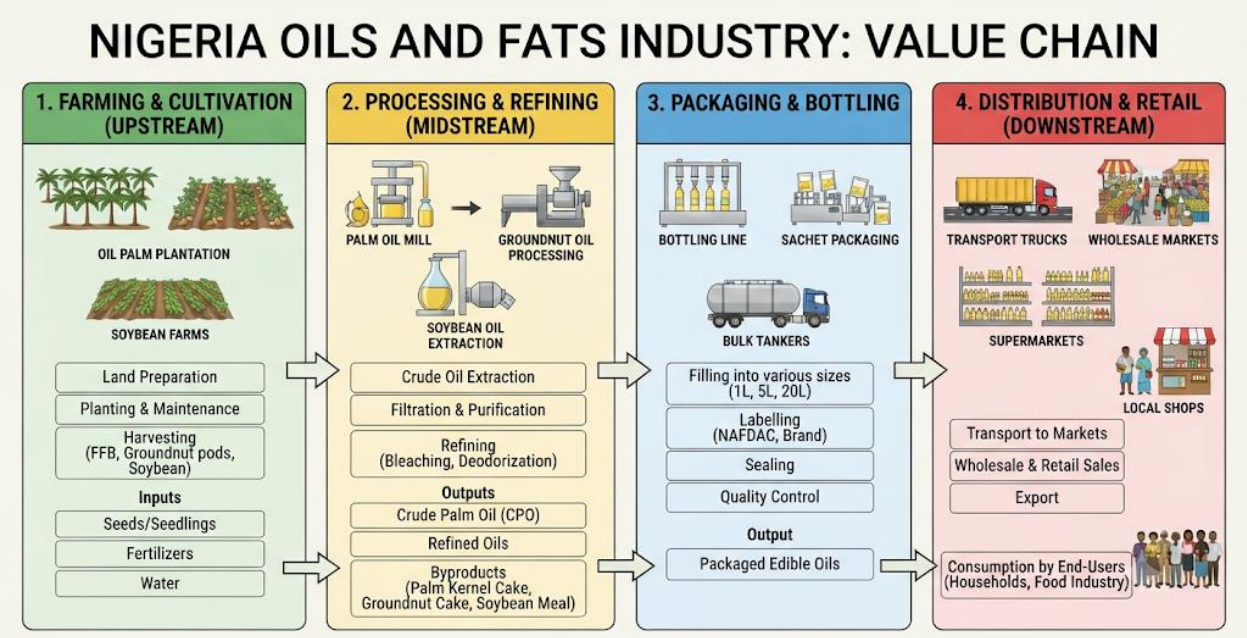


Diagram showing the value chain of oils and fats industry in Nigeria Caption: Figure 1.3 Value chain of oils and fats industry in Nigeria

1.3.2 Export and trade relevance

Nigeria's oils and fats industry has historically been important for **export trade**, particularly palm oil and groundnut oil. **Export trade** refers to the sale of goods produced in one country to buyers in other countries. These exports generate foreign exchange earnings, which strengthen the national economy.

Although Nigeria's share of global exports has declined due to competition from countries such as Malaysia and Indonesia, the industry still holds potential for regional trade within West Africa.

Fill in the blank: Nigeria's oils and fats industry generates _____ earnings through export trade.

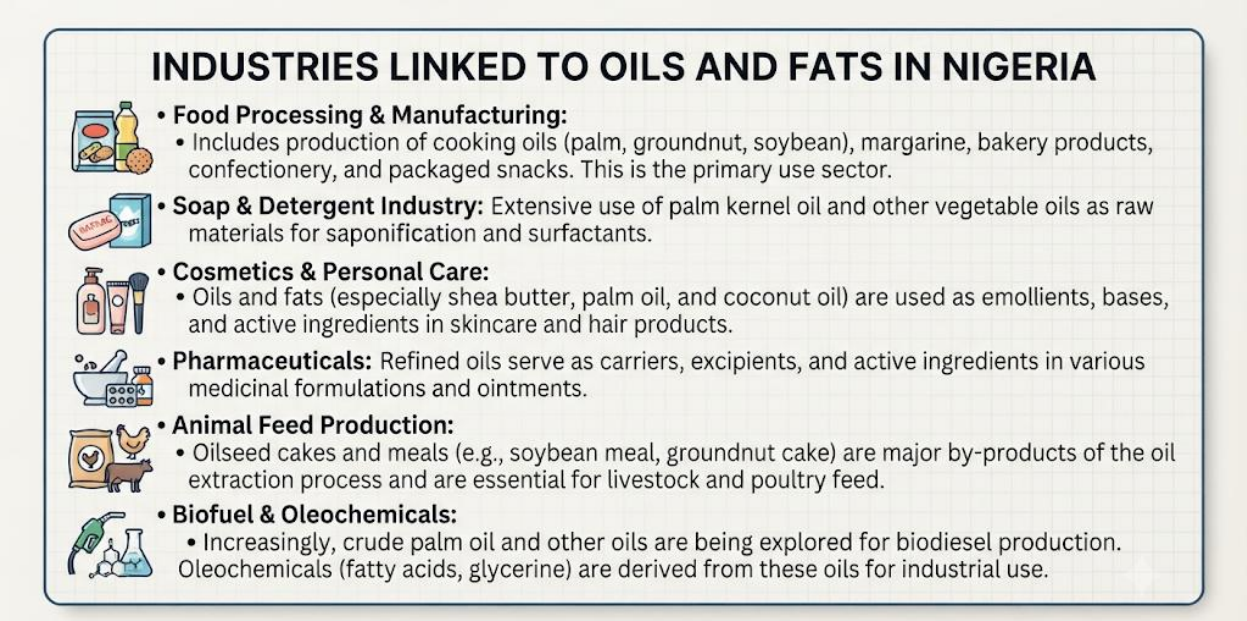
Image of palm oil packaged for export Caption: Plate 1.3 Palm oil packaged for export in Nigeria

1.3.3 Linkages with other industries

The oils and fats industry is closely linked with other sectors such as food manufacturing, cosmetics, and pharmaceuticals. **Linkages** refer to the connections between industries where the output of one serves as input for another. For example, refined vegetable oils are used in producing margarine, soaps, lotions, and medicinal products.

These linkages enhance industrial development and create opportunities for value addition. By strengthening these connections, Nigeria can maximise the benefits of its oils and fats industry.

Fill in the blank: Refined vegetable oils are used in producing _____, soaps, lotions, and medicinal products.



Box 1.2 Examples of industries linked to oils and fats

- Food manufacturing: margarine, confectionery
- Cosmetics: lotions, creams, soaps
- Pharmaceuticals: medicinal oils, capsules

Pilot questions 1.3

1. What does GDP stand for, and how does the oils and fats industry contribute to it?
2. Which two oils were historically Nigeria's major export commodities?
3. Name one country that has overtaken Nigeria in global palm oil exports.
4. What type of earnings are generated through export trade?
5. Give one example of an industry linked to oils and fats in Nigeria.

1.4 Challenges and Prospects

1.4.1 Quality control and adulteration issues

One of the major challenges facing Nigeria's oils and fats industry is **adulteration**, which refers to the practice of mixing pure oils with inferior or harmful substances to increase profit margins. This compromises **quality control**, the process of ensuring that oils meet established safety and nutritional standards. Adulterated oils can pose health risks to consumers and damage the reputation of Nigerian products in international markets.

Efforts to combat adulteration include stricter enforcement of regulations by agencies such as NAFDAC and SON, as well as public awareness campaigns. However, weak enforcement and limited resources often hinder progress.

Fill in the blank: Adulteration compromises _____ control by reducing the safety and nutritional quality of oils.

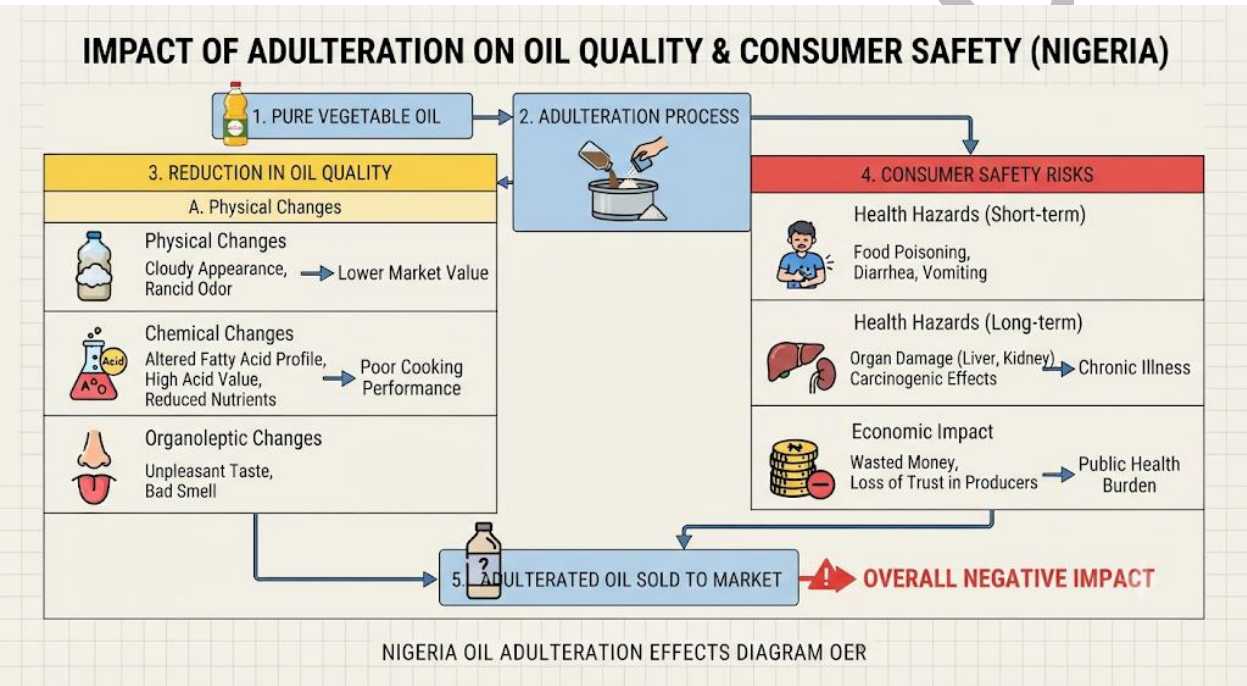


Diagram showing the effects of adulteration on oil quality Caption: Figure 1.4 Effects of adulteration on oil quality

1.4.2 Technological limitations

Despite progress, many Nigerian oil processing plants still rely on outdated equipment. **Technological limitations** refer to the lack of modern machinery and processes that can improve

efficiency, reduce waste, and enhance product quality. Small-scale processors often struggle to afford advanced technologies, which limits their competitiveness.

Modernisation of equipment and adoption of new technologies such as solvent extraction and continuous refining could improve productivity. However, this requires significant investment and technical expertise.

Fill in the blank: Many Nigerian oil processing plants still rely on _____ equipment, limiting efficiency and competitiveness.

Image of outdated oil processing equipment in Nigeria Caption: Plate 1.4 Outdated oil processing equipment in Nigeria

1.4.3 Opportunities for innovation and sustainability

Despite these challenges, the oils and fats industry in Nigeria has significant prospects for growth. **Innovation** refers to the introduction of new ideas, technologies, or processes to improve production and product quality. **Sustainability** means meeting current needs without compromising the ability of future generations to meet theirs.

Opportunities include developing improved oilseed varieties, adopting eco-friendly processing methods, and expanding into niche markets such as organic oils. With proper investment and policy support, Nigeria can strengthen its position in both domestic and international markets.

Fill in the blank: Opportunities for _____ and sustainability can help Nigeria's oils and fats industry grow and compete globally.

Box 1.3 Opportunities for innovation and sustainability in Nigeria's oils and fats industry

- Improved oilseed varieties
- Eco-friendly processing methods
- Expansion into organic oil markets
- Stronger policy support

Pilot questions 1.4

1. What does adulteration mean in the context of oils and fats?
2. Which two agencies are responsible for enforcing quality control in Nigeria's oils and fats industry?
3. What type of equipment limits efficiency in many Nigerian oil processing plants?
4. Name one modern technology that could improve oil processing productivity.
5. Give one example of an opportunity for innovation in Nigeria's oils and fats industry.

Series Summary

This Series has introduced you to the historical and contemporary dimensions of the oils and fats industry in Nigeria, highlighting its relevance to the wider study of fats and oils technology. We began by tracing the historical development of the industry, from traditional extraction methods through colonial expansion to modern industrial growth. Then, we examined the current status of the industry, focusing on producers, processors, market demand, and government regulation. Following that, we analysed the economic importance of oils and fats, considering their contribution to GDP, employment, export trade, and linkages with other industries. Finally, we evaluated the challenges of adulteration and technological limitations, while also identifying prospects for innovation and sustainability.

By completing this Series, you should now be able to define the historical development of the oils and fats industry in Nigeria (SLO 1.1), explain its current status (SLO 1.2), analyse its economic importance (SLO 1.3), and evaluate the challenges and prospects that shape its future (SLO 1.4).

Series Glossary

- **Adulteration**: The practice of mixing pure oils with inferior or harmful substances to increase profit margins.
- **Export trade**: The sale of goods produced in one country to buyers in other countries.
- **Gross Domestic Product (GDP)**: The total monetary value of goods and services produced within a country.
- **Industrial-scale oil processing plants**: Large facilities equipped with modern machinery for extraction, refining, and packaging of oils.
- **Innovation**: The introduction of new ideas, technologies, or processes to improve production and product quality.
- **Linkages**: Connections between industries where the output of one serves as input for another.
- **Mechanised processing techniques**: Industrial methods that use machines such as hydraulic presses and expellers to extract oil more efficiently.
- **Quality control**: Measures taken to ensure oils meet safety and nutritional standards.
- **Sustainability**: Meeting current needs without compromising the ability of future generations to meet theirs.
- **Vegetable oils**: Oils extracted from plant seeds or fruits, commonly used for cooking and industrial applications.

Concept Check Questions [Series 1]

Objective questions

1. Which oilseed was most commonly processed using traditional methods in Nigeria? (Linked to SLO 1.1)
2. Which agency enforces quality control standards in Nigeria's oils and fats industry? (Linked to SLO 1.2)
3. Nigeria's oils and fats industry contributes to which key economic indicator? (Linked to SLO 1.3)

Short-answer questions

4. Explain one way colonial expansion influenced Nigeria's oils and fats industry. (Linked to SLO 1.1)
5. Describe one consumption trend in Nigeria's oils and fats market today. (Linked to SLO 1.2)
6. Identify one industry that is linked to oils and fats in Nigeria. (Linked to SLO 1.3)

Long-answer questions

7. Analyse the economic importance of oils and fats in Nigeria, focusing on GDP, employment, and trade. (Linked to SLO 1.3)
    - **Basic response**: Learners should describe how oils and fats contribute to GDP, provide jobs, and generate foreign exchange through exports.
    - **Value-added response**: Outstanding learners may also evaluate how these contributions compare with other sectors, and suggest strategies to enhance Nigeria's competitiveness.
8. Evaluate the challenges and prospects of Nigeria's oils and fats industry. (Linked to SLO 1.4)
    - **Basic response**: Learners should explain issues such as adulteration and outdated technology, and mention opportunities for innovation.
    - **Value-added response**: Outstanding learners may propose specific policy interventions, technological upgrades, or sustainability practices to strengthen the industry.

Answers to Pilot Questions [Series 1]

1. Palm fruits.
2. Manual labour.
3. Soap-making and margarine production.
4. Mechanised processing techniques.

5. Government-backed initiatives and private investment.
6. Palm oil, groundnut oil, and soybean oil.
7. Population growth.
8. Refined oils.
9. Food manufacturing.
10. NAFDAC.
11. GDP.
12. Palm oil and groundnut oil.
13. Malaysia.
14. Foreign exchange.
15. Cosmetics industry.
16. Mixing pure oils with inferior substances.
17. NAFDAC and SON.
18. Outdated equipment.
19. Solvent extraction.
20. Organic oil markets.

References and Attributions [Series 1]

- Figure 1.1 Traditional palm oil extraction methods: Suggested AI prompt “Create a labelled diagram of traditional palm oil extraction using mortar, pestle, boiling, and pressing”. Search string: “traditional palm oil extraction Nigeria diagram OER”.
- Plate 1.1 Colonial palm oil plantation in Nigeria: Suggested AI prompt “Generate a historical image of colonial palm oil plantation with mechanical presses in Nigeria”. Search string: “colonial palm oil plantation Nigeria historical photo OER”.
- Table 1.1 Key milestones in Nigeria’s oils and fats industry: Suggested AI prompt “Generate a timeline table of Nigeria’s oils and fats industry milestones”. Search string: “Nigeria oils and fats industry history timeline OER”.
- Plate 1.2 Modern vegetable oil refinery in Nigeria: Suggested AI prompt “Generate an image of a modern vegetable oil refinery in Nigeria with processing equipment”. Search string: “Nigeria vegetable oil refinery photo OER”.
- Figure 1.2 Consumption trends of vegetable oils in Nigeria: Suggested AI prompt “Create a line graph showing consumption trends of palm oil, groundnut oil, and soybean oil in

Nigeria from 1990 to 2025". Search string: "Nigeria vegetable oil consumption trends graph OER".

- Box 1.1 Key government agencies regulating oils and fats in Nigeria: Suggested AI prompt "Generate a text box listing Nigerian government agencies regulating oils and fats industry". Search string: "Nigeria oil industry regulation agencies OER".
- Figure 1.3 Value chain of oils and fats industry in Nigeria: Suggested AI prompt "Create a labelled diagram showing farming, processing, packaging, and distribution stages of Nigeria's oils and fats industry". Search string: "Nigeria oils and fats industry value chain diagram OER".
- Plate 1.3 Palm oil packaged for export in Nigeria: Suggested AI prompt "Generate an image of palm oil packaged in drums for export trade from Nigeria". Search string: "Nigeria palm oil export packaging photo OER".
- Box 1.2 Examples of industries linked to oils and fats: Suggested AI prompt "Generate a text box listing industries linked to oils and fats in Nigeria". Search string: "Nigeria industries linked to vegetable oils OER".
- Figure 1.4 Effects of adulteration on oil quality: Suggested AI prompt "Create a diagram showing how adulteration reduces oil quality and consumer safety". Search string: "Nigeria oil adulteration effects diagram OER".
- Plate 1.4 Outdated oil processing equipment in Nigeria: Suggested AI prompt "Generate an image of outdated oil processing equipment in Nigeria compared with modern machinery". Search string: "Nigeria oil processing outdated equipment photo OER".
- Box 1.3 Opportunities for innovation and sustainability: Suggested AI prompt "Generate a text box listing opportunities for innovation and sustainability in Nigeria's oils and fats industry". Search string: "Nigeria oil industry innovation sustainability OER".

Series 2: Oil Seeds of Nigeria

Series outline

- **2.1 Characteristics of Nigerian oil seeds**
    - Physical features of major oil seeds
    - Nutritional composition and oil content
- **2.2 Composition of oil seeds**

- Chemical constituents (proteins, carbohydrates, lipids)
- Variations among different seed types

- **2.3 Uses of oil seeds**
  - Culinary applications
  - Industrial applications
  - Medicinal and cultural uses
- **2.4 Case studies of major oil seeds**
  - Palm seed
  - Groundnut seed
  - Soybean seed
  - Coconut and sunflower seed

Introduction

Oil seeds are the foundation of Nigeria's oils and fats industry, providing the raw materials that sustain both domestic consumption and industrial applications. They are valued not only for their oil content but also for their nutritional, cultural, and economic significance. By studying the characteristics, composition, and uses of these seeds, you will gain a deeper appreciation of their role in food security, trade, and industrial development.

The aim of this Series is to enable you to examine the characteristics, composition, and uses of Nigerian oil seeds, while also analysing selected case studies of major seeds such as palm, groundnut, soybean, coconut, and sunflower.

We shall commence this Series by exploring the general characteristics of Nigerian oil seeds, focusing on their physical features and oil content. Next, we will examine their composition, highlighting chemical constituents and variations among seed types. Following that, we will consider the diverse uses of oil seeds in culinary, industrial, and cultural contexts. Finally, we will conclude with case studies of major oil seeds, analysing their importance and applications in Nigeria.

Series Learning Outcomes

Upon completing this Series, you should be able to:

- **SLO 2.1** describe the physical characteristics and nutritional composition of Nigerian oil seeds,
- **SLO 2.2** explain the chemical constituents of oil seeds and their variations,

- **SLO 2.3** analyse the culinary, industrial, and cultural uses of oil seeds in Nigeria, and
- **SLO 2.4** evaluate case studies of major oil seeds such as palm, groundnut, soybean, coconut, and sunflower.

2.1 Characteristics of Nigerian Oil Seeds

2.1.1 Physical features of major oil seeds

Oil seeds in Nigeria display diverse **physical features**, which refer to the external attributes such as size, shape, colour, and texture. For example, palm seeds are small and reddish-brown, groundnut seeds are oval and encased in shells, while soybean seeds are round and pale yellow. These features often determine the ease of processing and the yield of oil obtained.

local variations Different regions in Nigeria cultivate oil seeds with slight variations in appearance due to soil type and climatic conditions. Such variations can influence oil content and quality, making regional knowledge important for processors and farmers.

Fill in the blank: The _____ features of oil seeds include size, shape, colour, and texture.

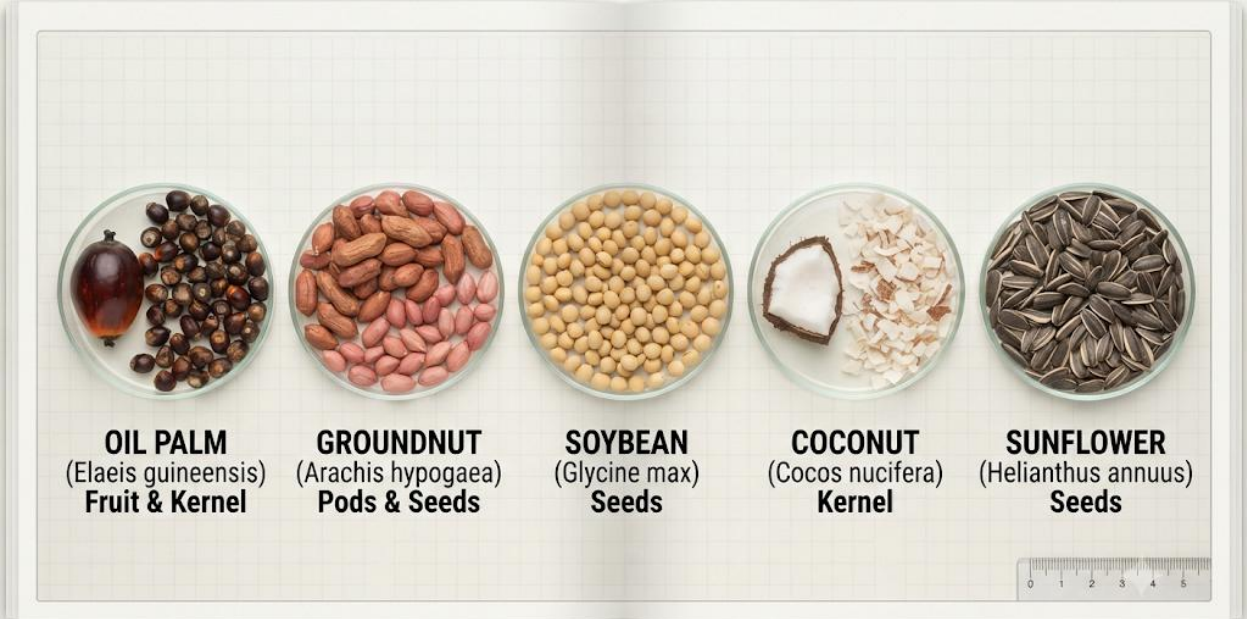


Image showing different Nigerian oil seeds (palm, groundnut, soybean, coconut, sunflower)
Caption: Plate 2.1 Physical features of Nigerian oil seeds

2.1.2 Nutritional composition and oil content

Oil seeds are valued for their **nutritional composition**, which refers to the balance of proteins, carbohydrates, lipids, vitamins, and minerals they contain. Palm seeds, for instance, are rich in

lipids, while soybeans provide high protein content alongside oil. Groundnuts are notable for their balanced protein and oil levels, making them versatile for both food and industrial uses.

oil yield potential The **oil content** of seeds is a critical factor in determining their economic value. Palm seeds can yield up to 45 per cent oil, groundnuts around 40 per cent, and soybeans approximately 20 per cent. These percentages vary depending on cultivation practices and seed variety.

Fill in the blank: Palm seeds can yield up to _____ per cent oil, making them highly valuable in Nigeria's oils and fats industry.

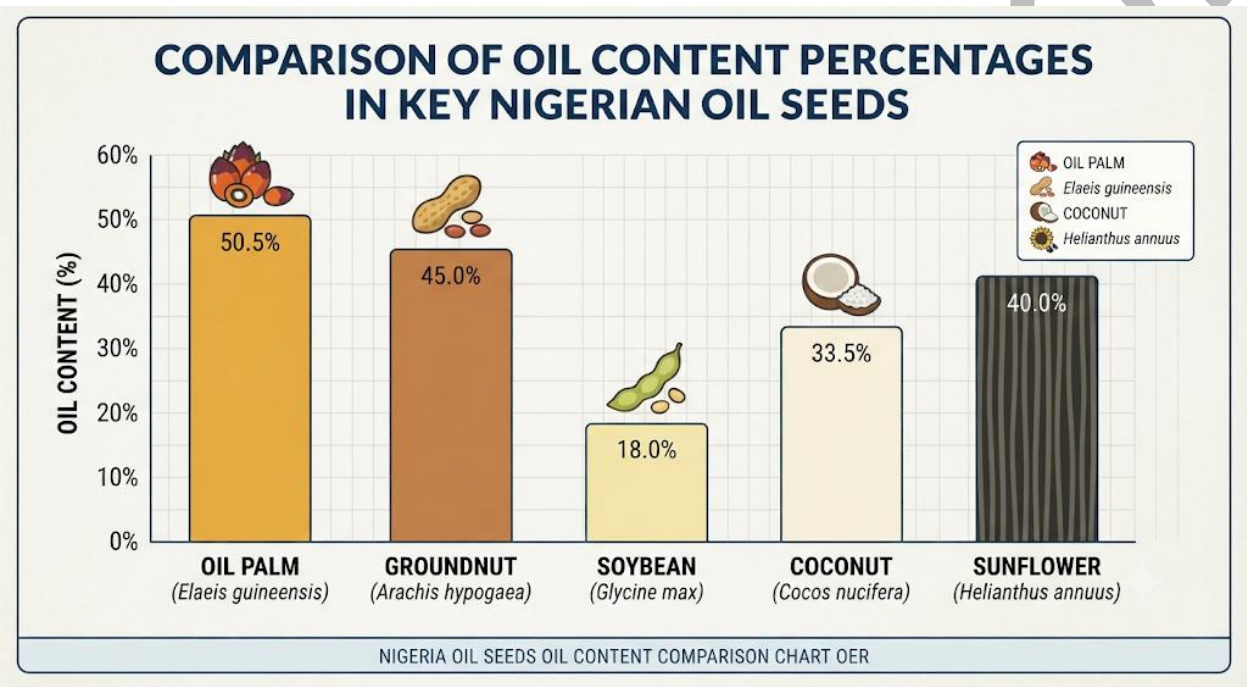


Diagram showing comparative oil content of palm, groundnut, soybean, coconut, and sunflower seeds Caption: Figure 2.1 Comparative oil content of Nigerian oil seeds

Pilot questions 2.1

1. What are the physical features of oil seeds?
2. Give one example of how regional variations affect oil seed characteristics.
3. Which oil seed in Nigeria is richest in protein?
4. What percentage of oil can palm seeds yield?
5. Why is oil content considered a critical factor in determining the economic value of oil seeds?

2.2 Composition of Oil Seeds

2.2.1 Chemical constituents

Oil seeds are composed of several **chemical constituents**, which are the basic substances that make up their nutritional and functional value. These include **proteins**, which are essential for body growth and repair, **carbohydrates**, which provide energy, and **lipids**, which are the fats and oils extracted for consumption and industrial use. In addition, oil seeds contain vitamins and minerals that enhance their nutritional importance.

Different oil seeds vary in their constituent proportions. For example, soybeans are particularly rich in protein, while palm seeds are dominated by lipids. Groundnuts provide a balanced mix of protein and oil, making them versatile for both food and industrial applications.

Fill in the blank: Oil seeds are composed of proteins, carbohydrates, lipids, vitamins, and _____.

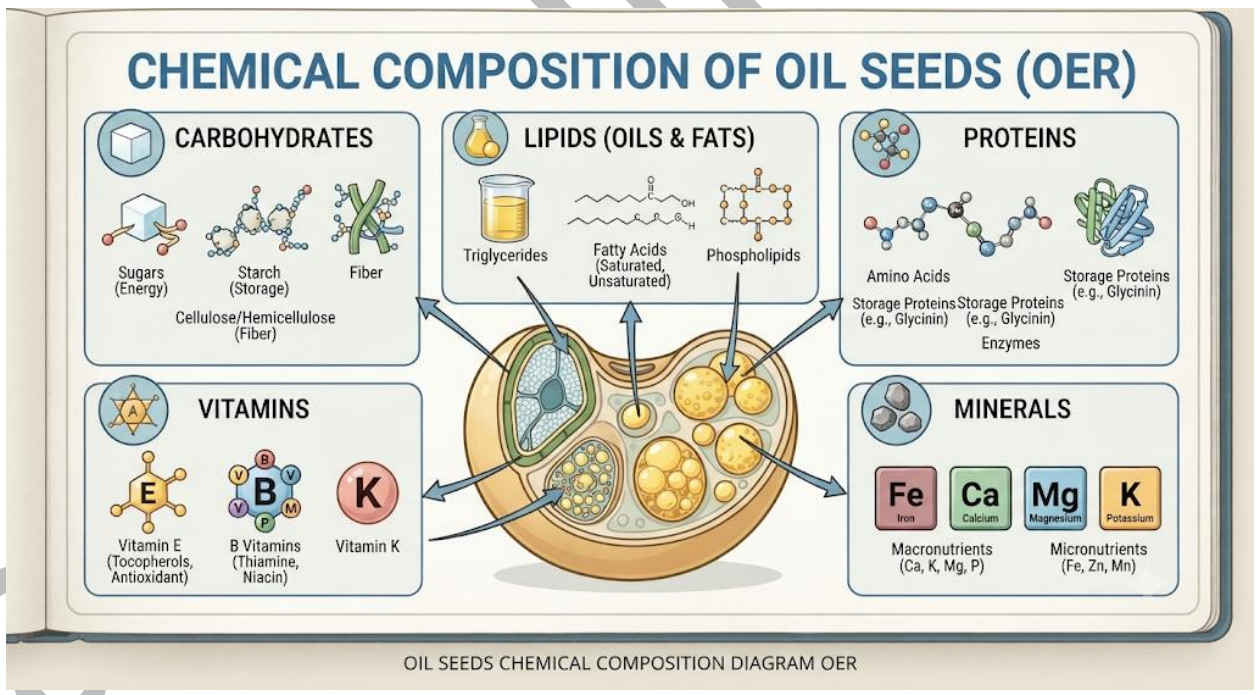


Diagram showing chemical constituents of oil seeds Caption: Figure 2.2 Chemical composition of oil seeds

2.2.2 Variations among different seed types

The composition of oil seeds varies significantly among different types, influencing their nutritional and economic value. For instance, palm seeds yield high oil content but relatively low protein,

while soybeans provide moderate oil with high protein. Coconut seeds are rich in saturated fats, whereas sunflower seeds are valued for their unsaturated fatty acids.

These variations determine the suitability of each seed for specific uses. Seeds with high protein content are often used in animal feed and food products, while those with high oil content are prioritised for cooking and industrial applications.

Fill in the blank: Soybeans are valued for their high _____ content, while palm seeds are valued for their high oil content.

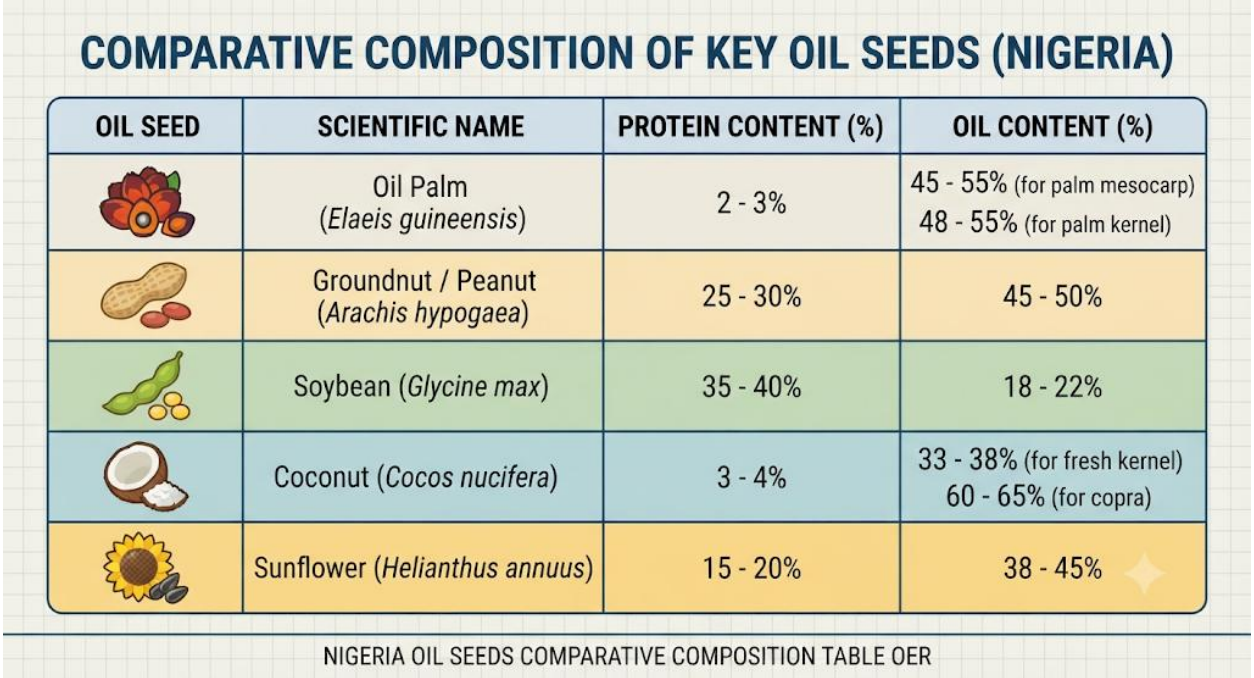


Table 2.1 Comparative composition of major Nigerian oil seeds

Oil seed	Protein (%)	Oil (%)	Notable feature
Palm seed	Low	High	Rich in lipids
Groundnut	Moderate	High	Balanced protein and oil
Soybean	High	Moderate	Rich in protein
Coconut	Low	High	Rich in saturated fats
Sunflower	Moderate	Moderate	Rich in unsaturated fatty acids

Pilot questions 2.2

1. Name three chemical constituents of oil seeds.
2. Which oil seed is richest in protein?
3. What type of fatty acids are sunflower seeds valued for?

4. Which oil seed is rich in saturated fats?
5. Why are variations in oil seed composition important for their uses?

2.3 Uses of Oil Seeds

2.3.1 Culinary applications

Oil seeds are widely used in Nigeria for **culinary applications**, which refer to their role in food preparation and consumption. Palm oil is a staple in many traditional dishes such as soups and stews, while groundnut oil is commonly used for frying and baking. Soybean oil is valued for its neutral flavour, making it suitable for diverse cooking methods.

Beyond oils, the seeds themselves are consumed directly. Groundnuts are eaten roasted or boiled, and sunflower seeds are enjoyed as snacks. These uses highlight the versatility of oil seeds in Nigerian diets.

Fill in the blank: Groundnut oil is commonly used for _____ and baking in Nigerian households.

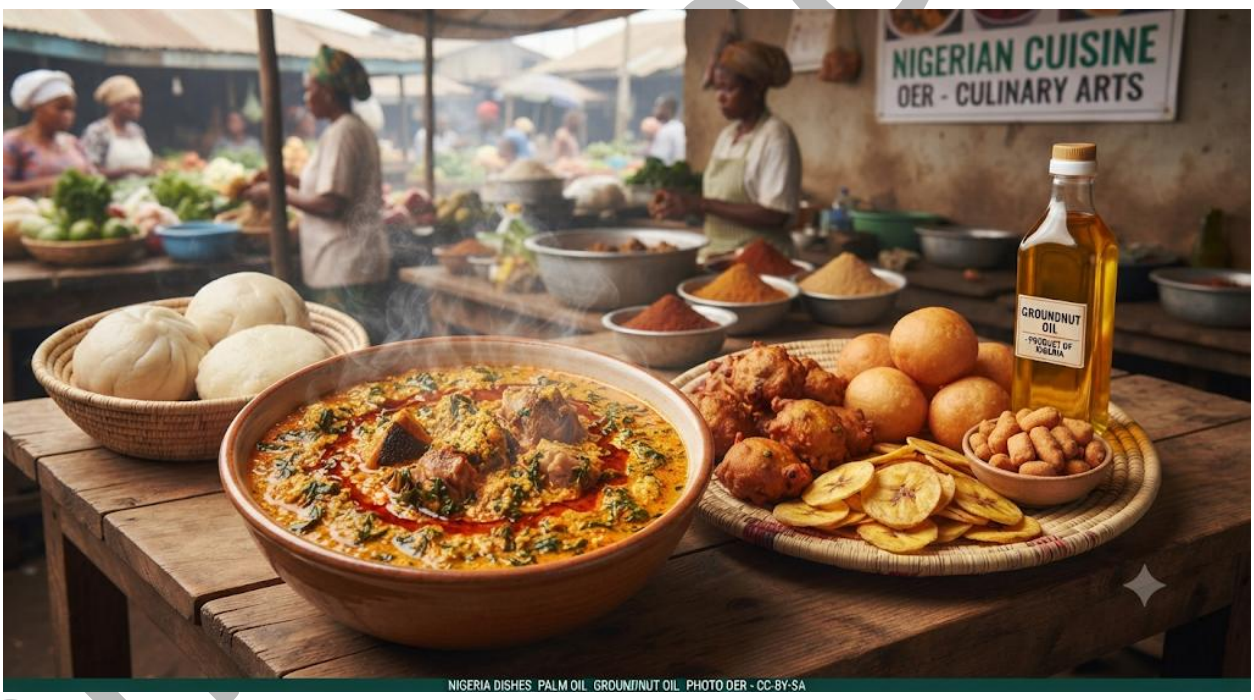


Image showing Nigerian dishes prepared with palm oil and groundnut oil Caption: Plate 2.2 Culinary uses of oil seeds in Nigeria

2.3.2 Industrial applications

Oil seeds also serve important **industrial applications**, meaning they are used as raw materials in non-food industries. Palm oil is used in soap and detergent production, groundnut oil in margarine and confectionery, and soybean oil in paints and lubricants. Coconut oil is widely applied in cosmetics, while sunflower oil is used in pharmaceuticals.

These applications demonstrate the economic value of oil seeds beyond food, creating opportunities for industrial growth and diversification.

Fill in the blank: Coconut oil is widely applied in _____ industries due to its moisturising properties.

Box 2.1 Industrial applications of Nigerian oil seeds

- Palm oil: soap, detergent, margarine
- Groundnut oil: confectionery, margarine
- Soybean oil: paints, lubricants
- Coconut oil: cosmetics, hair products
- Sunflower oil: pharmaceuticals, skincare

2.3.3 Medicinal and cultural uses

Oil seeds also have **medicinal uses**, which refer to their application in traditional and modern healthcare. For example, coconut oil is used to treat skin conditions, while palm oil is believed to aid in wound healing. Groundnut oil is sometimes used in massage therapy, and sunflower oil is valued for its anti-inflammatory properties.

Culturally, oil seeds play a role in rituals and ceremonies. Palm oil, for instance, is used in traditional rites and offerings, symbolising prosperity and vitality.

Fill in the blank: Palm oil is often used in traditional _____ and offerings, symbolising prosperity.

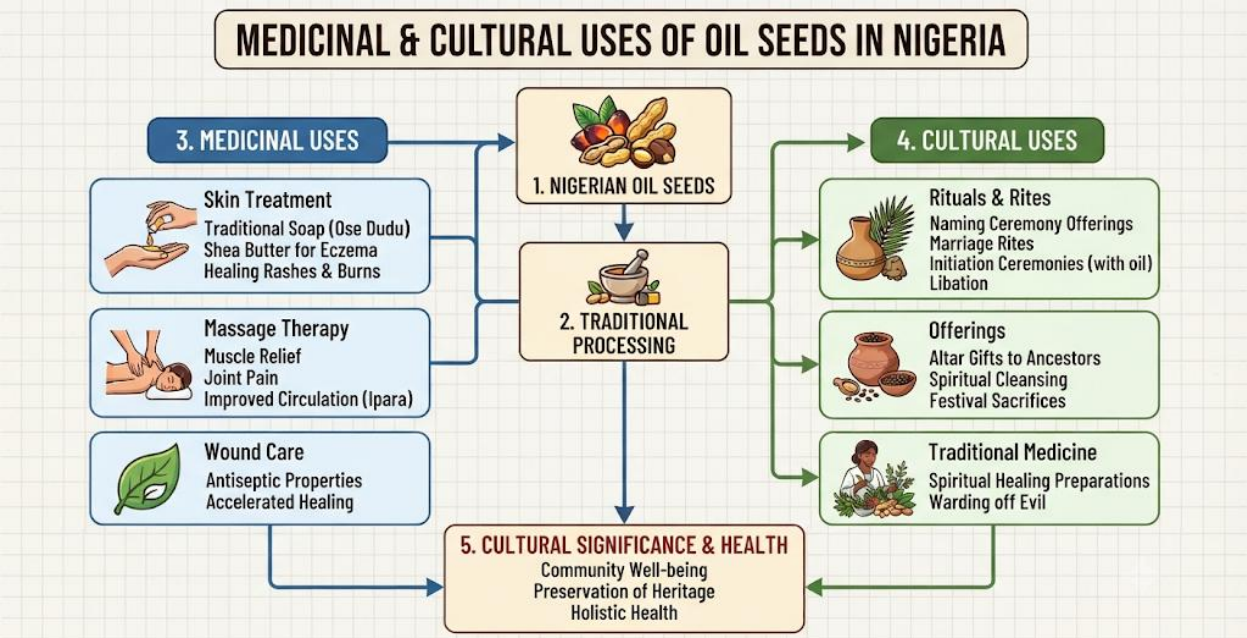


Diagram showing medicinal and cultural uses of oil seeds Caption: Figure 2.3 Medicinal and cultural uses of Nigerian oil seeds

Pilot questions 2.3

1. Which oil seed is commonly used for frying and baking in Nigeria?
2. Name one industrial product made from palm oil.
3. Which oil seed is widely applied in cosmetics industries?
4. What property makes sunflower oil valuable in pharmaceuticals?
5. In cultural contexts, palm oil symbolises what?

2.4 Case Studies of Major Oil Seeds

2.4.1 Palm seed

Palm seed is one of Nigeria's most important oil seeds, providing **palm oil**, which is widely used in cooking and industry. **Palm oil** is a reddish vegetable oil extracted from the fruit of the oil palm tree. It is rich in saturated fats and vitamin E, making it both nutritionally and economically significant. Nigeria has historically been a leading producer of palm oil, although global competition has reduced its export share.

Fill in the blank: Palm oil is extracted from the fruit of the _____ tree.

Image of palm fruits and oil extraction Caption: Plate 2.3 Palm fruits and oil extraction in Nigeria

2.4.2 Groundnut seed

Groundnut seed, also known as peanut, is valued for its balanced **protein** and **oil content**. Groundnut oil is widely used for frying and baking, while the seed itself is consumed roasted, boiled, or processed into paste. Industrially, groundnut oil is used in margarine and confectionery production.

Fill in the blank: Groundnut seed is also commonly known as _____.

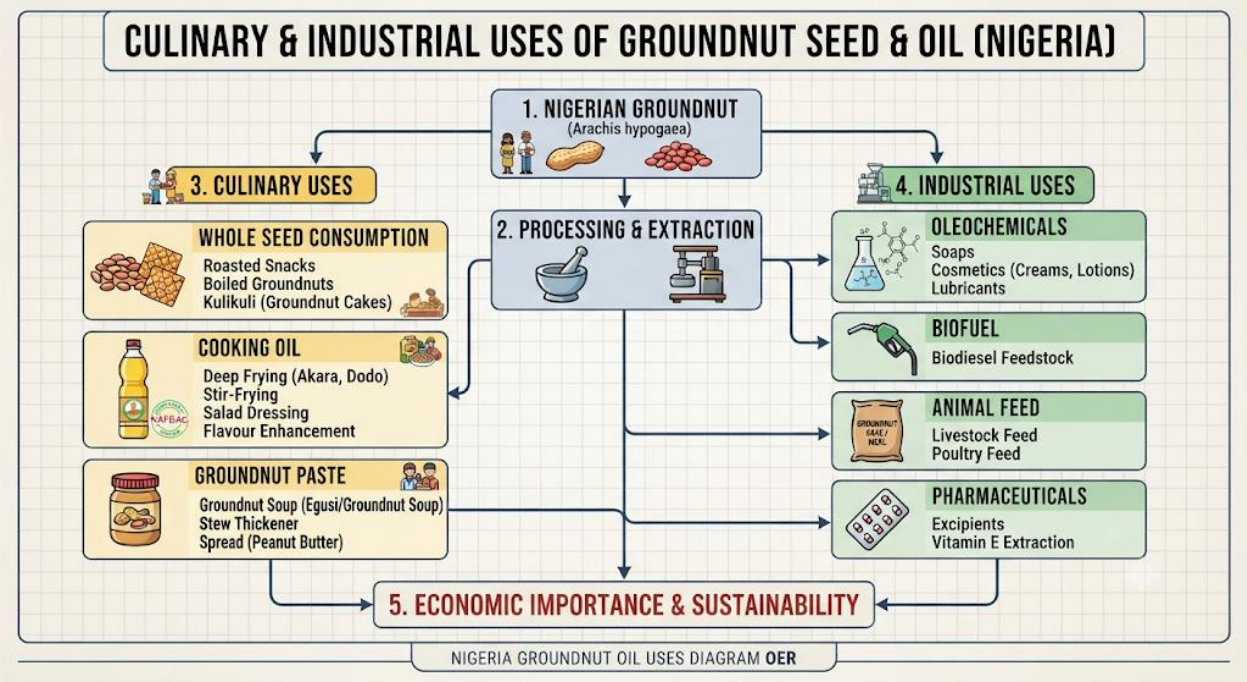


Diagram showing uses of groundnut seed and oil Caption: Figure 2.4 Uses of groundnut seed and oil

2.4.3 Soybean seed

Soybean seed is notable for its high **protein content**, making it valuable for both human consumption and animal feed. Soybean oil is neutral in flavour and widely used in cooking. Industrially, it is applied in paints, lubricants, and biodiesel production. Nigeria has increased soybean cultivation in recent years to meet rising demand.

Fill in the blank: Soybean seed is valued for its high _____ content.

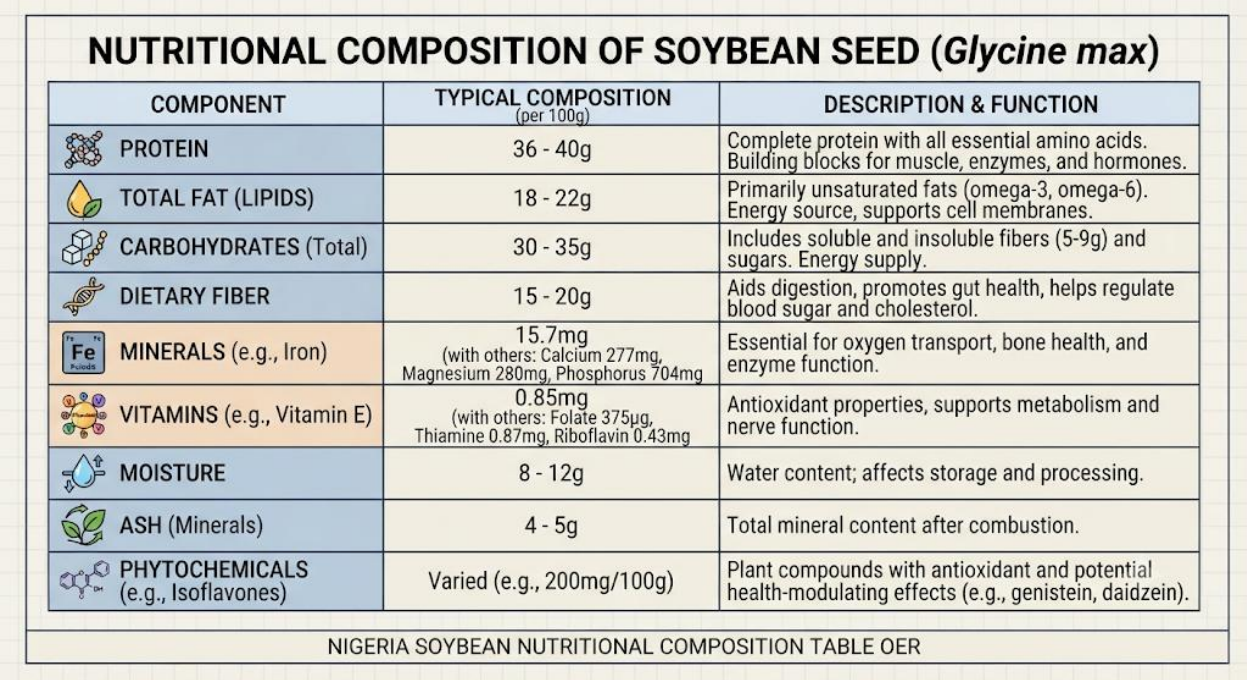


Table 2.2 Nutritional composition of soybean seed

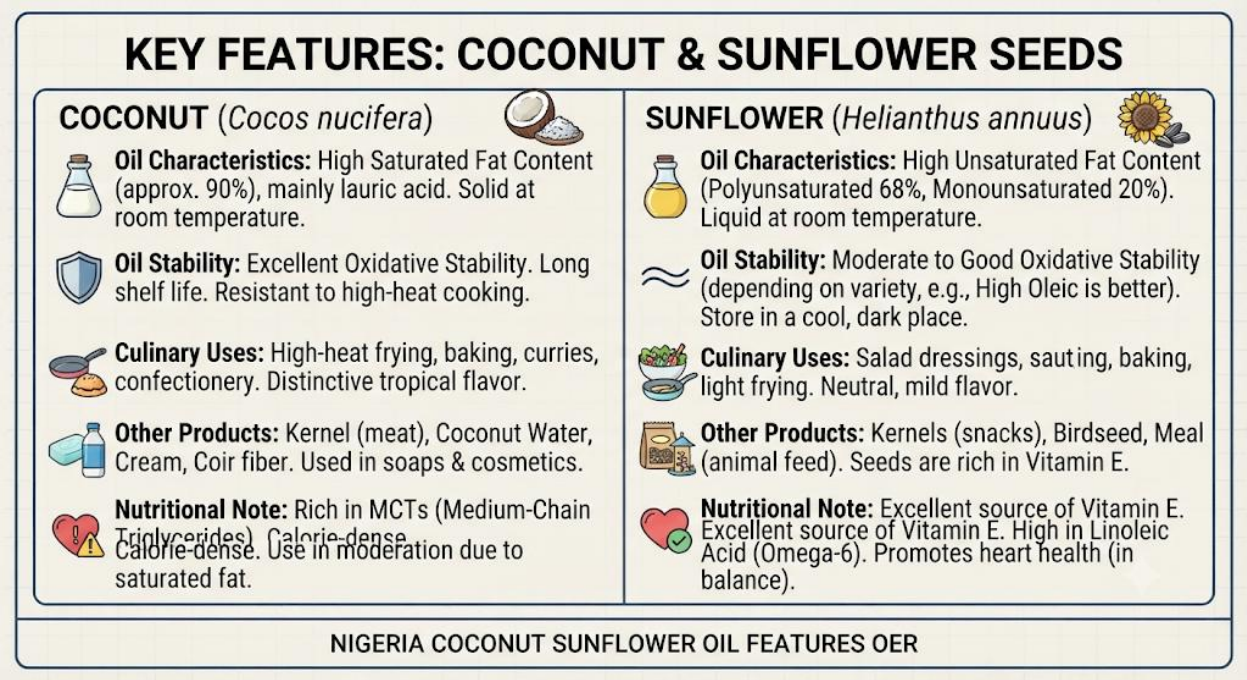
Component	Percentage	Notable feature
Protein	35–40%	High protein content
Oil	18–20%	Neutral flavour
Carbohydrate	30%	Energy source

”

2.4.4 Coconut and sunflower seed

Coconut seed yields **coconut oil**, which is rich in saturated fats and widely used in cosmetics, hair products, and cooking. It is also applied medicinally for skin care. Sunflower seed produces **sunflower oil**, valued for its unsaturated fatty acids and anti-inflammatory properties. Both seeds are increasingly cultivated in Nigeria to diversify oil sources.

Fill in the blank: Sunflower oil is valued for its _____ fatty acids and anti-inflammatory properties.



Box 2.2 Key features of coconut and sunflower seeds

- Coconut oil: rich in saturated fats, used in cosmetics and cooking
- Sunflower oil: rich in unsaturated fatty acids, used in pharmaceuticals and cooking

Pilot questions 2.4

1. From which tree is palm oil extracted?
2. What is another name for groundnut seed?
3. What percentage of protein is found in soybean seed?
4. Which oil seed is rich in saturated fats and used in cosmetics?
5. Which oil seed is valued for its unsaturated fatty acids?

Series Summary

This Series has examined the diverse oil seeds of Nigeria, which form the backbone of the oils and fats industry. We began by describing their physical features and nutritional composition, then moved on to analyse their chemical constituents and variations among different seed types. Following that, we explored their wide-ranging uses, from culinary to industrial and medicinal applications, as well as their cultural significance. Finally, we evaluated case studies of major oil seeds including palm, groundnut, soybean, coconut, and sunflower, highlighting their importance in Nigeria's economy and daily life.

By completing this Series, you should now be able to describe the characteristics of Nigerian oil seeds (SLO 2.1), explain their chemical composition (SLO 2.2), analyse their uses in different contexts (SLO 2.3), and evaluate case studies of major oil seeds (SLO 2.4).

Series Glossary

- **Coconut oil**: Oil extracted from coconut seeds, rich in saturated fats and widely used in cooking and cosmetics.
- **Groundnut seed**: Also known as peanut, valued for its balanced protein and oil content.
- **Lipids**: Fats and oils found in seeds, serving as a major energy source.
- **Palm oil**: A reddish vegetable oil extracted from the fruit of the oil palm tree.
- **Physical features**: External attributes of seeds such as size, shape, colour, and texture.
- **Protein**: A nutrient in seeds essential for growth and repair of body tissues.
- **Soybean seed**: A seed rich in protein and moderate oil content, used in food and industry.
- **Sunflower oil**: Oil extracted from sunflower seeds, valued for unsaturated fatty acids and medicinal properties.
- **Unsaturated fatty acids**: Healthy fats found in seeds such as sunflower, beneficial for heart health.
- **Vegetable oils**: Oils extracted from plant seeds or fruits, used for cooking and industrial purposes.

Concept Check Questions [Series 2]

Objective questions

1. Which oil seed is also known as peanut? (Linked to SLO 2.1)
2. Palm oil is extracted from the fruit of which tree? (Linked to SLO 2.4)
3. Which oil seed is valued for its unsaturated fatty acids? (Linked to SLO 2.2)

Short-answer questions

4. Describe one physical feature of Nigerian oil seeds. (Linked to SLO 2.1)
5. Explain one industrial application of soybean oil. (Linked to SLO 2.3)
6. Identify one medicinal use of coconut oil. (Linked to SLO 2.3)

Long-answer questions

7. Analyse the composition of Nigerian oil seeds, focusing on proteins, lipids, and carbohydrates. (Linked to SLO 2.2)

- **Basic response**: Learners should describe the presence of proteins, lipids, and carbohydrates in oil seeds, with examples.
- **Value-added response**: Outstanding learners may compare the composition across different seeds and discuss implications for nutrition and industry.

8. Evaluate the economic and cultural importance of palm, groundnut, soybean, coconut, and sunflower seeds in Nigeria. (Linked to SLO 2.4)
    - **Basic response**: Learners should explain the uses of each seed in food, industry, and culture.
    - **Value-added response**: Outstanding learners may also assess their role in trade, employment, and sustainability.

Answers to Pilot Questions [Series 2]

1. Size, shape, colour, and texture.
2. Soil type and climate.
3. Soybean.
4. 45 per cent.
5. Oil content determines economic value.
6. Proteins, carbohydrates, lipids.
7. Soybean.
8. Unsaturated fatty acids.
9. Coconut.
10. Variations determine suitability for uses.
11. Groundnut.
12. Soap.
13. Coconut oil.
14. Anti-inflammatory properties.
15. Prosperity.
16. Oil palm.
17. Peanut.
18. 35–40 per cent.

19. Coconut seed.
20. Sunflower seed.

References and Attributions [Series 2]

- Plate 2.1 Physical features of Nigerian oil seeds: Suggested AI prompt “Generate an image showing palm, groundnut, soybean, coconut, and sunflower seeds side by side”. Search string: “Nigeria oil seeds physical features photo OER”.
- Figure 2.1 Comparative oil content of Nigerian oil seeds: Suggested AI prompt “Create a bar chart comparing oil content percentages of palm, groundnut, soybean, coconut, and sunflower seeds”. Search string: “Nigeria oil seeds oil content comparison chart OER”.
- Figure 2.2 Chemical composition of oil seeds: Suggested AI prompt “Create a labelled diagram showing proteins, carbohydrates, lipids, vitamins, and minerals in oil seeds”. Search string: “oil seeds chemical composition diagram OER”.
- Table 2.1 Comparative composition of major Nigerian oil seeds: Suggested AI prompt “Generate a comparative table showing protein and oil content of palm, groundnut, soybean, coconut, and sunflower seeds”. Search string: “Nigeria oil seeds comparative composition table OER”.
- Plate 2.2 Culinary uses of oil seeds in Nigeria: Suggested AI prompt “Generate an image showing Nigerian dishes such as egusi soup with palm oil and fried snacks with groundnut oil”. Search string: “Nigeria dishes palm oil groundnut oil photo OER”.
- Box 2.1 Industrial applications of Nigerian oil seeds: Suggested AI prompt “Generate a text box listing industrial applications of palm, groundnut, soybean, coconut, and sunflower oils”. Search string: “Nigeria oil seeds industrial applications OER”.
- Figure 2.3 Medicinal and cultural uses of Nigerian oil seeds: Suggested AI prompt “Create a diagram showing medicinal uses (skin treatment, massage therapy) and cultural uses (rituals, offerings) of oil seeds in Nigeria”. Search string: “Nigeria oil seeds medicinal cultural uses diagram OER”.
- Plate 2.3 Palm fruits and oil extraction in Nigeria: Suggested AI prompt “Generate an image showing palm fruits and oil extraction process in Nigeria”. Search string: “Nigeria palm oil extraction photo OER”.
- Figure 2.4 Uses of groundnut seed and oil: Suggested AI prompt “Create a diagram showing culinary and industrial uses of groundnut seed and oil”. Search string: “Nigeria groundnut oil uses diagram OER”.
- Table 2.2 Nutritional composition of soybean seed: Suggested AI prompt “Generate a table showing nutritional composition of soybean seed”. Search string: “Nigeria soybean nutritional composition table OER”.

- Box 2.2 Key features of coconut and sunflower seeds: Suggested AI prompt “Generate a text box listing key features of coconut and sunflower seeds”. Search string: “Nigeria coconut sunflower oil features OER”.

Series 3: Vegetable Oil Raw Materials

Series outline

- **3.1 Classification of vegetable oil raw materials**
    - Oil-bearing seeds and fruits
    - Animal-based raw materials (brief overview for contrast)
    - Other minor sources
- **3.2 Properties of vegetable oil raw materials**
    - Physical properties (size, colour, texture)
    - Chemical properties (oil content, fatty acid profile)
    - Nutritional properties
- **3.3 Processing requirements**
    - Pre-treatment (cleaning, drying, dehulling)
    - Extraction methods (mechanical, solvent)
    - Refining and storage considerations
- **3.4 Case studies of selected raw materials**
    - Palm fruit
    - Groundnut
    - Soybean
    - Coconut and sunflower

Introduction

Vegetable oil raw materials form the essential base of Nigeria's oils and fats industry. They include oil-bearing seeds and fruits that provide the oils consumed daily and used in industrial applications. Understanding their classification, properties, and processing requirements is crucial for appreciating how raw materials are transformed into finished products. This Series will help you connect the science of raw materials with their practical applications in food, industry, and trade.

The aim of this Series is to introduce you to the classification, properties, and processing requirements of vegetable oil raw materials, while also examining selected case studies of major raw materials such as palm fruit, groundnut, soybean, coconut, and sunflower.

We shall commence this Series by classifying vegetable oil raw materials, distinguishing between oil-bearing seeds, fruits, and other sources. Next, we will explore their properties, focusing on physical, chemical, and nutritional aspects. Following that, we will consider the processing requirements, including pre-treatment, extraction, and refining. Finally, we will conclude with case studies of selected raw materials, highlighting their importance and applications in Nigeria.

Series Learning Outcomes

Upon completing this Series, you should be able to:

- **SLO 3.1** classify vegetable oil raw materials into seeds, fruits, and other sources,
- **SLO 3.2** describe the physical, chemical, and nutritional properties of vegetable oil raw materials,
- **SLO 3.3** explain the processing requirements of vegetable oil raw materials, including pre-treatment, extraction, and refining, and
- **SLO 3.4** evaluate case studies of selected raw materials such as palm fruit, groundnut, soybean, coconut, and sunflower.

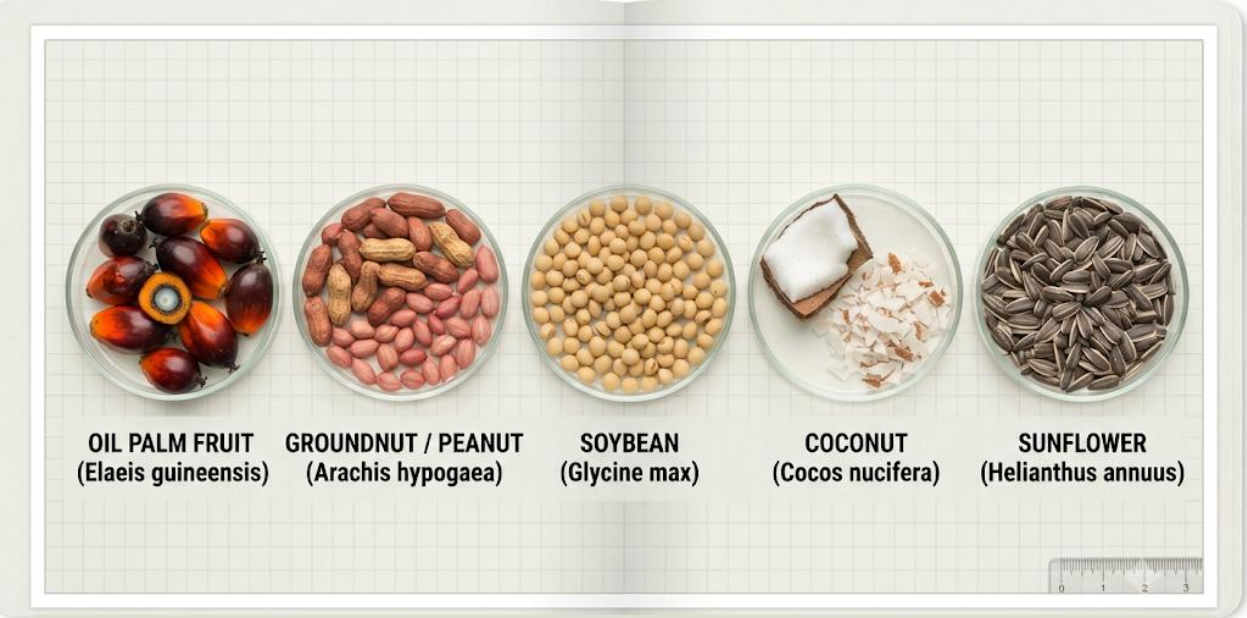
3.1 Classification of Vegetable Oil Raw Materials

3.1.1 Oil-bearing seeds and fruits

Vegetable oil raw materials in Nigeria are primarily derived from **oil-bearing seeds and fruits**, which are plants naturally rich in oils. Examples include palm fruit, groundnut, soybean, coconut, and sunflower. These seeds and fruits are cultivated across different regions of Nigeria and form the backbone of the oils and fats industry. Their oil content makes them suitable for both domestic consumption and industrial applications.

regional distribution Palm fruit is widely grown in the southern regions, groundnut in the north, and soybean across central Nigeria. This distribution reflects climatic and soil conditions that favour specific crops.

Fill in the blank: Palm fruit, groundnut, soybean, coconut, and sunflower are examples of _____ raw materials.



NIGERIA OIL-BEARING SEEDS AND FRUITS PHOTO OER - CC-BY-SA

Image showing palm fruit, groundnut, soybean, coconut, and sunflower side by side Caption: Plate 3.1 Oil-bearing seeds and fruits in Nigeria

3.1.2 Animal-based raw materials (brief overview for contrast)

Although the focus of this course is vegetable oils, it is useful to note that oils can also be derived from **animal-based raw materials**, such as fish oil and lard. **Animal-based raw materials** are fats and oils obtained from animals rather than plants. These are less common in Nigeria's oils and fats industry but provide a contrast to plant-based sources.

Fill in the blank: Fish oil and lard are examples of _____ raw materials.

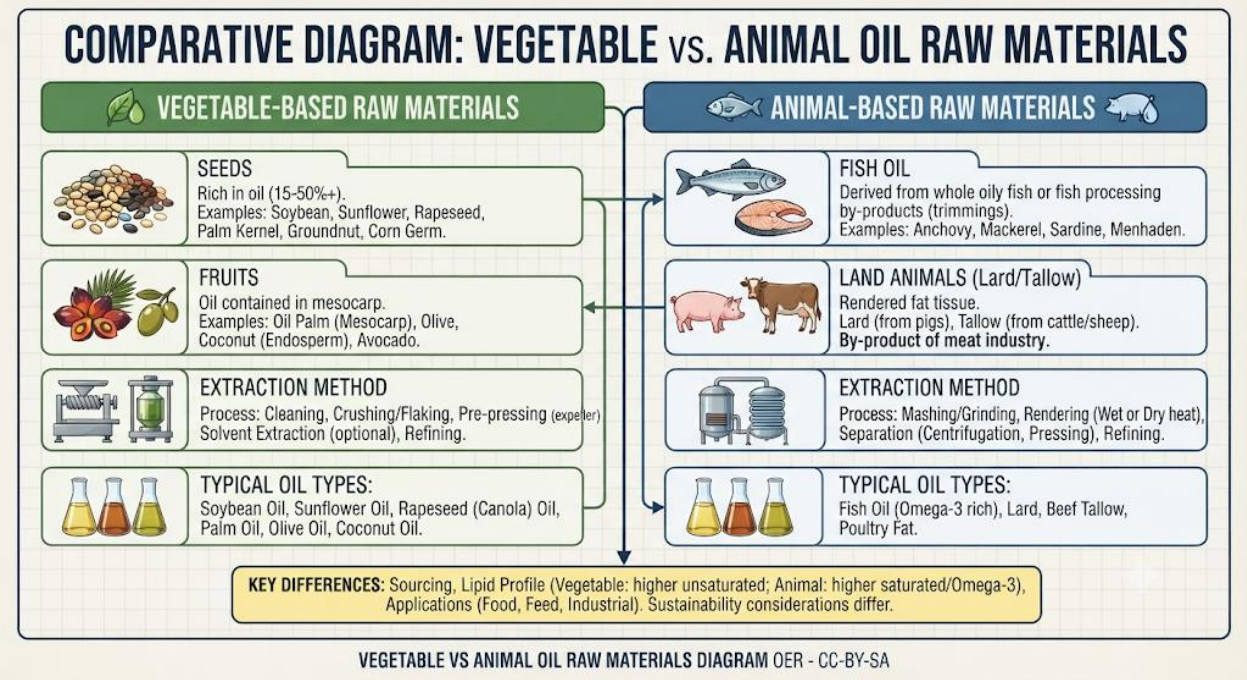
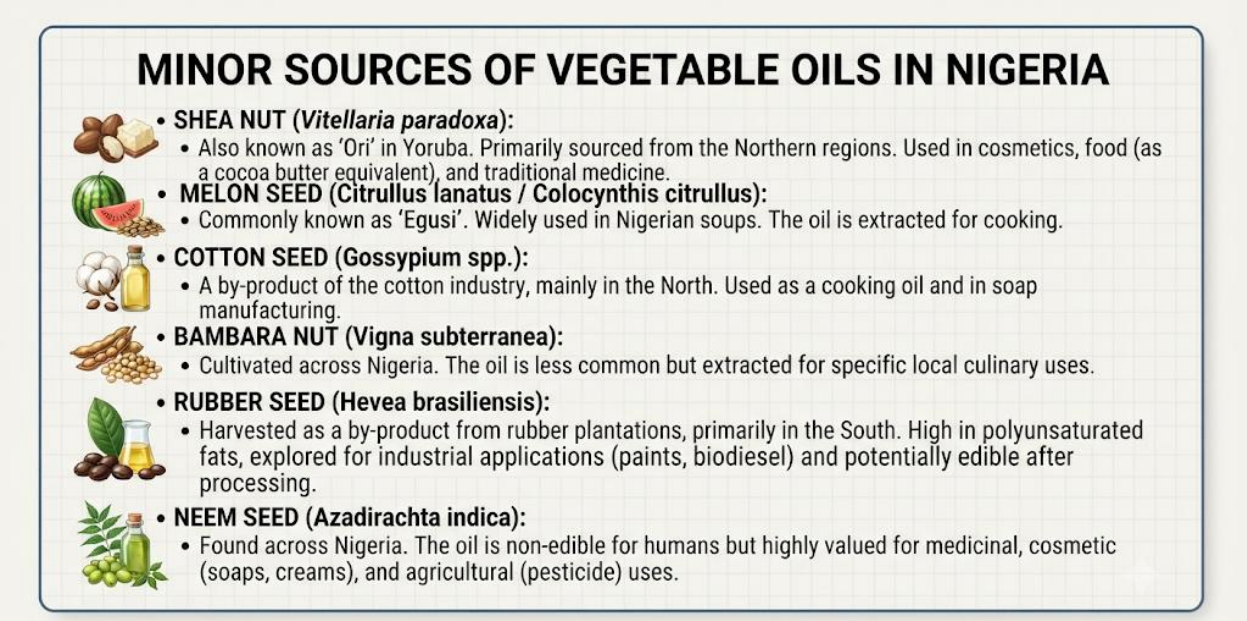


Diagram contrasting vegetable oil raw materials with animal-based raw materials Caption: Figure 3.1 Vegetable vs animal oil raw materials

3.1.3 Other minor sources

In addition to major seeds and fruits, Nigeria also has **minor sources of vegetable oils**, such as sesame seed, cottonseed, and castor seed. These are cultivated on a smaller scale but contribute to the diversity of oil sources. **Minor sources** are less dominant in production but can be important for niche markets and local consumption.

Fill in the blank: Sesame seed, cottonseed, and castor seed are examples of _____ sources of vegetable oils.



Box 3.1 Minor sources of vegetable oils in Nigeria

- Sesame seed
- Cottonseed
- Castor seed

Pilot questions 3.1

1. Name five major oil-bearing seeds and fruits in Nigeria.
2. Which region of Nigeria is most associated with palm fruit cultivation?
3. What are animal-based raw materials?
4. Give two examples of minor sources of vegetable oils in Nigeria.
5. Why are minor sources important despite their smaller scale of production?

3.2 Properties of Vegetable Oil Raw Materials

3.2.1 Physical properties

Vegetable oil raw materials possess distinct **physical properties**, which include size, colour, texture, and hardness. Palm fruits are reddish and fibrous, groundnuts are small and oval with a thin shell, while coconuts have a hard shell enclosing white flesh. These physical attributes influence how easily the raw materials can be processed and the type of equipment required.

Fill in the blank: The _____ properties of vegetable oil raw materials include size, colour, texture, and hardness.

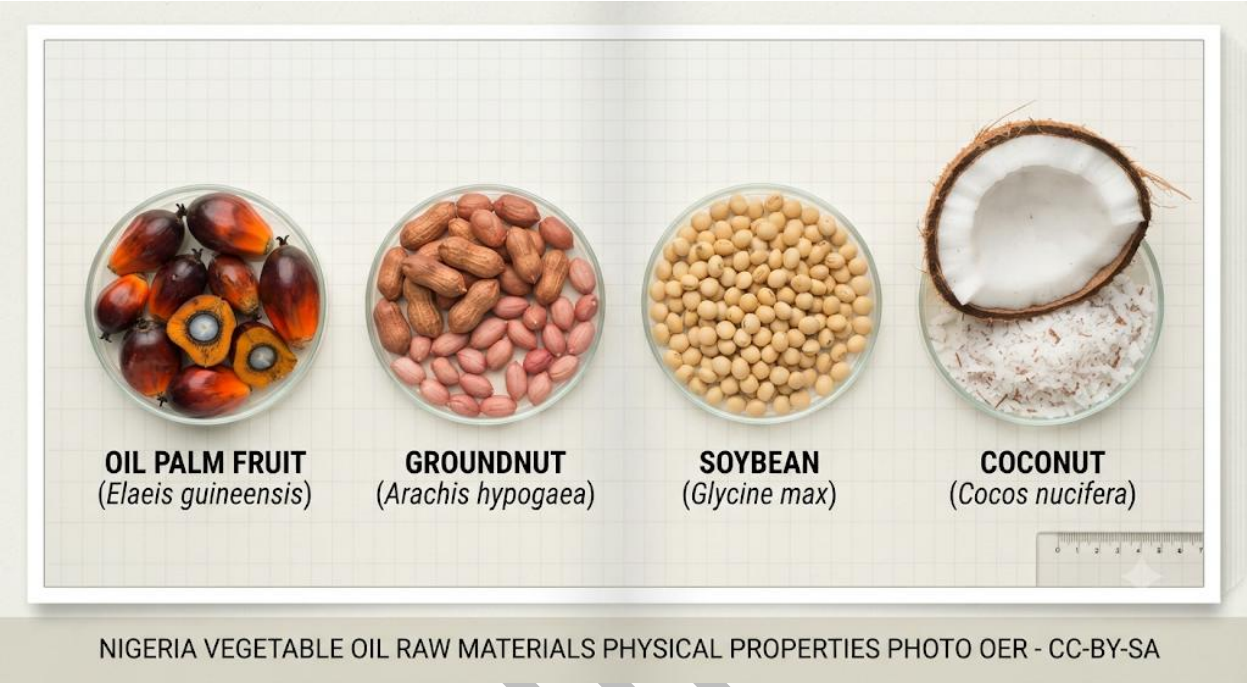
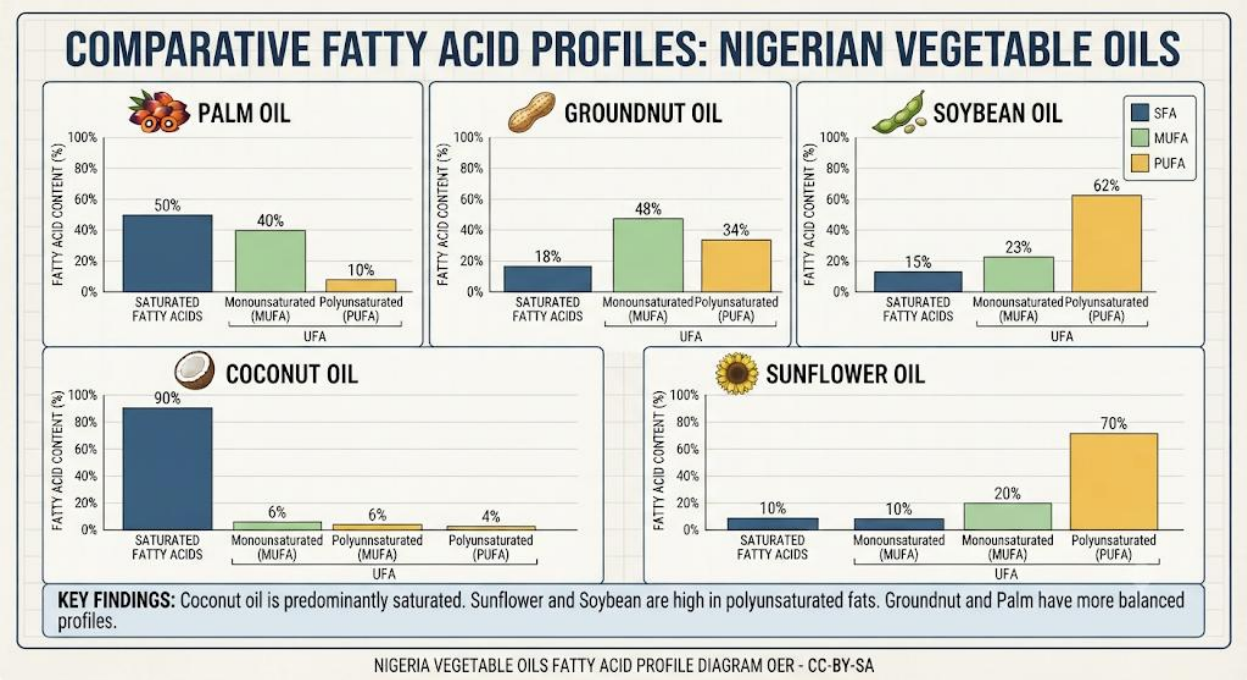


Image showing palm fruit, groundnut, soybean, and coconut with visible physical features Caption: Plate 3.2 Physical properties of vegetable oil raw materials

3.2.2 Chemical properties

The **chemical properties** of vegetable oil raw materials refer to their oil content, fatty acid profile, and other chemical constituents. Palm oil is rich in saturated fatty acids, while sunflower oil contains unsaturated fatty acids beneficial for heart health. Soybean oil has a balanced fatty acid profile, making it versatile for both food and industrial uses.

Fill in the blank: Palm oil is rich in _____ fatty acids, while sunflower oil is rich in unsaturated fatty acids.



NIGERIA VEGETABLE OILS FATTY ACID PROFILE DIAGRAM OER - CC-BY-SA

Diagram showing fatty acid profiles of palm, groundnut, soybean, coconut, and sunflower oils
Caption: Figure 3.2 Fatty acid profiles of selected vegetable oils

3.2.3 Nutritional properties

Vegetable oil raw materials also provide important **nutritional properties**, including proteins, vitamins, and minerals. Groundnuts and soybeans are rich in protein, making them valuable for human diets and animal feed. Palm oil contains vitamin E and carotenoids, while coconut oil provides quick energy due to its medium-chain triglycerides.

Fill in the blank: Soybeans and groundnuts are valued for their high _____ content, making them important in diets and animal feed.

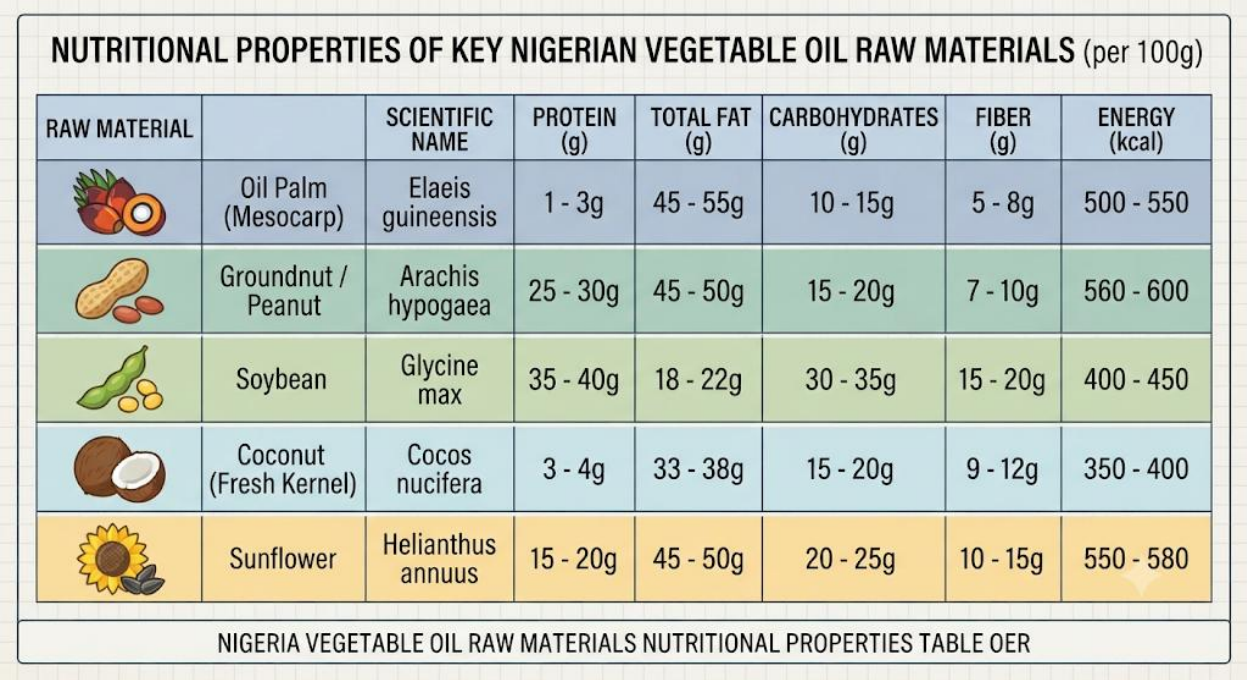


Table 3.1 Nutritional properties of selected vegetable oil raw materials

Raw material	Key nutrient	Nutritional benefit
Palm fruit	Vitamin E, carotenoids	Antioxidant properties
Groundnut	Protein, oil	Balanced nutrition
Soybean	Protein, oil	High protein source
Coconut	Medium-chain triglycerides	Quick energy
Sunflower	Unsaturated fatty acids	Heart health

Pilot questions 3.2

1. What are the physical properties of vegetable oil raw materials?
2. Which type of fatty acids are abundant in palm oil?
3. Name one oil seed rich in unsaturated fatty acids.
4. Which two oil seeds are valued for their high protein content?
5. What nutrient in palm oil provides antioxidant properties?

3.3 Processing Requirements of Vegetable Oil Raw Materials

3.3.1 Pre-treatment

Before extraction, vegetable oil raw materials undergo **pre-treatment**, which refers to preparatory steps such as cleaning, drying, and dehulling. Cleaning removes dirt and foreign matter, drying reduces moisture content to prevent spoilage, and dehulling separates the seed coat from the kernel. These steps improve oil yield and quality.

Fill in the blank: Cleaning, drying, and _____ are examples of pre-treatment processes for vegetable oil raw materials.

Image showing cleaning and dehulling of oil seeds Caption: Plate 3.3 Pre-treatment of vegetable oil raw materials

3.3.2 Extraction methods

The next stage involves **extraction methods**, which are techniques used to obtain oil from seeds and fruits. Mechanical extraction uses equipment such as hydraulic presses and expellers, while solvent extraction employs chemical solvents to dissolve and separate oils. Mechanical methods are common in small-scale operations, while solvent extraction is typical of large-scale industrial plants.

Fill in the blank: Hydraulic presses and expellers are examples of _____ extraction methods.

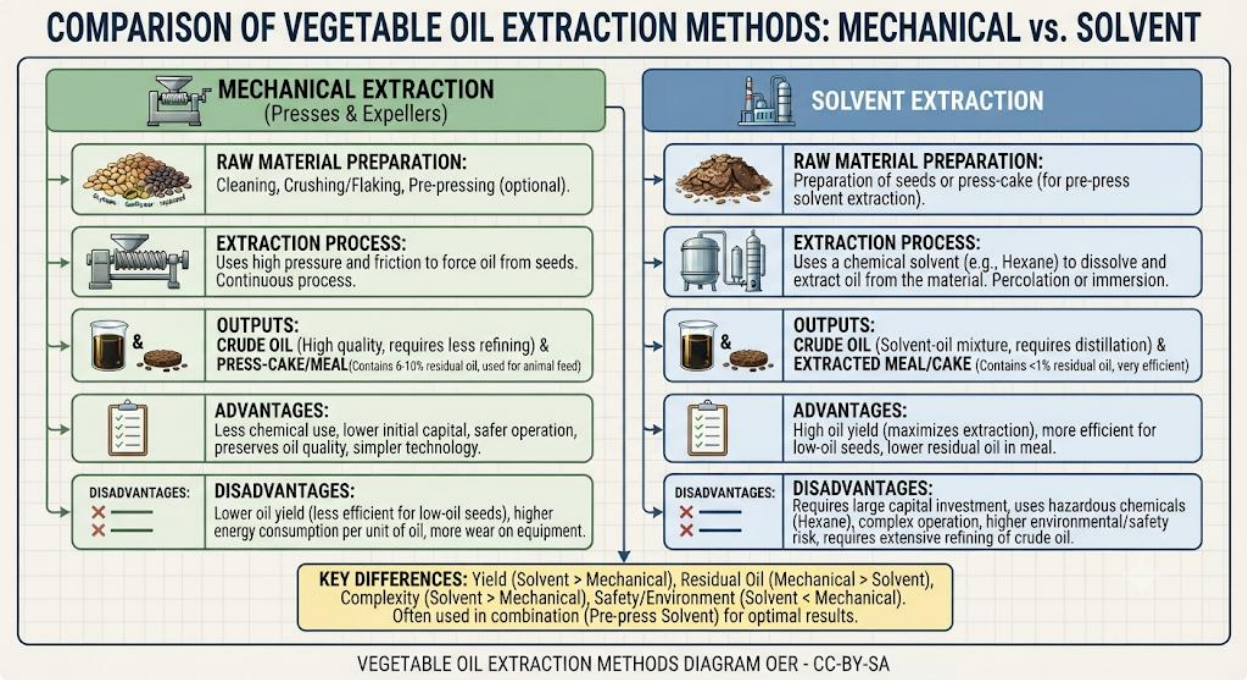


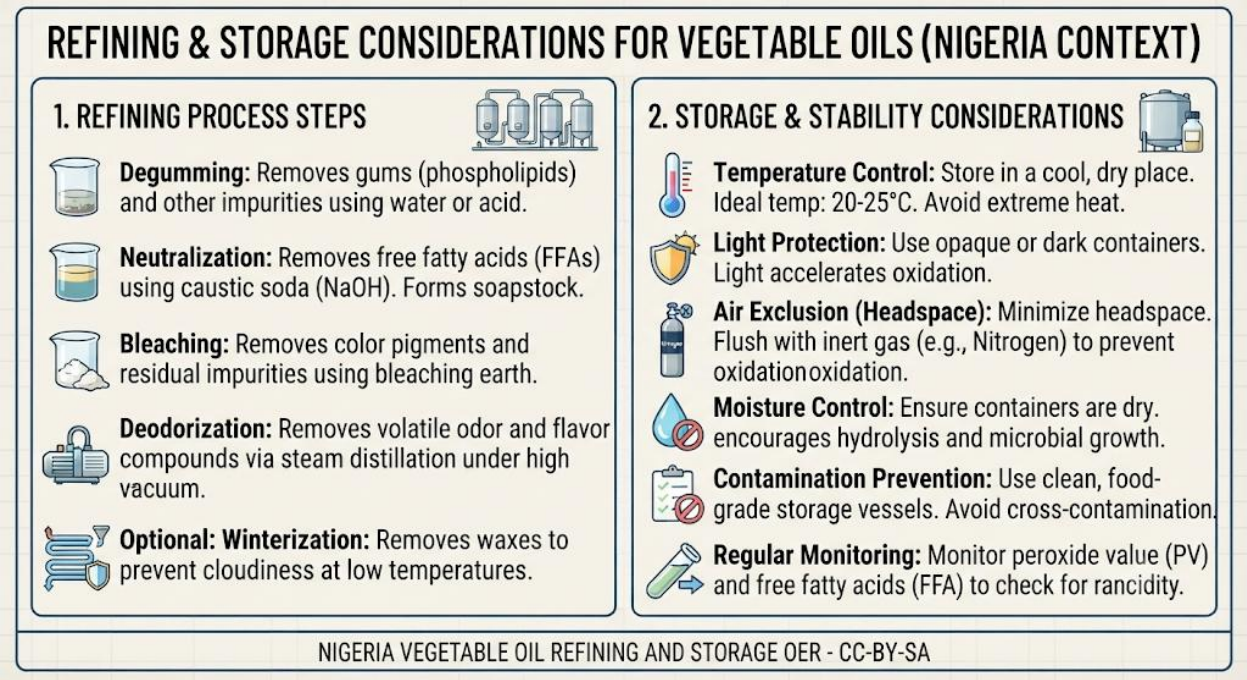
Diagram showing mechanical vs solvent extraction methods Caption: Figure 3.3 Mechanical and solvent extraction methods

3.3.3 Refining and storage considerations

After extraction, oils must be refined to remove impurities and improve quality. **Refining** involves processes such as neutralisation, bleaching, and deodorisation. These steps ensure oils are safe, clear, and suitable for consumption or industrial use.

Proper **storage** is also essential. Oils should be kept in clean, airtight containers away from heat and light to prevent rancidity. Good storage practices extend shelf life and maintain nutritional value.

Fill in the blank: Neutralisation, bleaching, and _____ are examples of refining processes for vegetable oils.



Box 3.2 Refining and storage considerations for vegetable oils

- Neutralisation: removes free fatty acids
- Bleaching: improves clarity and colour
- Deodorisation: removes odours
- Storage: airtight containers, cool environment

Pilot questions 3.3

1. What are three examples of pre-treatment processes for vegetable oil raw materials?
2. Which extraction method uses hydraulic presses and expellers?
3. What is solvent extraction, and where is it commonly used?
4. Name two refining processes applied to vegetable oils.
5. Why is proper storage important for vegetable oils?

3.4 Case Studies of Selected Raw Materials

3.4.1 Palm fruit

Palm fruit is Nigeria's most prominent vegetable oil raw material. It yields **palm oil**, which is widely used in cooking, soap-making, and industrial applications. The fruit is fibrous and reddish, with a

high oil content that makes it economically valuable. Nigeria has a long history of palm oil production, particularly in the southern regions.

Fill in the blank: Palm fruit is especially abundant in the _____ region of Nigeria.

Image of palm fruit bunches ready for oil extraction Caption: Plate 3.4 Palm fruit bunches in Nigeria

3.4.2 Groundnut

Groundnut is a major oil seed cultivated in northern Nigeria. It provides **groundnut oil**, which is widely used for frying, baking, and margarine production. Groundnuts are also consumed directly as snacks or processed into paste. Industrially, groundnut oil is applied in confectionery and soap-making.

Fill in the blank: Groundnut oil is widely used for _____ and baking in Nigeria.

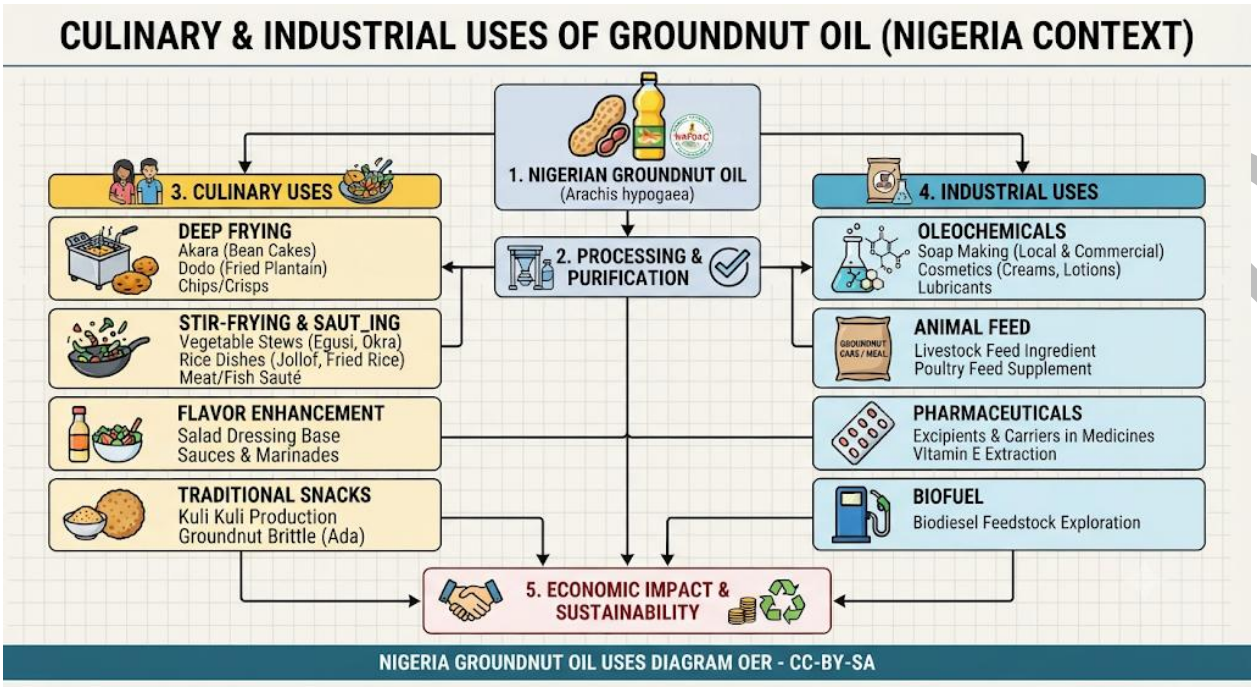
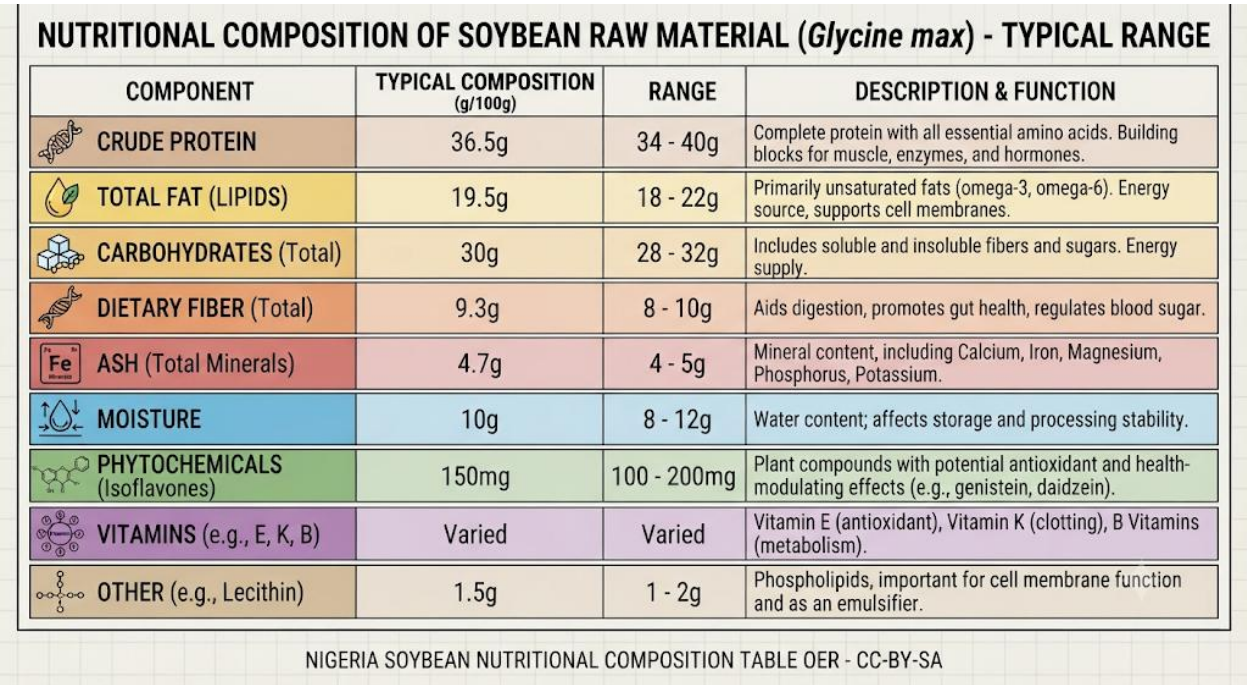


Diagram showing groundnut oil uses in Nigeria Caption: Figure 3.4 Groundnut oil uses in Nigeria

3.4.3 Soybean

Soybean is valued for its high **protein content** and moderate oil yield. Soybean oil is neutral in flavour, making it suitable for diverse cooking methods. Industrially, it is used in paints, lubricants, and biodiesel production. Soybeans also serve as a major source of animal feed due to their protein-rich composition.

Fill in the blank: Soybean is valued for its high _____ content, making it important for both human and animal diets.



NUTRITIONAL COMPOSITION OF SOYBEAN RAW MATERIAL (*Glycine max*) - TYPICAL RANGE

COMPONENT	TYPICAL COMPOSITION (g/100g)	RANGE	DESCRIPTION & FUNCTION
CRUDE PROTEIN	36.5g	34 - 40g	Complete protein with all essential amino acids. Building blocks for muscle, enzymes, and hormones.
TOTAL FAT (LIPIDS)	19.5g	18 - 22g	Primarily unsaturated fats (omega-3, omega-6). Energy source, supports cell membranes.
CARBOHYDRATES (Total)	30g	28 - 32g	Includes soluble and insoluble fibers and sugars. Energy supply.
DIETARY FIBER (Total)	9.3g	8 - 10g	Aids digestion, promotes gut health, regulates blood sugar.
ASH (Total Minerals)	4.7g	4 - 5g	Mineral content, including Calcium, Iron, Magnesium, Phosphorus, Potassium.
MOISTURE	10g	8 - 12g	Water content; affects storage and processing stability.
PHYTOCHEMICALS (Isoflavones)	150mg	100 - 200mg	Plant compounds with potential antioxidant and health-modulating effects (e.g., genistein, daidzein).
VITAMINS (e.g., E, K, B)	Varied	Varied	Vitamin E (antioxidant), Vitamin K (clotting), B Vitamins (metabolism).
OTHER (e.g., Lecithin)	1.5g	1 - 2g	Phospholipids, important for cell membrane function and as an emulsifier.

NIGERIA SOYBEAN NUTRITIONAL COMPOSITION TABLE OER - CC-BY-SA

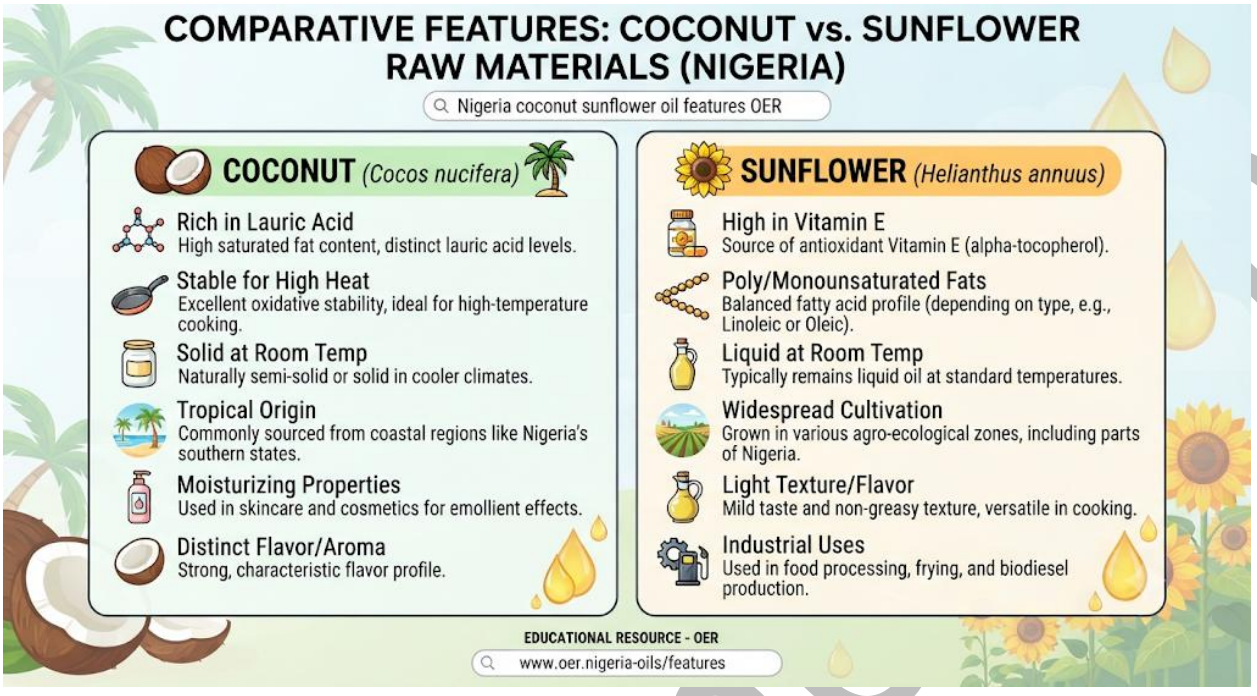
Table 3.2 Nutritional composition of soybean raw material

Component	Percentage	Notable feature
Protein	35–40%	High protein content
Oil	18–20%	Neutral flavour
Carbohydrate	30%	Energy source

3.4.4 Coconut and sunflower

Coconut yields **coconut oil**, rich in saturated fats and widely used in cooking, cosmetics, and hair products. It is also applied medicinally for skin care. Sunflower produces **sunflower oil**, valued for its unsaturated fatty acids and anti-inflammatory properties. Both raw materials are increasingly cultivated in Nigeria to diversify oil sources and reduce dependence on palm oil.

Fill in the blank: Sunflower oil is valued for its _____ fatty acids and anti-inflammatory properties.



Box 3.3 Key features of coconut and sunflower raw materials

- Coconut oil: rich in saturated fats, used in cooking and cosmetics
- Sunflower oil: rich in unsaturated fatty acids, used in pharmaceuticals and cooking

Pilot questions 3.4

1. Which region of Nigeria is most associated with palm fruit cultivation?
2. What is groundnut oil commonly used for in Nigeria?
3. Why is soybean important for both human and animal diets?
4. Which oil seed is rich in saturated fats and widely used in cosmetics?
5. Which oil seed is valued for its unsaturated fatty acids?

Series Summary

This Series has explored the essential raw materials that underpin Nigeria's vegetable oil industry. We began by classifying oil-bearing seeds and fruits, contrasting them briefly with animal-based sources, and identifying minor contributors such as sesame and cottonseed. We then examined their physical, chemical, and nutritional properties, showing how these characteristics influence processing and value. Following this, we considered the processing requirements, including pre-treatment, extraction methods, and refining and storage practices. Finally, we analysed case

studies of palm fruit, groundnut, soybean, coconut, and sunflower, highlighting their economic and nutritional importance.

By completing this Series, you should now be able to classify vegetable oil raw materials (SLO 3.1), describe their properties (SLO 3.2), explain their processing requirements (SLO 3.3), and evaluate case studies of selected raw materials (SLO 3.4).

Series Glossary

- **Animal-based raw materials**: Oils and fats obtained from animals, such as fish oil and lard.
- **Dehulling**: The process of removing the seed coat from oil seeds before extraction.
- **Extraction methods**: Techniques used to obtain oil from seeds and fruits, including mechanical and solvent extraction.
- **Fatty acid profile**: The balance of saturated and unsaturated fatty acids in oils.
- **Minor sources**: Oil seeds cultivated on a smaller scale, such as sesame, cottonseed, and castor seed.
- **Neutralisation**: A refining process that removes free fatty acids from oils.
- **Palm fruit**: A major oil-bearing fruit in Nigeria, yielding palm oil.
- **Pre-treatment**: Preparatory steps such as cleaning, drying, and dehulling before oil extraction.
- **Refining**: Processes applied to oils to remove impurities and improve quality.
- **Soybean**: An oil seed rich in protein and moderate oil content, used in food and industry.

Concept Check Questions [Series 3]

Objective questions

1. Which oil-bearing fruit is most associated with southern Nigeria? (Linked to SLO 3.1)
2. What type of fatty acids are abundant in sunflower oil? (Linked to SLO 3.2)
3. Which refining process removes free fatty acids from oils? (Linked to SLO 3.3)

Short-answer questions

4. Describe one physical property of vegetable oil raw materials. (Linked to SLO 3.2)
5. Explain the difference between mechanical and solvent extraction methods. (Linked to SLO 3.3)
6. Identify one minor source of vegetable oils in Nigeria. (Linked to SLO 3.1)

Long-answer questions

7. Analyse the processing requirements of vegetable oil raw materials, focusing on pre-treatment, extraction, and refining. (Linked to SLO 3.3)
    - **Basic response**: Learners should describe cleaning, drying, dehulling, mechanical and solvent extraction, and refining processes.
    - **Value-added response**: Outstanding learners may also evaluate efficiency differences between methods and propose improvements for Nigerian processors.
8. Evaluate the economic and nutritional importance of palm fruit, groundnut, soybean, coconut, and sunflower in Nigeria. (Linked to SLO 3.4)
    - **Basic response**: Learners should explain the uses of each raw material in food, industry, and nutrition.
    - **Value-added response**: Outstanding learners may also assess their role in regional economies, export trade, and diversification strategies.

Answers to Pilot Questions [Series 3]

1. Palm fruit, groundnut, soybean, coconut, sunflower.
2. Southern Nigeria.
3. Oils and fats obtained from animals.
4. Sesame seed and cottonseed.
5. They contribute to diversity and niche markets.
6. Size, colour, texture, hardness.
7. Saturated fatty acids.
8. Sunflower.
9. Soybean and groundnut.
10. Vitamin E.
11. Cleaning, drying, dehulling.
12. Mechanical extraction.
13. Use of chemical solvents in large-scale plants.
14. Neutralisation and bleaching.
15. To prevent rancidity and maintain quality.
16. Southern Nigeria.
17. Frying.

18. High protein content.
19. Coconut.
20. Sunflower.

References and Attributions [Series 3]

- Plate 3.1 Oil-bearing seeds and fruits in Nigeria: Suggested AI prompt “Generate an image showing palm fruit, groundnut, soybean, coconut, and sunflower seeds/fruits together”. Search string: “Nigeria oil-bearing seeds and fruits photo OER”.
- Figure 3.1 Vegetable vs animal oil raw materials: Suggested AI prompt “Create a diagram contrasting vegetable oil raw materials (seeds, fruits) with animal-based raw materials (fish oil, lard)”. Search string: “vegetable vs animal oil raw materials diagram OER”.
- Box 3.1 Minor sources of vegetable oils in Nigeria: Suggested AI prompt “Generate a text box listing minor sources of vegetable oils in Nigeria”. Search string: “Nigeria minor vegetable oil sources OER”.
- Plate 3.2 Physical properties of vegetable oil raw materials: Suggested AI prompt “Generate an image showing palm fruit, groundnut, soybean, and coconut highlighting their physical features”. Search string: “Nigeria vegetable oil raw materials physical properties photo OER”.
- Figure 3.2 Fatty acid profiles of selected vegetable oils: Suggested AI prompt “Create a diagram comparing saturated and unsaturated fatty acid profiles of palm, groundnut, soybean, coconut, and sunflower oils”. Search string: “Nigeria vegetable oils fatty acid profile diagram OER”.
- Table 3.1 Nutritional properties of selected vegetable oil raw materials: Suggested AI prompt “Generate a table showing nutritional properties of palm, groundnut, soybean, coconut, and sunflower raw materials”. Search string: “Nigeria vegetable oil raw materials nutritional properties table OER”.
- Plate 3.3 Pre-treatment of vegetable oil raw materials: Suggested AI prompt “Generate an image showing cleaning, drying, and dehulling of groundnut and soybean seeds”. Search string: “Nigeria vegetable oil raw materials pre-treatment photo OER”.
- Figure 3.3 Mechanical and solvent extraction methods: Suggested AI prompt “Create a diagram comparing mechanical extraction (presses, expellers) and solvent extraction methods for vegetable oils”. Search string: “vegetable oil extraction methods diagram OER”.
- Box 3.2 Refining and storage considerations for vegetable oils: Suggested AI prompt “Generate a text box listing refining and storage considerations for vegetable oils”. Search string: “Nigeria vegetable oil refining and storage OER”.

- Plate 3.4 Palm fruit bunches in Nigeria: Suggested AI prompt “Generate an image showing palm fruit bunches harvested for oil extraction in Nigeria”. Search string: “Nigeria palm fruit bunches photo OER”.
- Figure 3.4 Groundnut oil uses in Nigeria: Suggested AI prompt “Create a diagram showing culinary and industrial uses of groundnut oil in Nigeria”. Search string: “Nigeria groundnut oil uses diagram OER”.
- Table 3.2 Nutritional composition of soybean raw material: Suggested AI prompt “Generate a table showing nutritional composition of soybean raw material”. Search string: “Nigeria soybean nutritional composition table OER”.
- Box 3.3 Key features of coconut and sunflower raw materials: Suggested AI prompt “Generate a text box listing key features of coconut and sunflower raw materials”. Search string: “Nigeria coconut sunflower oil features OER”.

Series 4: Climatic and Storage Effects on Glycerides

Series outline

- **4.1 Introduction to glycerides**
    - Definition and types of glycerides (mono-, di-, tri-glycerides)
    - Importance in oils and fats industry
- **4.2 Climatic influences on glycerides**
    - Temperature effects on stability and rancidity
    - Humidity and moisture absorption
    - Regional climatic variations in Nigeria
- **4.3 Storage conditions and their impact**
    - Proper storage practices (containers, light, air exposure)
    - Chemical changes during storage (oxidation, hydrolysis)
    - Shelf life considerations
- **4.4 Case studies of glyceride behaviour**
    - Palm oil storage under tropical conditions

- Groundnut oil susceptibility to rancidity
- Soybean oil oxidation patterns
- Coconut and sunflower oil storage outcomes

Introduction

Glycerides, which include mono-, di-, and tri-glycerides, are the fundamental chemical compounds found in oils and fats. They serve as the primary storage form of energy in plants and animals and are central to the nutritional and industrial value of vegetable oils. However, their stability and quality are significantly influenced by external factors such as climate and storage conditions.

This Series focuses on how climatic factors (temperature, humidity, and regional variations) and storage practices (containers, exposure to light and air, refining, and shelf life) affect glycerides. By studying these influences, you will understand why oils and fats may deteriorate, lose nutritional value, or develop undesirable qualities, and how proper management can preserve their usefulness.

We shall commence this Series by introducing glycerides and their importance in the oils and fats industry. Next, we will examine climatic influences, focusing on temperature, humidity, and regional variations. Following that, we will consider storage conditions and their impact, including refining, oxidation, and shelf life. Finally, we will conclude with case studies of glyceride behaviour in palm, groundnut, soybean, coconut, and sunflower oils under different climatic and storage conditions.

Series Learning Outcomes

Upon completing this Series, you should be able to:

- **SLO 4.1** define glycerides and explain their types and importance in oils and fats,
- **SLO 4.2** analyse the effects of climatic factors such as temperature, humidity, and regional variations on glycerides,
- **SLO 4.3** explain how storage conditions influence glyceride stability, including oxidation, hydrolysis, and shelf life, and
- **SLO 4.4** evaluate case studies of glyceride behaviour in palm, groundnut, soybean, coconut, and sunflower oils under varying climatic and storage conditions.

4.1 Introduction to Glycerides

4.1.1 Definition of glycerides

Glycerides are chemical compounds formed when glycerol combines with fatty acids. They are the main constituents of oils and fats, serving as energy storage molecules in plants and animals. Depending on the number of fatty acids attached to glycerol, glycerides can be classified into mono-, di-, and tri-glycerides.

Fill in the blank: Glycerides are formed when _____ combines with fatty acids.

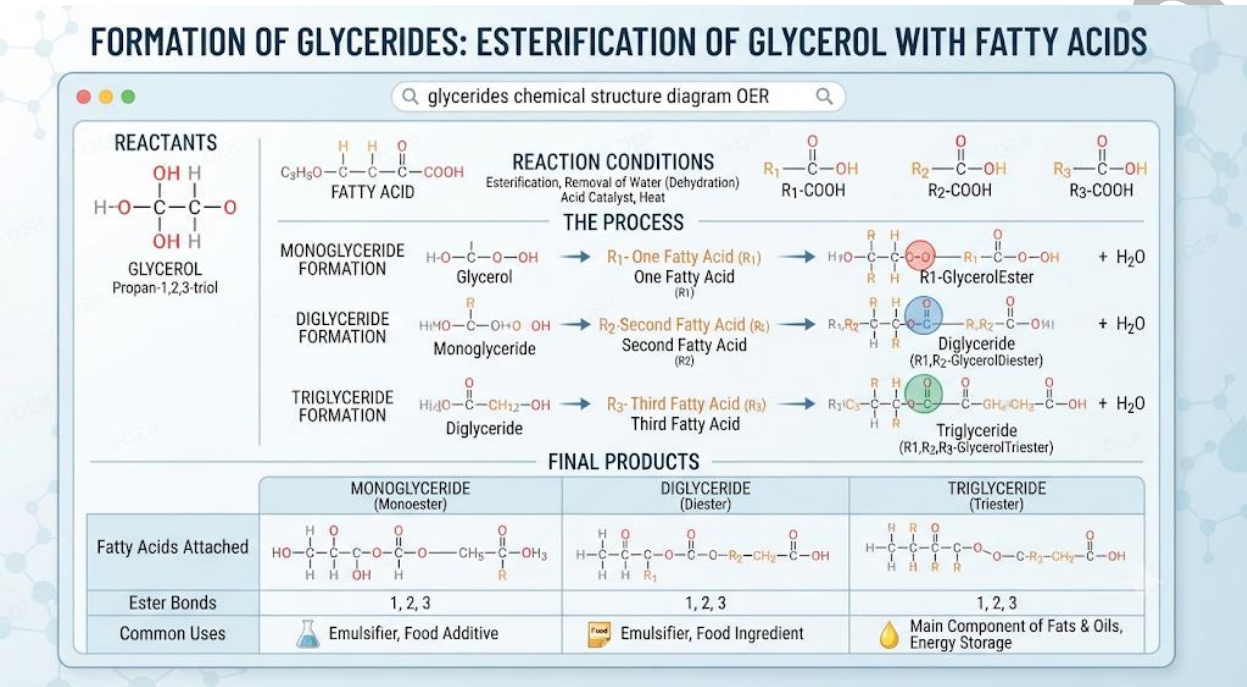


Diagram showing glycerol molecule bonding with fatty acids to form glycerides Caption: Figure 4.1 Formation of glycerides

4.1.2 Types of glycerides

- **Mono-glycerides**: contain one fatty acid attached to glycerol.
- **Di-glycerides**: contain two fatty acids attached to glycerol.
- **Tri-glycerides**: contain three fatty acids attached to glycerol; these are the most common in vegetable oils.

Tri-glycerides dominate in edible oils and fats, making them the most important type for food and industrial applications.

Fill in the blank: The most common glycerides in vegetable oils are _____.

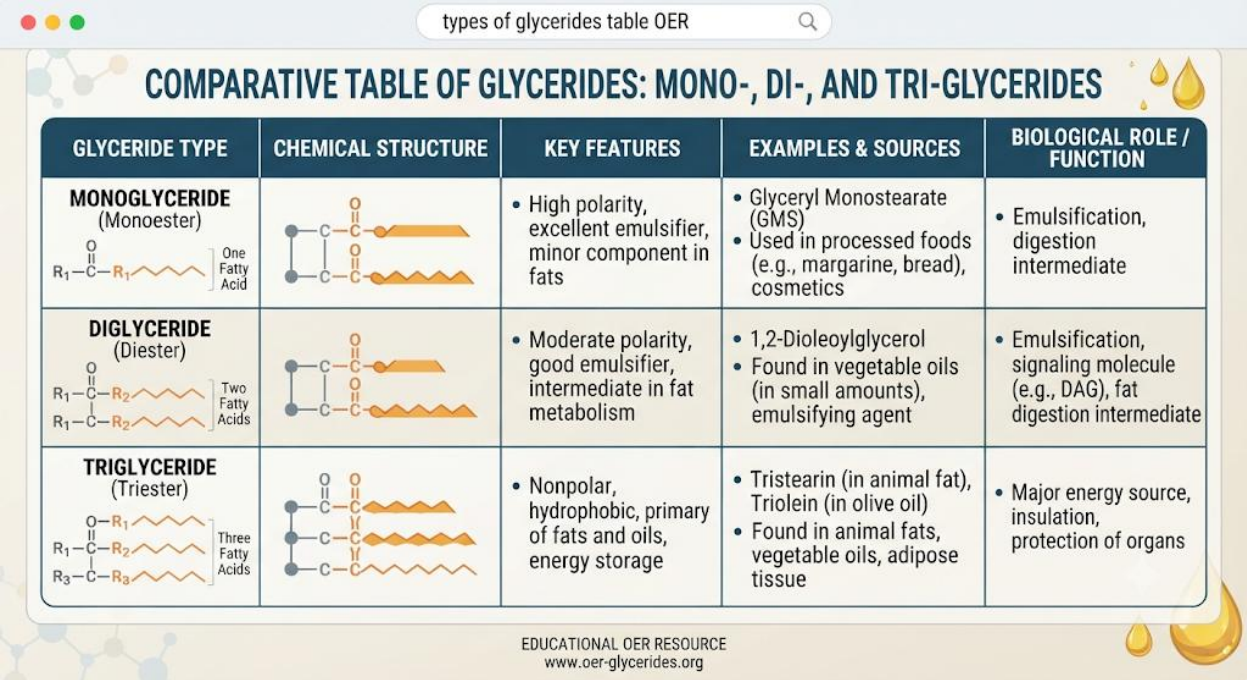


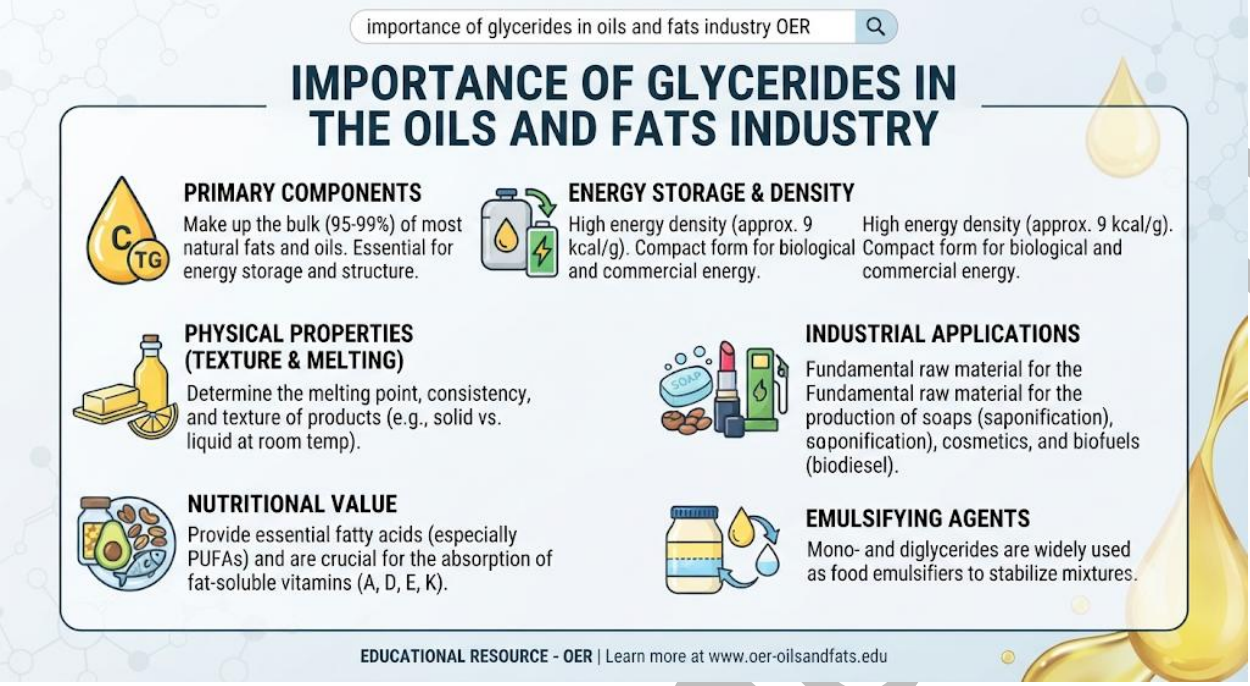
Table 4.1 Types of glycerides

Type	Fatty acids attached	Example use
Mono-glyceride	One	Food emulsifiers
Di-glyceride	Two	Intermediate compounds
Tri-glyceride	Three	Main component of oils and fats

4.1.3 Importance of glycerides in oils and fats industry

Glycerides are central to the **oils and fats industry** because they determine the nutritional value, stability, and industrial applications of oils. Tri-glycerides provide energy and essential fatty acids, while mono- and di-glycerides are used as emulsifiers in food processing. The behaviour of glycerides under climatic and storage conditions directly affects oil quality, shelf life, and usability.

Fill in the blank: Mono- and di-glycerides are commonly used as _____ in food processing.



Box 4.1 Importance of glycerides

- Energy source in diets
- Provide essential fatty acids
- Used as emulsifiers in food industry
- Influence oil stability and shelf life

Pilot questions 4.1

1. What are glycerides formed from?
2. Name the three types of glycerides.
3. Which type of glyceride is most common in vegetable oils?
4. What role do mono- and di-glycerides play in food processing?
5. Why are glycerides important in the oils and fats industry?

4.2 Climatic Influences on Glycerides

4.2.1 Temperature effects

Temperature plays a major role in the stability of glycerides. High temperatures accelerate **oxidation** and **rancidity**, causing oils to lose flavour, colour, and nutritional value. In tropical climates like Nigeria, oils such as palm and groundnut are particularly vulnerable to heat-induced

deterioration. Conversely, low temperatures can cause oils to solidify, affecting their usability but slowing down chemical changes.

Fill in the blank: High temperatures accelerate _____ and rancidity in glycerides.

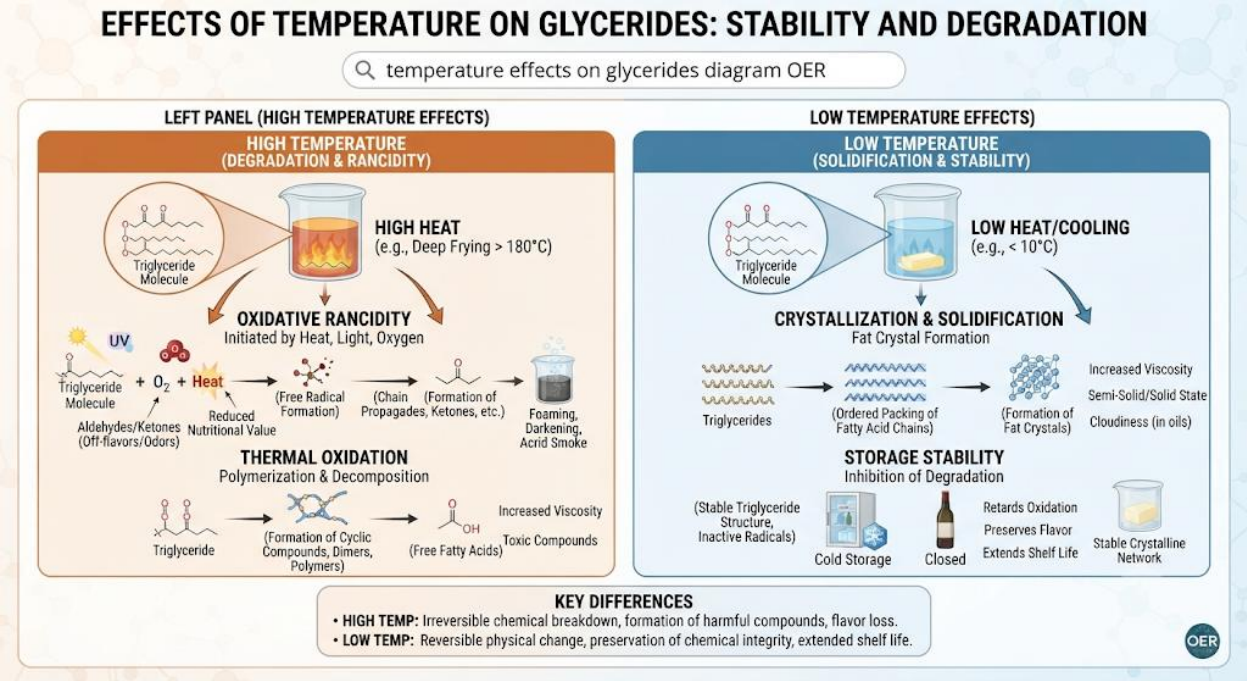


Diagram showing the effect of high vs low temperature on glyceride stability Caption: Figure 4.2 Temperature effects on glycerides

4.2.2 Humidity and moisture absorption

Humidity influences glycerides by promoting **moisture absorption**, which can lead to hydrolysis. Hydrolysis breaks down glycerides into free fatty acids, reducing oil quality and increasing acidity. Oils stored in humid environments without proper sealing are more likely to spoil quickly.

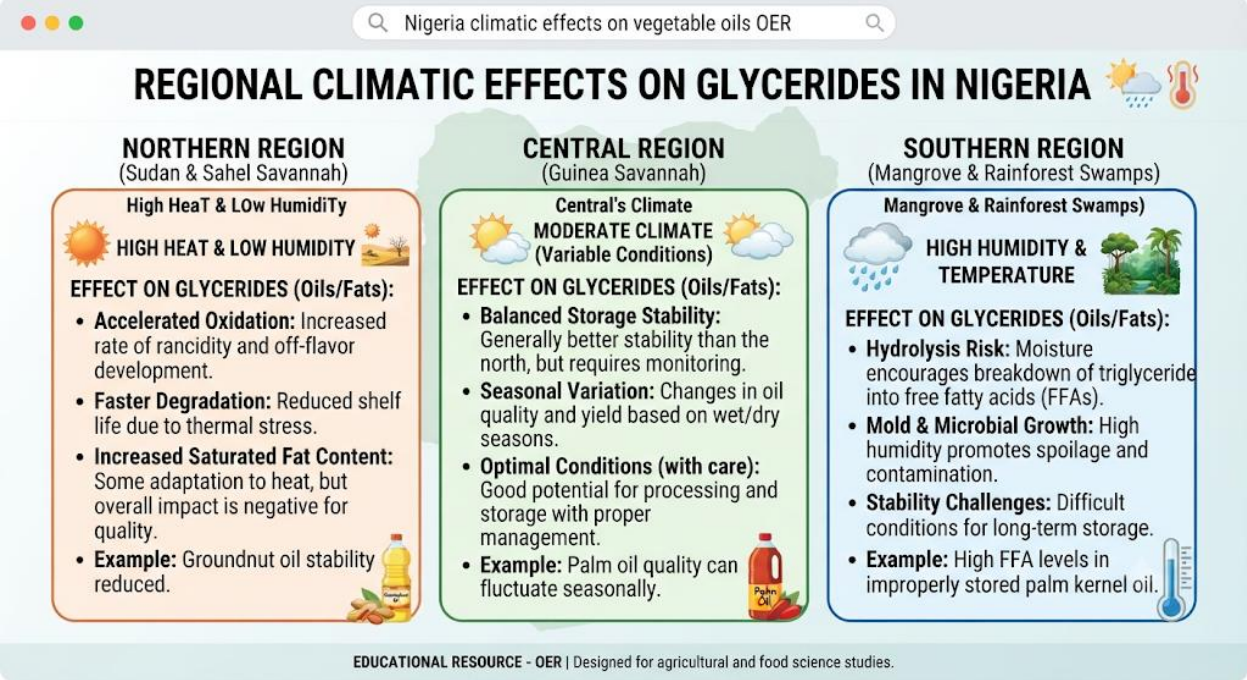
Fill in the blank: Humidity promotes _____ absorption, which can lead to hydrolysis of glycerides.

Image showing oil containers exposed to humid conditions Caption: Plate 4.2 Humidity effects on stored oils

4.2.3 Regional climatic variations in Nigeria

Nigeria's diverse climate zones affect glyceride behaviour differently. In the humid south, palm oil is prone to hydrolysis and rancidity due to high moisture levels. In the drier north, groundnut oil is more stable but still vulnerable to heat-induced oxidation. Soybean and sunflower oils, cultivated in central regions, face moderate risks from both heat and humidity.

Fill in the blank: In the humid southern regions of Nigeria, palm oil is prone to _____ and rancidity.



Box 4.2 Regional climatic effects on glycerides in Nigeria

- Southern Nigeria: high humidity → hydrolysis and rancidity in palm oil
- Northern Nigeria: high temperature → oxidation in groundnut oil
- Central Nigeria: moderate risks → soybean and sunflower oils affected by both heat and humidity

Pilot questions 4.2

1. What effect does high temperature have on glycerides?
2. How does humidity affect glyceride stability?
3. Which climatic condition in southern Nigeria makes palm oil prone to rancidity?
4. Why is groundnut oil more stable in northern Nigeria?
5. Which oils in central Nigeria face moderate risks from both heat and humidity?

4.3 Storage Conditions and Their Impact on Glycerides

4.3.1 Proper storage practices

Glycerides in oils and fats remain stable only when stored under proper conditions. Oils should be kept in **airtight containers**, away from direct sunlight and heat. Exposure to air leads to oxidation, while light accelerates rancidity. Metal containers may react with oils, so glass or food-grade plastic is preferred.

Fill in the blank: Oils should be stored in _____ containers to prevent oxidation and rancidity.

Image showing vegetable oils stored in airtight glass containers away from sunlight Caption: Plate 4.3 Proper storage practices for oils

4.3.2 Chemical changes during storage

During storage, glycerides undergo **chemical changes** such as oxidation and hydrolysis.

- **Oxidation**: reaction with oxygen, leading to rancidity and off-flavours.
- **Hydrolysis**: breakdown of glycerides into free fatty acids due to moisture, increasing acidity.

These changes reduce oil quality, shorten shelf life, and affect nutritional value.

Fill in the blank: Oxidation and _____ are two chemical changes that occur in glycerides during storage.

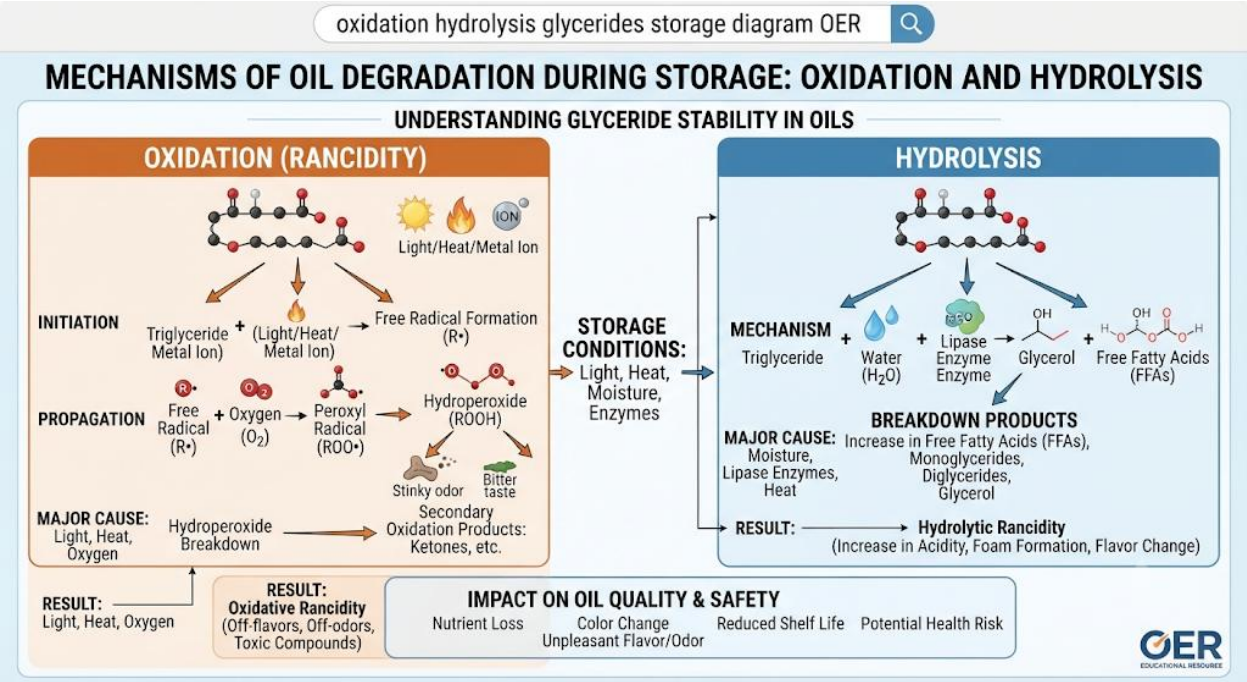
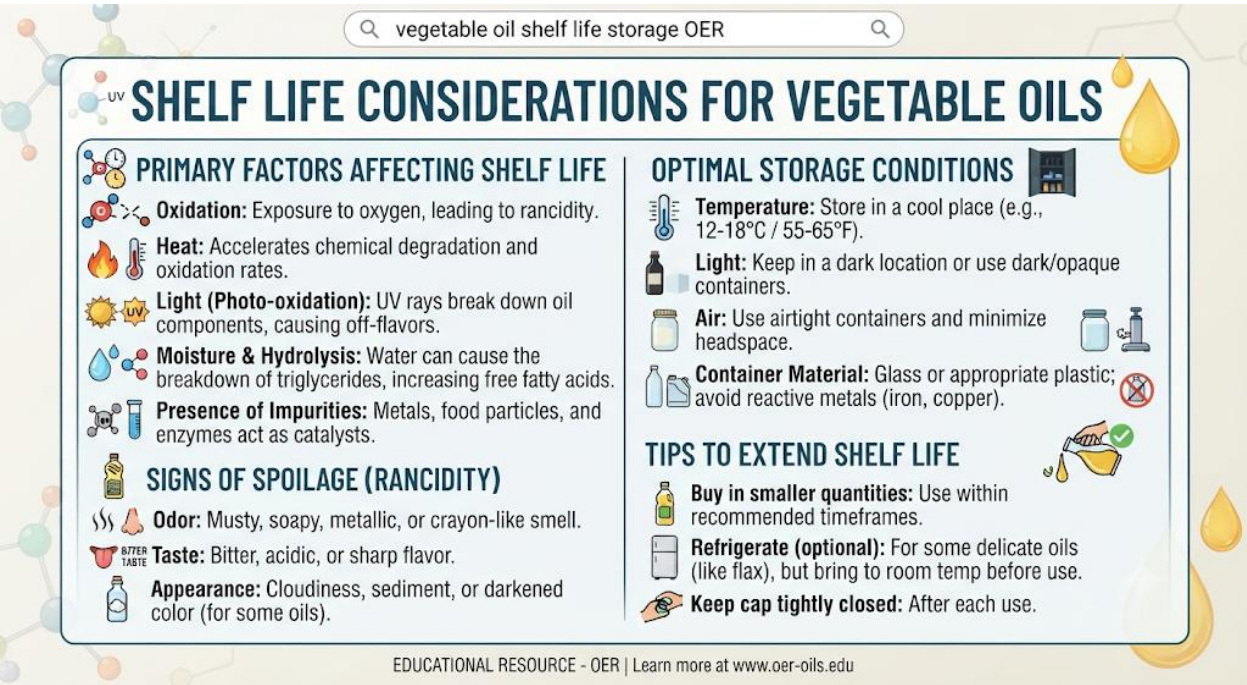


Diagram showing oxidation and hydrolysis processes in stored oils Caption: Figure 4.3 Chemical changes in glycerides during storage

4.3.3 Shelf life considerations

The **shelf life** of oils depends on both climatic conditions and storage practices. Oils stored in cool, dry, and dark environments last longer, while those exposed to heat, light, and humidity deteriorate quickly. Refined oils generally have longer shelf lives than crude oils because impurities that accelerate spoilage are removed during refining.

Fill in the blank: Refined oils generally have a longer _____ than crude oils.



Box 4.3 Shelf life considerations for oils

- Cool, dry, dark storage → longer shelf life
- Heat, light, humidity → faster spoilage
- Refined oils → longer shelf life than crude oils

Pilot questions 4.3

1. Why should oils be stored in airtight containers?
2. Name two chemical changes that occur in glycerides during storage.
3. What effect does oxidation have on oils?
4. Why do refined oils last longer than crude oils?
5. Which storage conditions extend the shelf life of oils?

4.4 Case Studies of Glyceride Behaviour

4.4.1 Palm oil under tropical storage

Palm oil, rich in saturated fatty acids, is prone to **hydrolysis and rancidity** when stored in humid tropical climates. High moisture levels in southern Nigeria accelerate spoilage, especially if oils are kept in open or poorly sealed containers.

Fill in the blank: Palm oil stored in humid tropical climates is prone to _____ and rancidity.

Image showing palm oil stored in open containers in humid conditions Caption: Plate 4.4 Palm oil storage challenges in humid climates

4.4.2 Groundnut oil susceptibility to rancidity

Groundnut oil, though stable in drier northern climates, is highly susceptible to **oxidation** when exposed to heat and air. This leads to rancidity, off-flavours, and reduced nutritional quality. Proper sealing and cool storage are essential to preserve its shelf life.

Fill in the blank: Groundnut oil is highly susceptible to _____ when exposed to heat and air.

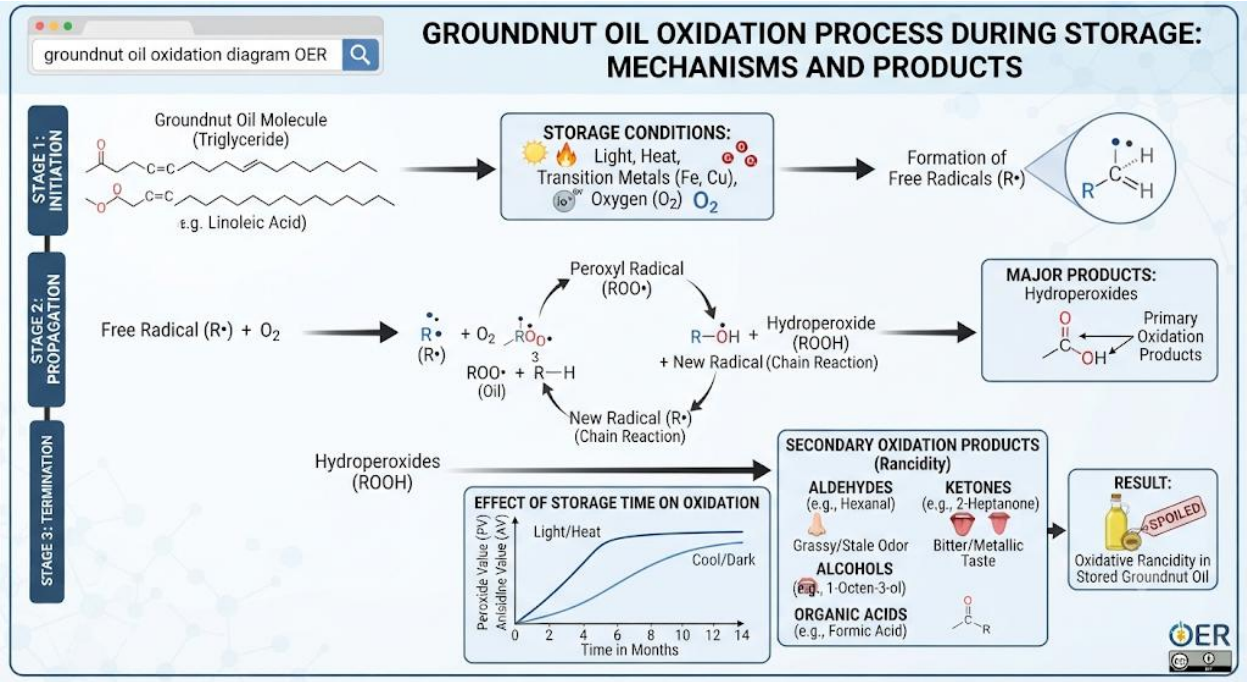


Diagram showing oxidation process in groundnut oil Caption: Figure 4.4 Oxidation in groundnut oil during storage

4.4.3 Soybean oil oxidation patterns

Soybean oil contains a balanced fatty acid profile but is vulnerable to **oxidative rancidity** due to its unsaturated fatty acids. In central Nigeria, where both heat and humidity are moderate, soybean oil requires careful storage in airtight, dark containers to prevent deterioration.

Fill in the blank: Soybean oil is vulnerable to _____ rancidity due to its unsaturated fatty acids.

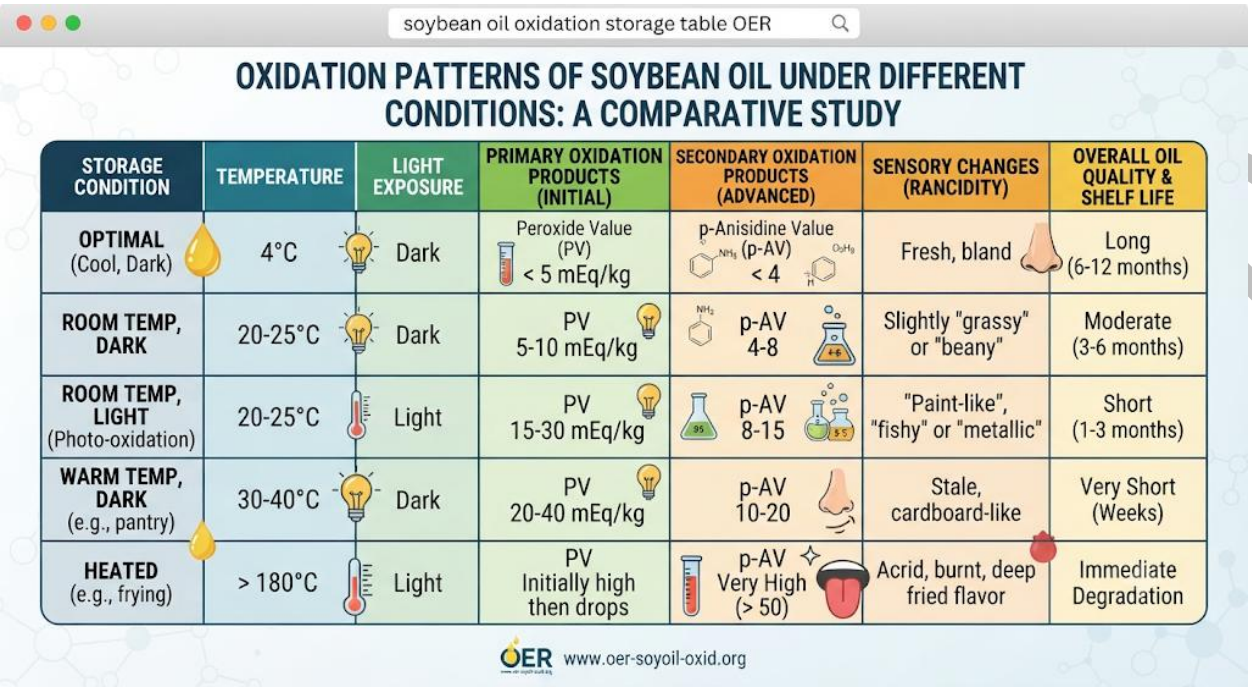


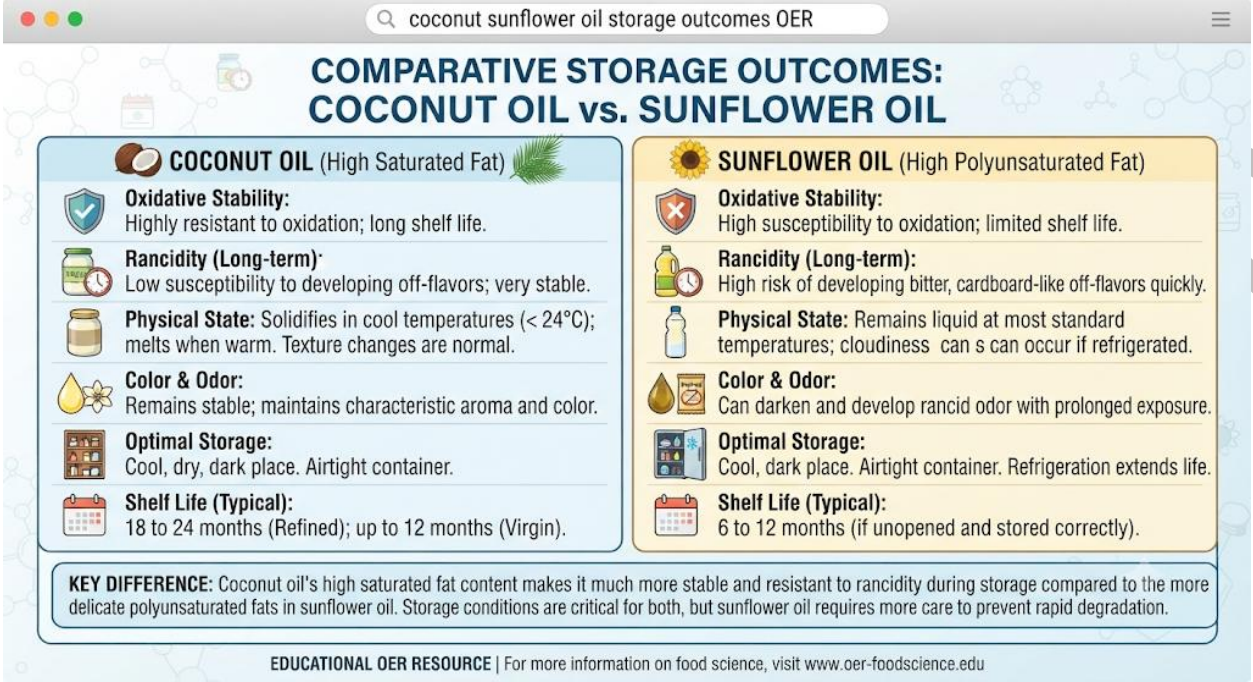
Table 4.2 Soybean oil oxidation patterns

Condition	Effect on soybean oil
Heat	Accelerates oxidation
Humidity	Promotes hydrolysis
Airtight storage	Reduces deterioration

4.4.4 Coconut and sunflower oil storage outcomes

Coconut oil, rich in saturated fats, is relatively stable but can develop off-flavours if exposed to light and air. Sunflower oil, with its high unsaturated fatty acid content, is more prone to oxidation and requires strict storage conditions. Both oils highlight the importance of tailoring storage practices to the chemical nature of the oil.

Fill in the blank: Sunflower oil requires strict storage conditions because of its high _____ fatty acid content.



Box 4.4 Storage outcomes of coconut and sunflower oils

- Coconut oil: stable, but sensitive to light and air
- Sunflower oil: prone to oxidation, requires airtight and dark storage

Pilot questions 4.4

1. What climatic condition makes palm oil prone to rancidity in southern Nigeria?
2. Which chemical process affects groundnut oil when exposed to heat and air?
3. Why is soybean oil vulnerable to oxidative rancidity?
4. What factor makes coconut oil relatively stable compared to sunflower oil?
5. Why does sunflower oil require strict storage conditions?

Series Summary

This Series examined how **climatic and storage conditions** affect the stability and behaviour of glycerides in oils and fats. We began with an introduction to glycerides, their types (mono-, di-, and tri-glycerides), and their importance in the oils and fats industry. We then analysed climatic influences, focusing on temperature, humidity, and Nigeria's regional variations. Next, we explored storage conditions, including proper practices, chemical changes such as oxidation and hydrolysis, and shelf life considerations. Finally, we studied case examples of palm, groundnut,

soybean, coconut, and sunflower oils, highlighting how their glycerides respond to different climates and storage environments.

By completing this Series, you should now be able to define glycerides and their types (SLO 4.1), analyse climatic effects on glycerides (SLO 4.2), explain storage impacts on glycerides (SLO 4.3), and evaluate case studies of glyceride behaviour (SLO 4.4).

Series Glossary

- **Glycerides**: Compounds formed when glycerol bonds with fatty acids.
- **Mono-glyceride**: Glyceride with one fatty acid attached to glycerol.
- **Di-glyceride**: Glyceride with two fatty acids attached to glycerol.
- **Tri-glyceride**: Glyceride with three fatty acids attached to glycerol; most common in oils.
- **Oxidation**: Chemical reaction with oxygen that causes rancidity in oils.
- **Hydrolysis**: Breakdown of glycerides into free fatty acids due to moisture.
- **Rancidity**: Spoilage of oils, producing off-flavours and odours.
- **Shelf life**: The period during which oils remain safe and usable under proper storage.
- **Humidity**: Moisture in the air that promotes hydrolysis in oils.
- **Refined oils**: Oils processed to remove impurities, giving them longer shelf life.

Concept Check Questions [Series 4]

Objective questions

1. What are glycerides formed from? (Linked to SLO 4.1)
2. Which type of glyceride is most common in vegetable oils? (Linked to SLO 4.1)
3. What climatic factor promotes hydrolysis of glycerides? (Linked to SLO 4.2)

Short-answer questions

4. Explain one effect of high temperature on glycerides. (Linked to SLO 4.2)
5. Name two chemical changes that occur in glycerides during storage. (Linked to SLO 4.3)
6. Why do refined oils generally last longer than crude oils? (Linked to SLO 4.3)

Long-answer questions

7. Analyse the impact of climatic factors such as temperature and humidity on glyceride stability. (Linked to SLO 4.2)
    - **Basic response**: Learners should describe how heat accelerates oxidation and humidity promotes hydrolysis.

- **Value-added response**: Outstanding learners may also compare regional climatic effects in Nigeria and propose mitigation strategies.

8. Evaluate case studies of palm, groundnut, soybean, coconut, and sunflower oils under different storage conditions. (Linked to SLO 4.4)
    - **Basic response**: Learners should explain how each oil responds to heat, humidity, and storage practices.
    - **Value-added response**: Outstanding learners may also assess economic implications of spoilage and suggest improved storage technologies.

Answers to Pilot Questions [Series 4]

1. Glycerol and fatty acids.
2. Mono-, di-, tri-glycerides.
3. Tri-glycerides.
4. Emulsifiers.
5. They provide energy, fatty acids, and stability.
6. Oxidation.
7. Moisture absorption.
8. Hydrolysis.
9. Hydrolysis.
10. Southern Nigeria.
11. Oxidation.
12. Unsaturated fatty acids.
13. Airtight containers.
14. Oxidation and hydrolysis.
15. Rancidity.
16. Impurities are removed.
17. Cool, dry, dark storage.
18. Hydrolysis.
19. Oxidation.
20. Unsaturated fatty acids.

References and Attributions [Series 4]

- Figure 4.1 Formation of glycerides: Suggested AI prompt “Create a labelled diagram showing glycerol bonding with fatty acids to form mono-, di-, and tri-glycerides”. Search string: “glycerides chemical structure diagram OER”.
- Table 4.1 Types of glycerides: Suggested AI prompt “Generate a table showing mono-, di-, and tri-glycerides with examples”. Search string: “types of glycerides table OER”.
- Box 4.1 Importance of glycerides: Suggested AI prompt “Generate a text box listing importance of glycerides in oils and fats industry”. Search string: “importance of glycerides in oils and fats industry OER”.
- Figure 4.2 Temperature effects on glycerides: Suggested AI prompt “Create a diagram showing glyceride behaviour under high temperature (oxidation, rancidity) and low temperature (solidification, stability)”. Search string: “temperature effects on glycerides diagram OER”.
- Plate 4.2 Humidity effects on stored oils: Suggested AI prompt “Generate an image showing oil containers exposed to humid tropical conditions”. Search string: “humidity effects on vegetable oil storage photo OER”.
- Box 4.2 Regional climatic effects on glycerides in Nigeria: Suggested AI prompt “Generate a text box summarising regional climatic effects on glycerides in Nigeria”. Search string: “Nigeria climatic effects on vegetable oils OER”.
- Plate 4.3 Proper storage practices for oils: Suggested AI prompt “Generate an image showing vegetable oils stored in airtight glass containers away from sunlight”. Search string: “vegetable oil proper storage photo OER”.
- Figure 4.3 Chemical changes in glycerides during storage: Suggested AI prompt “Create a diagram showing oxidation and hydrolysis processes in stored oils”. Search string: “oxidation hydrolysis glycerides storage diagram OER”.
- Box 4.3 Shelf life considerations for oils: Suggested AI prompt “Generate a text box listing shelf life considerations for oils”. Search string: “vegetable oil shelf life storage OER”.
- Plate 4.4 Palm oil storage challenges in humid climates: Suggested AI prompt “Generate an image showing palm oil stored in open containers in humid tropical conditions”. Search string: “Nigeria palm oil storage humid climate photo OER”.
- Figure 4.4 Oxidation in groundnut oil during storage: Suggested AI prompt “Create a diagram showing oxidation process in groundnut oil during storage”. Search string: “groundnut oil oxidation diagram OER”.

- Table 4.2 Soybean oil oxidation patterns: Suggested AI prompt “Generate a table showing oxidation patterns of soybean oil under different conditions”. Search string: “soybean oil oxidation storage table OER”.
- Box 4.4 Storage outcomes of coconut and sunflower oils: Suggested AI prompt “Generate a text box listing storage outcomes of coconut and sunflower oils”. Search string: “coconut sunflower oil storage outcomes OER”.

Series 5: Oil Refining and Quality Indices

Series Outline

- **5.1 Introduction to oil refining**
    - Definition and purpose of refining
    - Importance in oils and fats industry
- **5.2 Stages of oil refining**
    - Degumming and neutralisation
    - Bleaching and deodorisation
    - Winterisation and fractionation
- **5.3 Quality indices of oils**
    - Free fatty acid (FFA) content
    - Peroxide value (PV)
    - Iodine value (IV)
    - Saponification value (SV)
- **5.4 Factors affecting oil quality**
    - Climatic and storage influences
    - Processing methods and refining efficiency
    - Packaging and handling practices
- **5.5 Case studies of refined oils**
    - Palm oil refining outcomes

- Groundnut oil refining outcomes
- Soybean, coconut, and sunflower oil quality indices

Introduction

Oil refining is a critical stage in the processing of vegetable oils, transforming crude oils into safe, stable, and high-quality products suitable for consumption and industrial use. Refining removes impurities such as free fatty acids, phospholipids, pigments, and odours, thereby improving the oil's appearance, taste, and shelf life.

This Series focuses on both the **processes of oil refining** and the **quality indices** used to evaluate refined oils. You will learn the stages of refining, including degumming, neutralisation, bleaching, deodorisation, and fractionation. We will also explore the key quality indices—free fatty acid content, peroxide value, iodine value, and saponification value—that determine oil quality. Finally, we will examine factors affecting oil quality and case studies of refined oils such as palm, groundnut, soybean, coconut, and sunflower.

We shall commence this Series by introducing oil refining and its importance. Next, we will study the stages of refining, followed by the quality indices used to assess oils. We will then consider factors that influence oil quality, and conclude with case studies of refined oils in Nigeria.

Series Learning Outcomes

Upon completing this Series, you should be able to:

- **SLO 5.1** define oil refining and explain its purpose in the oils and fats industry,
- **SLO 5.2** describe the stages of oil refining, including degumming, neutralisation, bleaching, deodorisation, and fractionation,
- **SLO 5.3** identify and explain key quality indices of oils such as FFA, PV, IV, and SV,
- **SLO 5.4** analyse factors affecting oil quality during refining, storage, and handling, and
- **SLO 5.5** evaluate case studies of refined oils (palm, groundnut, soybean, coconut, sunflower) in terms of refining outcomes and quality indices.

5.1 Introduction to Oil Refining

5.1.1 Definition of oil refining

Oil refining is the process of purifying crude vegetable oils to remove impurities such as free fatty acids, phospholipids, pigments, and odours. The goal is to produce oils that are safe, stable, and suitable for human consumption or industrial use. Refining improves the oil's colour, flavour, and shelf life.

Fill in the blank: Oil refining removes impurities such as _____, pigments, and odours.

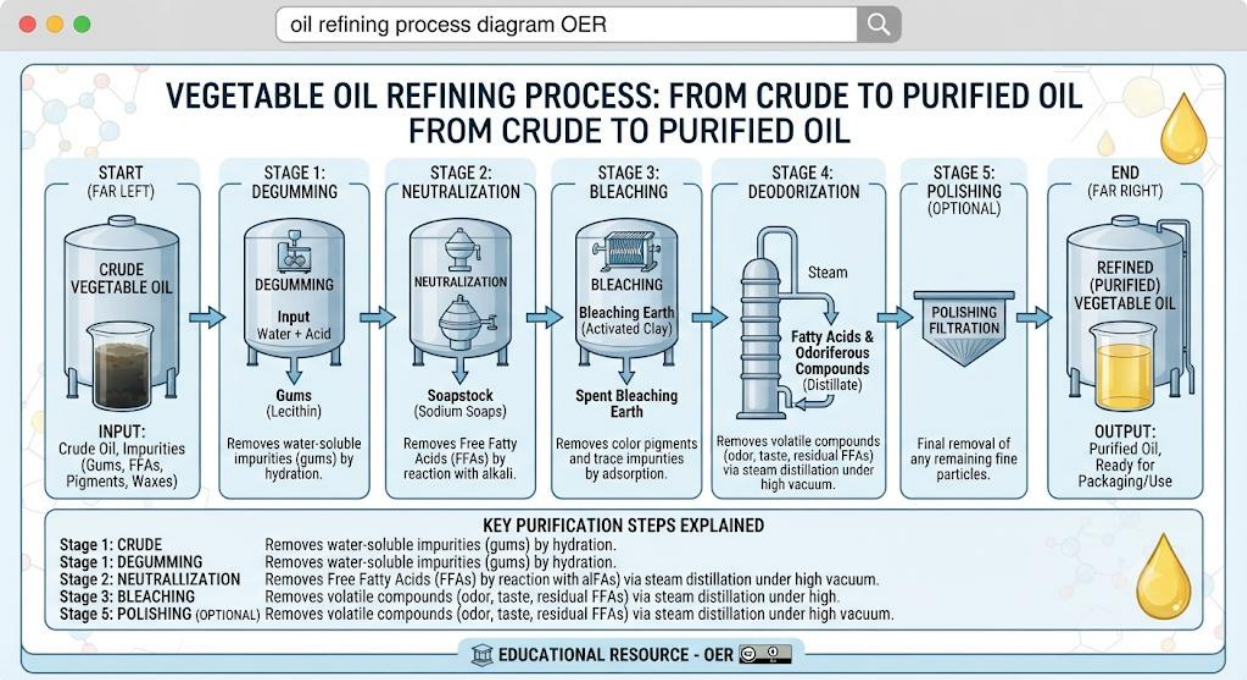


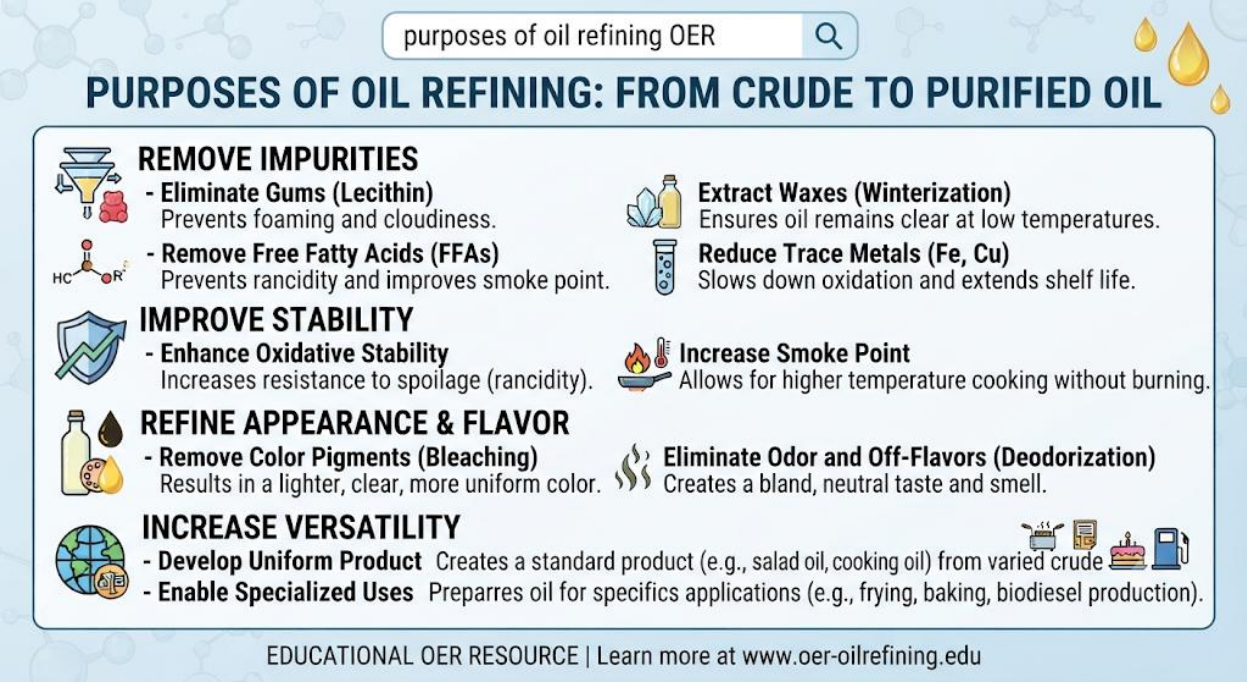
Diagram showing crude oil entering a refining process and emerging as purified oil Caption: Figure 5.1 Oil refining process overview

5.1.2 Purpose of oil refining

The purpose of refining is to:

- Improve **nutritional quality** by removing harmful compounds.
- Enhance **appearance and flavour** by eliminating pigments and odours.
- Extend **shelf life** by reducing rancidity.
- Ensure **industrial suitability** for products such as margarine, soap, and cosmetics.

Fill in the blank: Refining extends the _____ of oils by reducing rancidity.



Box 5.1 Purposes of oil refining

- Nutritional quality improvement
- Better appearance and flavour
- Longer shelf life
- Industrial suitability

5.1.3 Importance in oils and fats industry

Oil refining is essential in the **oils and fats industry** because crude oils often contain impurities that make them unsuitable for direct consumption. Without refining, oils may spoil quickly, taste unpleasant, or pose health risks. Refined oils meet international quality standards, making them competitive in both local and global markets.

Fill in the blank: Refined oils meet _____ quality standards, making them competitive in global markets.

Image showing bottles of refined vegetable oils ready for sale Caption: Plate 5.1 Refined vegetable oils in the market

Pilot questions 5.1

1. What impurities are removed during oil refining?
2. List two purposes of oil refining.
3. Why is refining important in the oils and fats industry?
4. How does refining affect the shelf life of oils?
5. What makes refined oils competitive in global markets?

5.2 Stages of Oil Refining

5.2.1 Degumming and neutralisation

- **Degumming**: Removes phospholipids and other gum-like substances from crude oil. This step improves clarity and prevents emulsification problems.
- **Neutralisation**: Eliminates free fatty acids (FFA) by treating the oil with an alkali solution, producing soapstock that is separated from the oil.

Fill in the blank: Degumming removes _____ from crude oil to improve clarity.

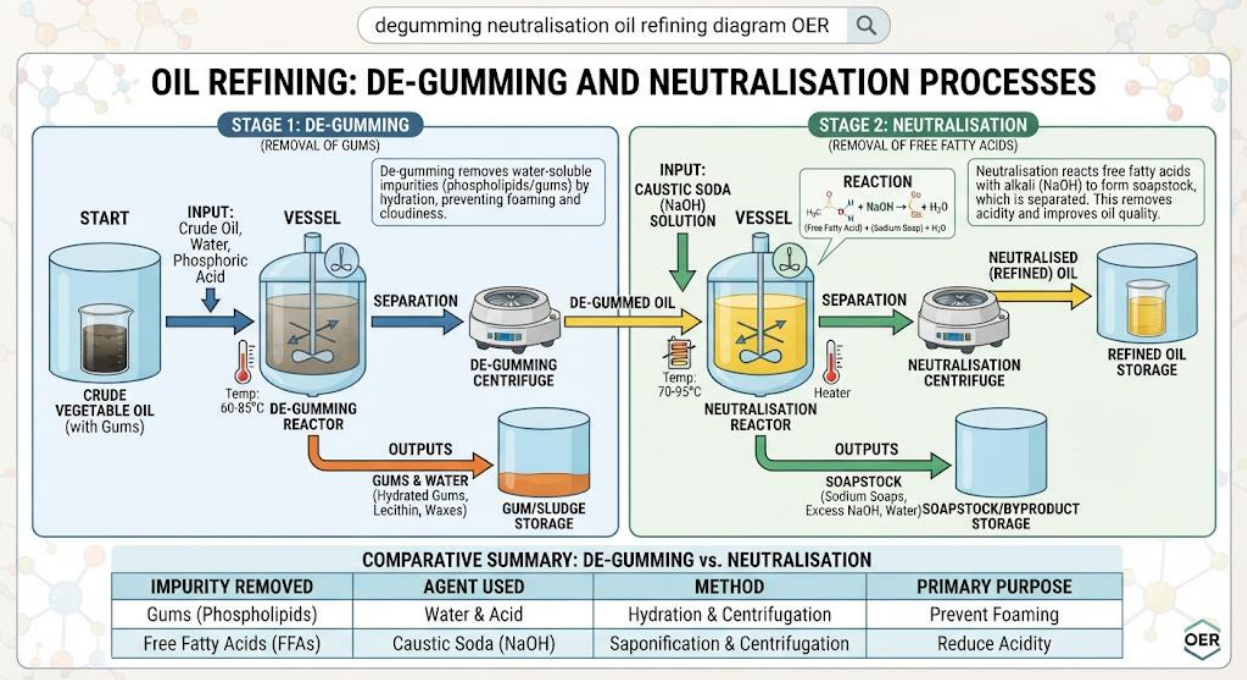


Diagram showing degumming and neutralisation steps in oil refining Caption: Figure 5.2 Degumming and neutralisation processes

5.2.2 Bleaching and deodorisation

- **Bleaching**: Uses adsorbent clays or activated carbon to remove pigments, trace metals, and residual soap. This step improves oil colour and stability.
- **Deodorisation**: Involves steam distillation under vacuum to remove volatile compounds responsible for odours and flavours.

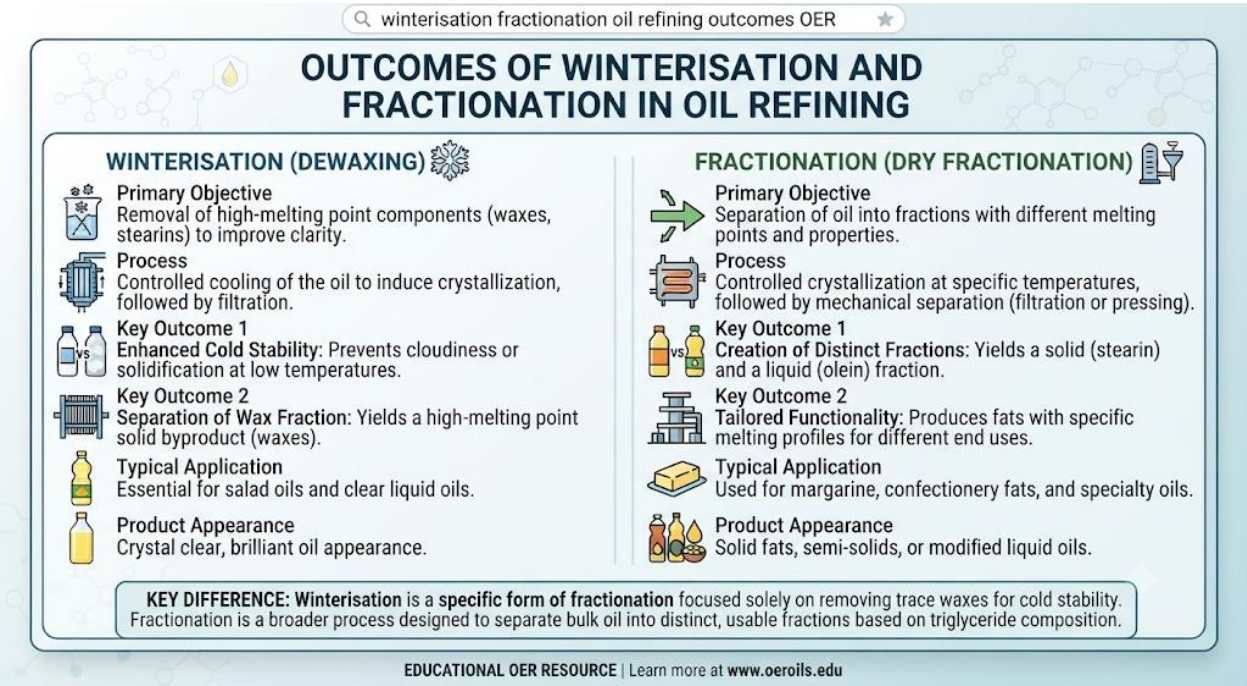
Fill in the blank: Bleaching improves oil _____ by removing pigments and trace metals.

Image showing bleaching earth being added to crude oil Caption: Plate 5.2 Bleaching process in oil refining

5.2.3 Winterisation and fractionation

- **Winterisation**: Removes waxes and high-melting triglycerides that cause cloudiness in oils at low temperatures.
- **Fractionation**: Separates oils into solid and liquid fractions based on melting points, producing products like palm olein and palm stearin.

Fill in the blank: Winterisation removes _____ that cause cloudiness in oils at low temperatures.



Box 5.2 Winterisation and fractionation outcomes

- Winterisation → clear oils at low temperatures
- Fractionation → solid and liquid fractions (e.g., palm olein, palm stearin)

Pilot questions 5.2

1. What does degumming remove from crude oil?
2. Which refining stage eliminates free fatty acids?
3. What is the purpose of bleaching in oil refining?
4. How does deodorisation improve oil quality?
5. What products are obtained from fractionation of palm oil?

5.3 Quality Indices of Oils

5.3.1 Free fatty acid (FFA) content

The **FFA content** measures the amount of free fatty acids present in oil. High FFA levels indicate poor refining or deterioration due to hydrolysis. Oils with low FFA are considered stable and of higher quality.

Fill in the blank: High levels of _____ indicate poor refining or deterioration in oils.

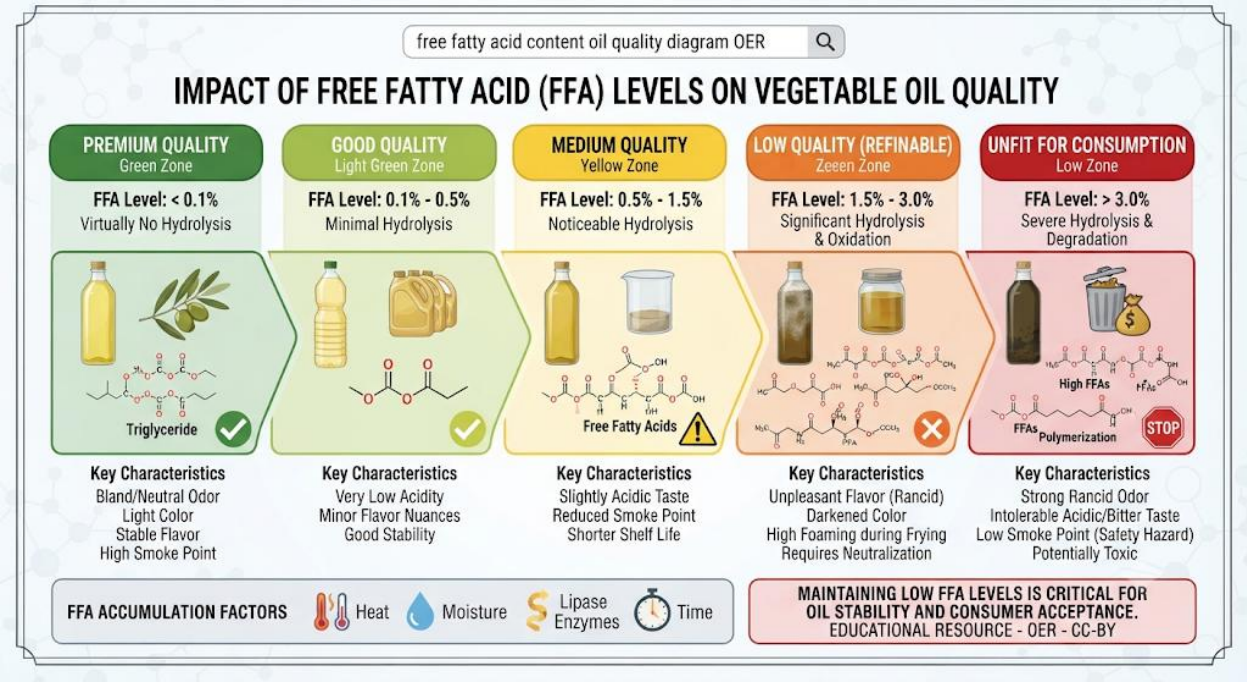


Diagram showing relationship between FFA levels and oil quality Caption: Figure 5.3 Free fatty acid content in oils

5.3.2 Peroxide value (PV)

The **peroxide value** measures the extent of oxidation in oils. A high PV indicates rancidity and reduced shelf life. PV is a key index for monitoring oil stability during storage.

Fill in the blank: A high peroxide value indicates _____ in oils.

Image showing rancid oil samples compared to fresh oil Caption: Plate 5.3 Peroxide value and rancidity in oils

5.3.3 Iodine value (IV)

The **iodine value** measures the degree of unsaturation in oils. Oils with high IV contain more unsaturated fatty acids, making them prone to oxidation but beneficial for health. Palm oil has a lower IV compared to sunflower oil, which is highly unsaturated.

Fill in the blank: The iodine value measures the degree of _____ in oils.

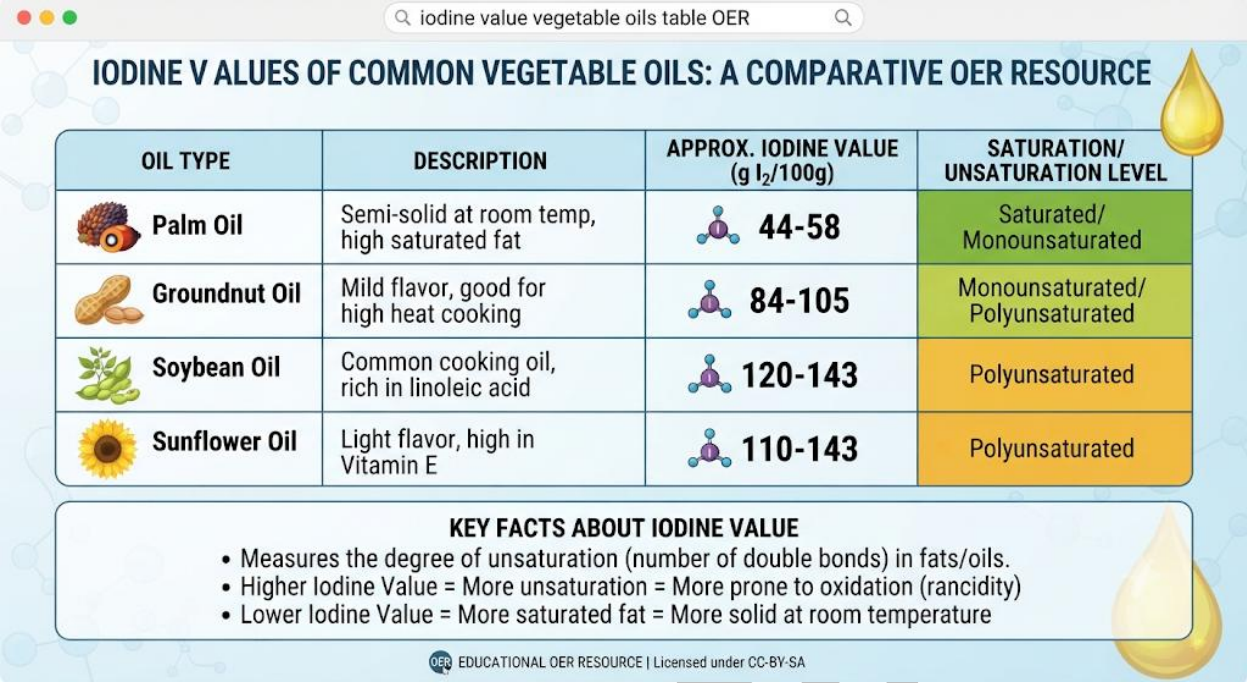


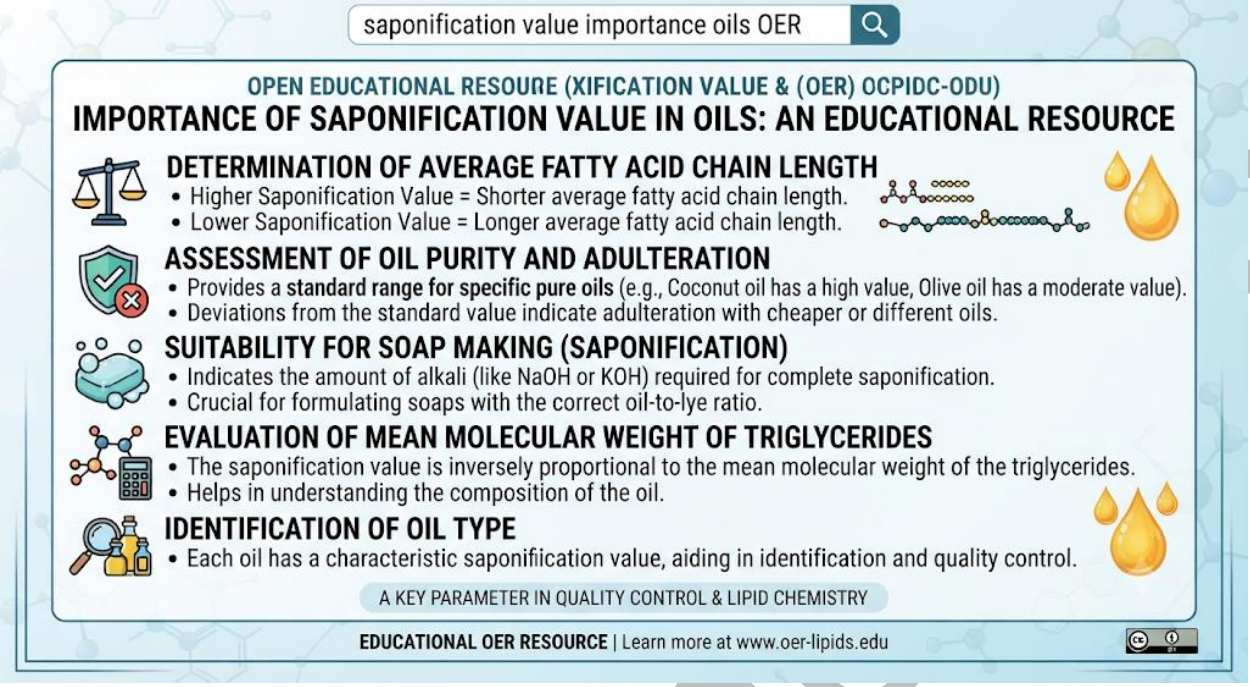
Table 5.1 Iodine values of selected oils

Oil type	Iodine value range	Notable feature
Palm oil	44–56	Low unsaturation
Groundnut oil	85–99	Moderate unsaturation
Soybean oil	120–140	High unsaturation
Sunflower oil	125–145	Very high unsaturation

5.3.4 Saponification value (SV)

The **saponification value** measures the average molecular weight of fatty acids in oils. A high SV indicates shorter-chain fatty acids, while a low SV indicates longer-chain fatty acids. SV is important in soap-making and industrial applications.

Fill in the blank: The saponification value measures the average _____ weight of fatty acids in oils.



Box 5.3 Importance of saponification value

- Determines fatty acid chain length
- Guides soap-making processes
- Indicates industrial suitability of oils

Pilot questions 5.3

1. What does the free fatty acid content indicate in oils?
2. What does a high peroxide value suggest about oil quality?
3. Which oil has the lowest iodine value among palm, groundnut, soybean, and sunflower?
4. What does the iodine value measure in oils?
5. Why is the saponification value important in soap-making?

5.4 Factors Affecting Oil Quality

5.4.1 Climatic and storage influences

Climatic conditions such as **temperature and humidity** directly affect oil quality. High temperatures accelerate oxidation, while humidity promotes hydrolysis. Poor storage practices—like exposure to air, light, or moisture—further reduce oil stability and shelf life.

Fill in the blank: High _____ accelerates oxidation, while humidity promotes hydrolysis in oils.

Image showing oil containers exposed to heat and humidity Caption: Plate 5.4 Climatic and storage influences on oil quality

5.4.2 Processing methods and refining efficiency

The **method of processing** and the efficiency of refining determine oil quality. Crude oils with poor pre-treatment or incomplete refining retain impurities that cause rancidity. Efficient refining ensures removal of free fatty acids, pigments, and odours, producing oils that meet international standards.

Fill in the blank: Efficient refining ensures removal of free fatty acids, pigments, and _____.

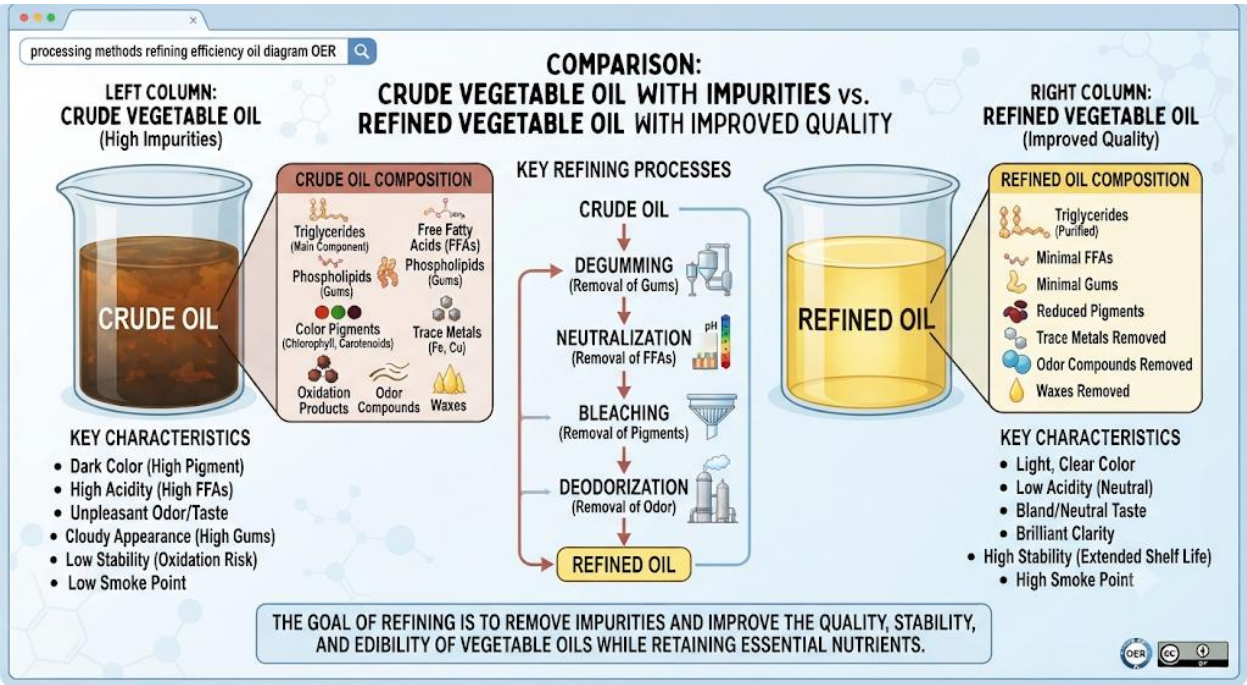
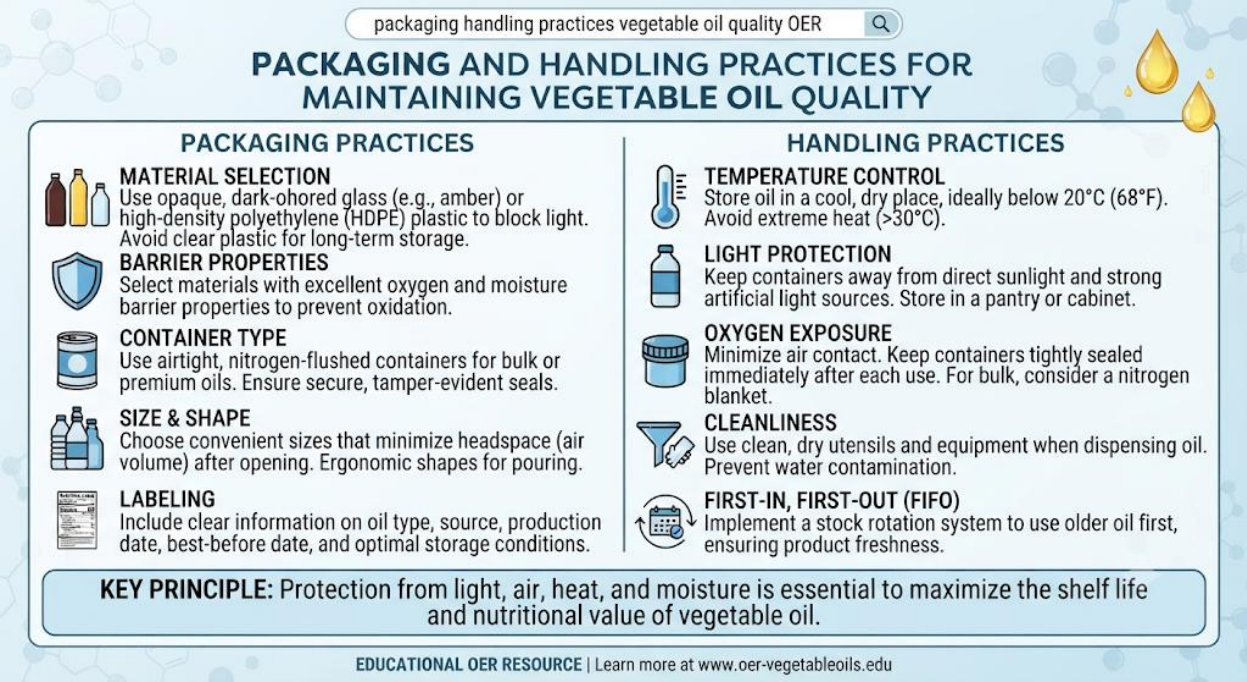


Diagram showing crude oil vs refined oil quality outcomes Caption: Figure 5.4 Processing methods and refining efficiency

5.4.3 Packaging and handling practices

Packaging and handling also influence oil quality. Oils stored in **airtight, food-grade containers** last longer than those kept in open or reactive containers. Handling practices such as avoiding contamination during transfer and maintaining hygiene standards are critical to preserving oil quality.

Fill in the blank: Oils stored in airtight, food-grade containers last longer than those kept in _____ containers.



Box 5.4 Packaging and handling practices for oil quality

- Airtight containers prevent oxidation
- Food-grade materials avoid chemical reactions
- Hygienic handling prevents contamination
- Proper sealing extends shelf life

Pilot questions 5.4

1. How does high temperature affect oil quality?
2. What role does humidity play in oil deterioration?
3. Why is refining efficiency important for oil quality?
4. Name two packaging practices that extend oil shelf life.
5. How does hygienic handling influence oil quality?

5.5 Case Studies of Refined Oils

5.5.1 Palm oil refining outcomes

Palm oil refining removes free fatty acids, carotenoids (pigments), and odours, producing a clear, stable oil. Refined palm oil is widely used in cooking, margarine, and confectionery. Fractionation produces **palm olein** (liquid fraction) and **palm stearin** (solid fraction), each with distinct industrial uses.

Fill in the blank: Fractionation of palm oil produces palm olein and _____.

Image showing refined palm oil and its fractions (olein and stearin) Caption: Plate 5.5 Refined palm oil and its fractions

5.5.2 Groundnut oil refining outcomes

Groundnut oil refining reduces free fatty acids and removes odours, producing a light-coloured oil suitable for frying and baking. Its refined form has a longer shelf life compared to crude groundnut oil, which is prone to rancidity.

Fill in the blank: Refined groundnut oil is suitable for _____ and baking.

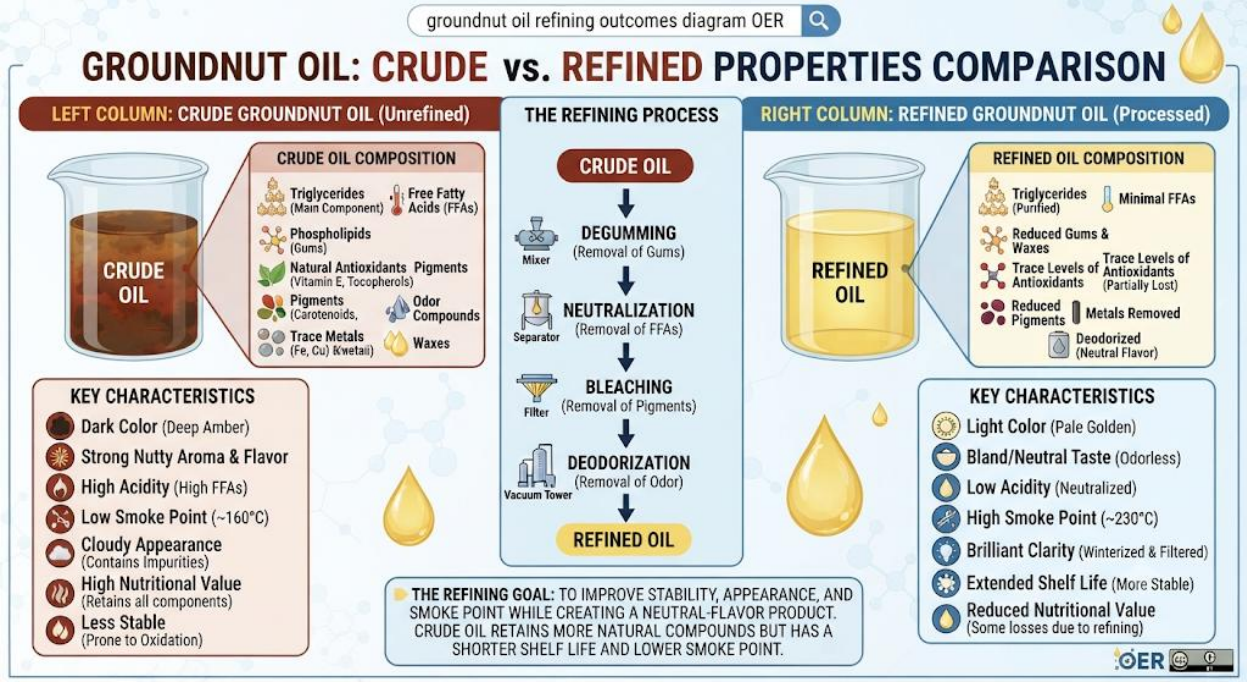


Diagram showing crude vs refined groundnut oil properties Caption: Figure 5.5 Groundnut oil refining outcomes

5.5.3 Soybean oil quality indices

Refined soybean oil has a high iodine value, reflecting its unsaturated fatty acid content. While nutritionally beneficial, this makes it prone to oxidation. Refining reduces impurities and improves stability, but careful storage is still required.

Fill in the blank: Soybean oil has a high _____ value due to its unsaturated fatty acids.

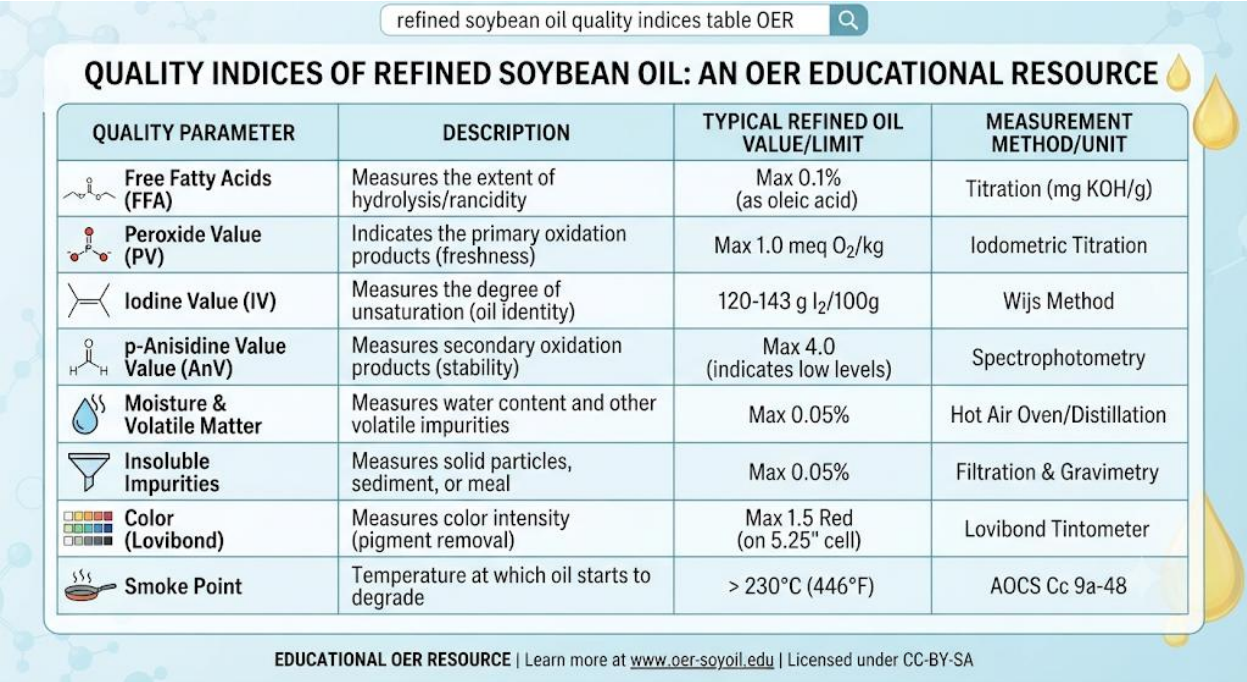


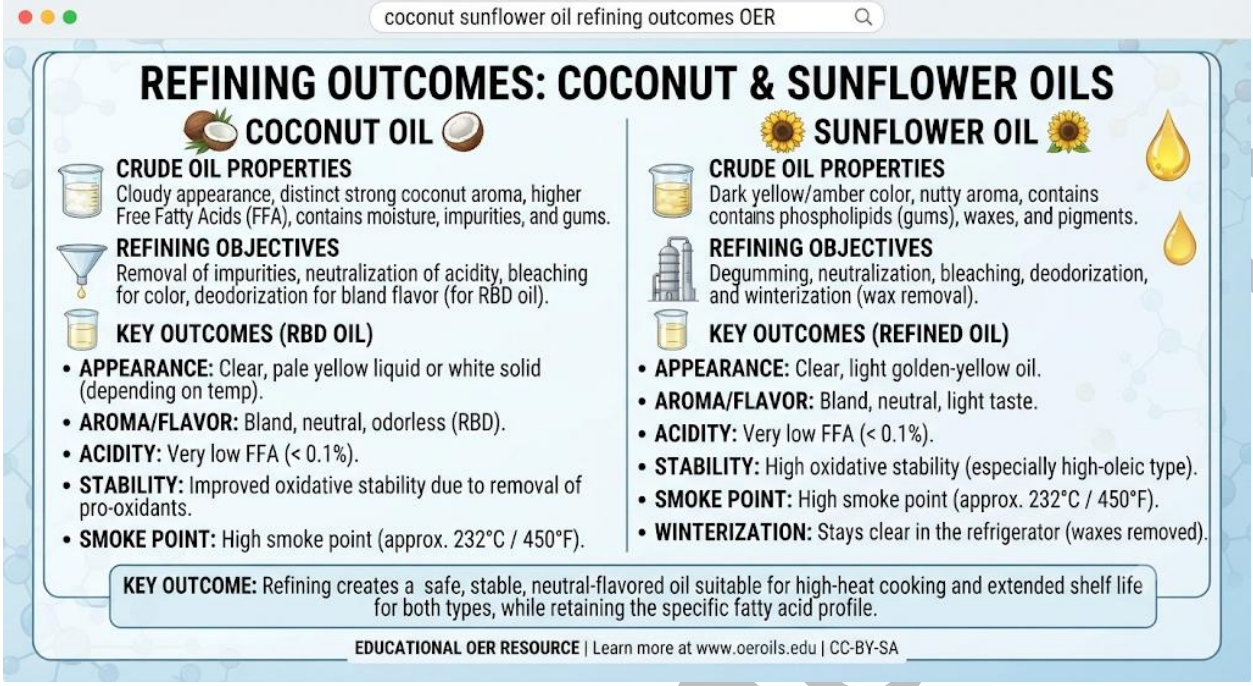
Table 5.2 Quality indices of refined soybean oil

Quality index	Value range	Implication
FFA	<0.1%	Stable oil
PV	<10 meq/kg	Low oxidation
IV	120–140	High unsaturation
SV	190–195	Suitable for soap-making

5.5.4 Coconut and sunflower oil refining outcomes

- **Coconut oil**: Refining produces a clear, odourless oil with a high saponification value, making it ideal for soap and cosmetic industries.
- **Sunflower oil**: Refining reduces peroxide value and stabilises the oil, but its high iodine value means it remains prone to oxidation.

Fill in the blank: Refined coconut oil is widely used in the _____ and cosmetic industries.



Box 5.5 Refining outcomes of coconut and sunflower oils

- Coconut oil: clear, odourless, high saponification value → soap and cosmetics
- Sunflower oil: reduced peroxide value, high iodine value → prone to oxidation

Pilot questions 5.5

1. What are the two fractions obtained from palm oil after fractionation?
2. Why does refined groundnut oil have a longer shelf life than crude oil?
3. Which quality index of soybean oil reflects its high unsaturation?
4. Why is refined coconut oil suitable for the cosmetic industry?
5. What makes refined sunflower oil prone to oxidation despite refining?

Series Summary

This Series explored the processes and outcomes of **oil refining** and the **quality indices** used to evaluate refined oils. We began with an introduction to oil refining, its definition, purpose, and importance in the oils and fats industry. Next, we examined the stages of refining—degumming, neutralisation, bleaching, deodorisation, winterisation, and fractionation. We then analysed the key quality indices: free fatty acid (FFA) content, peroxide value (PV), iodine value (IV), and saponification value (SV). Following this, we considered factors affecting oil quality, including climatic influences, refining efficiency, and packaging practices. Finally, we studied case examples of palm, groundnut, soybean, coconut, and sunflower oils, highlighting their refining outcomes and quality indices.

By completing this Series, you should now be able to define oil refining (SLO 5.1), describe its stages (SLO 5.2), identify and explain quality indices (SLO 5.3), analyse factors affecting oil quality (SLO 5.4), and evaluate case studies of refined oils (SLO 5.5).

Series Glossary

- **Degumming**: Removal of phospholipids and gums from crude oil.
- **Neutralisation**: Elimination of free fatty acids using alkali treatment.
- **Bleaching**: Removal of pigments and trace metals using adsorbents.
- **Deodorisation**: Steam distillation under vacuum to remove odours and flavours.
- **Winterisation**: Removal of waxes and high-melting triglycerides to prevent cloudiness.
- **Fractionation**: Separation of oils into solid and liquid fractions.
- **Free fatty acid (FFA)**: Indicator of oil deterioration or poor refining.
- **Peroxide value (PV)**: Measure of oxidation and rancidity in oils.
- **Iodine value (IV)**: Measure of unsaturation in oils.
- **Saponification value (SV)**: Measure of fatty acid chain length, important in soap-making.

Concept Check Questions [Series 5]

Objective questions

1. Which refining stage removes phospholipids and gums? (Linked to SLO 5.2)
2. What does a high peroxide value indicate? (Linked to SLO 5.3)
3. Which quality index measures the degree of unsaturation in oils? (Linked to SLO 5.3)

Short-answer questions

4. Explain the purpose of deodorisation in oil refining. (Linked to SLO 5.2)
5. Why do refined oils last longer than crude oils? (Linked to SLO 5.4)
6. Name two fractions obtained from palm oil after fractionation. (Linked to SLO 5.5)

Long-answer questions

7. Describe the stages of oil refining, highlighting the role of degumming, neutralisation, bleaching, deodorisation, and fractionation. (Linked to SLO 5.2)
    - **Basic response**: Learners should outline each stage and its purpose.
    - **Value-added response**: Outstanding learners may also evaluate efficiency differences and suggest improvements for Nigerian processors.

8. Evaluate the quality indices of palm, groundnut, soybean, coconut, and sunflower oils. (Linked to SLO 5.5)
    - **Basic response**: Learners should explain the significance of FFA, PV, IV, and SV in each oil.
    - **Value-added response**: Outstanding learners may also assess how refining outcomes affect economic value and export potential.

Answers to Pilot Questions [Series 5]

1. Free fatty acids, phospholipids, pigments, odours.
2. Shelf life.
3. International.
4. Phospholipids.
5. Neutralisation.
6. Colour.
7. Odours.
8. Waxes.
9. Palm stearin.
10. Frying.
11. Iodine.
12. Unsaturation.
13. Molecular.
14. Chain length, soap-making, industrial suitability.
15. Oxidation.
16. Hydrolysis.
17. Odours.
18. Reactive.
19. Palm olein and palm stearin.
20. Unsaturation.

References and Attributions [Series 5]

- Figure 5.1 Oil refining process overview: Suggested AI prompt “Create a diagram showing crude vegetable oil entering refining stages and emerging as purified oil”. Search string: “oil refining process diagram OER”.
- Box 5.1 Purposes of oil refining: Suggested AI prompt “Generate a text box listing purposes of oil refining”. Search string: “purposes of oil refining OER”.
- Plate 5.1 Refined vegetable oils in the market: Suggested AI prompt “Generate an image showing bottles of refined vegetable oils ready for sale in Nigeria”. Search string: “refined vegetable oils Nigeria market photo OER”.
- Figure 5.2 Degumming and neutralisation processes: Suggested AI prompt “Create a diagram showing degumming (removal of gums) and neutralisation (removal of free fatty acids) in oil refining”. Search string: “degumming neutralisation oil refining diagram OER”.
- Plate 5.2 Bleaching process in oil refining: Suggested AI prompt “Generate an image showing bleaching earth being added to crude oil during refining”. Search string: “oil bleaching process photo OER”.
- Box 5.2 Winterisation and fractionation outcomes: Suggested AI prompt “Generate a text box listing outcomes of winterisation and fractionation in oil refining”. Search string: “winterisation fractionation oil refining outcomes OER”.
- Figure 5.3 Free fatty acid content in oils: Suggested AI prompt “Create a diagram showing how free fatty acid levels affect oil quality”. Search string: “free fatty acid content oil quality diagram OER”.
- Plate 5.3 Peroxide value and rancidity in oils: Suggested AI prompt “Generate an image showing rancid oil samples compared to fresh oil”. Search string: “peroxide value rancid oil photo OER”.
- Table 5.1 Iodine values of selected oils: Suggested AI prompt “Generate a table showing iodine values of palm, groundnut, soybean, and sunflower oils”. Search string: “iodine value vegetable oils table OER”.
- Box 5.3 Importance of saponification value: Suggested AI prompt “Generate a text box listing importance of saponification value in oils”. Search string: “saponification value importance oils OER”.
- Plate 5.4 Climatic and storage influences on oil quality: Suggested AI prompt “Generate an image showing oil containers exposed to heat and humidity”. Search string: “climatic storage influences vegetable oil quality photo OER”.
- Figure 5.4 Processing methods and refining efficiency: Suggested AI prompt “Create a diagram comparing crude oil with impurities vs refined oil with improved quality”. Search string: “processing methods refining efficiency oil diagram OER”.

- Box 5.4 Packaging and handling practices for oil quality: Suggested AI prompt “Generate a text box listing packaging and handling practices for oil quality”. Search string: “packaging handling practices vegetable oil quality OER”.
- Plate 5.5 Refined palm oil and its fractions: Suggested AI prompt “Generate an image showing refined palm oil with palm olein and palm stearin fractions”. Search string: “refined palm oil olein stearin photo OER”.
- Figure 5.5 Groundnut oil refining outcomes: Suggested AI prompt “Create a diagram comparing crude groundnut oil with refined groundnut oil properties”. Search string: “groundnut oil refining outcomes diagram OER”.
- Table 5.2 Quality indices of refined soybean oil: Suggested AI prompt “Generate a table showing quality indices of refined soybean oil”. Search string: “refined soybean oil quality indices table OER”.
- Box 5.5 Refining outcomes of coconut and sunflower oils: Suggested AI prompt “Generate a text box listing refining outcomes of coconut and sunflower oils”. Search string: “coconut sunflower oil refining outcomes OER”.