COURSE TITLE:
OIL SEEDS PROCESSING AND UTILISATION

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By
Dr. Dupe Temilade Otolowo,
Department of Food Science and Technology,
Mountain Top University,
Nigeria

LECTURE 1

INTRODUCTION

DISCRIPTION OF OIL SEEDS AND NUTS

Oilseeds and nuts are oil-bearing grain or fruit-like food crops. They are rich sources of vegetable fats and oils in addition to other nutritive values such as; provision of calories and vitamins.

Some grows wild (e. g. oil palm) while others are cultivated (e.g. groundnut, soybean); oil palm is also cultivated

They are generally low in moisture content. But must be fully dried before storage to avoid quality deterioration.

Examples includes; groundnut, oil palm fruit, palm kernel, soybean, melon seeds, coconut fruit, corn, cotton, sunflower, rapeseed/canola, linseed/flax-seed, etc.

Processing of Selected Oil Seeds, Nuts and Fruits

The processing of oil seeds and nuts is done generally to extract the oil in them. Traditional, small-scale and industrial levels of operations are available.

The traditional method of oil extraction is characterised by manual operations which yields crude, unrefined oil while the small-scale and industrial scale employed various mechanical **oil extractors** with devices inbuilt or detached mechanism for refining.

The technology generally involve the crushing of the oil seeds, nuts or fruits under certain conditions followed by the pressing of the resulted mass or cake to obtain the oil.

Oil Press from Coconut

Coconut fruit

↓

Cracking ⟶ shell

↓

Crushing the meat

↓

Mixing with water (at 100^{o}C)

↓

Pressing/filtering ⟶ meat cake

↓

Boiling ⟶ water (vapour)

↓

Refining /modification ⟶ impurities

↓

Refined Coconut oil

Home Scale Production of Groundnut Oil

Groundnut seeds

↓

Sorting

↓

Cleaning

↓

Sun drying for 8 days

↓

Roasting at 150-200^{o}C/20-30 min

↓

Peeling/winnowing

↓

Grinding

↓

Mixing with water (1:4) /boiling/8-10 h → Separate paste

↓

Oil slurry

↓

Boiling/1-4 h → Excess moisture

↓

Cooling at room temp

↓

Packaging / Storage

Production of palm oil from palm fruit

Palm fruits bunch

⬇

Fruit fermentation → Loosen fruit base from spikelets

⬇

Bunch chopping → Facilitate manual removal of fruit

⬇

Fruit sorting → Remove fruit from spikelets

⬇

Fruit boiling → Sterilize and stop enzymatic spoilage, coagulate protein and expose microscopic oil cells

⬇

Fruit digestion → Rupture oil-bearing cells to allow oil flow during extraction while separating fibre from nuts

⬇

Mash pressing → Release fluid palm oil from ruptured oil cells using applied pressure

⬇

Oil purification → Boil mixture of oil and water to remove water-soluble gums and resins, dry decanted oil by further heating

⬇

Fibre-nut separation → Separate de-oiled fibre from palm nuts

⬇

Second Pressing → Recover residual oil for use as soap stock

Production of Oil from Soybean

Soybean

↓

Cleaning

↓

Drying ⟶ reduce mc (10%) and prevent moldiness

↓

Dehulling — by conventional, hot, or Esher wyss dehulling system

↓

Conditioning/tempering ⟶ to pre-heating/cook the seeds improves flaking/extraction

↓

Flaking

↓

Oil extraction ⟶ Meal ⟶ Meal desolventizing

↓

Desolventizing

↓

Crude soya oil

Importance of Oilseed Drying before Processing/Storage

- Reduces the moisture content of oilseeds to minimise degradation in storage.
- Drying prevents moldiness of seeds and Aflatoxins (poisons produced by *Aspergillus flavus*) contamination either in the oil or the oil cake.
- For example, soybeans are often received at 13% mc and need to be dried to 10% mc to facilitate efficient hull removal.
- Improve the effectiveness of downstream processing. Large, vertical, open-flame grain dryers with multiple columns can be used for oilseeds drying. The upper portion of the columns is used for drying and lower section is for cooling.

Shea Butter Processing

Shea nuts

↓

Washing

↓

Sun drying

↓

Boiling/1-3 h

↓

Dehusk

↓

Cracking into small pieces

↓

Roasting at 85-100^{o}C/2-3 h ⟶ Remove greater part of moisture

↓

Mill/Pressing ⟶ Separate meal

↓

Fat slurry

↓

Boiling ⟶ Remove the remaining moisture

↓

Cooling

↓

Storage

LECTURE 2

OIL EXTRACTION FROM OILSEEDS

Methods of Oil Extraction from Oilseeds

There are only a few basic extraction methods to obtain fats and oils from animal, marine and vegetable sources which is followed by various refining and modification procedures. These include:

- rendering,
- pressure expelling and
- solvent extraction.

Rendering

- Meat scraps are heated in steam or water to cause the fat to melt. The melted fat then rises and water and remaining tissue settle below.
- The melted fat is then separated by skimming or centrifugation.
- Rendering could be done by:

-dry heat under vacuum to remove moisture,

-wet rendering utilizes water steam, and

-low temperature rendering with enough heat to melt the fat- produce fat of lighter colour and less meaty flavour.

- Rendering is also used to obtain oil from fish tissues.

Pressing or Expelling/Filtering

This squeeze oil from oilseeds by mechanical presses and expellers or manual pressing of pre-ground oilseed. Prior to manual pressing, some preheating and addition of water can improve oil yield.

The heat from cooking or grinding should not be excessive to prevent darkening of oil colour. Expelled oil is pumped through multiple filter or by centrifugal clarification to removed seed residues. With some seeds e.g. Corn, only the germ of the seed is pressed to yield oil.

Solvent Extraction

- Employed in large-scale oil production.
- Non-toxic fat solvent such as hexane is used to remove oil from cracked or ground seeds at low temperature.
- Yield more oil than by pressing.
- Combined processes employ pressing to remove most of the oil followed by solvent extraction to remove final traces.
- The spent meal must be desolventised.

Choice of solvents

An ideal solvent for the oil extraction should possess the following properties:

- Good solubility of the oil.
- Poor solubility of non-oil components.
- High volatility (i.e. low boiling point), for feasibility and easy removal of the solvent from the micella and the meal by evaporation.
- Yet, the boiling point should not be too low
- Low viscosity
- Low latent heat of evaporation, so that **less energy** is needed for solvent recovery.
- Low specific heat, so that **less energy** is needed for keeping the solvent and the micella warm.
- The solvent should be chemically inert to oil.
- Absolute absence of toxicity and carcinogenicity.
- Non-inflammable and non-explosive.

LECTURE 3

Oil Refining

Degumming by hydration- to remove fat-like substance (such as phospholipids (phosphatides) fat-protein complexes). Water degumming process cannot achieve total removal of the gum, therefore the oil stream is further treated with alkali.

Neutralization or Caustic refining- to remove free fatty acids, phosphatides other unwanted materials using caustic soda. Some processors retreat crude oil with phosphoric acid to hydrate the phosphatides that are not water hydratable.

Bleaching over charcoal or various adsorbent clays and earths **-** to remove plant pigments, residual soap, metals, and phosphatides (gum) content

Deodorization- to remove odorous compounds by heat and vacuum or sometimes by adsorption onto activated charcoal

Winterization- to remove sufficient saturated triglycerides or wax so as to have a product higher in unsaturated fatty acid.

Anti-nutritional factors in oil seeds

Fibre: High fibre content of most oilseed meals limit the availability of nutrients in the meal and creates processing problems.

Phytate/phytic acid: They bind to divalent cations such as Ca, Fe, Zn & Ma, rendering them nutritionally unavailable.

Protease inhibitors: They form complex with proteinases and rendered them inactive and thus limiting bioavailability of proteins (amino acids).

Oxalic acid: Common in sesame seeds. They bind with mineral elements in food, rendering them biologically unavailable.

Flatulence and beany flavour: Soybean, peanut meal have characteristic beany flavour which has limited the incorporation in some food system. Indigestion associated with flatus is also common in some oilseed meal.

Gossypol: This has limited the use of cottonseed.

Glucosides and glycosides: Present in a number of oil seeds .e.g. peanut, sunflower and canola.

Treatment of Oilseeds to Remove Anti-nutritional Factors

- **Cooking-** trypsin and chymotrypsin inhibitors, saponin, phytates, allergens
- **Fermentation-** rafinnose oligosaccharides, phytates
- **Extraction-** heamagglutinin, tannin
- **Filtration-** phytates
- **Enzymatic method-** rafinnose oligosaccharides

Table 1: Characteristics and Uses of Vegetable Oils from Seeds and Nuts

Type of oil	Melting point	Colour	Uses
Groundnut	26 – 32	White/light brown	Cooking
Palm	40 – 47	Yellow to deep red	Cooking, soap making
Palm kernel	20 – 28	Yellow/white	Cooking, soap making
Coconut	20 – 24	White/yellow	Cooking, soap making
Cotton seed	30 – 37	Dark/light brown	Cooking, soap making
Sunflower	16 – 20	Light/yellow	Cooking, soap making
Cocoa	45 – 50	White, yellow	Confectionery
Soybean	20 – 21	Light brown	Cooking
Maize (germ)	14 – 20	Golden yellow	Cooking
Olive	17 – 26	Light brown	Cooking
Mustard	6 – 8	Yellow	Cooking
Sesame	20 – 25	Light brown	Cooking
Shea nut	Solid at rm temp/>rm temp	Yellowish-white	Medicament, cooking, traditional flavouring

FIRST TEST ON OILSEEDS PROCESSING/UTILISATION

Qn. 1. Mention four oilseeds and state the uses of the vegetable oil produced from each of them. 4 marks

Qn. 2. State the importance of **oilseed drying** before Processing / Storage. 4 marks

Qn. 3. Enumerate by means of a flow chart only, operations involved in the extraction of crude oil from **a named** oilseed. 2 marks

Qn. 4. Briefly explain the importance of each step of operation involved in oil refining. 10 marks

LECTURE 4

OILSEED PROTEIN

Many oil producing plants contain an appreciable level of protein (especially the defatted cake/flour after oil extraction) which has great potential for use in human diet. Soybean is known to be the best protein source among the oil producing plants.

The proteins found in seeds are classified as:

- Biologically active (e.g enzymes) protein,
- Structural protein or
- Storage/reserved protein: These are the prominent proteins in seeds and are a major resource for the nutrition of man and livestock. Therefore, they are of utmost interest when using these protein sources for human consumption.

Table 2: Some oil producing crops and their major storage proteins		
Botanical Name	**Common Name**	**Major Storage Proteins**
Brassica species	Canola/Rapeseed	Cruciferin or 12S protein
Zea mays	Corn	Zein
Gossypium species	Cotton seed	11S protein
Linum ulsitatissinum L	Flax seed	12S protein
Cannabis sativa L	Hemp	12S protein
Arachis hypogea L	Peanut	Arachin
Carthamus tinctorius L	Safflower	Carmin
Sesamum indicum	Sesame	α globulin
Glycine Max	Soybean	Glycinin
Helianthus annuus	Sunflower	Helianthin

Production of Oilseed Protein Concentrates

Oilseed protein concentrate are prepared from defatted flakes or flour by removing the water soluble non-protein constituents (e.g oligosaccharides, part of ash). They contain not less than 70% protein on a moisture free basis.

The objective in producing PCs especially, Soy protein concentrates (SPCs) is to remove strong flavour components and the flatulence sugars (stachynose and raffinose) and to concentrate the protein and dietary fibre contents (Lucas and Riaz 1995).

Three processes may be used:

(1) heating the white flakes resulting in denaturation of the protein and they become water insoluble before the extraction process begins. Drawback- the protein has lost most of its functional properties; this method is no longer used today;

(2) extraction with water at isoelectric pH (4.5) where the soy protein has its lowest possible solubility characteristics which can be restored by neutralization to the neutral pH.

- best tasting and most functional SPCs that have found applications in the preparation of fat emulsions;

(3) extraction with aqueous (70-90%) ethyl alcohol to remove the oligosaccharides- This process is based on the (irreversible) alcoholic denaturation of the protein.

- most popular; results in the most bland tasting and nutritionally most attractive SPCs.

Table 3: Composition of a typical food grade soy protein concentrate	
Constituent	**Composition**
Protein	70% minimum
Moisture	8% maximum
Crude fibre	4.5 % maximum
Ash	7% maximum
Fat	1% maximum
Particle size	95% < 150 microns
Standard plate count	15000/g maximum
Salmonella in 200 g	Negative
E. coli in g	Negative

Production of Oilseed Protein Isolates: Soy Protein Isolate (SPIs)

Protein isolates are more refined than concentrates, they contain 90% or more protein. The production consists of an aqueous solubulization of protein and carbohydrates at alkaline pH and the recovery of the solubilized protein, separation and, optionally washing and neutralization before drying (Moure et al., 2006).

Three **steps** are involved in the process of making SPIs.

(1) the soy flakes or flour are slurried with water under alkaline conditions (pH 6.8-10 at 27-66 ^{o}C using NaOH and other food grade alkaline substances) (Lusas and Riaz, 1995; Anon, 2008b);

(2) the supernatant containing the protein and the sugars in solution is acidified with HCl or phosphoric acid (H_2PO_4) to pH 4.5 (minimal proteins solubility-IEP).

(3) The solubility of the precipitated protein is restored by neutralizing to alkaline pH 6.5-7.0 after re-dilution with fresh water or spray dried in its acidic form and packed in multilayer paper bags (Anon 2008b; Lusas and Riaz, 1995).

Isoelectric Point- IP

The pH of a solution at which the net primary charge of a protein becomes zero. It is the pH of minimum protein solubility.

- At pH > IP the surface of protein is predominantly negatively charged and therefore like charged molecules will exhibit repulsive forces.
- At pH < IP the surface of the protein is predominantly positively charged and repulsion between proteins occurs.

However, at IP, the negative and positive charges cancel, repulsive electrostatic forces reduced and dispersive forces predominate. The dispersive force will cause aggregation and precipitation.

LECTURE 5

Utilisation of Oilseed Protein Concentrates and Isolates in Food Industry

Protein isolates has found many applications in the food industry ranging from nutritional, sensorial, and functional purposes. Soy protein concentrates and isolates are used in products and commercially accepted than other oilseed proteins.

There uses covers the following areas:

1) Nutritional Use: demonstrated in infant formula and weaning food preparation where protein requirement are most critical (e.g for growth and other development). Soy protein contains all the essential amino acids required for human nutrition

2) Health Uses: These include lowering of plasma cholesterol and prevention of cancer, diabetes and obesity as well as protection against bowel and kidney diseases.

Utilisation of Oilseed Protein Concentrates and Isolates in Food Industry Contd.

3) Use in Bakery and confectionaries: Defatted soy flour when used at 1-3% increases absorption, improves crumb body and resiliency, enhances crust colour and improves toasting characteristics in bread and buns.

4) Use in Meat products: In food industry, soy proteins is used in comminuted meat, poultry and fish products (emulsion type sausages) to increase water and fat retention.

5) Dairy-type products: Useful ingredient in milk-like beverages and simulated dairy products

6) Miscellaneous Use: Include brew flakes (soy flakes/grits); soup, gravies and sauces, tofu, etc.

7) Functional Use: Soy protein concentrates' water binding/absorption capacity, fat binding capacity and emulsifying properties are exploited in the production and design of convenience foods.

Table 4: Functional properties performed by functional proteins in food Systems

Functional property	Mode of action	Food system
Solubility	Protein solvation	Beverages
Water absorption and binding	Hydrogen bonding of water; Entrapment of water (no drip)	Meat, sausages Breads, cakes
Viscosity	Thickening; water binding	Soups, gravies
Gelation	Protein matrix formation and setting	Meats, curds, cheese
Cohesion-adhesion	Protein act as adhesive material	Meats, sausages, baked goods, pasta
Elasticity	Hydrophobic binding in gluten; Disulfide links in gels	Meats, bakery
Emulsification	Formation and stabilization of fat emulsions	Sausages, bologna, soups, cakes
Fat absorption	Binding of free fat	Meats, sausages, doughnuts
Flavor-binding	Adsorption, entrapment, release	Simulated meats, bakery etc.
Foaming	Form stable film to entrap gas	Whipped toppings, chiffon desserts, angel cakes

SECOND TEST ON OILSEEDS PROCESSING/UTILISATION

Qn. 1. Mention the classes of protein found in seeds, give example where applicable. **4 marks**

Qn. 2. State in tabular form, four oilseeds and the corresponding storage protein found in each. **4 marks**

Qn. 3. Enumerate four functional application of protein concentrates (PCs) and isolates (PIs) in food industry. **2 marks**

Qn. 4. Briefly explain the importance of isoelectric point in the production of PIs. **4 marks**

Qn.5. By means of a flow diagram only, explain the production of Soy Protein Isolates (SPIs). **6 marks**