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JABATAN PENDIDIKAN POLITEKNIK DAN KOLEJ KOMUNITI

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TUN SYED NASIR

Oil and Fat Processing Laboratory

Muhammad Izwan Norman
ChM. Siti Rasyidah Sapie
Ts. Aina Fathiah Zuhaidi

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Preface

This eBook is designed with interactive features to enhance the learning experience for students in the Diploma in Chemical Technology (Fat and Oil) programme. It integrates text, visuals, and multimedia elements to strengthen understanding of both laboratory operations and pilot plant processes.

Each module bridges theory and practice, allowing students to relate hands-on laboratory exercises to industrial-scale applications in the field of oil and fat processing. The content is aligned with the Outcome-Based Education (OBE) framework, fostering independent learning, critical thinking, and safety awareness.

Through the use of QR codes, hyperlinks, and Augmented Reality (AR) visuals, learners can explore:

- 3D process models
- Demonstration videos
- Supplementary diagrams and visuals

This eBook aims to be a comprehensive, engaging, and practical reference for students, educators, and professionals in the field of Oil and Fat Processing Technology.

💡 For guidance on navigating the interactive features, please refer to the next section, “How to Use This Interactive eBook.”

Acknowledgement

The authors would like to express their sincere appreciation to all individuals and institutions who contributed to the successful development of this eBook entitled Oil and Fat Processing Laboratory for the course DMK30122 Oil and Fat Processing, offered under the Diploma in Chemical Technology (Fat and Oil) programme.

Special thanks are extended to the Department of Chemical and Food Technology, Politeknik Tun Syed Nasir Syed Ismail, for continuous guidance, encouragement, and technical support throughout the preparation of this publication.

The authors also wish to acknowledge the constructive feedback from colleagues and students, whose insights during teaching and learning activities have greatly contributed to the improvement of this eBook.

It is our sincere hope that this publication will serve as a comprehensive and practical reference for understanding the principles, processes, and applications within the field of oil and fat technology.

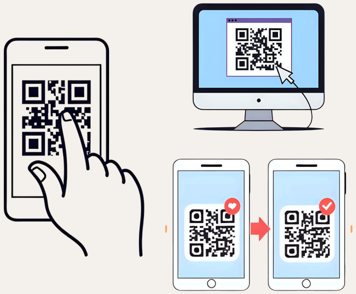
How to use this interactive book

This eBook includes digital learning tools such as QR codes, hyperlinks, and 3D/AR icons to create an immersive, self-paced learning experience.

For Digital Users

If you are using this eBook on a laptop, tablet, or smartphone:

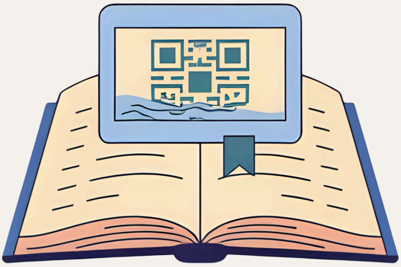
1. Click or tap QR code icon to access related videos or materials.
2. Scan QR codes with your device camera to open supporting visuals such as 3D models or demonstration clips.
3. Explore linked resources to deepen understanding of each Laboratory Exercise.



For Printed Users

If you're using a printed copy:

- Use your smartphone camera or a QR scanner app to access online videos and diagrams.
- Look for QR codes placed beside Laboratory Exercises or images.



Enjoy Your Learning!

Take advantage of every interactive feature — watch, scan, and explore — to visualize the processes in Oil and Fat Processing Technology more clearly and effectively.

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About the Authors

Muhammad Izwan bin Norman is a lecturer at Politeknik Tun Syed Nasir Syed Ismail (PTSN), a Graduate Engineer (BEM), and a Graduate Technologist (MBOT). He holds a Bachelor of Engineering (Process and Food) from Universiti Putra Malaysia (UPM). Formerly a Plant Operation Engineer at FGV Iffco Sdn. Bhd., his expertise includes industrial oil processing, adsorption systems, and sustainable oil technology. He has received multiple awards recognizing his applied research and innovation.

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Ts. Aina Fathiah binti Zuhaidi is a lecturer at PTSN and a Professional Technologist (Ts.) specializing in oleochemistry and environmental engineering. She holds a Master's in Environmental Engineering from UPM and a Bachelor's in Oleochemistry from UKM. Her work focuses on oil refining, waste oil recovery, and sustainable product innovation. She has received several Gold and Silver Awards for research and innovation.

Chapter 1

Introduction to Oil and Fat Processing

Introduction

This chapter provides an overview of the oil and fat processing industry, focusing on the nature, sources, and uses of oils and fats. Students will be introduced to the structure and composition of lipids, the distinction between animal and vegetable oils, and their industrial significance. This foundation prepares students to understand subsequent processing operations, including extraction, refining, and modification.

Learning Outcomes

- **Identify the main sources and types of oils and fats**
- **Describe the basic chemical structure and properties of lipids**
- **Explain the general steps involved in oil and fat processing**
- **Link raw material traits to processing needs and product quality**

Key Terms

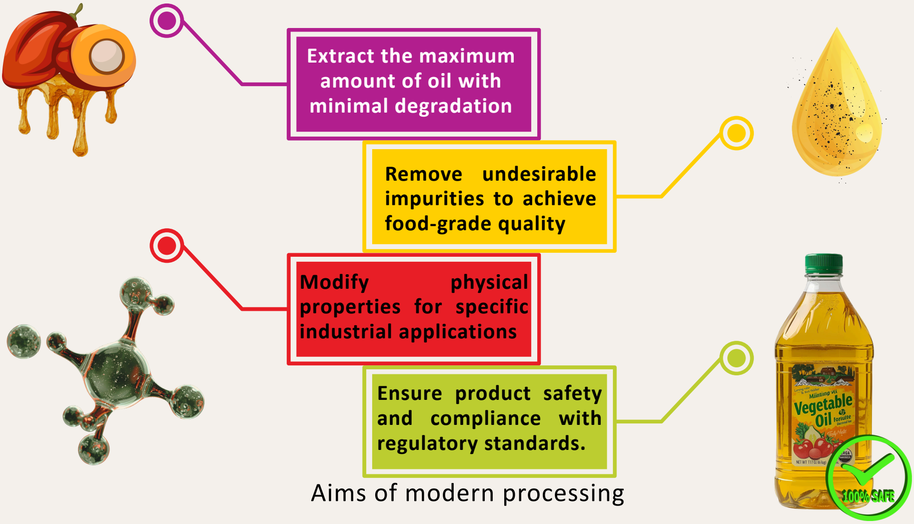
Lipids, Triglycerides, Vegetable Oils, Animal Fats, Processing, Refining, Quality.

CHAPTER I

1.1 Overview of the Oil and Fat Industry

Oils and fats are essential commodities in the global food and chemical industries, serving as major sources of energy and essential fatty acids while also providing raw materials for products such as soaps, biodiesel, cosmetics, and industrial lubricants. As such, the oil and fat sector plays a significant role in agriculture, food manufacturing, and renewable energy development.

These natural materials consist mainly of triglycerides esters of glycerol and longchain fatty acids whose properties vary according to fatty acid composition, degree of unsaturation, and the presence of minor compounds like phospholipids, pigments, tocopherols, and sterols. Because of these variations, processing techniques must be carefully selected and optimized for each oil type. The industry is increasingly focused on sustainability through cleaner extraction methods, energy-efficient refining, and better utilization of by-products. A solid understanding of oil and fat processing principles is therefore essential for professionals entering this field.



Extract the maximum amount of oil with minimal degradation

Remove undesirable impurities to achieve food-grade quality

Modify physical properties for specific industrial applications

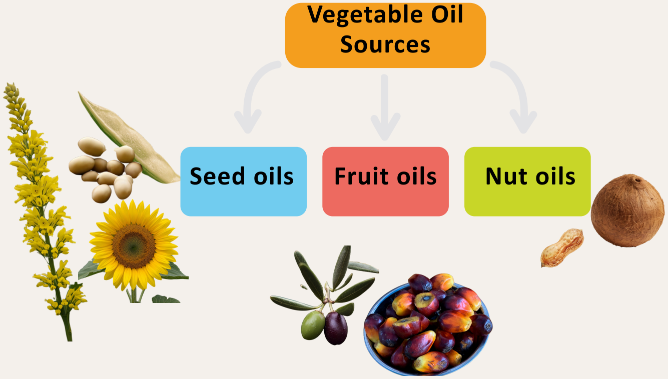
Ensure product safety and compliance with regulatory standards.

Aims of modern processing

CHAPTER I

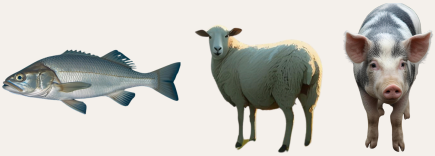
1.2 Raw Materials and Sources of Oils and Fats

Edible and non-edible oils originate from both plant and animal sources. Plant-based oils are generally referred to as **vegetable oils**, extracted mainly from seeds, nuts, or fruit mesocarps, while animal fats are obtained from adipose tissue or milk.



The composition of these raw materials determines their suitability for different processing routes:

- High-unsaturation oils (e.g., soybean, sunflower) require careful handling to prevent oxidation.
- Highly saturated oils (e.g., palm stearin, coconut) may need modification to achieve desired melting properties.



Animal fats include tallow, lard, and fish oil. These are more saturated and solid at room temperature, often used for non-edible or industrial applications.

CHAPTER I

1.3 Chemical Composition and Structure of Oils and Fats

Oils and fats are composed primarily of triglycerides, which are esters formed from one molecule of glycerol and three molecules of fatty acids. The nature of these fatty acids chain length, degree of unsaturation, and configuration determines the physical and chemical characteristics of each oil or fat.

Each triglyceride may contain identical or different fatty acids, giving rise to a wide variety of compositions. Understanding these molecular features is essential for interpreting processing behavior and analytical results in later chapters.

"Triacylglycerol (tristearate)" by Justus Mutanen, licensed under CC BY 4.0. Available at https://skfb.ly/otuxr.

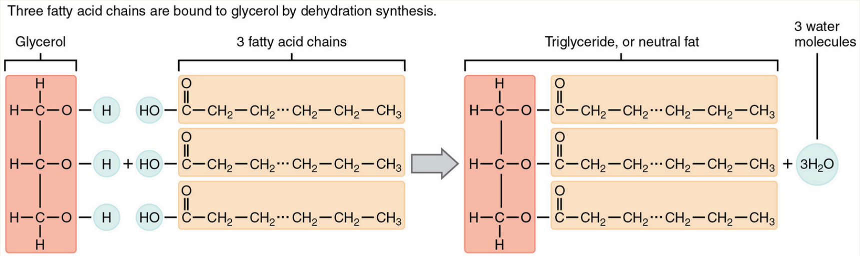


Figure 1.1: *Triglyceride molecular structure. OpenStax College. (2013, May 16). Triglycerides [Image]. Wikimedia Commons. https://commons.wikimedia.org/wiki/File:220_Triglycerides-01.jpg (CC BY 4.0)*

Fatty-Acid Classification

Saturated fatty acids contain no C=C double bonds (e.g., palmitic, stearic).

Monounsaturated fatty acids contain one double bond (e.g., oleic).

Polyunsaturated fatty acids contain two or more double bonds (e.g., linoleic, linolenic).

CHAPTER I

1.4 Typical Processing of Fats and Oils

The processing of oils and fats consists of several sequential operations designed to transform crude raw materials into refined and stable products suitable for consumption or industrial use. These operations include both physical and chemical treatments aimed at maximizing oil yield, improving purity, and achieving the desired functional properties of the final product.

A typical processing sequence begins with preparation and extraction of oil from plant or animal sources, followed by refining to remove impurities and unwanted compounds. Subsequent stages such as modification, blending, and quality analysis tailor the oil for specific applications and ensure it meets product standards.

The overall workflow of these operations is illustrated in Figure 1.3, which presents a typical fats and oils processing sequence from raw material handling to final product packaging.

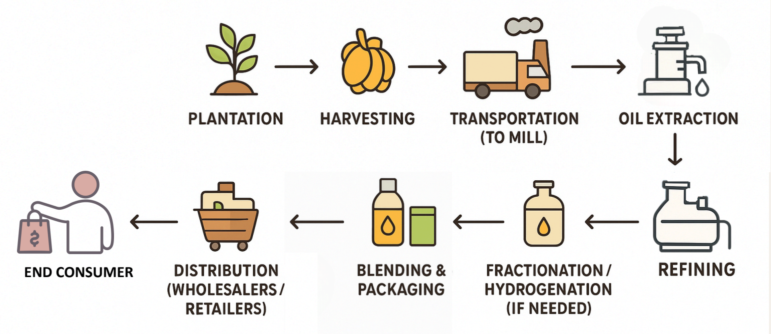


Figure 1.2: *Typical fats and oils supply chain from raw material handling to end consumer*

ASSESSMENT

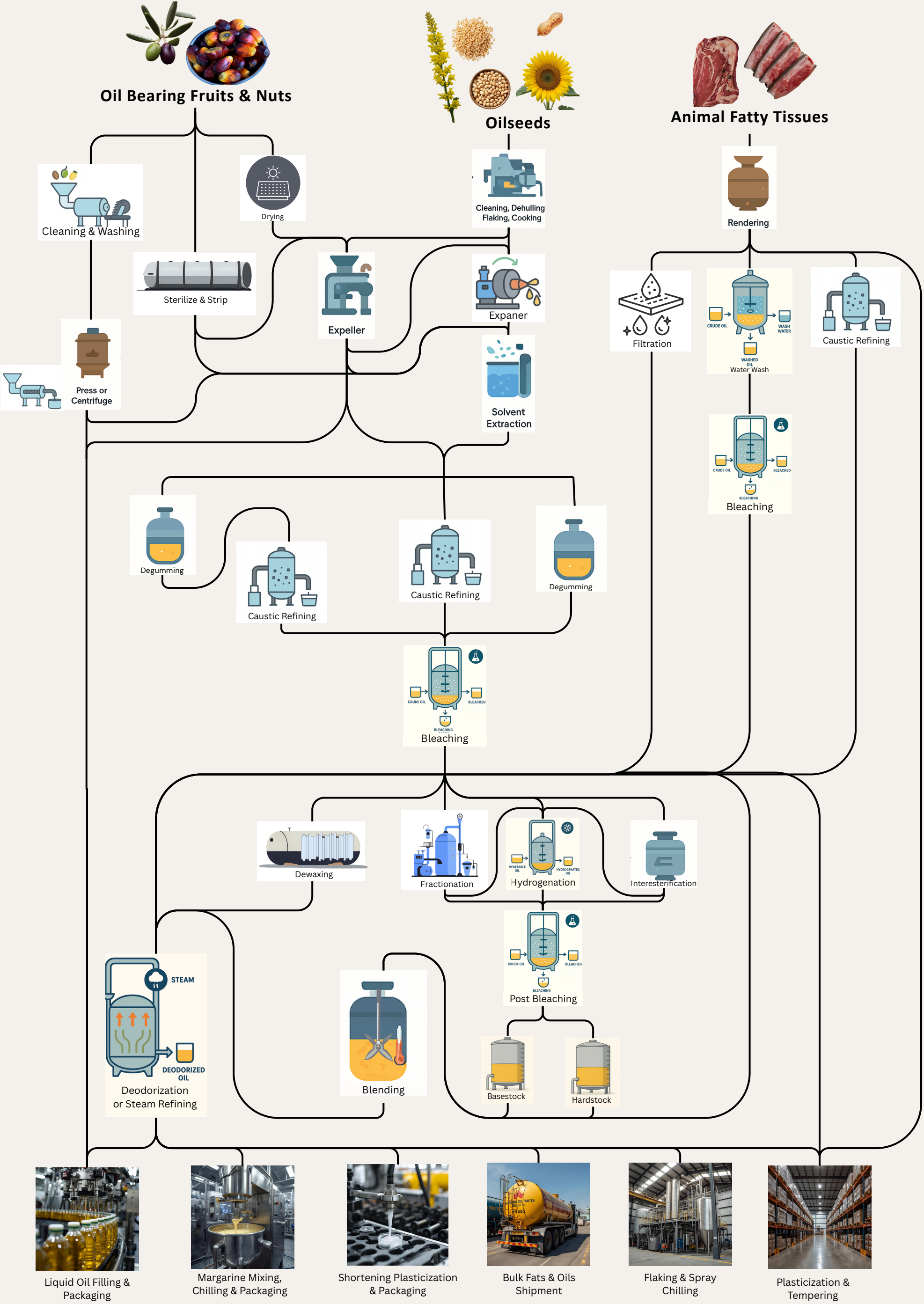


Figure 1.3: *Typical fats and oils processing sequence*

Chapter 2
Extraction Techniques

Introduction

This chapter explores the methods and scientific principles behind oil extraction. Emphasis is placed on mechanical and solvent extraction techniques, the effect of process variables on extraction efficiency, and the comparison of yield and quality across different methods. Laboratory exercises will guide students through wet rendering, hydraulic pressing, and Soxhlet extraction.

Learning Outcomes

1. **Distinguish between mechanical and solvent extraction techniques.**
2. **Operate laboratory-scale extraction equipment safely and effectively**
3. **Evaluate factors affecting oil yield and purity**
4. **Record, analyze, and compare extraction performance data.**

Key Terms

Extraction, Solvent, Soxhlet, Hydraulic Press, Rendering, Yield, Efficiency.

Check out these videos to see how vegetable oils and animal fats are extracted.


How it's made: Palm oil [Video]. How It's Made, 2016.


Salisbury soybean processing [Video]. Perdue AgriBusiness, 2023.


Tallow fat oil extraction machine / fat rendering machine [Video]. Henan Weto Machinery Co., Ltd, 2019.


How it's made: Olive oil [Video]. How It's Made, 2024.

CHAPTER II

2.1 Wet Rendering

Ever wondered how cooking fats like lard or tallow are made from raw animal parts? Welcome to the world of wet rendering a time-tested technique that transforms animal by-products like chicken skin into usable fat through the power of heat and water.

In this laboratory, you'll explore how moist heat breaks down tissues and releases fat without burning or degrading it. Unlike dry rendering (which uses direct heat and can scorch the product), wet rendering uses gentler simmering usually around 80–90°C helping preserve the quality, color, and stability of the final fat.

This method is more than just an old-school practice. Today, it's still used in food, cosmetics, animal feed, and even biofuel industries. Through this hands-on experience, you'll not only extract fat but also observe how temperature, time, and technique affect the yield and clarity of the product.

So, roll up your sleeves, this is where biology meets technology, and waste becomes something valuable.

Laboratory Exercise 1 – Wet Rendering

Learning Objectives

- Understand the principles of fat rendering using the wet method.
- Perform the wet rendering process on animal by-products.
- Demonstrate proper lab safety protocols.

Materials and Equipment

- Animal by-products containing fat (e.g., chicken skin)
- Lab coat and safety goggles
- Heat-resistant gloves
- Beaker
- Water
- Thermometer
- Sieve
- Glass containers with lids
- Cheesecloth or fine mesh strainer
- Stirring utensils
- Digital scale

SCAN HERE

Safety Precautions

- Always wear protective clothing including a lab coat, safety goggles, and gloves.
- Be cautious around hot surfaces and moving parts of the oil press.

Procedure

Note: Repeat the procedure three times using the same sample mass to ensure consistent results.

Oilseed Preparation

1. Cleaning - Place the oilseeds in a sieve and shake manually to remove dust, soil, and small unwanted particles.
2. Weighing - Accurately measure the oilseeds using a precision balance (to two decimal places). Always tare the balance with the empty container before adding the seeds to ensure the correct net weight is recorded.

Boiling

1. Place the animal by-products in the beaker.
2. Add enough water to submerge the by-products fully.

Rendering

1. Heat the beaker over medium heat.
2. Bring the water to a simmer (approximately 80-90°C).
3. Continue simmering for about 1 to 1.5 hours. Stir occasionally to prevent sticking and scorching.
4. As the fat melts, it will separate from the other components, and you'll notice clear liquid collecting on top.

Separation

1. Once the fat has separated and the water is clear, turn off the heat.
2. Allow the mixture to cool slightly.
3. Carefully skim off the top layer of fat using a spoon or ladle.
4. Pour the melted fat through a sieve or fine mesh strainer into a glass container to remove any remaining solids.

Storage

1. Allow the rendered animal fat to cool to room temperature.
2. Seal the container with a lid and label it properly.
3. Store the animal fat in the chiller for future use.
4. Record the weight of the rendered animal fat.

Cleanup

1. Clean all equipment thoroughly with soap and water.
2. Dispose of any remaining animal by-products and waste properly.

Result

Sample Description	Mass of Sample (g)	Mass of Fat Recovered (g)	Oil Yield (%)	Observation (Color / Clarity / Odor)
Chicken skin (Trial 1)				
Chicken skin (Trial 2)				
Chicken skin (Trial 3)				
Average				

ASSESSMENT

Calculation

$$\text{Oil Yield (\%)} = \frac{\text{Mass of Oil Recovered (g)}}{\text{Mass of Chicken Skin Used (g)}} \times 100$$

Discussion

- Discuss the importance of oilseed preparation
- Discuss the basic principles of rendering
- Explain the importance and benefits of wet rendering extraction

Conclusion

- Summarize the key findings and their relevance.

Reference

- Provide the sources of reference for your discussion

CHAPTER II

2.2 Mechanical Oil Extraction (Hydraulic Press)

Meet the Hydraulic Oil Press, the compact powerhouse that literally squeezes out value from seeds and nuts. Like the Bramah press from the 1800s, this tool leverages Pascal's principle, using a hydraulic cylinder and fluid to generate high-force compression.

In this lab, you'll use a benchtop hydraulic press to compress oilseed samples. Think sesame, peanut, or Sacha Inchi at controlled pressures up to around 50 MPa, available in both cold and hot-press modes, you will explore how pressure, temperature, and pressing duration influence the oil yield, viscosity, and chemical quality of what you extract.

Figure 2.1: *Hydraulic oil press apparatus*

Why does this matter?

- Optimizing yield & purity: hydraulic presses can achieve very high oil recovery with better flavor and lower FFA compared to screw or centrifugal
- Versatile applications: from spectroscopy pellet prep in research labs to food-grade or biofuel oil extraction, hydraulic presses serve a broad range of industries.

Laboratory Exercise 2 – Hydraulic Oil Press

Learning Objectives

- Understand the principles of hydraulic oil press
- Perform oil extraction from oilseeds using a hydraulic oil press
- Demonstrate proper lab safety protocols.

Materials and Equipment

- Hydraulic oil press
- Collection container (food-grade)
- Oilseeds (as per requirement)
- Weighing scale
- Pre-weighed collection container
- Laboratory-grade seed cleaner or sieve
- Thermometer
- Moisture meter (optional)

Safety Precautions

- Always wear protective clothing including a lab coat, safety goggles, and gloves.
- Be cautious around hot surfaces and moving parts of the oil press.

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Cold press castor oil [Video]. Zhou, S., YouTube.

Procedure

Note: Repeat the procedure three times using the same sample mass to ensure consistent results.

Oilseed Preparation

Cleaning

1. Place the oilseeds in a sieve and shake manually to remove dust, soil, and small unwanted particles.
2. Weighing
3. Accurately measure the oilseeds using a precision balance (to two decimal places). Always tare the balance with the empty container before adding the seeds to ensure the correct net weight is recorded.

Dehusking (If Applicable)

1. For seeds with loose husks, place them between two coarse cloths or rubber sheets and gently rub to dislodge the husks.
2. Alternatively, lightly crush the seeds using a mortar and pestle to break the husks without damaging the kernels. Afterward, separate the husks from the kernels.
3. Conditioning
4. Spread cleaned seeds thinly on a tray and heat at 80–90°C, monitoring constantly to prevent scorching.

Hydraulic Oil Press Start-Up

1. Switch on the main power supply to the hydraulic press unit.
2. Preheat the press to 65°C to bring it to optimal pressing temperature.
3. Run the press without load for 1–2 cycles to confirm that all systems are functioning properly.
4. Open the top ejector plate of the press based on Figure 2.2.
5. Position the pre-weighed oil collection container beneath the press outlet.
6. Place the prepared oilseeds into a tightly knotted filter bag and insert the bag carefully into the press barrel, following the sequence illustrated in the Figure 2.3.
7. Close the top ejector plate securely.
8. Close the top ejector plate securely.
9. Activate the hydraulic pump to begin the pressing process. Continuously monitor the pressure and temperature during operation.

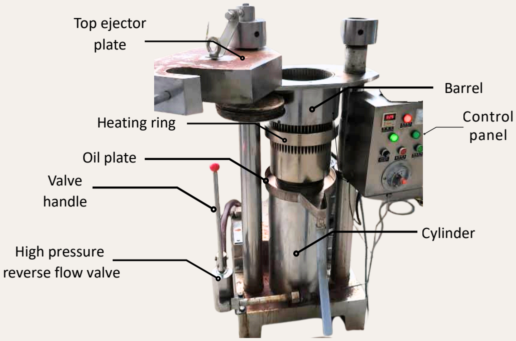


Figure 2.2: *Hydraulic oil press with top ejector plate opened.*

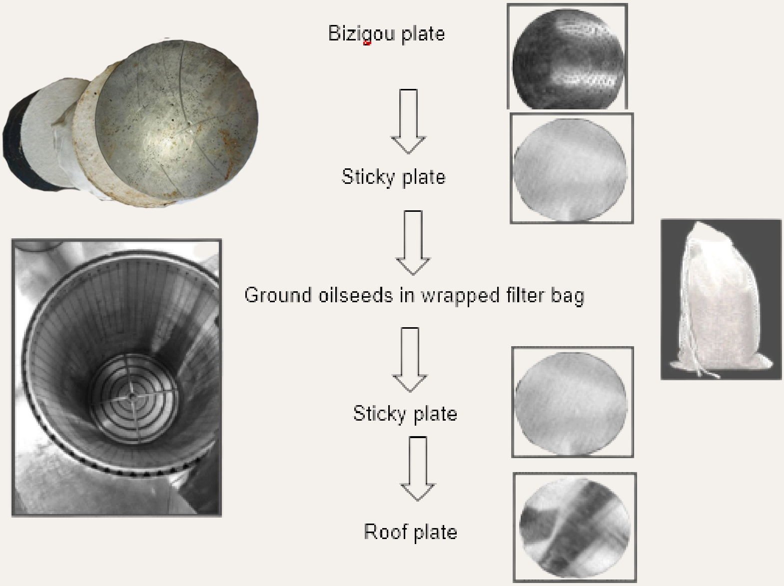


Figure 2.3: *Hydraulic oil press setup sequence*

Oil Collection

1. Once pressing is complete, weigh the extracted oil using a precision balance.
2. Transfer the oil into a clean, labeled storage container and store it in a chiller for future use.

Cleanup

1. Release the pressure in the hydraulic system and switch off the machine.
2. Remove the oilseed cake from the press and dispose of or repurpose it appropriately.
3. Thoroughly clean the press to remove any remaining oil or seed residue.
4. Clean and store all equipment properly in its designated place.

Discussion

- Discuss the importance of oilseed preparation
- Discuss the basic principles of how a hydraulic oil press works.
- Explain the importance and benefits of using mechanical extraction for oil production.

Conclusion

- Summarize the key findings and their relevance.

Reference

- Provide the sources of reference for your discussion

Result

Sample Description	Mass of Seeds (g)	Mass of Oil Recovered (g)	Oil Yield (%)	Observation (Color / Clarity / Odor)
Trial 1				
Trial 2				
Trial 3				
Average				

Calculation

$$\text{Oil Yield (\%)} = \frac{\text{Mass of Oil Recovered (g)}}{\text{Mass of Oilseeds Used (g)}} \times 100$$

ASSESSMENT

CHAPTER II

2.3 Solvent Extraction (Soxhlet Method)

Soxhlet extraction may look like complex glassware at first glance, but it's actually a brilliant example of recycling in chemistry automatically reusing a boiling solvent to extract lipids from solids with minimal waste.

Invented by Franz von Soxhlet in 1879, this method allows you to repeatedly wash a dry, ground sample with hot solvent (like hexane) without constantly refilling or replacing the solvent. That makes it ideal for extracting vegetable oils from seeds, nuts, or even food waste like okara.

In this lab, you'll set up the Soxhlet apparatus to extract oil from plant-based material. Once extraction is complete, you'll remove the solvent using a rotary evaporator and weigh the resulting oil to determine extraction efficiency. This mirrors real-world techniques used in the food, nutraceutical, environmental, and cosmetic industries.

Key Variables

Extraction time

Particle size

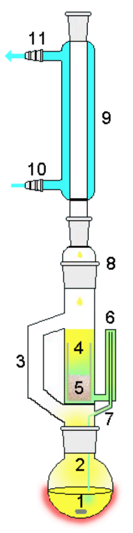
Solvent polarity

Sample moisture

Quick Fact:

Soxhlet is widely used in oilseed quality testing, environmental pollutant recovery, and food industry R&D. It is still the reference method in AOAC protocols for crude fat determination.

Soxhlet extractor mechanism [GIF]. Dolinowski, 2011, Wikimedia Commons



1: Stirrer bar/anti-bumping granules
2: Still pot
3: Distillation path
4: Soxhlet Thimble
5: Extraction solid (residue solid)
6: Syphon arm inlet
7: Syphon arm outlet
8: Expansion adapter
9: Condenser
10: Cooling water in
11: Cooling water out

Figure 2.4: *"Soxhlet extractor" by Quantockgoblin, licensed under CC BY-SA 2.5.*

Laboratory Exercise 3 – Solvent Extraction (Soxhlet Method)

Learning Objectives

- Understand the principles of Soxhlet extraction method.
- Perform extraction of crude vegetable oil from a plant material using Soxhlet extraction method.
- Demonstrate proper lab safety protocols.

Materials and Equipment

- Soxhlet extractor
- Round bottom flask
- Condenser
- Heating mantle
- Crude vegetable material (e.g., seeds or nuts)
- Solvent (e.g., hexane)
- Weighing balance
- Oven
- Rotary Evaporator

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Soxhlet extraction [Video]. Chemistry Teaching Labs – University of York, 2024, YouTube

Safety Precautions

- Wear lab coat, gloves, and safety goggles at all times.
- Ensure good ventilation as solvents are often flammable and toxic.
- Handle the heating mantle and hot apparatus with care.

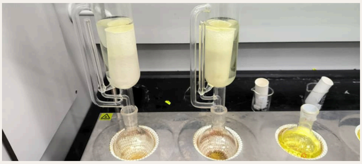

Figure 2.5: *Soxhlet extraction apparatus set up on a heating mantle.*

Procedure

Note: Repeat the procedure three times using the same sample mass and solvent ratio to ensure consistent results.

Drying

1. Place the crude vegetable sample in a drying oven at 105°C and heat until a constant weight is achieved, indicating complete moisture removal.

Grinding

1. Grind the dried sample into a fine, uniform powder to enhance extraction efficiency.

Weighing

1. Accurately weigh 25.00 g of the ground material using an analytical balance (to 2 decimal places).

Soxhlet apparatus assembly

1. Assemble the Soxhlet extractor, connecting the round-bottom flask (containing the chosen solvent) at the bottom and the condenser at the top.
2. Transfer the weighed ground material into a thimble and place it inside the extraction chamber of the Soxhlet apparatus.

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Tutorial penggunaan alat rotary evaporator [Video]. Abriani, 2022, YouTube

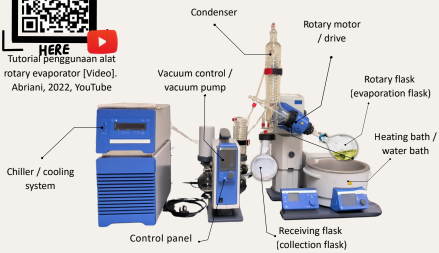


Figure 2.6: *Rotary evaporator.*

Oil Recovery

1. After extraction, carefully remove the thimble from the chamber and retain the flask containing the solvent-oil mixture.
2. Weigh an empty evaporating flask and record the mass.
3. Use a rotary evaporator under reduced pressure to remove the solvent from the oil in the flask.
4. Weigh the flask again after solvent removal. The oil content is determined by the difference in mass before and after evaporation.
5. Do not discard the used solvent. Transfer it into a properly labeled container for reuse or disposal according to lab policy.

Cleanup

1. Dispose of any waste materials, including spent plant material, in compliance with the laboratory's waste disposal procedures.
2. Clean, dry, and store all glassware and equipment in their appropriate locations.

Result

Sample Description	Mass of Sample (g)	Mass of Oil Extracted (g)	Oil Yield (%)	Observation (Color / Clarity / Odor)
Trial 1				
Trial 2				
Trial 3				
Average				

Calculation

$$\text{Oil Yield (\%)} = \frac{\text{Mass of Oil Extracted (g)}}{\text{Mass of Sample Used (g)}} \times 100$$

Discussion

- Discuss the yield of the oil extracted in relation to the weight of the starting material.
- Evaluate the effectiveness of the chosen solvent (e.g., hexane) in extracting oil. Discuss how the properties of the solvent influence the extraction efficiency.
- Discuss the characteristics of the crude vegetable oil obtained, including color, viscosity, and any observed impurities that may affect its quality or require further refinement.

Conclusion

Summarize the key findings and their relevance.

Reference

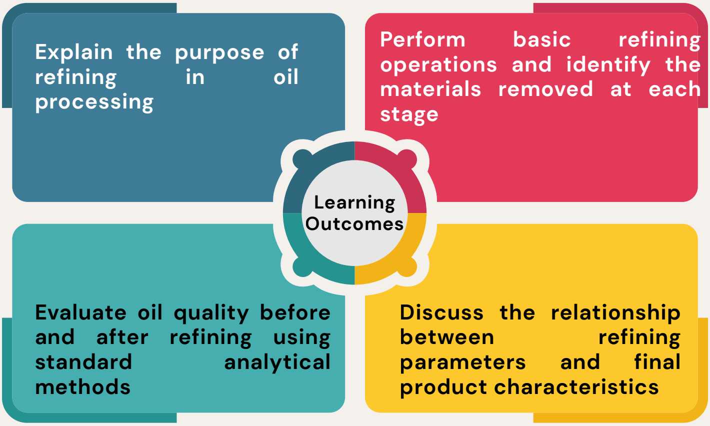
Provide the sources of reference for your discussion.

ASSESSMENT

Chapter 3
Refining Processes

Introduction

Refining improves the quality of crude oil by removing impurities such as free fatty acids, gums, pigments, and odor-causing compounds. This chapter covers both chemical and physical refining techniques, including degumming, neutralization, bleaching, and deodorization. Students will conduct experiments simulating each refining step and assess its impact on oil quality.



Learning Outcomes

- Explain the purpose of refining in oil processing
- Perform basic refining operations and identify the materials removed at each stage
- Evaluate oil quality before and after refining using standard analytical methods
- Discuss the relationship between refining parameters and final product characteristics

Key Terms

Degumming, Neutralization, Bleaching, Deodorization, Free Fatty Acids, Purity, Refining.

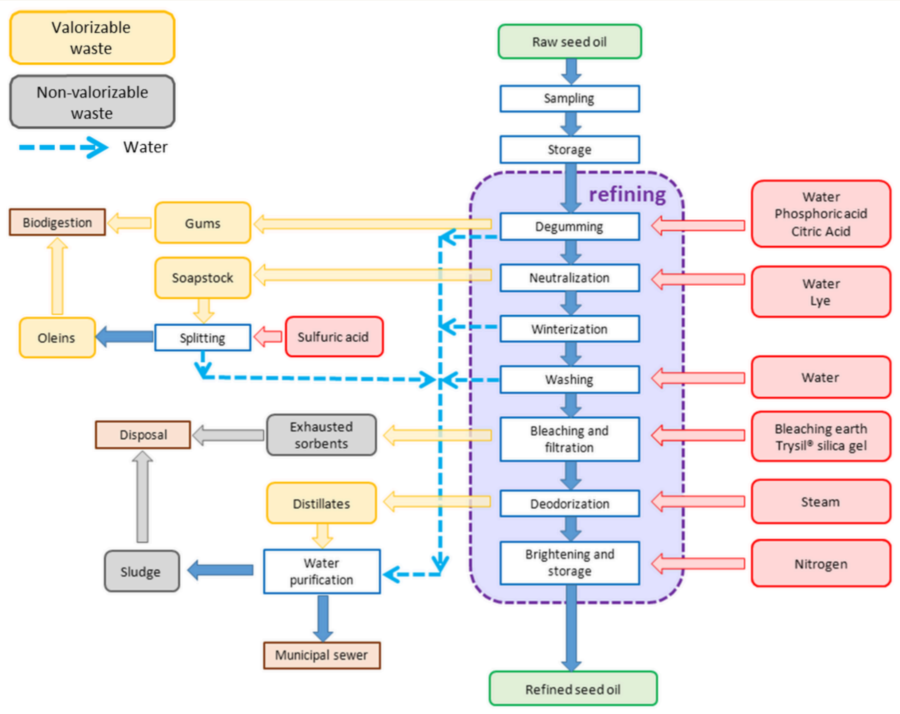


Figure 3.1: *Edible oil refining process (chemical route).*
Adapted from Casali & Tentori (2022). Edible oil refining process [Diagram]. (CC BY 4.0).

CHAPTER III

3.1 Chemical Refining

Chemical refining is the conventional method used to purify crude vegetable oils, especially soybean, sunflower, and canola oils. This process involves using alkali (usually NaOH) to neutralize free fatty acids (FFA) and remove impurities such as phospholipids, pigments, peroxides, and trace metals.

In this lab, you'll simulate the full chemical refining sequence using small-scale equipment, including:

Degumming	using phosphoric or citric acid to remove phosphatides (gums).
Neutralization	reacting FFA with sodium hydroxide to form soapstock.
Water washing	removing residual soap and salts.
Bleaching	using activated clay or bleaching earth to adsorb color pigments and metal ions.
Deodorization	steam distillation to remove odor compounds.

Compared to physical refining, chemical refining is better suited for low-FFA oils, yielding lighter-coloured, low-phosphorus oil but producing more effluent from soapstock and washing.

Why Study Chemical Refining?

- Fundamental in oil quality improvement: Especially for oils with low initial FFA.
- Control over by-products: Produces usable soap stock or lecithin.
- Precision in lab refining: Ideal for academic R&D, quality control, and refining trials.

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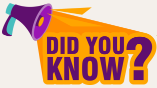
Degumming/neutralization process [Video]. DVC Process Technologists, 2019, YouTube

You will learn to monitor key parameters such as temperature, mixing time, and reagent dosage to optimise yield and quality, while evaluating changes in colour and FFA content throughout each refining stage.



Oils like soybean and sunflower are commonly refined chemically to achieve higher clarity, better stability, and greater cost efficiency, especially for low-FFA oils.

Laboratory Exercise 4 – Chemical Refining (Laboratory Scale)

Learning Objectives

- Understand the principles of edible oil refining.
- Perform the refining process including degumming, neutralization, bleaching, and deodorization.
- Demonstrate proper lab safety protocols.

Materials and Equipment

- Feed oil (Crude or off-spec edible oil e.g., crude palm oil, high FFA oil)
- Phosphoric acid or citric acid
- Sodium hydroxide (NaOH) solution
- Bleaching earth or activated carbon
- Distilled water
- Lab coat and safety goggles
- Heat-resistant gloves
- Beakers (various sizes)
- Stirring rod or magnetic stirrer
- Hot plate with thermometer
- Separatory funnel
- Filter paper and funnel
- Conical flask
- Analytical balance

Safety Precautions

- Always wear a lab coat, safety goggles, and heat-resistant gloves when handling chemicals and hot materials.
- Handle acids and bases with care to avoid spills and burns.

Procedures

Note: This procedure is carried out once due to the long processing time. Students may share results or compare with other groups to discuss data variation.

Preparation

1. Verify that all glassware and equipment are clean and completely dry before use.
2. Prepare a 0.1% solution of phosphoric acid or citric acid to be used in the degumming process.
3. Prepare a 10% sodium hydroxide (NaOH) solution for the neutralization step.

Degumming

1. Collect approximately 20 mL of crude (feed) oil and place it in a labeled, airtight vial for free fatty acid (FFA) analysis.
2. Heat the remaining crude oil in a beaker to 60°C using a hot plate.
3. While stirring continuously, slowly add the 0.1% acid solution to the heated oil.
4. Stir the mixture for 30 minutes to allow adequate reaction and mixing.
5. Transfer the mixture to a separatory funnel and allow the contents to settle.

6. Once separated, drain and discard the aqueous layer (containing gums), retaining the oil phase.

Neutralization

1. Heat the degummed oil to 70°C on a hot plate.
2. Slowly introduce the 10% NaOH solution while stirring continuously.
3. Maintain stirring for 30 minutes to ensure complete neutralization of free fatty acids.
4. Transfer the neutralized mixture into a separatory funnel and allow it to settle.
5. Carefully separate and discard the aqueous layer (containing soapstock), preserving the oil phase.
6. Take a 20 mL sample of the neutralized oil and store it in a labeled, airtight vial for further FFA analysis.

Bleaching

1. Heat the neutralized oil to 80°C on a hot plate.

Note: In industrial processes, bleaching is conducted under vacuum to enhance impurity removal and prevent oxidation. In this lab-scale version, bleaching is performed under atmospheric conditions due to equipment limitations.

Bleaching

1. Add 0.5% of bleaching earth or activated carbon while stirring continuously to adsorb color pigments and residual impurities.
2. Continue stirring for 30 minutes to ensure effective contact between the adsorbent and the oil.
3. Filter the mixture using a filter paper and funnel to remove the spent adsorbent.
4. Collect a 20 mL sample of the bleached oil and store it in a labeled, airtight vial for color analysis.

Deodorization

1. Heat the bleached oil to 100°C using a hot plate.*Note: Industrial deodorization typically occurs at temperatures above 200°C under high vacuum. This lab procedure uses a reduced temperature to accommodate standard lab setups.*
2. Apply vacuum to the heated oil using a vacuum pump to help remove volatile odor compounds.*Note: The vacuum applied here is milder than in industrial settings but is sufficient for demonstrating the principle.*
3. Maintain both the vacuum and temperature for 1 hour to complete the deodorization process.

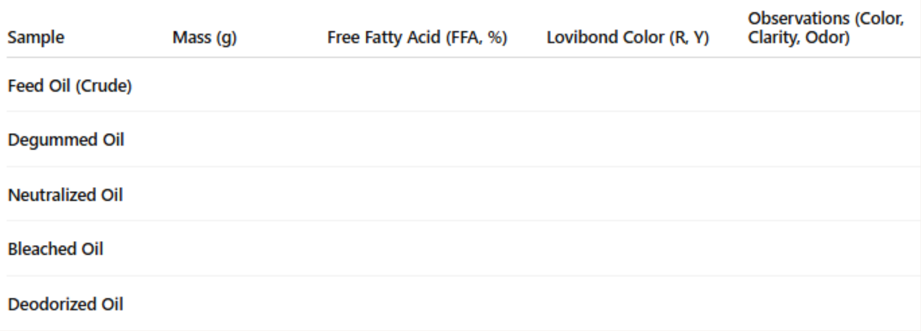
Post-Processing

1. Allow the refined oil to cool to room temperature.
2. Weigh the cooled, refined oil and record the final mass.
3. Collect a 20 mL sample of the deodorized oil and store it in a labeled, airtight vial for FFA and color analysis.

Cleanup

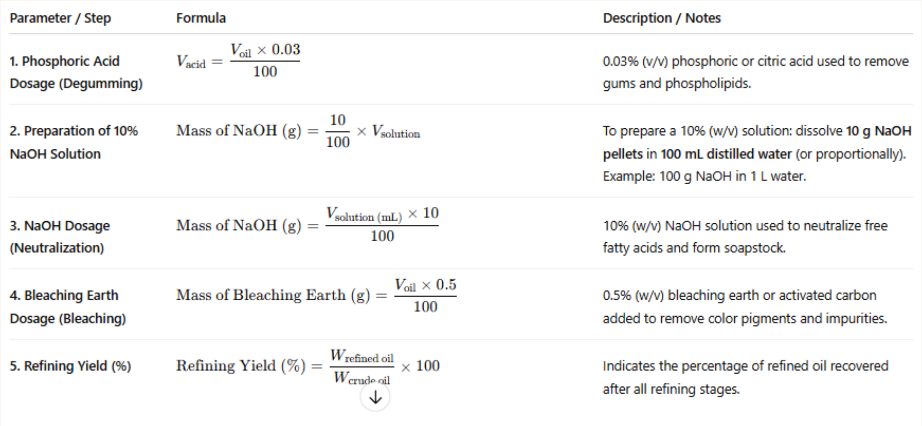
1. Thoroughly clean all equipment with soap and water, ensuring no residual oil or chemicals remain.
2. Dispose of all chemical and waste materials in accordance with laboratory safety and waste management protocols.

Result



Sample	Mass (g)	Free Fatty Acid (FFA, %)	Lovibond Color (R, Y)	Observations (Color, Clarity, Odor)
Feed Oil (Crude)				
Degummed Oil				
Neutralized Oil				
Bleached Oil				
Deodorized Oil				

Calculation



Parameter / Step	Formula	Description / Notes
1. Phosphoric Acid Dosage (Degumming)	$V_{\text{acid}} = \frac{V_{\text{oil}} \times 0.03}{100}$	0.03% (v/v) phosphoric or citric acid used to remove gums and phospholipids.
2. Preparation of 10% NaOH Solution	$\text{Mass of NaOH (g)} = \frac{10}{100} \times V_{\text{solution}}$	To prepare a 10% (w/v) solution: dissolve **10 g NaOH pellets** in **100 mL distilled water** (or proportionally). Example: 100 g NaOH in 1 L water.
3. NaOH Dosage (Neutralization)	$\text{Mass of NaOH (g)} = \frac{V_{\text{solution (mL)}} \times 10}{100}$	10% (w/v) NaOH solution used to neutralize free fatty acids and form soapstock.
4. Bleaching Earth Dosage (Bleaching)	$\text{Mass of Bleaching Earth (g)} = \frac{V_{\text{oil}} \times 0.5}{100}$	0.5% (w/v) bleaching earth or activated carbon added to remove color pigments and impurities.
5. Refining Yield (%)	$\text{Refining Yield (\%)} = \frac{W_{\text{refined oil}}}{W_{\text{crude oil}}} \times 100$	Indicates the percentage of refined oil recovered after all refining stages.

Discussion

- Discuss the purpose of the refining process and the key steps involved in detail (degumming, neutralization, bleaching, and deodorization)
- Discuss the initial FFA content of the crude oil and how it changed after each refining step.
- Describe the color changes observed in the oil after each refining step.
- Identify potential sources of error in the Laboratory Exercise, such as measurement inaccuracies, contamination, or procedural mistakes.

Conclusion

Summarize the key findings and their relevance.

Reference

Provide the sources of reference for your discussion

ASSESSMENT

Laboratory Exercise 5 – Chemical Refining (Pilot Scale)

Learning Objectives

- Understand the principles of chemical refining of vegetable oil
- Perform chemical refining of vegetable oil in a batch process.
- Demonstrate proper lab safety protocols.

Safety Precautions

- Always wear appropriate PPE including lab coats, safety goggles and gloves.
- Exercise caution around hot surfaces and equipment.

Procedures

Note: This procedure is carried out once due to the long processing time. Students may share results or compare with other groups to discuss data variation.

General Start-Up

1. Ensure that both heaters W1 and W2 are turned off at the control panel.
2. Power up the system by switching on the Main Switch.
3. Confirm that all valves are initially in the closed position.
4. Check the pressure regulators and adjust them if necessary:
    a. Set PR01 to 3 kgf/cm²
    b. Set PR02 to 2 kgf/cm²
5. The system is now ready for operation.

Feed Oil Preparation

1. Perform the general start-up procedures above.
2. Measure and transfer 20 L of feed oil into feed tank T1. Retain a small sample in a labeled beaker for reference or analysis.
3. Fully open valve HV12 to allow water into the vacuum pump L1 sealant ring.
4. Open HV02 and HV13.
5. Start pump L1 to create a vacuum in reactor R1, drawing the oil from T1 into R1.
6. Once T1 is emptied, stop L1, close HV02, and open HV14 to restore R1 to atmospheric pressure. Then close HV12.

Degumming

1. Perform acid degumming by slowly adding a 0.1% phosphoric or citric acid solution to the feed oil at 60°C while stirring continuously.
2. Continue mixing for 30 minutes to allow complete reaction.
3. Transfer the mixture to a separatory funnel and allow it to settle.
4. Discard the aqueous layer, which contains the gums

Neutralization

1. Set TIC102 (temperature controller for R1) to 60°C and switch on heater W2.
2. Set stirrer M1 to 100 rpm and start mixing gently to avoid emulsification.
3. Prepare 1.4 L of 10% sodium hydroxide (NaOH) solution in reagent tank T2.
4. Caution: Add NaOH slowly to water with constant stirring—this is an exothermic process.
5. Once TIC102 reaches the setpoint, open HV03 to introduce the NaOH solution into R1.
6. Set a timer for 10 minutes of mixing, then stop M1.
7. Allow the mixture to settle for 1 hour for soapstock separation.
8. Drain the soapstock via valves HV06 and HV07.

Washing

1. Increase TIC102 setpoint to 80°C and restart M1 at 100 rpm.
2. Prepare 2 L of distilled water in reagent tank T2.
3. Set TIC101 (T2 temperature) to 40°C and activate heater W1 to preheat the water.

1. Once R1 reaches 80°C, turn off heater W1; then, open HV03 to transfer preheated water into R1.
2. WARNING: Ensure W1 is off before draining T2 to prevent overheating or damage.
3. Mix for 10 minutes, then stop M1 and allow 30 minutes for phase separation.
4. Drain the water through HV06 and HV07.

Bleaching

1. Increase TIC102 to 90°C. Set M1 to 200 rpm and begin stirring.
2. Open HV04. Once the temperature is stable, add 100 g of bleaching earth via hopper T3.
3. Close HV03, HV04, and HV14. Then open HV13 (for vacuum suction) and HV12 (sealant water supply).
4. Start vacuum pump L1 to reach a vacuum pressure of 0.4 bar abs in R1 (as indicated by PT101).
5. Continue the bleaching process for 30 minutes.

Filtration

1. Reduce TIC102 to 40°C while maintaining mixing at 200 rpm.
2. Stop vacuum pump L1.
3. Open HV14 to restore atmospheric pressure in R1.
4. Open HV11 to cool down the reactor; simultaneously close HV12.
5. Once the temperature stabilizes, open HV06 and HV08 to begin multi-pass filtration. Keep HV10 closed.
6. Confirm PR01 and PR02 pressures (3 barg and 2 barg, respectively), then start pump P1.
7. Continue filtering until clear oil is visible through the sight glass.
8. To collect the product, open HV09 and close HV08 to redirect the flow to T1.
9. Weigh the bleached oil and retain a labeled sample in a clean container.
10. Before draining R1, switch off heater W2.
11. **WARNING**: Do not drain R1 with W2 on to avoid overheating.
12. Proceed to shutdown procedures to complete the Laboratory Exercise.

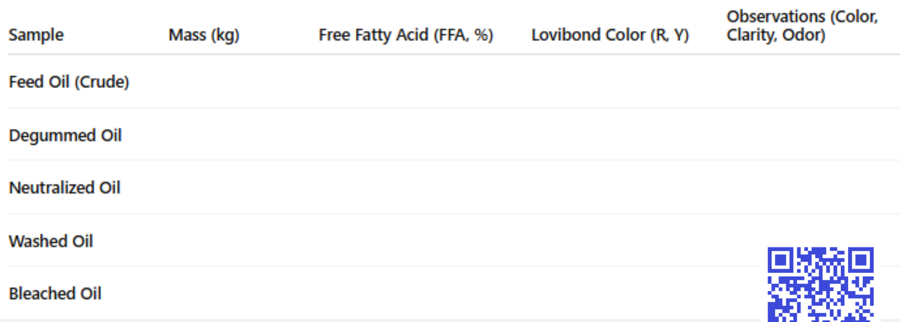
General Shutdown

1. Switch off heaters W1 and W2, all pumps (L1, P1), and stirrer M1.
2. Release pressure in R1 by opening HV13 and HV14.
3. Drain R1 completely using HV07 and empty T1 via HV01.
4. Remove any remaining liquid in T2 using HV03.
5. Prepare a waste container at filter S1, open the filter drain valve to release pressure and flush waste.
6. Close HV08 and HV09, then open HV10 to allow compressed air to clear the filter of any residual cake.
7. Turn off the unit at the Main Switch once fully drained.
8. Close all valves and proceed to sample analysis (e.g., FFA content, color).

Cleanup

1. Use compressed air or hot water to flush all pipelines.
2. Clean all tanks, reactors, and equipment surfaces to remove any residual oil.
3. Perform analytical tests on feed and bleached oil samples to evaluate processing efficiency, focusing on FFA content and color changes.

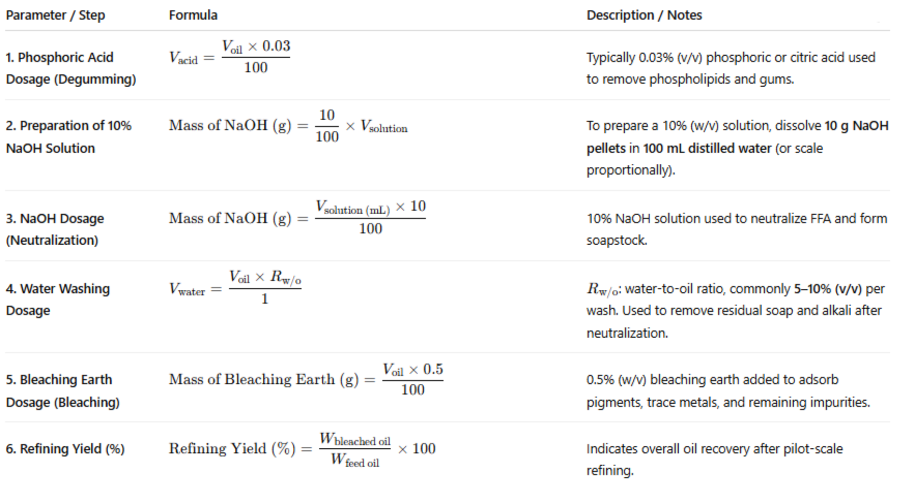
Result



Sample	Mass (kg)	Free Fatty Acid (FFA, %)	Lovibond Color (R, Y)	Observations (Color, Clarity, Odor)
Feed Oil (Crude)				
Degummed Oil				
Neutralized Oil				
Washed Oil				
Bleached Oil				

ASSESSMENT

Calculation



Parameter / Step	Formula	Description / Notes
1. Phosphoric Acid Dosage (Degumming)	$V_{\text{acid}} = \frac{V_{\text{oil}} \times 0.03}{100}$	Typically 0.03% (v/v) phosphoric or citric acid used to remove phospholipids and gums.
2. Preparation of 10% NaOH Solution	$\text{Mass of NaOH (g)} = \frac{10}{100} \times V_{\text{solution}}$	To prepare a 10% (w/v) solution, dissolve **10 g NaOH pellets in 100 mL distilled water** (or scale proportionally).
3. NaOH Dosage (Neutralization)	$\text{Mass of NaOH (g)} = \frac{V_{\text{solution (mL)}} \times 10}{100}$	10% NaOH solution used to neutralize FFA and form soapstock.
4. Water Washing Dosage	$V_{\text{water}} = \frac{V_{\text{oil}} \times R_{\text{w/o}}}{1}$	$R_{\text{w/o}}$: water-to-oil ratio, commonly **5–10% (v/v)** per wash. Used to remove residual soap and alkali after neutralization.
5. Bleaching Earth Dosage (Bleaching)	$\text{Mass of Bleaching Earth (g)} = \frac{V_{\text{oil}} \times 0.5}{100}$	0.5% (w/v) bleaching earth added to adsorb pigments, trace metals, and remaining impurities.
6. Refining Yield (%)	$\text{Refining Yield (\%)} = \frac{W_{\text{bleached oil}}}{W_{\text{feed oil}}} \times 100$	Indicates overall oil recovery after pilot-scale refining.

Discussion

- Discuss the purpose of the refining process and the key steps involved in detail (degumming, neutralization, bleaching, anddeodorization)
- Discuss the initial FFA content of the crude oil and how it changed after each refining step.
- Describe the color changes observed in the oil after each refining step.
- Identify potential sources of error in the experiment, such as measurement inaccuracies, contamination, or procedural mistakes.

Conclusion

Summarize the key findings and their relevance.

Reference

Provide the sources of reference for your discussion

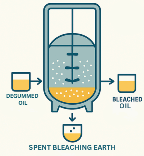
CHAPTER III

3.2 Physical Refining

Physical refining is the modern industry standard for purifying crude vegetable oils especially oils like palm, coconut, and rice bran that are rich in free fatty acids (FFA). Unlike chemical refining, this method skips the neutralization step and instead removes FFAs through steam distillation under vacuum. In this lab, you'll carry out a scaled-down version of industrial physical refining, including three key steps:

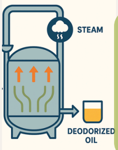
Degumming

removes phospholipids (gums) using acid and hot water



Bleaching

adsorbs color pigments and residual impurities using bleaching earth



Deodorization

applies steam under vacuum at high temperature to strip off FFAs and odor compounds

This process mimics what happens in modern palm oil refineries, which prioritize efficiency, yield, and lower chemical use. It's especially effective for oils with high FFA content, where chemical refining would lead to greater neutral oil losses.

Why Learn Physical Refining?

- **Cleaner product: Minimal chemical residues, better flavor stability.**
- **More sustainable: Less wastewater, fewer processing aids.**
- **Ideal for high-FFA oils such as crudepalm and rice bran oil.**

Fun Fact:

Most of the world's palm oil especially for food undergoes physical refining instead of chemical methods, due to lower cost and higher oil recovery.

See how bleaching earth works

SCAN ME

HERE

How bleaching earth works [Video]. AMCAdsorbents, 2013, YouTube

Laboratory Exercise 4 – Physical Refining (Pilot Scale)

Learning Objectives

- Understand the principles of physical refining of vegetable oil
- Perform physical refining of vegetable oil in a batch process.
- Demonstrate proper lab safety protocols.

Safety Precautions

- Always wear appropriate PPE including lab coats, safety goggles and gloves.
- Exercise caution around hot surfaces and equipment.

Procedures

Note: This procedure is carried out once due to the long processing time. Students may share results or compare with other groups to discuss data variation.

General Start-Up

1. Ensure that both heaters W1 and W2 are turned off at the control panel.
2. Power up the system by switching on the Main Switch.
3. Confirm that all valves are initially in the closed position.
4. Check the pressure regulators and adjust them if necessary:
    a. Set PR01 to 3 kgf/cm²
    b. Set PR02 to 2 kgf/cm²
5. The system is now ready for operation.

Feed Oil Preparation

1. Perform the general start-up procedures above.
2. Measure and transfer 20 L of feed oil into feed tank T1. Retain a small sample in a labeled beaker for reference or analysis.
3. Fully open valve HV12 to allow water into the vacuum pump L1 sealant ring.
4. Open HV02 and HV13.
5. Start pump L1 to create a vacuum in reactor R1, drawing the oil from T1 into R1.
6. Once T1 is emptied, stop L1, close HV02, and open HV14 to restore R1 to atmospheric pressure. Then close HV12.

Degumming

1. Perform acid degumming by slowly adding a 0.1% phosphoric or citric acid solution to the feed oil at 60°C while stirring continuously.
2. Continue mixing for 30 minutes to allow complete reaction.
3. Transfer the mixture to a separatory funnel and allow it to settle.
4. Discard the aqueous layer, which contains the gums

Bleaching

1. Increase TIC102 to 90°C. Set M1 to 200 rpm and begin stirring.
2. Open HV04. Once the temperature is stable, add 100 g of bleaching earth via hopper T3.
3. Close HV03, HV04, and HV14. Then open HV13 (for vacuum suction) and HV12 (sealant water supply).
4. Start vacuum pump L1 to reach a vacuum pressure of 0.4 bar abs in R1 (as indicated by PT101).
5. Continue the bleaching process for 30 minutes.

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Filtration

1. Reduce TIC102 to 40°C while maintaining mixing at 200 rpm.
2. Stop vacuum pump L1.
3. Open HV14 to restore atmospheric pressure in R1.
4. Open HV11 to cool down the reactor; simultaneously close HV12.
5. Once the temperature stabilizes, open HV06 and HV08 to begin multi-pass filtration. Keep HV10 closed.
6. Confirm PR01 and PR02 pressures (3 barg and 2 barg, respectively), then start pump P1.
7. Continue filtering until clear oil is visible through the sight glass.
8. To collect the product, open HV09 and close HV08 to redirect the flow to T1.
9. Weigh the bleached oil and retain a labeled sample in a clean container.
10. Before draining R1, switch off heater W2.
11. **WARNING**: Do not drain R1 with W2 on to avoid overheating.
12. Proceed to shutdown procedures to complete the Laboratory Exercise.

General Shutdown

1. Switch off heaters W1 and W2, all pumps (L1, P1), and stirrer M1.
2. Release pressure in R1 by opening HV13 and HV14.
3. Drain R1 completely using HV07 and empty T1 via HV01.
4. Remove any remaining liquid in T2 using HV03.
5. Prepare a waste container at filter S1, open the filter drain valve to release pressure and flush waste.
6. Close HV08 and HV09, then open HV10 to allow compressed air to clear the filter of any residual cake.
7. Turn off the unit at the Main Switch once fully drained.
8. Close all valves and proceed to sample analysis (e.g., FFA content, color).

Cleanup

1. Use compressed air or hot water to flush all pipelines.
2. Clean all tanks, reactors, and equipment surfaces to remove any residual oil.
3. Perform analytical tests on feed and bleached oil samples to evaluate processing efficiency, focusing on FFA content and color changes.

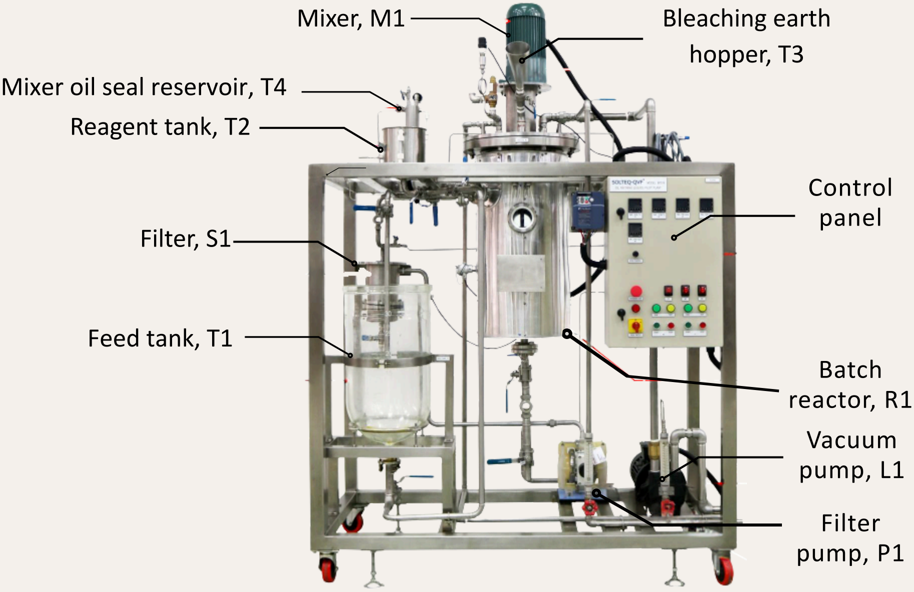
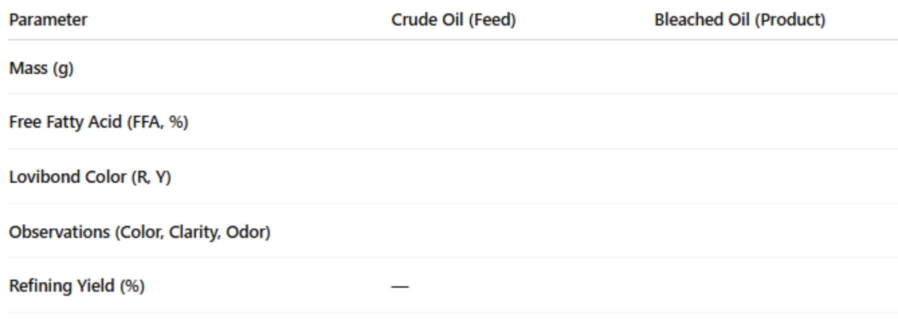


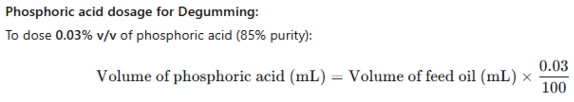
Figure 3.2: A p*hysical/chemical refining pilot plant.*

Result



Parameter	Crude Oil (Feed)	Bleached Oil (Product)
Mass (g)		
Free Fatty Acid (FFA, %)		
Lovibond Color (R, Y)		
Observations (Color, Clarity, Odor)		
Refining Yield (%)	—	

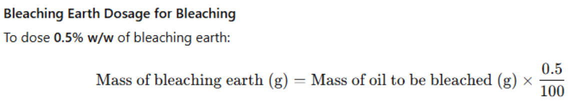
Calculation



Phosphoric acid dosage for Degumming:

To dose **0.03% v/v** of phosphoric acid (85% purity):

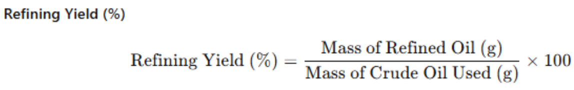
$$\text{Volume of phosphoric acid (mL)} = \text{Volume of feed oil (mL)} \times \frac{0.03}{100}$$



Bleaching Earth Dosage for Bleaching

To dose **0.5% w/w** of bleaching earth:

$$\text{Mass of bleaching earth (g)} = \text{Mass of oil to be bleached (g)} \times \frac{0.5}{100}$$



Refining Yield (%)

$$\text{Refining Yield (\%)} = \frac{\text{Mass of Refined Oil (g)}}{\text{Mass of Crude Oil Used (g)}} \times 100$$

Discussion

- Discuss how the type and concentration of acid used (phosphoric or citric) affect the removal of gums and other impurities.
- Discuss the impact of bleaching earth quantity and process temperature on the color and clarity of the oil. Analyze how vacuum conditions influence the bleaching efficiency.
- Evaluate the clarity and quality of the final filtered oil.

Conclusion

Summarize the key findings and their relevance.

Reference

Provide the sources of reference for your discussion

ASSESSMENT

CHAPTER III

3.3 Deodorization

Deodorization is the final—and often the most critical stage in edible oil refining. In this process, steam distillation under vacuum at elevated temperatures (typically 180–240 °C) removes odorous compounds, off-flavours, free fatty acids (FFAs), aldehydes, ketones, and other volatile impurities.

In this laboratory exercise, you will simulate the deodorization step using a pilot-scale system equipped with a vacuum pump, heater, and steam injection unit. The objective is to eliminate undesirable volatiles and lower the FFA content, thereby enhancing the refined oil's shelf life, flavour, and oxidative stability.

SCAN ME

See what happen in a deodorizer

HERE

Deodorization of vegetable oil [Video]. Norman, 2025, YouTube

Why is deodorization important?

- Removes thermal degradation compounds formed during earlier refining stages.
- Ensures the oil has a neutral taste and odor, critical for consumer acceptance.
- Reduces FFA to <0.05%, improving oxidative stability.
- Preserves beneficial minor components (like tocopherols) if conditions are controlled well.

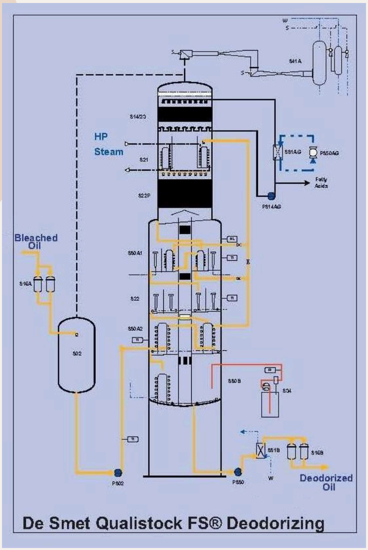


Figure 3.3: *Deodorizer schematic.* Adapted from Desost (2013). Deodorization unit for vegetable oil refining [Diagram]. Wikimedia Commons (CC BY-SA 3.0)

Industrial Insight:

Large-scale deodorization typically takes place in multi-tray deodorizer columns and can be tailored to "soft" (low temp) or "deep" (high temp) deodorization depending on oil type.

Laboratory Exercise 6 – Deodorization (Pilot Scale)

Learning Objectives

- Understand the principles of deodorization of vegetable oil
- Perform deodorization of vegetable oil in a batch process
- Demonstrate proper lab safety protocols.

Safety Precautions

- Always wear appropriate PPE including lab coats, safety goggles and gloves.
- Exercise caution around hot surfaces and equipment.

Procedures

Note: This procedure is carried out once due to the long processing time. Students may share results or compare with other groups to discuss data variation.

General Start-up

1. Ensure that heater W1 switch is in the off position on the control panel.
2. Power up the control panel with the Main Switch.
3. Ensure that all valves are initially closed.
4. Start the steam boiler. Open the steam trap bypass valve to drain leftover condensate. Close the bypass valve after a few minutes to allow steam pressure build up.
5. Check and if necessary, adjust the air pressure regulator PR01 to 3 kgf/cm2.
6. The unit is now ready for Laboratory Exercise.

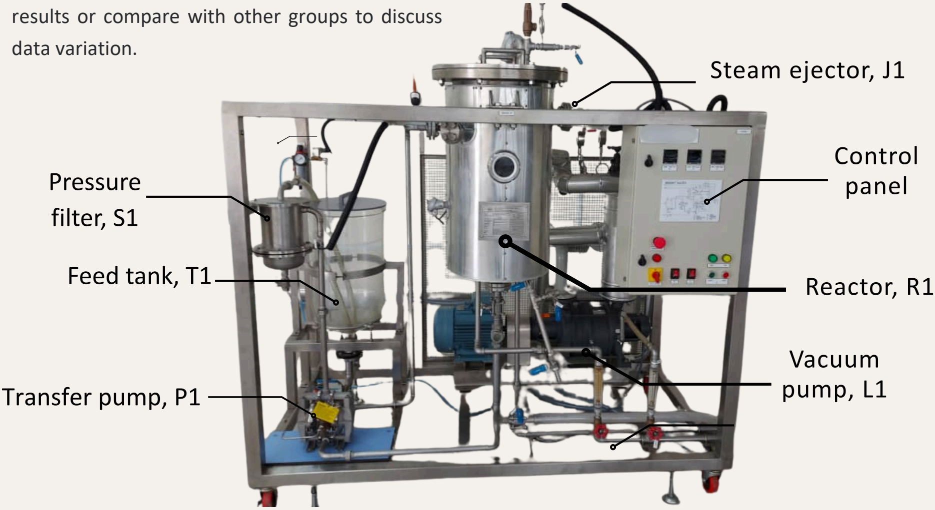


Figure 3.4: *An edible oil deodorization pilot plant*

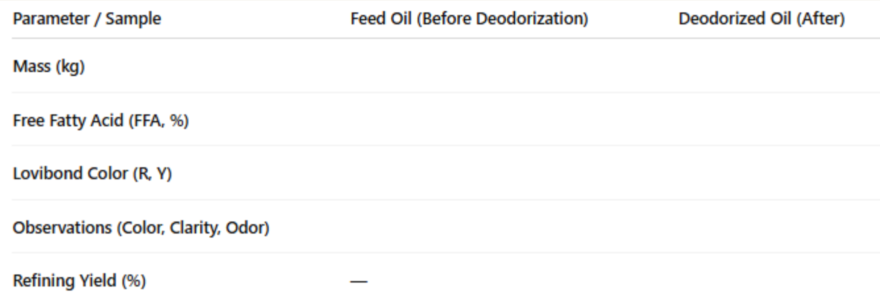
Deodorization

1. Perform the general start-up procedures as described in above section.
2. Weigh and prepare 20 L of feed oil in feed tank T1. Set aside a sample in a beaker or another appropriate container
3. Fully open HV11 to allow water into sealant ring of vacuum pump L1.
4. Open HV02 and HV10.
5. Start L1 to create a vacuum in reactor R1 and draw in the feed oil from feed tank T1.
6. Close HV02 when T1 is empty. Allow vacuum pull down to maximum.
7. Set temperature of TIC101 for R1 to 180 °C. Turn on heater W1.
8. Once set temperature is achieved, begin steam introduction.
9. Set PR02 to 2 barg (PG301) and slightly open HV13 to charge steam into R1. Avoid addition of excess steam which will increase the reactor pressure.
10. Open HV14 and adjust PR03 to achieve steam pressure of 1 barg at PG303 into ejector J1.
11. Adjust HV13 and HV14 accordingly to maintain PT101 pressure below 0.1 barg.
12. Set a timer for 30 minutes.
13. When deodorization is complete, close both HV13 and HV14. Switch off heater W1.
14. Open HV12 to allow cooling water into the coils. Cool down contents in R1 to less than 50°C.
15. Return reactor R1 to atmospheric conditions by venting with HV09.
16. To collect product, open valve HV06.
17. Start pump P1 to pass the oil through filter S1 and into tank T1 as product. Weigh the deodorized oil.
18. Adjust PR01 accordingly to increase pump speed. WARNING: Ensure heater W1 is off before draining the reactor R1 to prevent heater overheating.
19. Set aside a sample with label in a beaker or another appropriate container. End the Laboratory Exercise by performing shut down procedures.

General Shut Down

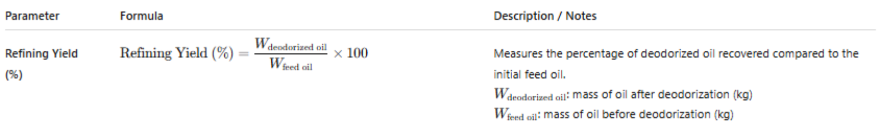
1. Switch off the heater (W1). Ensure steam supply valves are closed (HV13 and HV14).
2. Stop all pumps (L1 and P1). Allow sealant water into vacuum pump L1 to continue running to cool down.
3. Ensure the reactor R1 is returned to atmospheric pressure by opening valve HV09.

Result



Parameter / Sample	Feed Oil (Before Deodorization)	Deodorized Oil (After)
Mass (kg)		
Free Fatty Acid (FFA, %)		
Lovibond Color (R, Y)		
Observations (Color, Clarity, Odor)		
Refining Yield (%)	—	

Calculation



Parameter	Formula	Description / Notes
Refining Yield (%)	$\text{Refining Yield (\%)} = \frac{W_{\text{deodorized oil}}}{W_{\text{feed oil}}} \times 100$	Measures the percentage of deodorized oil recovered compared to the initial feed oil. $W_{\text{deodorized oil}}$: mass of oil after deodorization (kg) $W_{\text{feed oil}}$: mass of oil before deodorization (kg)

Discussion

- Discuss the theoretical background of deodorization in vegetable oil refining, focusing on the removal of odoriferous materials, free fatty acids, and other unwanted components.
- Explain the role of steam and vacuum in the deodorization process.
- Discuss the function and settings of the equipment used, including the steam boiler, vacuum pump, temperature and pressure regulators.

Conclusion

Summarize the key findings and their relevance.

Reference

Provide the sources of reference for your discussion

ASSESSMENT

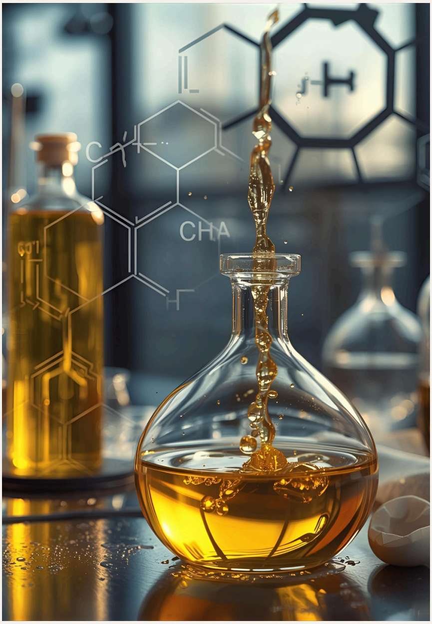
Chapter 4
Modification Processes

Introduction

Modification processes alter the physical and functional characteristics of refined oils to meet specific industrial and consumer needs. This chapter introduces hydrogenation, and dry fractionation. Students will observe how reaction conditions, catalysts, and cooling rates influence melting behavior, plasticity, and stability.

Learning Outcomes

- Define and differentiate modification techniques
- Describe the purpose and mechanism of hydrogenation and fractionation
- Analyze how modification affects oil texture and functionality
- Interpret results of modification experiments in relation to end-use properties



Key Terms

Hydrogenation, Fractionation, Interesterification, Catalysts, Plasticity, Stability.

CHAPTER IV

4.1 Dry Fractionation

Palm oil derivatives: Fractioning process [GIF]. Kruglova, 2022, ChinaDialogue

Dry fractionation is a physical modification process used to separate palm oil (or other fats) into their liquid (olein) and solid (stearin) components based on melting point differences. Unlike solvent fractionation, this method uses controlled cooling and crystallization, followed by filtration, without adding chemicals or solvents.

In this lab, you'll perform a pilot plant–scale version of dry fractionation using refined, bleached, and deodorized (RBD) palm oil. The process involves:

1. Preheating (Melting):
    - The RBD palm oil is first heated to about 70–80 °C to ensure all fat crystals are completely melted.
    - This provides a uniform starting point for the crystallization step and prevents unwanted nucleation that could affect fraction quality.
2. Controlled Cooling and Crystallization:
    - The molten oil is gradually cooled to a target crystallization temperature (typically 20–27 °C), allowing higher-melting triglycerides (stearin) to form crystals.
    - The mixture is then maintained at this temperature for a specific holding period to allow complete crystal growth and stabilization.
3. Filtration or Pressing:
    - The solid stearin crystals are separated from the liquid olein by filtration or hydraulic pressing.

Why Dry Fractionation?

Solvent-free & sustainable
No hexane or ethanol used

Cost-effective
Energy efficient and widely used in palm oil processing plants globally

Selective separation
Tailors fats for different applications—e.g., frying oils (olein) vs margarine or bakery fats (stearin)

How is palm oil produced? (3) Fractionation [Video]. European Palm Oil Alliance, 2017, YouTube

Real-World Use:
Most Malaysian and Indonesian palm oil producers use dry fractionation to produce olein for cooking oil and stearin for shortenings, margarines, and cocoa butter substitutes.

Laboratory Exercise 7 – Dry Fractionation (Pilot Scale)

Learning Objectives

- Understand the principles of palm oil fractionation
- Perform fractionation palm oil into its liquid and solid components using a pilot plant setup.
- Demonstrate proper lab safety protocols.

Materials and Equipment

- Refined, Bleached, Deodorized Palm Oil
- Fractionation equipment (including crystallizers, filters, heaters, etc.)
- Thermometers and pressure gauges
- Safety equipment (gloves, goggles, lab coats)
- Beakers, flasks, and other lab glassware
- Data recording sheets or software
- Apparatus Oil Fractional Pilot Plant

Safety Precautions

- Always wear appropriate personal protective equipment (PPE).
- Be aware of hot surfaces and high-pressure systems.
- Follow all lab safety protocols for handling oils and chemicals.

Dry fractionation pilot plant setup [3-D model]. Norman, 2025

Procedures

Note: This procedure is carried out once due to the long processing time. Students may share results or compare with other groups to discuss data variation.

General Start-Up

1. Confirm that all power switches are in the OFF position.
2. Visually inspect all electrical components for signs of damage or wear.
3. Verify that all electrical connections and fastenings are secure and properly tightened.
4. Place the equipment on a stable and level surface.
5. Plug in the main power cable and ensure the unit is connected to a power source.
6. Turn on the main power switch.
7. Confirm that all indicator lights illuminate.
8. Ensure that all hand valves, ball valves, globe valves, and gate valves are closed prior to operation.
9. Fill tank T-102 with water until the level is above the low-level sensor (LSL).
10. Fill T-103 with water until it reaches the jacket level.
11. The system is now ready for use.

Feed Tank Preparation

1. Fill T-101 with at least 30 kg of RBD palm oil. Keep a sample aside in a beaker for analysis.
2. Ensure LSL-101 does not trigger an alarm after filling.
3. Fill T-102 with tap water up to 25% full or until the heater HTR-101 is fully submerged.
4. Confirm LSL-102 is not in alarm state.
5. Input the desired temperature setpoint for HTR-101 (between 30–65°C) using SCADA.
6. On SCADA, select HTR-101 and turn it ON.
7. If LSL-102 is clear, the heater will activate.
8. If TE-102 exceeds the setpoint, HTR-101 will automatically shut off.
9. As heating begins, monitor TE-102. Wait until the desired temperature is reached.
10. Once the setpoint is achieved, HTR-101 will switch off automatically.

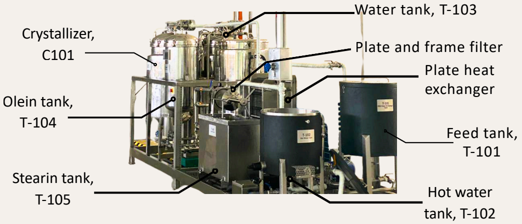


Figure 4.1: *A palm oil dry fractionation pilot plant*

Pre-heating unit model
[3-D model]. Norman, 2025

Chill Water Tank Preparation

1. Fill T-103 completely to jacket height with water. This prevents icing on refrigerant lines and protects the compressor.
2. Open MBV-113 and MBV-114 manually.

Feed Preheating

A. Hot Water Heating Method:

1. Open MBV-104 and MBV-106.
2. Turn ON pump P-102.
3. Open MBV-101 and MBV-103, then turn ON pump P-101.
4. Monitor TE-101 until it stabilizes at the target temperature.
5. Turn OFF P-102.
6. Close MBV-104 and MBV-106.

B. Steam Heating Method:

1. Ensure the steam boiler is turned on and pressure is stable.
2. Open MBV-101 and MBV-103.
3. Turn ON pump P-101.
4. Open MBV-123 and slowly adjust MGV-101 to 25% open.
5. Monitor TE-101 until it reaches 60–70°C.
6. Close MGV-101 and MBV-123.

Inside view of dry fractionation crystallizer [GIF]. Norman, 2025, GIPHY

Figure 4.2: *Inside view of oil crystallization*

Transferring Oil from T-101 to Crystallizer C-101/C-102

- Choose between C-101 or C-102 for operation.
- Based on selection, follow either steps:

For C-101:

1. Open MBV-108. If flow is low, partially close MBV-103.
2. Turn ON stirrer M-101.
3. If oil level in T-101 drops too low, P-101 will shut off automatically.
4. Confirm TE-104 matches TE-101 after transfer.

For C-102:

1. Open MBV-110. If flow is low, adjust MBV-103.
2. Turn ON stirrer M-102.
3. Low-level alarm in T-101 will shut off P-101 if necessary.
4. Confirm TE-105 matches TE-101 after transfer.

Crystallization unit model [3-D model]. Norman, 2025

Crystallization Process

For C-101:

1. Open MGV-103 and start P-103.
2. Monitor TE-104 and TE-106. Record temperature over time.
3. Once TE-104 reaches target temperature, turn OFF P-103 and maintain temperature.
4. Repeat cooling cycles until TE-104 nears 35°C.
5. Set CH-101 (cooler) to desired range (18–30°C) and start via SCADA.
6. When TE-103 reaches the setpoint, proceed with step-wise cooling.
7. Stop P-103 once TE-104 stabilizes at the crystallization temperature.
8. Once complete, turn OFF M-101.

For C-102:

1. Open MGV-104 and turn ON P-103.
2. Monitor TE-105 and TE-106.
3. After reaching target temperature, turn OFF P-103.
4. Repeat cooling cycles until TE-105 is near 35°C.
5. Set CH-101 to 18–30°C and activate via SCADA.
6. Wait for TE-103 to stabilize, then continue cooling.
7. Once TE-105 reaches target, stop P-103 and hold temperature.
8. After crystallization, turn OFF M-102.

Slurry Transfer to Product Tanks

For C-101

1. Confirm F-101 is sealed (tighten handwheel clockwise).
2. Open MBV-109, MBV-117, MBV-118.
3. Transfer slurry via MBV-115 to a cylinder until LSL-103 clears.
4. Start P-104 to transfer olein into T-104.
5. Stop P-104 if pressure reaches 0.4 bar.
6. Drain lines through the sampling valve.
7. Loosen filter (handwheel counter-clockwise), remove filter cake, and collect stearin into T-105. Save a sample.

or C-102

1. Repeat steps with MBV-111, MBV-117, MBV-118.
2. Transfer slurry to cylinder via MBV-115.
3. Start P-104 and transfer olein into T-104. Save a sample.
4. Stop pump at 0.4 bar or if LSL-103 triggers.
5. Drain lines and open filter. Collect filter cake into T-105.

Student collecting palm stearin from frame filter [GIF]. Norman, 2025, GIPHY

Stearin Transfer

1. Partially open MBV-122 until water overflows from the jacket around T-105.
2. Once jacket is filled, close MBV-122.
3. Set HTR-102 and HTR-103 to 30–65°C via SCADA.
4. Turn ON heaters through SCADA.
5. When TE-107 exceeds the setpoint, heaters will shut off automatically.
6. As stearin melts, TE-107 will rise. Wait for desired temperature.
7. Once molten, open MBV-121 to discharge stearin.

General Shut-Down

1. Turn OFF main power.
2. Drain water from T-102 and T-103 via MBV-107, MBV-112, MBV-113.
3. Empty residual oil from T-101, C-101, C-102 via MBV-102, MBV-115, MGV-109, MGV-111.
4. Connect hoses to MBV-119 and MBV-121 to collect olein and stearin.

Cleanup

1. Fully drain tanks and reactors. Use compressed air or hot water to flush pipes.
2. Thoroughly clean all tanks and reactor surfaces to remove remaining oil residues.
3. Conduct sample analysis (RBD palm oil, olein, stearin) with focus on iodine value and other quality indicators.

Result

In a graph paper, plot a curve entitled “Palm Oil Heating and Cooling Curve” with temperature (C) on y-axis versus Time (minute) on x-axis

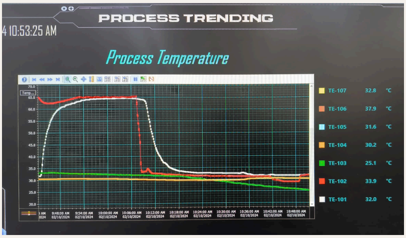


Figure 4.3: *Temperature profile during dry fractionation.*

Parameter / Sample	Feed Oil (Before Fractionation)	Liquid Fraction (Olein)	Solid Fraction (Stearin)
Mass (kg)			
Iodine Value (IV)			
Observations (Color, Clarity, Texture)			
Fraction Yield (%)	—		

ASSESSMENT

Calculation

Formula	Description / Notes
$\text{Stearin Yield (\%)} = \frac{W_{\text{stearin}}}{W_{\text{feed oil}}} \times 100$	W_{stearin}: mass of solid fraction (kg) $W_{\text{feed oil}}$: mass of feed oil before fractionation (kg).
$\text{Olein Yield (\%)} = \frac{W_{\text{olein}}}{W_{\text{feed oil}}} \times 100$	W_{olein}: mass of liquid fraction (kg) $W_{\text{feed oil}}$: mass of feed oil before fractionation (kg).

Discussion

- Explain the scientific principles behind the fractionation of RBD Palm Oil.
- Discuss the role of temperature and crystallization in separating the different components of the oil.
- Evaluate the quality of the stearin and olein produced. Discuss the characteristics of these fractions and their suitability for various applications in the food industry or other sectors.
- Discuss the efficiency of the fractionation process in the context of yield and purity of the fractions (stearin and olein).

Conclusion

Summarize the key findings and their relevance.

Reference

Provide the sources of reference for your discussion

CHAPTER IV

4.2 Hydrogenation

Hydrogenation is a chemical modification process that turns liquid oils into semi-solid or solid fats by adding hydrogen gas to unsaturated fatty acids in the presence of a metal catalyst (typically nickel). This process increases the saturation level, which improves oxidative stability, alters melting behavior, and extends shelf life. Based on Figure 4.4, Hydrogenation occurs as the double bond (C=C) reacts on a catalyst surface.

The reactants attach to the catalyst, and H_2 splits into separate atoms.

One hydrogen atom bonds to one carbon atom, while the other carbon remains attached to the surface.

Finally, the second carbon bonds with another hydrogen, and the molecule is released.

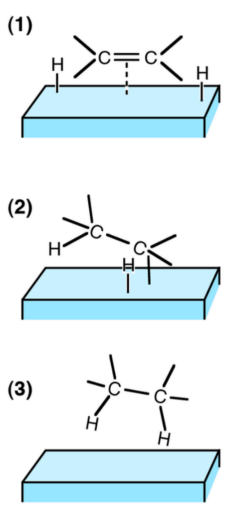


Figure 4.4.: *Hydrogenation of a C=C bond on a catalyst (Schmid, 2005, CC BY SA 3.0).*

Why is Hydrogenation Important?

Stability boost
Reduces rancidity by eliminating reactive double bonds.

Versatile applications
Hydrogenated fats are used in food, cosmetics, and candle industries.

Functional customization
Produces fats with desired textures for margarine, shortening, and confectionery coatings.

However, partial hydrogenation can produce trans fats, which are now being phased out due to health concerns.

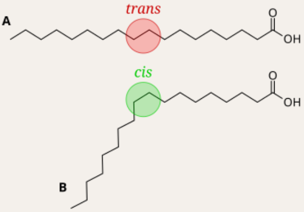


Figure 4.5: *Cis- and trans-configurations of oleic acid.*
Adapted from Pintor4257, Wikimedia Commons (https://commons.wikimedia.org/wiki/File:Cis_trans_svg.svg), CC BY-SA 3.0.

Laboratory Exercise 8 – Hydrogenation (Pilot Scale)

Learning Objectives

- Understand the principles of palm oil hydrogenation.
- Perform hydrogenation on unsaturated palm oil in a batch process using a pilot plant setup.
- Demonstrate proper lab safety protocols.
-

Materials and Equipment

- Refined, Bleached, Deodorized Palm Oil
- Hydrogenation pilot plant
- Nickel catalyst
- Compressed Hydrogen Gas
- Compressed Nitrogen Gas
- Beakers, flasks, and other lab glassware
- Data recording sheets or software
- Safety equipment (gloves, goggles, lab coats)

Safety Precautions

- Always wear appropriate personal protective equipment (PPE).
- Be aware of hot surfaces and high-pressure systems.
- Follow all lab safety protocols for handling oils and chemicals.

Procedures

General Start-Up

1. Turn on the control panel using the Main Switch.
2. Confirm all valves are initially closed.
3. Start the steam boiler.
4. Open the steam trap bypass valve to release any remaining condensate.
5. After a few minutes, close the bypass valve to allow steam pressure to build up.
6. Verify and, if necessary, set air pressure regulators PR01 and PR03 to 3 kgf/cm².
7. The system is now ready for operation.

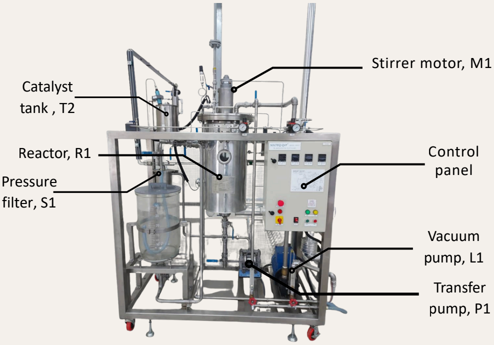


Figure 4.6: *An oil hydrogenation pilot plant*

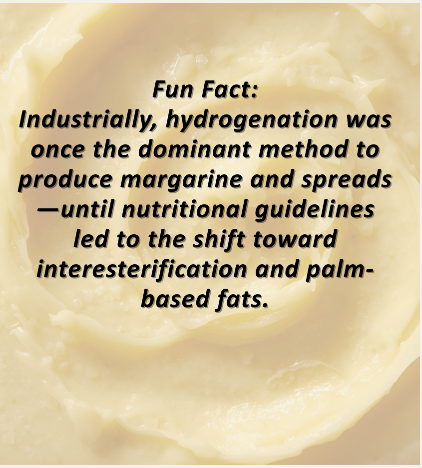
Operation

1. Complete the general start-up steps.
2. Load 18 liters of unsaturated palm oil into feed tank T1.
3. Prepare 2 liters of unsaturated palm oil in catalyst tank T2 and add 20 g of catalyst; mix thoroughly.
4. Open valve HV15 and adjust PR03 and PR05 to enable mixing of catalyst with oil in tank T2.
5. Fully open valve HV16 to supply water to the vacuum pump L1’s sealant ring.
6. Open valves HV02 and HV12.
7. Start vacuum pump L1 to create vacuum in reactor R1 and draw approximately 10 liters of oil from feed tank T1.
8. Close valve HV02 and open HV03 to transfer the catalyst-oil mixture into reactor R1.
9. Once tank T2 is empty, close HV03 and reopen HV02 to draw the remaining oil from tank T1 into reactor R1.
10. Close HV02 when T1 is empty and maintain vacuum at maximum level.
11. Open valve HV14 and adjust PR04 to achieve a mixing speed of approximately 150 rpm.
12. Adjust valve HV18 to begin nitrogen gas purging.
13. Stop vacuum pump L1.
14. Stop vacuum pump L1.
15. Slightly open valve HV19 to re-pressurize the vessel to atmospheric pressure (1 bar).
16. Close HV19 and restart vacuum pump L1 to maintain vacuum for 5 minutes.
17. Repeat steps 13 to 15 two more times.
18. After the third nitrogen purge, close valve HV12 to maintain vacuum in reactor R1.
19. Stop vacuum pump L1 and close valve HV16.
20. Change valve HV18 position to allow hydrogen gas sparging.
21. Slowly open HV19 to pressurize reactor R1 to approximately 3 bar absolute (as monitored by PT101)
22. Begin heating by introducing steam into the heating coils; open steam trap bypass valve to drain condensate.
23. Open the steam inlet valve and adjust PR06 to maintain about 3 barg steam pressure in the coils.
24. When the temperature stabilizes between 130°C and 140°C, start a 2-hour timer.
25. At the end of hydrogenation, close the steam supply valve.
26. Fully open cooling water valve HV17 and cool reactor contents below 50°C.
27. Vent reactor R1 to atmospheric pressure via valve HV09.

28. Adjust valve HV18 for nitrogen gas purging.
29. Open HV19 to continuously pass nitrogen gas through R1 for 5 minutes to displace hydrogen, ensuring pressure does not exceed 3 bar absolute.
30. Close HV19 and vent reactor back to atmospheric pressure.
31. Open valves HV05 and HV10.

Start pump P1 to pass the product through filter S1, separating catalysts and collecting the saturated product in tank T1.

32. Adjust PR02 as needed to increase flow rate.
33. Stop pump P1 when reactor R1 is emptied.
34. Conclude the Laboratory Exercise by performing shut-down procedures.



Fun Fact:
Industrially, hydrogenation was once the dominant method to produce margarine and spreads—until nutritional guidelines led to the shift toward interesterification and palm-based fats.

General Shut-Down

1. Ensure the steam supply valve is closed.
2. Close valves HV14 and HV15 to stop the stirring mechanisms.
3. If reactor R1 is still pressurized with hydrogen, slowly open valve HV11 to vent.
4. Verify valve HV19 is closed.
5. Once reactor pressure returns to atmospheric, purge R1 by introducing nitrogen gas.
6. Set valve HV18 to nitrogen, open HV19, and keep vent HV11 open during purging.
7. After 5 minutes of purging, close valve HV19.
8. Fully drain reactor R1 using valves HV05 and HV06; drain feed tank T1 via valve HV01.
9. Place a waste container for filter S1 discharge, then open filter drain valve HV08 to relieve pressure and discharge waste into the container.
10. Open valve HV07 to blow compressed air through the filter to clear residual catalysts.
11. Turn off the unit by switching off the Main Switch on the control panel.
12. Close all valves once the unit is fully drained.

Cleanup

1. Completely drain all tanks and reactor; either blow pipes with compressed air or flush them with hot water.
2. Clean all tanks and the reactor thoroughly, removing any remaining oil residue from surfaces and equipment.
3. Analyze samples of RBD Palm oil, palm olein, and palm stearin to evaluate processing effects, focusing on changes in iodine value.

Discussion

- Describe the physical and chemical changes observed in the oil before and after hydrogenation.
- Compare the iodine values of RBD Palm Oil and Hydrogenated Palm Oil.
- Explain how the iodine value indicates the degree of saturation achieved.
- Discuss the efficiency of the hydrogenation process based on the yield of hydrogenated oil.

Result

Parameter / Sample	Before Hydrogenation	After Hydrogenation
Mass (g)		
Iodine Value (IV)		
Observations (Texture, Odor)		

Calculation

Parameter	Formula	Description / Notes
1. Catalyst Dosage (%)	$\text{Mass of Catalyst (g)} = \frac{W_{\text{oil}} \times C_{\text{cat}}}{100}$	W_{oil}: mass of oil used (g) C_{cat}: catalyst concentration (typically 0.1–0.5% w/w). Used to determine the amount of nickel catalyst required for hydrogenation.
2. Hydrogenation Yield (%)	$\text{Hydrogenation Yield (\%)} = \frac{W_{\text{hydrogenated oil}}}{W_{\text{feed oil}}} \times 100$	Measures recovery of hydrogenated oil relative to the feed oil before hydrogenation.

Conclusion

Summarize the key findings and their relevance.

Reference

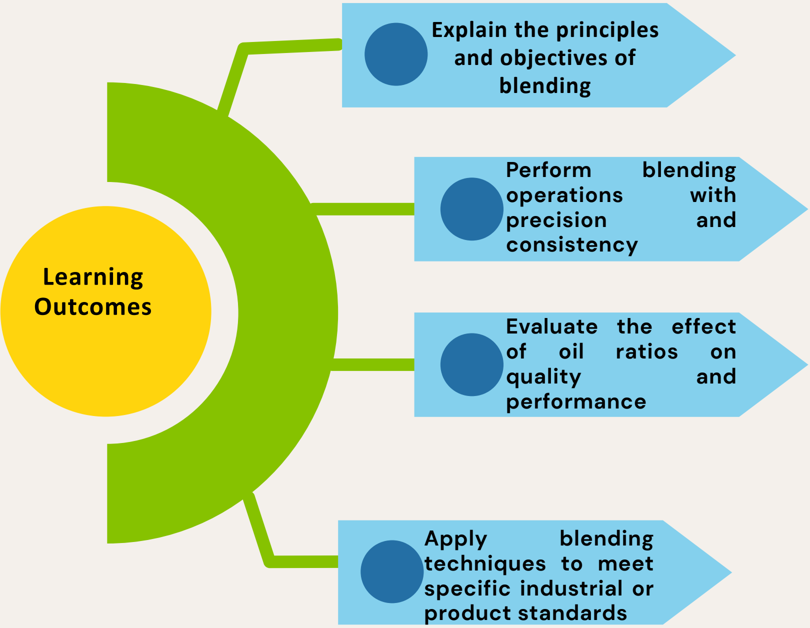
Provide the sources of reference for your discussion

ASSESSMENT

Chapter 5
Blending

Introduction

This chapter focuses on blending as a method to achieve desired properties by combining different refined oils. Students will understand the role of blending in producing functional fats, margarine bases, and specialty formulations. Exercises emphasize proper proportioning, mixing, and evaluation of blended samples.



Learning Outcomes

- Explain the principles and objectives of blending
- Perform blending operations with precision and consistency
- Evaluate the effect of oil ratios on quality and performance
- Apply blending techniques to meet specific industrial or product standards

Key Terms

Blending, Formulation, Stability, Consistency, Melting Profile, Product Quality.

CHAPTER V

5.1 Blending of Oils

Cloud point in rapeseed oil [Video]. ajvoice949, YouTube

Blending is a customization technique used in oil and fat processing to achieve desired melting points, flavor, oxidative stability, and cloud point, the temperature at which an oil starts to crystallize and turn cloudy.

In this lab, you'll blend two or more vegetable oils (e.g., palm olein and coconut oil) and evaluate their cloud point, a critical property for products stored in cold conditions or used in temperate climates. The Laboratory Exercise helps you understand how different fatty acid compositions influence the low-temperature behavior of oils.

The cloud point is determined by cooling the oil sample gradually and observing the temperature at which the first haze appears. The process reflects real-world challenges in oil formulation, such as:

Ensuring clear salad dressings at refrigeration temperatures

Creating stable biodiesel blends

Designing fats for chocolate, ice cream, or spreads

Why Blending and Cloud Point Matter?

Product stability

Oils with a high cloud point may solidify or turn hazy in cooler environments

Functional fats

Blending allows oil processors to modify spreadability, melting point, or crystallization behavior.

No chemical alteration

Blending changes physical behavior without affecting the oil's chemical identity.

Industry Insight:
In tropical climates, oils like palm olein are popular, but must be carefully blended for export to temperate countries where lower cloud points are required.

Laboratory Exercise 9 – Blending of Oils

Learning Objectives

- Understand the principles of vegetable oil blending
- Perform blending of different vegetable oils with varying compositions and study the cloud point of the blended mixture.
- Demonstrate proper lab safety protocols.

Materials and Equipment

Two different vegetable oils (e.g., palm olein and coconut oil)
Analytical balance
Beaker
Glass rod for stirring
Refrigerator or cooling bath
Precision thermometer
Pipettes or burettes
Heating mantle or hot plate
Oil sample bottle
Filter paper (if necessary)

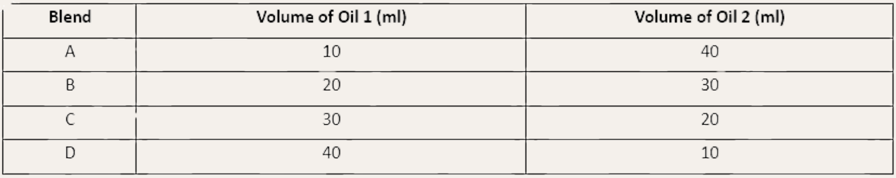
Safety Precautions

- Wear lab coats, gloves, and safety glasses.
- Handle heating equipment with care to avoid burns.

Procedure

Preparation of Oil Blend

1.Accurately measure specific volumes of the two oils according to table below
2.Transfer the oils into a beaker. Use a glass rod to mix them until homogeneous.
3.Gently heat the oil blend to be tested to 130°C on a hot plate to destroy any crystal nuclei.



Blend	Volume of Oil 1 (ml)	Volume of Oil 2 (ml)
A	10	40
B	20	30
C	30	20
D	40	10

Cooling and Cloud Point Determination

1. Prepare a water bath - made up of water, chipped ice and water; or chipped ice, salt and water.
2. Begin cooling the bottle and contents in a water bath, stirring to maintain uniform temperature.
3. When approximately 10°C above the expected cloud point, stir steadily to prevent supercooling. Maintain the sample level in the bottle at the same level as the water in the bath.
4. Regularly remove the beaker from the bath for inspection.
5. Determine the cloud point as the temperature at which the thermometer submerged in the oil becomes invisible when viewed horizontally through the bottle.
6. To ensure accuracy, it's recommended to conduct the test at least twice and take the average of the readings.

Cleanup

1. Clean all equipment thoroughly with soap and water.
2. Dispose of any remaining waste properly.

Calculation

Calculate the average cloud point (°C) of the blended oil based on the measured cloud points of Oil A and Oil B, and their respective blending ratio.

Discussion

- Compare the blends cloud point with the cloud points of the individual oils
- Discuss the influence of oil composition on cloud point

Conclusion

Summarize the key findings and their relevance.

Reference

Provide the sources of reference for your discussion

ASSESSMENT

Result

Blend	Volume of __________ Oil (ml)	Volume of __________ Oil (ml)	Cloud point °C			
			Trial 1	Trial 2	Trial 3	Average
A	10	40				
B	20	30				
C	30	20				
D	40	10				

References

Abd El-Salam, A. M., & El-Barbary, H. A. (2020). Design, manufacturing, and testing of hydraulic press to produce the oil from Egyptian Jatropha seeds. *International Journal of Engineering and Advanced Technology*, 9(3), 4333–4337.

Abriani, D. T. (2022, August 10). *Tutorial penggunaan alat rotary evaporator* [Video]. YouTube. https://youtu.be/P_twu_YRP-w

AJ Voice. (2022, December 29). *Cloud point in rapeseed oil* [Video]. YouTube. https://youtube.com/shorts/2hQ9zWcnHVA

AMC Adsorbents. (2013, November 14). *How bleaching earth works* [Video]. YouTube. https://youtu.be/BFkm-uno57o

AOCS. (2017). *Official methods and recommended practices of the AOCS* (7th ed.). American Oil Chemists' Society.

Azadmard-Damirchi, S., & Dutta, P. C. (2006). Stability of minor lipid components during refining. Food Chemistry, 96(3), 521–530. https://doi.org/10.1016/j.foodchem.2005.02.051

Bartolo, J., & Zeng, Y. (2017). Influence of rendering methods on yield and quality of chicken fat. *Asian-Australasian Journal of Animal Sciences, 30(5),* 722–727. https://doi.org/10.5713/ajas.16.0485

Büchi Labortechnik AG. (2020). *Soxhtherm® automated extraction system: Technical data and application note.* https://www.buchi.com/en/products/extraction/soxhtherm

Casali, B., & Tentori, F. (2022, February 7). Edible oil refining scheme [Diagram]. Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Edible_oil_refining_scheme.png

Chemistry Teaching Labs – University of York. (2024, July 10). *Soxhlet extraction* [Video]. YouTube. https://youtu.be/VL16RPNr-34

De Greyt, W. (2012). Fundamentals of deodorization. In C. C. Akoh (Ed.), *Food lipids* (3rd ed., pp. 313–348). CRC Press. https://doi.org/10.1201/b12039

De Greyt, W., & Kellens, M. (2000). Physical refining of vegetable oils. *European Journal of Lipid Science and Technology, 102(7)*, 472–486. https://doi.org/10.1002/1438-9312(200007)102:7<472::AID-EJLT472>3.0.CO;2-8

Desost. (2013, October 7). Qualistock FS.jpg [Diagram]. Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Qualistock_FS.jpg

Dolinowski, T. (2011, January 30). *Soxhlet extractor mechanism* [GIF]. Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Soxhlet_mechanism.gif (CC BY-SA 3.0)

Dr Lim Seng Joe. (2024, September 10). Laboratory practical: *Determining free fatty acid (FFA) content using titration method* [Video]. YouTube. https://youtu.be/vKTT1ZCumv4

DVC Process Technologists. (2019, March 11). *Edible/vegetable/cooking oil degumming/neutralization process* [Video]. YouTube. https://youtu.be/sXPfmW0i6nA

European Palm Oil Alliance. (2017, November 22). *How is palm oil produced? (3) Fractionation* [Video]. YouTube. https://youtu.be/NkGspWAGDM8

Fanny Urbanhomesteader. (2019, October 26). *How to render chicken fat – How to make schmaltz – Prepping* [Video]. YouTube. https://youtu.be/nNV3cWnfqJ8

FEDIOL. (2021). *Technical dossiers on vegetable oil refining, hydrogenation, deodorization, and fractionation*. Federation of the European Vegetable Oil and Proteinmeal Industry. https://www.fediol.eu

FuseSchool – Global Education. (2016, April 18). *How to harden vegetable oils through hydrogenation | Organic chemistry | Chemistry | FuseSchoo*l [Video]. YouTube. https://youtu.be/6J26Wmvltzs

Gadang Works Sdn. Bhd. (2018). *Instructor manual: Oil fractionation pilot plant (Model A1171), Revision 0*. Internal documentation.

Gunstone, F. D. (2011). *Vegetable oils in food technology: Composition, properties and uses (2nd ed.).* Wiley-Blackwell. https://doi.org/10.1002/9781444339913

Henan Weto Machinery Co., Ltd. (2019, September 10). *Tallow fat oil extraction machine / fat rendering machine* [Video]. YouTube. https://youtu.be/LjHUC0aMuKU

How It’s Made. (2016, November 4). *How it’s made: Palm oil* [Video]. YouTube. https://youtu.be/5jDj1nX-Q4o

How It’s Made. (2024, September 1). *How it’s made: Olive oil* [Video]. YouTube. https://youtu.be/Hz0QlRcnyio

ISO. (2015). *ISO 11085: Cereal and feed fat content by Randall extraction method.* International Organization for Standardization. https://www.iso.org/standard/62985.html

Kellens, M., Gibon, V., Hendrix, M., & De Greyt, W. (2007). Palm oil fractionation. *European Journal of Lipid Science and Technology, 109(4),* 336–349. https://doi.org/10.1002/ejlt.200600256

Kittiphoom, S., & Suwanmanee, S. (2014). Blending ratio and cloud point of coconut–palm oil blends. *International Food Research Journal, 21(5),* 1991–1996.

Kruglova, R. (2022, June 29). *Palm oil derivatives: Fractioning process* [GIF]. Dialogue Earth. https://dialogue.earth/content/uploads/2022/06/20220629_Palm-oil-derivatives-fractioning-process-animated_RitaKruglova_ChinaDialogue.gif

Lai, O. M., Tan, C. P., & Akoh, C. C. (2012). *Palm oil: Production, processing, characterization, and uses.* AOCS Press. https://doi.org/10.1016/B978-0-9818936-9-3.50006-6

Li, C., Wang, L., Wang, Y., & Wang, Y. (2020). Extraction of oil from okara by Soxhlet method. *Food Science and Human Wellness, 9(2),* 161–169. https://doi.org/10.1016/j.fshw.2020.03.002

Matthäus, B. (2010). Use of the Soxhlet method in food analysis. *European Journal of Lipid Science and Technology, 112(10),* 1181–1184. https://doi.org/10.1002/ejlt.201000146

MicroChem’s Laboratory Exercises. (2020, September 21). *Determination of iodine value: A complete procedure (AOAC 920.159)* [Video]. YouTube. https://youtu.be/fQ1hSNGnXYY

MPOB. (2016). *Hydrogenation of palm oil: Process and applications*. https://www.mpob.gov.my

MPOB. (2019). *Malaysian palm oil refining industry: Overview and best practices.* Malaysian Palm Oil Board. https://www.mpob.gov.my

Muhammad Izwan Bin Norman (PTSN). (2025, June 3). *Deodorization of vegetable oil* [Video]. YouTube. https://youtu.be/VWd_1bjxCLQ

Mutanen, J. (n.d.). *Triacylglycerol (tristearate)* [3D model]. Sketchfab. https://skfb.ly/otuxr
(CC BY 4.0)

Norizzah, A. R., Tan, C. P., & Mirhosseini, H. (2010). Physicochemical properties of palm-based blended oils. *Journal of Food, Agriculture & Environment, 8(2)*, 95–100.

Ockerman, H. W., & Hansen, C. L. (2000). *Animal by-product processing and utilization*. CRC Press.

OpenStax College. (2013, May 16). *Triglycerides* (illustration) [Image]. Wikimedia Commons. https://commons.wikimedia.org/wiki/File:220_Triglycerides-01.jpg

Perdue AgriBusiness. (2023, January 6). *Salisbury soybean processing* [Video]. YouTube. https://youtu.be/JGAg-wDeMA0

Quantockgoblin. (n.d.). Soxhlet extractor [Image]. Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Soxhlet_extractor.png

Pintor4257. (2013, May 31). File:Cis trans svg.svg [Illustration]. Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Cis_trans_svg.svg

POLISAS Shout! TVET. (2022, October 31). *Determine the oil quality using Lovibond tintometer* [Video]. YouTube. https://www.youtube.com/watch?v=iY12z7u_Pf0

Rajan, R., & Narayanan, M. (2011). Physicochemical properties of blended sunflower and palm olein oils. *Journal of Food Science and Technology, 48(4)*, 468–471. https://doi.org/10.1007/s13197-011-0243-3

Rossi, M., Gianazza, M., Alamprese, C., & Stanga, F. (2001). Deodorization temperature and trans fats. *European Journal of Lipid Science and Technology, 103(5),* 336–342. https://doi.org/10.1002/1438-9312(200105)103:5<336::AID-EJLT336>3.0.CO;2-6

Solution Engineering Sdn. Bhd. (2019). *SOLTEQ-QVFT™ operation & laboratory exercise manual: Oil deodorizer pilot plant (Model BP516).*

Solution Engineering Sdn. Bhd. (n.d.-a). *Operation & laboratory exercise manual: Oil modification pilot plant (Model BP517). SOLTEQ-QVF™.*

Solution Engineering Sdn. Bhd. (n.d.-b). *Operation & laboratory exercise manual: Oil refining (liquid) pilot plant (Model BP515). SOLTEQ-QVF™*

Specac Ltd. (n.d.). *Everything about laboratory hydraulic presses.* https://specac.com/everything-about-laboratory-hydraulic-presses/

Sugihartono, H., Prakoso, Y. A., & Damayanti, E. (2019). Extraction of fat/oil from fleshing by-product using a wet rendering process. *Majalah Kulit, Karet, dan Plastik, 35(2)*, 89–98. https://www.researchgate.net/publication/334747436

The Tintometer Ltd. (n.d.). Lovibond *Tintometer Model F instruction manual* [Instrument manual]. Salisbury, United Kingdom.

United States Environmental Protection Agency. (1995). *AP-42, Chapter 9.5.3: Meat rendering plants*. https://www3.epa.gov/ttnchie1/ap42/ch09/final/c9s05-3.pdf

View4u. (2020, October 1). *Precisa Gravimetrics Switzerland moisture analyser model XM60 demonstration* [Video]. YouTube. https://youtu.be/GOPuFUr-0Io

Zhengzhou Sunshine Machinery Co. Ltd. (n.d.). *English manual of hydraulic oil mill – 6YZ-230.*

Zhou, S. (2022, June 27). *Cold press castor beans oil / Castor oil press / hydraulic oil presser* [Video]. YouTube. https://www.youtube.com/shorts/RL_nhAWUWDk

Zock, P. L., Blom, W. A., Nettleton, J. A., Hornstra, G., & Katan, M. B. (1995). Trans fats from hydrogenated oils in humans. *American Journal of Clinical Nutrition, 61(3)*, 617–624. https://doi.org/10.1093/ajcn/61.3.617

Determination of Moisture Content

Introduction

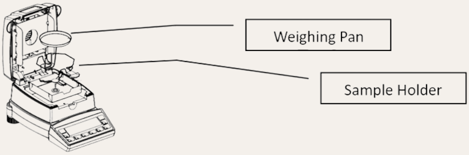
Moisture content analysis is essential for assessing the quality of powders, liquids, and other materials. This method utilizes thermogravimetric analysis, where a sample is heated, and the weight loss is measured to determine moisture content.

Equipment and Materials

- Moisture Analyzer
- Weighing Pan
- Sample Holder
- Fiber Glass Filter (recommended for liquid or semi-solid samples)

Procedure

1. Power on the moisture analyzer and wait for it to complete initialization.
2. Check that the device is level using the adjustable feet and the built-in bubble level.
3. Raise the hood to access the weighing platform.
4. Place the sample holder with an empty weighing pan evenly on the platform.
5. Press the "T" button to tare the balance and reset the display to zero.
6. Apply a small quantity of vegetable oil onto the filter, spreading it into a thin, uniform layer.



7. Close the hood firmly to prepare for measurement.

38.Start the test by pressing the "START/STOP" button; the heater will increase the temperature to 105°C and the fan will turn on to provide cooling.

9.Observe the display, which provides continuous updates on measurement progress and data.

10.Wait until the process finishes—an audio signal will sound, the heater will switch off, and the fan will keep running until the temperature falls below 40°C.

11.Carefully lift the hood and remove the weighing pan by the sample holder handle, as parts may still be hot.

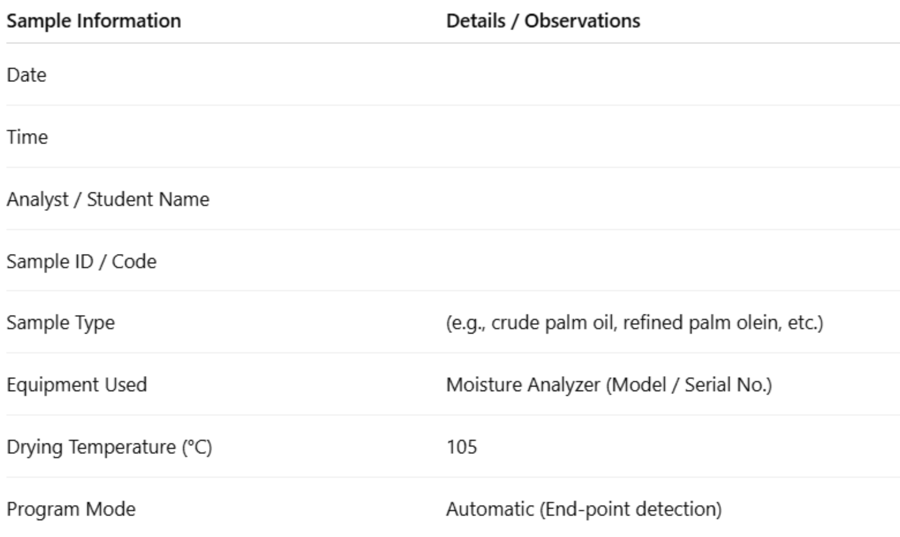
12.Let the pan and holder cool completely before further handling.

13.For the next test, place a fresh weighing pan on the holder and press "T" to reset the device.

14.Rinse the used weighing pan under running water and dry it thoroughly before using again.

Precisa Gravimetrics XM60 demo
[Video]. View4u, 2020, YouTube

Recording of Results



Sample Information	Details / Observations
Date	
Time	
Analyst / Student Name	
Sample ID / Code	
Sample Type	(e.g., crude palm oil, refined palm olein, etc.)
Equipment Used	Moisture Analyzer (Model / Serial No.)
Drying Temperature (°C)	105
Program Mode	Automatic (End-point detection)

Determination of Free Fatty Acids

Definition

This method quantifies the free fatty acid content present in fats and oils.

Materials and Reagents

- Containers: 250 mL conical flasks.
- Solvent: 95% ethanol.
- Indicator: 1% phenolphthalein solution in 95% ethanol.
- Titrant: Standardized sodium hydroxide solution (Molarity depends on the expected free fatty acid level).

Reagents

- Ethyl alcohol, 95%—
- Phenolphthalein indicator solution —1% in 95% alcohol.
- Sodium hydroxide solution. See Table 1 for the appropriate normality of the sodium hydroxide solution, depending on the expected free fatty acid concentration range in the sample

FFA range (%)	Test portion (g)	Alcohol (mL)	Strength of alkali
0.00 to 0.20	56.4 ± 0.2	50	0.1 M
0.20 to 1.00	28.2 ± 0.2	50	0.1 M
1.00 to 30.00	7.05 ± 0.05	75	0.25 M
30.00 to 50.00	7.05 ± 0.05	100	0.25 or 1.0 M
50.00 to 100.00	3.525 ± 0.001	100	1.0 M

Procedures

1. Sample Preparation: Ensure the sample is homogeneous and fully liquid before weighing. If necessary, warm it to a maximum of 10°C above its melting point.

Typical melting point of vegetable oil (°C)	
RBD Palm Oil	36-39
RBD Palm Stearin	46.7
RBD Palm Olein	24-26
Coconut Oil	24-25
Olive Oil	13-14
Sunflower Oil	17
Soybean Oil	16
Corn Oil	11
Canola Oil	10
Groundnut (Peanut) Oil	3

2. Weighing: Determine the appropriate test portion based on the expected free fatty acid concentration (refer to the standard table). Transfer the weighed sample into a conical flask.
   - FFA range (%)
   - Test portion (g) Alcohol (mL)
   - Strength of alkali
3. Reagent Addition: Add the required volume of pre-neutralized hot alcohol to the sample, followed by 2 mL of phenolphthalein indicator solution.
4. Titration: Gradually titrate with standard sodium hydroxide while shaking continuously.

The endpoint is reached when a stable pink color, matching the pre-neutralized alcohol, persists for at least 30 seconds.

Recording of Results

Sample Information	Details / Observations
Date	
Time	
Analyst / Student Name	
Sample ID / Code	
Sample Type	(e.g., crude oil, neutralized oil, bleached oil)
Temperature of Sample (°C)	

Determining free fatty acid (FFA) content using titration [Video]. Lim Seng Joe, 2024, YouTube

Experimental Data

Parameter	Trial 1	Trial 2	Trial 3	Average
Mass of sample (g)				
Burette reading (initial, mL)				
Burette reading (final, mL)				
Volume of NaOH used (mL)				
Normality of NaOH (M)				
Blank reading (mL)				
Corrected titration volume (mL)				

Calculations

$$\text{Free fatty acids as palmitic, \%} = \frac{\text{mL of alkali} \times M \times 25.6}{\text{mass of test portion (g)}}$$

$$\text{Free fatty acids as oleic, \%} = \frac{\text{mL of alkali} \times M \times 28.2}{\text{mass of test portion (g)}}$$

$$\text{Free fatty acids as lauric, \%} = \frac{\text{mL of alkali} \times M \times 20.0}{\text{mass of test portion (g)}}$$

Where:

- M = Molarity of alkali (NaOH or KOH)
- *mass of test portion* = mass of oil or fat sample (g)
- Conversion factors (25.6, 28.2, 20.0) correspond to the molecular weights of palmitic, oleic, and lauric acids respectively.

Determination of Oil Color

Objective

To determine the visual color of oil samples using the Lovibond Tintometer Model F, expressed in Lovibond Red (R), Yellow (Y), and Blue (B) units.

Principle

The Lovibond Tintometer measures color by visually matching the sample's transmitted or reflected light with standardized color filters. The result is recorded as a combination of Red, Yellow, and Blue Lovibond units that best reproduce the appearance of the sample. The method is widely accepted for oils and fats quality control, where color provides an indication of refining efficiency and product stability.

Equipment and Materials

- Lovibond Tintometer Model F
- Lovibond standard color glass racks (R, Y, B, and Neutral)
- Optical glass sample cells (typically 1-inch path length)
- Clean glass beakers
- Lint-free cloth or lens tissue
- Distilled water and mild detergent
- White Halon reference plate (standard reflector)
- Oil sample (filtered and moisture-free)

Determine the oil quality using Lovibond tintometer [Video]. POLISAS Shout!TVET, 2022, YouTube

Safety Precautions

- Ensure the instrument is properly earthed before switching on.
- Avoid touching lamps or internal optical parts with bare hands.
- Keep the sample chamber and optical cells clean to avoid contamination.
- Handle hot or viscous samples (e.g., palm oil) carefully using heat-resistant gloves.

Sample Preparation

Transparent liquids:

1. Filter to remove impurities.
2. For solidified oils, gently heat to 60–70 °C until clear, avoiding overheating or oxidation.
3. Pour into a clean optical glass cell and seal to prevent air bubbles.

Opaque or viscous samples:

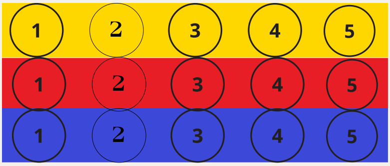
1. Fill a 1-inch Lovibond cell evenly.
2. Remove trapped air and wipe the exterior clean.
3. For pastes or powders, use the solid sample holder or place the sample flush against the rear aperture.

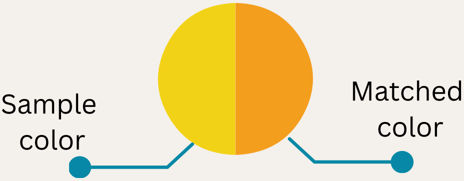
Instrument Setup

1. Place the Tintometer on a stable bench, away from direct light or reflective surfaces.
2. Connect to the power supply (ensure correct voltage selection).
3. Switch on the illumination and confirm both lamps are functioning.
4. Check that the Halon white reference plate is clean and properly fitted.
5. Verify that all color filter racks are pushed fully to the left before starting.
6. Close the sample chamber lid to prevent stray light.

Measurement Procedure

1. Place the prepared sample cell in the sample chamber.
2. Look through the eyepiece and adjust focus for a clear view of the split field (sample and reference).
3. Move the Red, Yellow, and Blue filter sliders until both fields appear to match in color and brightness



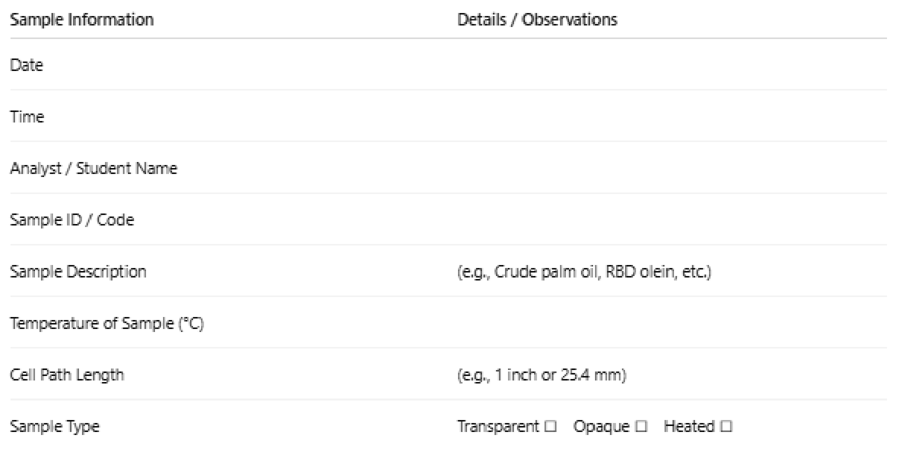


4. If the sample appears overly bright, introduce Neutral filters over the sample field until the match is achieved.
   - *Note: Do not use Neutral filters when all three color racks are active; instead, reduce the lowest color value.*
5. Record the red, yellow, and blue Lovibond values indicated in the viewing window.
6. For consistency, rest your eyes briefly between readings to reduce visual fatigue.

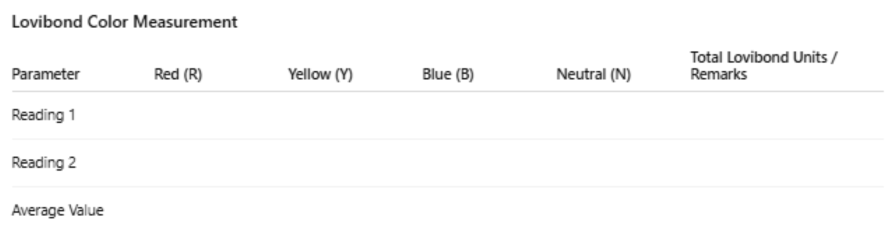
Cleaning and Maintenance

1. Clean any oil spills immediately using a lint-free cloth.
2. Rinse glass cells with mild detergent, followed by deionized water and acetone; air dry before reuse.
3. Regularly check that filters, lamps, and viewing optics are dust-free.
4. Replace lamps in pairs and avoid touching the bulbs directly.
5. Store optical cells in a clean, cushioned container to prevent scratches or cracks.

Recording of Results



Sample Information	Details / Observations
Date	
Time	
Analyst / Student Name	
Sample ID / Code	
Sample Description	(e.g., Crude palm oil, RBD olein, etc.)
Temperature of Sample (°C)	
Cell Path Length	(e.g., 1 inch or 25.4 mm)
Sample Type	Transparent ☐ Opaque ☐ Heated ☐



Lovibond Color Measurement

Parameter	Red (R)	Yellow (Y)	Blue (B)	Neutral (N)	Total Lovibond Units / Remarks
Reading 1					
Reading 2					
Average Value					

Interpretation of Results

- Low Lovibond values (light color) indicate efficient refining and minimal impurities.
- High Lovibond values (dark color) may indicate pigments, oxidation, or incomplete bleaching.
- For consistent comparison, use the same cell path length and temperature.

Determination of Iodine Value

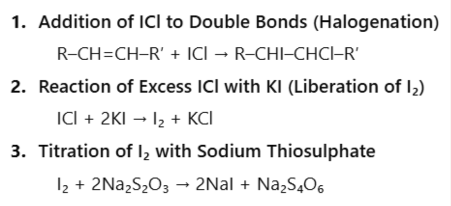
Definition

The iodine value measures the unsaturation level in fats and oils, expressed as the amount of iodine absorbed per gram of sample.

Apparatus

- Glass-stoppered conical flask: 500 mL.
- Volumetric Flasks: 1000 mL, glass-stoppered, for standard solutions.
- Pipette: 25 mL, for Wijs solution.
- Graduated Cylinder: 20 mL, for 10% potassium iodide solution.
- Pipette: 2 mL, for starch solution.
- Pipette: 50 mL, for distilled water.
- Pipette: 15 mL, for cyclohexane-acetic acid.
- Analytical Balance: Accurate to ±0.0001 g.
- Magnetic Stirrer.
- Filter Paper: Whatman no. 541 or equivalent.
- Beakers: 50 mL.
- Hot Air Oven.
- Timer.

Reactions involved



1. **Addition of ICl to Double Bonds (Halogenation)**

   R–CH=CH–R′ + ICl → R–CHI–CHCl–R′

2. **Reaction of Excess ICl with KI (Liberation of I_2)**

   $ICl + 2KI \rightarrow I_2 + KCl$

3. **Titration of I_2 with Sodium Thiosulphate**

   $I_2 + 2Na_2S_2O_3 \rightarrow 2NaI + Na_2S_4O_6$

Reagents

- Wijs Solution.
- Potassium Iodide Solution: 10% (Dissolve 50 g of potassium iodide (KI) in ~250 mL distilled water, transfer to a 500 mL volumetric flask, dilute to the mark with distilled water, and mix well)
- Cyclohexane: Reagent grade.
- Glacial Acetic Acid: Reagent grade.
- Starch Solution: Freshly prepared (1g starch in 100ml boiling water)
- Sodium Thiosulfate Solution: 0.1 M, standardized.
- (Dissolve 12.41 g of sodium thiosulphate pentahydrate in ~250 mL distilled water, transfer to a 500 mL volumetric flask, dilute to the mark with distilled water, mix well, and store in a dark bottle)

Iodine Value Expected	Mass (g) ± 0.001
<5	3.000
5-20	1.000
21-50	0.400
51-100	0.200
101-150	0.130
151-200	0.100

Procedures

Blank Determination: Perform at least one blank determination with each set of samples.

Sample Preparation

1. Melt the sample if solid, ensuring the temperature does not exceed the melting point by more than 10°C.
2. Filter through two pieces of filter paper to remove impurities and moisture. The sample must be dry.
3. Temperature Adjustment: Allow the filtered sample to reach 68-71°C before weighing.
4. Immediately weigh the sample into a 500 mL conical flask.
5. Add 15 mL of the cyclohexane-acetic acid mixture and swirl to dissolve the sample.

Reaction

1. Add 25 mL of Wijs solution, stopper the flask, and swirl. Set the timer for 1 or 2 hours based on the iodine value (1 hour for IV < 150, 2 hours for IV ≥ 150).
2. Store the flask in the dark at 25°C for the reaction time.*(1 hour for IV<150, 2 hours for IV>150)*
3. After the reaction time, add 20 mL of potassium iodide solution and 100 mL of distilled water.

Titration

1. Begin titrating with 0.1 M sodium thiosulfate solution while continuously shaking the mixture. When the yellow color starts to fade, add 1-2 mL of starch indicator.
2. Continue the titration until the blue color completely disappears.

Table 1. Typical Iodine Values and Melting Points of Selected Vegetable Oils

Vegetable Oil	Iodine Value (G I2/100G)	Melting Point (°C)
RBD Palm Oil	50-55	36-39
RBD Palm Stearin	27-38	46.7
RBD Palm Olein	54-56	24-26
Coconut Oil	6-10	24-25
Olive Oil	80-88	13-14
Sunflower Oil	118-141	-17
Soybean Oil	120-143	-16
Corn Oil	103-135	-11
Canola Oil	110-126	-10
Groundnut (Peanut) Oil	84-106	3

Recording of Results

Determination of Iodine Value

Sample Information	Details / Observations
Date	
Time	
Analyst / Student Name	
Sample ID / Code	
Sample Type	(e.g., crude oil, refined oil, bleached oil)

Experimental Data

Parameter	Trial 1	Trial 2	Trial 3	Average
Burette reading (initial, mL)				
Burette reading (final, mL)				
Volume of $Na_2S_2O_3$ used (mL)				
Blank reading (mL)				
Corrected volume (sample – blank) (mL)				
Normality of $Na_2S_2O_3$ (N)				

Calculation

$$\text{Iodine value} = \frac{(B - S) \times M \times 12.69}{\text{Mass of test portion (g)}}$$

Where—

B = volume of titrant, mL of blank

S = volume of titrant, mL of test portion

M = molarity of $Na_2S_2O_3$ solution

Determination of iodine value [Video]. MicroChem's Experiments, 2020, YouTube

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