



SNS COLLEGE OF TECHNOLOGY
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UNIT V – TOPIC 2

Calculation of extraction efficiency, new technologies in Oilseed processing

In oilseed processing, **extraction efficiency** refers to the percentage of oil extracted from the oilseeds relative to the total amount of oil that is theoretically present in the seeds. This efficiency can be affected by the extraction method (mechanical pressing, solvent extraction, or a combination of both), seed type, moisture content, and processing conditions.

Formula for Extraction Efficiency

The extraction efficiency can be calculated using the following formula:

$$\text{Extraction Efficiency (\%)} = \left(\frac{\text{Actual Oil Yield (kg)}}{\text{Theoretical Oil Content (kg)}} \right) \times 100$$

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Where:

- **Actual Oil Yield** is the amount of oil extracted from the oilseeds (in kg or liters).
- **Theoretical Oil Content** is the total amount of oil that could be obtained from the oilseeds based on their oil content (usually expressed as a percentage of the seed weight).

1. Determining Theoretical Oil Content

The theoretical oil content is determined based on the oilseed's oil percentage, which is typically available in literature or from laboratory analysis. For example, if a certain type of oilseed contains 40% oil by weight, then for every 100 kg of the seed, you can theoretically extract 40 kg of oil.

$$\text{Theoretical Oil Content} = \text{Seed Weight} \times \left(\frac{\text{Oil Content Percentage}}{100} \right)$$

$$\text{Theoretical Oil Content} = \text{Seed Weight} \times (\text{Oil Content Percentage} / 100)$$

For example, if you have 100 kg of groundnuts (peanuts) with an oil content of 45%, the theoretical oil content is:

$$\text{Theoretical Oil Content} = 100 \text{ kg} \times \left(\frac{45}{100} \right) = 45 \text{ kg}$$

$$\text{Theoretical Oil Content} = 100 \text{ kg} \times (0.45) = 45 \text{ kg}$$

2. Actual Oil Yield

This is the actual amount of oil obtained through the extraction process, which can be measured by collecting and weighing the oil after extraction.

For example, if you extract 40 kg of oil from the 100 kg of groundnuts, your actual oil yield is 40 kg.



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3. Calculation of Extraction Efficiency

Now, using the formula for extraction efficiency:

$$\text{Extraction Efficiency (\%)} = \left(\frac{40 \text{ kg}}{45 \text{ kg}} \right) \times 100 = 88.89\%$$

This means that 88.89% of the oil that was theoretically available in the groundnuts was extracted through the process.

Factors Affecting Extraction Efficiency:

1. **Seed Type:** Different oilseeds have varying oil content. Seeds like soybeans, sunflower, and canola have lower oil content (18-20%), while seeds like sesame, groundnut, and coconut have higher oil content (40-50%).
2. **Moisture Content:** The moisture content of the seeds affects the efficiency of the extraction. High moisture content can reduce oil yield.
3. **Extraction Method:**
 - o **Cold Pressing:** Extracts less oil but preserves more nutrients, usually with an efficiency of 60-70%.
 - o **Expeller Pressing:** Yields more oil (70-80%) than cold pressing but may still leave some oil behind in the cake.
 - o **Solvent Extraction:** This method is the most efficient, often extracting 98-99% of the oil from seeds.
4. **Seed Preparation:** The quality of seed preparation (cleaning, cracking, roasting, etc.) affects the extraction efficiency. Seeds that are adequately prepared result in better oil yields.

Example Calculation:

Let's consider a scenario with **sunflower seeds**:

- Seed weight = 200 kg
- Oil content = 40%
- Actual oil extracted = 78 kg

Step 1: Calculate theoretical oil content

$$\text{Theoretical Oil Content} = 200 \text{ kg} \times \left(\frac{40}{100} \right) = 80 \text{ kg}$$

Step 2: Calculate extraction efficiency

$$\text{Extraction Efficiency (\%)} = \left(\frac{78 \text{ kg}}{80 \text{ kg}} \right) \times 100 = 97.5\%$$

In this example, the extraction efficiency is 97.5%, meaning that almost all the oil that could be extracted from the seeds was obtained, indicating a highly efficient extraction process.



Conclusion:

By calculating the extraction efficiency, you can assess how effectively your oil extraction process is performing. A higher extraction efficiency is desirable as it indicates better utilization of the available oil in the seeds.

Oilseed processing has evolved significantly with new technologies aimed at improving extraction efficiency, product quality, and sustainability. These technologies help to address challenges such as energy consumption, waste generation, and environmental impact while increasing the yield and quality of the oil. Some of the most notable recent innovations in oilseed processing include:

1. Cold Pressing and Expeller Pressing Innovations

- **Mechanical Pressing with Reduced Heat Generation:** New designs in expeller presses aim to reduce the heat generated during the pressing process. This helps preserve the flavor, aroma, and nutritional value of the oil, especially for sensitive oils like **virgin coconut oil** and **sesame oil**.
- **Double or Triple Pressing:** This technique involves pressing the oilseeds multiple times to extract more oil without using solvents. New machines allow for higher oil yield with lower energy consumption.
- **Supercritical CO₂ Extraction:** A more recent innovation is the use of **supercritical carbon dioxide (CO₂)** for oil extraction. Supercritical CO₂ can extract oil at low temperatures, preserving the quality of the oil, and it's a clean method with minimal waste. This technology is particularly used for high-value oils like **coconut oil** and **soybean oil**.

2. Solvent Extraction Enhancements

- **Solvent Recovery Systems:** One of the challenges with solvent extraction (especially with hexane) is the recovery and recycling of the solvent. New solvent recovery systems and **closed-loop extraction** technologies enable the continuous reuse of solvents, minimizing environmental pollution and increasing process efficiency.
- **Low-Temperature Solvent Extraction:** Innovations in solvent extraction involve lowering the extraction temperature to preserve sensitive bioactive compounds in the oil, such as antioxidants and vitamins, which may be destroyed at higher temperatures.
- **Pulse Solvent Extraction:** This technique involves the use of pulsed solvent flows, which enhance the solvent's contact with the oil-bearing material. This can improve oil yield and reduce the amount of solvent required.

3. Enzyme-Assisted Extraction

- **Enzyme Treatment:** Enzyme-assisted extraction is gaining traction as an alternative to traditional mechanical pressing and solvent extraction methods. **Enzymes** are used to break down the cell walls and oil-bearing tissue of seeds, making the oil more accessible and increasing oil yield. This method can also result in lower energy usage and reduced need for solvents.
- **Enzyme Pre-treatment:** Enzymes such as **cellulases** and **pectinases** are applied to oilseeds like soybeans, canola, or sunflower before mechanical pressing or solvent extraction. This process softens the seed and improves the efficiency of oil extraction.

4. Ultrasound-Assisted Extraction (USAE)

- **Ultrasound Technology:** Ultrasound waves can be applied to oilseeds to break down cell walls, allowing for better oil extraction with lower energy consumption. Ultrasound-assisted extraction has been shown to enhance oil yield by improving solvent penetration and extraction rates, all while maintaining oil quality.



- **Cavitation Effects:** Ultrasound produces cavitation bubbles in the liquid medium, which implode and create microjets that disrupt the oilseed structure. This mechanical effect can help release more oil from the seed.

5. Microwave-Assisted Extraction

- **Microwave Heating:** This method uses microwave energy to heat the oilseeds rapidly, disrupting the cell walls and making it easier to extract oil. **Microwave-assisted extraction (MAE)** can increase extraction efficiency, reduce extraction time, and lower energy consumption compared to traditional methods.
- **Combination with Solvent:** When combined with solvent extraction, microwave-assisted extraction can reduce the amount of solvent required while improving oil yield. It also helps reduce the temperature, which minimizes damage to sensitive compounds in the oil.

6. Membrane Technology for Oil Recovery

- **Microfiltration and Ultrafiltration:** These membrane technologies are used to filter out impurities and separate oil from solids during extraction or refining. **Membrane filtration** offers high efficiency, reducing the need for chemical solvents and heat treatment, thus maintaining the quality of the oil and reducing environmental impacts.
- **Nanofiltration:** This newer membrane technology can be used to separate oil from impurities, increase the concentration of bioactive compounds, and improve the overall quality of the oil without the need for traditional refining.

7. Cold and Hot Pressing Hybrid Systems

- **Combined Cold and Hot Pressing:** Some new technologies combine cold and hot pressing processes in a single operation. In this system, seeds undergo a mild cold pressing to extract the initial oil, followed by hot pressing to extract the remaining oil. This hybrid system allows for a higher yield than cold pressing alone, while maintaining the integrity of the oil.

8. Bio-based Solvents and Green Chemistry

- **Green Solvents:** Research is being conducted into environmentally friendly solvents that can replace traditional chemical solvents like hexane. Examples include **supercritical CO₂**, **ionic liquids**, and **biodegradable solvents**. These green solvents are less toxic, more sustainable, and can improve the quality of the oil by avoiding the harmful chemicals typically involved in extraction.
- **Enzyme-Catalyzed Processes:** The use of enzymes in combination with bio-based solvents is a growing area of research. Enzymatic processes can replace certain chemical steps in refining and oil extraction, making the process greener and more sustainable.

9. Smart Technology and Automation in Processing

- **Automation and Monitoring:** The use of automation and real-time monitoring systems (such as **IoT-based sensors**) allows for precise control over temperature, pressure, and extraction time. These systems help optimize oil extraction, reduce energy consumption, and improve overall efficiency by continuously adjusting parameters for the best results.
- **AI and Machine Learning:** Artificial intelligence (AI) is being applied to optimize oilseed processing parameters. Machine learning algorithms analyze data from processing systems to predict the best settings for maximum oil yield, reduce energy consumption, and minimize waste.



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10. Zero-Waste and Circular Economy Models

- **Waste Valorization:** Many oilseed processing methods generate by-products like oilseed cake, husks, and shells. New technologies focus on converting these by-products into valuable products. For instance, oilseed cakes can be turned into biofuels, fertilizers, or animal feed.
- **Zero-Waste Processing:** There is a growing trend in the oilseed processing industry toward developing **zero-waste** technologies. These processes minimize or eliminate waste products and use every part of the oilseed to its maximum potential, such as turning waste oils into biodiesel or converting seed husks into bioplastics.

11. Integrated Refining and Extraction

- **Single-Stage Processing:** Innovations are leading to integrated systems that combine both extraction and refining stages into a single process. This reduces the number of steps, lowers energy consumption, and improves overall efficiency by streamlining the entire oilseed processing operation.

Conclusion:

New technologies in oilseed processing are focused on improving the efficiency of oil extraction, enhancing product quality, reducing energy consumption, and minimizing environmental impact. These innovations include advanced mechanical pressing methods, solvent alternatives, enzyme-assisted extractions, ultrasound, and microwave-assisted extractions. Additionally, automation, AI, and circular economy principles are also improving the overall sustainability and profitability of oilseed processing industries.